DEVELOPING INSURANCE SOLUTIONS SOFTWARE FOR NATURAL HAZARD LOSS ESTIMATION

by
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A thesis submitted in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY
in

CIVIL ENGINEERING
UNIVERSITY OF PUERTO RICO
MAYAGÜEZ CAMPUS

2007

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ABSTRACT

The population explosion in the second half of the twentieth century has caused exponential growth in economic losses associated with the natural and man-made disasters. Efforts to better understand economic consequences of catastrophic events have resulted in a number of computer programs that are best exemplified by the well known HAZUS software from the Federal Emergency Management Agency. HAZUS implements a multi-hazard loss estimation methodology that focuses on big picture solutions to regional problems. It has proven valuable when used within the framework specified by the program. This framework, however, is not ideally suited to predict loss-benefit ratios for individual structures of the types used by insurance industries. There are several commercial insurance programs, each suffering from their own model limitations and with closed source codes hindering industry wide contributions. The focus of this research is on the methodology by which basic insurance solution software may be developed and implemented to meet the societal and commercial needs for regulating and writing the policies issued to individual home owners.

The insurance solution software developed as part of this investigation offers two types of analysis. An event based analysis assumes specific design scenarios while a maximum probable loss analysis considers the likely outcome over a user defined time span. The input data required by the computer program is structured in three levels, depending on the user expertise and the extent by which the input data may be generated. The investigation requirement ranges from a basic inquiry to an engineering review of the characteristics of the

building. Using the city of Mayaguez in the western part of Puerto Rico as a test bed, building inventories are developed to analyze a real construction environment. Assimilating the outcome from the analysis tools, retrofitting measures, and uncertainty modeling, seismic and hurricane wind fragilities are quantified. Long term projections based on the maximum probable loss analysis are also reported. The changes in existing vulnerability functions are examined to reflect differences in the building types and construction practice.

RESUMEN

La explosión de la población en la segunda mitad del siglo veinte ha causado un crecimiento exponencial de las pérdidas económicas asociadas a los desastres naturales y artificiales. Esfuerzos por mejorar la comprensión de las consecuencias económicas de los eventos catastróficos han resultado en varios programas de computadora los cuales son bien ejemplificados por el conocido software HAZUS de la Agencia Federal de Manejo de Emergencias. HAZUS implementa una metodología para la estimación de pérdidas por múltiples amenazas enfocada a la solución a gran escala de problemas regionales. Si bien, este programa ha demostrado ser valioso al utilizarse dentro del marco de aplicación para el cuál ha sido especificado, este marco no es ideal para predecir las relaciones de costo-beneficio para estructuras individuales del tipo utilizadas por la industria aseguradora. También existen muchos programas comerciales destinados a la industria de las aseguradoras, los cuáles sufren de las propias limitaciones de sus modelos y sus códigos fuentes cerrados impiden grandes contribuciones de la industria. Esta investigación se enfoca en la metodología por la cual se pueda desarrollar e implementar un programa de estimación de pérdidas destinado a las compañías aseguradoras para satisfacer las necesidades sociales y comerciales de regular y escribir las pólizas de seguro emitidas a los dueños de edificios.

La herramienta computacional desarrollada como parte de esta investigación ofrece dos tipos de análisis. Un análisis basado en eventos asume escenarios específicamente diseñados, mientras que un análisis de pérdida máxima probable considera el resultado probable en un

lapso de tiempo definido por el usuario. Los datos de entrada requeridos por el programa se estructuran en tres niveles, dependiendo de las habilidades del usuario y de la extensión con que los datos pueden generarse. La investigación requerida varía desde preguntas básicas hasta una revisión ingenieril de las características del edificio. Utilizando la ciudad de Mayagüez en la parte oeste de Puerto Rico como entorno de pruebas, se desarrollaron inventarios de edificios para analizar un entorno constructivo real. Asimilando los resultados de la herramienta de análisis, medidas de retro adaptación, e incertidumbres en la modelación, se evalúan las curvas de fragilidad para terremotos y huracanes. Proyecciones a largo plazo basadas en análisis de pérdida máxima probable también son reportadas. Los cambios en funciones de vulnerabilidad existentes son examinados para reflejar las diferencias en los tipos de edificios y las practicas constructivas.

A quienes son la razón de mi vida:
mis padres, Carlos y Betty
mi abuela Ida
mis hermanos Carlos y Viviana
y mi esposa Lorena.

Acknowledgements

This work has been supported by a grant from the Insurance Commissioner of Puerto Rico. I want to thank the contribution of several graduate students who participated in various aspects of this research, including Jorge Botero, Norberto Caraballo, Joanna Cataño, Gustavo Cortés, Javier García, Rolando García, Arturo Llavona, Héctor D. López, Irvin López, Lourdes Mieses, Kevin Jhonson, Alan Rivera and Juan Sánchez. I would like to thank my advisor Dr. Ali Saffar because he gave me motivation, encouragement and a continuous guidance during all my studies. I would also like to thank the members of my graduate committee, Dr. Luis Godoy, Dr. José Lluch and Dr. Ricardo López for their contributions and revisions.

Quiero agradecer a todos los nuevos amigos que tengo gracias a esta aventura. Son muchos para enumerarlos pero cada amigo que lea esto sabrá que este agradecimiento es para el. Gracias por compartir tantos momentos, en especial, mis primeros y mis últimos meses en la isla que fueron muy difíciles para mí.

A la distancia, mi familia fue siempre un apoyo incondicional. Sus palabras de ánimo fueron una razón más para seguir hasta el final. Los quiero mucho!

Por últmo, quiero dedicarle este párrafo al amor de mi vida, Lorena. Mil palabras no alcanzarían para reconocer su esfuerzo para lograr este y todos nuestros objetivos. Por todo lo que vivimos esta tesis tiene un significado especial para nosotros y más que nunca es para vos. Te amo!

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1 INTRODUCTION

1.1 GENERAL

The population explosion in the second half of the twentieth century has placed considerable financial and operational strains on emergency management agencies. Economic losses due to the natural catastrophic events have grown exponentially since 1950. The human rescue and relocation problems in the aftermath of a catastrophe have also become a logistic and economic nightmare. The impact is more pronounced for poor developing countries with the national government carrying the largest burden and the agriculture being hit most strongly. For the richer countries, risk management is often shared by individuals, business communities, and insurers as well as local and national governments.

The trend lines in Figure 1-1 is consistent with the global temporal data showing significant increases in weather related hazards from zero in exceptional years of 1952 and 1958 to fourteen in 1993. While geological catastrophes including earthquakes and tsunamis are responsible for close to 60 percent of all fatalities during this time period, windstorms are responsible for about 75 percent of all insured losses (Munich Re Group 2005). Figure 1-2 shows the division of natural catastrophes in decades by geological and climate related events. Notice the relatively constant number of geological events in contrast to sharp increases in climate related events. The exponential increase in insurance losses caused by weather related catastrophes is one reason the climate change has become a hot bottom issue to the insurance industry.

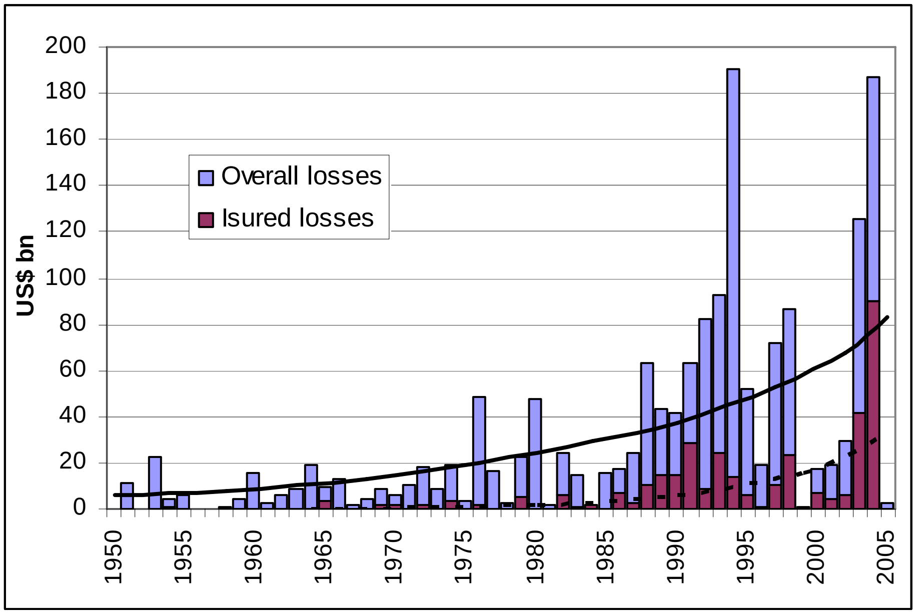


Figure 1-1 Trends in economics losses due to natural catastrophes. Data source: (Munich Re Group 2005)

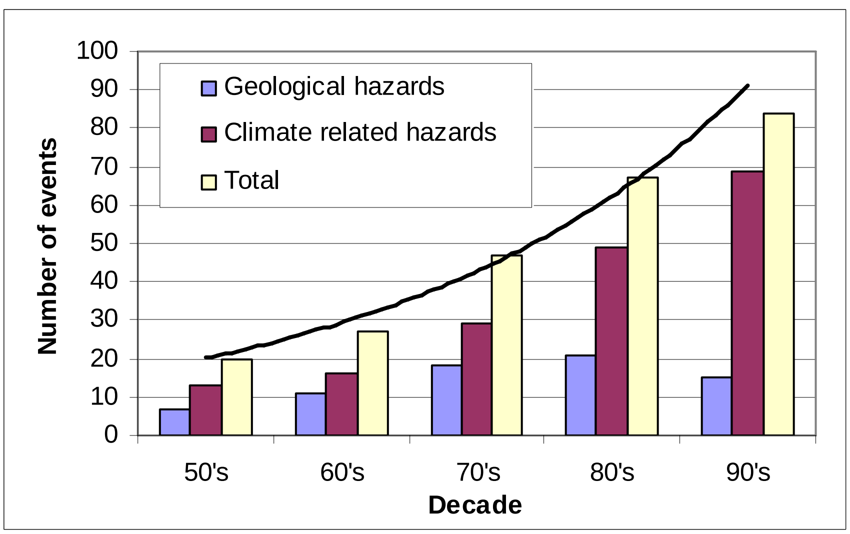


Figure 1-2 Great natural disaster. Data source: (Munich Re Group 2005)

Table 1-1 depicts socio-economic trends related to natural catastrophes over the latter half of the twentieth century. Notice that while the general population has increased by 2 to 1 ratio and the number of catastrophes has also increased by more than 5 to 1 ratio, the number of fatalities have actually decreased to only 20 percent of the high mark of 3427 in 1950's. Much of the credit should go to improve construction practices and emergence management strategies. The overall economic losses, however, have increased by 15 folds. The increase in insurance losses is even worse, a whopping 86 to 1 ratio. Consequently, the need of the insurance industry to better project their losses can not be overstated.

Table 1-1 Trends in economic losses due to natural catastrophes [from Munich Re Group (2005) and CRED (2005)

Decade		50's	60's	70's	80's	90's	Ratio 90:50s
Population (billions)		2.7	3.3	4	5	5.4	2.0
Number of events	Geological	7	11	18	21	15	2.1
	Climate	13	16	29	49	69	5.3
	Total	20	27	47	67	84	4.2
Fatalities		3427	2418	1993	1082	759	0.2
Losses (billion US$)	Overall	48.1	87.5	151.7	247.0	728.8	15.2
	Insured	1.6	7.1	14.6	29.9	137.7	86.1

The multi-hazard risk assessment cannot be considered an exclusive discipline of a single field of the engineering since it requires the integration of structural, architectural, geotechnical and socio-economic components. Recent studies in the fields of multi-hazard exposure analysis, vulnerability analysis, and loss estimation have shown great potential for future collaboration. However, very little research has been done to synthesis these components into a systematic assessment of multi-hazard risks. Furthermore, most of the investigations have been developed with target buildings located primarily in the continental United States. Therefore, their adaptation to other areas, even ones as close in overall characteristics as Puerto Rico is, will require major undertakings. In this research, we will present means by which to address all these concerns.

1.2 JUSTIFICATION

In recent years, efforts to better understand economic consequences of catastrophic events have resulted in a number of computer programs that are best exemplified by the well known HAZUS software from the Federal Emergency Management Agency. HAZUS implements a multi-hazard loss estimation methodology that focuses on big picture solutions to regional problems. It has proven valuable when used within the framework specified by the program. This framework, however, is not ideally suited to predict loss-benefit ratios for individual structures of the types used by insurance industries. There are several commercial insurance programs, each suffering from their own model limitations and with closed source codes hindering industry wide contributions.

Multi-hazard loss estimation studies serve several purposes, prominent amongst which is the design of insurance policies and reinsurance decisions. In traditional insurance models, losses are predicted using recent past experience and limited data. This is ineffective in dealing with low frequency, high severity catastrophic losses and produce sharp periodic jump in premiums. This is bad for homeowners and the insurance firms. Catastrophe models take a long term view using scientific models and can potentially result in relatively stable premiums.

Loss estimation is also of vital importance to municipal and national authorities in order to prepare emergency response and disaster recovery plans and natural hazard risk mitigation strategies. Such strategies include the development of design codes and systematic retrofit to the existing building stock.

In 1992, Hurricane Andrew spawned the adoption of catastrophe models in the insurance and reinsurance industry. Andrew caused the insolvency of a number of insurers and severe financial losses to a number of other insurers and reinsurers (Fulcher et al. 2006). The management of these insurers, confronted with unexpected levels of loss provokes the necessity of more scientific ways of assessing and estimating their exposures.

For a number of reasons, the source code for many existing catastrophe risk models is rarely made available. The need for catastrophe risk models can be efficiently fulfilled with freely available source code. The insurers would be interested in additional information provided by an open-source modeling effort. This effort could also benefit commercial model vendors by providing them with additional scientific, engineering, and financial expertise. Several research efforts on developing different components of an open-source catastrophe risk model have already begun. Some examples of freely available code are OpenSHA (Abrams 2002; Field et al. 2003) for conducting Seismic Hazard Analyses and OpenSEES (2006).

The latter was developed as the computational platform for research in performance-based earthquake engineering at the Pacific Earthquake Engineering Research Center. In the case of hurricanes, the State of Florida develops a "Public Hurricane Loss Projection Model" (Cope 2004).

1.3 OBJECTIVES

The focus of this research is on the methodology by which basic insurance solution software may be developed and implemented to meet the societal and commercial needs for regulating and writing the policies issued to individual home owners. The following objectives are the means by which such goals may be achieved:

- To classify buildings based on occupancies and structural systems for Puerto Rico.
- To identify hazard demands on buildings caused by Earthquakes, Hurricanes, and Floods. The governing factors are location, soil condition, and topography.
- To select fragility curves relating hazard demands to structural damage. These fragility curves are adopted in a way to allow both the user defined and automatic selection based on the building classification.
- To establish relationships between structural damage and insurable losses.
- To integrate the components in an intuitive, multi-level insurance solutions software.

1.4 METHODOLOGY

The proposed insurance solution software for buildings will be developed under the sponsorship of the Insurance Security Commission for the Commonwealth of Puerto Rico. The computer program is structured in three levels, depending on the user expertise and the extent by which the input data may be generated. The first level input is simple and easy to identify from photographs or site visits. The resulting calculations are based on the soil maps and hazard and fragility curves developed by our teams of experts. The second level input relies on better classification of buildings such as those expected from expert site visits or access to structural plans. The third level input option is for engineers only, and it requires detailed structural input. Highly insured buildings are the likely candidates for this more refined analysis. This is a level intended for future implementation and as such will be covered only in terms defining the basic menus.

The program offers two types of analysis. An event based analysis assumes specific design earthquakes, hurricane winds, or flood scenarios and projects the resulting monetary losses. A maximum probable loss analysis considers the likely events over the user specified time spans and reports on earthquake, wind and flood damages in combination or as separate entities.

The standard frameworks for catastrophe modeling always include a hazard module, a vulnerability module and a loss estimation or financial analysis module (Hartington et al. 1997; Fulcher et al. 2006; Murnane 2006). Additions to this basic scheme can be found. For example, the HAZUS framework for earthquake and flood divides the loss estimation module in two sub-modules: “direct economic loss” and “indirect economic loss” and the HAZUS hurricane framework adds a database module with included data of the terrain, the inventory and the topography between others. Similarly, some methodologies incorporate an exposure module to define the relevant parameters of the elements at risk (Boissonnade and Ulrich 1995). Other variation of the hurricane models consist in the addition of a stochastic event module to generate random storms (Boissonnade 2005).

The framework of the methodology used in this thesis includes the four major modules shown: Hazard module, Exposure module (or input module), Vulnerability module and Loss estimation module. This scheme is suitable to fit the three hazards considered here without modifications. The Exposure module relies primarily on data input by the user, and it feeds to the other three modules that represent the engine of the catastrophe model. These three engine modules are interdependent to each other with the output of a module acting as input of the other one.

The Hazard module determines the hazard of each event at each location. The hazard is the consequence of the event that causes damage (for a hurricane it is the wind at ground level, for an earthquake the ground shaking).

The exposure module contains tools for describing the group of the insured systems and structures. It uses a classification system described in Chapter 4. As well as location this will include further details such as age, occupancy, construction type. This module is the base for the data collection to develop city inventories.

Vulnerability is the fragility or the damageability of the buildings. This module provides the damage estimates to a particular system or structure resulting from exposure to a given hazard.

Finally, in the Loss Estimation module the damages obtained from the vulnerability module are associated to the repair cost and the risk is presented. The term risk refers to the expected losses from a given hazard to a given element at risk, over a specified future time period (Coburn et al. 1994). Risk can be described and expressed in a number of ways. The Expected Annual Loss (EAL) can be useful for estimating losses over a long period of time, but it can give a misleading idea the nature of risk from natural hazards. Most of the losses from these events actually occur trough infrequent large single events, rather than in the form of slow continuous process of destruction. A variety of different methods have been developed for the presentation of risk to help overcome this difficulty (Scenario, potential loss, etc).

To better understand and describe the methodology, the features of each module will be described in chapter 3 and specialized for different hazards in chapters 5, 6 and 7.

1.5 ORGANIZATION OF THE THESIS

This thesis is divided into ten chapters with the current chapter introducing the basic concepts, motivation, and methodology. Chapter 2 is on literature review showing that despite many studies in the analysis of multi-hazard exposure, vulnerability, and loss assessment, very little research has been done to synthesis these components into a systematic multi-hazard risk assessment tool. The need for open source insurance solution software is clearly demonstrated. Chapter 3 describes how the structural, architectural, geotechnical and socioeconomic components are integrated into a framework which includes four major modules. Chapter 4 covers the input data required to run the computer analysis. The input is structured in three levels, depending on the user expertise and the desired accuracy. The default parameters are assigned internally by the program if not otherwise specified.

Different aspects of evaluating natural hazards are discussed in Chapter 5 for earthquakes, Chapter 6 for hurricanes and Chapter 7 for floods. Probabilistic and deterministic hazards, fragility curves, site effects and repair costs are described. Chapter 8 presents two basic maximum probable loss examples on earthquakes and hurricanes. Sensitivity analysis is carried out to determine the most important factors for each hazard type. The economic losses due to earthquakes and hurricanes are compared, and the errors introduced when using default values are examined. Chapter 9 accentuates a different facet to the program by running hurricane and earthquake scenarios for the city of Mayaguez located in the western part of Puerto Rico. Conclusions and recommendations are presented in Chapter 10.

2 LITERATURE REVIEW

2.1 INTRODUCTION

One of the first attempts at systematic loss assessment, the book *Earthquake Damage and Earthquake Insurance* by (Freeman 1932) was published in 1932. The author reviewed the known history of damaging events, collated data on geotechnical and structural causes of damage, and concluded with estimates of fair earthquake insurance rates. This work was years ahead of its time, and it was only in the 1970s that the rising number of catastrophic events brought back the focus on the loss assessment development and improvement (Scawthorn 2005).

The methodologies for loss assessment (Whitman 1973; ATC 1985; Bernardi et al. 1990; Whitman et al. 1997; Calvi 1999; D'Ayala and Speranza 2002) range from minimalist Delphi type inquiries to complex computation extensive models. Furthermore, they can be specific to one building or common to several categories of buildings. In addition, the damage data used in the methodologies can be created by statistical or empirical evidence (past damage) coupled with statistical procedures such as regression analysis, expert opinions (Delphi), engineering principles and analysis, or a combination thereof (Rossetto and Elnashai 2003).

Over the last 20 years, various government agencies have worked to develop loss assessment software for planning of emergency preparedness procedures and response strategies, and also for the reconstruction phases (Whitman et al. 1997; Erdik et al. 2003; FEMA 2003; MAE 2006b). Most of these programs focus on regional losses, thus providing a big picture approach. However, they are not typically user friendly and can be run only on high end computer systems. The proper implementations by the local authorities often require significant upgrades in personnel and equipments. On the other hand, there are several commercial insurance programs: CLASIC/2 (AIR 2006), WORLDCATenterprise (EQECAT 2006), RiskLink (RMS 2006), ALLRISK (REI 2006), each suffering from their own model limitations and with closed source codes hindering industry wide contributions.

In this chapter, prominent loss assessment methodologies and software are reviewed. Section 2.2 presents some basic tools of the trade including damage probability matrix and fragility assessment models. Government sponsored and academic general purpose loss estimation software programs are discussed in Section 2.3. Existing insurance commercial software are reviewed briefly in chronological order in Section 2.4.

2.2 LOSS ESTIMATION METHOLOGIES

2.2.1 Damage Probability Matrix

The Damage Probability Matrix, “DPM” as developed by (Whitman 1973) was an early attempt to formulate large scale seismic scenarios. This method is based on the belief that buildings having a common structural system would exhibit similar performances when subjected to an earthquake. Each element of the matrix is the conditional probability of a certain damage level given a specific building type and earthquake intensity. In equation form:

$$DPM\left(DV, I, T\right) = P\left(DV \middle| I, T\right) \qquad [2.1]$$

where *DV* corresponds to a given level of damage, *T* is a specific structural type and *I* is the earthquake intensity.

This concept can be generalized to include others hazards by changing the demand used to define the matrix (wind speed, flood depth, etc.). The qualitative damage states (slight, moderate, complete, etc.) are related to damage factors expressed as the ratio of repair cost to replacement cost.

Despite its simplicity, the Whitman's model has all the essential ingredients of the later more sophisticated models. One of the main disadvantages of the DPM method is the use of discrete measure of the demand intensity.

2.2.2 ATC-13

ATC-13 methodology (ATC 1985) was intended for estimating damages and losses associated with 40 different general categories of buildings rather than for individual buildings. Damage factors, expressed as the ratio of repair cost to replacement cost, were determined by expert opinion for each type of building construction as a function of Modified Mercalli Intensity. Damage probability matrices were determined for seven damage states, ranging from "no damage" to "destroyed."

2.2.3 VULNUS

In the second half of the 1980's, the researchers at the University of Padova developed the *VULNUS* approach for evaluating the seismic vulnerability of a single building or group of buildings (Bernardi et al. 1990). The methodology is based on the evaluation of the geometrical and mechanical characteristics of each building combined with qualitative judgments on some other important factors controlling the response of the structure. The whole procedure is developed under the fuzzy set theory that is used for the definition of the safety criterion.

The geometrical and mechanical characteristics are described with two indices or collapse multipliers I_1 and I_2. I_1 is the collapse multiplier for in-plane behavior considering shear failure at ground floor. I_2 is the collapse multiplier for the out-of-plane behavior, considering each single wall and several failure modes. Finally a third factor is included in the calculation which depends on the qualitative judgments. The qualitative judgments are expressed as a combination of seven vulnerability factors S_i and their corresponding weights W_i. Tables 1 and 2 shows the proposed values for the size and the weight of each vulnerability factor, respectively. After the three parameters I_1, I_2 and I_3 have been computed, fuzzy set theory is applied in order to compute the vulnerability value.

Table 2-1 Classification and corresponding values of the vulnerability factors (Bernardi et al. 1990)

Class	Size S
1 Good or corresponding to code	0
2 Almost good	15
3 Almost poor	30
4 Poor or unsafe	45

Table 2-2 Vulnerability factors related to qualitative judgments and their corresponding weights (Bernardi et al. 1990)

Vulnerability factors	Weight W
1 Walls system quality	0.15
2 Soil and foundations interaction	0.75
3 Floors interaction	0.5
4 Elevation regularity	0.5
5 Roof interaction	0.5
6 Interaction of non-structural elements	0.25
7 General maintenance conditions	0.5

2.2.4 Fragility assessments

Over the last twenty years, advances in structural reliability analysis supported by finite element platforms have made it possible to systematize and quantify the approach for establishing relations between earthquake intensity and motion characteristics to structural response and damage (Wen et al. 2003). This improves on the purely empirical nature of some of the earlier approaches. (Singhal and Kiremidjian 1996) constructed fragilities and damage probability matrices using a Monte Carlo simulation approach involving nonlinear finite element dynamic analysis of building response to an ensemble of artificial non-stationary ground motions. Later studies have built on this earlier work, providing methods for updating fragility and damage probabilities based on data collected from damage surveys following earthquakes (Singhal and Kiremidjian 1998; Chang et al. 2000; Shinozuka et al. 2000).

2.2.5 Calvi

(Calvi 1999) proposes a simplified displacement-based method for deriving the capacity of column-sway reinforced concrete frames, starting from basic principles of mechanics and structural response to arrive at an estimation of seismic vulnerability of classes of buildings. That procedure considers the energy dissipation and displacement capacity of the existing buildings, and through a very simplified probabilistic approach, computes the probability of occurrence of a specific damage state limit for a given earthquake motion. The main drawback in this methodology is that the out-of-plane behavior has not been included.

2.2.6 Assembly-based vulnerability

Assembly-based vulnerability (ABV) method is a framework for estimating earthquake-related repair costs for a facility as a function of ground motion intensity (Porter et al. 2001). This new method extends the technique previously established in researches by (School and Kustu 1981), (Kustu et al. 1982), and (Kustu 1986). The building is conceptualized as a collection of standard assemblies, such as reinforced concrete beam-columns, wallboard partitions, windows, etc. A structural model is created for structural analysis. Mass, damping, and force deformation parameters are treated as uncertain (random) variables. One selects a ground-motion intensity of interest, and then selects or generates a ground-motion time history with the desired intensity.

Using the ground-motion time history and structural model, a nonlinear time-history structural analysis is performed, and the peak structural responses (member forces, deformations, interstory drifts, floor accelerations, etc.) are recorded. Each damageable assembly in the facility is associated with one or more fragility functions, which give the probability that the assembly will experience or exceed a particular damage state, given some relevant structural response to which it is subjected. Damage states are defined by the repairs required to restore the assembly to its undamaged condition.

For each damageable assembly in the facility, one compares the structural response to which that assembly is subjected with the assembly's capacity. If the response exceeds the capacity, the assembly is taken as damaged; otherwise, the damage state has not been reached. Given the damage state for each assembly, one estimates the direct cost to repair each of these damages, adds contractor overhead and profit, and produces an estimate of total repair cost.

Uncertainties at all stages of the analysis are propagated through the model by Monte Carlo simulation, including damage states and associated costs. The treatment of uncertainty at all stages of the analysis is among the most comprehensive of all methodologies developed to date, and the inclusion of uncertainty in the relation between damage and cost is noteworthy (Wen et al. 2003). The drawback in this methodology is the intensive computation and specialized data required to apply the method to an individual building.

2.2.7 FaMIVE

In the year 2002, D'Ayala and Speranza developed the Failure Mechanism Identification and Vulnerability Evaluation method, *FaMIVE,* to assess seismic vulnerability of historic buildings in town centers (D'Ayala and Speranza 2002). The procedure is based on a failure analysis of the structures through the identification of feasible collapse mechanisms and calculation of their associated failure load factors. This is made by means of an electronic survey form that helps to gather the information. This procedure can be applied to “medium size samples of buildings” without sacrificing the benefit of a detailed knowledge of the mechanical and geometrical features of each individual building.

2.3 LOSS ESTIMATION SOFTWARE

2.3.1 HAZUS

Of all the computer programs developed to estimate probable catastrophic losses, HAZUS from the Federal Emergency Management Agency is the most famous (Whitman et al. 1997). This program incorporates an extensive collation of technology based on three fundamental concepts: capacity curve, design point and fragility curve. It is intended to be used for estimating future social and economic losses to a community, and for emergency preparedness and disaster recovery planning activities.

HAZUS uses four damage states: slight, moderate, extensive and complete – which are related to the repair-replacement cost ratios. An important advantage of *HAZUS* is its ability to estimate the damage not just in buildings but also in lifelines, transportation systems, utility systems, and essential and high potential loss facilities. Initially this program was developed to compute the damage due to earthquake hazard and later was expanded to take into account flood, fire, wind and hazardous materials (FEMA 2003).

Although HAZUS is distributed free of charge, the source code is closed and the software is seen as difficult to use. It is therefore regarded as something of a 'black box', and has had limited acceptance. As a result, rather than promoting risk-based mitigation, HAZUS has tended to stifle innovation in that potential supporters of new risk-based software question why they should compete with 'free' software, while at the same time the inaccessibility of the source code precludes its free and open enhancement. Other disadvantage stems from its complexity; *HAZUS* takes a lot of resources to be implemented in a real application for a small to medium community.

2.3.2 KOERILoss

The KOERILoss software developed by the Kandilli Observatory and Earthquake Research Institute of Bogaziçi University applies a loss estimation methodology developed by the Institute to perform analysis for estimating potential losses under probabilistic earthquake hazard or exposure to a "scenario earthquake" (Erdik et al. 2003). The procedure has been coded into user-friendly software that operates through a geographic information system (GIS), MapInfo. The output of the program consists of economic losses associated with the general building stock that are estimated using building damage losses and costs for different structural damage of each building group.

2.3.3 MAEViz

MAEviz is a joint effort between the Mid-America Earthquake (MAE) Center and the National Center for Supercomputing Applications (NCSA) to develop the next generation of seismic risk assessment software. MAEviz follows the Consequence-based Risk Management methodology developed by the center. Consequence-based engineering is defined as: “a new paradigm for seismic risk reduction across regions or systems that incorporates identification of uncertainty in all components of seismic risk modeling and quantifies the risk to societal systems and subsystems enabling policy-makers and decision-makers to ultimately develop risk reduction strategies and implement mitigation actions” (Abrams 2002).

MAEviz uses a visually-based menu-driven system to generate damage estimates from scientific and engineering principles and data, test multiple mitigation strategies, and support modeling efforts to estimate higher level impacts of earthquake hazards. These includes impacts on transportation networks, social, or economic systems (MAE 2006a). Figure 2-1 shows the environment of the program with a scenario in the visualization window. The program has a great flexibility and potential; however it is not too intuitive and has a lot of definitions prior to run an analysis.

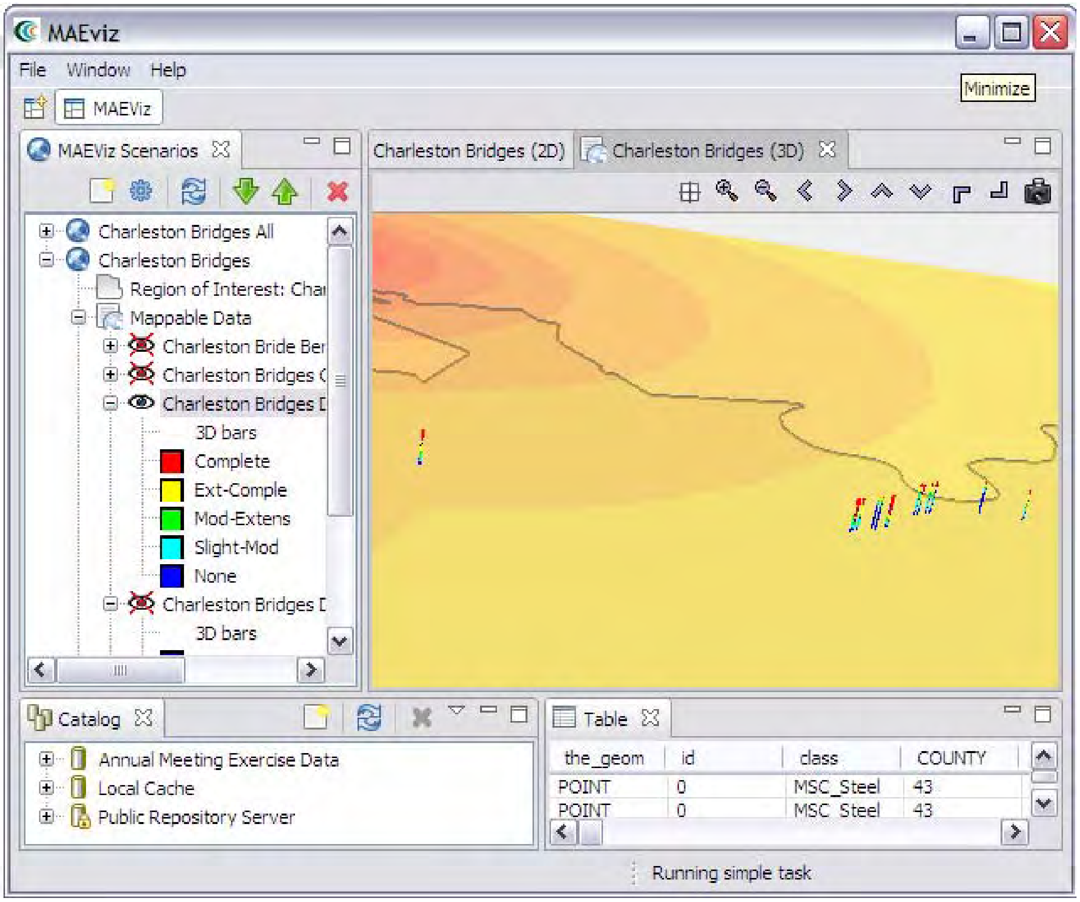


Figure 2-1 MAEViz screen shot

2.4 INSURANCE COMMERCIAL SOFTWARE

2.4.1 RiskLink

Risk Management Solutions (RMS) developed the RiskLink software. This is general-purpose software for estimating property losses for various hazards, usually applied to large portfolios of properties. This can be performed using both deterministic and probabilistic methods at the site-specific or portfolio levels. Their models cover all major insurance markets in North America, Europe, Asia-Pacific, Latin America, and the Caribbean and include residential, commercial and industrial buildings types. RMS uses this program for calculating loss estimates in the real estate and insurance industry. Use of the program by others requires an annual licensing fee and trained users. In the past, this software has been known as IRAS. Figure 2-2 show several screen outputs of the program. One output of the program is the “loss curve” relating the economic loss with the annual probability of exceedance.

2.4.2 WORLDCATenterprise

There are several risk analysis tools developed by the ABS Consulting subsidiary EQECAT. The WORLDCATenterprise is general-purpose software for estimating property losses for various hazards. A probabilistic approach is used to estimate probable maximum loss, net expected loss, and annual expected losses for an individual risk or portfolio. ABS Consulting uses this program for calculating loss estimates in the real estate and insurance industry. Use of the program by outside companies requires an annual licensing fee and trained users.

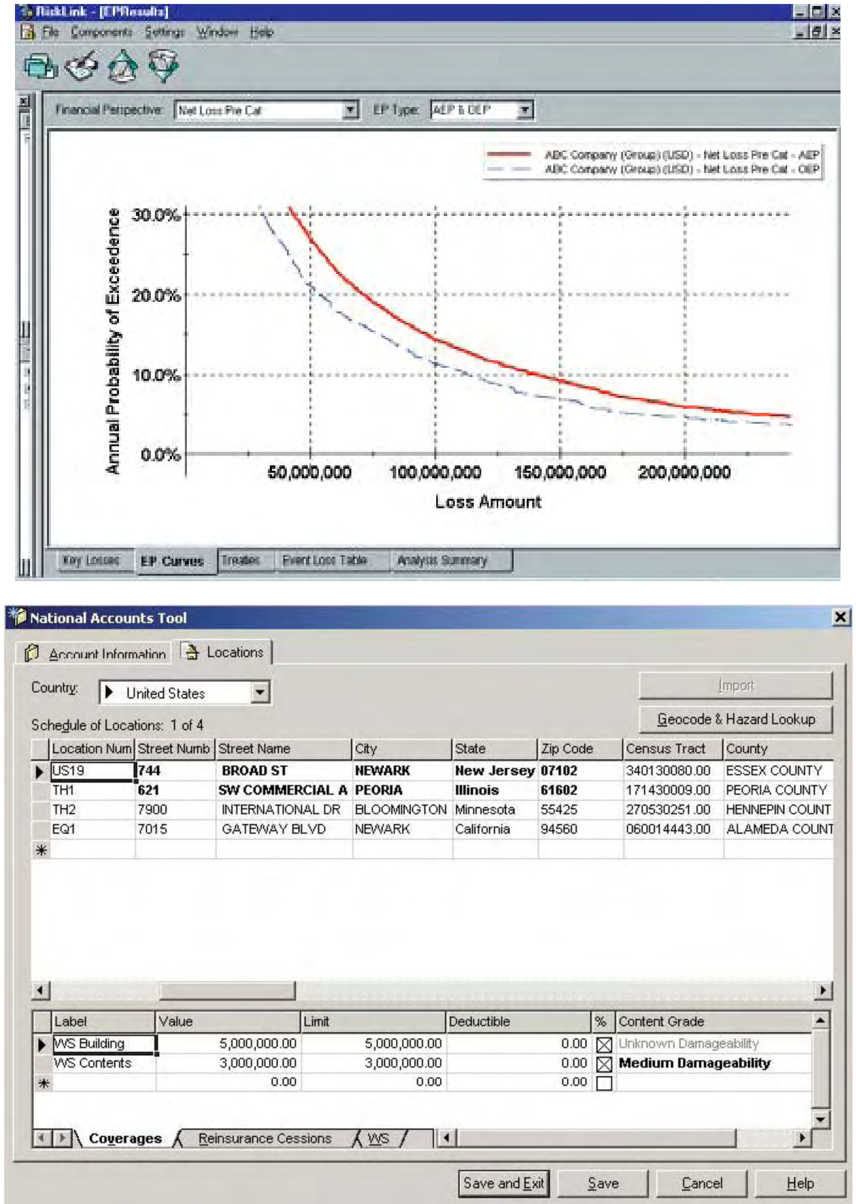


Figure 2-2 Screen shots of RisLink software

Figure 2-3 shows a screen shot of the input form the WORLDCATenterprise program. Some required data are the location of the building (city and address), type of structure, occupancy, year of construction and number of stories.

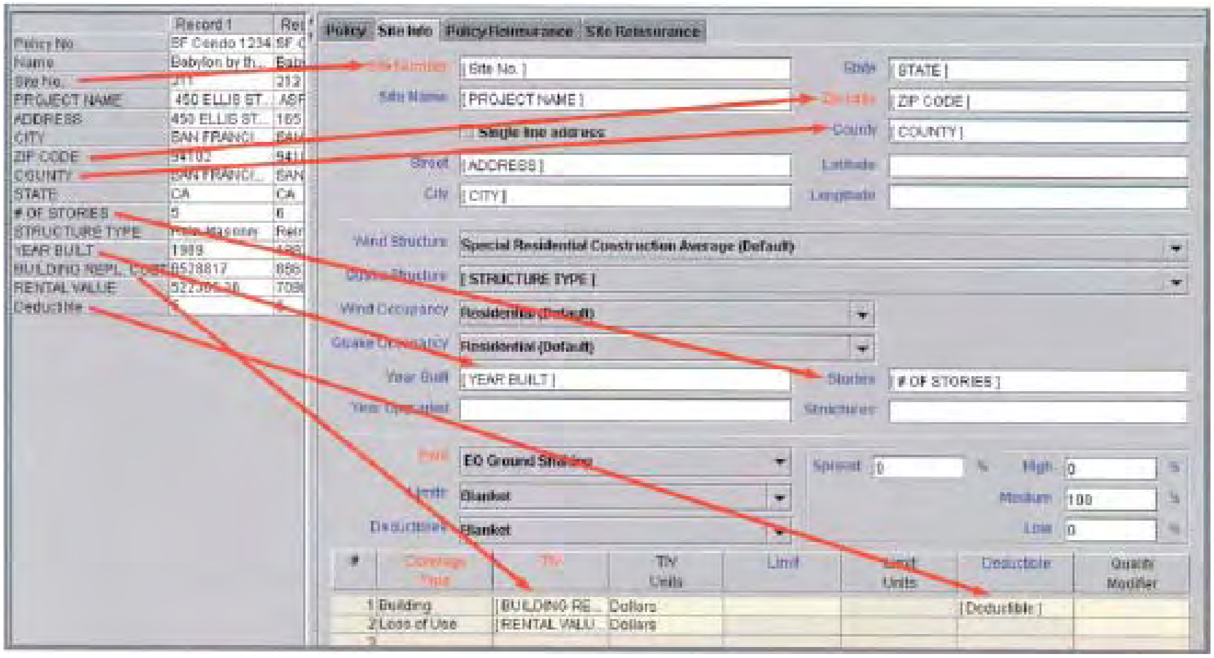


Figure 2-3 Screen shot of WORLDCATesterprise software

2.4.3 CLASIC/2

AIR Worldwide Corporation has developed CLASIC/2 software for the use by insurance and facultative reinsurance underwriters, catastrophe risk managers, managing general agents, claims managers and others.   CLASSIC/2 assesses the catastrophe loss potential of individual risks, policies, and portfolios of policies. Utilizing detailed exposure information on each location and policy, this intuitive and logically designed system facilitates individual risk selection and pricing decisions.

2.4.4 ST-RISK and ALLRISK

Risk Engineering Incorporated (REI) and Degenkolb Engineers developed ST-RISK and ALLRISK. ST-RISK is easy-to-use software for estimating property losses from earthquakes for individual buildings. It will give you Probable Maximum Loss (PML), Probable Loss (PL), Scenario Expected Loss (SEL) and many other metrics. Engineers use this program for calculating loss estimates in the real estate and insurance industry. The software is available on-line and requires a modest usage fee, negotiated based on the CPU time. The data input is carried out by means of a building characteristic list. Each characteristic has a typical value assigned for each type of structure that the user can modify (Figure 2-4). ALLRISK is general-purpose software for estimating property losses for various hazards. It is a tool specially designed for portfolio risk management and can be used by insurers or property owners. REI uses this program for calculating loss 1estimates in the real estate and insurance industry. Use of the program by others requires an annual licensing fee and trained users.

2.5 CONCLUSIONS

The usability of most insurance commercial software is limited by their inclusion of proprietary information that is not subject to normal disclosure processes. As a consequence, these programs tend to produce results that are substantially different from each other without providing the means to justify such differences. An example of this is given in Figure 2-5. Furthermore, most of these programs have been developed with target buildings located primarily in the continental United States. Therefore, their adaptation to other areas, even ones as close in overall characteristics as Puerto Rico is, will require major undertakings.

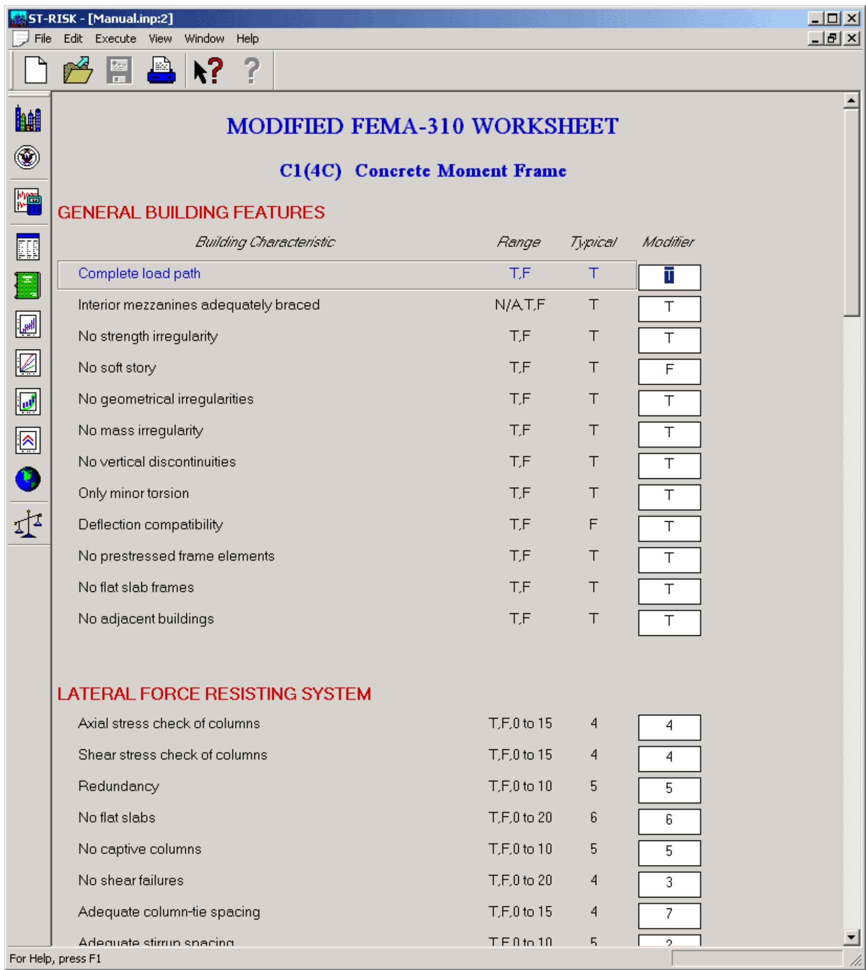


Figure 2-4 ST-RISK Input worksheet

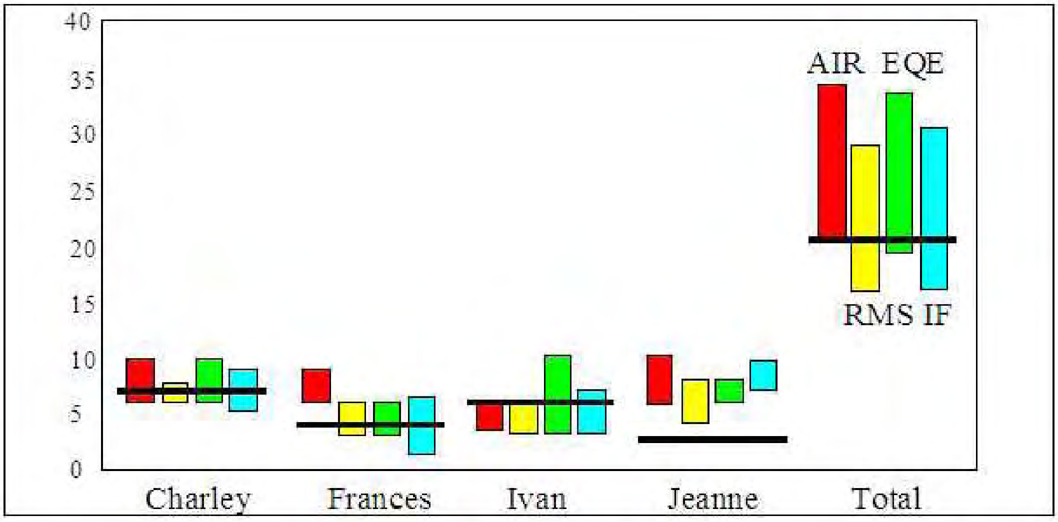


Figure 2-5 Wind loss estimation (Billions of dollars)

At a minimum, a methodology applicable to Puerto Rico should meet the following criteria (Stubbs 1996):

1. Accommodate construction practices unique to Puerto Rico.
2. Make an adequate representation of the hazard in Puerto Rico.
3. Clearly state how a hazard is modified to address a specific site.
4. Present details of the resistance model for structures along with all assumptions used to generate the models.
5. Allow modifications to the default data to exploit user available information.
6. Measure the uncertainty associated with the methodology.
7. Provide validation examples of the methodology.

In this research, we will present themmeans by which to address all these concerns.

3 GENERAL METHODOLOGY

3.1 INTRODUCTION

More and more, the insurance companies manage their exposure to the potential losses from catastrophic events by limiting the amount of exposure to such events that underwriters are authorized to expose the company to (Sanders et al. 2002). A common method of limiting the exposure includes applying caps to Probable Maximum Loss (PML) aggregate. Many stakeholders may wish to know the probability in a single year or number of years that losses of a given size will be experienced. Still others will wish to deal with performance and risk information on a scenario basis. For example, they may wish to know how much loss they can expect, given that a certain earthquake scenario occurs. Within this group of stakeholders and decision-makers, some may wish to know this information on an upper bound or "probable maximum" basis, while others will want to know a "best estimate" of the probable losses, given the scenario (Applied Technology Council 2006).

The exposure limits of the types discussed are often specified as being applicable to the amount in respect to individual perils rather than for the whole account. This chapter presents the procedure used to calculate the probable losses in a general way. The refinements based on improved levels of input and hazard definitions are presented in Chapters 4 through 7.

3.2 OVERVIEW

The catastrophe model implemented in our software has four basic modules: Exposure (or inventory model), Hazard module, Vulnerability module and Loss estimation module. A schematic diagram of this is shown in Figure 3-1. The exposure is the group of the insured systems and structures. Basic input includes location, age, occupancy, and construction type. The Hazard module determines the hazard of each event at each location. The hazard is the consequence of the event that causes damage (for a hurricane it is the wind at ground level, for an earthquake the ground shaking and for flood the water depth and water velocity). Vulnerability is the fragility or the damageability of the buildings. This module determines the degree of loss to a particular system or structure resulting from exposure to a given hazard. Finally, in the Loss Estimation module the damages obtained from the vulnerability module are associated to the repair cost and the risk is presented.

These loss assessment modules are interdependent to each other with the output of a module acting as input of the other one. The modular organization permits an easy adaptation of the methodology as research progresses and the state-of-the-art advances.

3.3 EXPOSURE MODULE

Exposure module relies primarily on the input data by the user to define the problem while the other three modules represent the engine of the catastrophe model. The input data is structured in three levels, depending on the user expertise and the extent by which the default values may be used. The investigation requirement ranges from a basic inquiry to an engineering review of the characteristics of the buildings. Theses levels of investigation are defined in Chapter 4. Although a complete analysis is performed for all levels of investigation, the lower the level of investigation the higher the uncertainties in results.

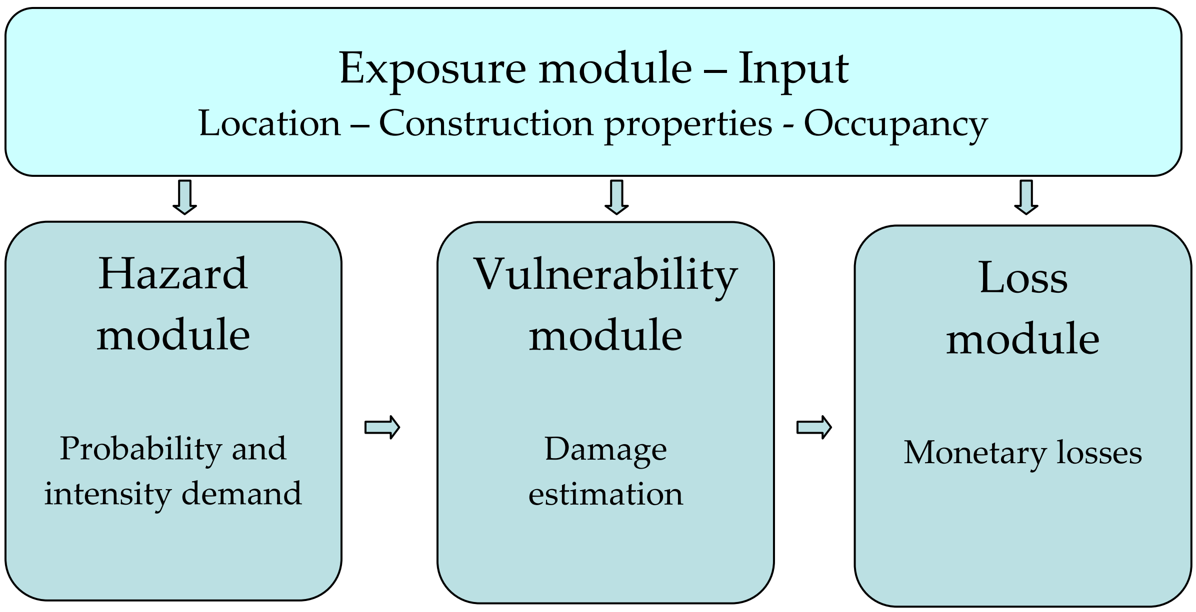


Figure 3-1 Catastrophe model modules

One of the most common uses of catastrophe models is aggregate modeling. Companies use catastrophe models to assess for a given peril (e.g. Mayagüez earthquake), and given portfolio, their estimated losses to that peril at different return periods. To show the potential use of the program over a spatially distributed system, we populate an inventory of buildings for Mayagüez as described in Chapter 9.

3.4 HAZARD MODULE

The hazard module assigns the probabilities and the intensity of the natural hazards and the corresponding demand on a particular site. The fundamental input to this module is the building location. Other parameters are the soil type, wind exposure and topography of the site.

Hazard simulation is the most crucial factor because the uncertainty related to it can be orders of magnitude greater than that related to other model components. The uncertainty in the natural event demand can be therefore approximately described in terms of a random variable (S) of an adequate intensity measure, such as the peak ground acceleration for earthquake or 3-second peak gust for hurricanes, over a given period of time (t). The mean annual probability of exceedance (λ) of such a random variable is generally referred to as the hazard curve:

$$\lambda(s) = P_{annual}(S \geq s) \qquad [3.1]$$

This curve can be expressed in other two equivalent probabilistic terms: the average return period between events and the probability of exceedance over a specific interval of time (exposure time).

Assuming that the temporal occurrence of the events follows a Poisson process, the probability of exceedance (P_{Te}) in a given exposure time (Te) is related to the annual probability of exceedance (λ) as follows:

$$P_e\left(s\right) = 1 - e^{-\lambda(s)T_e} \qquad [3.2]$$

The reciprocal of the annual probability of exceedance is the return period, which represents the average number of years between exceedance:

$$T_R\left(s\right) = \frac{1}{\lambda\left(s\right)} \qquad [3.3]$$

The following notation is used to denote an event intensity corresponding to a probability of exceedance P_e over a period T_e:

$$S\left(P_e, T_e\right) = s_{P_e, T_e} \qquad [3.4]$$

While probabilistic hazard information is commonly used for site-specific analysis, for geographically distributed systems, the spatial correlation between the event demands across many sites is important. Deterministic loss scenarios provide a traditional means for assessing regional natural hazards impacts that accounts for spatial correlation. The scenario events are described by mean of the spatial distribution of the demand intensity s for a particular event j:

$$S_{Event:j}\left(x, y\right) = s \qquad [3.5]$$

3.5 VULNERABILITY MODULE

Vulnerability is the propensity of things to be damaged by a hazard. Each type of hazard puts a somewhat different set of elements at risk. For a full definition of vulnerability, the expected levels of damage at all hazard severities must be known. Vulnerability for a range of events of different severities can be given by means of a continuous function mapping values of damage to values of hazard severity.

The vulnerability module of our program estimates the damage level of the building using fragility curves that relate the demands generated in the hazard module with the damage in the building. The fragility curves are defined based on the building construction class and in some cases are sensitive to additional material and geometric properties.

For an specific damage state, DS, a fragility curve is a plot, as function of a demand, S, of the conditional probability of the building being or exceeding the damage state. Commonly, a fragility curve is taken to be lognormal, in which case it can be expressed algebraically in terms of the standard cumulative Normal distribution Φ by:

$$P\left(d \geq DS \middle| S\right) = \Phi\left[\frac{\ln\left(S\right) - \mu_{LN}}{\sigma_{LN}}\right] \quad [3.6]$$

where σ_{LN} is the lognormal standard deviation which takes into account the sources of uncertainty and μ_{LN} is the mean value of lognormal of S at which the building reaches the threshold of the damage state DS.

There are numerous types of damage scales with various attributes, qualities, difficulties, and advantages (Whitman 1973; Whitman et al. 1975; Hirschberg et al. 1978; Rojahn et al. 1985). The scales found use between 4 and 15 levels (including no damage). Most scales have 6 to 8 levels indicating different degrees of damage. It is desirable that the selected damage scale is defined in terms of at least three damage limit states (Rossetto and Elnashai 2003). Here, the building performance is described by means of four damage states: slight, moderate, extensive and complete. These damage states are described for each hazard in Chapters 5 through 7.

Design fragility curves for the construction classes most common to Puerto Rico were derived by our groups of specialists in earthquake, hurricane and flood hazards. A variety of analytical procedures have been followed, ranging from static elastic analysis to nonlinear time history analyses of 3D models to laboratory testing. The choices made for the analysis method, structural idealization, hazard definition and damage models strongly influence the derived curves. This thesis presents only a summary of these results. For a detailed discussion, the reader is referred to the thesis works by Avilés (2006), Cortés (2006), García González (2007), Nadal (2007) and Mieses (2007).

3.6 LOSS ESTIMATION MODULE

The term risk refers to the expected losses from a given hazard to a given element at risk, over a specified future time period (Coburn et al. 1994). Risk can be described and expressed in a number of ways. The Expected Annual Loss (EAL) can be useful for estimating losses over a long period of time, but it can be misleading given the recurrence rates for various hazards. Most of the losses from these events actually occur trough infrequent large single events, rather than in the form of slow continuous process of destruction. A variety of different methods have been developed for the presentation of risk to help overcome this difficulty (event scenarios, potential losses, etc).

The loss expressions are defined according to the ASTM E2026-99 Standard Guide for the Estimation of Building Damageability in Earthquakes (ASTM 1999). This guide defines and establishes good commercial, customary practice and standard-of-care in the United States for conducting a probabilistic study of expected losses to buildings from earthquakes. Although specially written for earthquakes, the definitions in this guide can be extended to cover hurricanes and floods.

The ASTM E2026-99 does not recommend the use of the term "Probable Maximum Loss" (PML) because it has had a number of significantly different explicit and implicit definitions. Instead, it is recommended that the terms probable loss (PL) and scenario loss (SL), whose definitions are precise, be used to characterize the earthquake damageability of buildings and groups of buildings.

The ASTM E2026-99 defines Probable Loss (PL) as:

> loss to the building(s), not including contents or equipment, that has a specified probability of being exceeded in a given time period from earthquake shaking. PL values are expressed as a percentage of building replacement construction cost (current).

In terms of usage:

> PL values are given either as a value(s) with a specified return period(s), PLN, or as the value that has specified probability of exceedance (from 1 % to 50 %) in a given time period (1 to 50 years). The most common return periods used are 72, 190 and 475 years, that correspond to a 50 % probability of exceedance in 50 years, and a 10 % probability of exceedance in 20 and 50 years, respectively. The most commonly used probability of exceedance is 10 %, and the most common time periods are 20 and 50 years.

Also defined by the ASTM E2026-99 is the Scenario Loss (SL) as:

> loss to the building(s), not including contents or equipment, resulting from a specified scenario event on specific faults affecting the building, or specified ground motions. The specific damageability and ground motion characterizations are to be specified. SL values are expressed as a percentage of building construction cost (current replacement cost).

Expanding on this definition, Scenario Expected Loss (SEL) is

> the expected value loss in the specified ground motion of the scenario selected. Since the damage probability distribution usually is skewed, rather than symmetrical, it should not be inferred that the probability of exceeding the SEL is 50 %; it can be higher or lower than this amount.

And Scenario Upper Loss (SUL) is

> the scenario loss that has a 10 % percent probability of exceedance due to the specified ground motion of the scenario considered.

The general equation for the probable loss with a probability of exceedance P_e over a period of time T_e can be given by:

$$PL^{m,n}_{P_e,T_e} = \sum_{i=2}^{5} RC^n_i P_m \left[DS = d_i \,\middle|\, S_{P_e,T_e} \right] \qquad [3.7]$$

The term $P_m\left[DS = d_i \middle| S\right]$ is the discrete probability for one structure type *m*, defined as the conditional probability of reach a damage state $DS=d_i$ given the occurrence of the specific hazard intensity *S* among the spectrum of hazards. The damages states d_i correspond to slight (i = 2), moderate (i = 3), extensive (i = 4) and complete (i = 5).

The discrete probabilities are obtained as difference between the fragility curves described in section 3.5:

$$P_m\left[DS = d_i \middle| S = s_{P_e,T_e}\right] = \begin{cases} P\left(DS \geq d_i \middle| S = s_{Pe,T_e}\right) - P\left(DS \geq d_{i+1} \middle| S = s_{Pe,T_e}\right) & i = 2,3,4 \\ P\left(DS \geq d_i \middle| S = s_{Pe,T_e}\right) & i = 5 \end{cases} \qquad [3.8]$$

The term s_{Pe,T_e} represents the intensity of the hazard *S* with a likelihood of exceedance P_e over a period of time T_e (Section 3.4). The third term RC^n_i is the building repair to replacement ratio associated to an occupancy type *n* in a damage state $DS=d_i$. This mapping process between damage states and economic losses is one of the most significant research issues at the present time. In this study the loss model is assumed to be deterministic.

Repeating the calculation for various annual probability of exceedance, it is possible to get the loss exceedance probability (EP) curve. A loss exceedance probability curve (EP) is a graphical representation of the probability that a certain level of loss will be exceeded on an annual basis. The y-axis of the EP curve represents economic loss as a percentage of the building replacement cost and the x-axis represent the probability of exceedance.

As mentioned earlier, other value of interest for the decision-makers is the expected annual loss. The expected or mean value of a random variable, such as probable loss, is the mathematical centroid of the probability distribution for the random variable; that is, it is determined as the sum (or integral) of all the values, such as economic losses, that can occur multiplied by their probability of occurrence (ASTM 1999).

The area under the mean EP curve represents an approximation to the expected annual losses and is equivalent to taking the summation of the losses multiplied by their annual probability of occurrence (FEMA 2003). In equation form:

$$EAL = E\left[PL\right] = \int_{\lambda(s)} \lambda\left(s\right) PL\left(\lambda\left(s\right)\right) \cdot d\lambda \qquad [3.9]$$

The choice for the number of return periods is important for evaluating average annual losses, so that a representative curve connected through the points and the area under the probabilistic loss curve is a good approximation. The number of points must be determined from a sensitivity study and is established in the Chapters 5, 6 and 7 for each type of hazard. Consequently, the probable maximum loss can be determined by reading the loss associated with a given low annual probability of exceedance from the EP curve.

While the expected annual loss provides basic information needed to calculate the amount that insurers must incorporate into the premium to cover future losses in the long term, the probable maximum loss gives the insurer an idea of the loss amount it could be liable to cover in the case of an extreme catastrophic event.

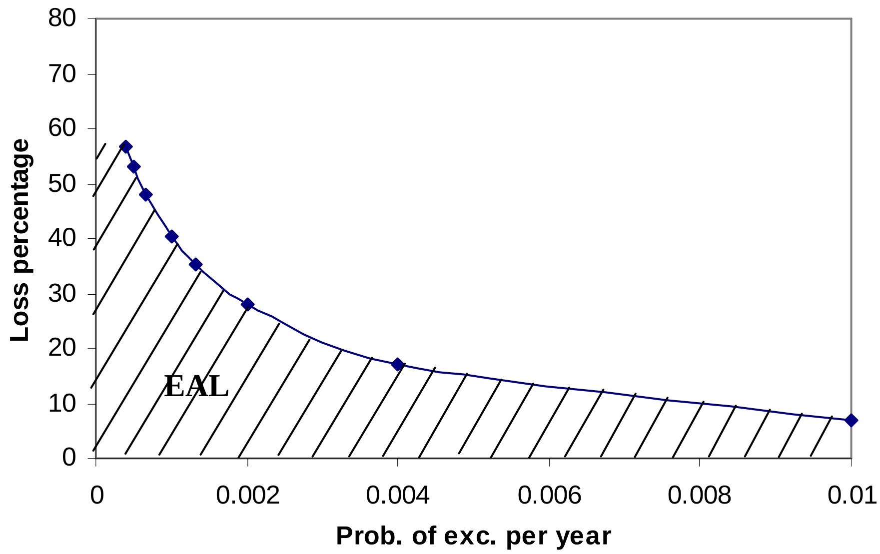


Figure 3-2 Loss exceedance probability curve

4 MULTILEVEL INPUT DATA

4.1 INTRODUCTION

This chapter describes the input data and default assumptions underlying the multi-hazard risk assessment methodology implemented in our program. The input data is structured in three levels, depending on the user expertise and the degree of uncertainties associated with various damage states. The investigation requirement ranges from a basic inquiry to an engineering review of the characteristics of the buildings. The user could perform a complete analysis under any level of investigation, but lower levels of investigation result in higher uncertainties in results.

4.2 LEVELS OF INVESTIGATION

The standard guide ASTM E-2026 defines and establishes good commercial practice and standard-of-care in the United States for conducting a probabilistic study of expected losses to buildings from seismic events (ASTM 1999). It identifies four levels of investigation, of which Levels 0, I, and II are considered for this study. Each level can be easily extended to define the requirements for all hazards, including wind and flood. A summary of the input data and default assumptions for the three levels is shown in Figure 4-1.

Level 0 inputs present the minimum data required to perform an analysis. These inquiries consist of, but are not limited to, occupancy type, age of the structure, number of stories and location. The inputs are simple and easy to identify from photographs or site visits. The resulting calculations are based on the soil maps and hazard and fragility curves developed by our teams of experts. The uncertainties associated with this level of analysis are the highest allowed by the program.

Level I inputs rely on better classification of buildings that can be expected from expert site visits or access to structural plans. Compared with Level 0, building geometry and type are identified in more details, quality of construction is accounted for, and nonstructural components that may contribute to the damage states are recognized. The inputs at this level are not required to run the analysis but they will improve the selection by improving on default values.

Level II input option requires an engineering review of the seismic response characteristics of the building by assessing those issues likely to dominate its performance. These include configuration, continuity of load paths, compatibility of system deformation characteristics, redundancy of load paths, strength of elements and systems, toughness of elements and connections, and physical condition. The analysis based on the Level II inputs has moderately low levels of uncertainties.

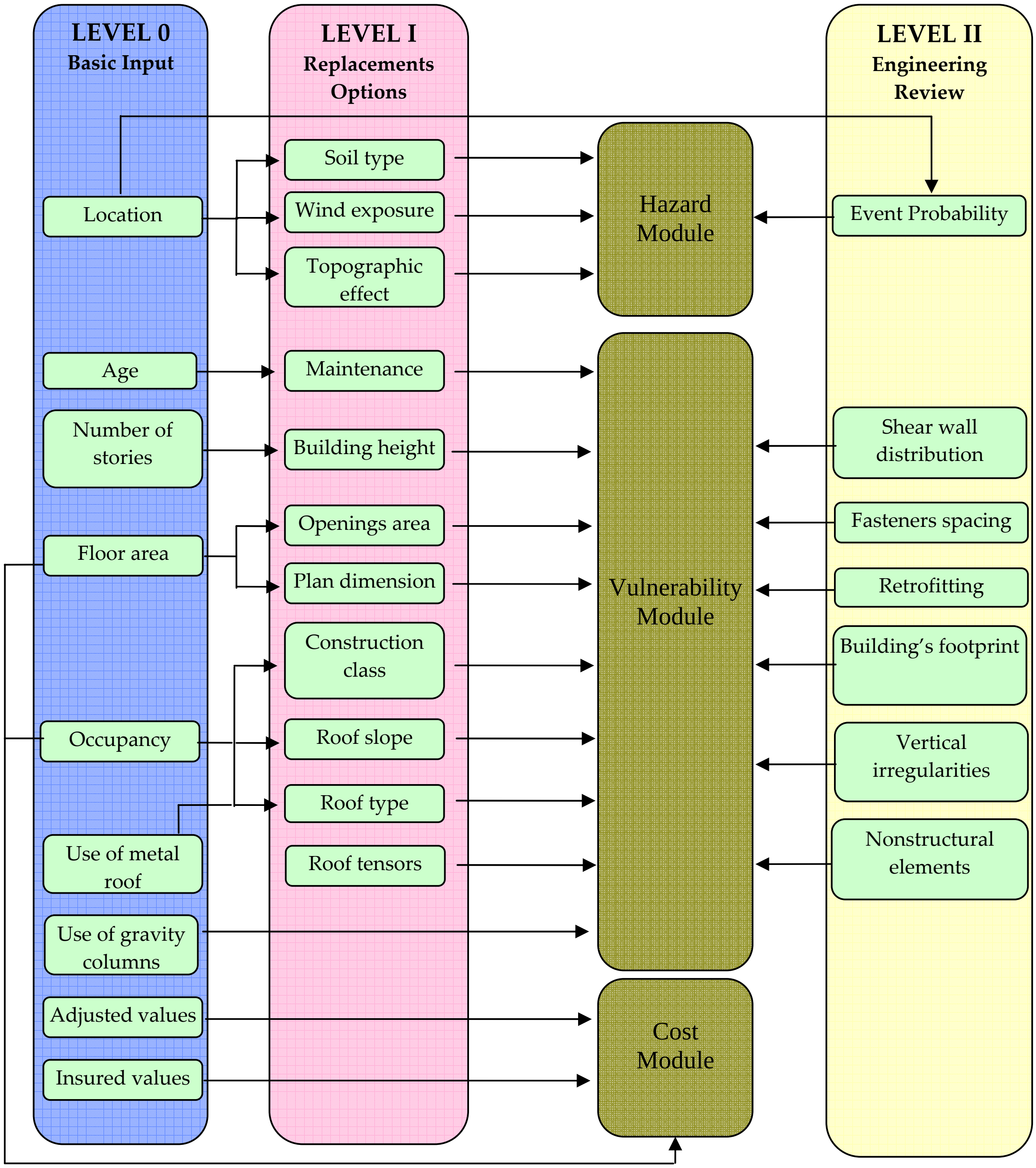


Figure 4-1 Input and default assumptions

The last level of investigation (Level III) is for engineers only, and it requires detailed structural input. Typical calculations will involve such factors as story accelerations and inter-story displacements to estimate the expected damage states. Highly insured buildings are the likely candidates for this more refined analysis. Level III analysis is not ideally suited to general loss estimation software and will not be implemented here.

4.3 LEVEL 0 INPUTS

4.3.1 Location

The location of the building is the basic input of the hazard module. Four of the most important cities in the Commonwealth of Puerto Rico were considered for this study. These are San Juan, Ponce, Arecibo and Mayagüez. Each city is divided into barrios (neighborhoods). Once a barrio is selected, the user is provided by a map to mark the location (Figure 4-2).

Location of a building is used to assign hazard levels for earthquake, hurricane, and flood under various analysis modes in the program. It is also used to assign default soil types, wind exposure and topographic effects (Section 4.4).

4.3.2 Occupancy types

The occupancy classification facilitates the user selection of their building type and is useful for the planned expansion of the program to include content losses and socio-economic factors. Occupancy class is also important in determining direct economic losses, since building value is primarily a function of building use. Four basic divisions are considered: residential, commercial, industrial and institutional. As shown in Figure 4-3, the divisions follow the classification by (R.S. Means 2007) which were used to prepare the cost factors for this research (Botero 2004; Jhonson 2007).

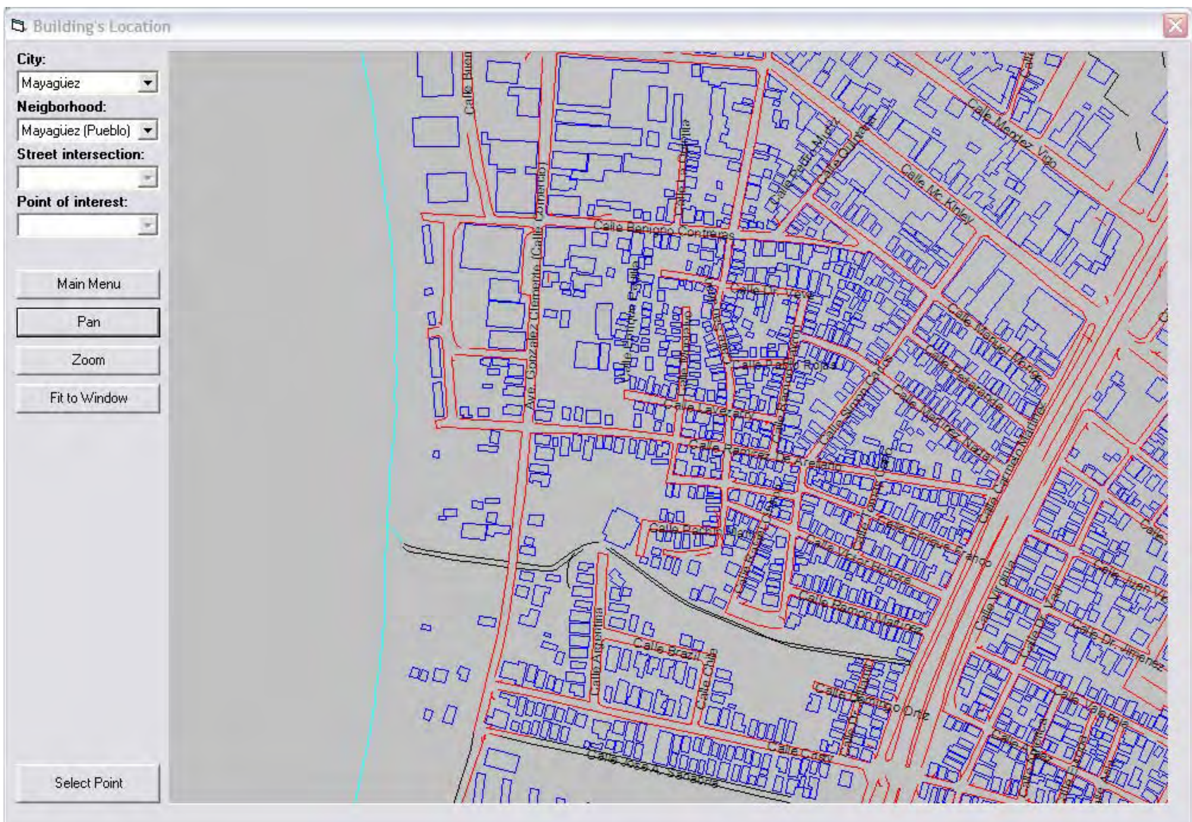


Figure 4-2 Building's location input

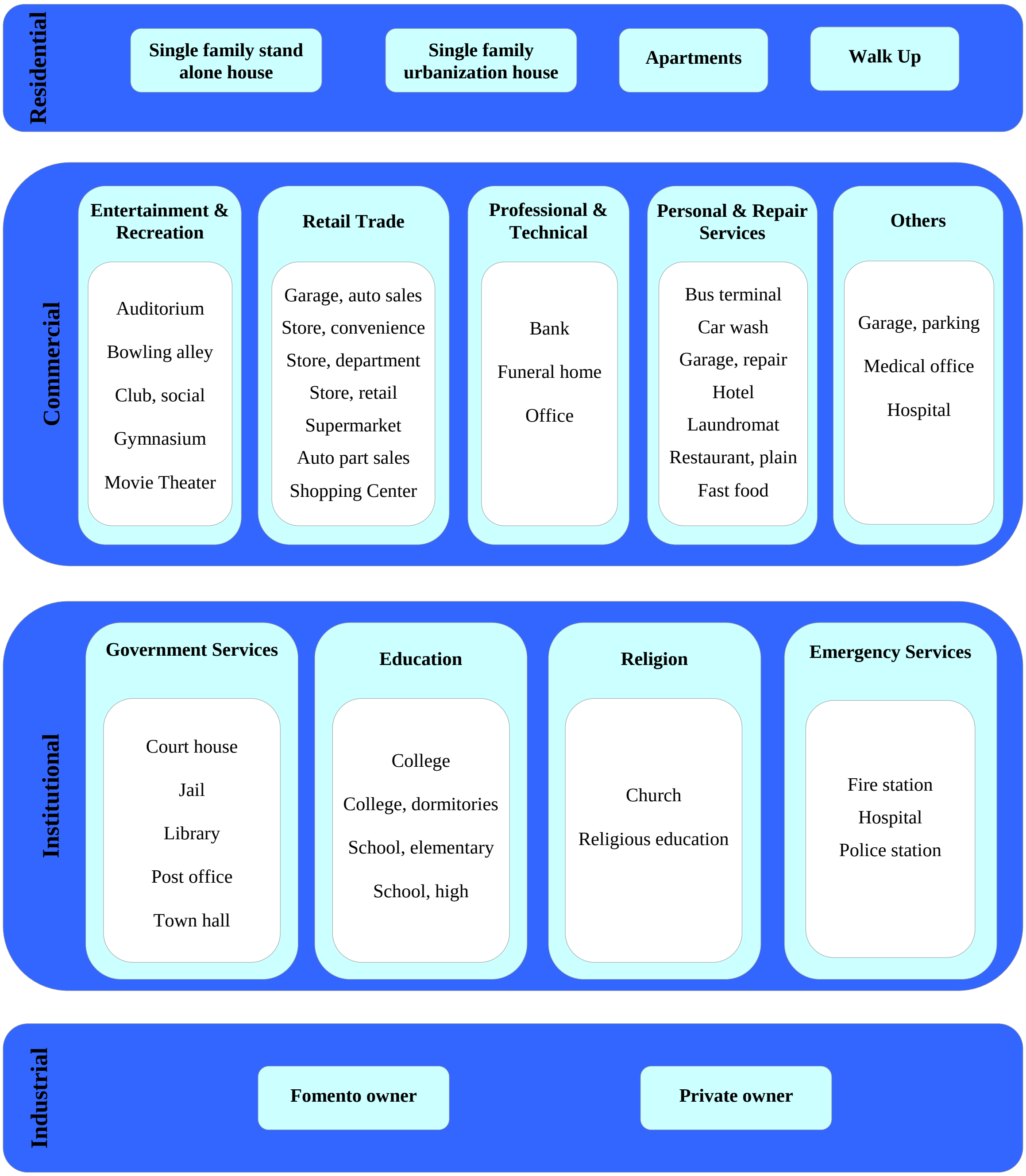


Figure 4-3 Classification of buildings by occupancy

The classification of buildings in Figure 4-3 is also used to set the default values for construction types. This is discussed in Section 4.4. The selections from R. S. Means are limited to occupancies present in Puerto Rico and are divided in subgroups to facilitate both the programming and the user interface. Photographs of various occupancy types are incorporated into the program. Residential buildings are classified into four categories: single family urbanization house, single family stand alone house, apartments and walk ups. The list of commercial buildings includes 25 specific types in 5 groups. Institutional buildings are divided into four general categories and 14 specific uses. Finally, Industrial buildings are divided in two groups based on the ownership. A large number of industrial buildings in Puerto Rico are owned by FOMENTO and are leased to various companies as part of continuing effort to bring industries to the Island. These buildings share common characteristics which are helpful in assigning the fragility curves.

4.3.3 Number of stories

Buildings are often classified according to their heights as low-rise, mid-rise and high-rise. By our standards, buildings of up to three stories are low-rise, four to seven stories are mid-rise, and over seven stories are high-rise. The organization chart in Figure 4-4 is from a field survey, showing the most likely height options for different occupancies in Puerto Rico.

	Residential	Commercial	Institutional	Industrial
Low-rise	Single family house (1-3 stories) Walk-Up (3- 4 stories)	Bowling alley Club, social Gymnasium Garage, auto sales Auto part sales Store, convenience Store, department Store, retail Supermarket Bank Funeral home Bus terminal Car wash Garage, repair Laundromat Restaurant, plain Restaurant, fast food Medical office Movie Theater Auditorium Garage parking	Post office Town hall College School, elementary School, high Church Library Religious education Fire station Police station	Fomento (1-2 stories) Private owner (1-2 stories)
Mid-rise	Apartments (4-7 stories)	Hospital Office Hotel Auditorium	Court house Jail Library College College, dormitories Hospital	
High-rise	Apartments (>7 stories)	Office Hotel Hospital	Hospital	

Figure 4-4 Building's heights

In residential buildings, wood and concrete house are usually one to three stories, walk-ups are usually three or four stories and apartments have more than four. The difference between houses of three floors and walk-ups of three floors is that houses are composed of one dwelling unit and walk-ups are composed of multiple dwelling units. The field visits showed that most of the commercial buildings were low-rise. The exception is the office buildings that can be mid-rise or high-rise. In case of institutional buildings, although most are low-rise, the number of mid-rise buildings is significant.

4.3.4 Floor area

Information on Floor area is used to estimate the building cost and compare it against the insured value. In cases where the insured value is substantially higher, the damage loss estimate is scaled down accordingly. In addition, it is envisioned that future versions of the program will use an extended library of fragility curves that will rely more heavily on division by size as well as building class.

4.3.5 Age

There are two issues associated with the age of a building, the changes in practice and design philosophies over the years and the probable maintenance problems. The latter is yet to be formulated and will be left for a future revision to the program. The former was found not to influence the default setting for building types going back to 1930s. In addition, the seismic performances of older buildings are found comparable to modern ones if we were to discount the maintenance issues (Mieses 2007). The repair cost to the façade and some interior parts, however, was shown to be higher for older buildings as certain materials are no longer readily available. For the most part, the age is retained as Level 0 input with future use in mind.

4.3.6 Roof types

The metal roof options are available for certain building types that are known to use it in the Island. These are prominently walkups and commercial and industrial buildings. In addition, wood-zinc roof systems common to low-cost residential and older institutional buildings are also considered. The hurricane fragility curves for these structures were specially developed as part of the collaborative research with the Mid-America Earthquake Center (Aviles 2006, Garcia 2007).

4.3.7 Gravity columns

It is common practice in Puerto Rico to build elevated reinforced concrete structures in hillsides and hilly terrains by supporting them on very slender gravity columns (Figure 4-5). Two recent studies on these structures have shown high vulnerability to seismic events, especially when factoring in the amplification due to the site topography (Vázquez 2002; González Solá 2007). There are different sets of seismic fragility curves assigned to these structures including options on retrofitting measures. Further details on how our program treats these structures can be found in Section 5.6.

Figure 4-5 House with gravity columns

4.4 DEFAULT SETTINGS

In deciding on Level 0 input as the minimum to run an analysis, the emphasis was placed on accommodating the users by requiring only such data that can be obtained from typical insurance files. It was then become necessary that on some levels, default parameters based on user input are assigned internally by the program to complete the analysis. To define the default settings for Puerto Rico, detailed studies on soil types and wind exposure characteristics were augmented by a building classification survey. The survey included field visits, plans reviews, and gathering of expert opinions. It revealed the more common building exposure characteristics by occupancies including construction class and building size. *Level I inputs may replace one or more default settings.*

4.4.1 Soil type

Detailed soil maps for several major cities in Puerto Rico were developed as part of the Insurance Commissionaire initiative funding this research. These maps are based on standardized site geology classification proposed in the NEHRP (National Earthquake Hazard Reduction Program) provisions. A geotechnical database was created that includes available borehole information, SPT (Standard Penetration Test) and CPT (Cone Penetration Test) data, and groundwater information. It was complemented with shear wave velocity profiles from geophysical tests where available. Procedural summary citing references are given in Section 5.4.1. Soil maps for the cities of Mayagüez, Ponce, San Juan and Arecibo can be found in Appendix J. In our program, the soil data is a hidden layer under the street maps. Once a location is selected, the associated soil type is tagged and the user is warned if liquefaction poses a problem. Users have the option to override the selection and in case of liquefaction to decide whether preventive measures are in place.

4.4.2 Wind exposure and topographic effects

Typical calculations for wind effects assume an isolated structure in an open terrain. Henceforth, corrective measures are added to account for different exposures. Of importance is the ruggedness of the land and wind speed-up effects at isolated hills, ridges, and escarpments that constitutes abrupt changes in the general topography. Wind exposure and topographic effects maps for several cities of Puerto Rico are developed by means of satellite photos and topographic maps. Details of how these maps are generated can be found in the section 6.4 and the results for each city are presented in Appendix K.

4.4.3 Building geometry

The building prototypes used for generating system fragilities in our program offer a wide range of options. In most cases, by narrowing the size of the building, a more refined selection of fragility curves may be possible. Building height and floor area are two such factors. Another factor is opening sizes which are of interest when considering damages caused by flying debris or flood surge.

4.4.4 Construction class

In this research, structural types as well as form and function define construction classes. Visually identifying structural types, however, is not always easy. For example, the facades of buildings constructed using moment resisting steel or reinforced concrete frames may have similar characteristics. In turn, this can produce erroneous user assumptions. It is therefore desirable to link structural systems to building functions. Once again, field survey and expert opinions are used to make these assignments.

Residential buildings

The 1990 US Census (Negociado del Censo 1990) lists fifteen percents of the island's housing as either wood frame or mixed construction with wood-zinc roofs. The rest are shear wall or reinforced concrete frame structures. The wood-zinc houses in Puerto Rico are distinct and easy to identify visually. Based on the construction practices in the Island, the concrete houses in urbanizations are shear wall structures. Stand alone housing construction is typically concrete frame with infill block walls. Walk-up buildings and apartments are likely to be concrete shear wall structures with metal roofs a possibility for walk-ups. The residential buildings construction classes are summarized in the Table 4-1. The term "mixed house" in this table refers to houses that have a wood-zinc addition on the top.

Table 4-1 Default structural types for residential buildings

Residential Buildings	Structural Type
Urbanization Concrete House	Shear Wall
Stand alone Concrete House	Moment Resistant Frame
Wood House	Wood
Mixed House	Shear Wall and Wood
Walk-Up	Shear Wall
Apartments	Shear Wall

Commercial buildings

Table 4-2 lists default structural types for commercial buildings by use. The listing is consistent with the results from (Khanduri and Morrow 2002) that shows steel and concrete as the dominant construction material for all sizes of commercial buildings in Puerto Rico (Figure 4-6). Note that for office buildings and Hotels, the default structural type is based on the number of component units. For more than 10 units, the favorite construction class is the concrete shear wall. For less than 10 units, the most used system is moment resistant reinforced concrete frame.

Table 4-2 Default structural types for commercial buildings

Shear wall	Concrete MRF	Steel MRF
Medical office	Bus terminal	Movie theater
Hospital	Garage parking	Auditorium
Office > 10 units	Club, social	Garage, auto sales
Hotel > 10 units	Funeral home	Car wash
	Small Store Retail	Garage, repair
	Restaurant	Bowling alley
	Laundromat	Gymnasium
	Bank	Auto part sales
	Office < 10 units	Supermarket
	Hotel < 10 units	Shopping Center

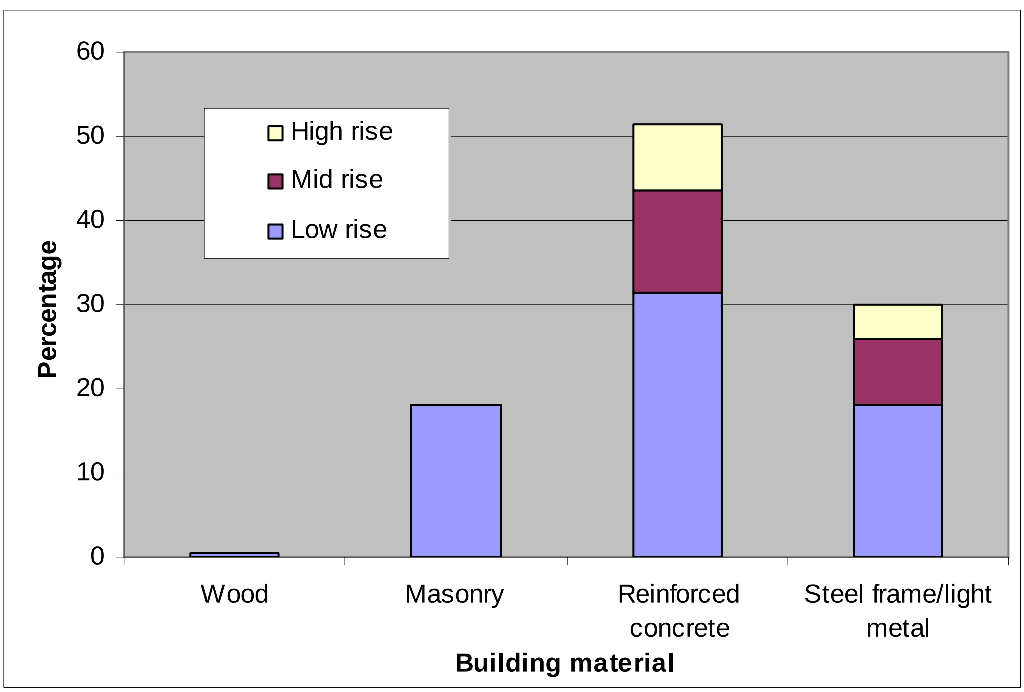


Figure 4-6 Commercial buildings materials (Khanduri and Morrow 2002)

Institutional buildings

Like commercial buildings, structural types for institutional buildings are also related to their function. Table 4-3 provides a listing.

Table 4-3 Default structural types for institutional buildings

Shear wall	Concrete MRF	Steel MRF
Post office	School, elementary	College
College	School, high	
Court house	College, dormitories	
Jail	Fire station	
Library	Church	
Hospital	Police station	

Industrial Buildings

All Industrial buildings in Puerto Rico use steel frames supported on pedestals or simple footings. They are differentiated by their façade and roof type. The variations listed in Table 4-4 include concrete, metallic, mixed facade and mixed. The first two divisions are self explanatory. A mixed facade building is a multistory using concrete or masonry in the facades of the first level and metallic sheets in the upper floors. A mixed building uses concrete or masonry materials in their facades and steel decks on the roof.

Table 4-4 Default structural types for industrial buildings

Industrial Buildings	Facade	Roof
Concrete	Concrete	Concrete
Metallic	Metallic	Metallic
Mixed facade	Metallic and concrete or masonry	Metallic
Mixed	Concrete or masonry	Metallic

4.4.5 Roof types

As part of Level 0 inputs, the user will tag the buildings with metal roofs. The program would then assign default roof types in accordance with the classification listed in Table 4-5. According to the type of construction and the building occupancy, only some roof types can be available. For example, the roofs for wood houses are either wood-zinc or plywood diaphragms. Older institutional buildings will use concrete, wood-zinc or steel roofs, although more and more of wood-zinc roofs are being converted. Most industrial buildings use steel decks fastened to steel joists. Commercial buildings with steel frames use steel deck covers. Commercial buildings with concrete frame or shear walls use concrete roofs.

Table 4-5 Default roof types

Classification	Metallic	Non- Metallic
Concrete Shear Wall House	Wood-Zinc	Concrete
Wood House	Wood-Zinc	Wood
Mixed House	Wood-Zinc	Wood
Walk-Up	Steel deck	Concrete
Apartments		Concrete
Concrete commercial	Steel deck	Concrete
Steel frame commercial	Steel deck	Concrete
Institutional	Steel deck	Concrete
Industrial	Steel deck	

4.5 ADVANCED OPTIONS

Level 2 inputs under advanced option label cover deficiencies inherent to certain structural types as well as pre-assigned retrofitting and soil improvement schemes. A reinforced concrete frame building, for example, may include a weak story or short columns that will adversely affect fragility curves assigned to these structures. The proper treatments of many of these options are left for future expansions to the program. However, the basic framework is in place and it includes certain approximations when more refined solutions are not available.

4.5.1 Shear wall distributions

A large number of low-rise concrete shear wall buildings on the island are constructed lacking adequate lateral support in one direction. The Fragility curves assigned to these structures were developed accordingly. The selection is improved if the information on the percentage of shear walls in each direction is provided. The procedure is described in Section 5.6.

4.5.2 Fastener spacing

Wind fragilities of wood-zinc and steel deck roof systems are greatly influenced by the spacing between fasteners securing metal sheetings to supporting members. A good construction practice for wood-zinc roof systems will be to place nails at 6-in intervals. However, field observation by our research partners has demonstrated that this fastening profile is not observed in most cases (García González 2007). Typically, nails are spaced 6-in on the edge of the roof and 12-in elsewhere or even worse 12-in everywhere. The fastener spacing for steel decks are 6-in in the lines of fasteners spaced 3 to 5 feet on center. Fragility curves for the Level 0 analysis must account for all these variations. However for a user specified fastener spacing, the selection of fragility curves is more precise.

4.5.3 Retrofitting schemes

The insurance software allows the user to account for several retrofitting measures that may already be in place. The option can also be used to run a cost-benefit analysis for a proposed scheme. This may in turn lead to revised insurance policies when certain criteria are met. The retrofitting schemes considered are those evaluated by research partners in the University of Puerto Rico at Mayaguez.

For wind fragilities of metal deck roofs, reduced fastener spacing, the use of oversize washers, and eliminating footing pedestals are proven effective. For wood-zinc houses, the following options are available:

1. Using reinforcing zinc straps to improve the fatigue life of zinc sheets (Avilés 2006; García González 2007).

2. Reducing the internal spacing between the fasteners on the roof.

3. Using metal straps in roof-to-wall connections to improve the transference of the uplift loading from the roof to the foundation.

4. Installing steel cables or guys to tie down the roof system. The steel guys are placed outside the residence, over the roof and perpendicular to the roof ridge.

Detailed discussions on these measures can be found in the research by (García González 2007). Some of the fragility parameters are presented in Section 5.6.

For improving seismic fragility, the available options are more limited. This should be an area of interest when considering future revisions to our software. At present, the program considers:

1. Inverted-Y steel bracing system or concrete shear walls as retrofitting measures for elevated concrete houses on gravity columns, commonly constructed on the hillsides and hilly terrains. More details can be found in the research by (González Solá 2007).

2. Soil treatment options in locations susceptible to liquefaction. These includes Stone columns, Soil admixtures (lime, cement, other), Deep dynamic compaction, Grouting (cement grouting, chemical grouting, jet grouting) and Vibroconcrete columns (Pando 2007).

These options are included in the model by the means of parameters discussed in Section 5.6.

4.5.4 Building footprints

Seismic performance of a building is greatly influenced by its footprint (FEMA 2004). A good configuration will provide for a balanced force distribution, so that the earthquake forces are carried directly and easily back to the foundations. The inelastic demands produced by strong ground shaking tend to be well distributed throughout the structure, resulting in a dispersion of energy dissipation and damage. A poor configuration results in stress concentrations and torsion, and suffers greater damage than the regular ones. An irregular plan shape can be easily identifying by the user by means of drawings (Figure 4-7). The effect of the building’s footprint in the building performance is considered in section 5.6.

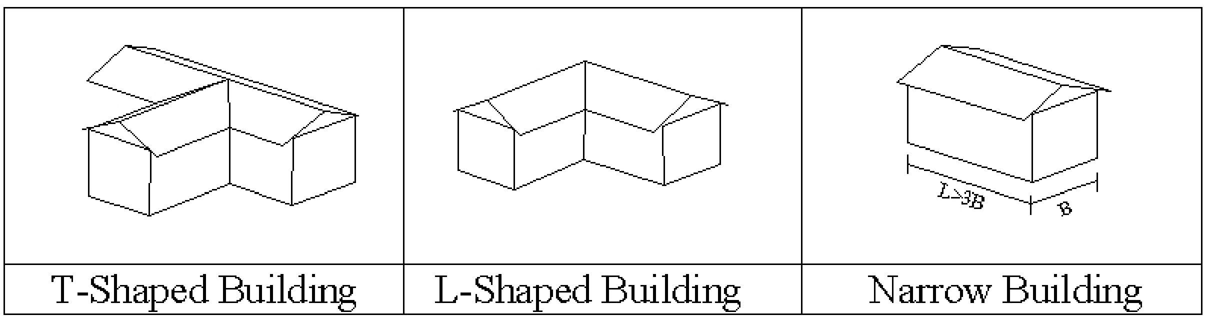
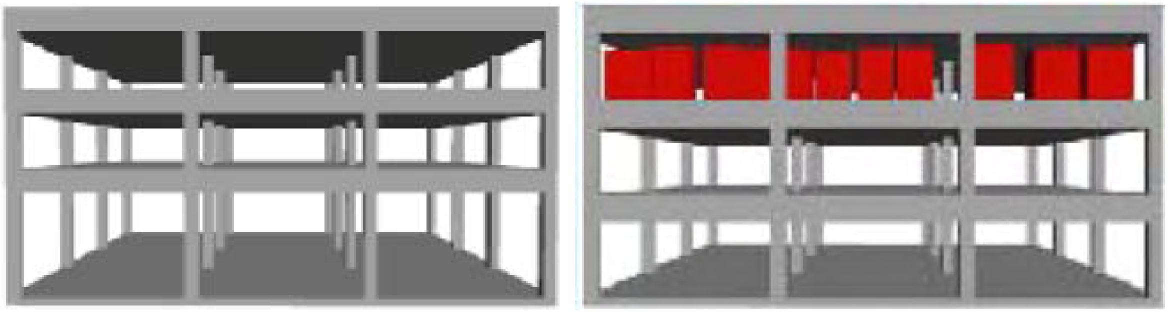


Figure 4-7 Irregular plan shapes

4.5.5 Vertical irregularities

There are several types of vertical irregularities: stiffness irregularity, weight or mass irregularity, vertical discontinuity in capacity and vertical discontinuity in load path.

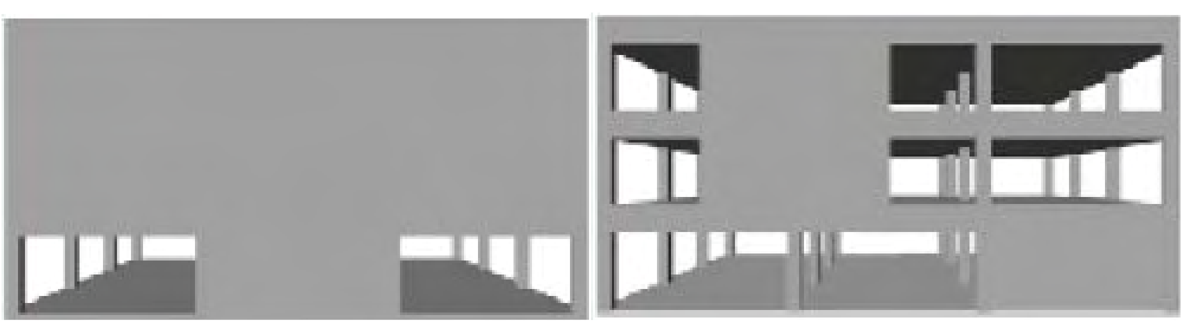
Stiffness irregularity (Figure 4-8a) results when one or more stories are significantly softer (i.e., one story more high than others) than the stories directly above. This problem is more common in moment resistant frames (MRF). Weight or mass irregularity (Figure 4-8b) occurs when the mass of any story is substantially greater than the effective mass of an adjacent story.



(a) **(b)**

Figure 4-8 Vertical stiffness and mass irregularity

By definition, the story strength is the total strength of all the seismic-resisting elements sharing the story shear for the direction under consideration. Vertical discontinuity in capacity (Figure 4-9a) occurs when the story strength at any level (weak story) is significantly lower than that in the story above. In Puerto Rico, except for apartment buildings, weak stories are not present in residential houses but they can be found in commercial and institutional buildings. Vertical discontinuity in load path is a condition where the elements resisting lateral forces (i.e., moment frames, shear walls, or braced frames) are not continuous from one floor to the next. Figure 4-9b shows a common example.



(a) **(b)**

Figure 4-9 Vertical discontinuity in capacity (weak story) and load path

The effect of these irregularities in the building performance is considered in Section5.6.

4.5.6 Non-structural elements

The percentage of unreinforced block or masonry walls is an important factor affecting the building damage during an earthquake (Rossetto and Elnashai 2003; Calvi et al. 2004). If asymmetrically located, heavy masonry partitions that are rigidly attached to columns and under floor slabs can introduce localized stiffness and create stress concentrations and torsional forces. A particular form of this condition that has caused significant structural damage is when short column conditions are created by the insertion of partial masonry walls between columns (Figure 4-10), placement of floor slabs at intermediate levels, or location of the building on a slope. The result is that the shortened columns, having relatively high stiffness, attract a large percentage of the earthquake forces and fail. A short column condition is only present in concrete moment resistant frame (CMRF) constructions. Short column is common in institutional buildings such as Schools.

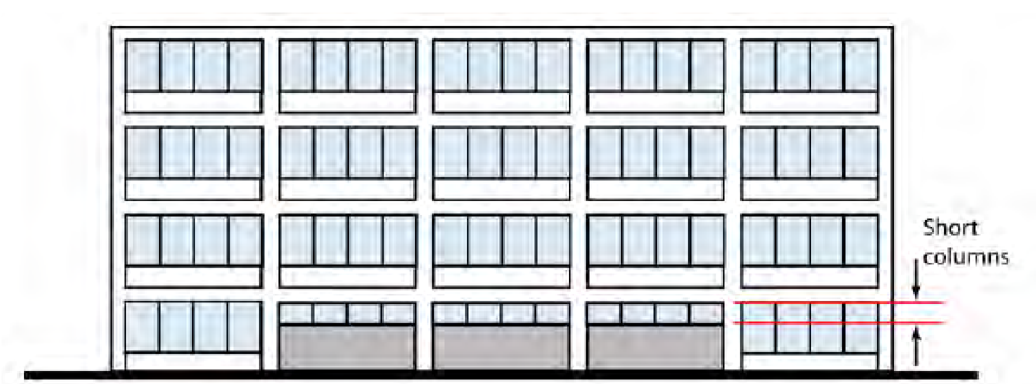


Figure 4-10 Short columns

In storage areas or library stacks, heavy storage items can introduce torsion into a structure. While buildings are designed to accommodate such occupancy loads, the effects of unsymmetrical loading over time, such as when library books are acquired (Figure 4-11), are not always considered. Details on the treatment of short columns and unsymmetrical loadings are presented in Section 5.6.

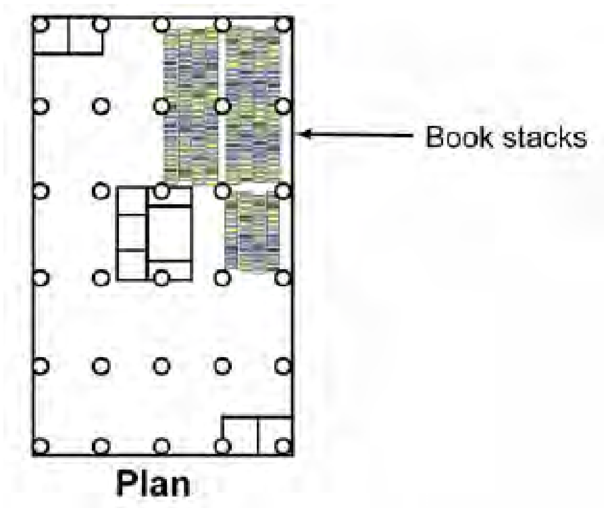


Figure 4-11 Unsymmetrical loading

5 EARTHQUAKE DEFINITION

5.1 INTRODUCTION

Of all the major earthquakes in the history of Puerto Rico, the three most devastating were in 1918, 1867 and 1787. The earthquake of 1918 killed 116 people and caused more than 4 million dollars in damages. The earthquake of 1867 was a magnitude 7.3 earthquake causing wide spread devastations on the eastern side of the Island. The earthquake in 1787 destroyed El Rosario and La Concepcion monasteries and the church in Arecibo. It also caused considerable damages to the churches in Bayamon, Toa Baja and Mayaguez, and the castles of San Felipe del Morro and San Cristobal.

Although the Mayaguez earthquake of 1918 was the last major earthquake in Puerto Rico, geologists have warned for years that potentially devastating earthquakes are just around the corner. In fact, there have been no less than thirteen major earthquakes in the recorded history of the Island. Calculated probabilities for an earthquake of strong intensity (Intensity VII or more in the Modified Mercalli scale) over a period of 50 years stand at 33 to 50 percent (McCann 1985).

5.2 PROBABILISTIC SEISMIC HAZARD

The definition of the ground motion can be a deterministic scenario event such as a historical or a maximum credible earthquake. It may also be based on a probabilistic seismic hazard of the region with a given return period presented in the form of hazard functions. The hazard function for a site is simply an expression of the probability that ground shaking of different intensities may be experienced at the site.

The probabilistic seismic hazard is defined according to the latest version of U.S. Geological Survey (USGS) seismic hazard maps for Puerto Rico and the Virgin Island (Mueller et al. 2003). They compute hazard curves for approximately 16000 sites using a site grid spacing of 0.05 degree in latitude and longitude. These functions are formed considering all potential earthquakes on all known faults and the probability of occurrence of each within a defined period. Each earthquake is assumed to occur randomly in time, representing time-independent seismic hazard. USGS also generates maps of probabilistic ground motions including peak ground acceleration, 1.0-second spectral response, and 0.2-second spectral response, with 2 percent and 10 percent probability of exceedance in 50 years, corresponding to return times of approximately 2500 and 500 years, respectively.

For our calculations, we used primarily a set of hazard curves relating the seismic hazard measured by peak ground acceleration (PGA) and the annual frequency of exceeding this PGA. The earthquake hazard curves shown in Figure 5-1 cover six of the eight most populated cities in Puerto Rico that are considered for this study. The San Juan Metropolitan curve is used for the cities of San Juan, Carolina and Bayamon. Completing the list are Ponce, Arecibo and Mayagüez. Left out for future revisions are Caguas and Gaynabo.

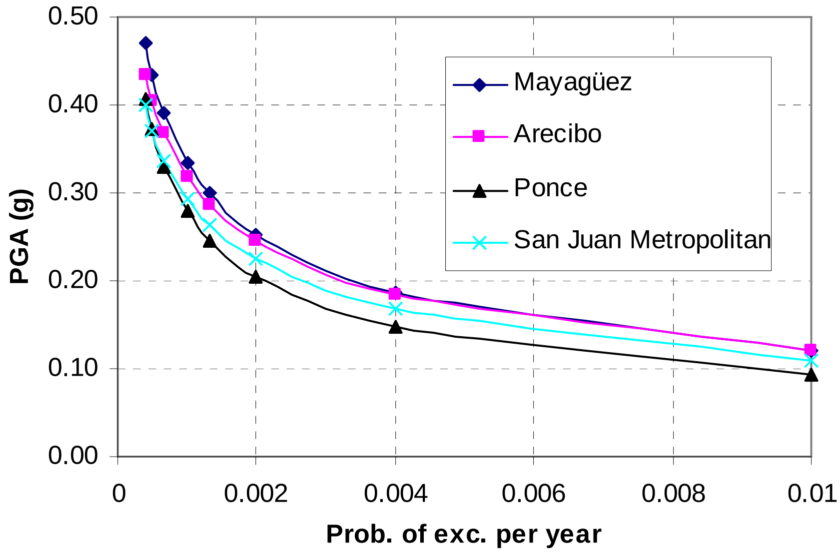


Figure 5-1 Earthquake hazard curves

The methodology used to develop the USGS hazards maps is described by Frankel et al. (1996). The first step was to identify the seismic source using specific fault sources with published slip-rate or recurrence information and gridded historic seismicity, including earthquakes with moment magnitudes greater than or equal to 4.5 in the period between 1963 and 2001. For the specific faults in Puerto Rico, USGS follows the scheme of (Petersen et al. 1996) using the slip rate of the faults to get the recurrence intervals of future earthquakes with certain magnitude. The recurrence times are also calculated for each source zone using the Gutenberg-Richter return law (Richter 1958) setting forth a linear relationship between the logarithm of the average number of annual earthquakes and their magnitudes. In equation form:

$$\log N(m) = a - bm \qquad [5.1]$$

where *N(m)* is the average number of earthquakes per year with a magnitude greater than or equal to *m*, and *a* and *b* are the constants determined from a regression analysis of the seismic data.

For the gridded area, the number of events greater than the moment magnitude of 4.5 is counted on a grid with spacing of 0.05º in latitude and longitude. The maximum likelihood a-value for each grid cell in obtained as the logarithm of the number of event in that cell. Then the gridded a-values are smoothed using a function. Finally, because of the significant regional differences in b-value, a regional b-value is adopted to fit the frequency-magnitude distribution of each uniform earthquakes catalog.

The next step will be to generate estimates of peak ground parameter for each cell of the grid. Attenuation relationships are used to predict the expected ground motion in these cells as a function of the distance to the source of energy release. Figure 5-2 show peak ground acceleration envelope for one grid cell in San Juan, Puerto Rico. Also shown are curves corresponding to different seismic sources covered under this envelope. The 500 and 2500 years return period lines are drawn at 0.002 and 0.0004 probabilities of exceedance per year, respectively. The reference site condition used for the maps and curves is a typical "firm-rock" that corresponds to a NEHRP class B.

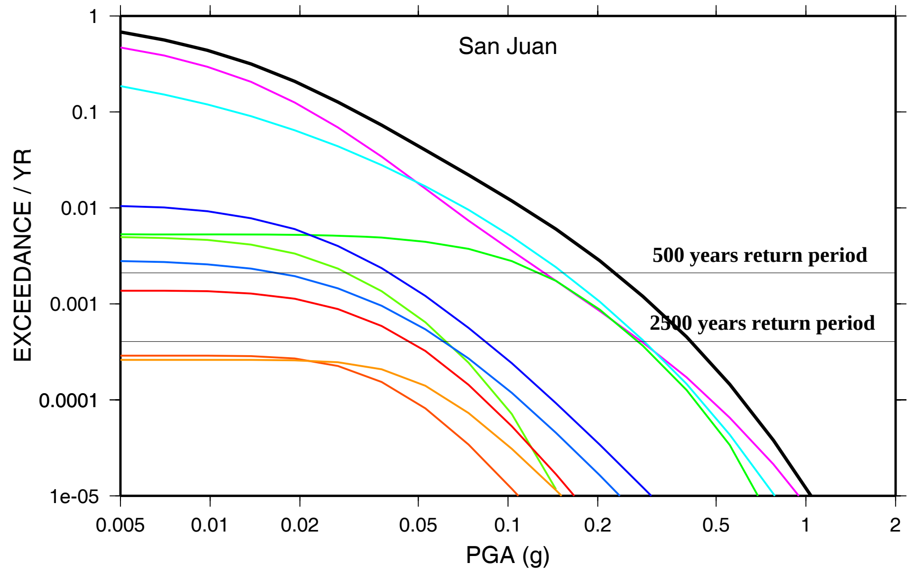


Figure 5-2 Peak ground parameter envelope for one grid cell (Mueller et al. 2003)

5.3 DETERMINISTIC SEISMIC HAZARD

In deterministic seismic hazard analysis, a single event is used to arrive at a scenario-like description. Put another way, *Earthquake Scenarios* take the expected ground motions and effects of a specific hypothetical large earthquake (ShakeMap Working Group 2001). The ground shaking produced by an earthquake is represented by means of ShakeMaps. For an earthquake magnitude and epicenter, ShakeMaps show the range of ground shaking levels at sites throughout the region depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the Earth's crust. The methodology to generate scenarios assumes that a particular fault or fault segment will rupture over a certain length relying on consensus-based information about the potential behavior of the fault.

For the loss estimation process, a controlling earthquake is generally assumed. This is often defined as the “maximum earthquake” to be expected in a certain time frame. It is then necessary to estimate ground motions at all locations in a chosen region surrounding the causative fault. Peak ground values, such as acceleration, velocity or spectral accelerations and earthquake intensity expressed by the Modified Mercalli Scale (MMI) at each station are contoured. For moderate to large events, the pattern of peak ground acceleration is typically quite complicated, with extreme variability over distances of a few kilometers. This is attributed to the small scale geological differences near the sites that can significantly change the high-frequency acceleration amplitude and waveform characteristics. Although distance to the causative fault clearly dominates the pattern, there are often exceptions due to local amplifications.

Included in the insurance software are three earthquake scenarios developed by the Puerto Rico Seismic Network (PRSN). These scenarios are listed in Table 5-1 and are used as part of our event studies in Chapter 9.

Table 5-1 Scenarios events

Earthquake scenario	**Fault Location**	**Magnitude**	**Average PGA**			
			Mayagüez	**San Juan**	**Arecibo**	**Ponce**
1918 Mayagüez	N18.44 W67.50: Mona Passage	7.3	0.33	0.12	0.20	0.20
Lajas M7	N18.01 W66.95: Lajas Valley	7.0	0.35	0.12	0.20	0.30
1867 Mayagüez	N18.00 W65.66: Virgin Islands	7.5	0.15	0.40	0.30	0.25

5.4 LOCAL SITE EFFECTS

Once the seismic waves reach the building site they undergo further modifications, dependent upon the characteristics of the ground and soil beneath the building and the topography of the terrain. This is known as local site effects.

Each site presents specific conditions of topography and characteristics of soil such as thickness, compactness, and saturation. It is therefore difficult to estimate the effects on the ground motions from one place to another, and the local site effects are generally considered by means of relative factors.

5.4.1 Soil effects

The PGA values for rock sites obtained from the hazard curves are modified to consider the amplification of ground shaking caused by local site conditions. Using the NEHRP provisions (BSSC 2001), a standardized site geology classification scheme and specific soil amplification factors are defined for short-period (0.3-second) spectral acceleration (Table 5-2) and for 1.0 second spectral acceleration. No amplification factors are available for Site Class F, which requires special site-specific geotechnical evaluation and is discussed in Section 5.5.

Let PGA and PGA_i represent peak ground accelerations for site class B (rock) and site class i in units of g, respectively. Let F_{Ai} represent the short-period amplification factor for site class i. Following a methodology similar to that of HAZUS:

$$PGA_i = PGA \cdot F_{Ai} \quad [5.2]$$

The amplification factor is dependent on the short period spectral acceleration. This value is obtained together with the PGA from the USGS hazard curves and is listed in Table 5-2. The ASCE-7 definitions for various site classes are also included in this Table. Soils requiring site specific evaluation are classified as Site F and will be subject to liquefaction.

Table 5-2 Soil amplification factor (Building Seismic Safety Council 2001)

Site class B Spectral acceleration (Short Period) (g)	Short-Period Amplification Factor, F_A				
	Site Class				
	A Hard rock	B Rock	C Very dense soil And soft rock	D Stiff soil	E Soft soil
0.25	0.8	1	1.2	1.6	2.5
0.5	0.8	1	1.2	1.4	1.7
0.75	0.8	1	1.1	1.2	1.2
1	0.8	1	1	1.1	0.9
1.25	0.8	1	1	1	0.9

In our program, the soil type at each site is pre-assigned from the soil maps developed by the geotechnical group of the Insurance Commissionaire Project. These soil maps can be found in Appendix J. As always, the user will have the option to override the default settings.

5.4.2 Topographic effects

Topographic irregularities are known to significantly influence the intensity of ground motion (Celebi 1987). Hillsides, scarpment and hills produce an alteration and diffraction of the waves that in turn causes amplification in the acceleration of the floor. The relatively small size, hilly terrains, and high population density have combined to make many structures in Puerto Rico subject to topographic amplifications. This program uses an amplification factor of 2.35 (Arroyo 2001).

5.5 BASIC FRAGILITY CURVES

In the case of earthquake hazard, the basic construction classes considered are: concrete moment resistant frames (CMRF), concrete shear walls (SW) and steel moment resistant frames (SMRF). Commercial steel buildings and Industrial buildings are considered in individual categories due to their special characteristics. Fragility curves for these basic construction classes were developed by our earthquake damage assessment subproject (Cortés-Areizaga 2006; Mieses 2007). Numerical 2-D models of the buildings were created assuming that torsional effects are sufficiently small to be neglected. Nonlinear time history analysis was used to compute displacements and floor accelerations using the program RAM Performance for the steel buildings and the program LARZ (Saiidi and Sozen 1979) for concrete buildings. For buildings not covered in the project, like wood structures, the best fragilities available in the literature are selected.

Table 5-3 lists earthquake fragility parameters for basic cases used in our program. Generally, damages to buildings include both structural and non-structural components. The parameters listed in Table 5-3 are for structural damages. While the failure of structural components can lead to extensive or complete damage states, the number of casualties and economic losses associated with the minor and moderate damage states are often caused by non-structural components. The relevant damage state descriptions from HAZUS (FEMA 2003) can be found in Appendix I.

Table 5-3 Earthquake fragility curves parameters for basic cases

Building type	Number of Stories	X = Fragility threshold as a function of PGA (g)								Source
		Slight		Moderate		Extensive		Complete		
		μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}	
Concrete Shear Wall	**1**	-2.55	1.10	-1.85	0.97	-1.61	0.95	-1.46	0.94	(Mieses 2007)
	2	-2.05	0.72	-1.69	0.70	-1.43	0.68	-1.29	0.66	
	>2	-0.18	0.98	0.13	0.90	0.29	0.89	0.38	0.80	
Concrete MRF	**1**	-1.81	1.03	-1.37	0.87	-1.18	0.82	-1.04	0.78	
	2	-1.83	0.55	-1.44	0.56	-1.21	0.51	-1.03	0.49	
Steel MRF	**1-3**	-1.55	0.37	-1.11	0.38	-0.49	0.33	-0.024	0.30	(Cortés-Areizaga 2006)
	4-7	-1.07	0.22	-0.67	0.26	-0.13	0.25	0.15	0.19	
	>7	1.2	0.41	-0.77	0.42	-0.28	0.32	-0.057	0.25	
Commercial Steel	**2**	-1.46	0.33	-0.98	0.38	-0.4	0.31	0.044	0.23	
	3	-1.46	0.25	-1	0.27	-0.33	0.27	0.029	0.21	
	4	-1.11	0.19	-0.67	0.19	-0.11	0.17	0.32	0.28	
Industrial	**1**	-1.66	0.33	-1.12	0.33	-0.59	0.38	0.015	0.35	
	2	-1.5	0.36	-1.05	0.33	-0.48	0.24	-0.05	0.28	
Wood	**1-2**	-1.81	0.64	-1.28	0.64	-0.70	0.64	-0.26	0.64	(FEMA 2003)

5.6 FRAGILITY CURVES FOR SPECIAL CASES

The use of unreinforced block walls is an important factor affecting the seismic performance (Vélez Vélez 2007). To consider this effect, fragility curves are obtained using a set of known functions together with our fragility curves for Concrete Moment Resisting Frames. The new obtained fragility curves using this approach don't change significantly with regard to the fragility curves for Concrete Moment Resisting Frames. Then, this effect is not included until the fragility curves that consider the effect of the walls are developed.

In Section 4.3.7, potential problems with buildings constructed over “gravity columns” were discussed briefly. Fragility curves for these buildings were developed using the calculated drifts for prototype models reported by (González Solá 2007).

Table 5-5 lists the governing parameters. Also developed were fragility curves for the systems retrofitted with inverted-Y steel bracings or shear walls. These fragility curves indicate a very good substructure performance. Thus, if these retrofittings are adopted, the basic fragility curve of the superstructure is used.

Other special case considered is constituted by shear walls buildings with adequate percentage of shear walls in both directions. These types of buildings have a performance significantly better than the typical buildings constructed with shear walls in only one direction. For these buildings, the fragility curves were developed using only the buildings excited in the strong direction (Mieses 2007). Table 5-5 lists the corresponding fragility parameters.

Mitigation options to eliminate potential problems of liquefaction are included in the program by allowing ground improvements at foundations. The Soil treatment measures considered include: stone columns, deep dynamic compaction, soil admixtures (lime, cement, other), grouting (cement grouting, chemical grouting, jet grouting) and vibroconcrete columns (Pando 2007). Once an appropriate selection is made, the program will set the liquefaction probability to zero.

Finally, deficient designs such as irregular building’s footprints, vertical irregularities, short columns and nonsymmetrical distribution of the mass are considered by means of a reduction in the drift limits for the damage states. Then the drift obtained by (Mieses 2007) are compared with the pre-code drift limits proposed in the HAZUS manual (FEMA 2003) presented in Table 5-4 and lognormal medians and standard deviations of fragility curves for concrete structures with irregularities are determined (Table 5-3). This approach is an approximation of the effect of the irregularities in the damage estimation but a more detailed study is suggested for a future work.

Table 5-4 Pre-code limits used to develop the fragility curves for irregular buildings

Building type	Drift limits			
	Slight	Moderate	Extensive	Complete
CMRF	0.004	0.0064	0.016	0.04
SW	0.0032	0.0061	0.0158	0.04
Multistory	0.0021	0.0041	0.0105	0.0267

Table 5-5 Earthquake fragility curve parameters for special cases

Building type	X = Fragility threshold as a function of PGA (g)							
	Slight		Moderate		Extensive		Complete	
	μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}
Gravity columns	-2.55	1.10	-1.85	0.97	-1.61	0.95	-1.46	0.94
Shear walls in two directions	-1.20	1.00	-1.12	1.00	-0.68	0.70	-0.11	0.39
CMRF 1 Story Irregular	-2.10	1.12	-1.72	0.95	-1.07	0.73	-0.40	0.62
CMRF 2 Stories Irregular	-2.14	0.55	-1.80	0.54	-1.06	0.50	-0.31	0.41
SW 1 Story Irregular	-2.02	1.69	-1.95	1.62	-1.35	1.12	-0.60	0.76
SW 2 Story Irregular	-2.81	0.86	-2.51	0.71	-1.67	0.66	-0.87	0.66
Multistory Irregular	-0.77	1.12	-0.38	0.95	0.15	0.91	0.66	0.67

5.7 LIQUEFACTION

Liquefaction of saturated sands during earthquakes is caused by the soil tendency to decrease in volume generating high excess pore-water pressure that will build to the point at which the sand loses all its strength (Seed and Lee 1966). For evaluating the liquefaction effects on the building performance, the methodology proposed in HAZUS (FEMA 2003) is followed. The development of an improved model for predicting liquefaction effects is planned for the next phase of the Insurance Commissionaire Project.

5.7.1 Liquefaction susceptibility

The first step in evaluating ground failure hazard due to liquefaction is to determine the liquefaction susceptibility of the soils classified as type F. The results from several studies by our research partners in the Insurance Commissionaire Project are used in identifying the liquefaction potential index, LPI. The liquefaction potential index is an estimation of the expected damage at a site by means of a weighted average of the soil stratus (Iwasaki et al. 1982). This classification was conducted assuming an earthquake magnitude of 7.0 and a maximum acceleration in rock of 0.20 g.

From 140 bore-holes classified as soils type F in Ponce, the 97.9 % of them would present some level of damage (21.4% major, 48.6% moderate and 27.9% minor). All tests over the regions clasfied as soil type F for the cities of Mayagüez and Arecibo indicate a high probability of have damage due to liquefaction (Mayagüez: 53% major and 47 % moderate;

Arecibo: 28.6% major, 46.4% moderate and 25% minor). According to the classification used by HAZUS these soils have a very high susceptibility to liquefaction. The susceptibility to liquefaction for the San Juan Metropolitan Area was obtained from liquefaction susceptibility digital map prepared by USGS. In this map all the area assigned as site class F present a high and very high susceptibility to liquefaction.

5.7.2 Probability of liquefaction

Having determined the liquefaction susceptibility of the soil, the probability of liquefaction will be given by:

$$P\left[Liquefaction_{SC}\right] = \frac{P\left[Liquefaction_{SC} \middle| PGA = a\right]}{K_M K_W} P_{ml} \qquad [5.3]$$

where $P\left[Liquefaction_{SC} \middle| PGA = a\right]$ is the conditional probability for a given susceptibility category at a specific level of peak ground acceleration (Figure 5-3). K_M is the moment magnitude (M) correction factor calculated from (Figure 5-4):

$$K_m = 0.0027M^3 - 0.0267M^2 - 0.2055M + 2.9188 \qquad [5.4]$$

K_W is the ground water correction factor given by:

$$K_w = 0.022d_w + 0.93 \qquad [5.5]$$

and set conservatively equal to 1 in our program (Figure 5-5). P_{ml} is the proportion of map unit susceptible to liquefaction (Table 5-6). This factor recognizes different liquefaction susceptibilities in the same deposit due to common variations such as grain size distribution and relative density.

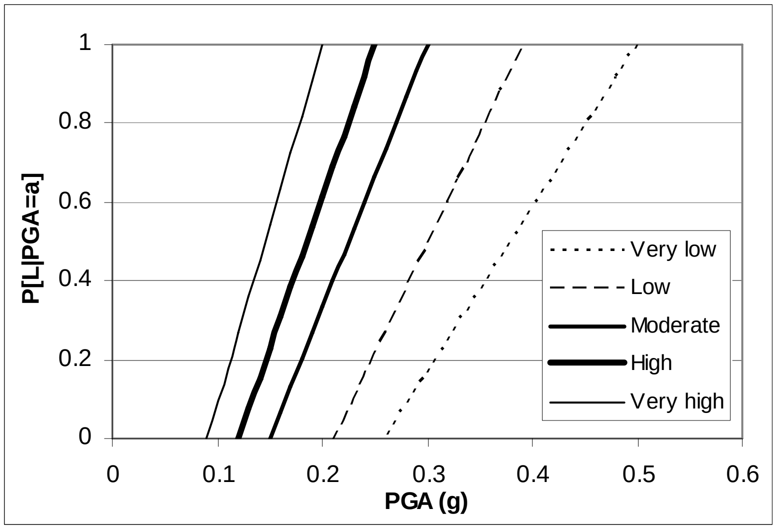


Figure 5-3 Conditional liquefaction probability relationships

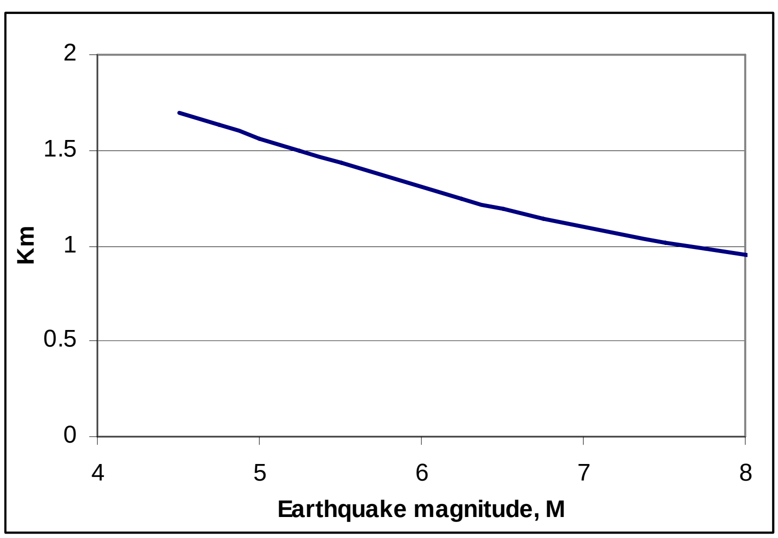


Figure 5-4 Moment magnitude correction factor

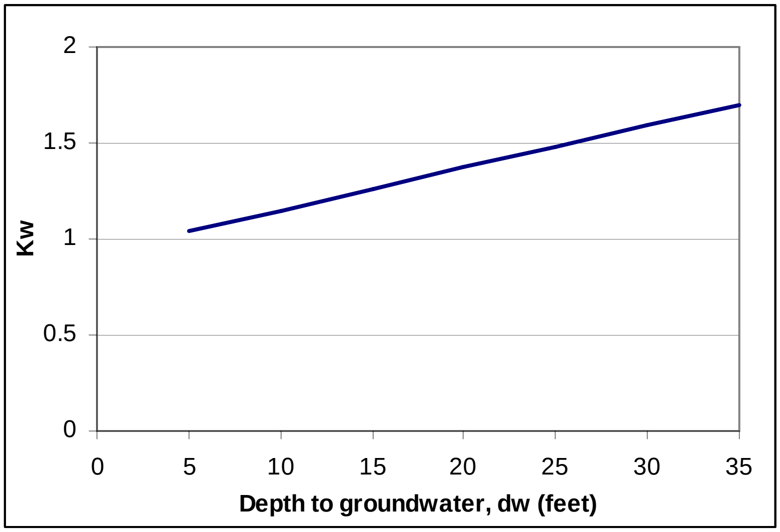


Figure 5-5 Ground water depth correction factor

Table 5-6 Proportion of map unit susceptible to liquefaction

Susceptibility	Proportion of map unit
Very high	0.25
High	0.20
Moderate	0.10
Low	0.05
Very low	0.02
None	0.00

5.7.3 Damages due to liquefaction

The liquefaction probability measures presented in Section 5.7.2 are used to weigh fragility data generated from the parameters in Table 5-7. The expected permanent ground displacements considered are lateral spreading and ground settlement. Table 5-2 lists threshold ground acceleration, *PGA*(*t*), and ground settlements in terms of relative liquefaction susceptibility discussed in Section 5.7.1. The normalized ground shaking calculated as *PGA/PGA*(*t*) will be used to obtain the expected lateral spreading from Figure 5-6. The result will be multiplied by the displacement correction factor K_{Δ} given by:

$$K_{\Delta} = 0.0086M^3 - 0.0914M^2 + 0.4698M - 0.9835 \qquad [5.6]$$

Table 5-7 Fragilities curves for ground failure

	Settlement		Lateral Spread	
	μ_{ln}	σ_{ln}	μ_{ln}	σ_{ln}
Shallow Foundations	1.58	1.20	3.37	1.2
Deep Foundations	1.58	1.20	3.37	1.2

Table 5-8 Threshold ground acceleration and settlement amplitudes

Relative susceptibility	PGA(t)	Settlement (inches)
Very high	0.09g	12
High	0.12g	6
Moderate	0.15g	2
Low	0.21g	1
Very low	0.26g	0
None	N/A	0

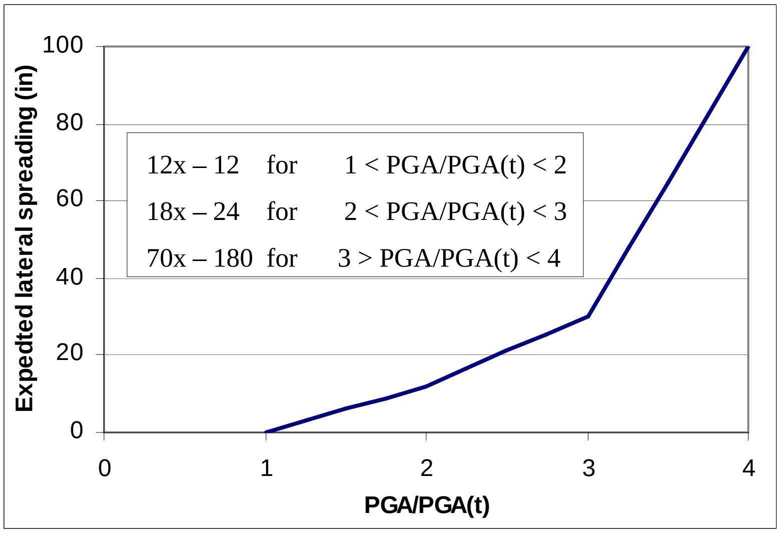


Figure 5-6 Lateral spreading displacement relationship

5.8 LOSS ESTIMATION

The general Equation [3.7] for the calculation of probable losses presented in chapter 3 is specialized for the earthquake hazard as follows:

$$PL^{m}_{P_e,T_e} = \sum_{i=2}^{5} RC_i^m P_m \left[DS = d_i \,\middle|\, PGA_{P_e,T_e} \right] \qquad [5.7]$$

The term $P_m\left[DS = d_i \middle| PGA_{P_e,T_e}\right]$ is a direct readout from the fragility curves defined in Section 0. It is the discrete conditional probability for one structure type *m* (Table 5-3) reaching a damage state $DS=d_i$ given the occurrence of a PGA value with a probability of exceedance P_e over a period T_e (Figure 5-1). As described in section 3.5, the damage state d_i corresponds to slight (i = 2), moderate (i = 3), extensive (i = 4) or complete (i = 5). The third term RC_i^n is the repair cost ratio associated to a building type *m* in a damage state $DS=d_i$.

The mapping process between damage states and economic losses is one of the most significant research issues at the present time. In this study, the loss model is assumed to be deterministic. Research partners have computed the means ratio of repair cost to replacement cost for each earthquake damage state and a building type according to the fragility curves available (Table 5-9).

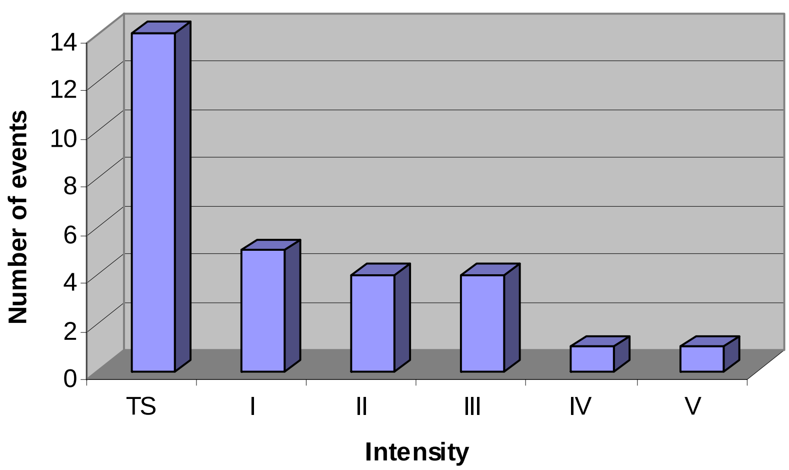
Table 5-9 Replacement cost ratios for earthquake damage states

Building type	Damage type	Replacement cost ratio				Source
		Slight	Moderate	Extensive	Complete	
Concrete Shear Wall	Structural	0.4	3.8	16.8	19	(Johnson 2007)
	Nonstructural	1.5	7.7	33	81	(FEMA 2003)
	Total	1.9	11.5	49.8	100	
Concrete MRF	Structural	0.4	3.0	8.8	16.8	(Johnson 2007)
	Nonstructural	1.5	7.7	33.0	83.2	(FEMA 2003)
	Total	1.85	10.72	41.75	100	
Steel MRF	Structural	0.5	2.3	11.7	23.4	(FEMA 2003)
	Nonstructural	2	10	44.7	100	
	Total	1.5	7.7	33	76.6	
Commercial Steel	Structural	0.3	1.3	7.5	15	
	Nonstructural	1.7	8.7	32.5	85	
	Total	2	10	40	100	
Industrial	Structural	0.4	1.6	7.8	15.7	
	Nonstructural	1.6	8.4	27.7	84.3	
	Total	2	10	35.5	100	
Wood	Structural	0.5	2.3	11.7	23.4	
	Nonstructural	1.5	7.7	33	76.6	
	Total	2	10	44.7	100	

6 HURRICANE DEFINITIONS

6.1 INTRODUCTION

Since the second half of the nineteenth century, Puerto Rico has been hit by a total of 15 hurricanes and 14 tropical storms. This will amount to approximately one every 5.5 years. Of these, five have been category III or higher hurricanes (Figure 6-1). The predominant paths of most tropical storms and hurricanes travel from east or southeast to west or northeast (Lopez 2005).



Category	1-minute Wind speed [mph]
Tropical storm	<74
I	74-95
II	96-110
III	111-130
IV	131-155
V	>155

Figure 6-1 Events in Puerto Rico (1851-2004)
(National Oceanic and Atmospheric Administration 2007)

The most expensive hurricane in the history of Puerto Rico was Hurricane Georges of September 22, 1998. The total losses are estimated at over 4 billion US dollars. And yet

Hurricane Georges was only a borderline category 3 hurricane, emphasizing yet again the significance of increasing population densities. In terms of structural damages, commercial buildings suffered an estimated 185 million US dollars and dwellings suffered an estimated 753 million US dollars (Junta de Planificación 1999). The societal and business needs to better predict this type of losses can not be overstated.

6.2 PROBABILISTIC HURRICANE HAZARD

One can use a deterministic scenario event or an event based on a probabilistic model to define the hurricane hazards. Similar alternatives were used in Chapter 5 for earthquake hazards. A probabilistic hurricane hazard model considers many hurricanes at a given location and assigns a probability of occurrence to each hurricane. This approach will lead to the annual frequency with which different losses are expected to occur, or alternatively, the annual expected loss at a given location for a defined value of exposed buildings.

Tropical cyclones involve both atmospheric and hydrologic effects. These individual phenomena are addressed separately in this work. The flood hazard induced by hurricanes is discussed in Chapter 7.

The first step of wind field simulation is to establish hurricane recurrence model for the target site. A recent study estimates the hurricane frequency using data from 1870 to 2003 (Landsea et al. 2004). Charts giving return periods of tropical cyclones, having winds of least specified value near storm center, and passing within specified distances from site were developed for the principal cities of Puerto Rico (Figure 6-2).

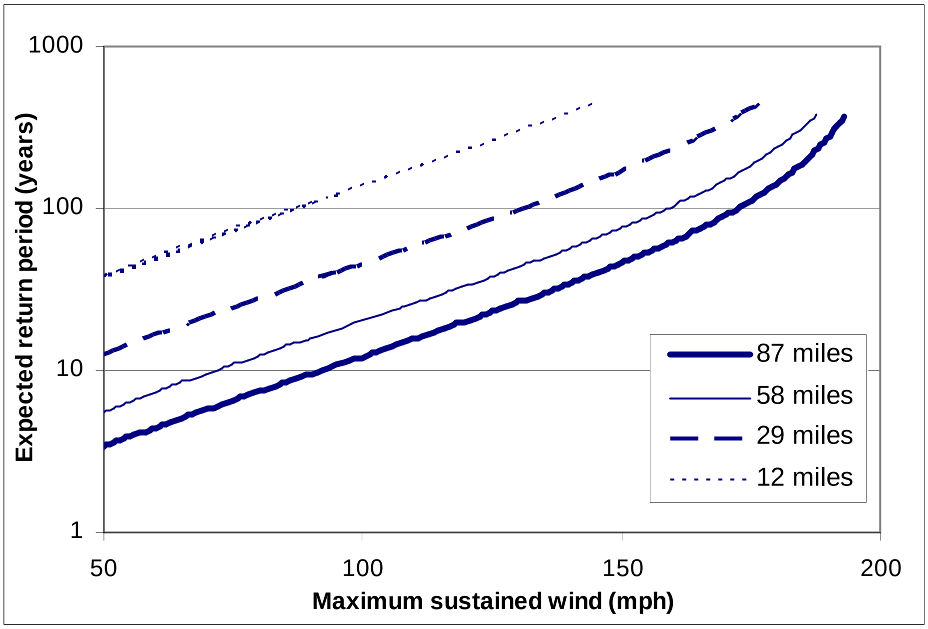


Figure 6-2 Tropical storms and hurricanes passing within 87 miles of a site (Landsea et al. 2004)

This chart is developed using a population of tropical cyclones failing within a radius of 86 miles from the site. This data is obtained from the National Hurricane Center Database (National Hurricane Center 2003). For that set of storm, the maximum wind within the circle is found. Then, a count is conducted to find how many systems had different winds ranges. Once the count is known, a function is used to fit the distribution. The smooth function is used to estimate the numbers of systems that would occur over a longer time period.

The wind speeds in the Figure 6-2 are not necessarily at the building site, so this chart does not address expected wind return periods at site itself. A simple meteorological model HURRECON (Boose et al. 1994; Boose and Chamberlin 1997; Boose et al. 2001; Boose et al. 2004), based on published empirical studies of many hurricanes, was used to estimate the wind speed at site. HURRECON uses information on the track, size, and intensity of a hurricane, as well as the cover type, to estimate surface wind speed:

$$V_s = F\left[V_m - S\left(1-\sin T\right)\frac{V_h}{2}\right]\left[\left(\frac{R_m}{R}\right)^B \exp\left(1-\left[\frac{R_m}{R}\right]^B\right)\right]^{1/2} \qquad [6.1]$$

V_s is the sustained wind velocity at any point P in the northern hemisphere. V_m is the maximum sustained wind velocity over water anywhere in the hurricane. V_h is the forward velocity of the hurricane. F is the scaling parameter for friction effects, 1.0 on water and 0.8 on land. S is the scaling parameter for asymmetry due to forward motion of storm (1.0). T is the clockwise angle between the forward path of hurricane and a radial line from hurricane center to point P. R_m is the radius of maximum winds (20-80 Km). R is the radial distance from the hurricane center to point P. B is the scaling parameter controlling the shape of the wind profile curve (1.2-1.5).

The peak wind gust velocity (V_g) at point P is calculated from V_S using:

$$V_g = GV_S \qquad [6.2]$$

G is the gust factor, 1.2 over water and 1.5 over land.

Parameters of the model were adopted according to the work of (Boose et al. 2004). They assign some values directly from the literature and adjust others in base to detailed studies of seven major hurricanes. F and G were selected to get the same peak gust speed over water and land. Because of the scarce data to define the wind speed along a radial line, the controlling parameters of the wind profile, B and R_m are simulated randomly to span the range from very narrow to very wide storms.

For each hurricane category, a set of probable wind speeds at the site are generated using the Monte Carlo simulation (Figure 6-3). Also generated are random values for the site distance from the center of hurricane, distance to maximum wind speed, forward velocity of the hurricane and a shape factor of the HURRECON model.

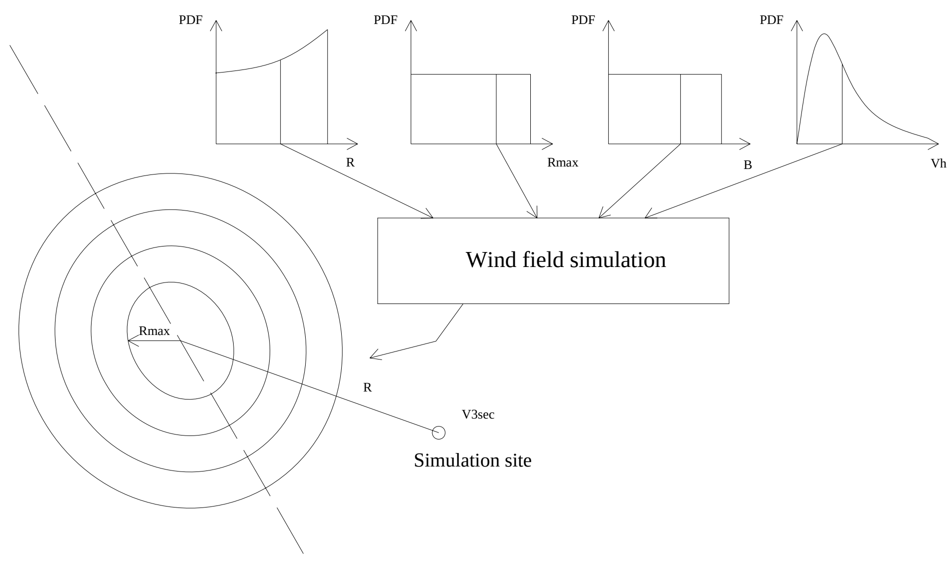


Figure 6-3 Wind field simulation

6.3 DETERMINISTIC HURRICANE HAZARD

As for earthquakes, one may consider a single past hurricane with a known wind field distribution, to subject a predetermined zone to this field, and then compute the resulting losses ("scenario" hurricane). In general the variation of wind intensity over the zone of interest will depend upon the size and meteorological characteristics of the hurricane and certain physical characteristics of the zone.

Using Equation [6.1], it is possible to demonstrate that the variations in wind speeds over the limits of a city in Puerto Rico is small compared with the level of precision inherent to the overall loss estimates. Then, for each hurricane scenario considered, a constant wind speed may be assigned to a city.

Included in the program is the ability to assess the effects of past hurricanes if they were to occur today. Table 6-1 lists the scenarios for the city of Mayagüez, including the historical date, wind speed, closest point of approach, and direction.

Table 6-1 Hurricane scenarios for Mayagüez (Caribbean Hurricane Network 2007)

Hurricane	Date	Wind speed [mph]	Closest point approach [miles]	Direction
San Ciriaco	1899, August 7-8	138	15	ESE to WNW
San Felipe II	1928, September 13	161	19	SE to NW
Georges	1998, September 22	109	15	E to W

6.4 SITE EFFECTS

The wind pressures used to develop the fragility curves for our study are calculated according to the ASCE-7 standards (ASCE 2005). The ASCE-7 defines the design wind pressure, q_z, as:

$$q_z = 0.00256 K_z K_{zt} K_d V^2 I \qquad [6.3]$$

The wind speed, V, is the 3 second gust. The equation is unit sensitive, with q_z in psf and V in mph. The wind exposure factor, K_z, represents changes in wind speed with height and exposure type. K_{zt} is the topographic factor. K_d is the directionality factor. And I is the importance factor.

In developing the fragility curves, the basic wind speeds are adjusted for the building heights and assume a wind exposure C. Exposure classes are discussed in Section 6.4.1. K_{zt} is set equal to 1, assuming flat terrains. I was set equal to 1 which is typical for non-essential facilities. Less intuitive is the taking out of the K_d factor and adding a 0.8 multiplier to counteract the safety factor inherent to Equation 6.3 (Cope 2004). In summary:

$$q_z = 0.002048 K_z^{\exp C} V^2 \qquad [6.4]$$

An equivalent wind speed, V_{eq}, is calculated in order to access the fragility curves in our program. It accounts for the changes in exposure class and topography and will be given by:

$$V_{eq} = \sqrt{K_{zN} K_{zt}} V \qquad [6.5]$$

In the above equation, K_{zN} is the normalized exposure factor that will be formulated in Section 6.4.1. The topographic effects defining K_{zt} are discussed in Section 6.4.2.

6.4.1 Exposure effect

Prior studies indicate that wind pressures on buildings are affected by terrain roughness. In the case of an isolated building, with increased surrounding obstructions the mean wind pressures acting on the building decrease (Khanduri et al. 1998).

The ASCE-7 standard proposes three exposure classes (American Society of Civil Engineers and Structural Engineering Institute. 2005). Exposure B defines "urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger." Also:

> This surface roughness must prevail in the upwind direction for a distance of at least 2,600 ft (792 m) or 20 times the height of the building, whichever is greater. For buildings whose mean roof height is less than or equal to 30 ft, the upwind distance may be reduced to 1,500 ft (457 m).

Exposure C includes "open terrain with scattered obstructions having heights generally less than 30 ft (9.1 m)" and "all water surfaces in hurricane prone regions." This is the default exposure type. Exposure D presents "flat, unobstructed areas and water surfaces outside hurricane prone regions". This surface must "prevails in the upwind direction for a distance greater than 5,000 ft (1,524 m) or 20 times the building height, whichever is greater."

The high population density, irregular topography, and the vegetation types eliminate exposure D as an exposure class for Puerto Rico. In fact, exposure B is the classification for most of the Island. The areas adjacent to the coast will qualify as exposure C until some distance from the shoreline that will satisfy the requirements for exposure B. Because the required distance will depend on the height of the building under consideration, exposure maps with offsets off the shoreline at specific distances were developed to apply the corresponding factors. These maps can be found in Appendix K.

The ASCE-7 formula for wind exposure factor is given by:

$$K_z = \begin{cases} 2.01\left(\dfrac{z}{z_g}\right)^{\frac{2}{\alpha}} & \text{for } 15' \le z \le z_g \\ 2.01\left(\dfrac{15}{z_g}\right)^{\frac{2}{\alpha}} & \text{for } z < 15' \end{cases}$$

The parameters α and z_g are set equal to 7 and 1200 for exposure B, and 9.5 and 900 for exposure C, respectively. The parameter z is the elevation above ground at which the wind pressure is calculated. The normalized exposure factor, K_{zN}, is calculated from:

$$K_{zN} = \begin{cases} \dfrac{K_z^{\text{exposure B}}}{K_z^{\text{exposure C}}} & \text{for exposure B} \\ 1 & \text{for exposure C} \end{cases}$$

In using the above equation, any differences between the actual heights of the buildings and the average heights of the building inventories are ignored.

6.4.2 Topographic effects

Recent hurricane events in the Caribbean have demonstrated the significant influence of topography on the levels of damages caused by the wind (Gibbs 2001). When Hurricane

Marilyn struck the island of St Thomas in the US Virgin Islands in September 1995, it caused extensive damages along the ridges of the mountain ranges. Although Marilyn was only a borderline Category 3 hurricane, the extent of the damages convinced the local population that St Thomas had experienced a Category-5 event.

The issue of topographic effects on wind speeds has been the focus of several studies in the field (Jackson and Hunt 1975; Falcinelli et al. 2003; Chock et al. 2005). Although some investigations have used model testing, most are theoretical. The current design norm to include factors to consider the topography of the site were shown to provide only an order of magnitude of the wind speed in the building (Falcinelli et al. 2003).

According to the ASCE-7 standard, the wind speed-up effects at topographic features shall be included in the analysis if and only if all the following conditions are met (American Society of Civil Engineers and Structural Engineering Institute. 2005):

1. "The hill, ridge, or escarpment is isolated and unobstructed upwind by other similar topographic features of comparable height for 100 times the height of the topographic feature (100H) or 2 mi (3.22 km), whichever is less. This distance shall be measured horizontally from the point at which the height *H* of the hill, ridge, or escarpment is determined."

2. "The hill, ridge, or escarpment protrudes above the height of upwind terrain features within a 2-mi (10,560 ft) (3.22 km) radius in any quadrant by a factor of two or more. For example, if a significant upwind terrain feature has a height of 35 ft above its base elevation and has a top elevation of 100 ft above mean sea level then the

topographic feature (hill, ridge, or escarpment) must have at least the *H* specified and extend to elevation 170 mean sea level (100 ft + 2 × 35 ft) within the 2-mi radius specified."

3. "The structure is located as shown in Fig. 6-4 in the upper one-half of a hill or ridge or near the crest of an escarpment."

4. $H/L_h > 0.2$ (See Figure 6-4)

5. "*H* is greater than or equal to 15 ft (4.5 m) for Exposures C and D and 60 ft (18 m) for Exposure B." (The condition is more difficult to meet for Exposure B.)

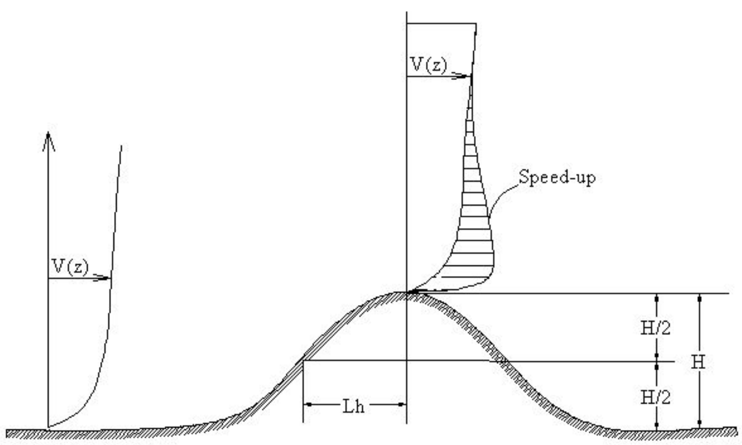


Figure 6-4 Wind speed-up over topographic feature

The wind speed-up effect is included in the calculation by using the topographic factor K_{zt}:

$$K_{zt} = \left(1 + K_1 K_2 K_3\right)^2 \qquad [6.6]$$

where K_1, K_2 and K_3 are parameters given in Table 6-2 and Equations [6.7] and [6.8]:

Table 6-2 Parameter K_1 for speed-up over topographic features

Hill Shape	$\frac{K_1}{H / L_h}$		
	Exposure B	Exposure C	Exposure D
2-D Ridges or Valleys with Negative H	1.3	1.45	1.55
2-D Escarpments	0.75	0.85	0.95
3-D Axisymmetric Hill	0.95	1.05	1.15

$$K_2 = \left(1 - \frac{|x|}{\mu L_h}\right) \quad [6.7]$$

$$K_3 = \exp\left(-\frac{\gamma z}{L_h}\right) \quad [6.8]$$

In the above equations:

μ = 1.5 (except use 4 for 2-D escarpment where the downwind is of crest.)

γ = 4 for 3-dimensional hill, 3 for 2-D ridges and 2.5 for 2-D escarpments.

When calculating K_3, Use $L_h = 2H$ for H/L_h ratios more than 0.5.

We propose an approximate methodology to develop the topographic effect maps. The maps will then be used to generate the topographic factor, K_{zt}, for the use in Equation [6.5]. The procedure is as follows:

1. Assume the topographic features will form a wall along the shoreline.

2. The base elevation is defined at the contour where the abrupt changes in contour-lines typical to hilly sites are stopped.

3. For each hill, the contour for the effected area is drawn at one-half heights (Rule 3).

4. Hills with similar properties in the same area are grouped together and the maximum H and minimum L_h is assigned to the group.

5. Break escarpment into combination of hills (This will be conservative when calculating K_1, not necessarily so when calculating K_2).

6. The first side of the wall (close to the shoreline) is defined by a tangent line to the affected areas defined in step 3.

7. The other side of the wall is defined with a line parallel to the first side at a distance equal to 4 times L_h.

In using the topographic effect maps, the following simplified forms for parameters K_1, K_2 and K_3 are preferred:

- Set $K_1 = \frac{H}{L_h} \leq 0.5$, averaging the 0.95 and 1.05 coefficients used for exposures B and C.

- Set $K_2 = 1$

- Conservatively set $K_3 = \exp\left(-\frac{4z}{L_h}\right)$

The maps developed for the principal cities are shown in appendix L.

6.5 BASIC FRAGILITY CURVES

In developing the fragility curves for this study, a component-based approach was used (García González 2007). In this approach, the performance of a building is judged based on the resistant capacity of its components, excluding the interactions for the most parts. (García González 2007) developed the fragilities for the roof deck, wall sheathing, windows, roof to wall connection, and wall structure. For the components whose failure can affect the integrity of the building's structure, like roof to wall connection and wall structure, damage sequences are not considered. Instead, the fragility curves for these components reflect the probability of its failure (Figure 6-5). Fragility curves for windows, roof deck and wall sheathing relates the peak gust wind speed with the probability of having slight, moderate, extensive and complete damage states.

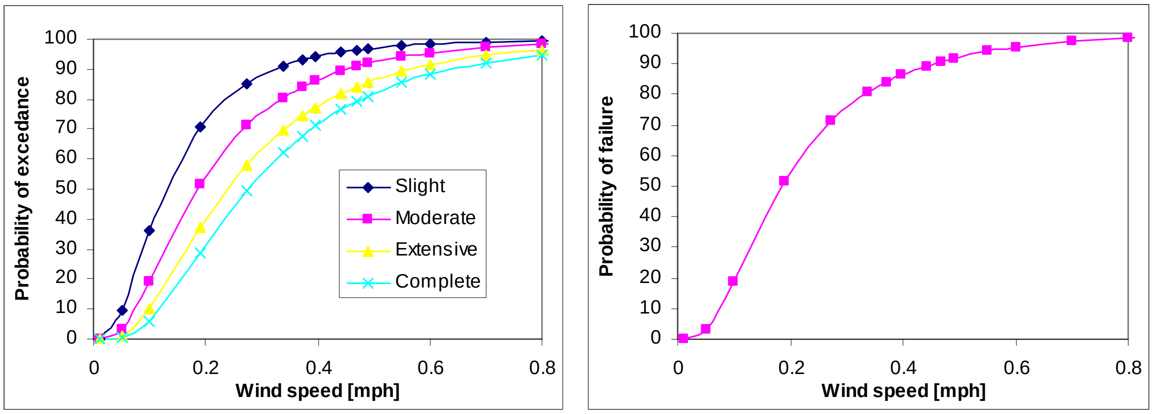


Figure 6-5 Component fragility curves with progressive damage (left) and without progressive damage (right)

Fragility curves for systems combining the components were also developed. The system fragility curves are developed based on the damage matrix that defines the system damage states in terms of its components. Table 6-3 gives an example of damage matrices. The parameters defining the system fragility curves are presented in Table 6-4.

Table 6-3 Damage matrix for system fragility curves of an industrial buildings

Damage	Roof System	Roof-to-Wall Connections	Wall Siding	Wall Structure	Windows
State	<15 %	No	<5%	No	<5%
Slight	15%-33%	No	5%-10%	No	5%-15%
Moderate	33%-50%	No	10%-20%	No	15%-50%
Extensive	>50%	Yes	>20%	Yes	>50%

Table 6-4 Hurricane fragility curve parameters for basic cases

Building type	Nº of Stories	X = Fragility threshold as a function of 3-second gust wind speed [mph]							
		Slight		Moderate		Extensive		Complete	
		μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}
Concrete	**1**	4.920	0.150	5. 110	0.190	7.000	0.100	7.000	0.100
	2	4.920	0.140	5.200	0.220	7.000	0.100	7.000	0.100
	3	4.900	0.130	5.180	0.220	5.640	0.080	5.740	0.100
Multistory	**2-4**	4.775	0.090	5.120	0.140	7.000	0.100	7.000	0.100
	5-7	4.775	0.090	5.090	0.130	5.750	0.120	5.750	0.120
	8-10	4.775	0.090	5.090	0.130	5.510	0.145	5.530	0.145
	11-13	4.775	0.090	5.050	0.110	5.360	0.135	5.380	0.130
	14-16	4.775	0.090	5.000	0.100	5.240	0.140	5.260	0.140
Wood	**1**	4.840	0.110	4.910	0.160	5.100	0.170	5.160	0.180
	2	4.840	0.110	4.910	0.160	5.050	0.170	5.100	0.180
Mixed	**2**	4.840	0.110	4.910	0.160	5.100	0.170	5.150	0.180
	3	0.500	0.200	0.068	0.000	0.000	0.000	0.000	0.000
Small Institutional	**1**	4.880	0.100	5.020	0.120	5.325	0.070	5.385	0.090
	2	4.880	0.100	5.020	0.120	5.280	0.070	5.350	0.095
Mixed Institutional	**1**	4.880	0.100	5.020	0.120	5.310	0.070	5.390	0.100
Large Institutional	**1**	4.880	0.140	5.050	0.140	5.180	0.130	5.230	0.150
Industrial	**1**	4.810	0.180	4.900	0.190	5.010	0.220	5.100	0.220

6.6 FRAGILITY CURVES FOR SPECIAL CASES

Some retrofitting options that can improve the performances of select building types during a hurricane are part of the insurance software. For wood-zinc houses and industrial buildings, the user can choose to reduce the interior spacing between fasteners. In addition, wood-zinc houses can use reinforcing straps on the line of fasteners connecting zinc sheets to supporting members, and larger capacity metal connectors in the roof to wall connection. There are options on foundation types for industrial buildings, and options for improving the overall performance of mixed type construction. The parameters for the fragility curves that are defined by these cases are presented in Table 6-5.

Table 6-5 Hurricane fragility curve parameters for special cases

Action	Building type	Nº of Stories	X = Fragility threshold as a function of 3-sec. gust wind speed [mph]							
			Slight		Moderate		Extensive		Complete	
			μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}	μ_{lnX}	σ_{lnX}
Close fasteners	Wood	1	4.900	0.130	5.100	0.180	5.510	0.080	5.570	0.060
		2	4.900	0.130	5.120	0.180	5.480	0.080	5.540	0.080
	Mixed	2	4.900	0.130	5.120	0.180	5.500	0.100	5.615	0.070
		3	4.900	0.130	5.120	0.180	5.380	0.100	5.410	0.110
	Small Institutional	1	4.900	0.130	5.100	0.180	5.510	0.080	5.570	0.060
		2	4.900	0.130	5.120	0.180	5.480	0.080	5.540	0.080
	Mixed Institutional	1	4.900	0.130	5.100	0.180	5.525	0.090	5.630	0.060
	Large Institutional	1	4.940	0.160	5.180	0.180	5.300	0.140	5.540	0.130
Reinforcing straps	Wood	1	4.900	0.130	5.100	0.180	5.530	0.070	5.580	0.060
		2	4.900	0.130	5.100	0.180	5.500	0.075	5.545	0.080
	Mixed	2	4.900	0.130	5.100	0.180	5.525	0.080	5.640	0.070
		3	4.900	0.130	5.100	0.180	5.390	0.105	5.410	0.110
	Small Institutional	1	4.900	0.130	5.100	0.180	5.530	0.070	5.580	0.060
		2	4.900	0.130	5.100	0.180	5.500	0.075	5.545	0.080
	Mixed Institutional	1	4.900	0.130	5.100	0.180	5.545	0.070	5.630	0.060
	Large Institutional	1	4.940	0.160	5.180	0.180	5.300	0.140	5.540	0.130
Oversize washers Industrial		1	4.910	0.140	5.050	0.140	5.250	0.220	5.300	0.220
Roof-wall	Wood	1	4.880	0.100	5.020	0.120	5.325	0.070	5.385	0.090
		2	4.880	0.100	5.020	0.120	5.280	0.070	5.350	0.095
	Mixed	2	4.880	0.100	5.020	0.120	5.280	0.070	5.635	0.095
		3	4.850	0.090	4.990	0.115	5.230	0.070	5.280	0.085

6.7 LOSS ESTIMATION

The hurricane loss assessment for a building can be carried out using the component approach or using the system fragility curves. In the component approach, the total expected damage at a given wind speed is calculated by combining the expected damage percentages for each component with the probability of collapse. In a system approach, the system fragility defines the level of component loss.

Figure 6-6 shows the scheme for a component based loss assessment. The probability of collapse is obtained as a function of the probability of failure of the components 1 and 2:

$$. \ P(collapse) = P(1 \cup 2) = P(1) + P(2) - P(1)P(2) \tag{6.9}$$

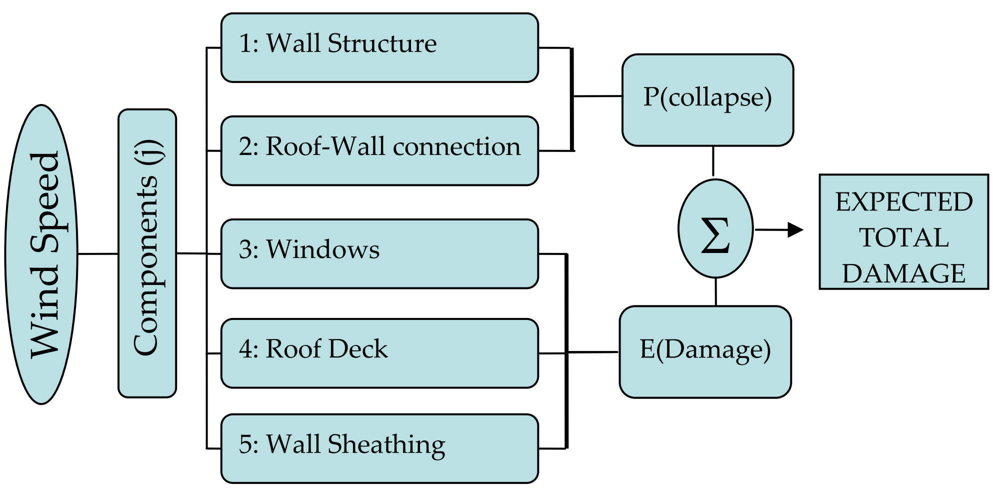


Figure 6-6 Total damage calculation scheme

The expected damage for the rest of components is expressed as a percentage of the total building replacement cost is:

$$E\left(Damage\right) = \sum_{j=3}^{5} \sum_{ds=2}^{5} P(ds, j \,|\, V) \cdot D_{ds,j} \cdot CPR_j \qquad [6.10]$$

CPR_j is the cost participation ratio of the component type *j* defined as the cost of replacing a damaged component of a home divided by the cost of constructing a complete new home of the same type. $D_{ds,j}$ is the damage percentage of the component *j* for the damage state *ds*. *V* is the 3-second maximum wind gust. Finally the total expected damage is calculated as:

$$E\left(Total\ \ Damage\right) = 100 \cdot P\left(collapse\right) + \sum_{i=1}^{3} E\left(Damage_i\right) \cdot \left(1 - P\left(collapse\right)\right) \qquad [6.11]$$

The system approach is simpler and is adopted in this thesis. The repair cost ratio is expressed as a percentage of the replacement cost of the building for a damage state '*ds*' and for the building system type '*i'*. In equation form:

$$RC_{ds}^{m} = \sum_{j} d_{ds}^{\,j} CPR_j^m \qquad [6.12]$$

where, $d_{ds}^{\,j}$ is the percentage of damage of the component *j* in a damage state *ds* (Table 6-3). CPR_j^m is the cost participation ratio of the component type *j* in a building type *m.* (Table 6-6)

The repair cost ratio for each damage state will be function of the building type. Some examples of the changes in the number of building components by occupancy is given in Table 6-7 .

Table 6-6 Cost participation ratios

Occupancy	Buildings assemblies		
	Windows	Roof system	Wall Siding
Residential	6	6	4
Commercial	6	-	-
Industrial	3	10	-
Institutional	5	6	-

Table 6-7 Repair ratios for a wood-zinc house

Damage state	Component damage ratio			System damage
	Windows	Roof system	Wall Sheathing	
Slight	0.05	0.15	0.05	0.014
Moderate	0.15	0.25	0.1	0.028
Extensive	0.5	0.5	0.2	0.068
Complete	1	1	1	1

Once the repair cost ratio for each damage state is determined, a specialized form of Equation [3.7] is used to calculate probable losses:

$$PL^{m}_{P_e,T_e} = \frac{1}{n}\sum_{j=1}^{n}\left\{\sum_{i=2}^{5} RC_i^m P_m\left[DS = d_i \,\middle|\, V^{j}_{P_e,T_e}\right]\right\} \quad [6.13]$$

In this case, the probable losses are calculated by averaging the results for the set (*j*) of probable wind speeds at the site that represents the events with a probability of exceedance P_e over a period T_e passing within a radius of 86 miles from the site. Then, for each wind speed (j) of the set, the term $P_m\left[DS = d_i \middle| V^{j}_{P_e,T_e}\right]$ is the discrete probability for one structure type m (Table 6-4), defined as the conditional probability of reaching a damage state $DS=d_i$ given the wind speed V. The damages states d_i's correspond to slight (i = 2), moderate (i = 3), extensive (i = 4) and complete (i = 5).

7 FLOOD DEFINITIONS

7.1 INTRODUCTION

Some of the largest unit discharge flood peaks in the stream gaging records of the U.S. Geological Survey (USGS) have occurred in Puerto Rico (Perry et al. 2001). Many of these flood peaks are associated with tropical cyclones. Hurricane Georges, which passed directly over the island on the night of September 22,1998, produced record flood peaks at numerous USGS stations in Puerto Rico (Smith et al. 2005).

Southern Puerto Rico was affected by intense flooding during October 6-7, 1985. The flood was a result of a nearly stationary tropical storm that caused intense rains. A 24-hour rainfall record was set in Cerro Maravilla, which received 24.6 inches of rain. Many rivers produced discharges that exceeded the 100-year recurrence interval. There were 170 deaths and 125 million US dollars in damages (Paulson et al. 1991).

On September 16, 1975, Hurricane Eloise produced 24-hour rainfall totals as high as 23 inches in some areas. Discharges on several streams peaked at or near the 100-year recurrence interval. About 10,000 residents had to evacuate their homes as a result of the flooding and landslides. Thirty-four deaths were recorded, and damages were 125 million US dollars (Paulson et al. 1991).

7.2 FLOOD HAZARD

Floods can be categorized as riverine and coastal. In the case of coastal floods, they may result from storm surges, unusually high tides, or tsunamis. The flood hazard is characterized in the program by means of the spatial variation in flood depth and velocity field for either riverine or coastal flooding conditions.

The first step in the development of the flood hazard maps is the hydrologic analyses of the amount of water flowing in a stream during flood events. The peak rates of flow in stream for Puerto Rico are available from the FEMA’s Flood Insurance Study for the 10, 50, 100 and 500 years flood events. Next, hydraulic analyses are conducted to determine the water surface elevations on streams or rivers. Topographic information, stream discharge and other data are used in a hydraulic model by research partners from Insurance Commissionaire Project (Nadal et al. 2006) for five of the major rivers in Puerto Rico. These are Río Guanajibo, Río Yagüez, Río Grande de Añasco (Figure 7-1 and Figure 7-2), Río Grande de Arecibo, and Río Grande de Manatí.. The research produced recurrence flood maps for 10, 50, 100 and 500 years.

Storm surge hazard is represented by the percentage of land area below mean 50-year stillwater elevation. The 50-year stillwater elevations of municipalities and unincorporated areas were obtained from National Flood Insurance Program flood insurance studies.

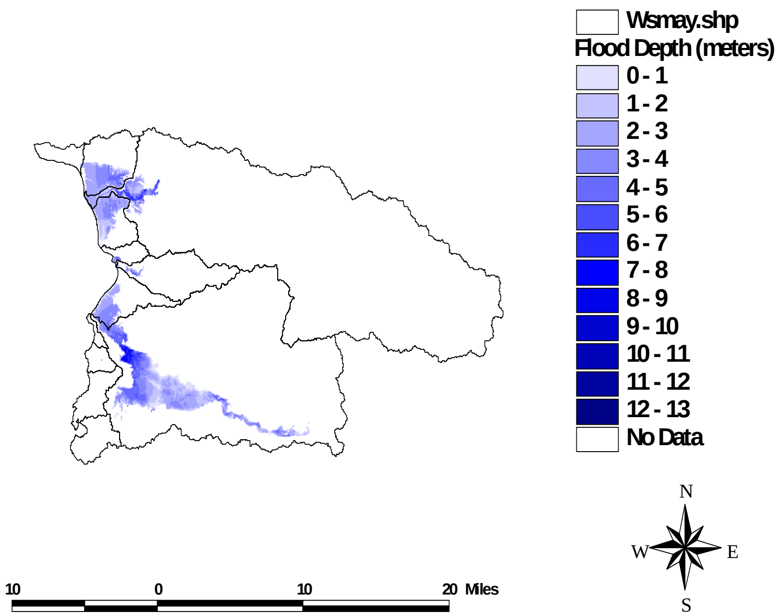


Figure 7-1 Flood Hazard for Río Grande de Añasco: Water depth (Nadal 2007)

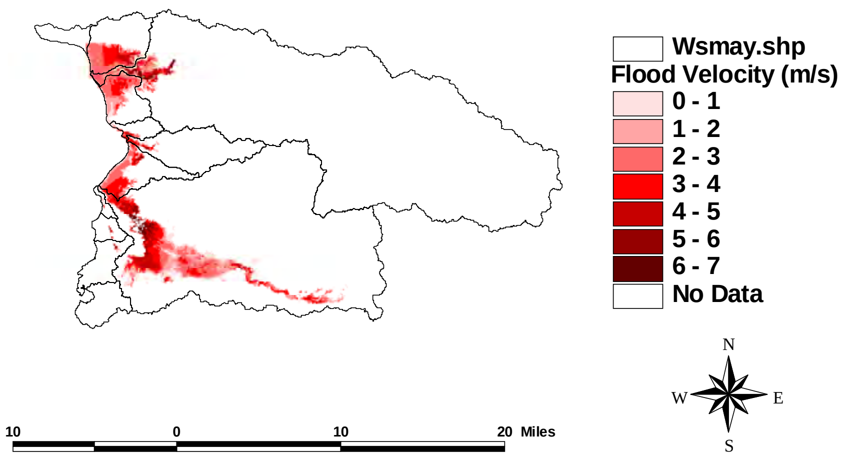


Figure 7-2 Flood Hazard for Río Grande de Añasco: Water velocities (Nadal 2007)

The FEMA surge model used to develop the flood insurance studies in coastal regions simulates coastal surge generated by storms based on probability distributions of five storm parameters: central pressure depression, radius to maximum winds, forward speed, shoreline crossing point, and crossing angle (FEMA 1999). Storm surge elevations for the 50-year floods include the contributions from wave action effects. It considers the stillwater elevations due to tidal effects and wind and wave setup effects (FEMA 1999).

7.3 FRAGILITY CURVES

The extent of damage to a building is estimated directly from the depth of flooding by the application of a depth-damage curve for the concrete houses. While the depth damage curves may be applied to a single building as well as to all buildings of a given type, they are more reliable as predictors of damage for large, rather than small, population groups. The flood loss must include the structural (load-bearing) system, as well as architectural, mechanical and electrical components, and building finishes.

Expected flood damage of individual building units located in riverine and costal zones of Puerto Rico was study in a Insurance Commissionaire subproject (Nadal et al. 2006; Nadal 2007). Structural and geometric data was acquired for 28 typical residential buildings in Puerto Rico. Then, based on this data, a Monte Carlo simulation is conducted to generate 10,000 synthetic buildings. The fragility analysis compares the random resistant of the components of these buildings with the load imposed by the acting floodwater forces. The failure of a building component occurs when its resistance is exceeded by the demand. The building is divided in four vulnerable components: Reinforced-Concrete Frame, Concrete-Block Wall, Doors and Windows and Utilities and Finishes.

In a typical two-dimensional linear elastic analysis, building frames were modeled using the SAP2000 software. The internal forces were compared with the capacity of the members calculated using analytical equations of simplified models. The vulnerability of concrete-block walls is estimated by yield line analysis (YLA). The vulnerability of doors and windows is assessed considering the damage to their respective connections as the primary failure mechanism. These building components were modeled using two-dimensional rigid-body static analysis.

The magnitude *m* of the building damage generated during a flooding event is established by means of a combination of floodwater depth and floodwater velocity. The results can be presented in the form of log-normal fragility curves for specific velocities or in vulnerability matrixes, where a value of replacement cost ratio as a percentage of building replacement cost is assigned to each pair of floodwater depth and floodwater velocity coordinates:

$$RC^m = f^m\left(depth, velocity\right) \qquad [7.1]$$

7.4 LOSS ESTIMATION

The expected flood damage (EFD) values represent the average damage registered by the 10,000 synthetic buildings generated by the Monte Carlo simulation:

$$EFD\left(\%\right)=\frac{\sum_{i=1}^{10,000}\left(flood\ damage\right)}{10,000} \qquad [7.2]$$

The expected flood damage to buildings located in riverine zones should be estimated using the vulnerability matrices developed for the slow rise flood loading case. Table 7-1 shows the outcome in terms of water depth, h, and water velocity, U. The slow rise flood is representative of the typical riverine flood event. The flash flood loading case should be considered when a conservative estimate of flood damage is desired.

Table 7-1 Expected Flood Damage for Slow Rise Flood (%)

h (ft)	**U** (ft/s)										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0	0
1	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.4	4.5	4.7
2	9.1	9.1	9.1	9.1	9.1	9.2	9.3	9.6	10.0	10.5	11.1
3	13.0	13.0	13.0	13.0	13.1	13.3	13.9	14.9	16.1	17.5	19.4
4	16.6	16.6	16.6	16.6	16.9	17.7	19.2	21.1	23.1	28.0	32.8
5	20.0	20.0	20.0	20.1	20.8	22.4	24.7	27.2	32.1	37.3	41.1
6	23.3	23.3	23.3	23.6	24.7	27.0	29.9	33.4	38.7	42.9	45.5
7	26.5	26.5	26.5	27.0	28.6	31.5	34.6	38.8	43.5	46.4	48.0
8	29.6	29.6	29.7	30.3	32.5	35.8	39.0	43.1	47.1	49.2	50.4
9	32.7	32.7	32.8	33.7	36.4	40.0	43.0	46.8	49.9	51.5	52.4
10	35.7	35.7	35.8	37.1	40.2	44.0	46.8	49.8	52.3	53.6	54.3

In the case of coastal zones, the expected flood damage can be estimated using the vulnerability matrices for both the surging flood (Table 7-2) and breaking waves (Table 7-3) loading cases, depending on the location of the building relative to the coastline.

The surging flood loading case is representative of the typical coastal flood event. The breaking wave case should be considered when buildings are located immediately at the coastline or at farther locations when the potential exists for the wind-driven waves to reach buildings without any obstruction in the pathway. In addition, during storm surge events the coastline can move inland. Likewise, in such cases, the breaking waves matrices can be used when there are no obstructions seaward of the buildings.

Table 7-2 Expected Flood Damage for Surging Flood (%)

h	**U** (ft/s)										
(ft)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0	0
1	4.3	4.3	4.3	4.3	4.3	4.5	4.7	5.1	5.5	5.9	6.5
2	9.1	9.1	9.4	9.5	10.1	11.1	12.5	15.9	22.0	28.1	33.3
3	13.0	13.5	13.6	14.6	16.5	19.8	28.1	35.3	40.3	43.8	46.3
4	16.6	17.2	17.5	19.9	23.5	33.3	40.0	44.1	46.6	48.3	49.7
5	20.0	20.6	21.3	25.3	32.7	41.4	45.6	47.7	49.1	50.4	51.6
6	23.3	23.9	25.5	30.4	39.2	45.7	48.3	49.7	50.9	52.1	69.4
7	26.5	27.2	29.6	35.1	43.8	48.2	49.9	51.0	52.3	53.6	85.6
8	29.6	30.3	33.4	39.3	47.3	50.5	51.8	52.9	54.1	55.5	100
9	32.7	33.4	37.2	43.3	50.1	52.5	53.6	54.7	55.9	57.3	100
10	35.7	36.4	41.0	47.1	52.4	54.4	55.3	56.3	57.5	74.9	100

Table 7-3 Expected Flood Damage for Breaking Waves (%)

h	**U** (ft/s)										
(ft)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0	0
1	5.6	5.6	5.7	5.9	6.1	6.4	6.9	7.5	8.8	10.7	12.9
2	38.4	38.6	39.1	39.8	40.7	41.7	42.7	43.7	44.6	45.5	46.3
3	47.6	47.7	47.7	47.7	47.8	47.9	48.0	48.2	48.5	49.0	49.7
4	48.1	48.1	48.1	48.1	48.1	48.2	48.4	48.8	49.4	50.2	51.1
5	48.7	48.7	48.7	48.7	48.8	49.0	49.4	50.1	51.0	52.0	85.5
6	49.9	49.9	49.9	49.9	50.0	50.3	50.9	51.7	52.8	85.6	100
7	50.8	50.8	50.8	50.8	50.9	51.3	52.0	53.0	54.2	100	100
8	52.3	52.3	52.3	52.3	52.5	52.9	53.7	54.7	70.2	100	100
9	54.0	54.0	54.0	54.0	54.1	54.5	55.3	56.3	87.1	100	100
10	55.7	55.7	55.7	55.7	55.8	56.2	56.9	57.9	87.8	100	100

Finally, the probable losses can be obtained from the damage matrixes using the corresponding values of water depth and water velocity associated to several return periods:

$$PL^{m}_{P_e,T_e} = RC^{m}\left[depth_{P_e,T_e}, velocity_{P_e,T_e}\right] \qquad [7.3]$$

8 PROBABLE LOSS ESTIMATES

8.1 INTRODUCTION

This chapter provides an insight into the use of loss estimation reports prepared by the insurance software. Two complete case studies on earthquake and hurricane hazards are presented. Each study includes probable loss and sensitivity analyses and examines the eventual errors introduced when using the default settings. Finally, the losses due to earthquakes and hurricanes are compared.

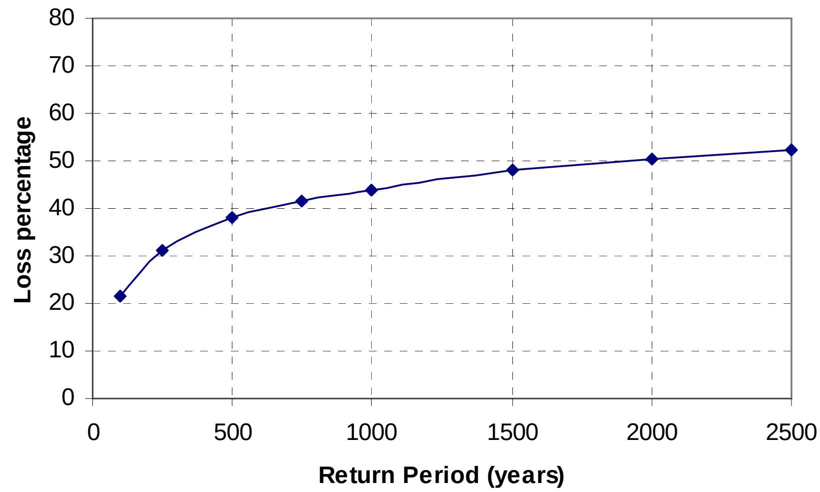
8.2 PROBABLE LOSS REPORT

The output from our insurance software is presented in the form of a loss estimation report. Application examples in Appendix M highlight two residential houses of different construction types. In each case, the loss report title page is followed by a summary of the input data including the default settings. The results for hurricane and earthquake losses are then presented. The expected annual loss is expressed as a percentage of the replacement value. Probable losses associated with different return periods are also listed in the context of hurricane categories and peak ground accelerations. Figure 8-1 shows the earthquake loss data for a one story single family concrete shear wall house in Mayaguez. The hurricane loss data shown in Figure 8-2 is for a one story wood-zinc house located nearby. In either case, the probable maximum loss will correspond to the return period selected by the user.

Earthquake

Peak Ground Acceleration [g]	Return Period [years]	Probable Loss [%]	[US$]
0.12	100	21	25,200
0.19	250	31	37,200
0.25	500	38	45,600
0.30	750	41	49,200
0.34	100	44	51,800
0.39	1500	48	57,600
0.43	2000	50	60,000
0.47	2500	52	62,400

Expected Annual Loss = 0.316 % (US$ 379)



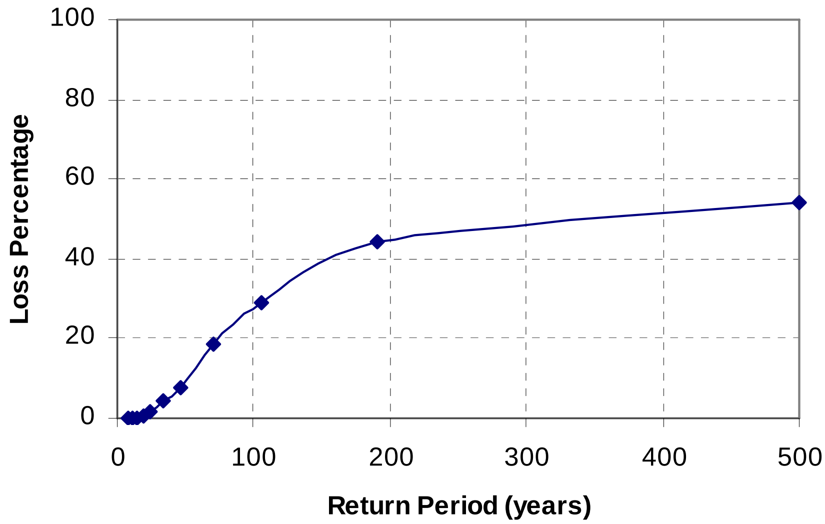
Earthquake Loss Curve

Figure 8-1 Example of loss estimation report for earthquakes

Hurricane

Sustained Wind Speed [mph]	Hurricane Category	Return Period [years]	Probable Loss [%]	[US$]
96	II	15	0.2	72
111	III	25	1.4	504
131	IV	45	7.4	2664
145	IV	70	18.5	6660
156	V	110	28.9	10404
170	V	190	44.0	15840
185	V	500	54.3	19548

Expected Annual Loss = 0.697 % (US$ 251)



Hurricane Loss Curve

Figure 8-2 Example of loss estimation report for hurricanes

8.3 EARTHQUAKE LOSSES

For earthquake hazards, one can generate more than 150 response cases by counting all the possible combinations resulting from the the soil type, the construction class and the height of the building. This is shown in Figure 8-3.

At present, the insurance software make allowance for the seismic risk assessment of eight construction classes of different heights (1 story, 2 floors, low-rise, mid-rise and high-rise) for six of the most populated cities in Puerto Rico. The soil type is also considered as well as the liquefaction potentials. Special considerations such as design irregularities, shear wall distributions and soil treatment options are included in the menu. The loss curves for all the earthquake cases can be found in the Appendices A, B, C and D.

To illustrate the procedure for the loss curve calculations, the methodology described in Chapter 5 is applied to a Shear Wall house of two stories, built on soil type D and located in Mayagüez.

First, the PGA's and short period spectral accelerations in a Rock site for different return periods are obtained from the U.S.G.S. hazard curve for the city of Mayagüez (Figure 5-1). These PGA's are modified by means of the soil factors as function of the short period spectral acceleration described in section 5.2 to reflect the soil condition at the site. The PGA's obtained for this case are listed in Table 8-1.

Next, the probabilities of exceedance for each damage state are obtained from the fragility curves for concrete shear wall of two stories as illustrated in Figure 8-4. The values that define these fragility curves were presented in the Table 5-3. The probabilities are combined with repair ratios (Table 5-9) using the Equation [5.7] to obtain the probable loss (Table 8-2). The loss curves are shown in Figure 8-5

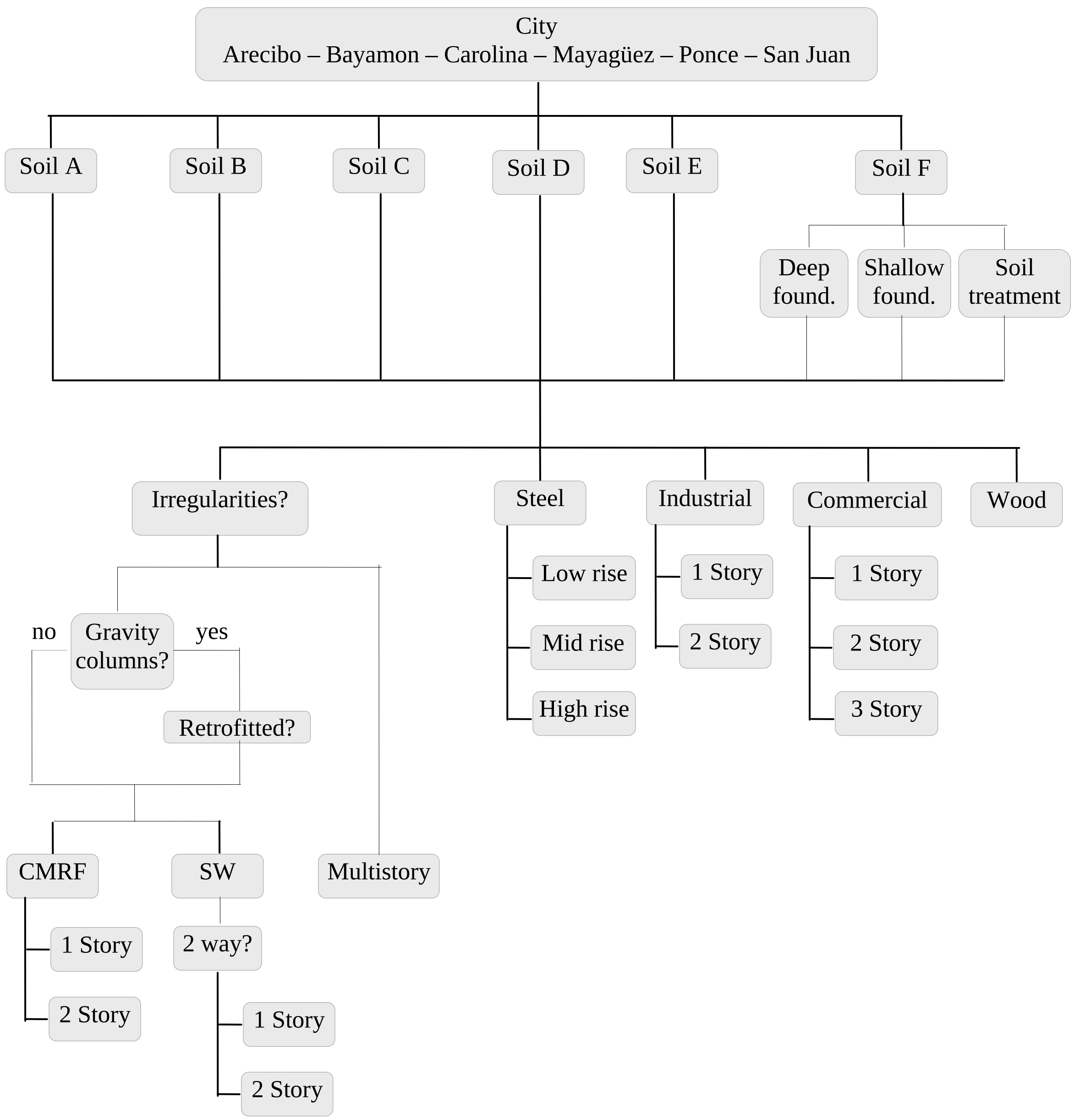


Figure 8-3 Combination of factors for earthquake loss curves cases

Table 8-1 PGAs for soil type D in Mayagüez

Return Period	Ex/Yr	Rock PGA	Short Period acceleration	Soil Factor Fa	PGA at site
100	0.01	0.1202	0.2644	1.59	0.1909
250	0.004	0.1871	0.4235	1.46	0.2734
500	0.002	0.2531	0.5836	1.33	0.3374
750	0.00133	0.2994	0.6985	1.24	0.3716
1000	0.001	0.3348	0.7884	1.18	0.3966
1500	0.00067	0.392	0.935	1.13	0.4414
2000	0.0005	0.4342	1.0477	1.08	0.4693
2500	0.0004	0.4697	1.1413	1.04	0.4901

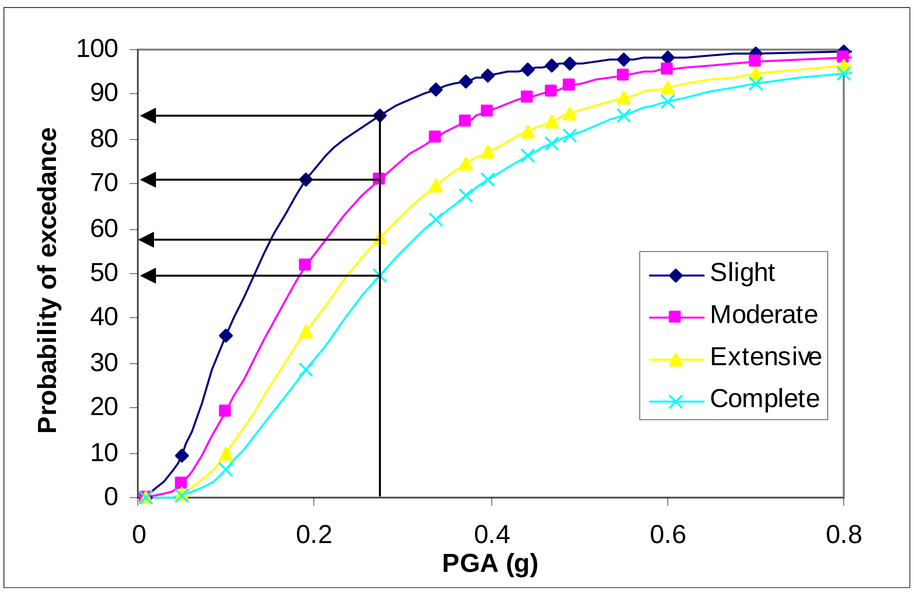


Figure 8-4 Fragility curves for concrete shear walls of two stories

Table 8-2 Results for a concrete shear wall of two stories in Mayagüez

Soil D PGA	Probability				Loss [%]	Designation
	Slight	Moderate	Extensive	Complete		
0.1909	70.83	51.82	37.07	28.76	35.0	PL_{100}
0.2734	85.27	71.18	57.96	49.49	55.5	PL_{250}
0.3374	91.01	80.49	69.57	62.10	67.3	PL_{500}
0.3716	93.00	84.07	74.37	67.56	72.2	PL_{750}
0.3966	94.14	86.22	77.37	71.05	75.4	PL_{1000}
0.4414	95.68	89.31	81.84	76.36	80.1	PL_{1500}
0.4693	96.41	90.84	84.14	79.15	82.5	PL_{2000}
0.4901	96.86	91.82	85.64	81.00	84.1	PL_{2500}

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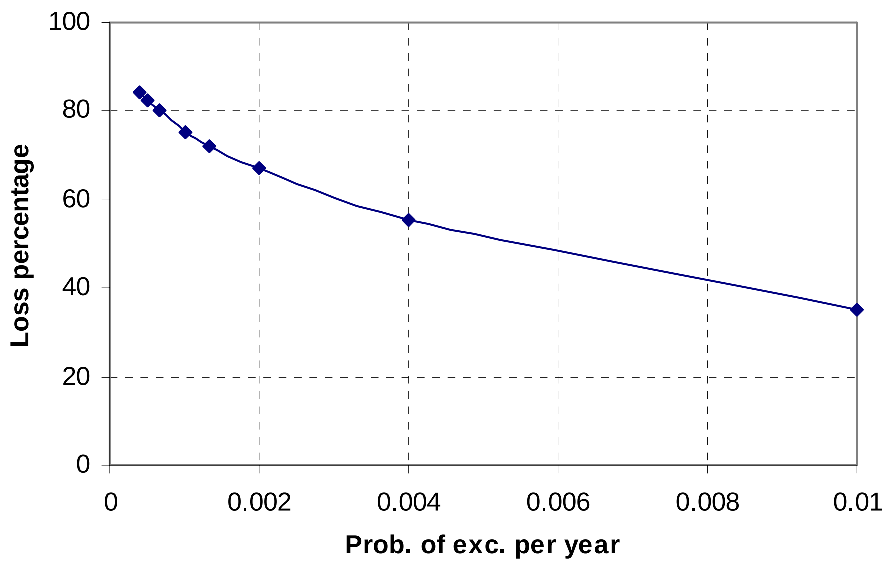

Figure 8-5 Earthquake loss curve - Shear Wall - 2 Stories - Soil type D – Mayagüez

8.4 HURRICANE LOSSES

For hurricane hazards, one can generate more than 400 response cases by counting all the possible combinations resulting from the exposures, topographic effects, construction types and building heights (Figure 8-6). Others factors considered are the roof types (concrete or metal), roof nailing alternatives, roof-to-wall connection types and retrofitting schemes to reduce low cycle fatigues on the roofs and improve the foundation. The loss curves for all the hurricane cases can be found in the Appendices E, F, G and H.

Except for the hazard definition, the procedure for estimating probable losses is similar to earthquakes. As an example, the procedure described in Chapter 6 is applied to a Wood-zinc house of one story in Mayaguez with exposure C.

As previously discussed in Chapter 6, the wind hazard curves do not give the wind speeds at the building site. Instead they give the probability of hurricanes passing at specific distance from the site and having different maximum wind speeds near the center. Then, the first step in a loss estimation process will be to generate a set of probable wind speeds at the site representing the hurricane of a given category passing within certain distances from the site. Table 8-3 shows the number of different hurricanes categories passing at different radii from the site.

Next, the wind field parameters for these hurricanes are simulated. The simulation process generates random values for distance from site to the eye of the hurricane (R), distance from eye of the hurricane to maximum wind speed (R_m), wind profile factor (B) and velocity of translation (V_h). R_m and B are generating using a uniform distribution between the ranges of values specified in section 6.2. V_h is assumed to be Gumbel distributed. Table 8-4 shows the simulated values.

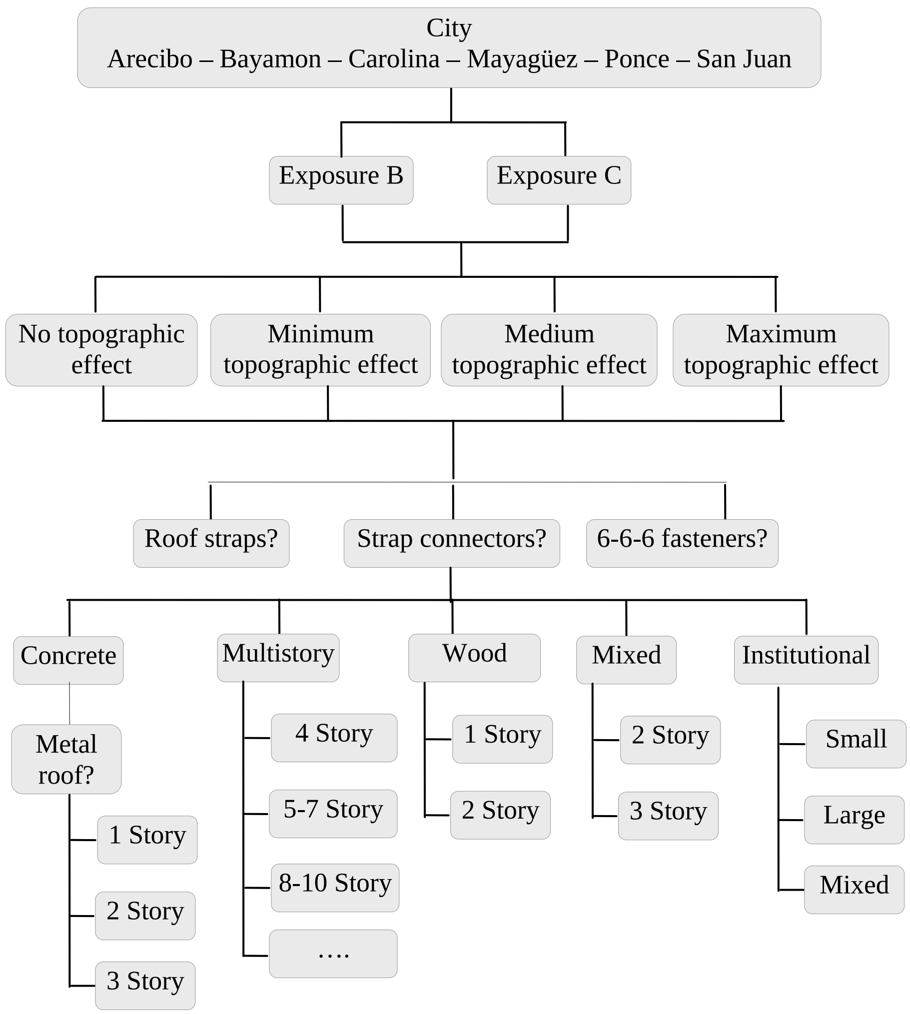

Figure 8-6 Combination of factors for hurricane loss curve cases

Table 8-3 Number of hurricanes in function to distance to site

	Hurricane Category									
	I		II		III		IV		V	
Distance [miles]	Return [years]	Number Storms	Return [years]	Number Storms	Return [years]	Number Storms	Return [years]	Number Storms	Return [years]	Number Storms
12	75	26	125	16	210	9	450	4	700	2
29	35	57	54	37	90	22	195	10	290	6
58	17	117	28	71	48	41	110	18	155	12
87	11	181	19	105	33	60	70	28	105	19

The sustained wind speed at the site is determined using the HURRECON model (section 6.2) for two different configurations (V_s at R_m and V_s at R). After that, the maximum of these two values is used to calculate the peak gust wind speed in open terrain, and finally this value is adjusted to get the peak gust velocity for exposure B and C (Table 8-5).

Table 8-4 Random generation of wind field parameters

N	rand1	rand2	rand3	rand4	R [Km]	R_m [km]	B	V_h [km/h]
1	0.365	0.530	0.617	0.791	6.8	51.8	1.39	13.41
2	0.332	0.014	0.447	0.706	27.7	20.8	1.33	12.53
3	0.881	0.906	0.159	0.339	43.0	74.4	1.25	9.72
4	0.100	0.485	0.806	0.248	21.3	49.1	1.44	9.03
5	0.505	0.482	0.564	0.523	32.6	48.9	1.37	11.05
6	0.850	0.512	0.984	0.489	85.7	50.7	1.50	10.80
7	0.684	0.116	0.224	0.728	78.0	27.0	1.27	12.74
8	0.023	0.706	0.080	0.161	47.4	62.4	1.22	8.26
9	0.387	0.109	0.746	0.487	64.3	26.6	1.42	10.79
10	0.167	0.163	0.495	0.707	54.0	29.8	1.35	12.54
11	0.176	0.448	0.397	0.595	54.5	46.9	1.32	11.59
12	0.639	0.299	0.740	0.911	122.2	37.9	1.42	15.28
13	0.209	0.922	0.447	0.705	102.3	75.3	1.33	12.52
14	0.275	0.440	0.150	0.059	105.4	46.4	1.25	6.96
15	0.164	0.529	0.342	0.182	100.2	51.8	1.30	8.46
16	0.652	0.239	0.272	0.574	122.9	34.3	1.28	11.44
17	0.875	0.701	0.979	0.320	133.2	62.1	1.49	9.58
18	0.286	0.043	0.349	0.849	105.9	22.6	1.30	14.16
19	0.072	0.962	0.887	0.248	96.0	77.7	1.47	9.03

Table 8-5 Wind speed set for a Hurricane V passing near Mayagüez

			Basic	EXP B	EXP C
V_s at R_m [km/hr]	V_s at R [km/hr]	V_s max [km/hr]	V_{3sec} [mph]	V_{3sec} [mph]	V_{3sec} [mph]
161	29	198	185	155	171
133	189	198	186	156	171
137	197	199	187	156	172
102	200	200	187	157	173
101	193	193	181	152	167
154	191	191	179	150	165
164	195	199	187	156	172
106	143	143	134	112	124
163	190	190	178	149	164
139	194	194	182	152	168
157	187	187	175	147	162
106	121	121	114	95	105
171	190	190	178	149	164
157	158	158	148	124	137
117	122	122	114	96	105
172	192	192	180	150	166
164	179	179	167	140	154
149	167	167	157	131	145
128	148	148	139	116	128

It will now be possible to obtain the probabilities of exceedance for each damage state from the fragility curves for wood zinc houses at each wind speed. The parameters that define these fragility curves were presented in the Table 6-4. The probabilities are combined with repair ratios (Table 6-7) using Equation [6.13] to obtain the probable loss (Table 8-6). Repeating the procedure for different hurricane intensities, it is possible to obtain the Table 8-7 and the Figure 8-7.

Table 8-6 Results for a Hurricane V passing near Mayagüez

Vgust [mph]	Damage state probability				Loss [%]
	Slight	Moderate	Extensive	Complete	
171	100	93	60	46	48
171	100	93	60	47	48
172	100	93	61	48	50
173	100	93	62	48	50
167	99	90	54	41	43
165	99	89	52	39	41
172	100	93	61	47	49
124	42	28	5	3	4
164	99	89	51	37	40
168	99	91	55	42	44
162	99	86	47	34	36
105	5	5	0	0	0
164	99	88	50	37	39
137	76	52	14	9	11
105	5	6	0	0	0
166	99	89	52	39	41
154	97	79	36	25	27
145	89	65	23	15	17
128	54	36	7	4	6

Average	**31**

Table 8-7 Results for a wood-zinc house of one story in Mayagüez

Return Period	Ex/yr	Wind [mph]	Loss [%]
8	0.125	74	0.0
11	0.091	85	0.0
15	0.067	96	0.2
19	0.053	104	0.8
24	0.042	111	1.8
33	0.030	121	4.9
46	0.022	130	8.5
70	0.014	144	20.6
105	0.010	156	31.4
190	0.005	168	46.8
500	0.002	185	57.0

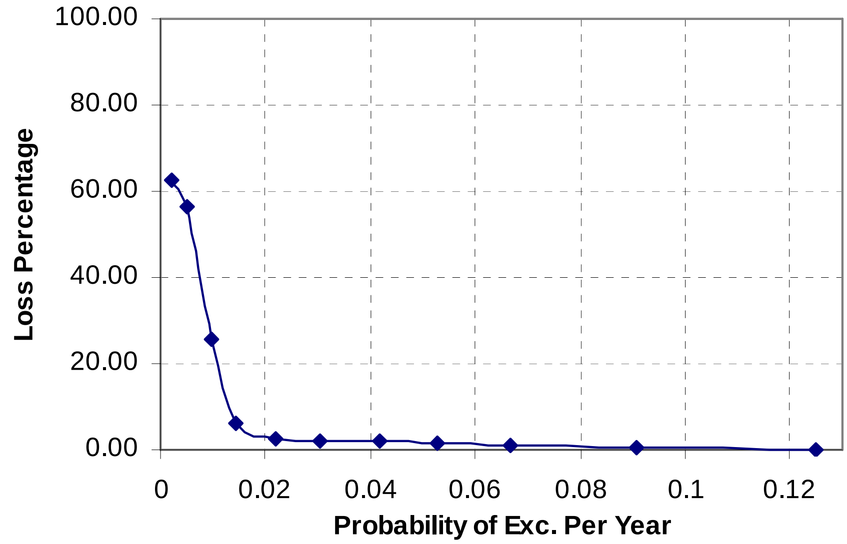

Figure 8-7 Hurricane loss curve – wood zinc house – one story – Mayagüez

8.5 HAZARDS COMPARISONS

Hurricane and earthquake hazards are different in terms of the nature of the hazards, frequency of occurrence and the associated return period for design, hazard-resistant design philosophy, consequence, and disaster mitigation strategies. Comparative risk assessments of these hazards should be performed using an equivalent measure, such as the percentage of replacement value or dollar losses.

Figure 8-8 shows the probable loss percentage for the wood houses of one story in Mayagüez, PR built over a topographic feature (K_{zt} = 2.3) in a soil type D. Wind damages are generally more severe than earthquake damages for wood buildings. In the case of concrete houses with concrete roof the damage due to hurricane are insignificant in comparison with the damages due to earthquakes. This is due to the fact that openings are the only vulnerable components to wind hazard in this case. Figure 8-9 shows the probability of damage to concrete shear wall houses of two stories in Mayagüez, PR built over a topographic feature in a soil type D. If the same concrete house has a wood-zinc roof, the caused by hurricanes is more important (Figure 8-10).

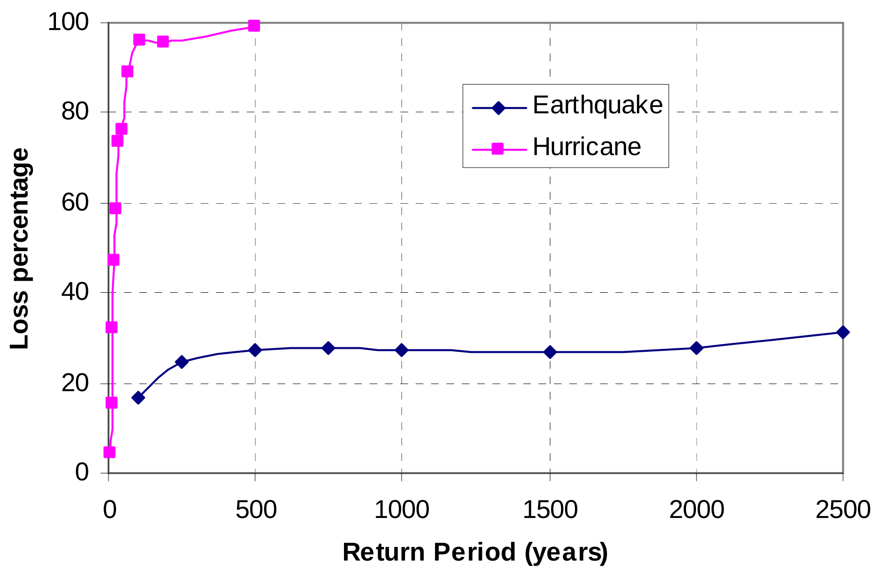

Figure 8-8 Wood house – 1 Story – Soil type D – Mayagüez – Maximum topographic effect

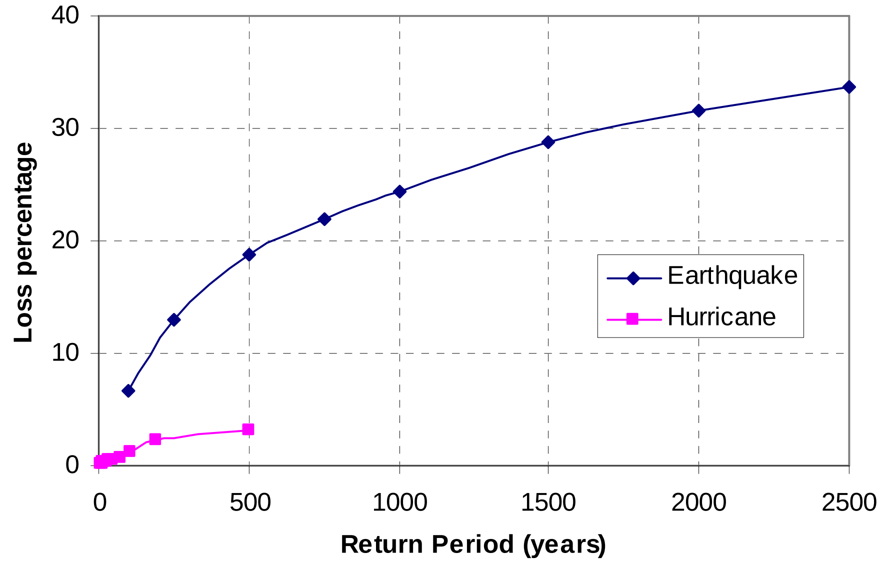

Figure 8-9 Concrete MRF house – Concrete roof - 2 Story – Soil type D – Mayagüez – Maximum topographic effect

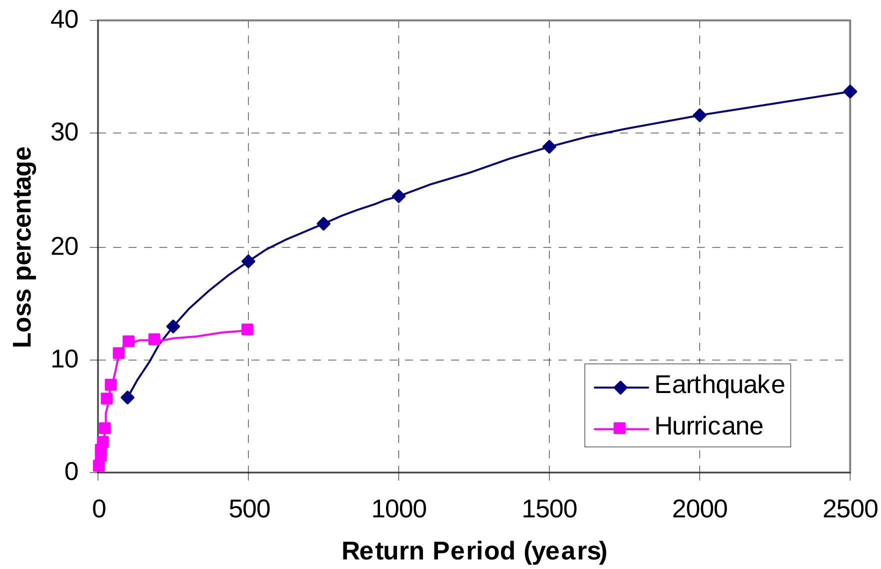

Figure 8-10 Concrete MRF house – Metal roof - 2 Story – Soil type D – Mayagüez – Maximum topographic effect

8.6 SENSITIVITY ANALYSIS

A sensitivity analysis was carried out to examine the parameters most strongly affecting the hazard loss estimation. For earthquake hazard, this will include soil type, construction class and building heights. To measure the variations in the average expected annual loss (EAL) percentage, 1000 response cases were randomly generated. The selection was weighted based on the field data from Mayaguez. Taking the response cases corresponding to the extreme values of one variable, the swing between the average EAL values is evaluated. The selection is repeated for other variables.

To compare the variables, a bar graph is used to illustrate the sensitivity of the EAL percentages to the contributing input parameters. As shown in Figure 8-11, the construction type parameter is the greatest contributor to the sensitivity results for earthquake hazard loss estimation.

The average EAL percentage for each construction class is shown in Figure 8-12. The most affected type is the shear wall (SW) and the wood-zinc buildings (W) buildings. The constructions types least effected are Steel Moment Resisting Frames (SMRF), Multistory concrete buildings and Industrial buildings.

The most influential factor effecting the loss estimation for hurricanes is the site topography (Figure 8-13). The construction type is also an important factor. Wood-zinc houses suffer the most losses and concrete buildings are the least affected (Figure 8-14).

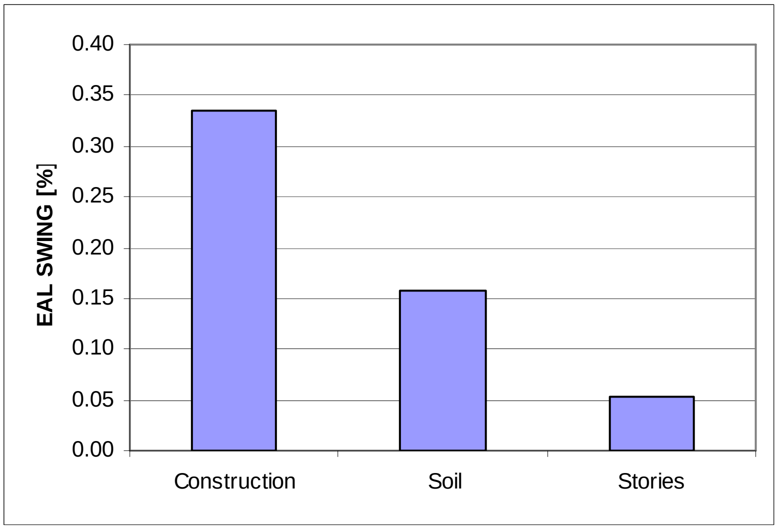

Figure 8-11 Sensitivity results for earthquake hazard loss estimation

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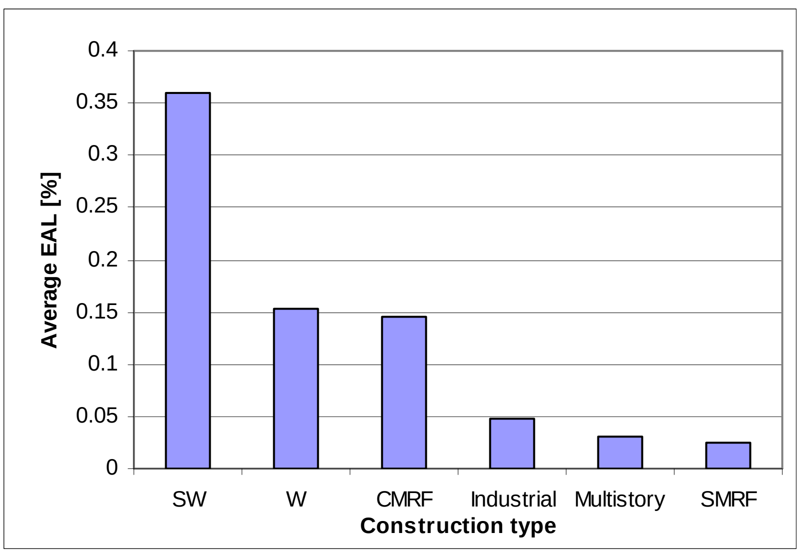


Figure 8-12 Construction type influence on earthquake losses

Figure 8-13 Sensitivity results for hurricane hazard loss estimation

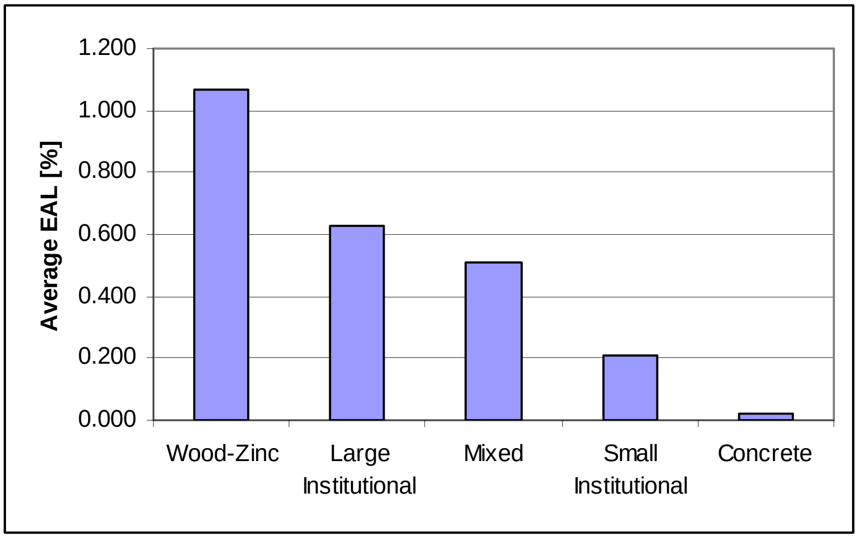


Figure 8-14 Construction type influence on hurricane losses

8.7 UNCERTAINTY MEASURES FOR DEFAULT SETTINGS

The levels of uncertainties when a default setting is used are examined. For the soil type obtained from the default map, the results are altered by moving one class in either directions, i.e. from type C to B and D. Figure 8-15 depicts the outcome where the errors vary from -45 to +29 percents depending on the case. Likewise, to study the effects of topography, we have compared the results from many cases with and without using the topography maps included with the program. The results in Figure 8-16 show the importance of getting this factor right.

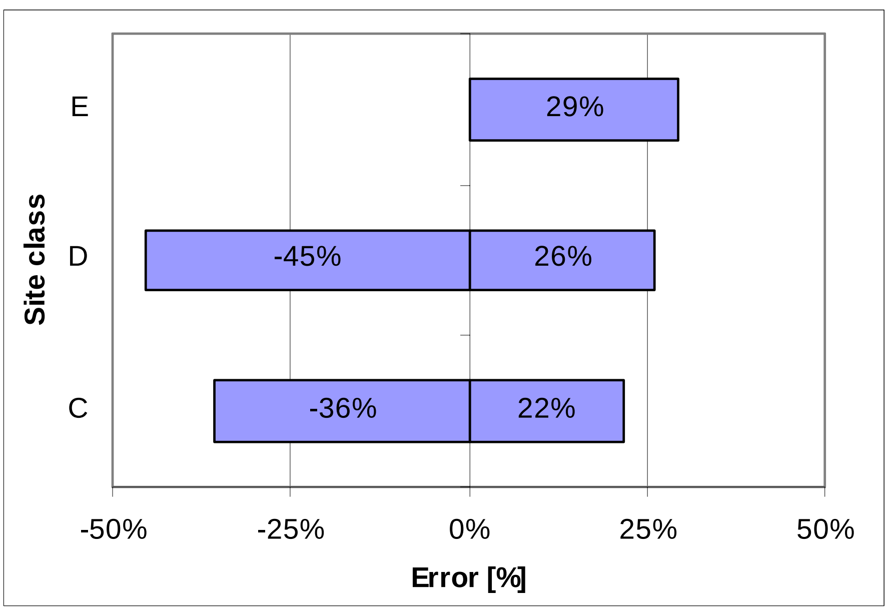


Figure 8-15 Possible error when adopting the default soil types

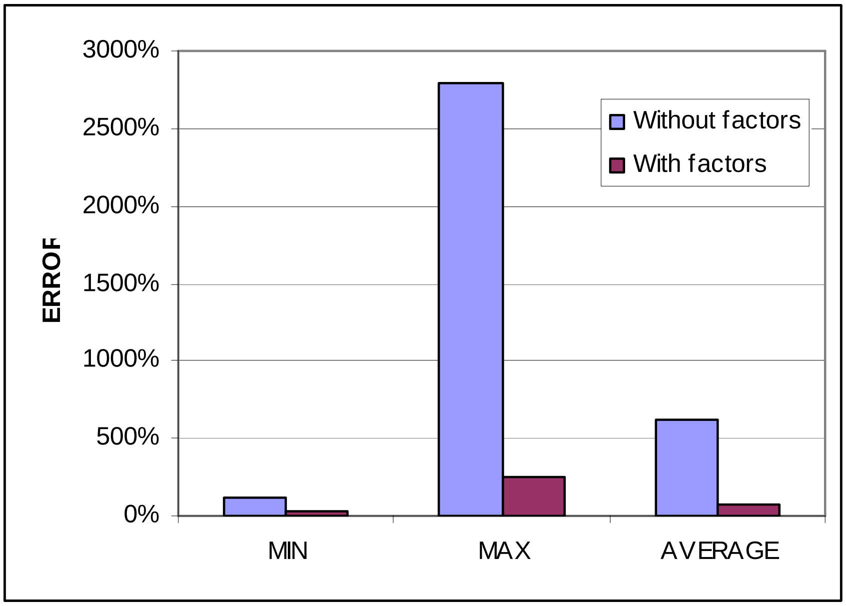


Figure 8-16 Possible error when adopting the default topographic factors

The uncertainties in building types are analyzed by calculating the EAL percentages for select structures. Changes from Concrete Moment Resistant Frame (CMRF) to Concrete Shear Wall (SW) to Steel Moment Resistant Frame (SMRF) are considered. Figure 8-17 depicts the outcome for earthquakes. The results show that the multi-story buildings, perhaps because of the improved quality of construction, are more forgiving toward errors in construction classifications than 1-2 story houses.

Considering the high levels of uncertainties associated with any natural hazard loss estimation process, the errors in using default settings are not outside the norms and will considerably improve if the user were to exercise some caution in selecting them. The soil types and the topographic factors are the two factors which are very difficult to obtain under the best of conditions. Unless the user has access to more refined data, he is advised to use default settings for these factors. This is especially true with regard to soil types where our maps are the most current. However, other factors such as structural type and building footprints can be obtained more easily from the field data or insurance files. In these cases, the user can improve the accuracy by substituting for default values.

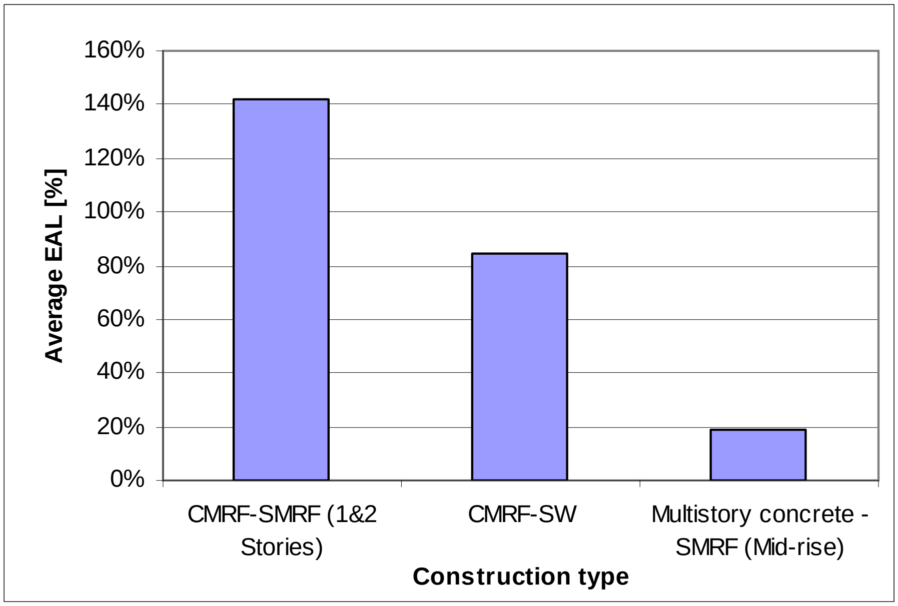


Figure 8-17 Possible error when adopting the default construction types in seismic hazard analysis

9 EVENT DRIVEN LOSS ESTIMATES

9.1 DATA COLLECTION

Deterministic loss scenarios are the traditional means for assessing natural hazard impacts that accounts for spatial correlation. A building inventory for the city of Mayagüez in the western part of Puerto Rico was created based on the interpretation of satellite images and aerial photos stored in a Geographic Information System by the Center for Collection of Municipal Taxes (CRIM, as per its acronym in Spanish). The census track units shown in Figure 9-1 are used as the basic mapping units for the building survey.

Figure 9-1 Census track of the city of Mayagüez

For each census track, the following data is extracted:

- The number and size of the buildings are collected using the CRIM database.
- The number of buildings with metal roof is counted using the satellite images. Industrial buildings are differentiating of the rest.
- Soil types are obtained from the soil maps developed in the project.
- Wind exposure and topographic effects are assigned, based on the maps developed in the project.
- The zoning classifications are noted.

9.1.1 Building inventory classification for earthquakes

Combining the information of each census track with the default assumptions described in Section 4.4, it is possible to approximate the percentage of each construction class in the census. The procedure for the inventory classification is as follows.

1. Industrial buildings are easily distinguished from the satellite images. Summing the areas of the industrial buildings from the CRIM database and dividing it by the total building areas from the sector, the results are expressed as a percentage of the total building areas.
2. The percentage of one story buildings multiplied by the percentage of metal roof buildings is assumed to be wood-zinc house types.

3. The percentage of one story buildings minus the percentage of wood-zinc house types are assumed shear wall for urbanizations and concrete moment resisting frame for the owner built.

4. Two story buildings are assumed shear wall for urbanizations and concrete moment resisting frame for the owner built.

5. The 90 percent of buildings between three and seven stories are assumed concrete multistory type and the other 10 percent are assumed steel frame.

6. Buildings of more than seven stories are assumed high-rise steel.

9.1.2 Building inventory classification for hurricanes

The procedure for the inventory classification for hurricanes is as follows:

1. The area percentage of Industrial buildings is calculated.

2. The area percentage of institutional buildings is identified and divided into small and large institutional buildings according to their square footage.

3. The percentage of one story buildings multiplied by the percentage of metal roof buildings is assumed wood-zinc type.

4. The percentage of two story buildings times the percentage of metal roof buildings is assumed two stories mixed buildings.

5. The percentage of three story buildings times the percentage of metal roof buildings is assumed three stories mixed buildings.

6. The buildings without metal roof are assumed concrete and are divided according to their heights.

9.2 EARTHQUAKE SCENARIOS

Three different earthquake scenarios with a Modified Mercalli Intensity of VIII are used. The first earthquake scenario simulates the historic 1918 Mona Passage earthquake (M= 7.3) with an average PGA of 0.33 *g* in the city. The second scenario corresponds to an earthquake event of magnitude 7.0 and epicenter in the Lajas valley. The third and last scenario reproduces a magnitude 7.3 earthquake from 1867 with its epicenter located in the Virgin Islands and an average PGA of 0.35 *g* in the city.

The expected loss percentage for each construction class in each census track is calculated, combining the fragility curves with the PGA and considering the soil type of the census. Then, using the mean square foot cost data from RMS Means (R.S. Means 2007) and the area of each building type, the dollar exposure is calculated for each census track. The monetary loss is calculated as the multiplication of the dollar exposure by the loss percentage. The repair ratio is the total loss divided by the total exposure. Examples of loss calculation for two census track are shown in Table 9-1 and Table 9-2.

Table 9-1 Earthquake loss in a census track 821.03 (65% soil type E, 35 % soil type F)

Building type	Footprint Area (%)	Total Area (sqf)	Unit Cost (US$/sqf)	Exposure (US$)	Loss (US$)		
					1918 Mayagüez	Lajas M7	1867 Mayagüez
Industrial	9.8%	190480	150	28572040	5951769	5393368	4183132
Wood	11.6%	223594	33	7378598	2760024	2512263	2210320
Shear Wall 1 S	44.3%	857278	75	64295857	32896787	31064929	29012958
Shear Wall 2 S	29.3%	1135427	75	85157028	55208640	52149848	50555655
CMRF 1 S	0.0%	0	45	0	0	0	0
CMRF 2 S	0.0%	0	45	0	0	0	0
LowRise Steel	0.0%	0	68	0	0	0	0
MidRise Steel	0.5%	46883	68	3188061	376341	365446	167242
HighRise Steel	0.1%	1705	68	115929	15789	14957	8410
Multistory	4.4%	421949	75	31646193	4777373	4678717	2652501
Total	100.0%			220353707	101986724	96179528	88790218
			Repair ratio =		0.46	0.44	0.40

Table 9-2 Earthquake loss in census track 821.04 (Soil type D)

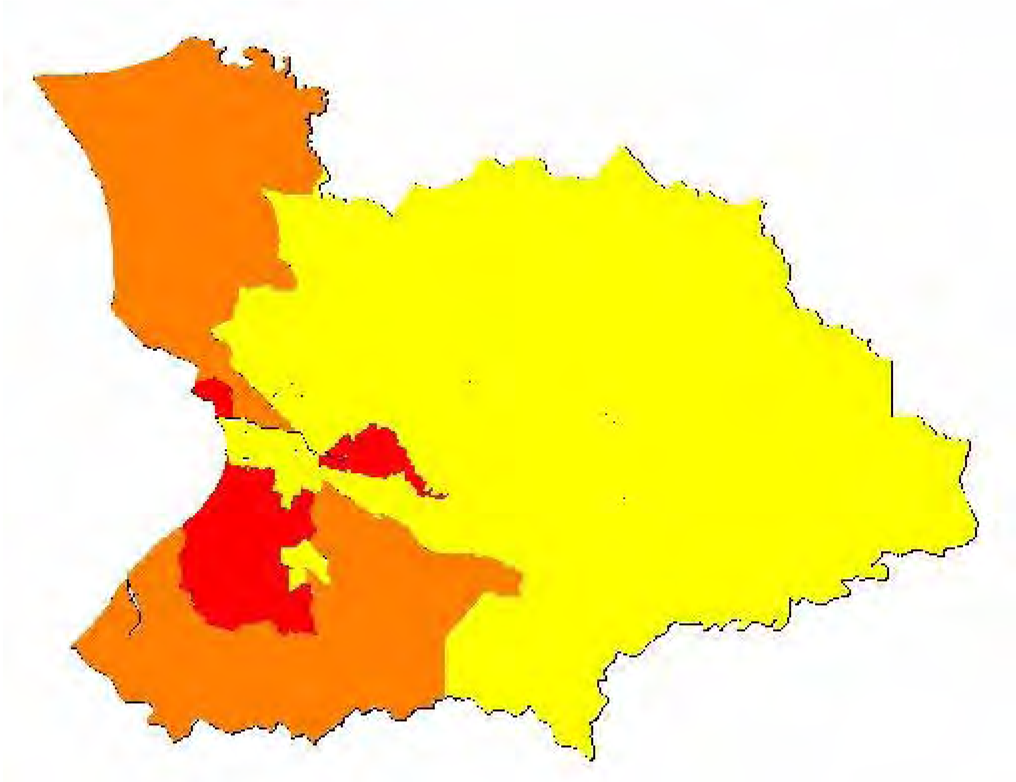
Building type	Footprint Area (%)	Total Area (sqf)	Unit Cost (US$/sqf)	Exposure (US$)	Loss (US$)		
					1918 Mayagüez	Lajas M7	1867 Mayagüez
Industrial	4.7%	47442	150	7116262	1019480	1006865	315878
Wood	3.0%	29923	33	987449	300332	297661	134312
Shear Wall 1 S	62.0%	623919	75	46793898	21336972	21232006	14063718
Shear Wall 2 S	21.1%	423925	75	31794405	19299657	19214464	12804343
CMRF 1 S	0.0%	0	45	0	0	0	0
CMRF 2 S	0.0%	0	45	0	0	0	0
Low-Rise Steel	0.0%	0	68	0	0	0	0
Mid-Rise Steel	0.9%	45307	68	3080872	103287	101167	8994
High-Rise Steel	0.0%	0	68	0	0	0	0
Multistory	8.1%	407762	75	30582185	1959631	1939241	819811
Total	100%			120355071	44019360	43791403	28147056
			Repair ratio =		0.37	0.36	0.23

The total losses in each census track are shown in Table 9-3. The aggregated losses for the entire city of Mayagüez range from 1.5 to 2 billion US dollars.

Table 9-3 Earthquake scenarios losses

Census track	Nº buildings	Exposure	Earthquake Scenarios		
			1918 Mayagüez	Lajas M7	1867 Mayagüez
801	753	$308,890,739	$36,336,990	$31,376,654	$31,215,647
802	564	$243,640,434	$111,053,716	$105,985,696	$92,023,543
803	559	$109,995,020	$59,071,652	$57,382,505	$46,870,548
804	826	$124,237,251	$46,628,622	$45,527,151	$30,209,468
805	1286	$61,701,218	$17,988,642	$16,433,739	$14,234,890
806	1643	$61,701,218	$10,116,667	$9,202,870	$7,706,634
808	566	$229,066,458	$115,034,920	$107,186,976	$106,917,551
809	868	$81,185,579	$17,807,168	$17,646,178	$8,273,033
810	596	$59,653,668	$13,934,388	$3,439,722	$690,470
811	644	$81,544,470	$19,509,385	$17,045,209	$16,964,510
812	828	$271,191,723	$143,127,968	$139,320,840	$112,439,415
813	942	$238,096,095	$124,685,601	$116,280,610	$115,992,039
815.01	1643	$271,522,255	$76,650,394	$27,482,612	$9,124,625
815.12	1745	$398,154,005	$191,085,661	$185,832,659	$145,466,854
815.22	1268	$338,987,147	$149,700,197	$138,374,883	$137,990,750
816.01	259	$42,684,135	$10,431,532	$9,130,652	$9,088,054
817	1286	$218,640,317	$45,343,072	$44,926,058	$20,744,154
818	278	$25,661,744	$5,598,554	$5,547,991	$2,605,244
820.01	1999	$618,055,498	$276,586,642	$263,854,170	$225,415,815
820.12	1606	$393,833,290	$175,961,456	$175,130,715	$114,981,449
820.22	861	$157,126,818	$74,748,623	$74,397,265	$48,972,635
821.02	1035	$276,089,803	$161,047,768	$155,039,594	$135,863,239
821.03	1023	$220,353,707	$101,986,724	$96,179,528	$88,790,218
821.04	566	$120,355,071	$44,019,360	$43,791,403	$28,147,056
Total		**$4,952,367,661**	**$2,028,455,700**	**$1,886,515,680**	**$1,550,727,838**

The losses obtained for these three earthquake scenarios ranges from 30% to 40 % of the total dollar exposure. This percentage of losses is equivalent to the losses to an inventory of bad construction quality buildings subject to an earthquake of high VIII to IX intensity in the scale of Mercalli according to a report of Swiss Re (2005). This is not a surprise, if one considered the bad performance of the concrete shear wall structures discussed in the previous chapter and the poor soil properties in the western area of the city. The clear effect of the local soil conditions are demonstrated with a map of the spatial distribution of the damages over the city of Mayagüez for the 1918 earthquake scenario (Figure 9-2). In this figure, the more heavily damaged areas are also the sectors with soils type F and E.



Damage < 40 %   40 % > Damage < 50 %   50 % > Damage < 60 %

Figure 9-2 Spatial distribution of damages for the historic earthquake of 1918

9.3 EARTHQUAKE MITIGATION ALTERNATIVES

The effects of mitigation schemes to reduce the percentage of losses from earthquakes are quantified in this section. The first option considered is the improvement to shear wall construction by the novel idea of actually providing adequate number of shear walls in both direction and sizing them properly. The results of implementing this retrofitting scheme (Table 9-4) show a reduction of almost 10 percent in the total aggregation of the losses and more than 15 % in some census tracks. The second mitigation alternative analyzed is the soil treatment changing the soil type F with certain level of susceptibility to liquefaction to a soil type E. In this case, the loss reductions varied from 1 to 5 percent in the total aggregation of the losses and almost 15 % in some census tracks (Table 9-5).

9.4 HURRICANE SCENARIOS

Three different historic hurricane scenarios with high wind speeds in the city of Mayagüez are used. These are San Ciriaco (1899), San Felipe II (1928) and Georges (1998) with sustained wind speeds of 138 mph, 161 mph and 109 mph, respectively.

The expected loss percentage for each construction class in each census track is calculated by combining the fragility curves with the wind speeds and considering the exposure and the topographic features of the census. Then, following a similar procedure explained in Section 9.2 the repair ratios for the census track are calculated. Examples of loss assessments for two census tracks are shown in Table 9-6 and Table 9-7.

Table 9-4 Resulting losses of a shear wall strengthening

Census track	Nº buildings	1918 Mayagüez		Lajas M 7		1867 Mayagüez	
		Typical SW	Strong SW	Typical SW	Strong SW	Typical SW	Strong SW
801	753	0.12	0.12	0.10	0.10	0.10	0.10
802	564	0.46	0.36	0.44	0.34	0.38	0.27
803	559	0.54	0.42	0.52	0.41	0.43	0.29
804	826	0.38	0.38	0.37	0.37	0.24	0.24
805	1286	0.29	0.29	0.27	0.27	0.23	0.23
806	1643	0.16	0.16	0.15	0.15	0.12	0.12
808	566	0.50	0.37	0.47	0.33	0.47	0.33
809	868	0.22	0.22	0.22	0.22	0.10	0.10
810	596	0.23	0.23	0.06	0.06	0.01	0.01
811	644	0.24	0.24	0.21	0.21	0.21	0.21
812	828	0.53	0.44	0.51	0.42	0.41	0.31
813	942	0.52	0.37	0.49	0.33	0.49	0.33
815.01	1643	0.28	0.26	0.10	0.08	0.03	0.02
815.12	1745	0.48	0.39	0.47	0.38	0.37	0.25
815.22	1268	0.44	0.31	0.41	0.27	0.41	0.27
816.01	259	0.24	0.24	0.21	0.21	0.21	0.21
817	1286	0.21	0.21	0.21	0.21	0.09	0.09
818	278	0.22	0.22	0.22	0.22	0.10	0.10
820.01	1999	0.45	0.35	0.43	0.33	0.36	0.26
820.12	1606	0.45	0.32	0.44	0.31	0.29	0.17
820.22	861	0.48	0.33	0.47	0.33	0.31	0.18
821.02	1035	0.58	0.44	0.56	0.42	0.49	0.33
821.03	1023	0.46	0.34	0.44	0.32	0.40	0.28
821.04	566	0.37	0.24	0.36	0.23	0.23	0.12
Total		**0.41**	**0.32**	**0.38**	**0.29**	**0.31**	**0.22**

Table 9-5 Resulting losses of improving soil F to soil E

Census track	Real soil	Improved soil	1918 Mayagüez		Lajas M7		1867 Mayagüez	
			Real	Improved	Real	Improved	Real	Improved
801	E	E	0.12	0.12	0.10	0.10	0.10	0.10
802	E/F	E	0.46	0.39	0.44	0.36	0.38	0.36
803	F	E	0.54	0.42	0.52	0.39	0.43	0.39
804	F	E	0.38	0.23	0.37	0.20	0.24	0.20
805	E/F	E	0.29	0.25	0.27	0.22	0.23	0.22
806	E/F	E	0.16	0.13	0.15	0.12	0.12	0.12
808	E	E	0.50	0.50	0.47	0.47	0.47	0.47
809	D	D	0.22	0.22	0.22	0.22	0.10	0.10
810	D/E	D/E	0.23	0.23	0.06	0.06	0.01	0.01
811	E	E	0.24	0.24	0.21	0.21	0.21	0.21
812	F	E	0.53	0.41	0.51	0.38	0.41	0.38
813	E	E	0.52	0.52	0.49	0.49	0.49	0.49
815.01	D/E	D/E	0.28	0.28	0.10	0.10	0.03	0.03
815.12	F	E	0.48	0.36	0.47	0.33	0.37	0.33
815.22	E	E	0.44	0.44	0.41	0.41	0.41	0.41
816.01	E	E	0.24	0.24	0.21	0.21	0.21	0.21
817	D	D	0.21	0.21	0.21	0.21	0.09	0.09
818	D	D	0.22	0.22	0.22	0.22	0.10	0.10
820.01	E/F	E	0.45	0.37	0.43	0.34	0.36	0.34
820.12	D	D	0.45	0.45	0.44	0.44	0.29	0.29
820.22	D	D	0.48	0.48	0.47	0.47	0.31	0.31
821.02	E/F	E	0.58	0.50	0.56	0.47	0.49	0.47
821.03	E/F	E	0.46	0.42	0.44	0.39	0.40	0.39
821.04	D	D	0.37	0.37	0.36	0.36	0.23	0.23
Total			**0.41**	**0.37**	**0.38**	**0.33**	**0.31**	**0.30**

Table 9-6 Hurricane loss in census track 804 (Exposure C)

Building type	Footprint Area (%)	Area (sqf)	Unit Cost (US$/sqft)	Loss (US$) San Ciriaco	San Felipe	Georges
Industrial	12.7%	189530	150	1340510	2634600	263117
Small Institutional	0.0%	0	47	0	0	0
Large Institutional	0.0%	0	118	0	0	0
Wood-zinc 1S	20.0%	297839	33	4034676	7175624	689248
Mixed 2S	21.8%	647682	47	5470365	9076622	1161957
Mixed 3S	1.8%	80369	47	1257544	1817703	327157
Concrete 1S	20.0%	297499	65	80983	103250	28164
Concrete 2S	21.7%	646943	65	166646	207610	63284
Concrete 3-4S	1.9%	82639	65	30884	85870	1116
Concrete 5-7S	0.1%	4722	65	1765	4907	64
Concrete 8-10S	0.0%	0	65	0	0	0
Concrete 11-13S	0.1%	21619	65	8079	22464	292
Total	100%			12391452	21128650	2534399
			Repair ratio =	8.79%	14.99%	1.80%

Table 9-7 Hurricane loss in census track 815.01 (15% Exposure C, 85% Exposure B)

Building type	Footprint Area (%)	Area (sqf)	Unit Cost (US$/sqft)	Loss (US$) San Ciriaco	San Felipe	Georges
Industrial	0.0%	0	150	0	0	0
Small Institutional	0.0%	0	47	0	0	0
Large Institutional	7.6%	235857	118	800236	1885587	127691
Wood-zinc 1S	2.5%	78505	33	658654	1452517	78574
Mixed 2S	2.2%	137479	47	760514	1526482	113787
Mixed 3S	0.2%	22186	47	244255	425704	44247
Concrete 1S	44.1%	1376800	65	291461	428565	67001
Concrete 2S	38.6%	2411063	65	503121	696833	116605
Concrete 3-4S	4.7%	438980	65	72932	293309	1568
Concrete 5-7S	0.1%	19954	65	3315	13332	71
Concrete 8-10S	0.0%	0	65	0	0	0
Concrete 11-13S	0.0%	0	65	0	0	0
Total	100%			3334488	6722330	549545
			Repair ratio =	1.06%	2.14%	0.18%

The total losses in each census track are shown in Table 9-8. The aggregated losses for the entire city of Mayagüez range from 72 to 260 million US dollars.

Table 9-8 Hurricane scenarios losses

Census track	Nº buildings	Exposure	Hurricane Scenarios		
			San Ciriaco	San Felipe	Georges
801	753	$308,890,739	$10,831,763	$22,699,925	$1,468,180
802	564	$243,640,434	$8,383,794	$13,237,865	$3,210,158
803	559	$109,995,020	$3,373,959	$4,535,357	$2,578,765
804	826	$124,237,251	$10,922,247	$18,623,509	$2,233,905
805	1286	$61,701,218	$6,736,894	$5,360,472	$711,938
806	1643	$61,701,218	$1,806,755	$3,510,129	$290,419
808	566	$229,066,458	$7,783,869	$16,289,954	$1,024,023
809	868	$81,185,579	$10,571,379	$11,322,029	$7,137,727
810	596	$89,473,868	$3,848,378	$8,034,095	$508,461
811	644	$119,759,481	$6,641,914	$11,397,019	$2,217,477
812	828	$271,191,723	$11,230,552	$18,883,057	$2,432,725
813	942	$238,096,095	$6,733,724	$8,258,488	$4,758,221
815.01	1643	$271,522,255	$2,883,695	$5,813,530	$475,251
815.12	1745	$398,154,005	$16,064,438	$23,298,348	$8,115,293
815.22	1268	$338,987,147	$5,222,328	$9,209,139	$1,802,301
816.01	259	$42,684,135	$262,265	$500,651	$40,330
817	1286	$218,640,317	$5,182,675	$11,043,436	$704,494
818	278	$25,661,744	$640,995	$1,315,977	$87,267
820.01	1999	$618,055,498	$35,203,445	$39,960,547	$26,574,688
820.12	1606	$393,833,290	$2,725,301	$4,786,318	$812,921
820.22	861	$157,126,818	$1,976,902	$4,049,502	$271,991
821.02	1035	$276,089,803	$1,600,529	$2,823,438	$688,593
821.03	1023	$220,353,707	$7,277,340	$12,001,665	$3,379,014
821.04	566	$120,355,071	$1,180,721	$2,562,841	$167,887
Total		**$5,020,402,872**	**$169,085,862**	**$259,517,290**	**$71,692,028**

9.5 HURRICANE MITIGATION ALTERNATIVES

The effects of mitigation schemes to reduce the percentage of losses from hurricanes are quantified in this section. The first option considered is the reduction in spacing between fasteners. The results of implementing this retrofitting scheme (Table 9-10) show a reduction of only 1 to 2 percent in the total aggregation of the losses and more than 10 % in some census tracks. The total losses for the retrofitted inventory were reduced by half (Table 9-9). Also analyzed are the addition of reinforcing zinc straps to reduce low-cycle fatigue of zinc sheets and the use of metal straps in roof-to-wall connections. Both of these retrofitting options produce results similar to the first scheme.

Table 9-9 Total monetary losses for typical and retrofitted inventories

	Hurricane Scenarios		
	San Ciriaco	San Felipe	Georges
Typical	$165,683,838	$253,202,890	$70,814,974
Retrofitted	$64,328,133	$107,334,033	$25,514,069

Table 9-10 Resulting losses of reduce the spacing between fasteners

Census track	San Ciriaco		San Felipe		Georges	
	Typical	Retrofitted	Typical	Retrofitted	Typical	Retrofitted
801	0.035	0.007	0.073	0.011	0.005	0.001
802	0.034	0.013	0.054	0.024	0.013	0.005
803	0.031	0.016	0.041	0.030	0.023	0.011
804	0.088	0.012	0.150	0.020	0.018	0.004
805	0.109	0.038	0.087	0.015	0.012	0.003
806	0.029	0.005	0.057	0.011	0.005	0.001
808	0.034	0.006	0.071	0.009	0.004	0.001
809	0.130	0.025	0.139	0.075	0.088	0.011
810	0.043	0.007	0.090	0.011	0.006	0.001
811	0.055	0.009	0.095	0.021	0.019	0.003
812	0.041	0.008	0.070	0.014	0.009	0.003
813	0.028	0.010	0.035	0.026	0.020	0.006
815.01	0.011	0.005	0.021	0.008	0.002	0.001
815.12	0.040	0.020	0.059	0.034	0.020	0.008
815.22	0.015	0.008	0.027	0.014	0.005	0.003
816.01	0.006	0.003	0.012	0.005	0.001	0.001
817	0.024	0.006	0.051	0.010	0.003	0.001
818	0.025	0.005	0.051	0.008	0.003	0.001
820.01	0.057	0.040	0.065	0.058	0.043	0.019
820.12	0.007	0.004	0.012	0.007	0.002	0.001
820.22	0.013	0.004	0.026	0.006	0.002	0.001
821.02	0.006	0.004	0.010	0.008	0.002	0.002
821.03	0.033	0.012	0.054	0.025	0.015	0.004
821.04	0.010	0.004	0.021	0.008	0.001	0.001
Total	**0.033**	**0.013**	**0.051**	**0.022**	**0.014**	**0.005**

10 CONCLUSIONS

10.1 SUMMARY

As part of a multi-disciplinary project encompassing a variety of engineering fields, this thesis represents a synthesis of work conducted by several research groups. The final product of this work is an insurance solution software implementing a multi-hazard loss estimation methodology. The specific research contributions of this study include building classification efforts, identification of hazard demands on buildings caused by Earthquakes, Hurricanes, and Floods, selection of fragility curves, establishment of relationships between structural damage and insurable losses, and the integration of the components in an intuitive, multi-level insurance solutions software.

While most of the risk assessments are focused on selected single hazards, this dissertation presents an integrated multi-hazard approach. This approach has several benefits because different hazards affect different building types and different geographic zones. The software interface builds on the existing commercial insurance programs and can be easily adopted with minimum training of the personnel. The open-source code can be easily upgraded and will have the added advantage of allowing tailor made versions to be created for different users. This will allow for inclusion of the proprietary information at the company level without overriding normal disclosure processes. The science underneath the program is believed to be superior to those of competing software, as the structural data has been thoroughly researched and in many cases unavailable elsewhere.

Risk modeling introduces concepts that are relatively new to risk management stakeholders and non-technical issues provide greater barriers to successful implementation in the insurance environment. This issue was successfully solved using three levels of input requirements, depending on the user expertise and the extent by which the input data may be generated. For the most basic level of input, some default parameters were assigned internally by the program to fill the unknown data, providing a result inside the range of tolerance error.

Of the three included natural hazards in this thesis, the flood risk assessment potential is quite limited because only one type of construction was included. However, this hazard is included in the program for an easy incorporation of the fragility curves as they became available.

The program offers two types of analysis. An event based analysis assumes specific design scenarios while a maximum probable loss analysis considers the likely outcome over a user defined time span. Using the city of Mayaguez in the western part of Puerto Rico as a test bed, building inventories are developed to represent some 33 urbanizations and more than 60 years of construction. Assimilating the outcome from the analysis tools, retrofitting measures, and uncertainty modeling, seismic and hurricane wind fragilities are quantified. Long term projections based on the maximum probable loss analysis are also reported. The changes in existing vulnerability functions are examined to reflect differences in the building types and construction practice.

10.2 CONCLUSIONS

The computer program developed during the course of this investigation is capable of carrying out multi-hazard loss estimation with focus on individual structures as required by insurance industries. The results presented in this thesis demonstrated the potential of the program in the following areas:

- visualizing the events
- identifying problem areas
- help in government planning
- identify areas of investments and determine code adjustments

Intelligently defined default settings solve the potential problems with the availability of data and the lack of expertise on the user part. The outcomes even under the worst conditions are well within the norms for the industry.

This multi-hazard approach permits all types of sensitivity analysis to identify the disparities or synergies of effects from different hazards. It helped identify the most vulnerable building types in Puerto Rico as shear wall for earthquakes and wood-zinc houses for hurricanes. The multi-hazard assessment also has the advantage of allowing the user to evaluate a broad range of variables that influence different hazards and may be concurrent. We had found the construction type and the wind speed-up due to the topography to be the most influential factors for earthquakes and hurricanes, respectively.

The results from running deterministic earthquake and hurricane loss scenarios for the target city of Mayagüez revealed economic losses on the high end of the spectrum. This is explained in part by some questionable construction practices in the Island, especially with regards to shear wall structures. The coastal areas in the western part of the city suffered the most damages under earthquake scenarios because of the liquefaction problems. The estimated losses for the hurricane scenarios were between 5 to 10 percent of the expected losses from a major earthquake. However, these calculations did not consider the damages caused by floods during a hurricane, and the losses to the interior of the buildings when an element of the building's envelope fails. Again, the biggest damages were found in the coastal areas in parts due to topography and the concentration of light frame industrial structures.

The ability to change one or all default settings will enable the user to test different hypothesis and the cost-benefit of various alterations, soil treatments and retrofitting schemes. In fact, based on our models, mitigation measures can save more than 400 million US dollars in earthquakes and from 50 to more than 100 million US dollars for hurricanes in Mayaguez alone. These savings lend support to the idea of providing incentives, such as reductions in insurance premiums, to increase mitigation efforts.

10.3 RECOMMENDATIONS FOR FUTURE WORK

This dissertation has highlighted a number of research issues that must be addressed during the next several years to allow the loss estimation software developed to achieve its full potential. The major problem experienced during the period in which this work was completed was the gathering of information on construction practices as it related to quality of construction and cost. In addition, validating the results from analysis was proven difficult because insurance companies were not forth coming in sharing their internal data for obvious policy reasons. Post-disaster data collection is crucial to test our model against real world events. The damage records should be organized in a systematic way based on the input data structure of the program. Further calibrations of the fragility curves and repair cost ratios may be required. Specific recommendations discussed in this section are organized in general categories of vulnerability, building inventory, loss estimation and site effects.

10.3.1 Vulnerability

Earthquake and hurricane fragility curves were developed for the most common building types on the island. The especial construction classes not covered for earthquake include: concrete moment resistant frames with unreinforced block wall infill, wood houses and mixed construction. The only especial construction class not covered for hurricanes is all wood houses. In the case of flood hazard, however, only one construction class has been considered. It is recommended that additional research in this area should have high priority, especially as it applies to wood houses.

Seismic economic losses caused by nonstructural components are considerable. Therefore, specific fragility curves for nonstructural components sensitive to drift and sensitive to acceleration should be developed to reduce the margins of error.

Deficient designs such as irregular building's footprints, vertical irregularities, short columns and nonsymmetrical distribution of the mass has been considered in an approximate way but a more detailed study is suggested for a future work.

The soil-structure interaction affects the performance of buildings. A numerical structural model without proper consideration of soil-structure interaction may result in inaccurate seismic fragility curves. Although this effect has been accounted for using a simplified method, it is recommended to develop seismic fragility curves for different types of foundations in order to adjust the building performance.

The drift limits used to define the damage states for the earthquake fragility curves should be improved by means of experimentation and post-disaster field surveys.

Water damage to the interior of the buildings in the aftermath of a hurricane has not been considered. The vulnerable components include interior walls, carpets, doors, ceiling, and wall painting. At this time, there are no explicit means by which damages to the interiors are computed. A future study is recommended to relate the extent of interior damage with the amount of total exterior damage and other influential factors.

10.3.2 Building inventory

The loss estimation procedure is data-intensive, and an extensive database will be required for any successful implementation. The building inventory for the city of Mayagüez was created based on the interpretation of satellite images and aerial photos supplemented with visits to the field. It is indispensable to maintain updated information and to extend the inventory to include all municipalities in the Island.

10.3.3 Loss estimation

The mapping process between damage states and economic losses is one of the most significant research issues at the present time. In this study, the repair cost ratios have been assumed deterministic and calculated for some types of construction classes considering only the structural damages. However, this ratio also depends on the nature of the building occupancy and on the nonstructural components. Therefore, proper formulation should apply to general categories of building occupancy and include both structural and nonstructural components. Furthermore, because there are large uncertainties in the relationships between cost ratio and damage, probabilistic models linking economic losses to damage states must be developed.

The quality of construction and building maintenance greatly influence building fragility and deserve a closer inspection. The relationships between the added costs associated with a better construction quality and the benefits due to improved performance must be determined.

A detailed cost estimate of various retrofitting schemes considered in this thesis should be helpful in better justifying the upgrade decisions. Indirect costs such as occupancy interruptions, lost business opportunities or loss of productions are also important and need to be included as options in future revisions of the software.

10.3.4 Site effects

The liquefaction susceptibility has been quantified in general form for the complete region of soils classified as type F. It is convenient to develop maps of liquefaction hazard to show how the hazard differs from place to place. These maps of liquefaction susceptibility should be delineated in five units from Very High to Very Low hazard.

The incorporation of the speed-up due to topographic features by means of the indications of the norm had demonstrated a significant influence on the levels of damage caused by the wind. On the other hand, recent studies demonstrate that the indications of the norm give only a reference to the order of magnitude of the wind speed. A more proper assessment of this effect will go a long way in reducing the uncertainties regarding wind fragilities.

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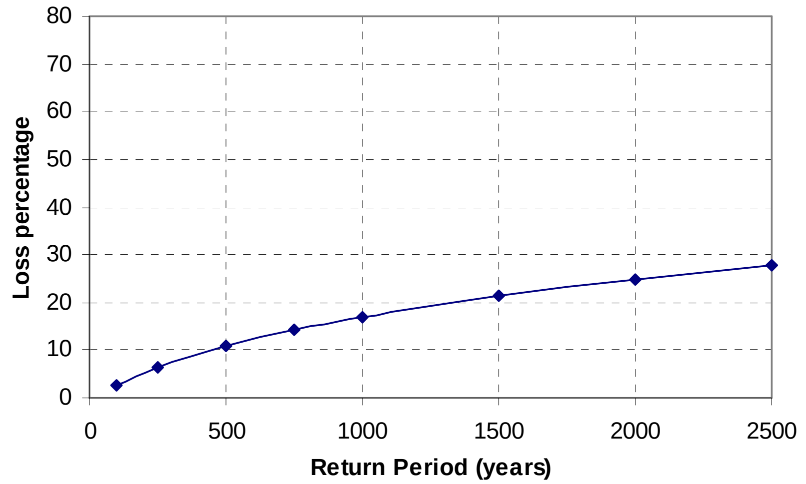
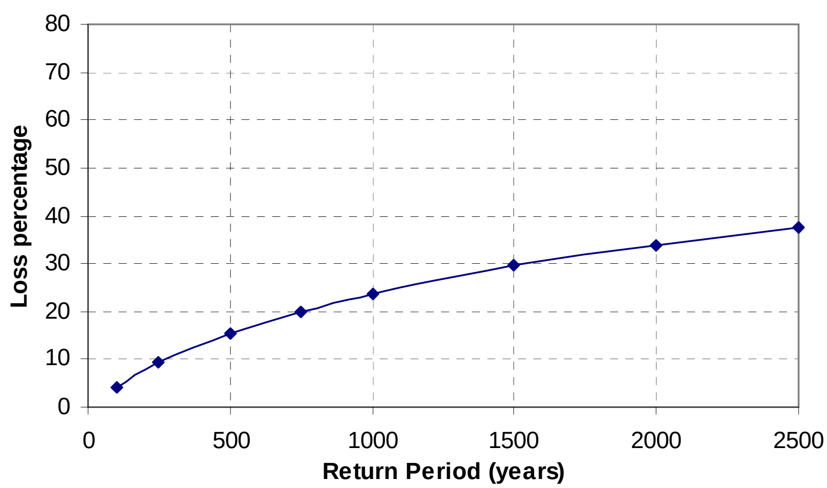
Appendix A. Earthquake Loss Curves for Mayagüez



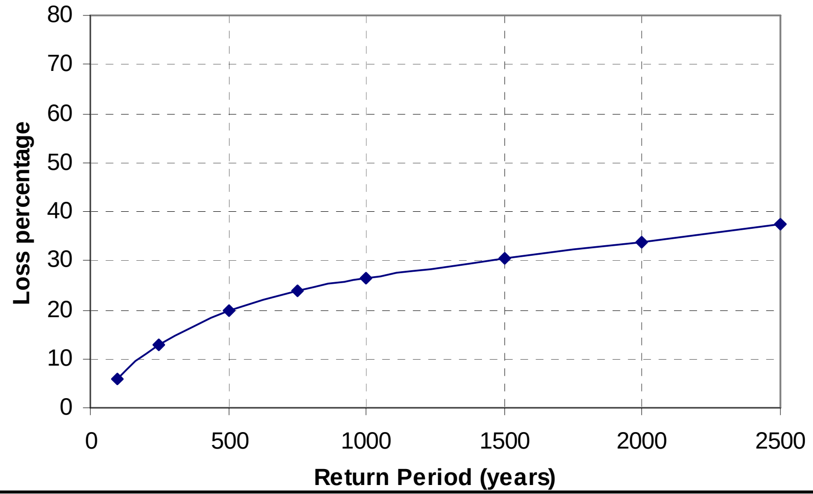
Probable Loss [%]	Name
2.8	PL_{100}
6.4	PL_{250}
10.8	PL_{500}
14.2	PL_{750}
16.9	PL_{1000}
21.5	PL_{1500}
25.0	PL_{2000}
27.9	PL_{2500}
0.082	EAL

Figure A- 1 Concrete Moment Resistant Frame – 1 Story - Soil type A – Mayagüez



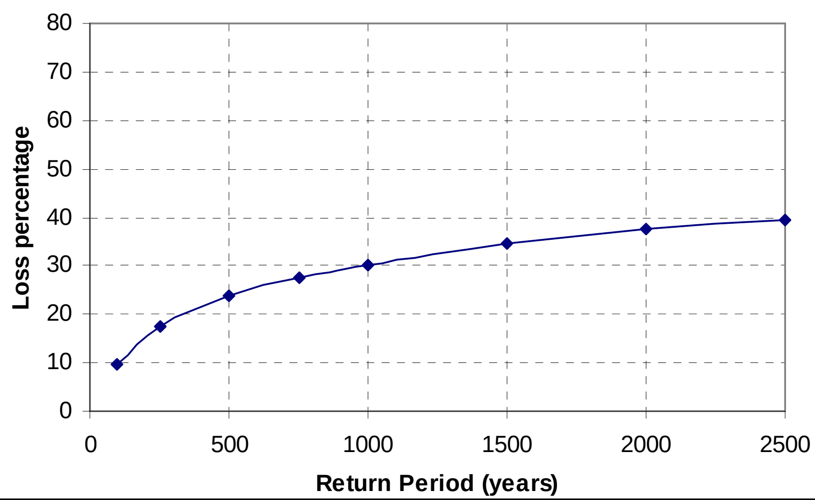
Probable Loss [%]	Name
4.3	PL_{100}
9.4	PL_{250}
15.5	PL_{500}
20.1	PL_{750}
23.7	PL_{1000}
29.6	PL_{1500}
33.9	PL_{2000}
37.5	PL_{2500}
0.118	EAL

Figure A- 2 Concrete Moment Resistant Frame – 1 Story - Soil type B – Mayagüez



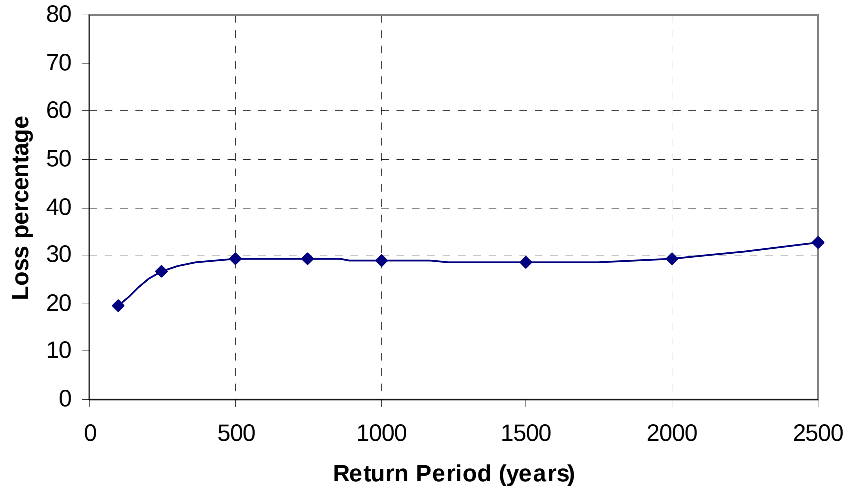
Probable Loss [%]	Name
6.0	PL_{100}
12.8	PL_{250}
19.7	PL_{500}
23.7	PL_{750}
26.6	PL_{1000}
30.6	PL_{1500}
33.9	PL_{2000}
37.5	PL_{2500}
0.145	EAL

Figure A- 3 Concrete Moment Resistant Frame – 1 Story - Soil type C – Mayagüez



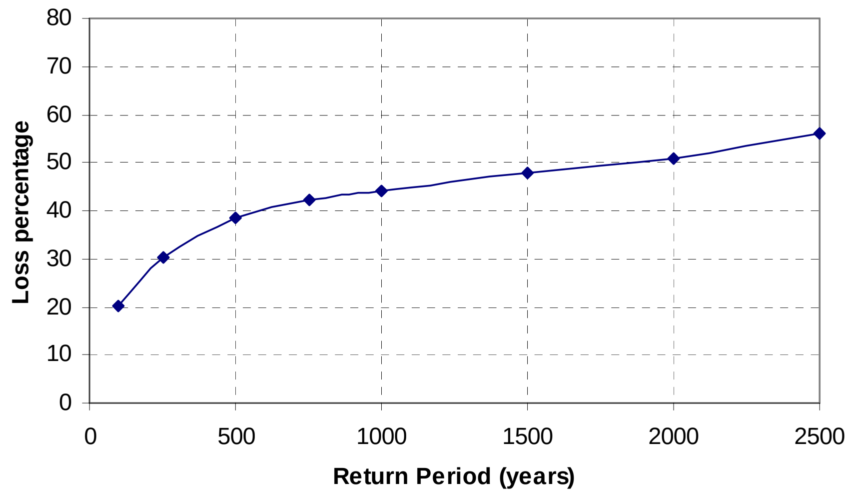
Probable Loss [%]	Name
9.8	PL_{100}
17.5	PL_{250}
23.9	PL_{500}
27.5	PL_{750}
30.1	PL_{1000}
34.7	PL_{1500}
37.5	PL_{2000}
39.6	PL_{2500}
0.186	EAL

Figure A- 4 Concrete Moment Resistant Frame – 1 Story - Soil type D – Mayagüez



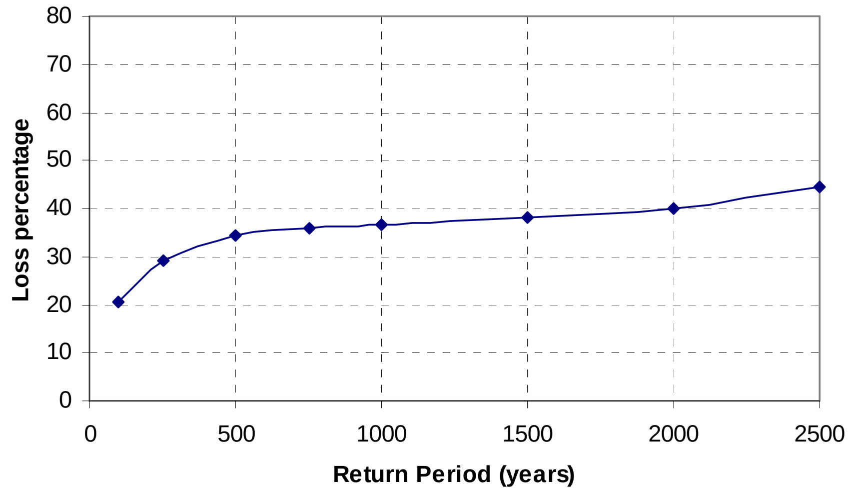
Probable Loss [%]	Name
19.6	PL_{100}
26.7	PL_{250}
29.2	PL_{500}
29.4	PL_{750}
29.0	PL_{1000}
28.7	PL_{1500}
29.5	PL_{2000}
32.8	PL_{2500}
0.255	EAL

Figure A- 5 Concrete Moment Resistant Frame – 1 Story - Soil type E – Mayagüez



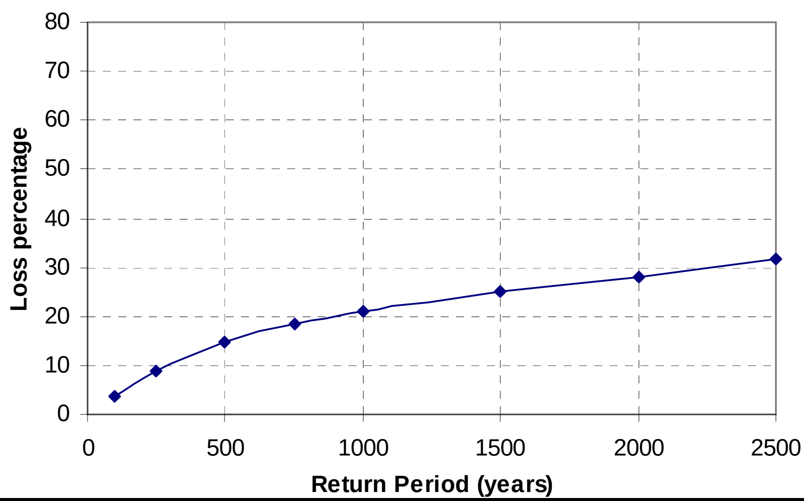
Probable Loss [%]	Name
20.1	PL_{100}
30.2	PL_{250}
38.6	PL_{500}
42.1	PL_{750}
44.2	PL_{1000}
47.7	PL_{1500}
50.7	PL_{2000}
56.2	PL_{2500}
0.312	EAL

Figure A- 6 Concrete Moment Resistant Frame – 1 Story - Soil type F (Shallow Foundation) – Mayagüez



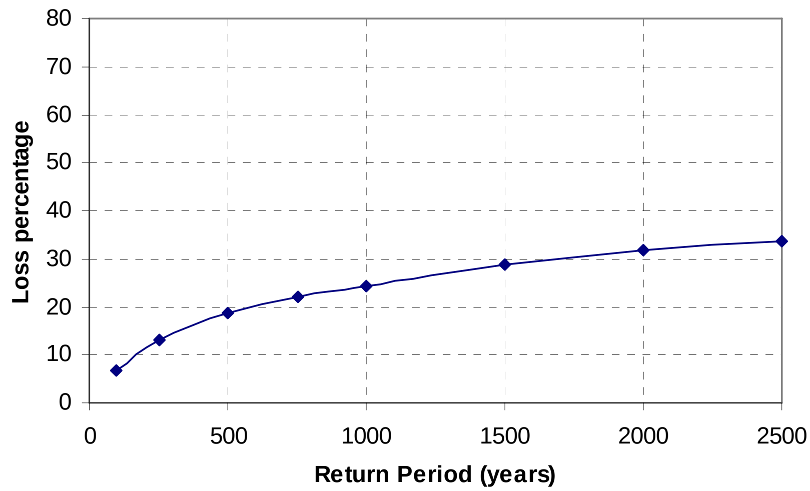
Probable Loss [%]	Name
20.5	PL_{100}
29.3	PL_{250}
34.2	PL_{500}
35.9	PL_{750}
36.6	PL_{1000}
38.2	PL_{1500}
40.1	PL_{2000}
44.5	PL_{2500}
0.290	EAL

Figure A- 7 Concrete Moment Resistant Frame – 1 Story - Soil type F (Deep Foundation) – Mayagüez



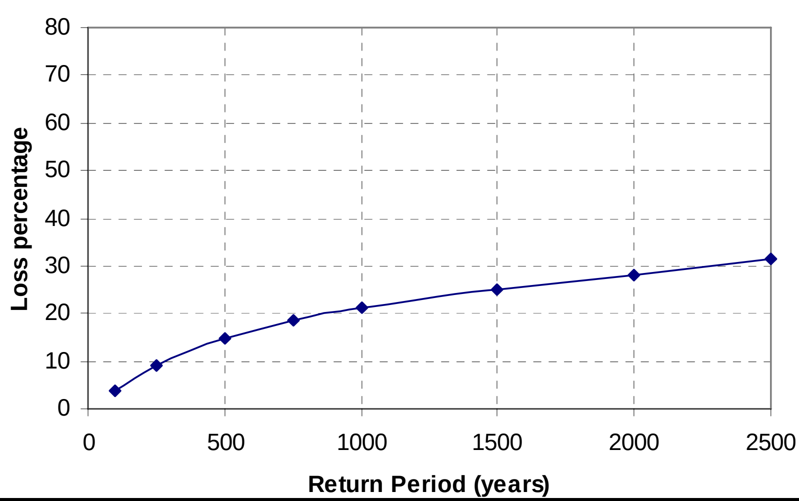
Probable Loss [%]	Name
1.3	PL_{100}
4.1	PL_{250}
7.4	PL_{500}
10.1	PL_{750}
12.4	PL_{1000}
16.5	PL_{1500}
19.6	PL_{2000}
22.4	PL_{2500}
0.056	EAL

Figure A- 8 Concrete Moment Resistant Frame – 2 Stories - Soil type A – Mayagüez



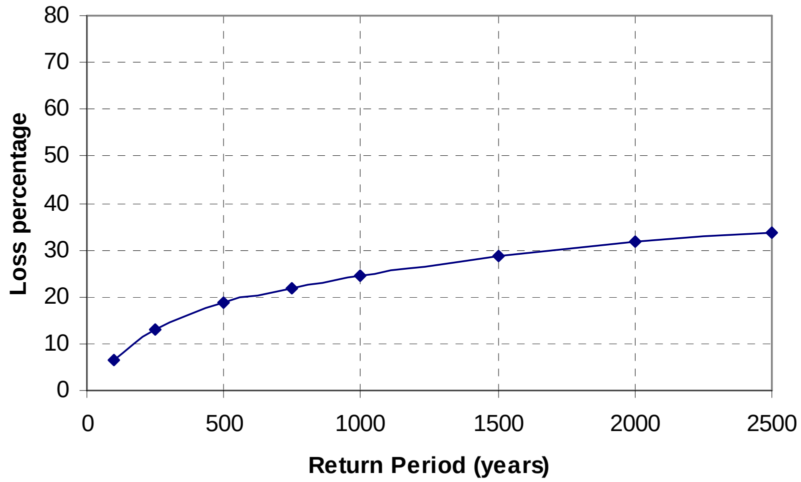
Probable Loss [%]	Name
2.5	PL_{100}
6.4	PL_{250}
11.2	PL_{500}
15.2	PL_{750}
18.4	PL_{1000}
24.0	PL_{1500}
28.1	PL_{2000}
31.6	PL_{2500}
0.086	EAL

Figure A- 9 Concrete Moment Resistant Frame – 2 Stories - Soil type B – Mayagüez



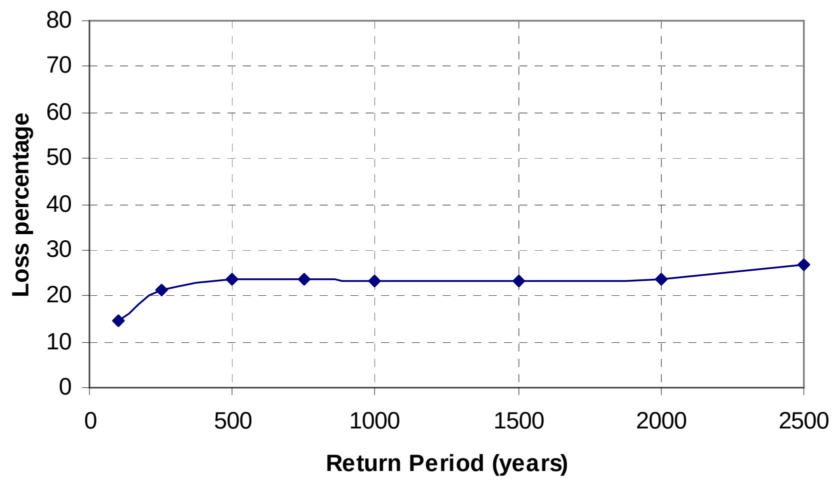
Probable Loss [%]	Name
3.8	PL_{100}
9.0	PL_{250}
14.8	PL_{500}
18.5	PL_{750}
21.1	PL_{1000}
25.0	PL_{1500}
28.1	PL_{2000}
31.6	PL_{2500}
0.108	EAL

Figure A- 10 Concrete Moment Resistant Frame – 2 Stories - Soil type C – Mayagüez



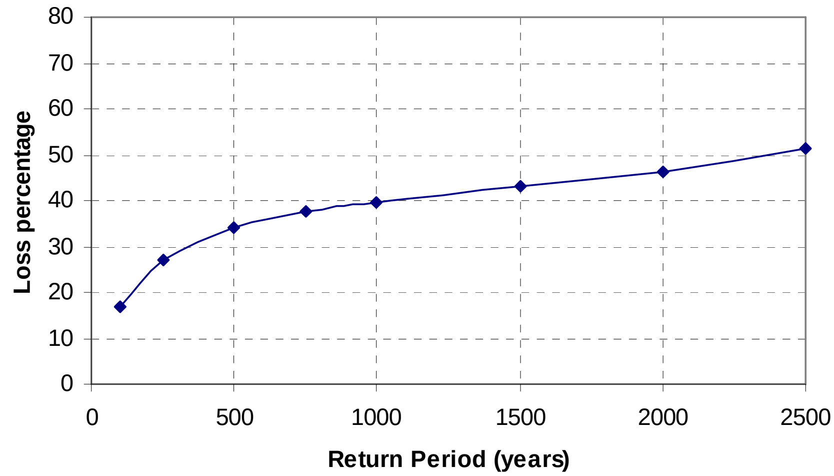
Probable Loss [%]	Name
6.7	PL_{100}
12.9	PL_{250}
18.7	PL_{500}
22.0	PL_{750}
24.4	PL_{1000}
28.8	PL_{1500}
31.6	PL_{2000}
33.7	PL_{2500}
0.142	EAL

Figure A- 11 Concrete Moment Resistant Frame – 2 Stories - Soil type D – Mayagüez



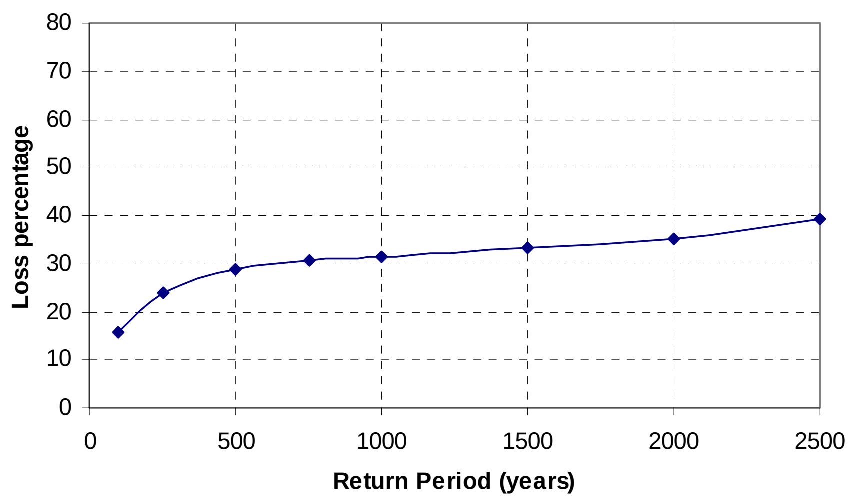
Probable Loss [%]	Name
14.8	PL_{100}
21.2	PL_{250}
23.6	PL_{500}
23.8	PL_{750}
23.4	PL_{1000}
23.1	PL_{1500}
23.8	PL_{2000}
27.0	PL_{2500}
0.201	EAL

Figure A- 12 Concrete Moment Resistant Frame – 2 Stories - Soil type E – Mayagüez



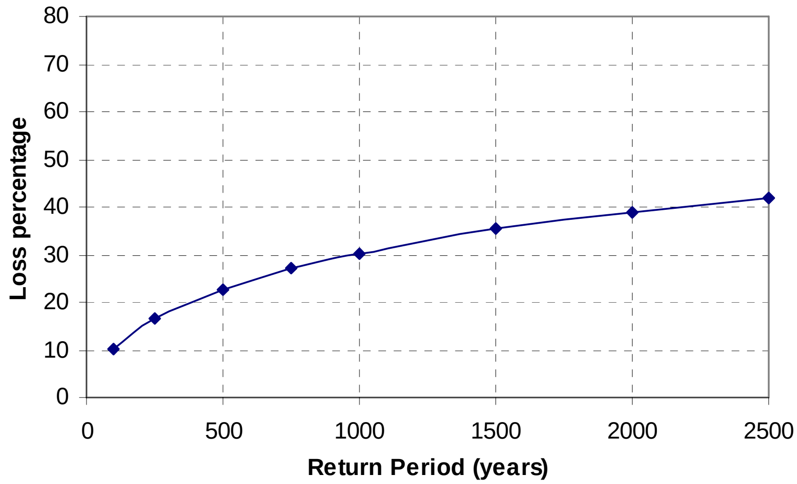
Probable Loss [%]	Name
16.7	PL_{100}
26.9	PL_{250}
34.3	PL_{500}
37.5	PL_{750}
39.6	PL_{1000}
43.3	PL_{1500}
46.4	PL_{2000}
51.4	PL_{2500}
0.276	EAL

Figure A- 13 Concrete Moment Resistant Frame – 2 Story - Soil type F (Shallow Foundation) – Mayagüez



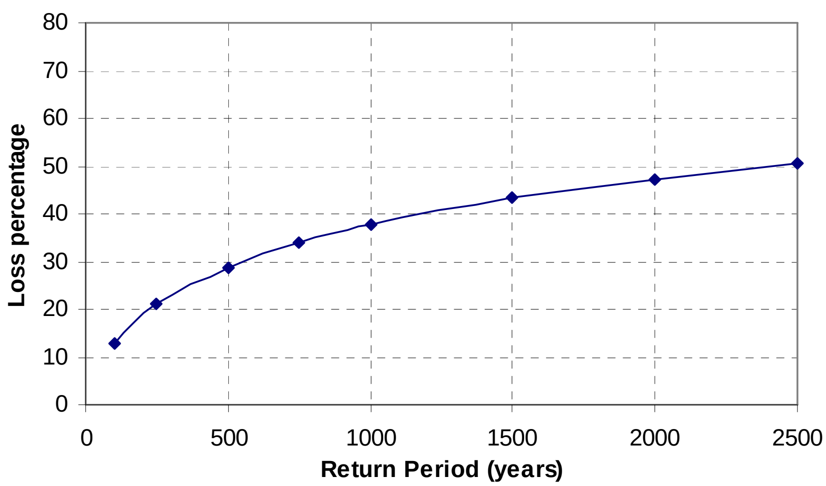
Probable Loss [%]	Name
15.8	PL_{100}
24.1	PL_{250}
28.9	PL_{500}
30.6	PL_{750}
31.5	PL_{1000}
33.2	PL_{1500}
35.1	PL_{2000}
39.2	PL_{2500}
0.239	EAL

Figure A- 14 Concrete Moment Resistant Frame – 2 Story - Soil type F (Deep Foundation) – Mayagüez



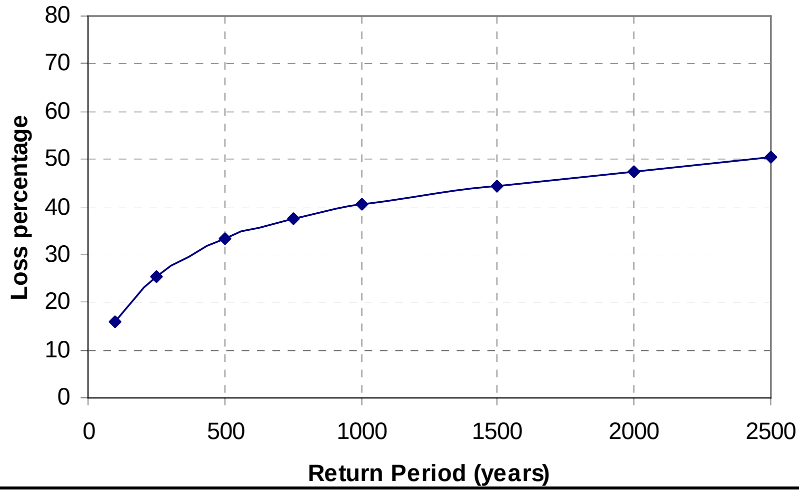
Probable Loss [%]	Name
10.1	PL_{100}
16.5	PL_{250}
22.8	PL_{500}
27.1	PL_{750}
30.4	PL_{1000}
35.4	PL_{1500}
38.9	PL_{2000}
41.8	PL_{2500}
0.183	EAL

Figure A- 15 Concrete Shear Wall – 1 Stories - Soil type A – Mayagüez



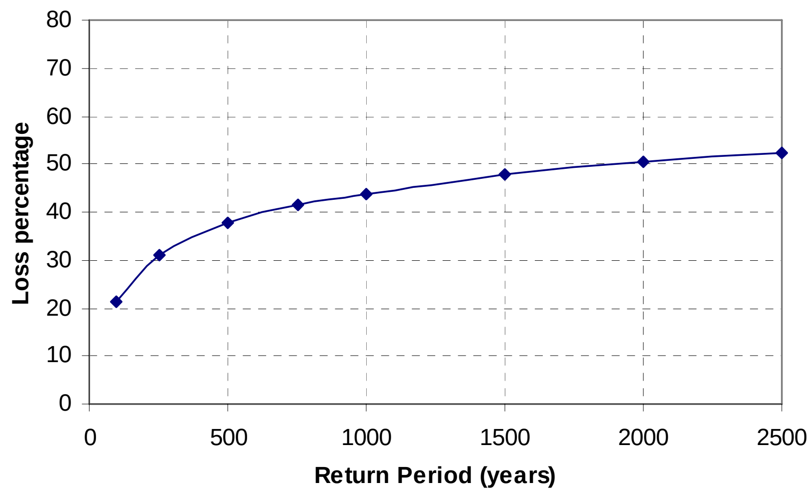
Probable Loss [%]	Name
13.0	PL_{100}
21.0	PL_{250}
28.7	PL_{500}
33.8	PL_{750}
37.6	PL_{1000}
43.4	PL_{1500}
47.3	PL_{2000}
50.5	PL_{2500}
0.231	EAL

Figure A- 16 Concrete Shear Wall – 1 Story - Soil type B – Mayagüez



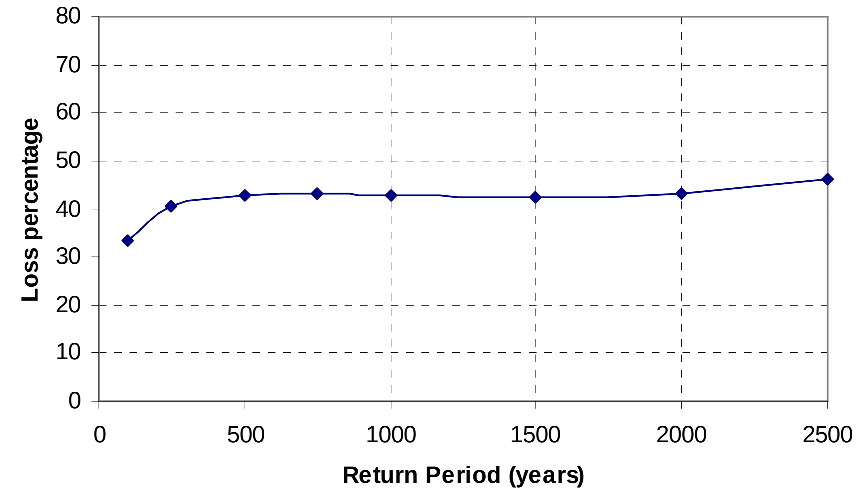
Probable Loss [%]	Name
15.9	PL_{100}
25.4	PL_{250}
33.4	PL_{500}
37.7	PL_{750}
40.5	PL_{1000}
44.4	PL_{1500}
47.3	PL_{2000}
50.5	PL_{2500}
0.266	EAL

Figure A- 17 Concrete Shear Wall – 1 Stories - Soil type C – Mayagüez



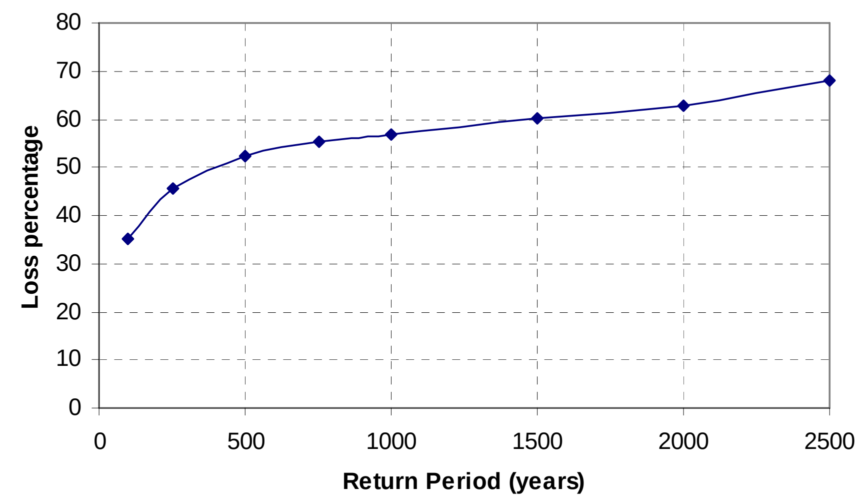
Probable Loss [%]	Name
21.5	PL_{100}
31.0	PL_{250}
37.9	PL_{500}
41.4	PL_{750}
43.8	PL_{1000}
48.0	PL_{1500}
50.4	PL_{2000}
52.2	PL_{2500}
0.316	EAL

Figure A- 18 Concrete Shear Wall – 1 Stories - Soil type D – Mayagüez



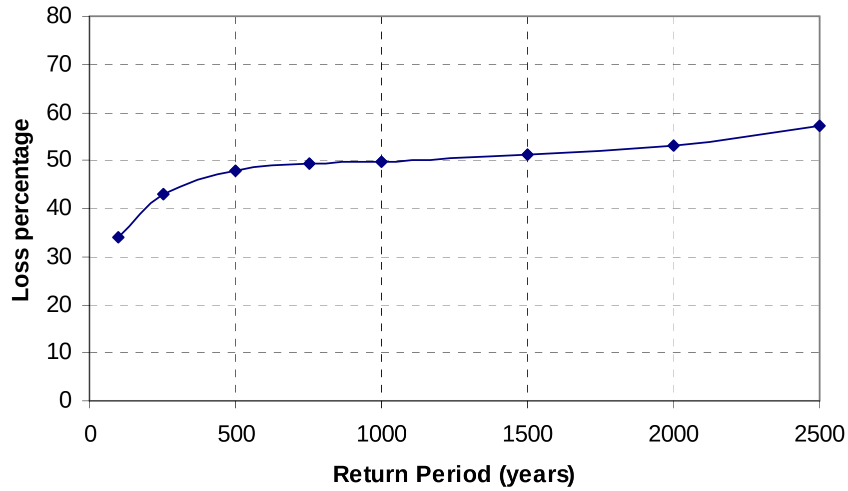
Probable Loss [%]	Name
33.4	PL_{100}
40.6	PL_{250}
43.0	PL_{500}
43.2	PL_{750}
42.8	PL_{1000}
42.5	PL_{1500}
43.3	PL_{2000}
46.3	PL_{2500}
0.393	EAL

Figure A- 19 Concrete Shear Wall – 1 Stories - Soil type E – Mayagüez



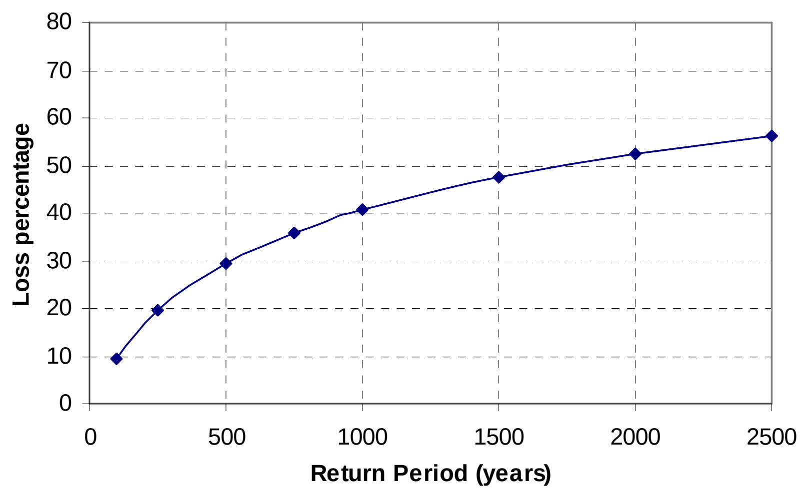
Probable Loss [%]	Name
35.0	PL_{100}
45.5	PL_{250}
52.4	PL_{500}
55.2	PL_{750}
57.0	PL_{1000}
60.1	PL_{1500}
63.0	PL_{2000}
68.2	PL_{2500}
0.457	EAL

Figure A- 20 Concrete Shear Wall – 1 Story - Soil type F (Shallow Foundation) – Mayagüez



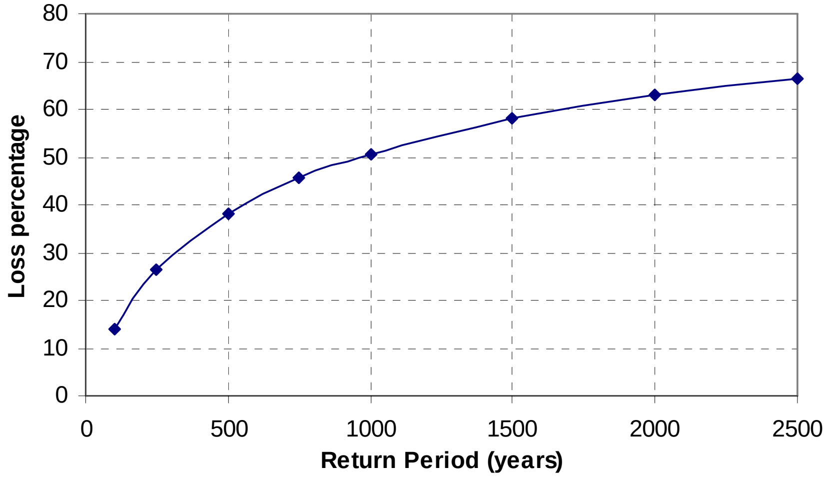
Probable Loss [%]	Name
34.2	PL_{100}
43.0	PL_{250}
47.7	PL_{500}
49.2	PL_{750}
49.9	PL_{1000}
51.3	PL_{1500}
53.1	PL_{2000}
57.2	PL_{2500}
0.425	EAL

Figure A- 21 Concrete Shear Wall – 1 Story - Soil type F (Deep Foundation) – Mayagüez



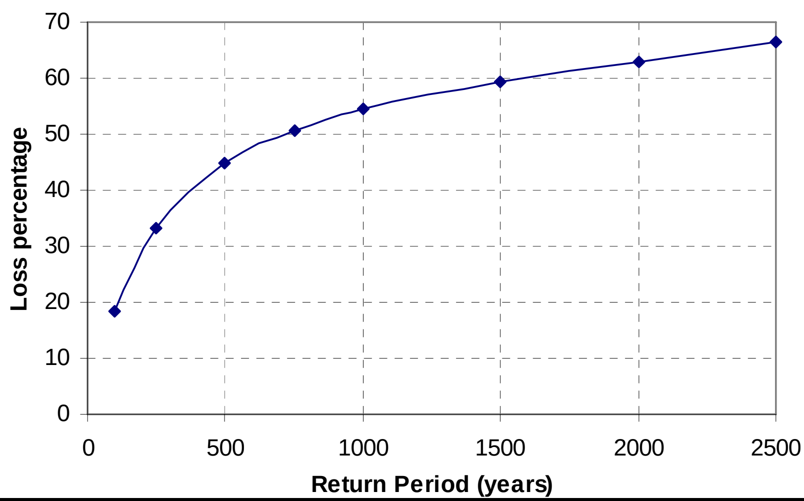
Probable Loss [%]	Name
9.4	PL_{100}
19.5	PL_{250}
29.3	PL_{500}
35.9	PL_{750}
40.6	PL_{1000}
47.7	PL_{1500}
52.4	PL_{2000}
56.1	PL_{2500}
0.221	EAL

Figure A- 22 Concrete Shear Wall – 2 Stories - Soil type A – Mayagüez



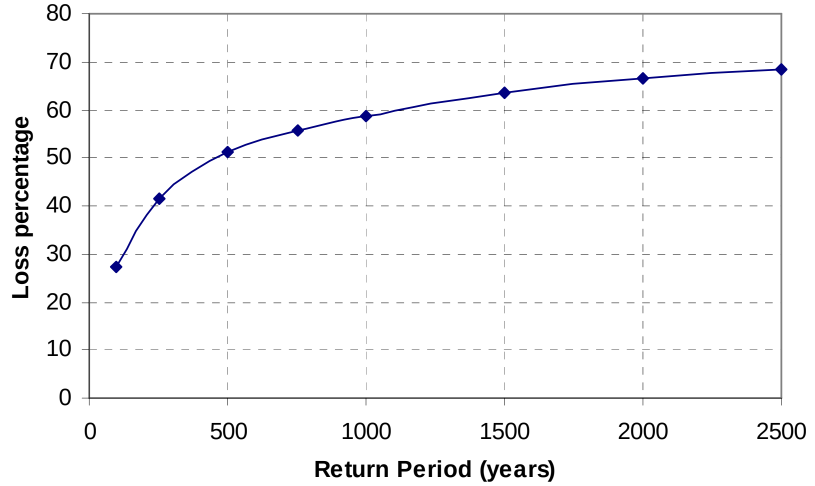
Probable Loss [%]	Name
13.8	PL_{100}
26.5	PL_{250}
38.2	PL_{500}
45.6	PL_{750}
50.7	PL_{1000}
58.1	PL_{1500}
62.9	PL_{2000}
66.5	PL_{2500}
0.291	EAL

Figure A- 23 Concrete Shear Wall – 2 Story - Soil type B – Mayagüez



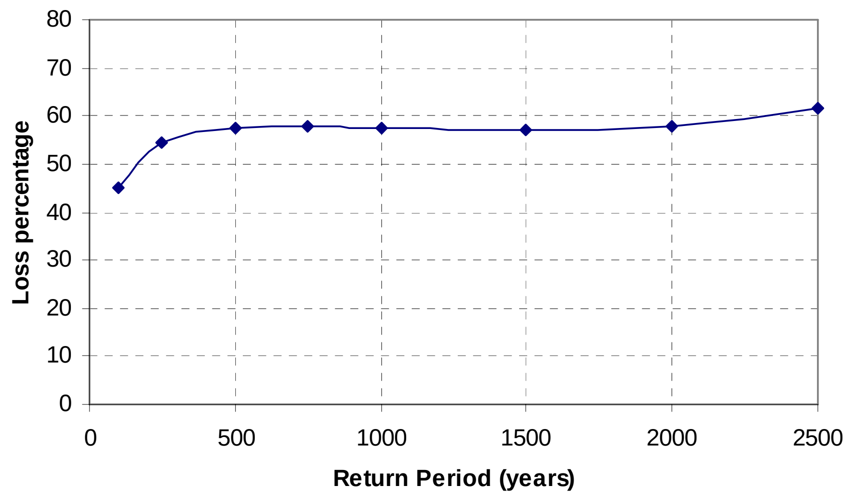
Probable Loss [%]	Name
18.4	PL_{100}
33.3	PL_{250}
44.9	PL_{500}
50.8	PL_{750}
54.5	PL_{1000}
59.3	PL_{1500}
62.9	PL_{2000}
66.5	PL_{2500}
0.345	EAL

Figure A- 24 Concrete Shear Wall – 2 Stories - Soil type C – Mayagüez



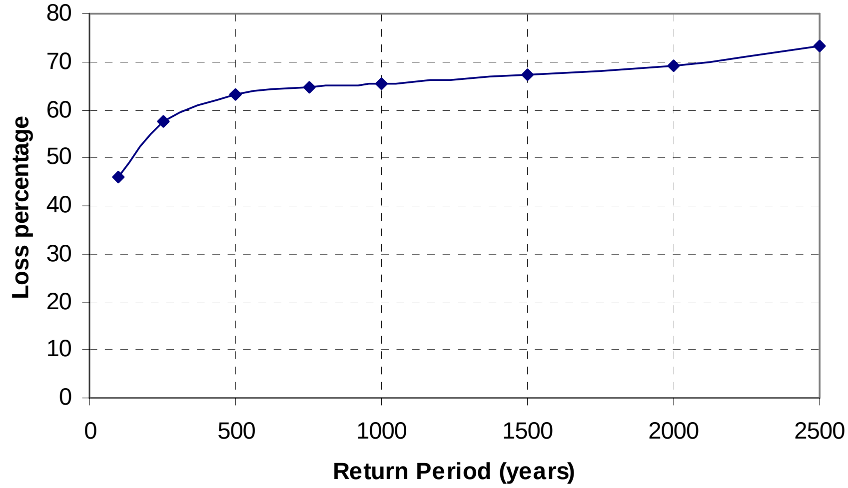
Probable Loss [%]	Name
27.2	PL_{100}
41.5	PL_{250}
51.1	PL_{500}
55.6	PL_{750}
58.7	PL_{1000}
63.7	PL_{1500}
66.5	PL_{2000}
68.5	PL_{2500}
0.419	EAL

Figure A- 25 Concrete Shear Wall – 2 Stories - Soil type D – Mayagüez



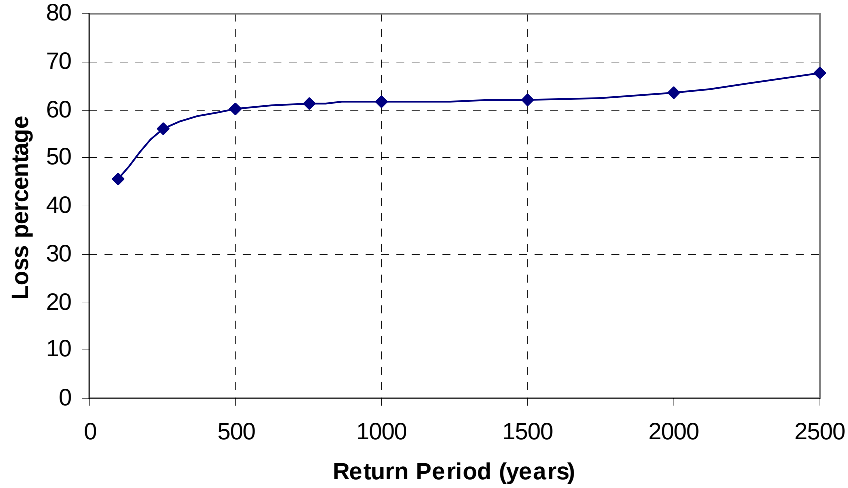
Probable Loss [%]	Name
44.9	PL_{100}
54.6	PL_{250}
57.6	PL_{500}
57.9	PL_{750}
57.4	PL_{1000}
57.1	PL_{1500}
58.0	PL_{2000}
61.7	PL_{2500}
0.528	EAL

Figure A- 26 Concrete Shear Wall – 2 Stories - Soil type E – Mayagüez



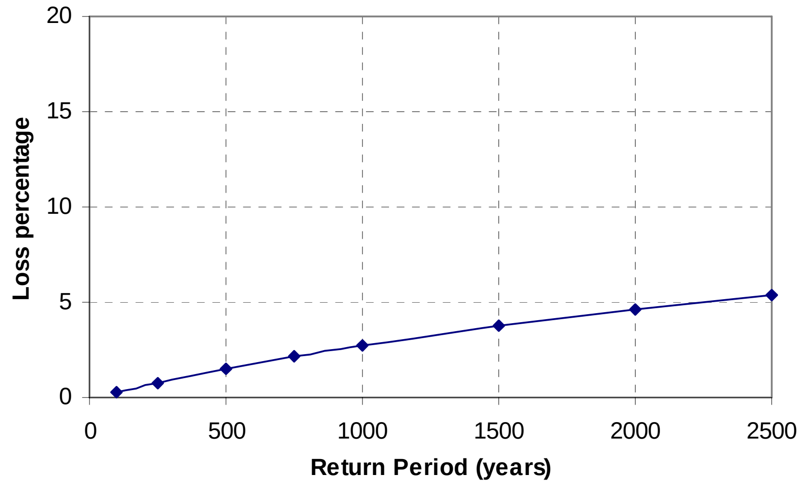
Probable Loss [%]	Name
46.0	PL_{100}
57.6	PL_{250}
63.0	PL_{500}
64.7	PL_{750}
65.6	PL_{1000}
67.2	PL_{1500}
69.2	PL_{2000}
73.4	PL_{2500}
0.566	EAL

Figure A- 27 Concrete Shear Wall – 2 Stories - Soil type F (Shallow Foundation) – Mayagüez



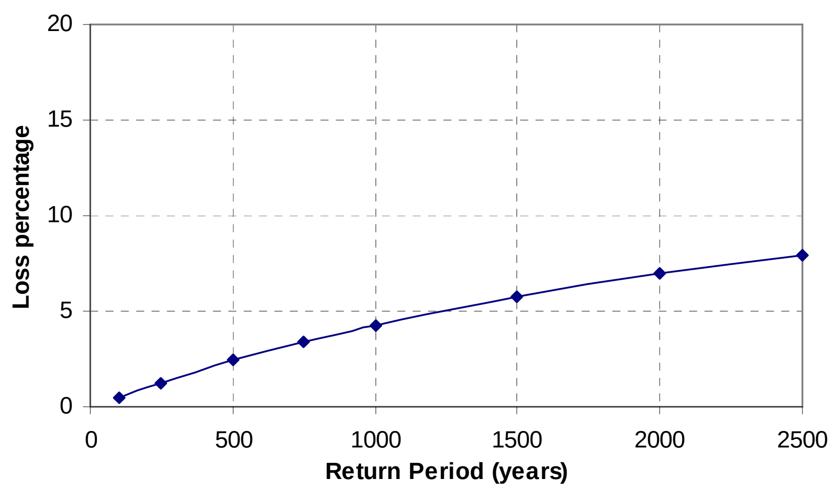
Probable Loss [%]	Name
45.5	PL_{100}
56.1	PL_{250}
60.3	PL_{500}
61.3	PL_{750}
61.5	PL_{1000}
62.2	PL_{1500}
63.6	PL_{2000}
67.5	PL_{2500}
0.547	EAL

Figure A- 28 Concrete Shear Wall – 2 Stories - Soil type F (Deep Foundation) – Mayagüez



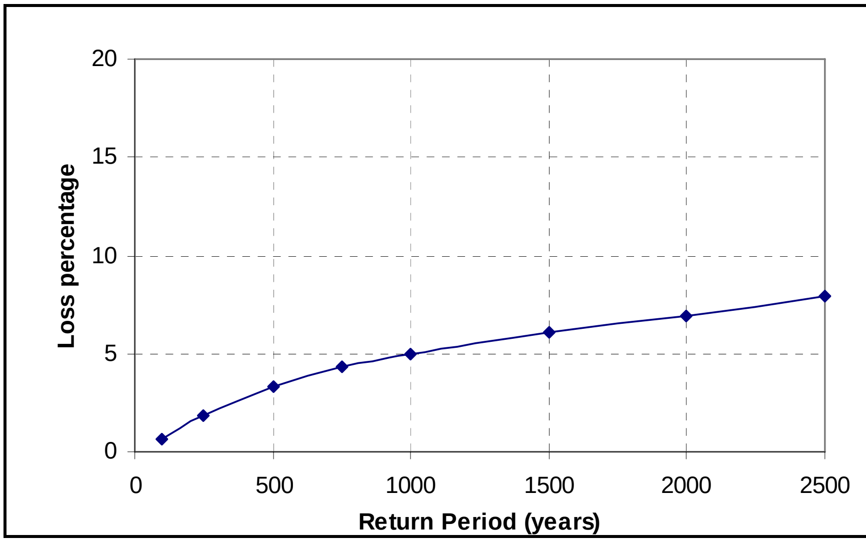
Probable Loss [%]	Name
0.2	PL_{100}
0.8	PL_{250}
1.5	PL_{500}
2.2	PL_{750}
2.7	PL_{1000}
3.8	PL_{1500}
4.6	PL_{2000}
5.3	PL_{2500}
0.012	EAL

Figure A- 29 Concrete - Multistory - Soil type A – Mayagüez



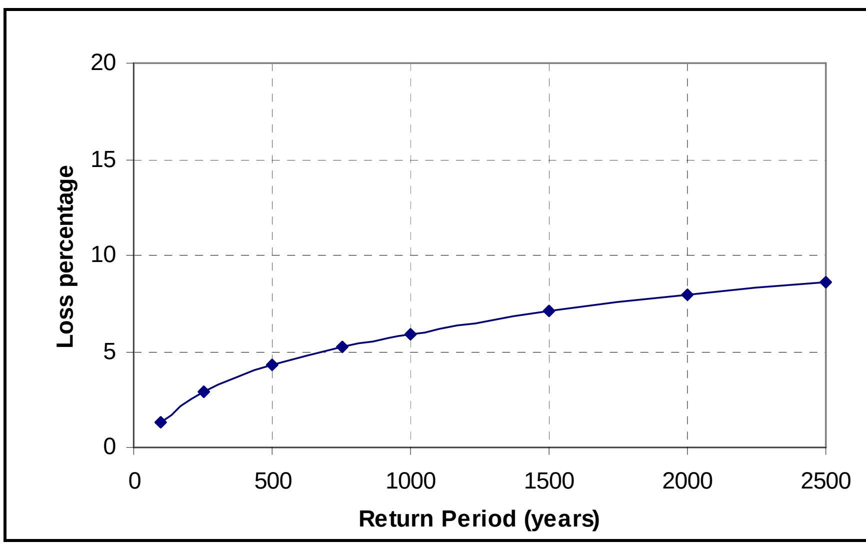
Probable Loss [%]	Name
0.4	PL_{100}
1.3	PL_{250}
2.4	PL_{500}
3.4	PL_{750}
4.3	PL_{1000}
5.8	PL_{1500}
6.9	PL_{2000}
8.0	PL_{2500}
0.019	EAL

Figure A- 30 Concrete - Multistory - Soil type B – Mayagüez



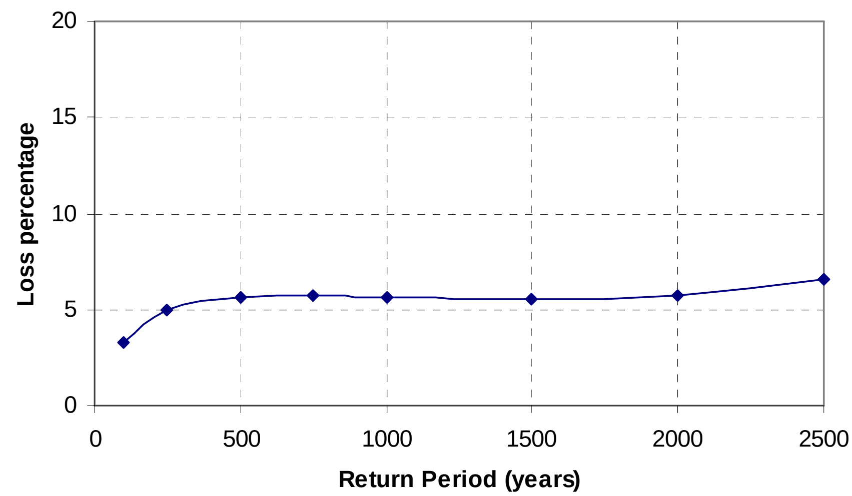
Probable Loss [%]	Name
0.7	PL_{100}
1.9	PL_{250}
3.3	PL_{500}
4.3	PL_{750}
5.0	PL_{1000}
6.0	PL_{1500}
6.9	PL_{2000}
8.0	PL_{2500}
0.024	EAL

Figure A- 31 Concrete - Multistory - Soil type C – Mayagüez



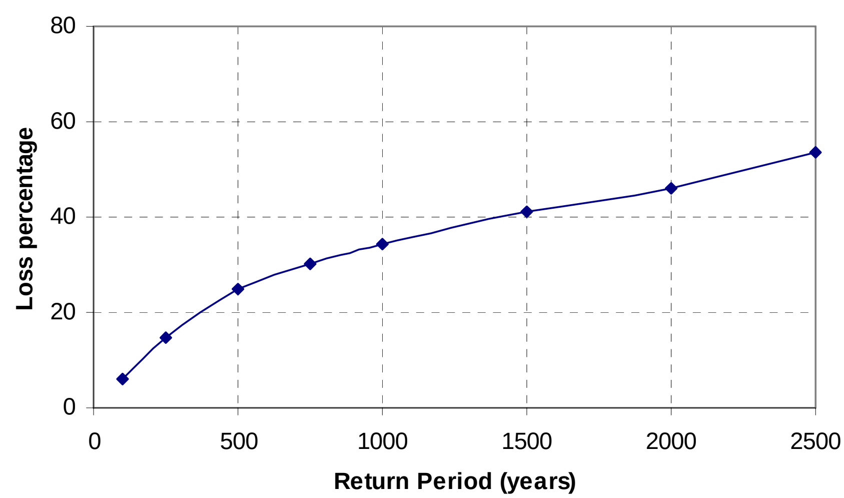
Probable Loss [%]	Name
1.3	PL_{100}
2.9	PL_{250}
4.3	PL_{500}
5.2	PL_{750}
5.9	PL_{1000}
7.1	PL_{1500}
7.9	PL_{2000}
8.6	PL_{2500}
0.032	EAL

Figure A- 32 Concrete - Multistory - Soil type D – Mayagüez



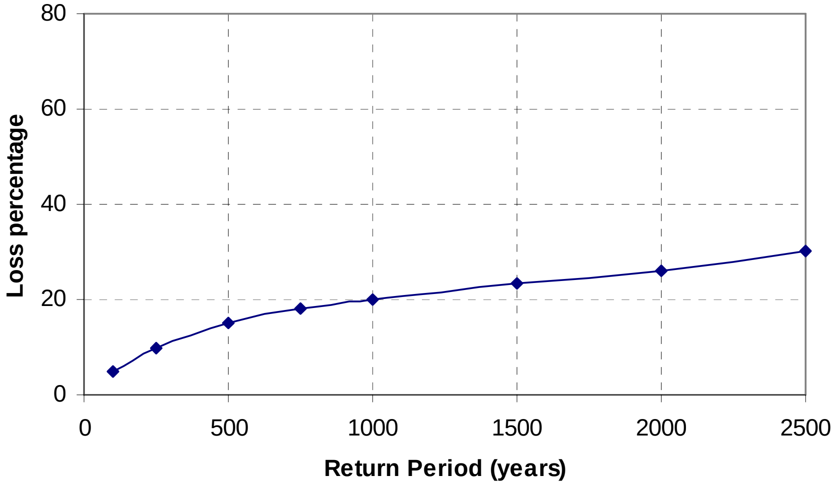
Probable Loss [%]	Name
3.3	PL_{100}
5.0	PL_{250}
5.7	PL_{500}
5.7	PL_{750}
5.6	PL_{1000}
5.5	PL_{1500}
5.7	PL_{2000}
6.6	PL_{2500}
0.047	EAL

Figure A- 33 Concrete - Multistory - Soil type E – Mayagüez



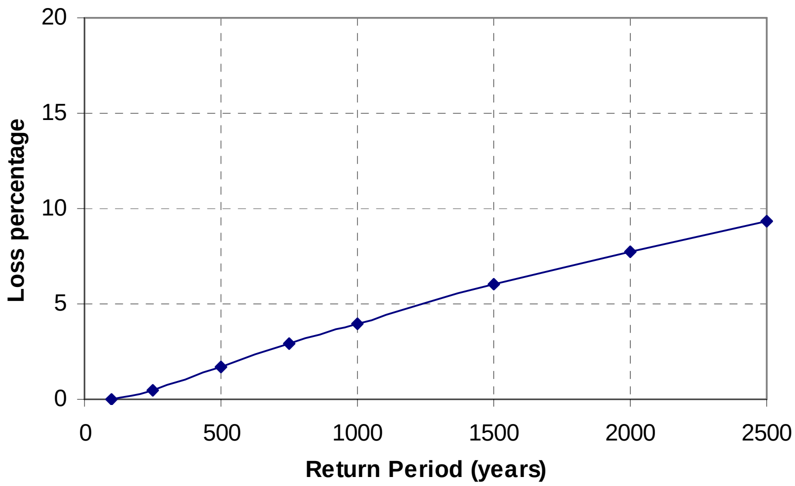
Probable Loss [%]	Name
6.2	PL_{100}
14.6	PL_{250}
24.7	PL_{500}
30.2	PL_{750}
34.3	PL_{1000}
41.0	PL_{1500}
46.0	PL_{2000}
53.6	PL_{2500}
0.177	EAL

Figure A- 34 Concrete - Multistory - Soil type F (Shallow foundation) – Mayagüez



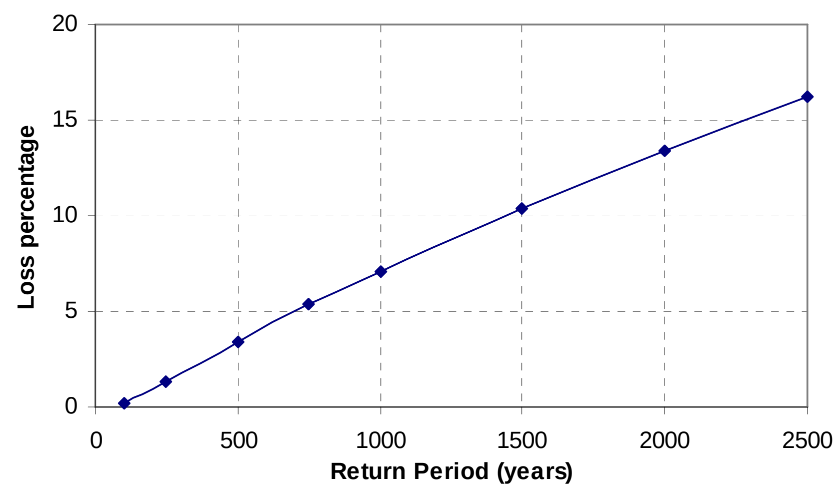
Probable Loss [%]	Name
4.8	PL_{100}
9.8	PL_{250}
15.2	PL_{500}
18.0	PL_{750}
20.0	PL_{1000}
23.2	PL_{1500}
25.9	PL_{2000}
30.1	PL_{2500}
0.112	EAL

Figure A- 35 Concrete - Multistory - Soil type F (Deep foundation) – Mayagüez



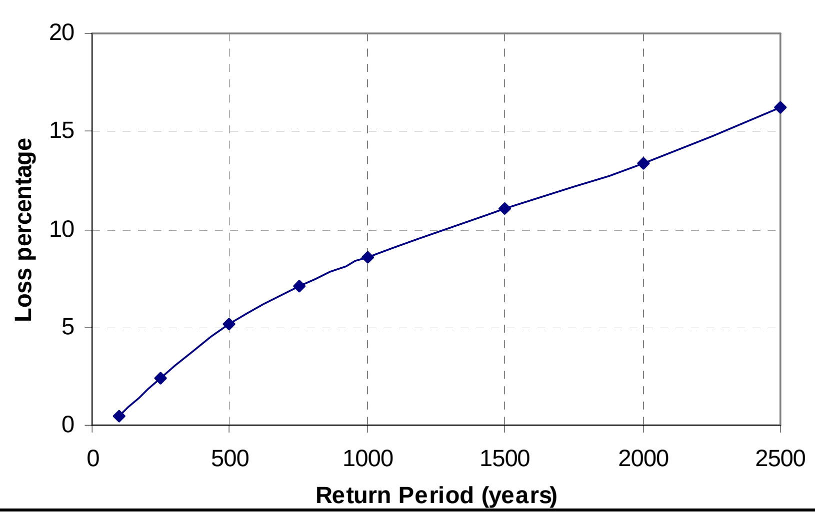
Probable Loss [%]	Name
0.0	PL_{100}
0.5	PL_{250}
1.7	PL_{500}
2.9	PL_{750}
4.0	PL_{1000}
6.0	PL_{1500}
7.7	PL_{2000}
9.4	PL_{2500}
0.014	EAL

Figure A- 36 Steel – Low Rise - Soil type A – Mayagüez



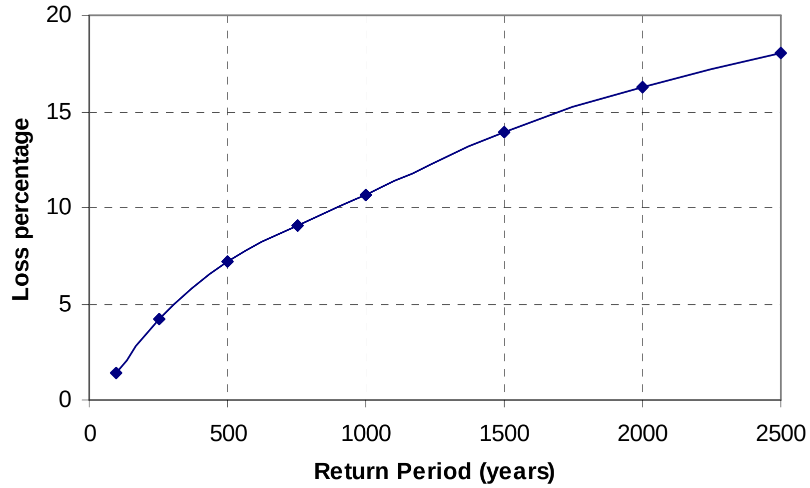
Probable Loss [%]	Name
0.2	PL_{100}
1.3	PL_{250}
3.4	PL_{500}
5.3	PL_{750}
7.0	PL_{1000}
10.4	PL_{1500}
13.4	PL_{2000}
16.2	PL_{2500}
0.027	EAL

Figure A- 37 Steel – Low Rise - Soil type B – Mayagüez



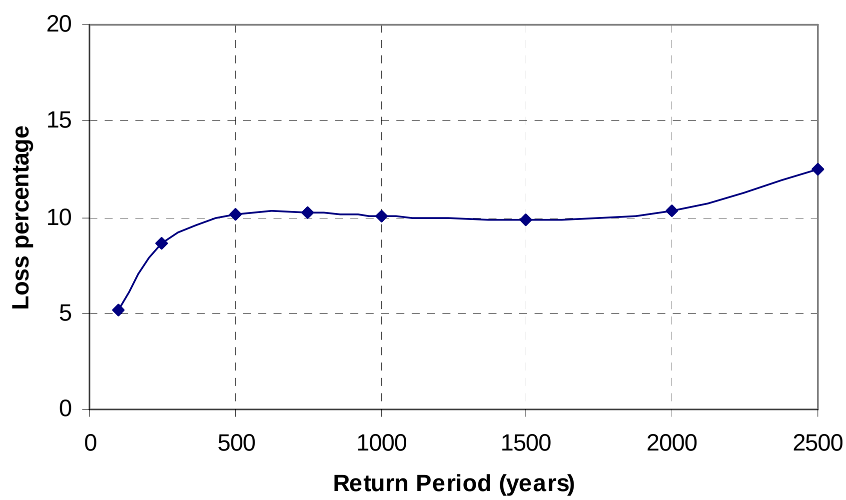
Probable Loss [%]	Name
0.4	PL_{100}
2.4	PL_{250}
5.2	PL_{500}
7.1	PL_{750}
8.6	PL_{1000}
11.1	PL_{1500}
13.4	PL_{2000}
16.2	PL_{2500}
0.036	EAL

Figure A- 38 Steel – Low Rise - Soil type C – Mayagüez



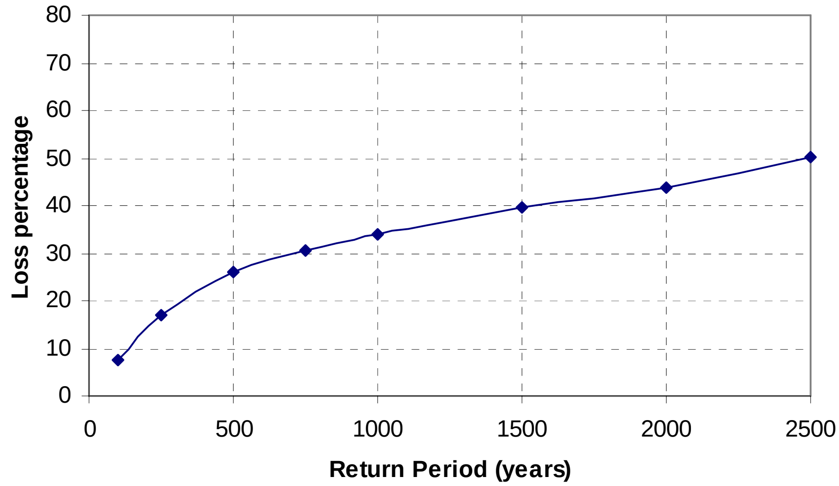
Probable Loss [%]	Name
1.4	PL_{100}
4.2	PL_{250}
7.2	PL_{500}
9.1	PL_{750}
10.7	PL_{1000}
13.9	PL_{1500}
16.2	PL_{2000}
18.0	PL_{2500}
0.053	EAL

Figure A- 39 Steel – Low Rise - Soil type D – Mayagüez



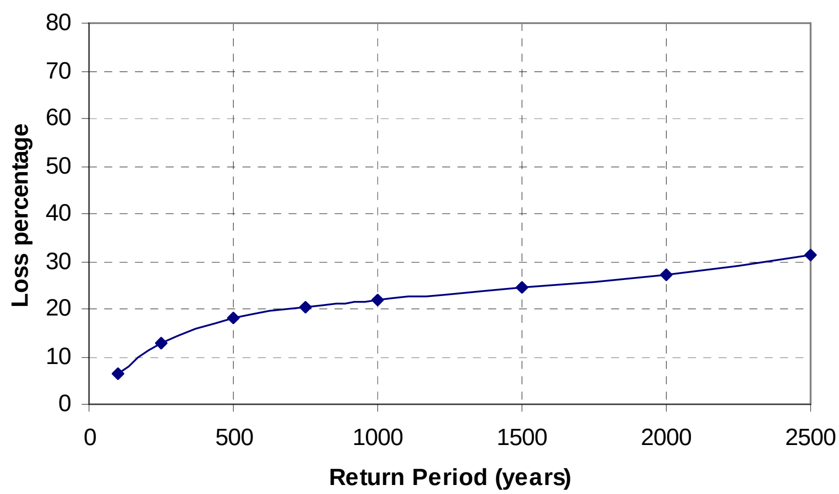
Probable Loss [%]	Name
5.1	PL_{100}
8.6	PL_{250}
10.1	PL_{500}
10.3	PL_{750}
10.0	PL_{1000}
9.8	PL_{1500}
10.3	PL_{2000}
12.5	PL_{2500}
0.081	EAL

Figure A- 40 Steel – Low Rise - Soil type E – Mayagüez



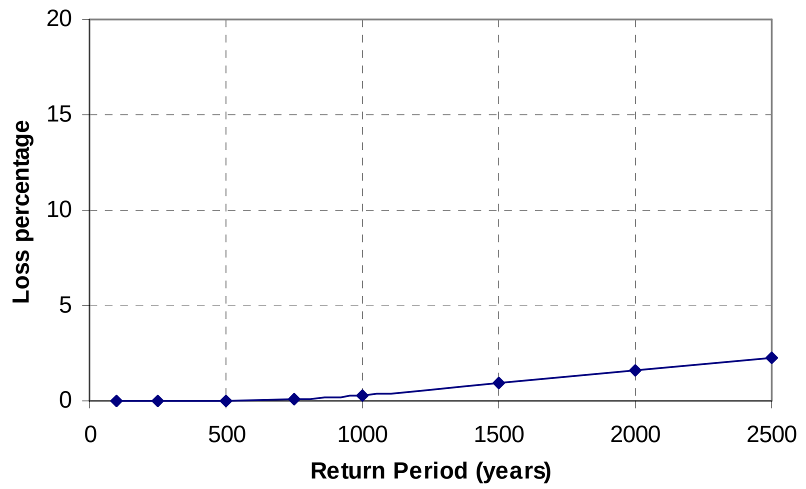
Probable Loss [%]	Name
7.7	PL_{100}
16.8	PL_{250}
26.1	PL_{500}
30.7	PL_{750}
34.0	PL_{1000}
39.5	PL_{1500}
43.8	PL_{2000}
50.3	PL_{2500}
0.190	EAL

Figure A- 41 Steel – Low Rise - Soil type F (Shallow foundation) – Mayagüez



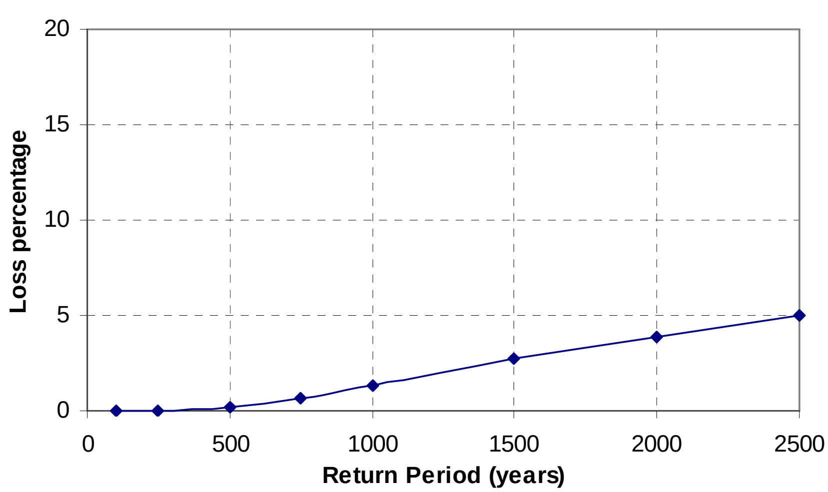
Probable Loss [%]	Name
6.4	PL_{100}
12.7	PL_{250}
18.1	PL_{500}
20.5	PL_{750}
22.0	PL_{1000}
24.7	PL_{1500}
27.1	PL_{2000}
31.4	PL_{2500}
0.136	EAL

Figure A- 42 Steel – Low Rise - Soil type F (Deep foundation) – Mayagüez



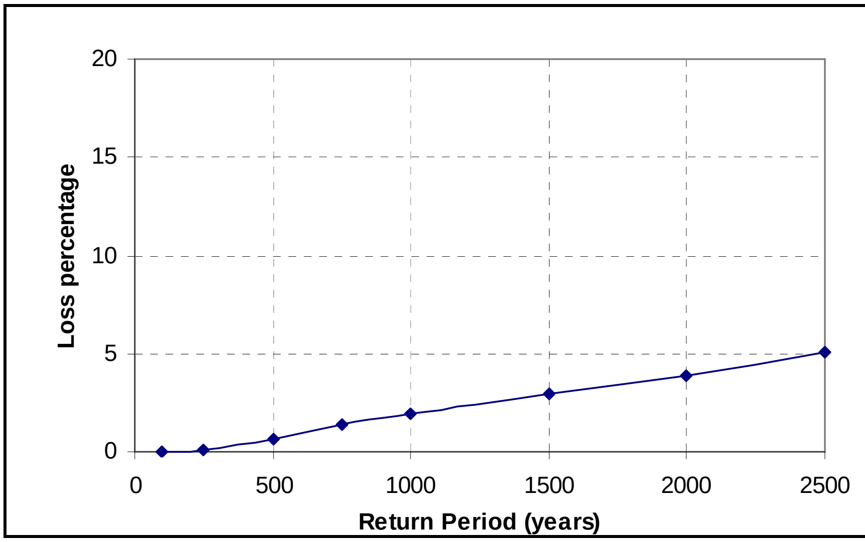
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.1	PL_{750}
0.3	PL_{1000}
0.9	PL_{1500}
1.6	PL_{2000}
2.3	PL_{2500}
0.002	EAL

Figure A- 43 Steel – Mid Rise - Soil type A – Mayagüez



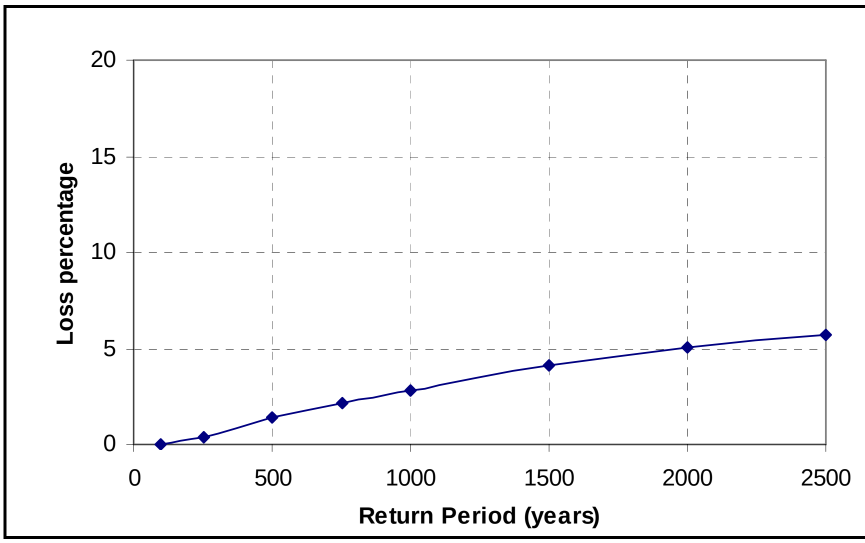
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.2	PL_{500}
0.7	PL_{750}
1.3	PL_{1000}
2.7	PL_{1500}
3.9	PL_{2000}
5.0	PL_{2500}
0.005	EAL

Figure A- 44 Steel – Mid Rise - Soil type B – Mayagüez



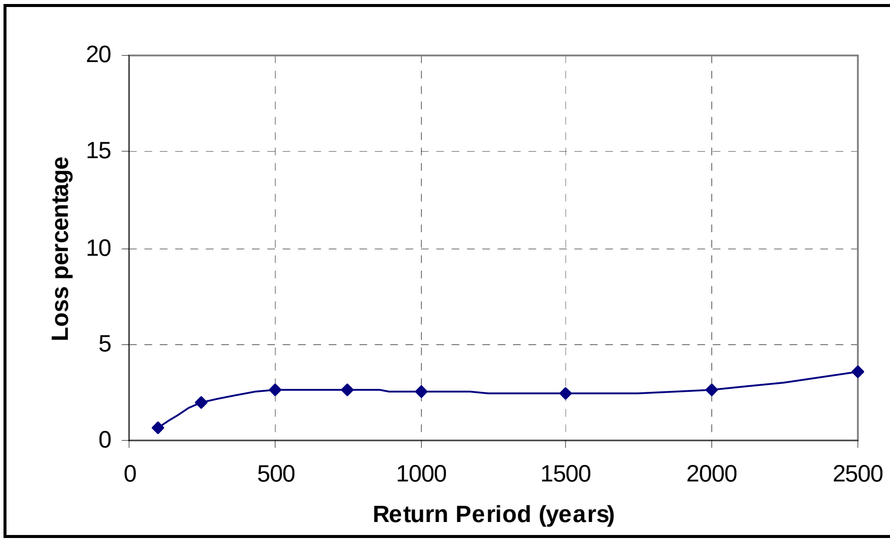
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.6	PL_{500}
1.3	PL_{750}
2.0	PL_{1000}
3.0	PL_{1500}
3.9	PL_{2000}
5.0	PL_{2500}
0.006	EAL

Figure A- 45 Steel – Mid Rise - Soil type C – Mayagüez



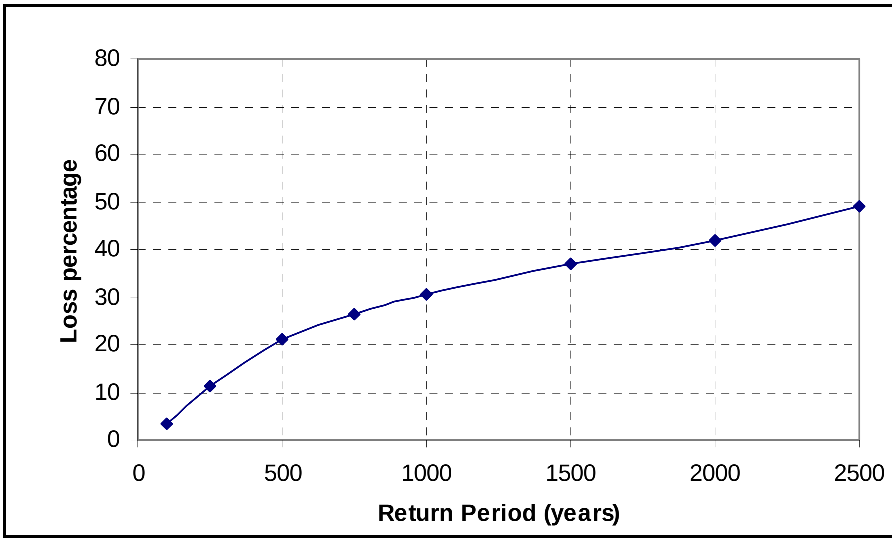
Probable Loss [%]	Name
0.0	PL_{100}
0.4	PL_{250}
1.4	PL_{500}
2.2	PL_{750}
2.8	PL_{1000}
4.1	PL_{1500}
5.0	PL_{2000}
5.7	PL_{2500}
0.010	EAL

Figure A- 46 Steel – Mid Rise - Soil type D – Mayagüez



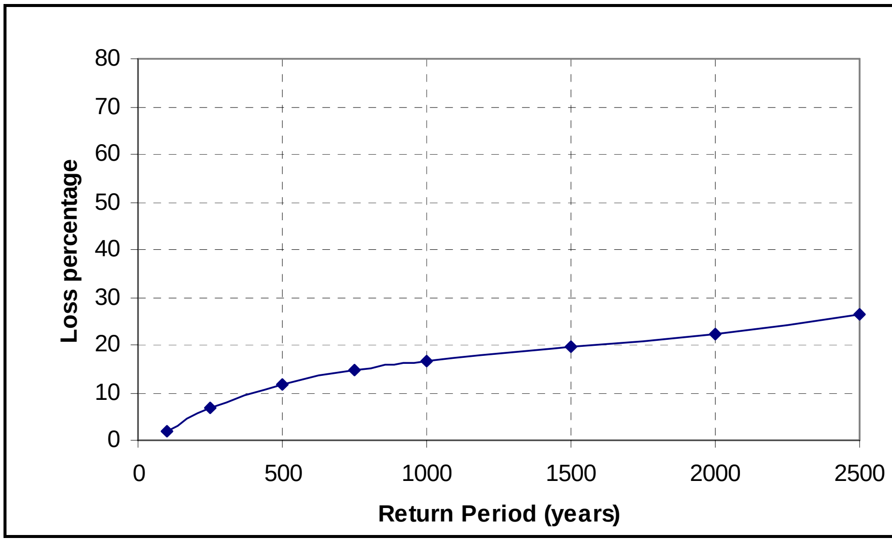
Probable Loss [%]	Name
0.6	PL_{100}
2.0	PL_{250}
2.6	PL_{500}
2.7	PL_{750}
2.6	PL_{1000}
2.5	PL_{1500}
2.7	PL_{2000}
3.6	PL_{2500}
0.018	EAL

Figure A- 47 Steel – Mid Rise - Soil type E – Mayagüez



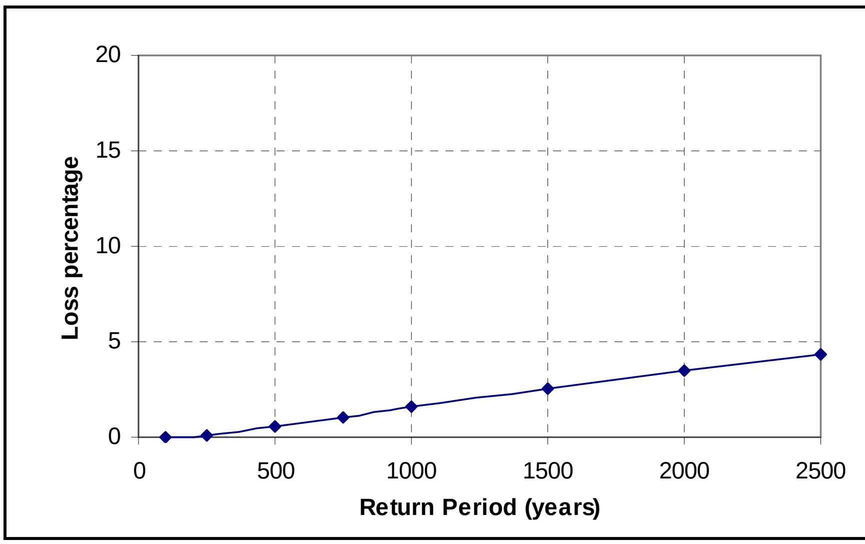
Probable Loss [%]	Name
3.4	PL_{100}
11.3	PL_{250}
21.1	PL_{500}
26.4	PL_{750}
30.4	PL_{1000}
36.9	PL_{1500}
41.8	PL_{2000}
49.1	PL_{2500}
0.144	EAL

Figure A- 48 Steel – Mid Rise - Soil type F (Shallow foundation) – Mayagüez



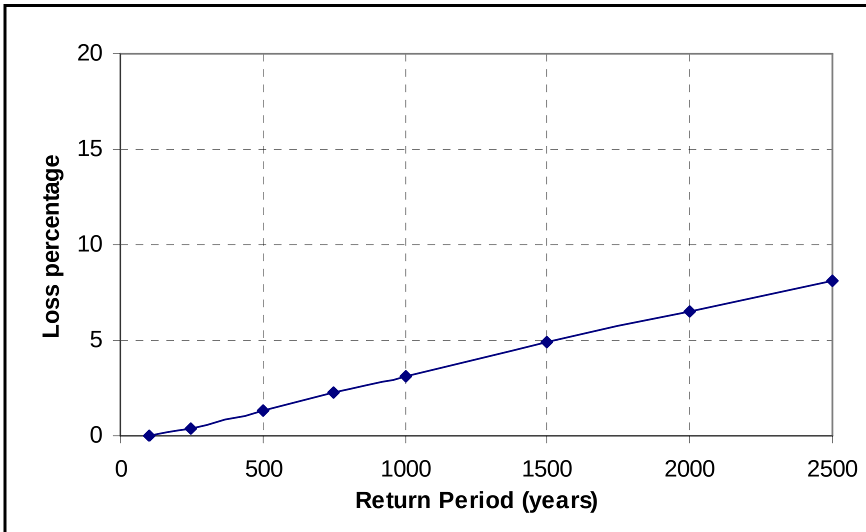
Probable Loss [%]	Name
2.0	PL_{100}
6.6	PL_{250}
11.9	PL_{500}
14.5	PL_{750}
16.5	PL_{1000}
19.7	PL_{1500}
22.2	PL_{2000}
26.3	PL_{2500}
0.081	EAL

Figure A- 49 Steel – Mid Rise - Soil type F (Deep foundation) – Mayagüez



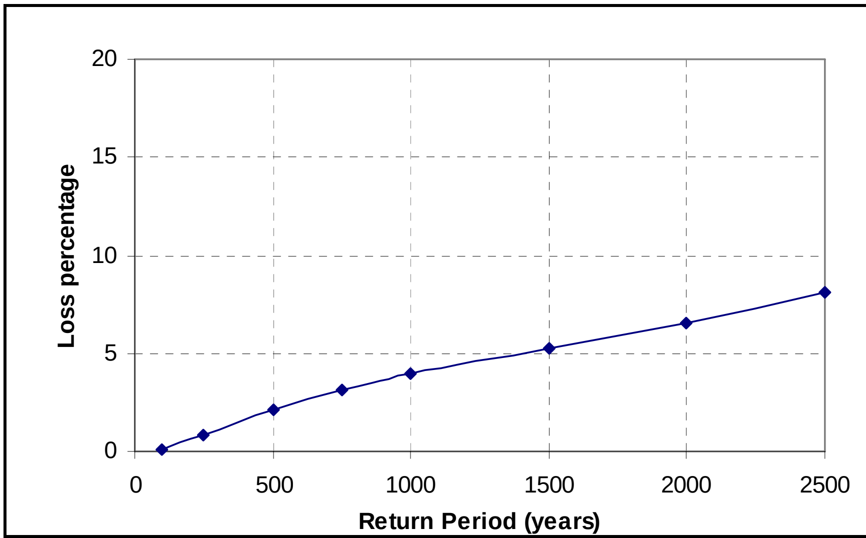
Probable Loss [%]	Name
0.01	PL_{100}
0.11	PL_{250}
0.52	PL_{500}
1.04	PL_{750}
1.56	PL_{1000}
2.58	PL_{1500}
3.48	PL_{2000}
4.34	PL_{2500}
0.005	EAL

Figure A- 50 Steel – High Rise - Soil type A – Mayagüez



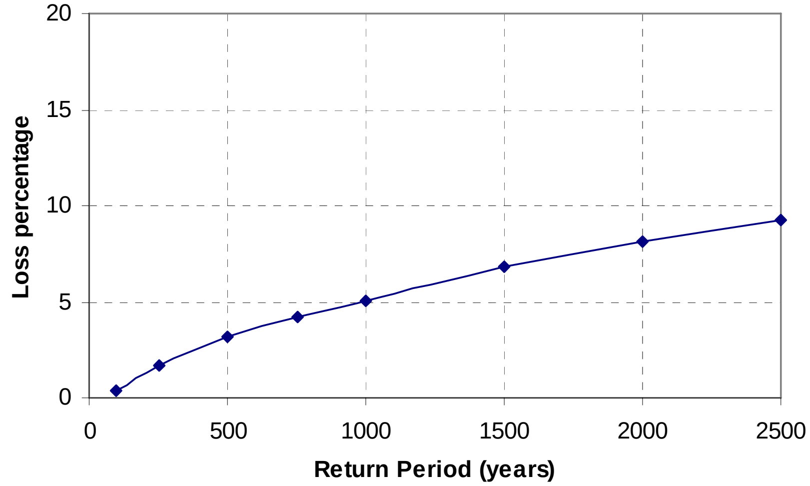
Probable Loss [%]	Name
0.0	PL_{100}
0.4	PL_{250}
1.3	PL_{500}
2.2	PL_{750}
3.1	PL_{1000}
4.9	PL_{1500}
6.5	PL_{2000}
8.2	PL_{2500}
0.011	EAL

Figure A- 51 Steel – High Rise - Soil type B – Mayagüez



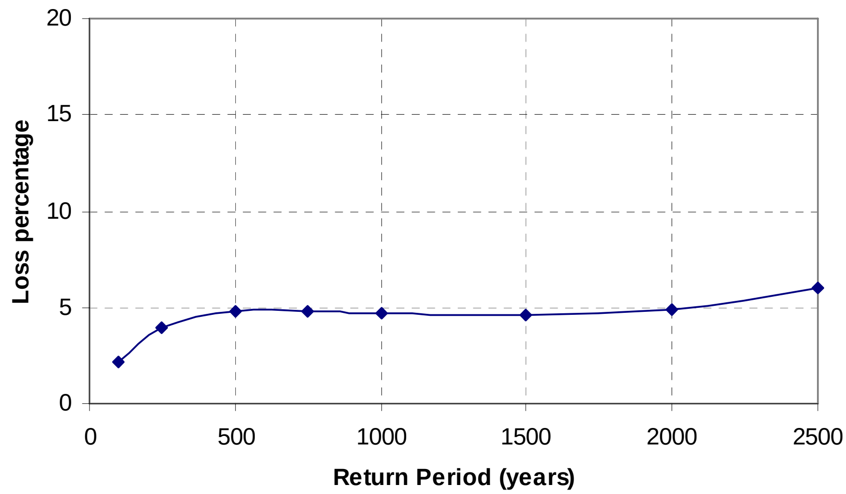
Probable Loss [%]	Name
0.1	PL_{100}
0.8	PL_{250}
2.1	PL_{500}
3.1	PL_{750}
3.9	PL_{1000}
5.2	PL_{1500}
6.5	PL_{2000}
8.2	PL_{2500}
0.015	EAL

Figure A- 52 Steel – High Rise - Soil type C – Mayagüez



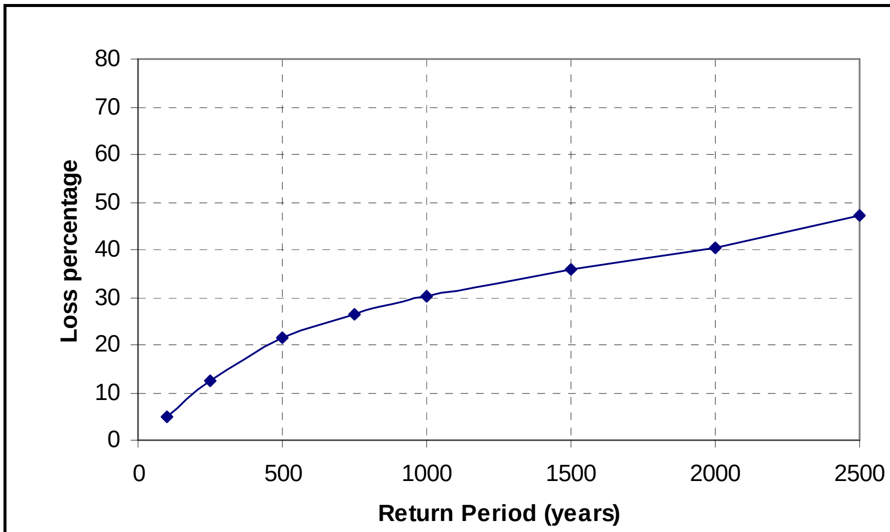
Probable Loss [%]	Name
0.4	PL_{100}
1.7	PL_{250}
3.2	PL_{500}
4.2	PL_{750}
5.0	PL_{1000}
6.8	PL_{1500}
8.1	PL_{2000}
9.2	PL_{2500}
0.023	EAL

Figure A- 53 Steel – High Rise - Soil type D – Mayagüez



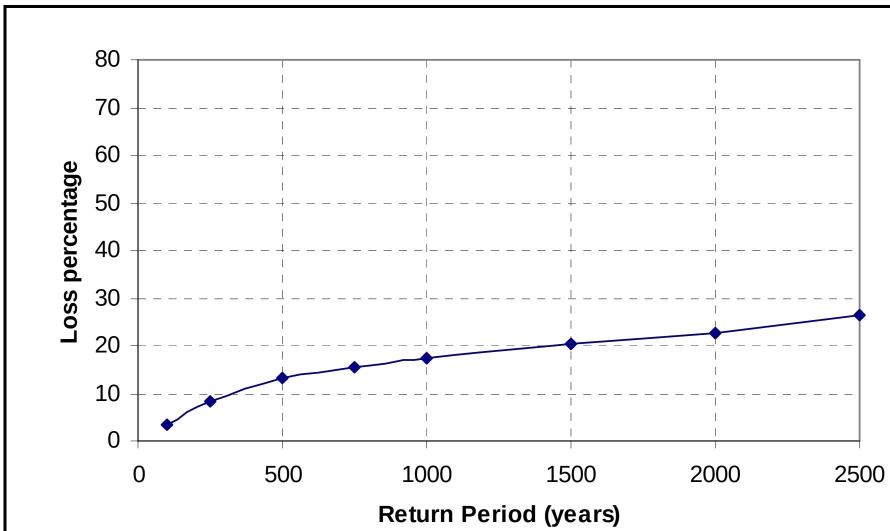
Probable Loss [%]	Name
2.1	PL_{100}
4.0	PL_{250}
4.7	PL_{500}
4.8	PL_{750}
4.7	PL_{1000}
4.6	PL_{1500}
4.8	PL_{2000}
6.0	PL_{2500}
0.037	EAL

Figure A- 54 Steel – High Rise - Soil type E – Mayagüez



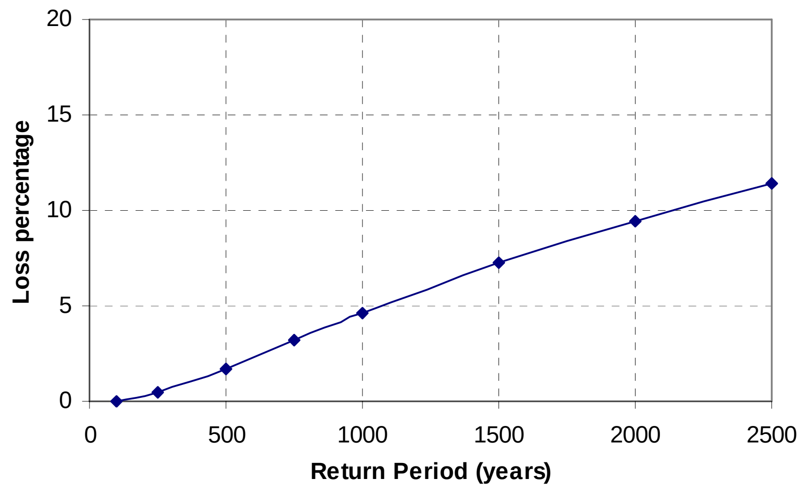
Probable Loss [%]	Name
4.7	PL_{100}
12.5	PL_{250}
21.6	PL_{500}
26.4	PL_{750}
30.0	PL_{1000}
35.9	PL_{1500}
40.4	PL_{2000}
47.0	PL_{2500}
0.152	EAL

Figure A- 55 Steel – High Rise - Soil type F (Shallow foundation) – Mayagüez



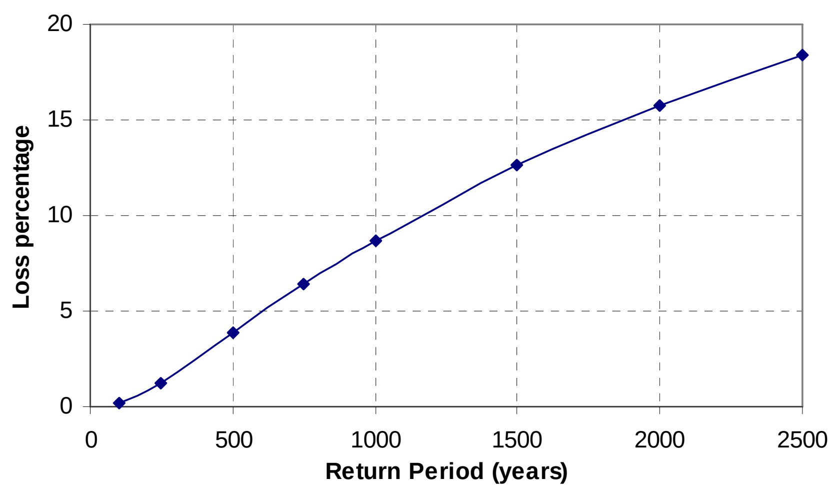
Probable Loss [%]	Name
3.4	PL_{100}
8.2	PL_{250}
13.2	PL_{500}
15.6	PL_{750}
17.4	PL_{1000}
20.2	PL_{1500}
22.6	PL_{2000}
26.5	PL_{2500}
0.094	EAL

Figure A- 56 Steel – High Rise - Soil type F (Deep foundation) – Mayagüez



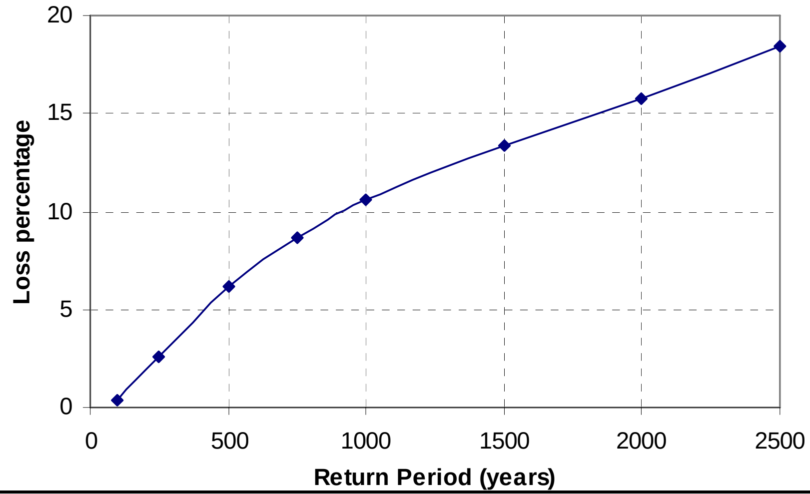
Probable Loss [%]	Name
0.0	PL_{100}
0.5	PL_{250}
1.7	PL_{500}
3.2	PL_{750}
4.6	PL_{1000}
7.3	PL_{1500}
9.5	PL_{2000}
11.5	PL_{2500}
0.016	EAL

Figure A- 57 Steel – Industrial – 1 Story - Soil type A – Mayagüez



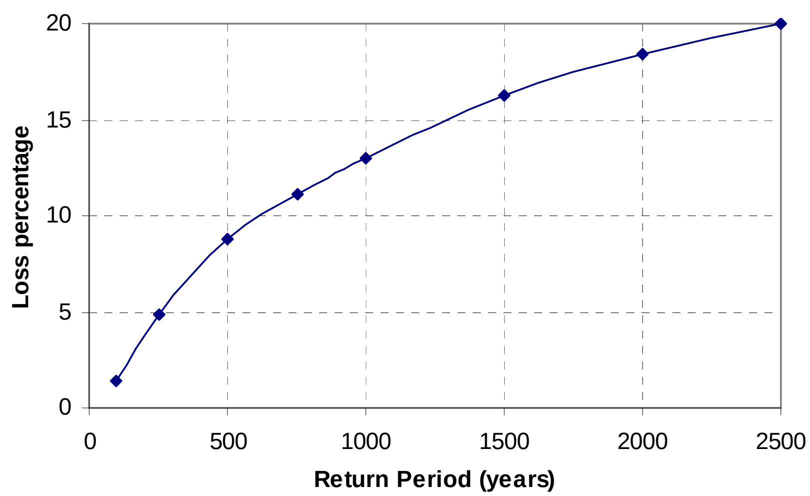
Probable Loss [%]	Name
0.1	PL_{100}
1.3	PL_{250}
3.8	PL_{500}
6.4	PL_{750}
8.6	PL_{1000}
12.6	PL_{1500}
15.7	PL_{2000}
18.4	PL_{2500}
0.030	EAL

Figure A- 58 Steel – Industrial – 1 Story - Soil type B – Mayagüez



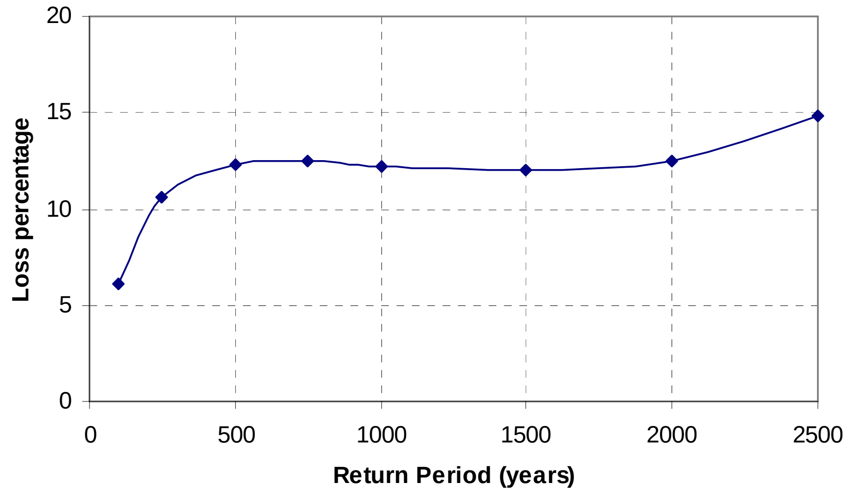
Probable Loss [%]	Name
0.4	PL_{100}
2.5	PL_{250}
6.1	PL_{500}
8.7	PL_{750}
10.6	PL_{1000}
13.4	PL_{1500}
15.7	PL_{2000}
18.4	PL_{2500}
0.041	EAL

Figure A- 59 Steel –Industrial – 1 Story - Soil type C – Mayagüez



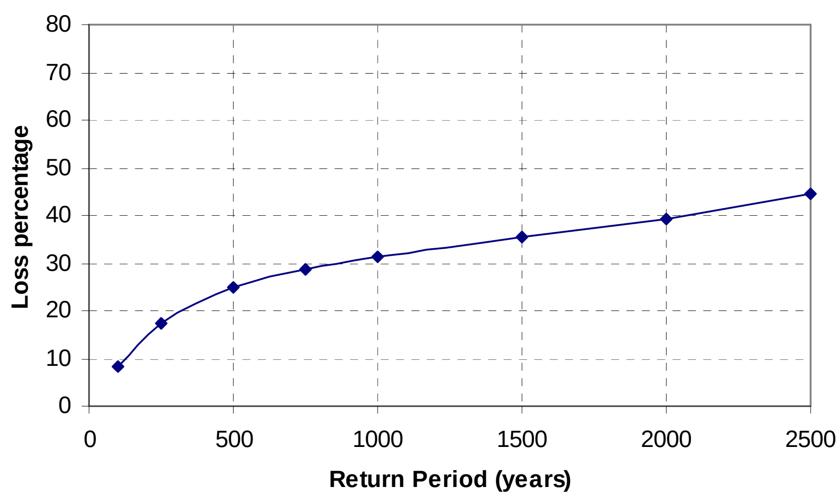
Probable Loss [%]	Name
1.4	PL_{100}
4.9	PL_{250}
8.8	PL_{500}
11.2	PL_{750}
12.9	PL_{1000}
16.3	PL_{1500}
18.4	PL_{2000}
20.0	PL_{2500}
0.061	EAL

Figure A- 60 Steel – Industrial – 1 Story - Soil type D – Mayagüez



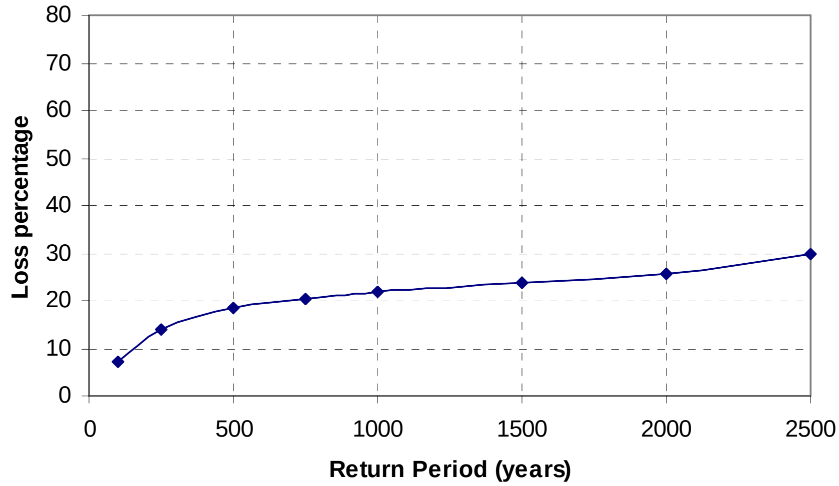
Probable Loss [%]	Name
6.1	PL_{100}
10.6	PL_{250}
12.3	PL_{500}
12.5	PL_{750}
12.2	PL_{1000}
12.0	PL_{1500}
12.5	PL_{2000}
14.9	PL_{2500}
0.099	EAL

Figure A- 61 Steel –Industrial – 1 Story - Soil type E – Mayagüez



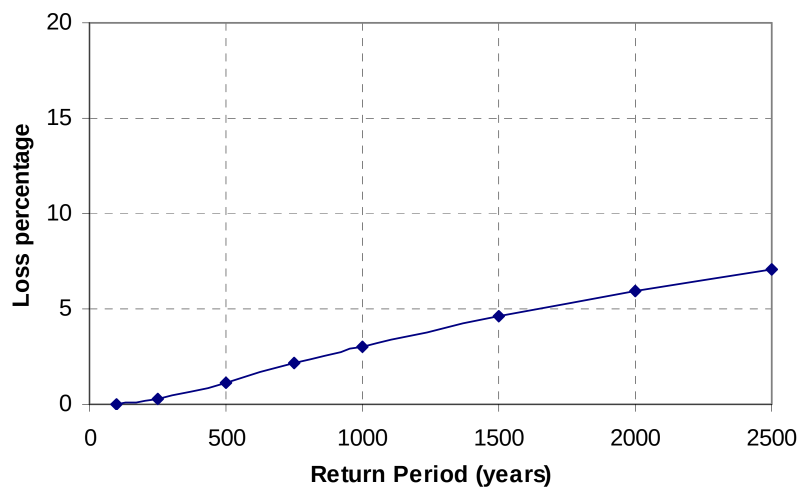
Probable Loss [%]	Name
8.3	PL_{100}
17.2	PL_{250}
25.0	PL_{500}
28.6	PL_{750}
31.2	PL_{1000}
35.6	PL_{1500}
39.1	PL_{2000}
44.4	PL_{2500}
0.186	EAL

Figure A- 62 Steel – Industrial – 1 Story - Soil type F (Shallow foundation) – Mayagüez



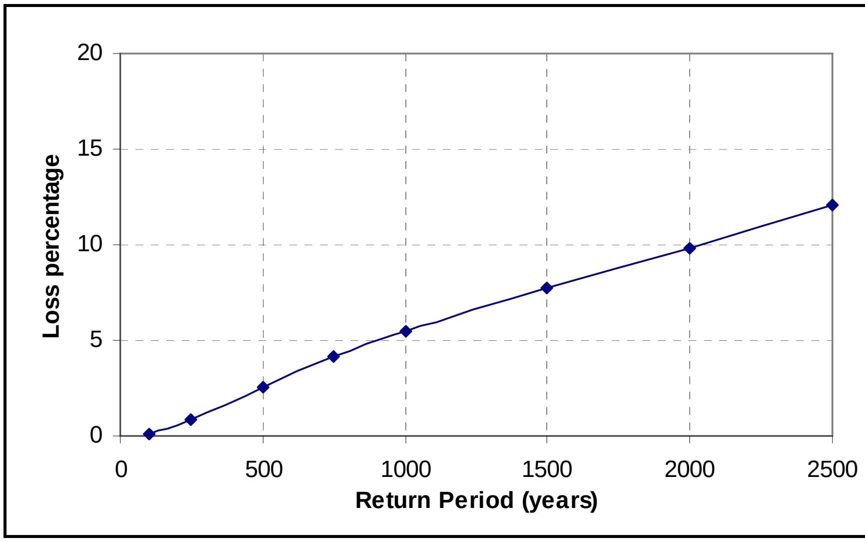
Probable Loss [%]	Name
7.2	PL_{100}
13.9	PL_{250}
18.6	PL_{500}
20.6	PL_{750}
21.7	PL_{1000}
23.8	PL_{1500}
25.8	PL_{2000}
29.6	PL_{2500}
0.142	EAL

Figure A- 63 Steel –Industrial – 1 Story - Soil type F (Deep foundation) – Mayagüez



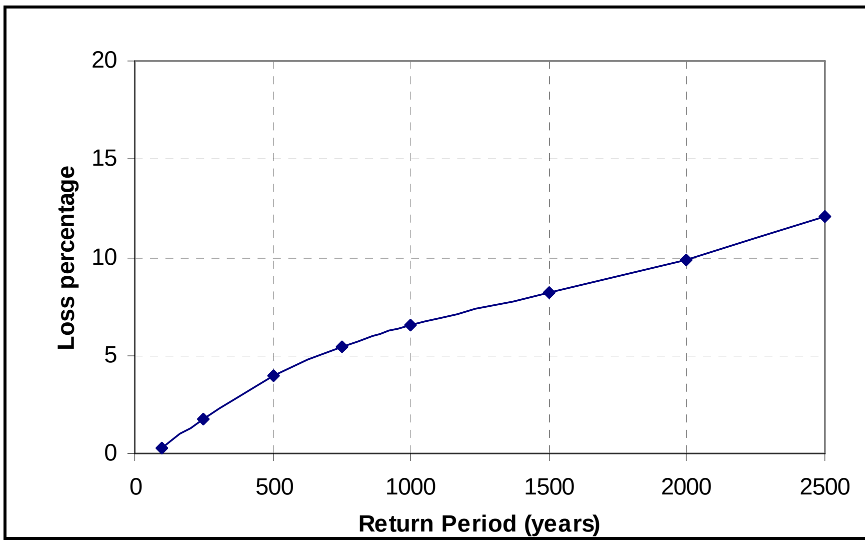
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.2	PL_{500}
2.1	PL_{750}
3.0	PL_{1000}
4.7	PL_{1500}
5.9	PL_{2000}
7.1	PL_{2500}
0.010	EAL

Figure A- 64 Steel – Industrial – 2 Story - Soil type A – Mayagüez



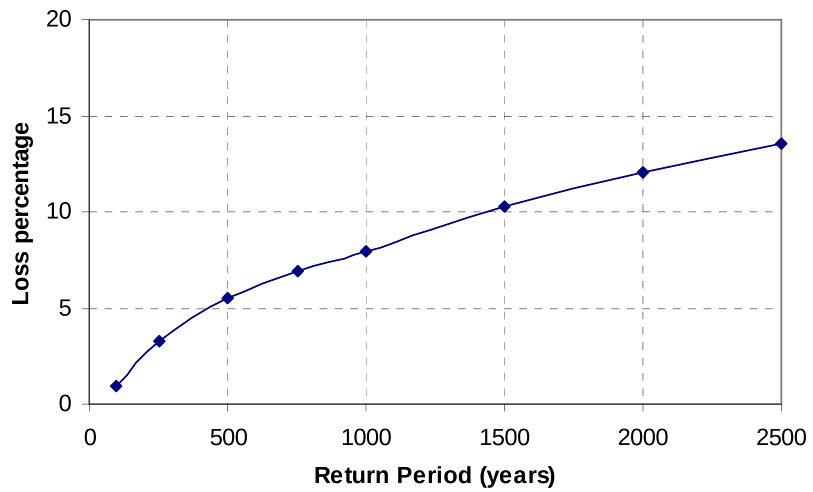
Probable Loss [%]	Name
0.1	PL_{100}
0.8	PL_{250}
2.6	PL_{500}
4.1	PL_{750}
5.4	PL_{1000}
7.7	PL_{1500}
9.9	PL_{2000}
12.1	PL_{2500}
0.020	EAL

Figure A- 65 Steel – Industrial – 2 Story - Soil type B – Mayagüez



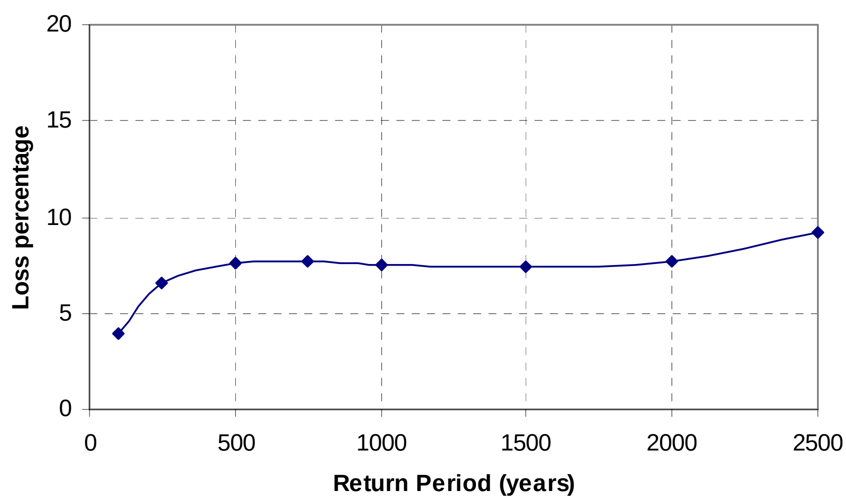
Probable Loss [%]	Name
0.2	PL_{100}
1.7	PL_{250}
4.0	PL_{500}
5.5	PL_{750}
6.5	PL_{1000}
8.2	PL_{1500}
9.9	PL_{2000}
12.1	PL_{2500}
0.027	EAL

Figure A- 66 Steel –Industrial – 2 Story - Soil type C – Mayagüez



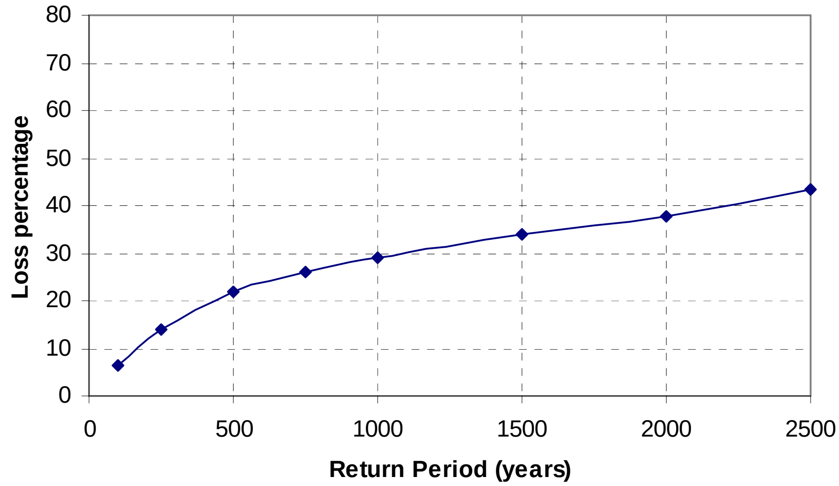
Probable Loss [%]	Name
0.9	PL_{100}
3.2	PL_{250}
5.5	PL_{500}
6.9	PL_{750}
8.0	PL_{1000}
10.3	PL_{1500}
12.0	PL_{2000}
13.6	PL_{2500}
0.039	EAL

Figure A- 67 Steel – Industrial – 2 Story - Soil type D – Mayagüez



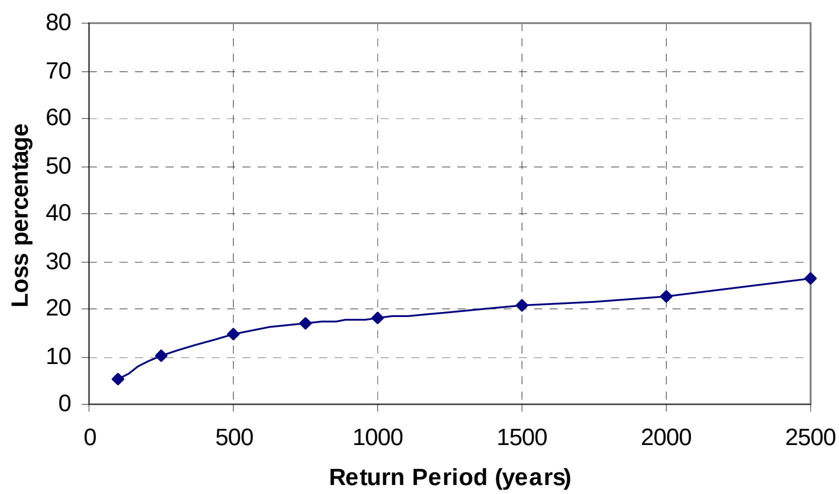
Probable Loss [%]	Name
4.0	PL_{100}
6.6	PL_{250}
7.6	PL_{500}
7.7	PL_{750}
7.5	PL_{1000}
7.4	PL_{1500}
7.7	PL_{2000}
9.2	PL_{2500}
0.062	EAL

Figure A- 68 Steel –Industrial – 2 Story - Soil type E – Mayagüez



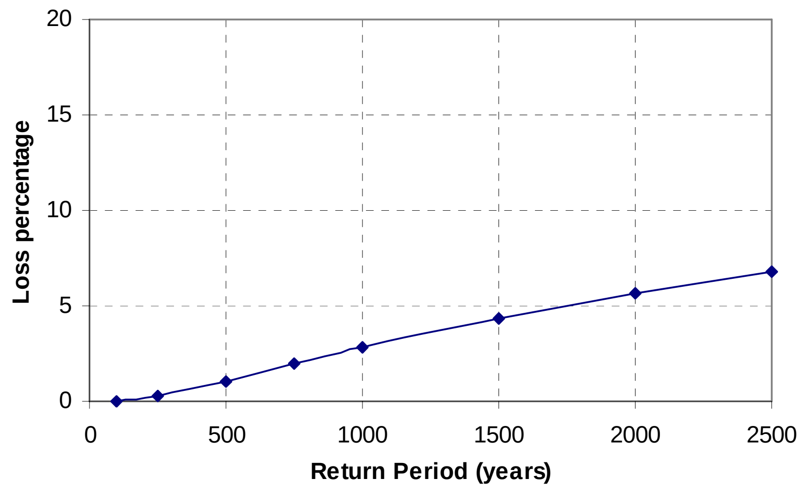
Probable Loss [%]	Name
6.2	PL_{100}
13.8	PL_{250}
21.8	PL_{500}
25.9	PL_{750}
28.9	PL_{1000}
33.9	PL_{1500}
37.7	PL_{2000}
43.5	PL_{2500}
0.159	EAL

Figure A- 69 Steel – Industrial – 2 Story - Soil type F (Shallow foundation) – Mayagüez



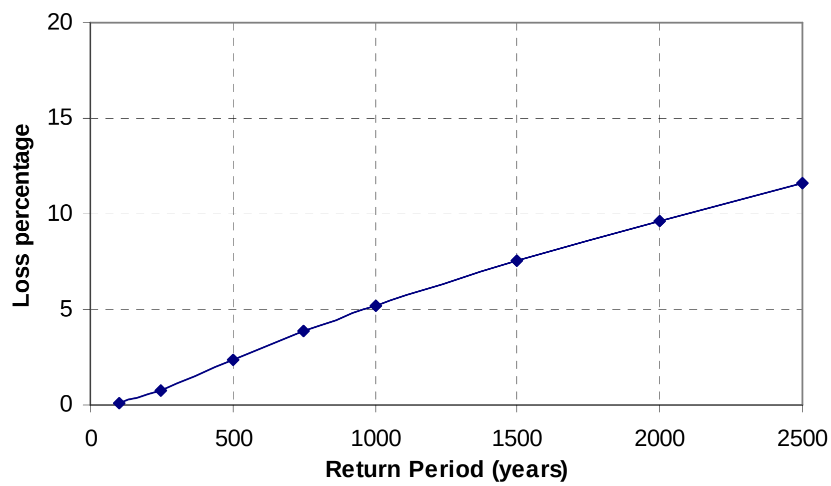
Probable Loss [%]	Name
5.1	PL_{100}
10.2	PL_{250}
14.7	PL_{500}
16.8	PL_{750}
18.2	PL_{1000}
20.6	PL_{1500}
22.7	PL_{2000}
26.3	PL_{2500}
0.110	EAL

Figure A- 70 Steel –Industrial – 2 Story - Soil type F (Deep foundation) – Mayagüez



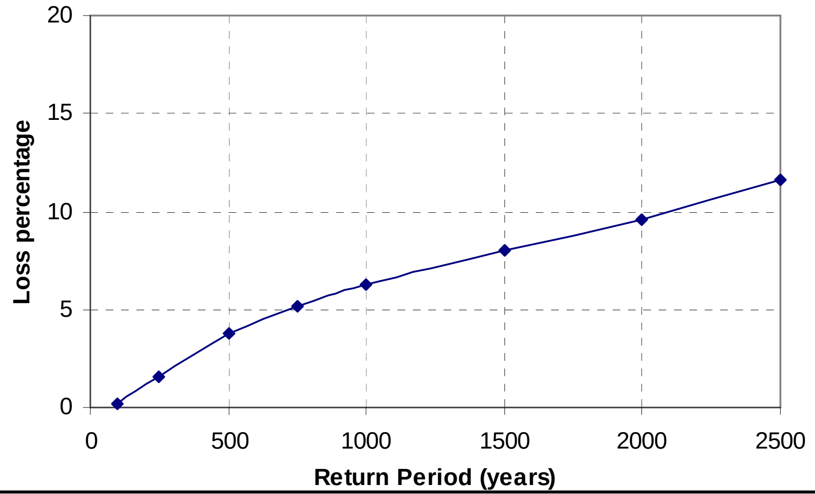
Probable Loss [%]	Name
0.0	PL_{100}
0.2	PL_{250}
1.1	PL_{500}
2.0	PL_{750}
2.9	PL_{1000}
4.4	PL_{1500}
5.6	PL_{2000}
6.8	PL_{2500}
0.009	EAL

Figure A- 71 Steel – Commercial – 2 Story - Soil type A – Mayagüez



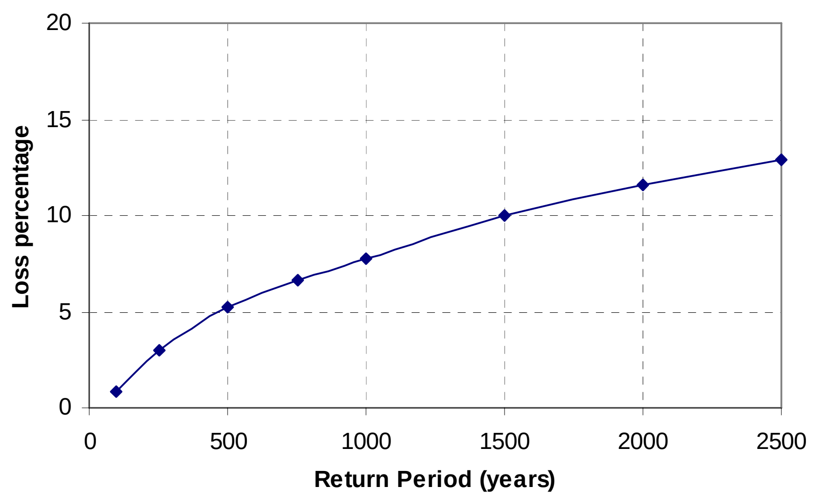
Probable Loss [%]	Name
0.1	PL_{100}
0.8	PL_{250}
2.4	PL_{500}
3.9	PL_{750}
5.2	PL_{1000}
7.5	PL_{1500}
9.6	PL_{2000}
11.6	PL_{2500}
0.019	EAL

Figure A- 72 Steel – Commercial – 2 Story - Soil type B – Mayagüez



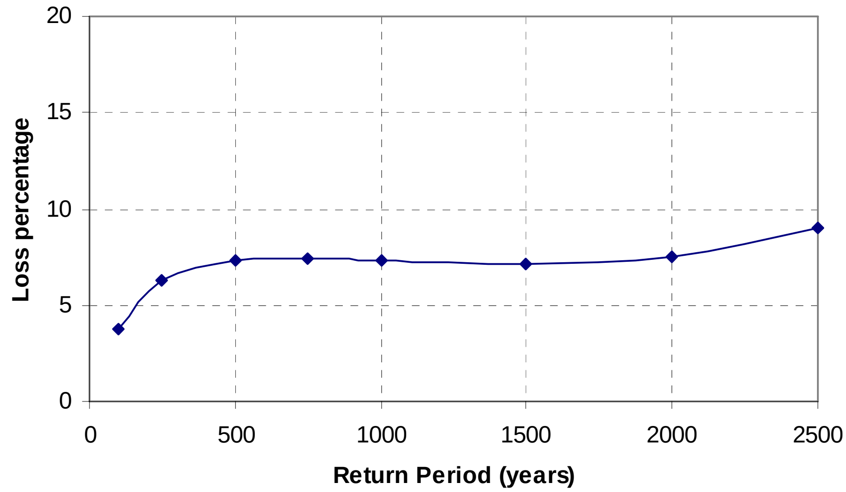
Probable Loss [%]	Name
0.2	PL_{100}
1.6	PL_{250}
3.7	PL_{500}
5.2	PL_{750}
6.3	PL_{1000}
8.0	PL_{1500}
9.6	PL_{2000}
11.6	PL_{2500}
0.025	EAL

Figure A- 73 Steel –Commercial– 2 Story - Soil type C – Mayagüez



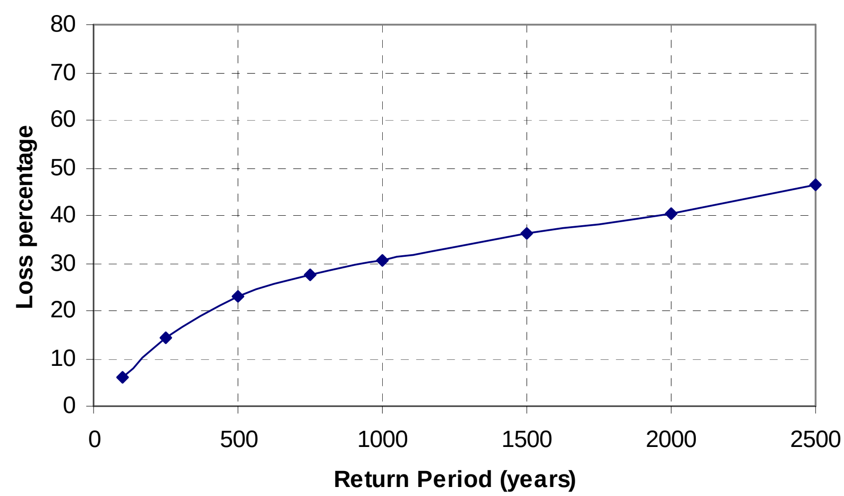
Probable Loss [%]	Name
0.8	PL_{100}
3.0	PL_{250}
5.3	PL_{500}
6.6	PL_{750}
7.8	PL_{1000}
10.0	PL_{1500}
11.6	PL_{2000}
12.9	PL_{2500}
0.037	EAL

Figure A- 74 Steel – Commercial – 2 Story - Soil type D – Mayagüez



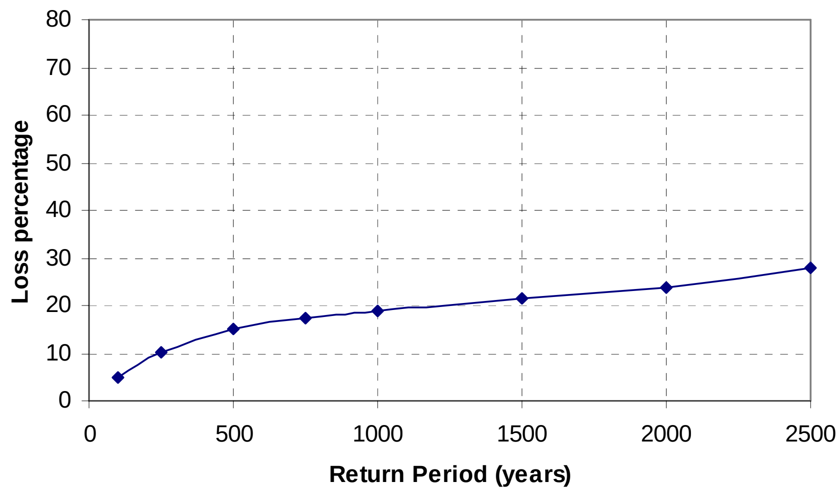
Probable Loss [%]	Name
3.7	PL_{100}
6.3	PL_{250}
7.4	PL_{500}
7.5	PL_{750}
7.3	PL_{1000}
7.2	PL_{1500}
7.5	PL_{2000}
9.0	PL_{2500}
0.059	EAL

Figure A- 75 Steel –Commercial – 2 Story - Soil type E – Mayagüez



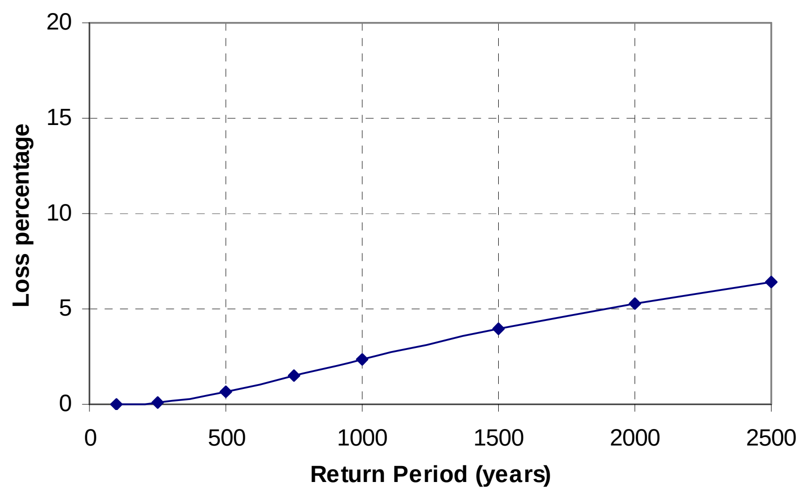
Probable Loss [%]	Name
6.2	PL_{100}
14.2	PL_{250}
22.9	PL_{500}
27.4	PL_{750}
30.7	PL_{1000}
36.1	PL_{1500}
40.3	PL_{2000}
46.5	PL_{2500}
0.165	EAL

Figure A- 76 Steel – Commercial – 2 Story - Soil type F (Shallow foundation) – Mayagüez



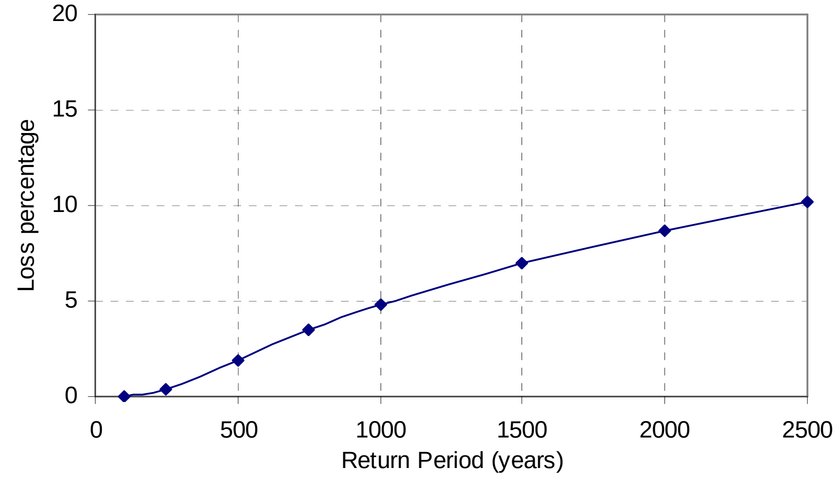
Probable Loss [%]	Name
5.0	PL_{100}
10.3	PL_{250}
15.1	PL_{500}
17.4	PL_{750}
19.0	PL_{1000}
21.6	PL_{1500}
23.9	PL_{2000}
27.8	PL_{2500}
0.112	EAL

Figure A- 77 Steel –Commercial – 2 Story - Soil type F (Deep foundation) – Mayagüez



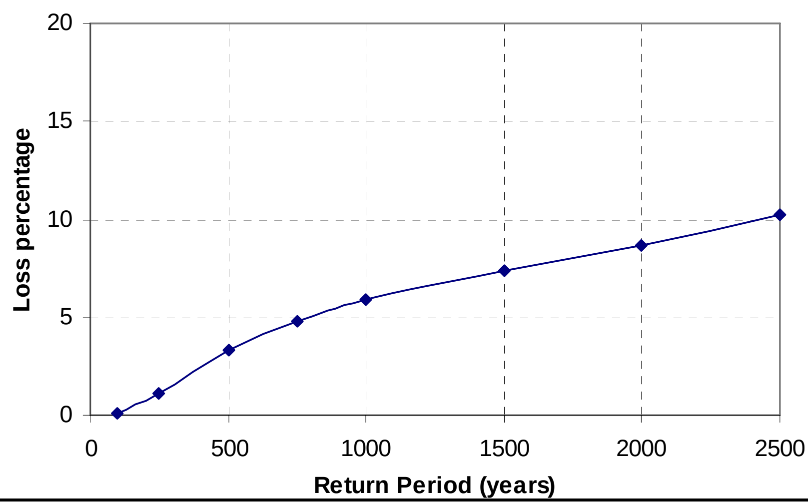
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.7	PL_{500}
1.5	PL_{750}
2.4	PL_{1000}
4.0	PL_{1500}
5.3	PL_{2000}
6.4	PL_{2500}
0.007	EAL

Figure A- 78 Steel – Commercial – 3 Story - Soil type A – Mayagüez



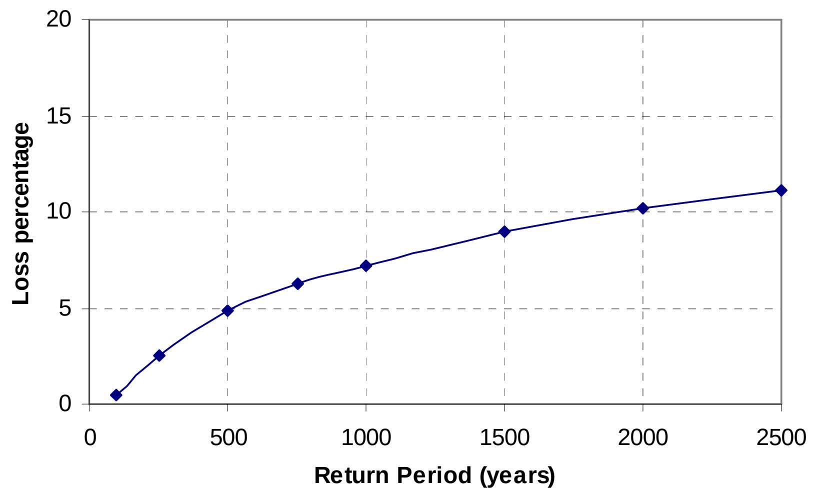
Probable Loss [%]	Name
0.0	PL_{100}
0.4	PL_{250}
1.9	PL_{500}
3.5	PL_{750}
4.8	PL_{1000}
7.0	PL_{1500}
8.7	PL_{2000}
10.2	PL_{2500}
0.015	EAL

Figure A- 79 Steel – Commercial – 3 Story - Soil type B – Mayagüez



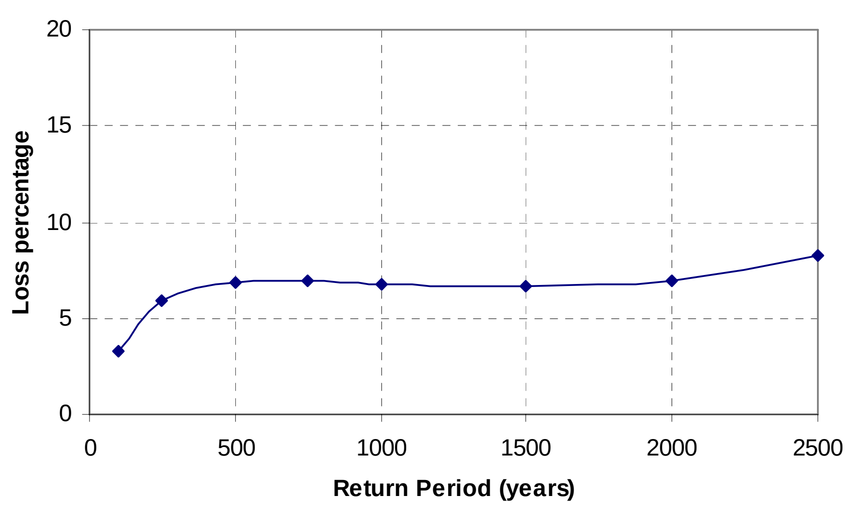
Probable Loss [%]	Name
0.1	PL_{100}
1.1	PL_{250}
3.3	PL_{500}
4.8	PL_{750}
5.9	PL_{1000}
7.4	PL_{1500}
8.7	PL_{2000}
10.2	PL_{2500}
0.021	EAL

Figure A- 80 Steel –Commercial– 3 Story - Soil type C – Mayagüez



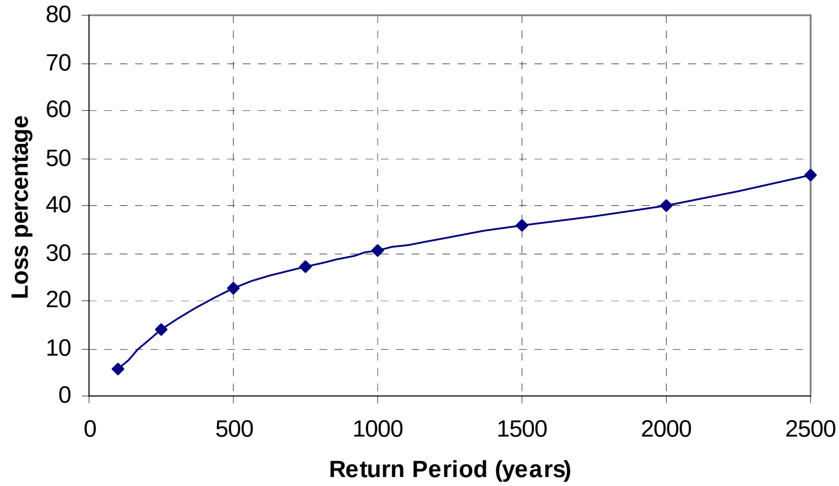
Probable Loss [%]	Name
0.5	PL_{100}
2.6	PL_{250}
4.9	PL_{500}
6.2	PL_{750}
7.2	PL_{1000}
9.0	PL_{1500}
10.2	PL_{2000}
11.1	PL_{2500}
0.032	EAL

Figure A- 81 Steel – Commercial – 3 Story - Soil type D – Mayagüez



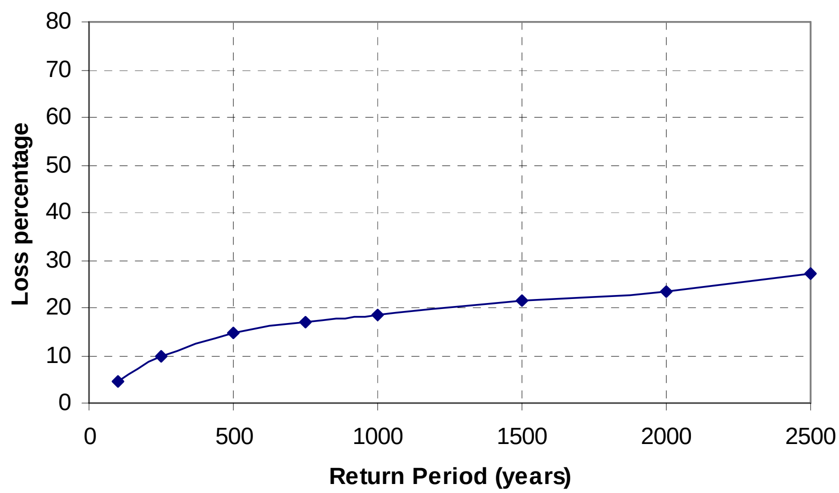
Probable Loss [%]	Name
3.3	PL_{100}
5.9	PL_{250}
6.9	PL_{500}
6.9	PL_{750}
6.8	PL_{1000}
6.7	PL_{1500}
7.0	PL_{2000}
8.2	PL_{2500}
0.055	EAL

Figure A- 82 Steel –Commercial – 3 Story - Soil type E – Mayagüez



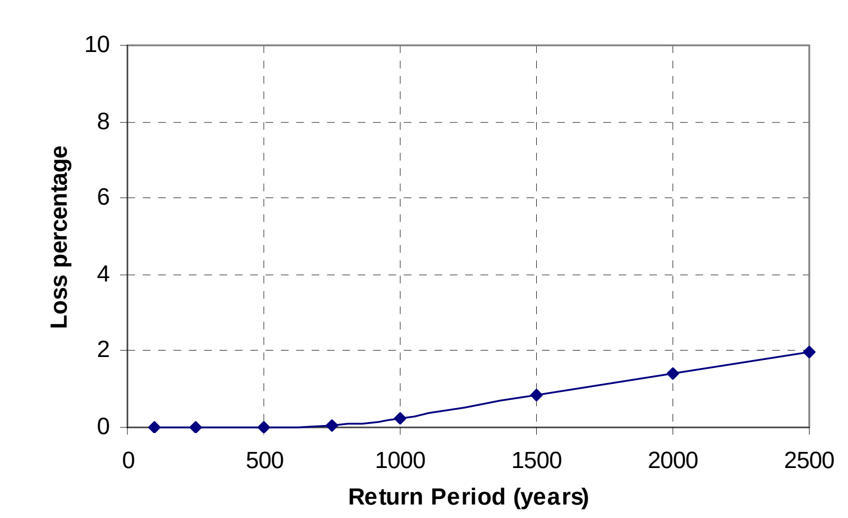
Probable Loss [%]	Name
5.8	PL_{100}
13.9	PL_{250}
22.6	PL_{500}
27.1	PL_{750}
30.5	PL_{1000}
36.0	PL_{1500}
40.1	PL_{2000}
46.4	PL_{2500}
0.162	EAL

Figure A- 83 Steel – Commercial – 3 Story - Soil type F (Shallow foundation) – Mayagüez



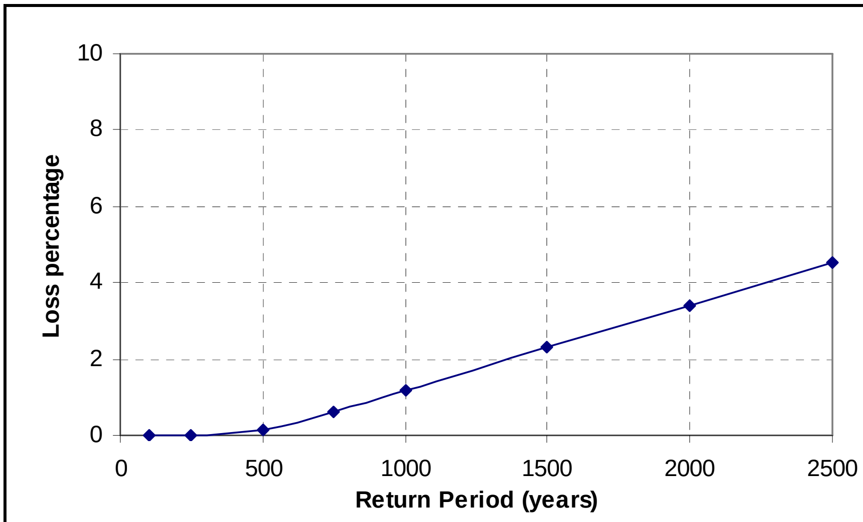
Probable Loss [%]	Name
4.5	PL_{100}
9.9	PL_{250}
14.7	PL_{500}
17.0	PL_{750}
18.6	PL_{1000}
21.3	PL_{1500}
23.6	PL_{2000}
27.3	PL_{2500}
0.108	EAL

Figure A- 84 Steel –Commercial – 3 Story - Soil type F (Deep foundation) – Mayagüez



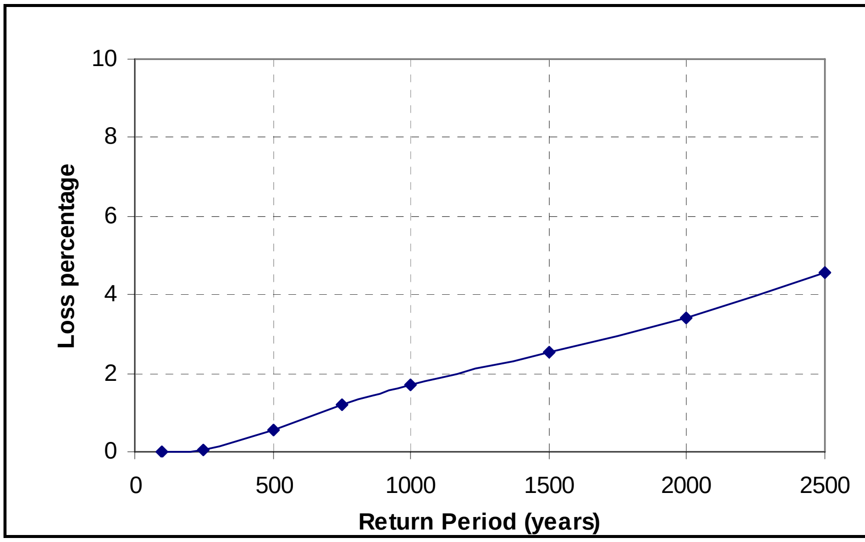
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.1	PL_{750}
0.2	PL_{1000}
0.8	PL_{1500}
1.4	PL_{2000}
2.0	PL_{2500}
0.001	EAL

Figure A- 85 Steel – Commercial – 4 Story - Soil type A – Mayagüez



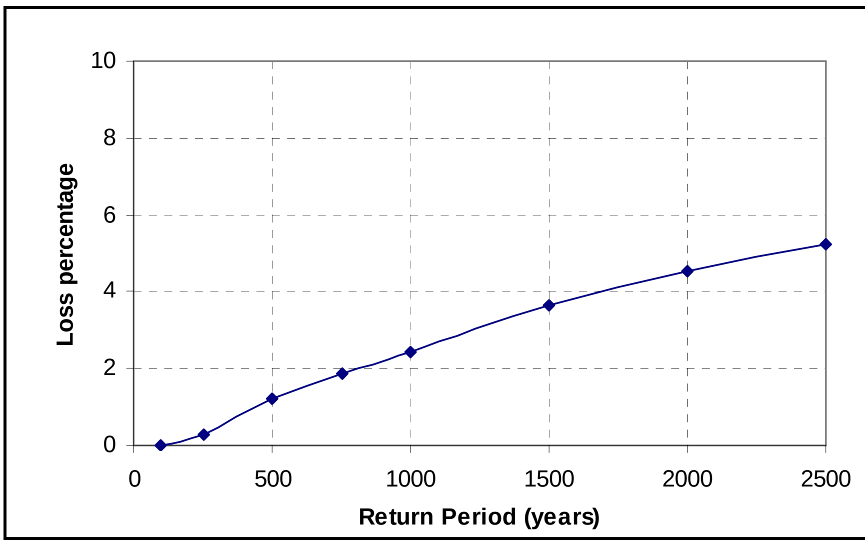
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.1	PL_{500}
0.6	PL_{750}
1.2	PL_{1000}
2.3	PL_{1500}
3.4	PL_{2000}
4.5	PL_{2500}
0.004	EAL

Figure A- 86 Steel – Commercial – 4 Story - Soil type B – Mayagüez



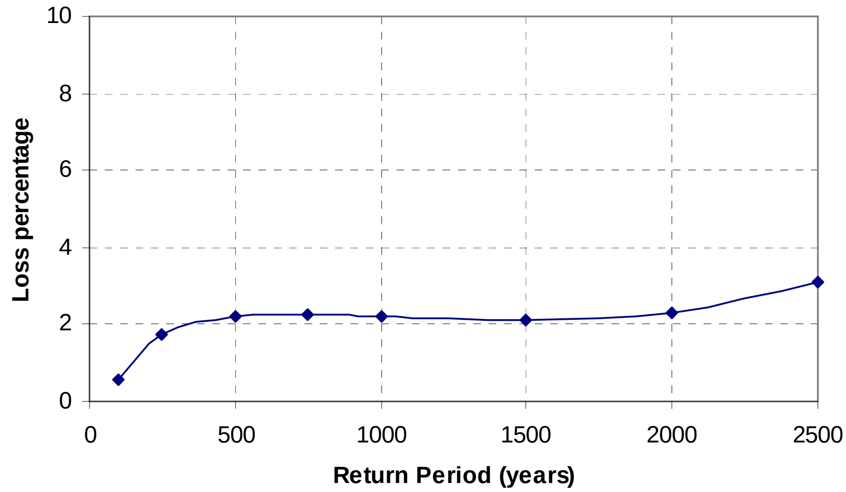
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.6	PL_{500}
1.2	PL_{750}
1.7	PL_{1000}
2.6	PL_{1500}
3.4	PL_{2000}
4.5	PL_{2500}
0.005	EAL

Figure A- 87 Steel –Commercial– 4 Story - Soil type C – Mayagüez



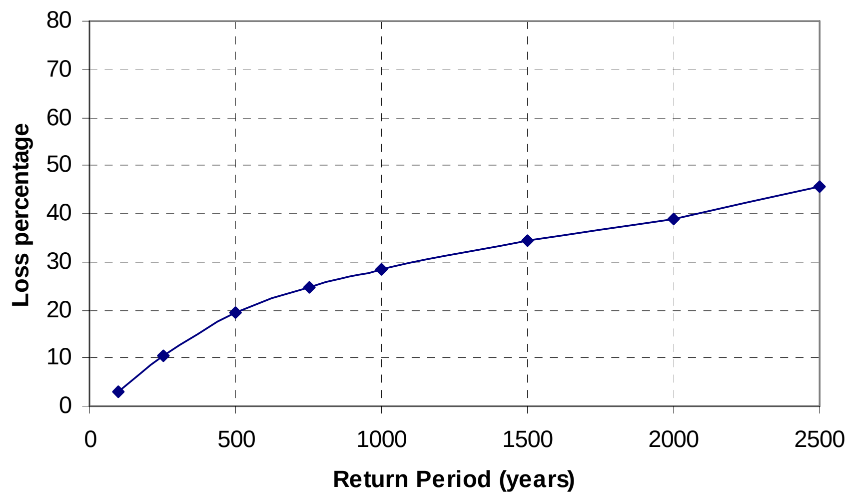
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.2	PL_{500}
1.9	PL_{750}
2.4	PL_{1000}
3.6	PL_{1500}
4.5	PL_{2000}
5.2	PL_{2500}
0.008	EAL

Figure A- 88 Steel – Commercial – 4 Story - Soil type D – Mayagüez



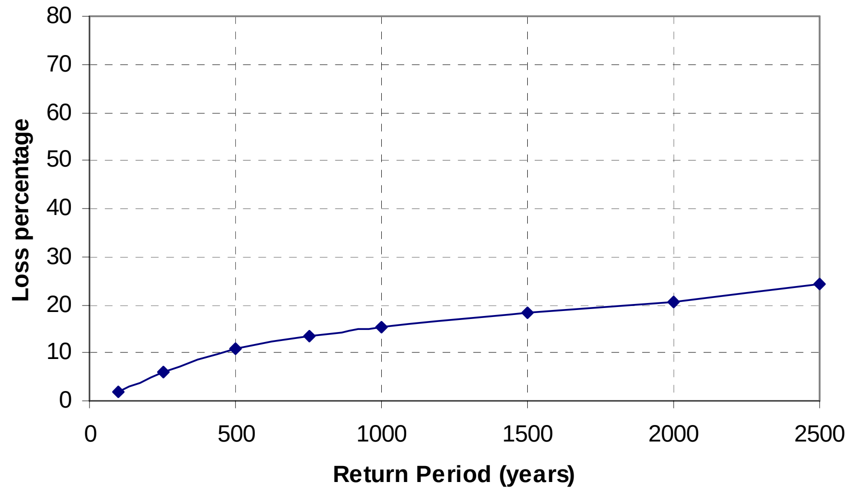
Probable Loss [%]	Name
0.5	PL_{100}
1.7	PL_{250}
2.2	PL_{500}
2.3	PL_{750}
2.2	PL_{1000}
2.1	PL_{1500}
2.3	PL_{2000}
3.1	PL_{2500}
0.016	EAL

Figure A- 89 Steel –Commercial – 4 Story - Soil type E – Mayagüez



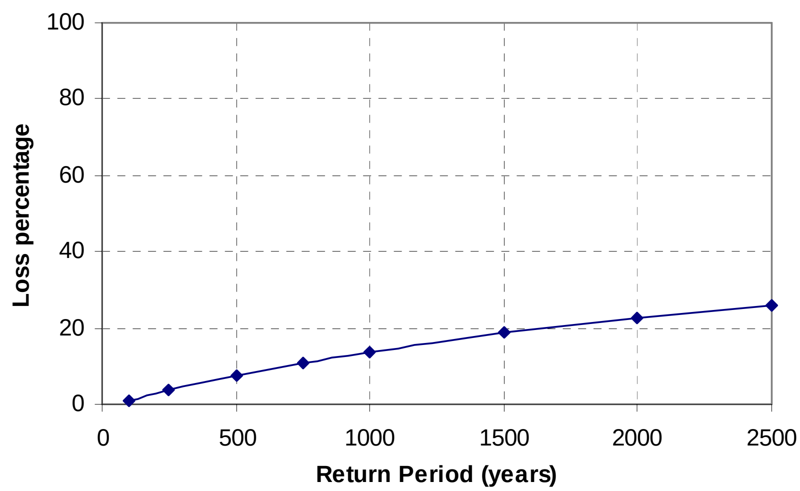
Probable Loss [%]	Name
3.2	PL_{100}
10.4	PL_{250}
19.6	PL_{500}
24.5	PL_{750}
28.3	PL_{1000}
34.4	PL_{1500}
38.9	PL_{2000}
45.7	PL_{2500}
0.133	EAL

Figure A- 90 Steel – Commercial – 4 Story - Soil type F (Shallow foundation) – Mayagüez



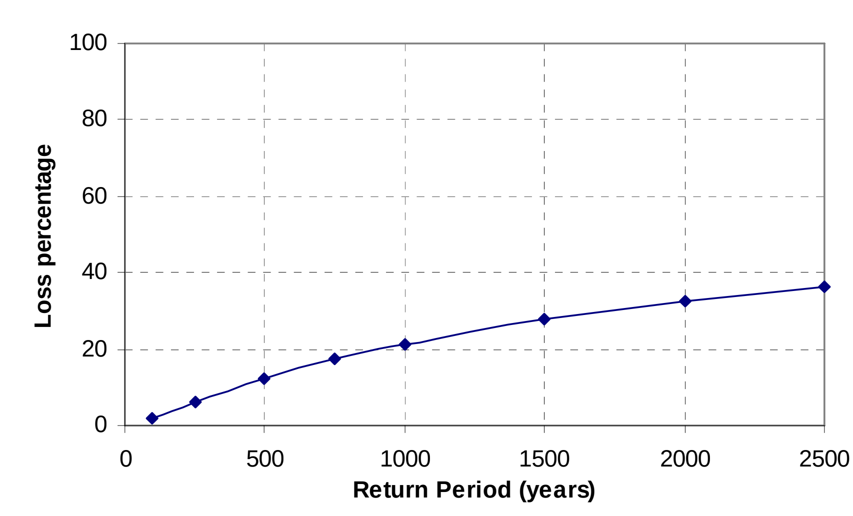
Probable Loss [%]	Name
1.9	PL_{100}
6.1	PL_{250}
10.9	PL_{500}
13.4	PL_{750}
15.2	PL_{1000}
18.2	PL_{1500}
20.6	PL_{2000}
24.4	PL_{2500}
0.075	EAL

Figure A- 91 Steel –Commercial – 4 Story - Soil type F (Deep foundation) – Mayagüez



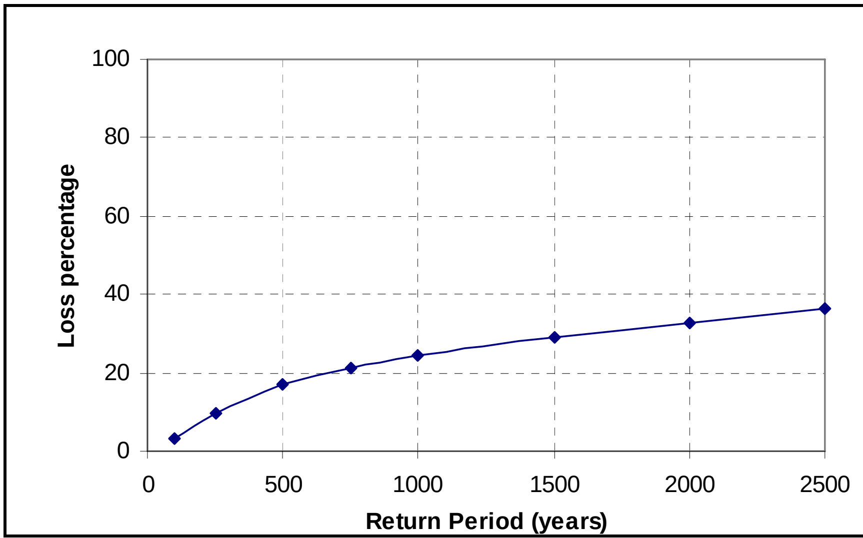
Probable Loss [%]	Name
1.0	PL_{100}
3.6	PL_{250}
7.5	PL_{500}
11.0	PL_{750}
13.9	PL_{1000}
18.9	PL_{1500}
22.7	PL_{2000}
25.9	PL_{2500}
0.042	EAL

Figure A- 92 Wood House - Soil type A – Mayagüez



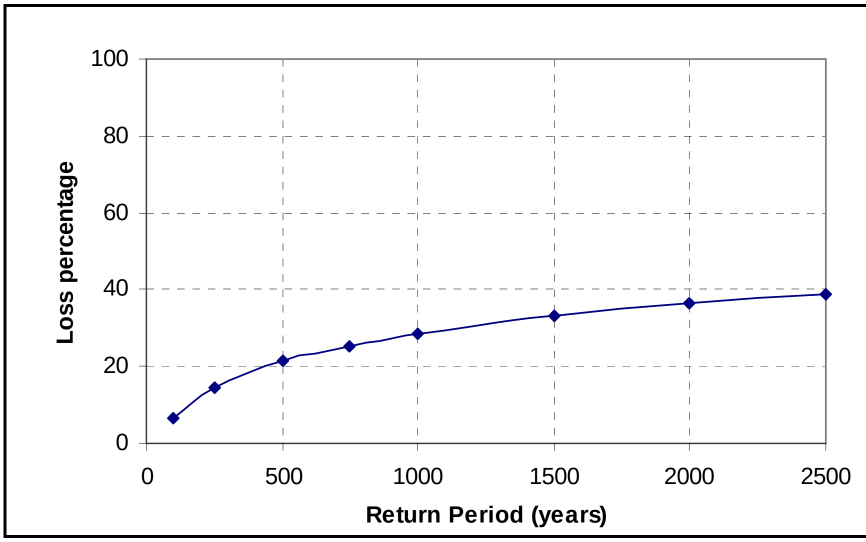
Probable Loss [%]	Name
2.0	PL_{100}
6.3	PL_{250}
12.4	PL_{500}
17.3	PL_{750}
21.2	PL_{1000}
27.8	PL_{1500}
32.5	PL_{2000}
36.4	PL_{2500}
0.068	EAL

Figure A- 93 Wood House - Soil type B – Mayagüez



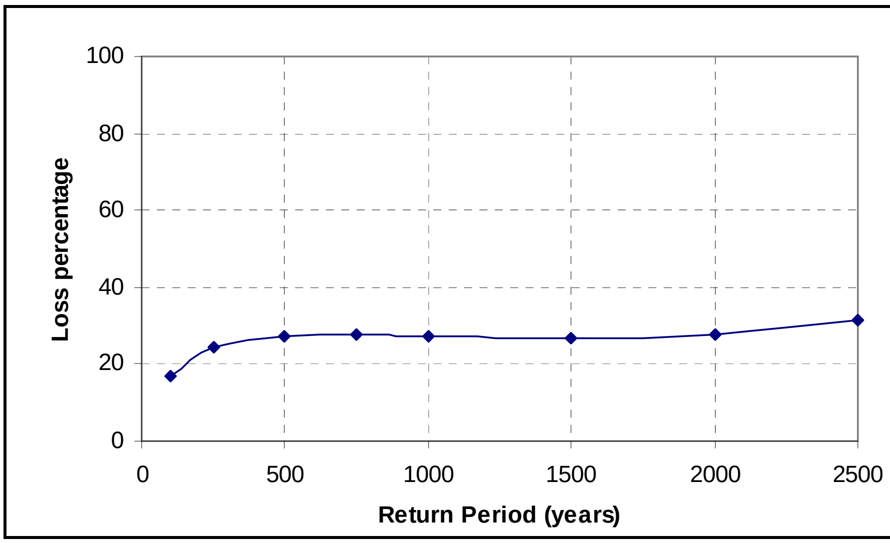
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.6	PL_{500}
1.2	PL_{750}
1.7	PL_{1000}
2.6	PL_{1500}
3.4	PL_{2000}
4.5	PL_{2500}
0.004	EAL

Figure A- 94 Wood House - Soil type C – Mayagüez



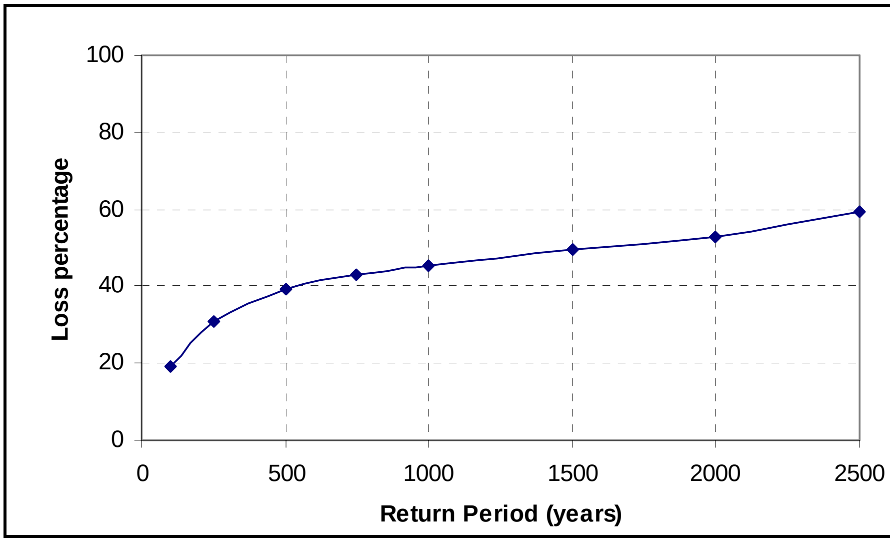
Probable Loss [%]	Name
6.6	PL_{100}
14.5	PL_{250}
21.5	PL_{500}
25.4	PL_{750}
28.3	PL_{1000}
33.3	PL_{1500}
36.4	PL_{2000}
38.6	PL_{2500}
0.125	EAL

Figure A- 95 Wood House - Soil type D – Mayagüez



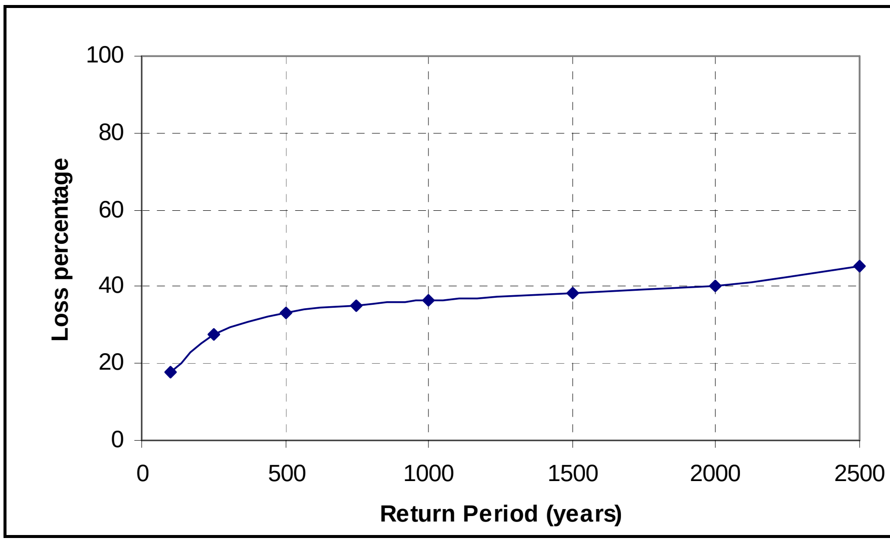
Probable Loss [%]	Name
16.8	PL_{100}
24.6	PL_{250}
27.3	PL_{500}
27.6	PL_{750}
27.1	PL_{1000}
26.8	PL_{1500}
27.6	PL_{2000}
31.2	PL_{2500}
0.206	EAL

Figure A- 96 Wood House - Soil type E – Mayagüez



Probable Loss [%]	Name
6.6	PL_{100}
14.5	PL_{250}
21.5	PL_{500}
25.4	PL_{750}
28.3	PL_{1000}
33.3	PL_{1500}
36.4	PL_{2000}
38.6	PL_{2500}
0.125	EAL

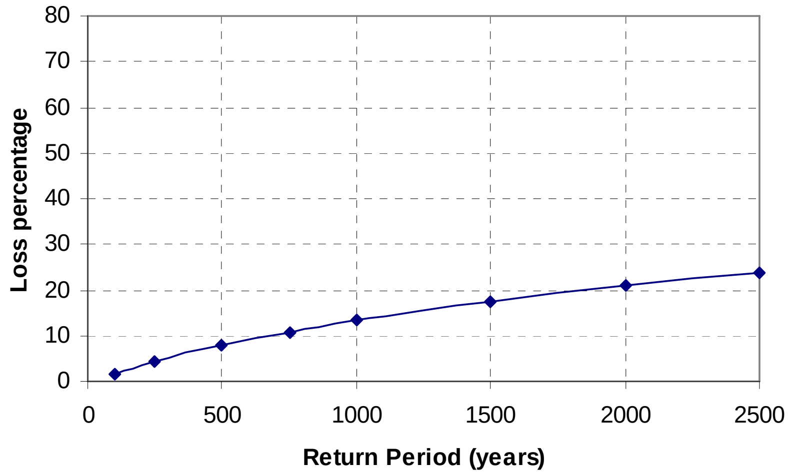
Figure A- 97 Wood House - Soil type F (Shallow foundation) – Mayagüez



Probable Loss [%]	Name
16.8	PL_{100}
24.6	PL_{250}
27.3	PL_{500}
27.6	PL_{750}
27.1	PL_{1000}
26.8	PL_{1500}
27.6	PL_{2000}
31.2	PL_{2500}
0.206	EAL

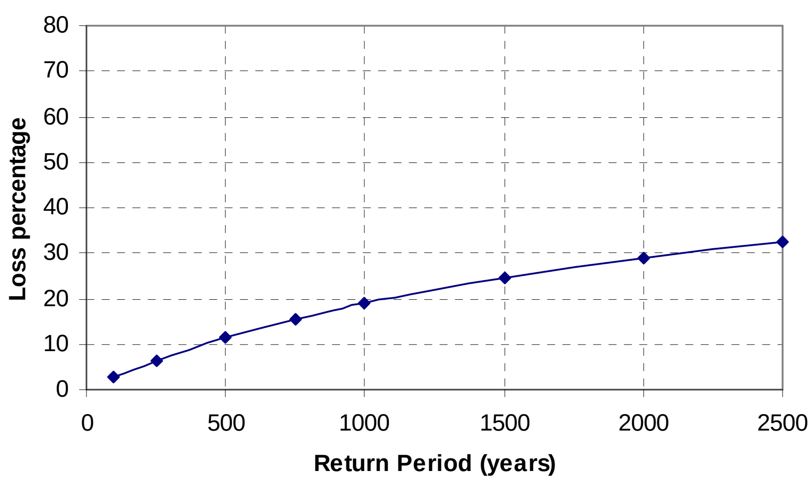
Figure A- 98 Wood House - Soil type F (Deep foundation) – Mayagüez

Appendix B Earthquake Loss Curves for Ponce



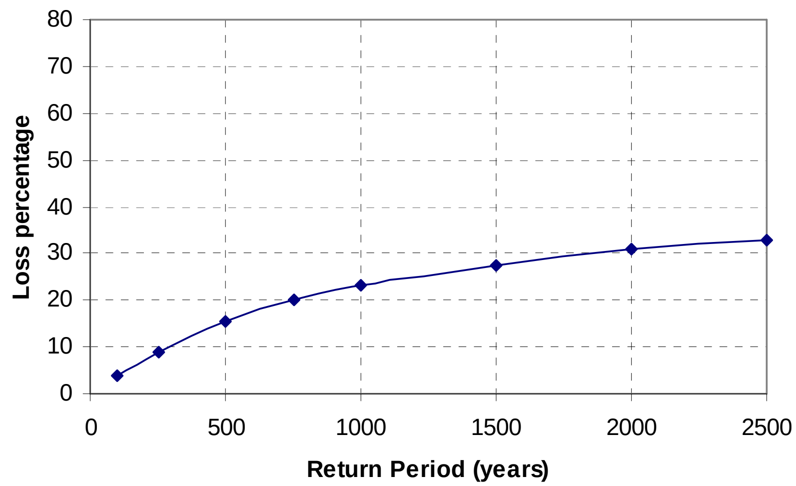
Probable Loss [%]	Name
1.6	PL_{100}
4.2	PL_{250}
7.8	PL_{500}
10.8	PL_{750}
13.4	PL_{1000}
17.5	PL_{1500}
21.0	PL_{2000}
23.9	PL_{2500}
0.060	EAL

Figure B- 1 Concrete Moment Resistant Frame – 1 Story - Soil type A – Ponce



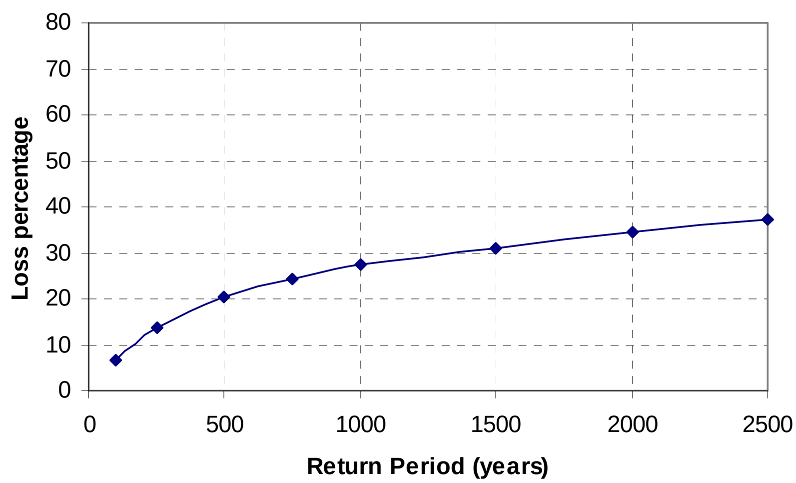
Probable Loss [%]	Name
2.6	PL_{100}
6.5	PL_{250}
11.6	PL_{500}
15.6	PL_{750}
19.0	PL_{1000}
24.4	PL_{1500}
28.9	PL_{2000}
32.6	PL_{2500}
0.088	EAL

Figure B- 2 Concrete Moment Resistant Frame – 1 Story - Soil type B – Ponce



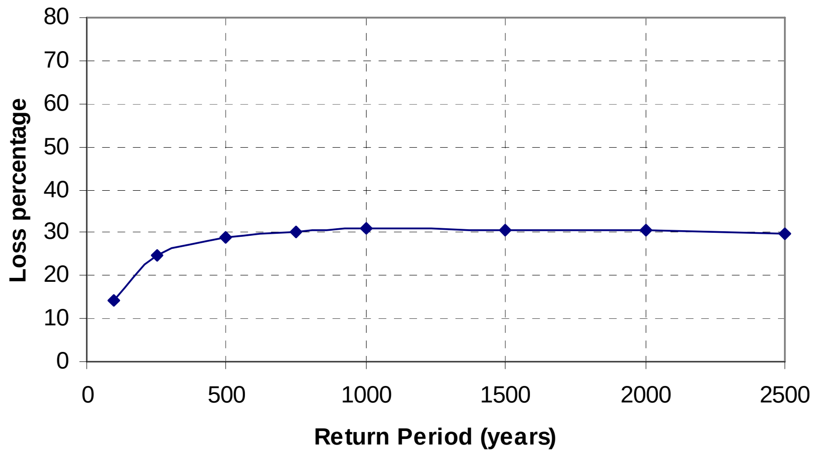
Probable Loss [%]	Name
3.8	PL_{100}
9.0	PL_{250}
15.6	PL_{500}
20.0	PL_{750}
23.2	PL_{1000}
27.6	PL_{1500}
30.8	PL_{2000}
33.0	PL_{2500}
0.112	EAL

Figure B- 3 Concrete Moment Resistant Frame – 1 Story - Soil type C – Ponce



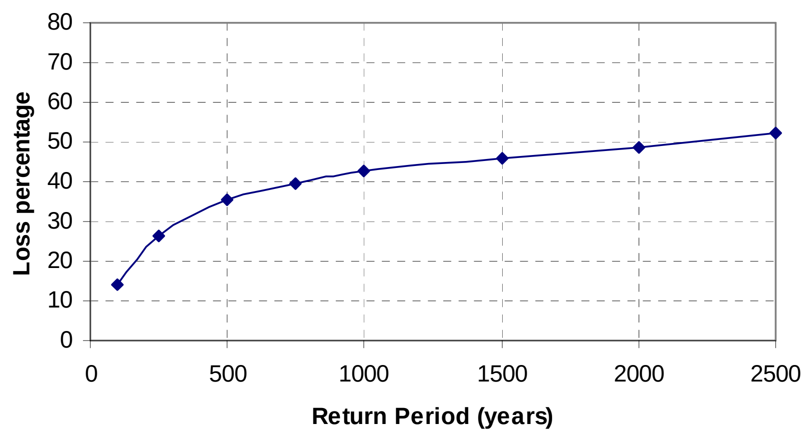
Probable Loss [%]	Name
6.5	PL_{100}
13.7	PL_{250}
20.4	PL_{500}
24.5	PL_{750}
27.3	PL_{1000}
31.1	PL_{1500}
34.7	PL_{2000}
37.3	PL_{2500}
0.152	EAL

Figure B- 4 Concrete Moment Resistant Frame – 1 Story - Soil type D – Ponce



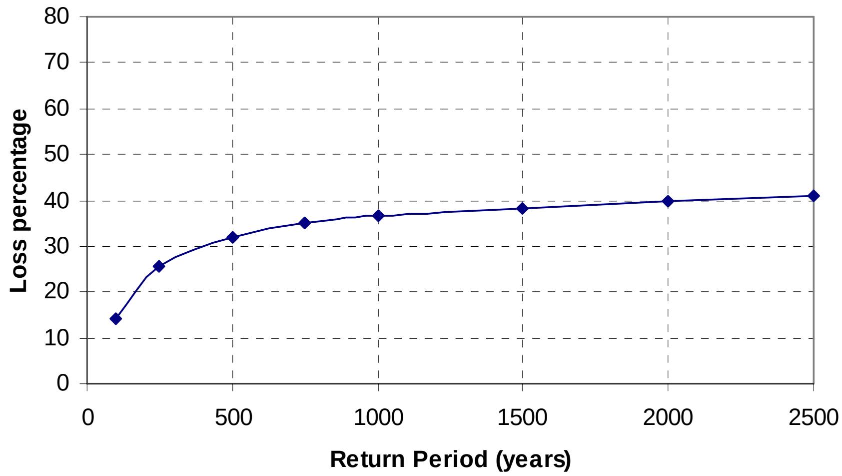
Probable Loss [%]	Name
14.1	PL_{100}
24.6	PL_{250}
28.8	PL_{500}
30.3	PL_{750}
31.0	PL_{1000}
30.4	PL_{1500}
30.6	PL_{2000}
29.7	PL_{2500}
0.230	EAL

Figure B- 5 Concrete Moment Resistant Frame – 1 Story - Soil type E – Ponce



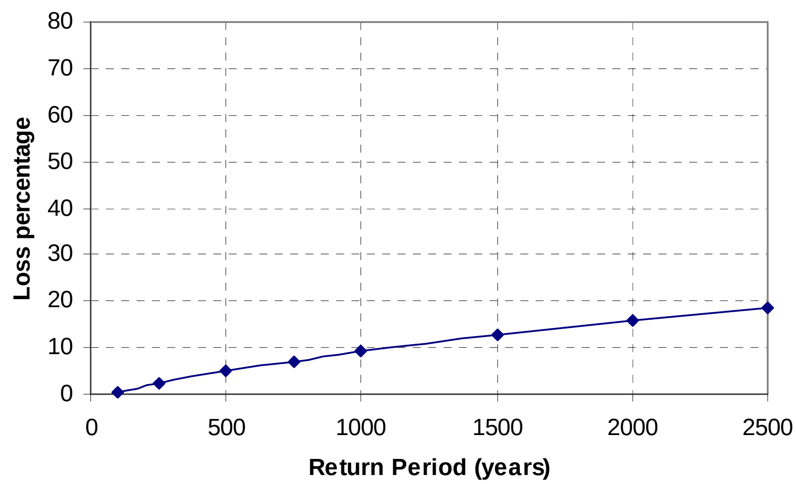
Probable Loss [%]	Name
14.1	PL_{100}
26.3	PL_{250}
35.4	PL_{500}
39.7	PL_{750}
42.7	PL_{1000}
46.0	PL_{1500}
48.9	PL_{2000}
52.1	PL_{2500}
0.270	EAL

Figure B- 6 Concrete Moment Resistant Frame – 1 Story - Soil type F (Shallow Foundation) – Ponce



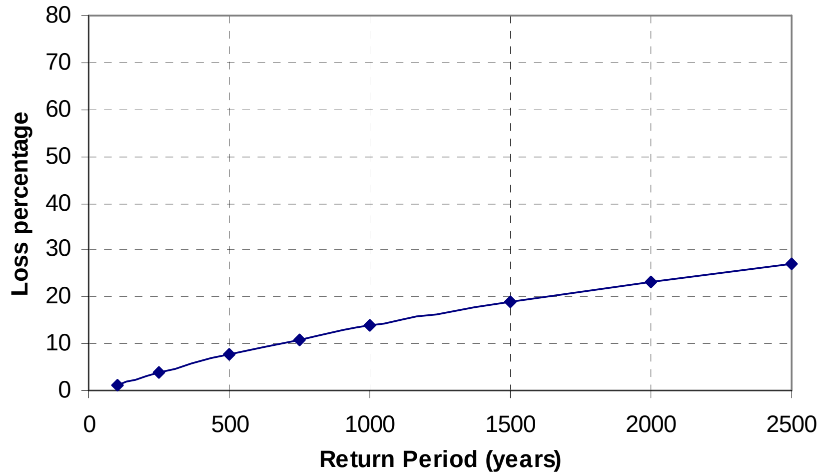
Probable Loss [%]	Name
14.1	PL_{100}
25.4	PL_{250}
32.1	PL_{500}
35.0	PL_{750}
36.8	PL_{1000}
38.2	PL_{1500}
39.7	PL_{2000}
40.9	PL_{2500}
0.250	EAL

Figure B- 7 Concrete Moment Resistant Frame – 1 Story - Soil type F (Deep Foundation) – Ponce



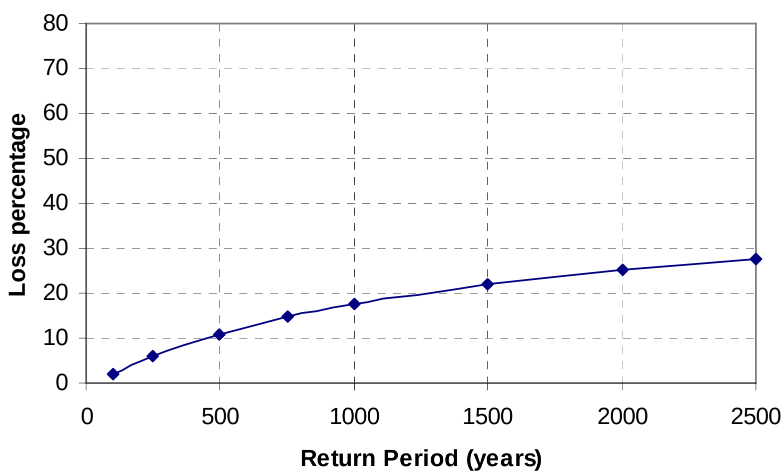
Probable Loss [%]	Name
0.6	PL_{100}
2.4	PL_{250}
5.0	PL_{500}
7.1	PL_{750}
9.1	PL_{1000}
12.6	PL_{1500}
15.7	PL_{2000}
18.5	PL_{2500}
0.038	EAL

Figure B- 8 Concrete Moment Resistant Frame – 2 Stories - Soil type A – Ponce



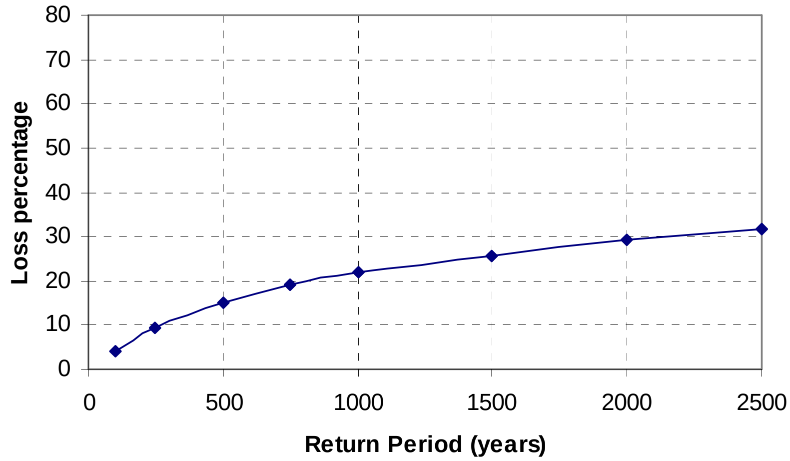
Probable Loss [%]	Name
1.2	PL_{100}
4.0	PL_{250}
7.7	PL_{500}
10.9	PL_{750}
13.9	PL_{1000}
19.0	PL_{1500}
23.3	PL_{2000}
27.0	PL_{2500}
0.060	EAL

Figure B- 9 Concrete Moment Resistant Frame – 2 Stories - Soil type B – Ponce



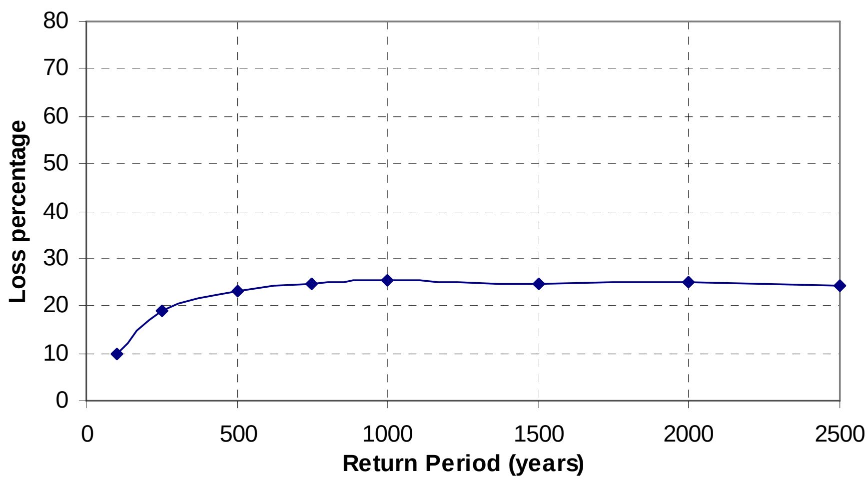
Probable Loss [%]	Name
2.0	PL_{100}
5.8	PL_{250}
11.0	PL_{500}
14.8	PL_{750}
17.8	PL_{1000}
22.0	PL_{1500}
25.2	PL_{2000}
27.4	PL_{2500}
0.078	EAL

Figure B- 10 Concrete Moment Resistant Frame – 2 Stories - Soil type C – Ponce



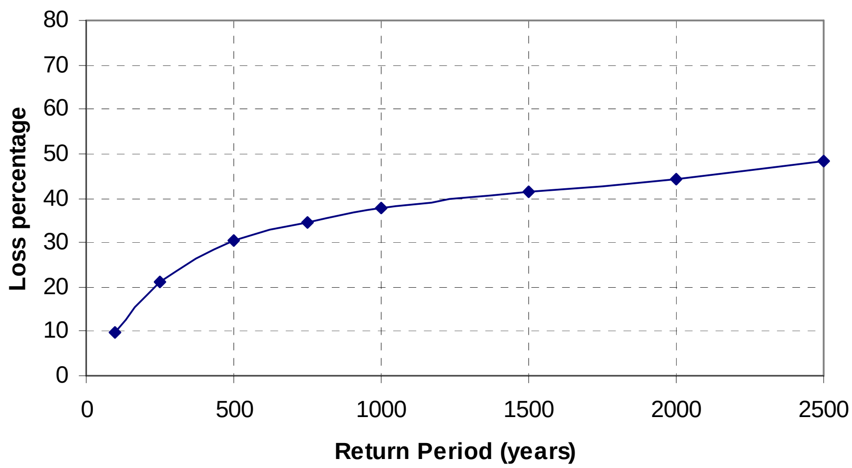
Probable Loss [%]	Name
4.0	PL_{100}
9.4	PL_{250}
15.2	PL_{500}
19.0	PL_{750}
21.8	PL_{1000}
25.5	PL_{1500}
29.1	PL_{2000}
31.7	PL_{2500}
0.111	EAL

Figure B- 11 Concrete Moment Resistant Frame – 2 Stories - Soil type D – Ponce



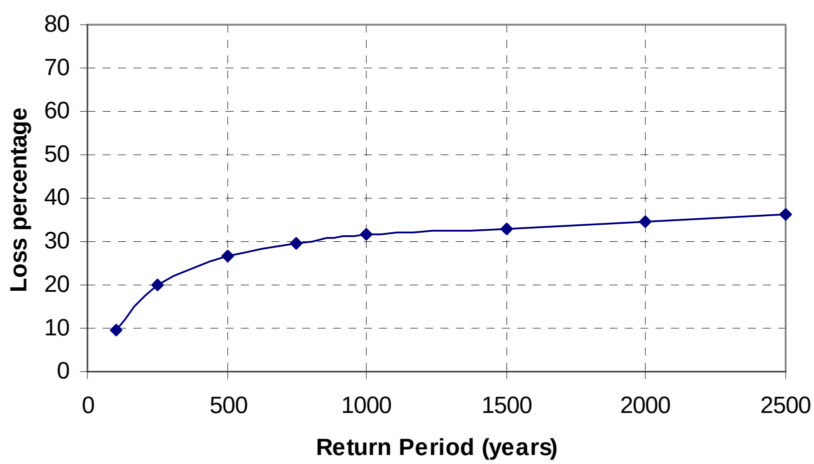
Probable Loss [%]	Name
9.7	PL_{100}
19.1	PL_{250}
23.2	PL_{500}
24.7	PL_{750}
25.4	PL_{1000}
24.8	PL_{1500}
25.0	PL_{2000}
24.1	PL_{2500}
0.178	EAL

Figure B- 12 Concrete Moment Resistant Frame – 2 Stories - Soil type E – Ponce



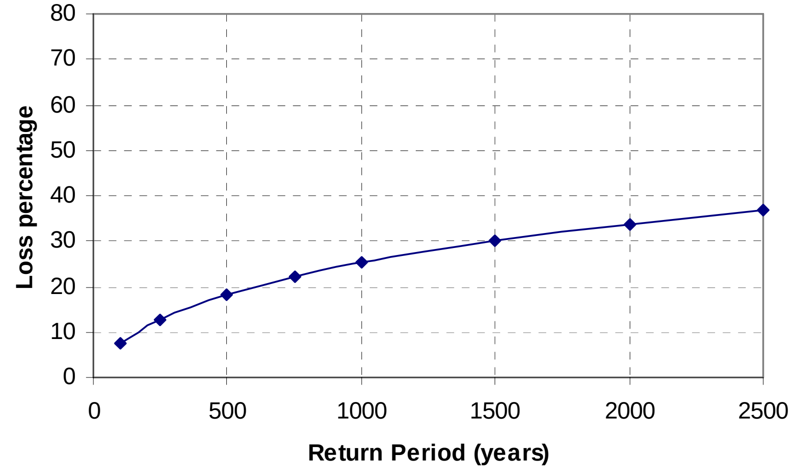
Probable Loss [%]	Name
9.8	PL_{100}
21.0	PL_{250}
30.4	PL_{500}
34.7	PL_{750}
37.8	PL_{1000}
41.4	PL_{1500}
44.5	PL_{2000}
48.1	PL_{2500}
0.222	EAL

Figure B- 13 Concrete Moment Resistant Frame – 2 Story - Soil type F (Shallow Foundation) – Ponce



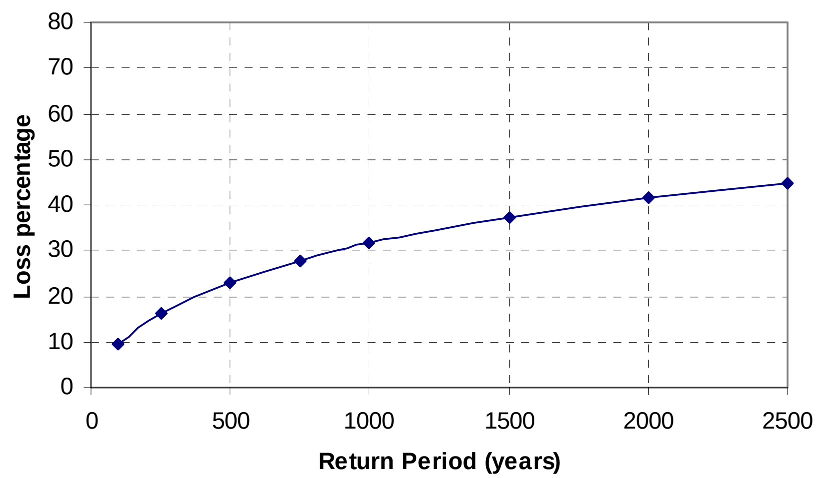
Probable Loss [%]	Name
9.7	PL_{100}
20.1	PL_{250}
26.8	PL_{500}
29.7	PL_{750}
31.6	PL_{1000}
33.1	PL_{1500}
34.7	PL_{2000}
36.1	PL_{2500}
0.200	EAL

Figure B- 14 Concrete Moment Resistant Frame – 2 Story - Soil type F (Deep Foundation) – Ponce



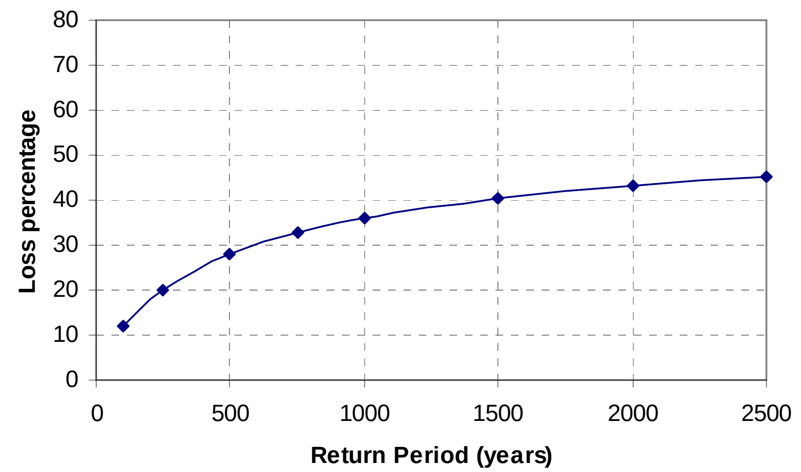
Probable Loss [%]	Name
7.4	PL_{100}
12.7	PL_{250}
18.2	PL_{500}
22.1	PL_{750}
25.2	PL_{1000}
29.9	PL_{1500}
33.7	PL_{2000}
36.7	PL_{2500}
0.145	EAL

Figure B- 15 Concrete Shear Wall – 1 Stories - Soil type A – Ponce



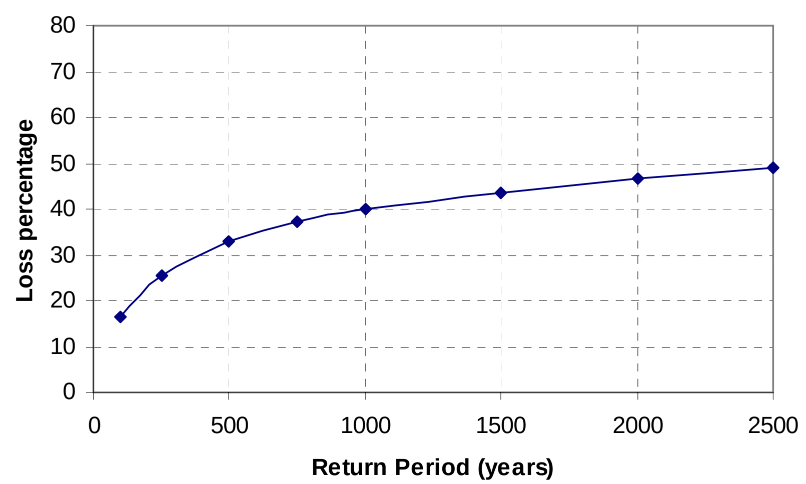
Probable Loss [%]	Name
9.6	PL_{100}
16.3	PL_{250}
23.1	PL_{500}
27.8	PL_{750}
31.6	PL_{1000}
37.1	PL_{1500}
41.4	PL_{2000}
44.8	PL_{2500}
0.184	EAL

Figure B- 16 Concrete Shear Wall – 1 Story - Soil type B – Ponce



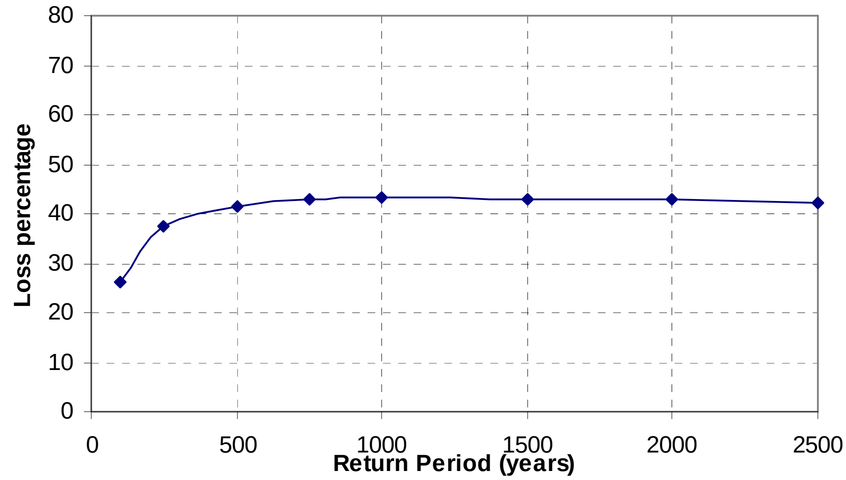
Probable Loss [%]	Name
11.9	PL_{100}
19.8	PL_{250}
27.8	PL_{500}
32.6	PL_{750}
35.9	PL_{1000}
40.2	PL_{1500}
43.2	PL_{2000}
45.2	PL_{2500}
0.216	EAL

Figure B- 17 Concrete Shear Wall – 1 Stories - Soil type C – Ponce



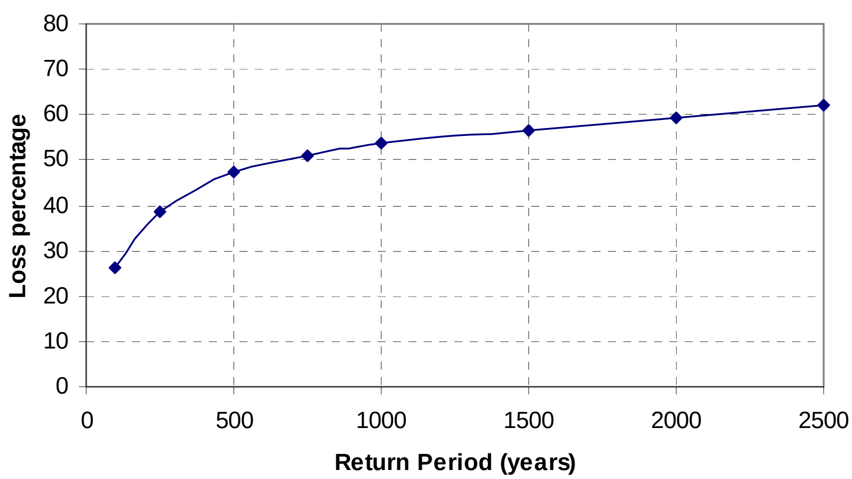
Probable Loss [%]	Name
16.3	PL_{100}
25.7	PL_{250}
33.1	PL_{500}
37.2	PL_{750}
40.0	PL_{1000}
43.5	PL_{1500}
46.7	PL_{2000}
48.9	PL_{2500}
0.267	EAL

Figure B- 18 Concrete Shear Wall – 1 Stories - Soil type D – Ponce



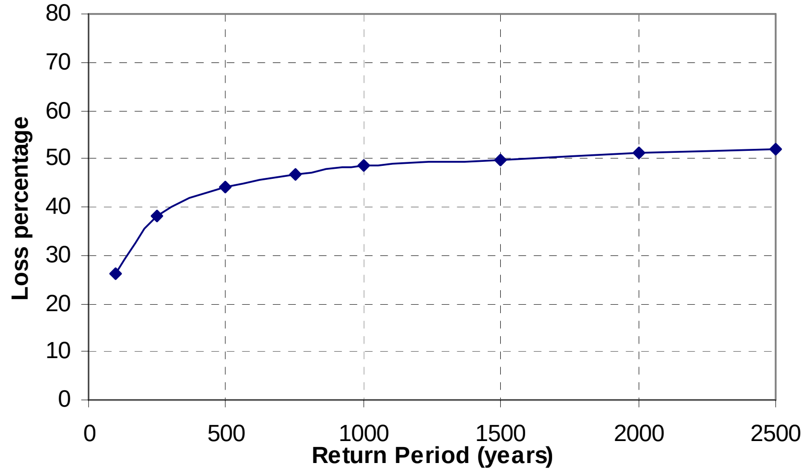
Probable Loss [%]	Name
26.1	PL_{100}
37.3	PL_{250}
41.3	PL_{500}
42.8	PL_{750}
43.4	PL_{1000}
42.8	PL_{1500}
43.0	PL_{2000}
42.2	PL_{2500}
0.354	EAL

Figure B- 19 Concrete Shear Wall – 1 Stories - Soil type E – Ponce



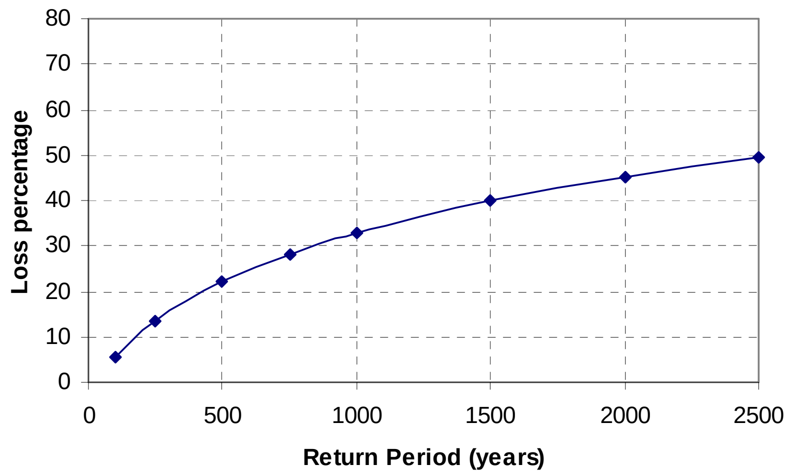
Probable Loss [%]	Name
26.2	PL_{100}
38.8	PL_{250}
47.2	PL_{500}
51.0	PL_{750}
53.8	PL_{1000}
56.6	PL_{1500}
59.2	PL_{2000}
62.1	PL_{2500}
0.390	EAL

Figure B- 20 Concrete Shear Wall – 1 Story - Soil type F (Shallow Foundation) – Ponce



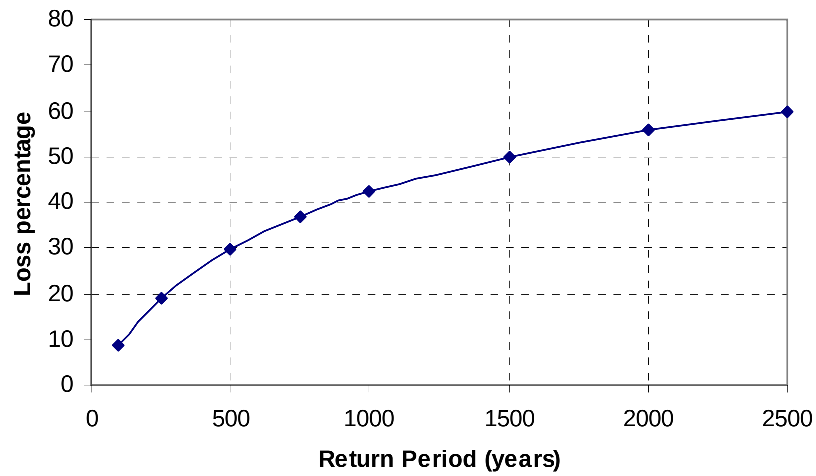
Probable Loss [%]	Name
26.1	PL_{100}
38.1	PL_{250}
44.3	PL_{500}
46.9	PL_{750}
48.6	PL_{1000}
49.7	PL_{1500}
51.1	PL_{2000}
52.1	PL_{2500}
0.372	EAL

Figure B- 21 Concrete Shear Wall – 1 Story - Soil type F (Deep Foundation) – Ponce



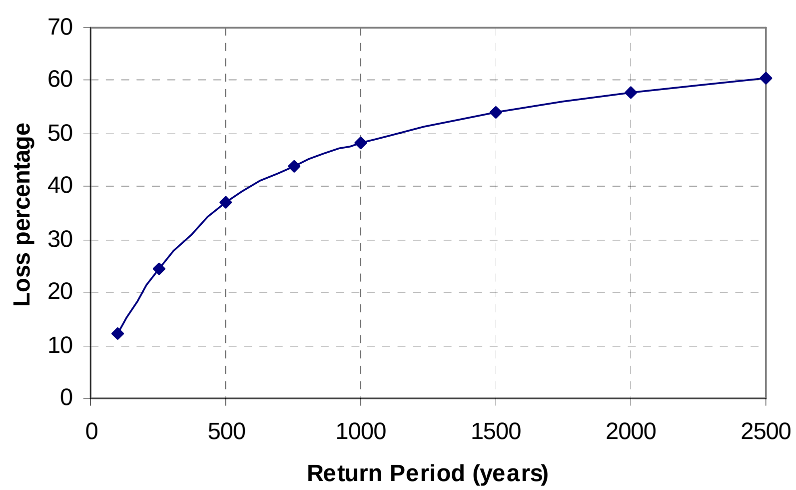
Probable Loss [%]	Name
5.7	PL_{100}
13.4	PL_{250}
22.1	PL_{500}
28.2	PL_{750}
33.0	PL_{1000}
40.0	PL_{1500}
45.3	PL_{2000}
49.4	PL_{2500}
0.164	EAL

Figure B- 22 Concrete Shear Wall – 2 Stories - Soil type A – Ponce



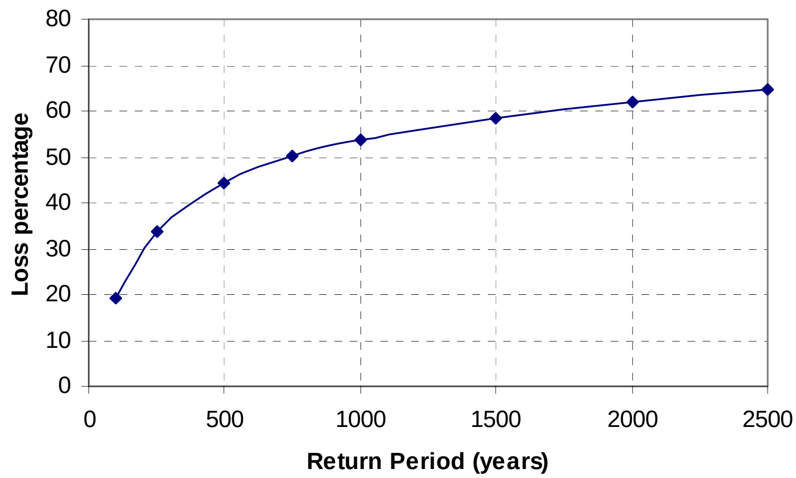
Probable Loss [%]	Name
8.7	PL_{100}
19.0	PL_{250}
29.7	PL_{500}
36.9	PL_{750}
42.4	PL_{1000}
50.1	PL_{1500}
55.7	PL_{2000}
59.9	PL_{2500}
0.221	EAL

Figure B- 23 Concrete Shear Wall – 2 Story - Soil type B – Ponce



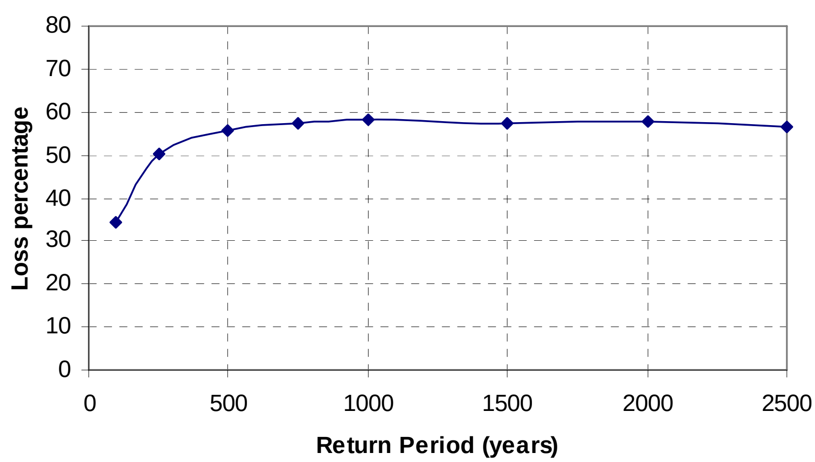
Probable Loss [%]	Name
12.1	PL_{100}
24.6	PL_{250}
36.9	PL_{500}
43.8	PL_{750}
48.4	PL_{1000}
54.1	PL_{1500}
57.9	PL_{2000}
60.4	PL_{2500}
0.270	EAL

Figure B- 24 Concrete Shear Wall – 2 Stories - Soil type C – Ponce



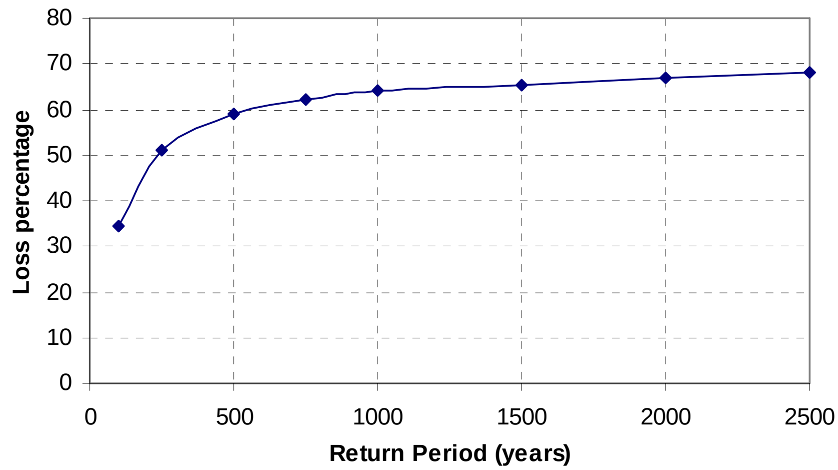
Probable Loss [%]	Name
19.1	PL_{100}
33.7	PL_{250}
44.5	PL_{500}
50.2	PL_{750}
53.8	PL_{1000}
58.2	PL_{1500}
62.1	PL_{2000}
64.8	PL_{2500}
0.346	EAL

Figure B- 25 Concrete Shear Wall – 2 Stories - Soil type D – Ponce



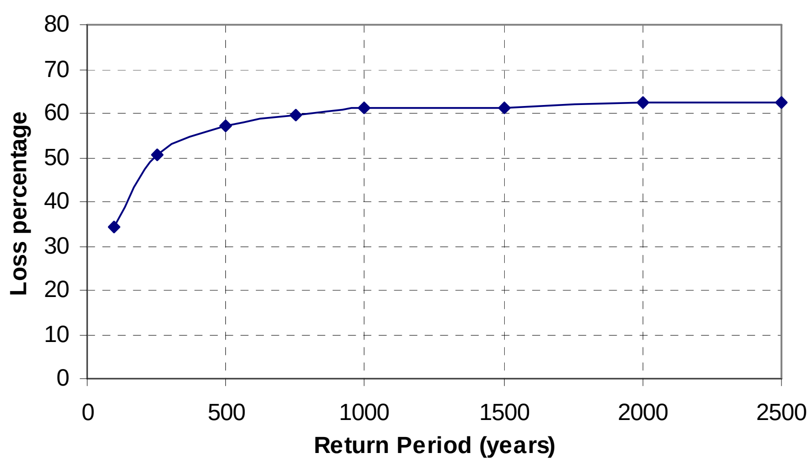
Probable Loss [%]	Name
34.4	PL_{100}
50.3	PL_{250}
55.6	PL_{500}
57.4	PL_{750}
58.1	PL_{1000}
57.5	PL_{1500}
57.6	PL_{2000}
56.6	PL_{2500}
0.474	EAL

Figure B- 26 Concrete Shear Wall – 2 Stories - Soil type E – Ponce



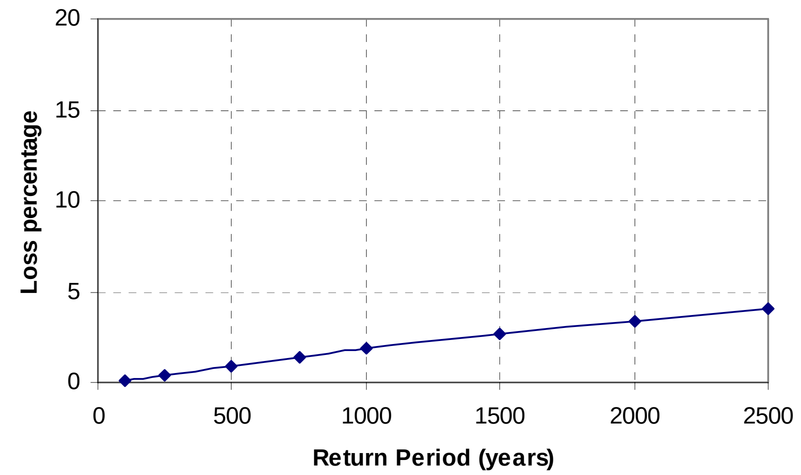
Probable Loss [%]	Name
34.4	PL_{100}
51.3	PL_{250}
59.0	PL_{500}
62.1	PL_{750}
64.0	PL_{1000}
65.4	PL_{1500}
67.0	PL_{2000}
68.2	PL_{2500}
0.495	EAL

Figure B- 27 Concrete Shear Wall – 2 Stories - Soil type F (Shallow Foundation) – Ponce



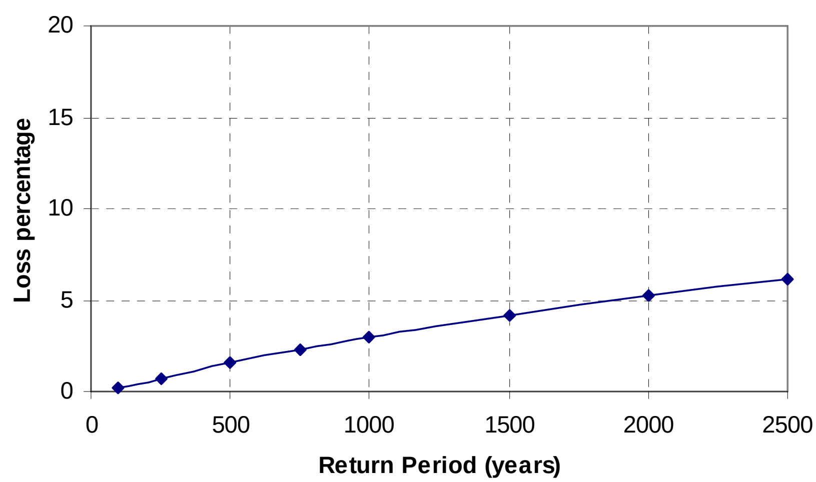
Probable Loss [%]	Name
34.4	PL_{100}
50.8	PL_{250}
57.3	PL_{500}
59.7	PL_{750}
61.1	PL_{1000}
61.4	PL_{1500}
62.3	PL_{2000}
62.4	PL_{2500}
0.485	EAL

Figure B- 28 Concrete Shear Wall – 2 Stories - Soil type F (Deep Foundation) – Ponce



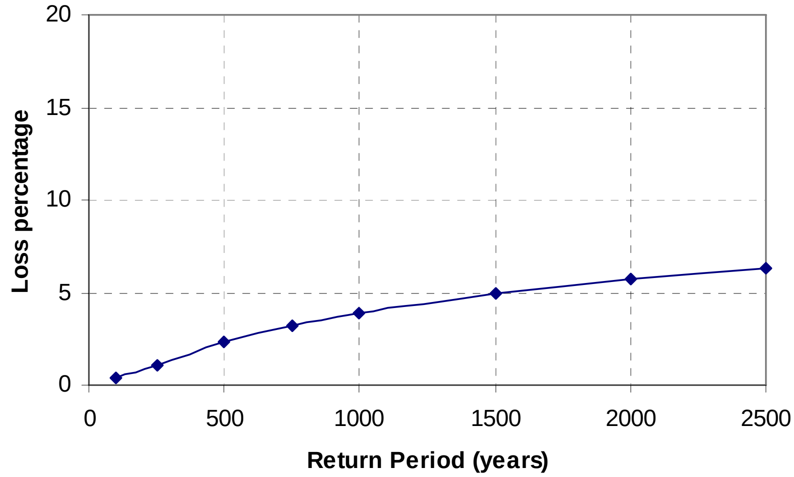
Probable Loss [%]	Name
0.1	PL_{100}
0.4	PL_{250}
0.9	PL_{500}
1.4	PL_{750}
1.9	PL_{1000}
2.7	PL_{1500}
3.4	PL_{2000}
4.1	PL_{2500}
0.008	EAL

Figure B- 29 Concrete - Multistory - Soil type A – Ponce



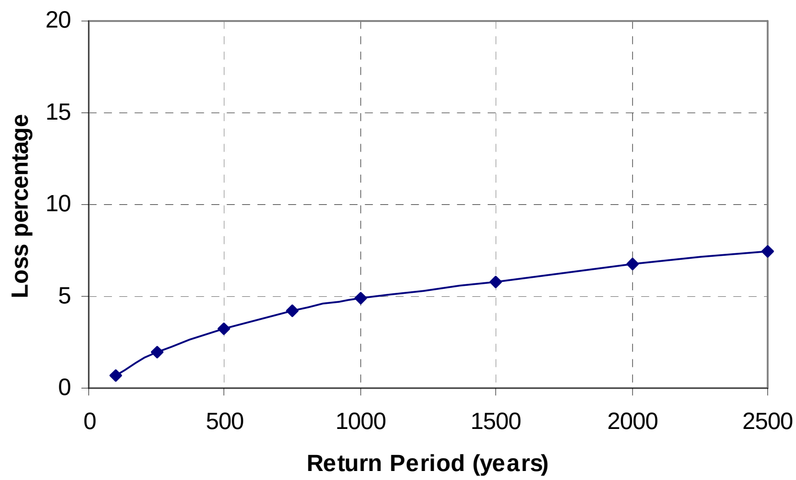
Probable Loss [%]	Name
0.2	PL_{100}
0.7	PL_{250}
1.5	PL_{500}
2.3	PL_{750}
3.0	PL_{1000}
4.2	PL_{1500}
5.2	PL_{2000}
6.2	PL_{2500}
0.012	EAL

Figure B- 30 Concrete - Multistory - Soil type B – Ponce



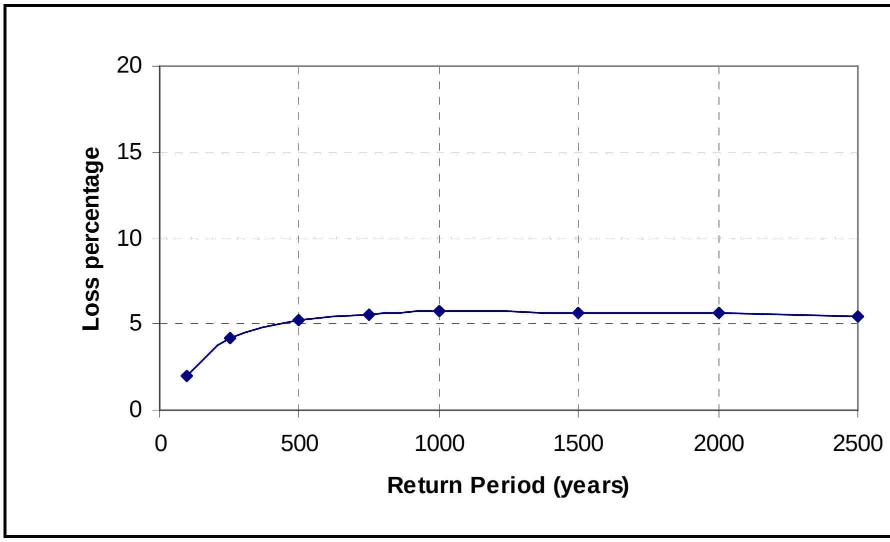
Probable Loss [%]	Name
0.4	PL_{100}
1.1	PL_{250}
2.3	PL_{500}
3.2	PL_{750}
3.9	PL_{1000}
4.9	PL_{1500}
5.7	PL_{2000}
6.3	PL_{2500}
0.016	EAL

Figure B- 31 Concrete - Multistory - Soil type C – Ponce



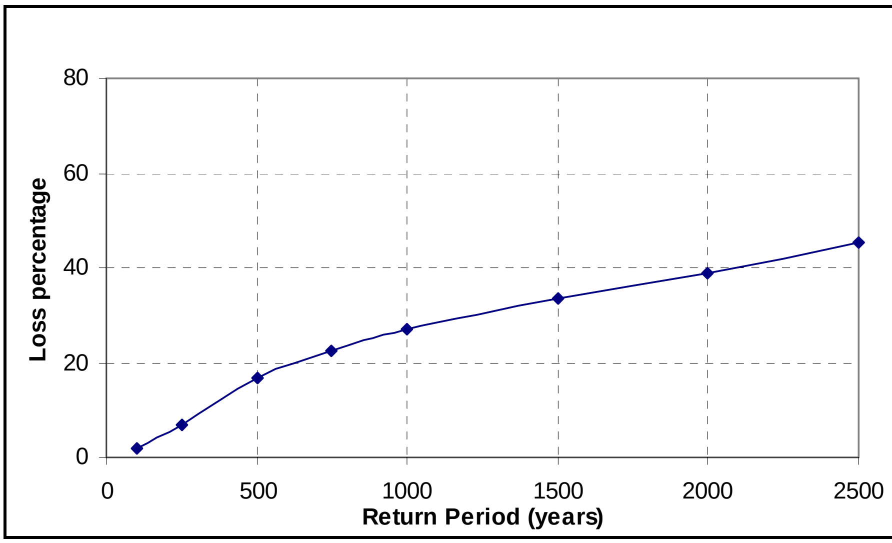
Probable Loss [%]	Name
0.7	PL_{100}
1.9	PL_{250}
3.3	PL_{500}
4.2	PL_{750}
4.9	PL_{1000}
5.8	PL_{1500}
6.7	PL_{2000}
7.4	PL_{2500}
0.024	EAL

Figure B- 32 Concrete - Multistory - Soil type D – Ponce



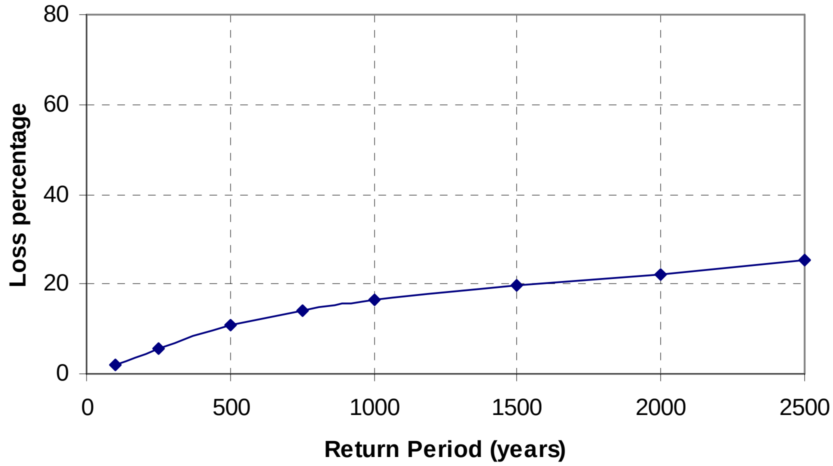
Probable Loss [%]	Name
2.0	PL_{100}
4.2	PL_{250}
5.2	PL_{500}
5.6	PL_{750}
5.8	PL_{1000}
5.6	PL_{1500}
5.7	PL_{2000}
5.4	PL_{2500}
0.039	EAL

Figure B- 33 Concrete - Multistory - Soil type E – Ponce



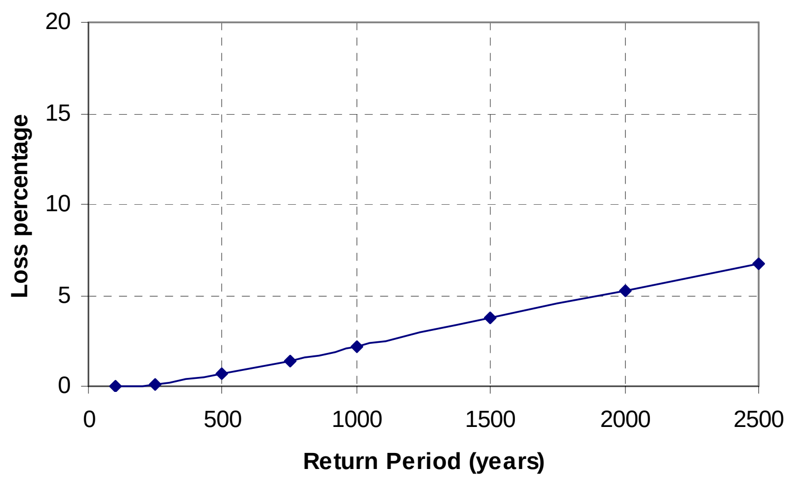
Probable Loss [%]	Name
2.0	PL_{100}
6.9	PL_{250}
16.8	PL_{500}
22.4	PL_{750}
27.0	PL_{1000}
33.6	PL_{1500}
38.7	PL_{2000}
45.4	PL_{2500}
0.111	EAL

Figure B- 34 Concrete - Multistory - Soil type F (Shallow foundation) – Ponce



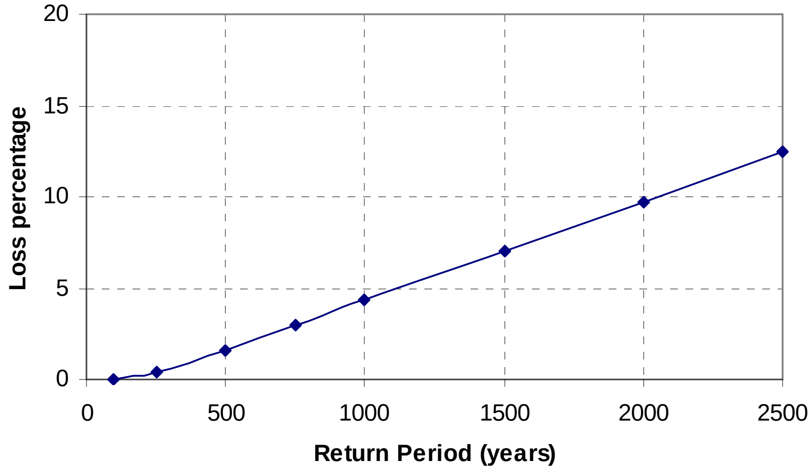
Probable Loss [%]	Name
2.0	PL_{100}
5.6	PL_{250}
11.0	PL_{500}
14.0	PL_{750}
16.4	PL_{1000}
19.6	PL_{1500}
22.2	PL_{2000}
25.4	PL_{2500}
0.075	EAL

Figure B- 35 Concrete - Multistory - Soil type F (Deep foundation) – Ponce



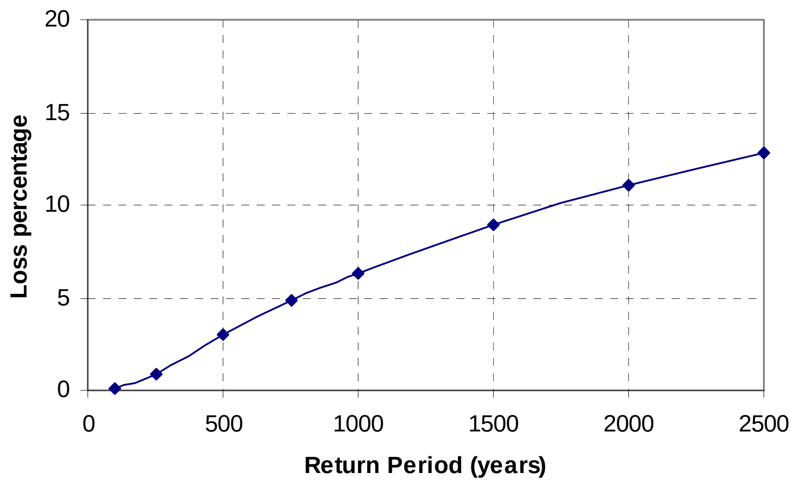
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.7	PL_{500}
1.4	PL_{750}
2.2	PL_{1000}
3.7	PL_{1500}
5.3	PL_{2000}
6.7	PL_{2500}
0.007	EAL

Figure B- 36 Steel – Low Rise - Soil type A – Ponce



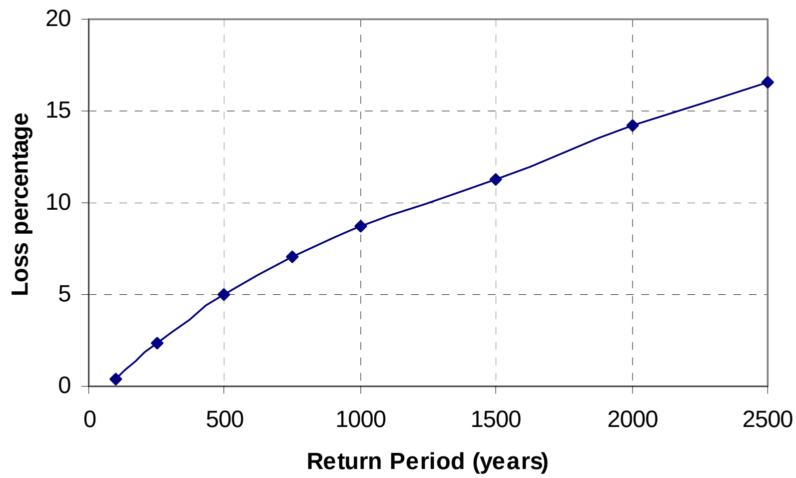
Probable Loss [%]	Name
0.0	PL_{100}
0.4	PL_{250}
1.6	PL_{500}
3.0	PL_{750}
4.4	PL_{1000}
7.0	PL_{1500}
9.7	PL_{2000}
12.4	PL_{2500}
0.015	EAL

Figure B- 37 Steel – Low Rise - Soil type B – Ponce



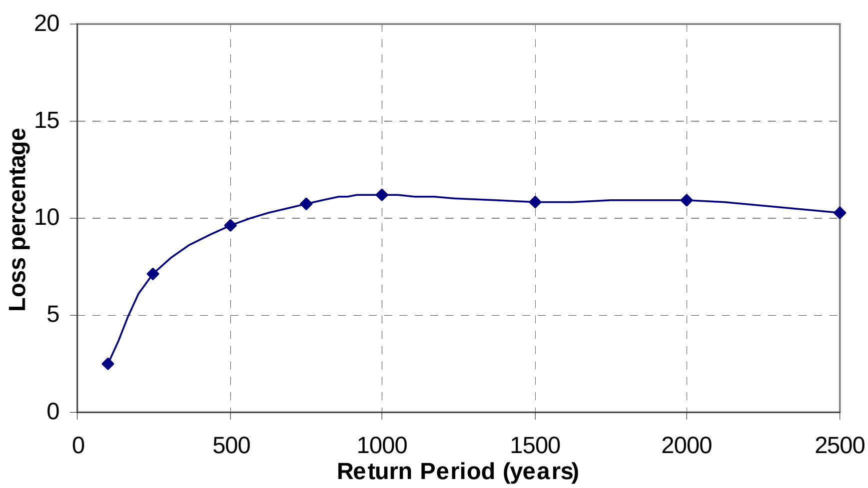
Probable Loss [%]	Name
0.1	PL_{100}
0.9	PL_{250}
3.0	PL_{500}
4.8	PL_{750}
6.3	PL_{1000}
8.9	PL_{1500}
11.1	PL_{2000}
12.8	PL_{2500}
0.022	EAL

Figure B- 38 Steel – Low Rise - Soil type C – Ponce



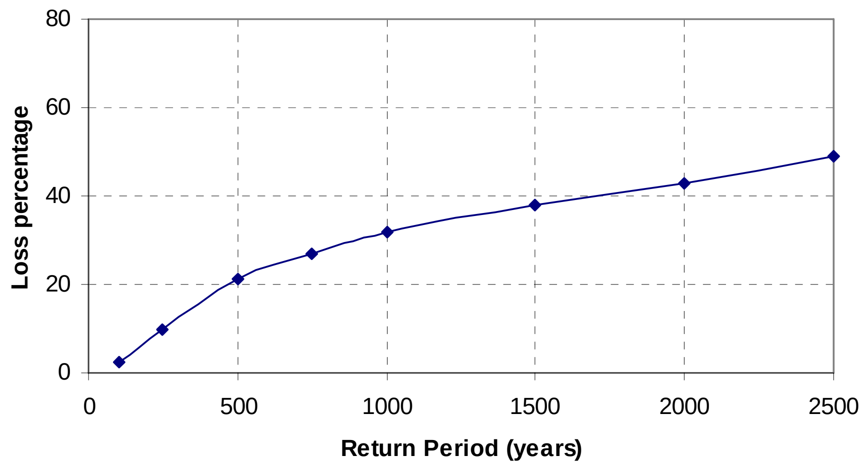
Probable Loss [%]	Name
0.4	PL_{100}
2.3	PL_{250}
5.0	PL_{500}
7.1	PL_{750}
8.7	PL_{1000}
11.3	PL_{1500}
14.2	PL_{2000}
16.5	PL_{2500}
0.036	EAL

Figure B- 39 Steel – Low Rise - Soil type D – Ponce



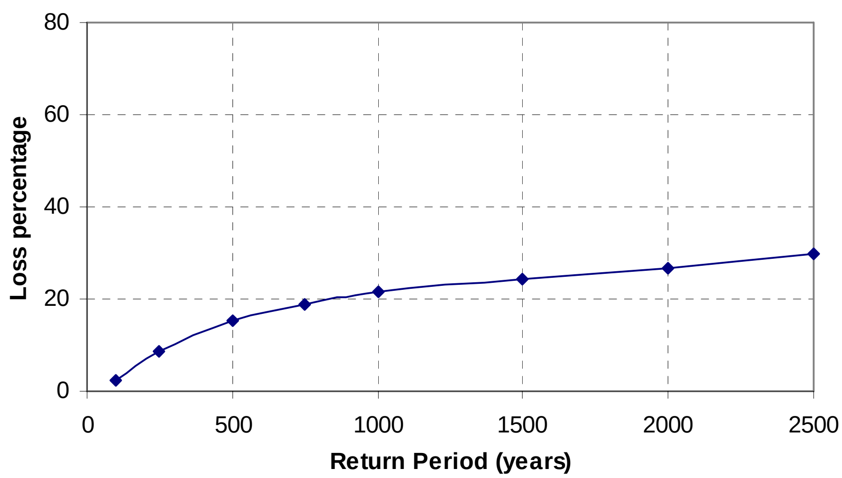
Probable Loss [%]	Name
2.5	PL_{100}
7.1	PL_{250}
9.7	PL_{500}
10.7	PL_{750}
11.2	PL_{1000}
10.8	PL_{1500}
10.9	PL_{2000}
10.3	PL_{2500}
0.067	EAL

Figure B- 40 Steel – Low Rise - Soil type E – Ponce



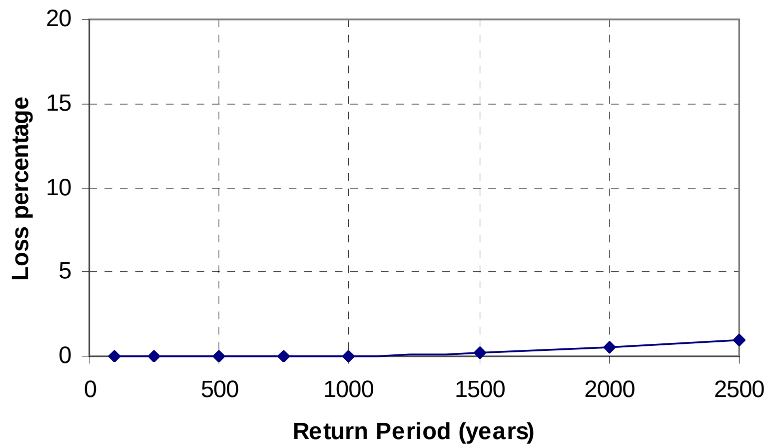
Probable Loss [%]	Name
2.5	PL_{100}
9.9	PL_{250}
21.1	PL_{500}
27.0	PL_{750}
31.6	PL_{1000}
37.9	PL_{1500}
42.8	PL_{2000}
49.2	PL_{2500}
0.136	EAL

Figure B- 41 Steel – Low Rise - Soil type F (Shallow foundation) – Ponce



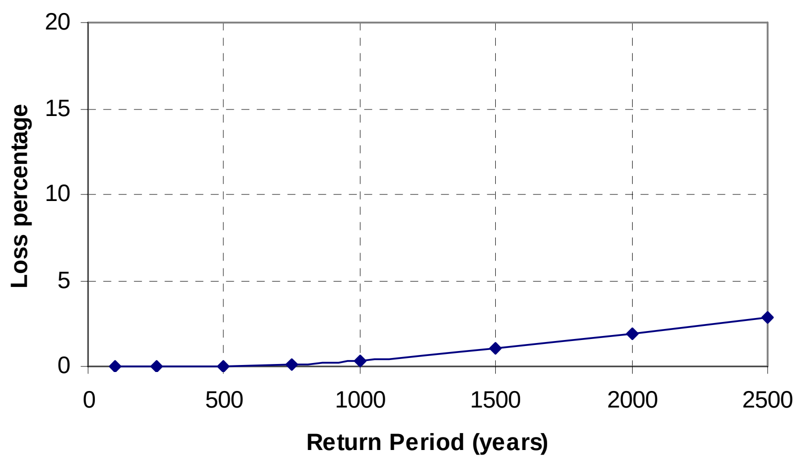
Probable Loss [%]	Name
2.5	PL_{100}
8.5	PL_{250}
15.4	PL_{500}
18.9	PL_{750}
21.4	PL_{1000}
24.3	PL_{1500}
26.9	PL_{2000}
29.7	PL_{2500}
0.101	EAL

Figure B- 42 Steel – Low Rise - Soil type F (Deep foundation) – Ponce



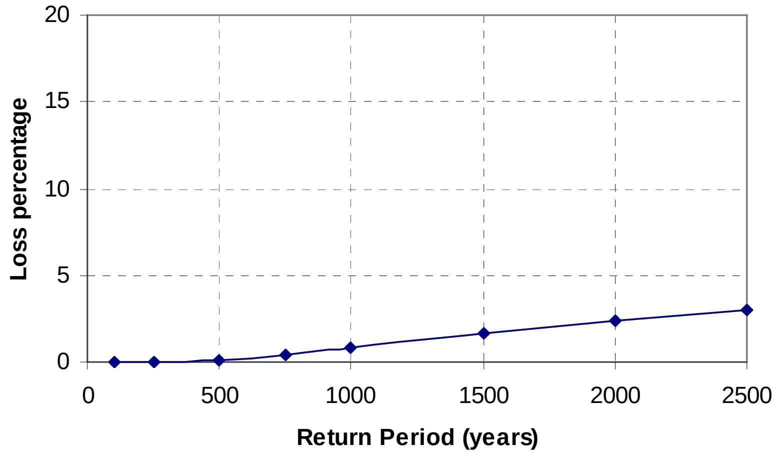
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.0	PL_{750}
0.0	PL_{1000}
0.2	PL_{1500}
0.6	PL_{2000}
1.0	PL_{2500}
0.001	EAL

Figure B- 43 Steel – Mid Rise - Soil type A – Ponce



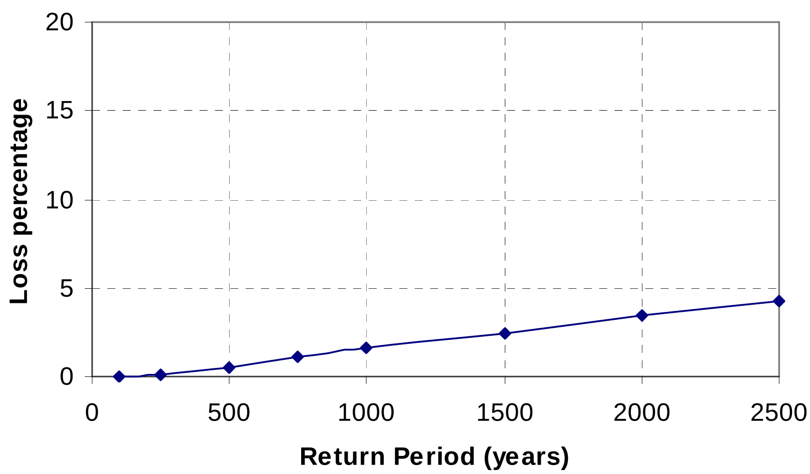
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.1	PL_{750}
0.3	PL_{1000}
1.1	PL_{1500}
1.9	PL_{2000}
2.9	PL_{2500}
0.002	EAL

Figure B- 44 Steel – Mid Rise - Soil type B – Ponce



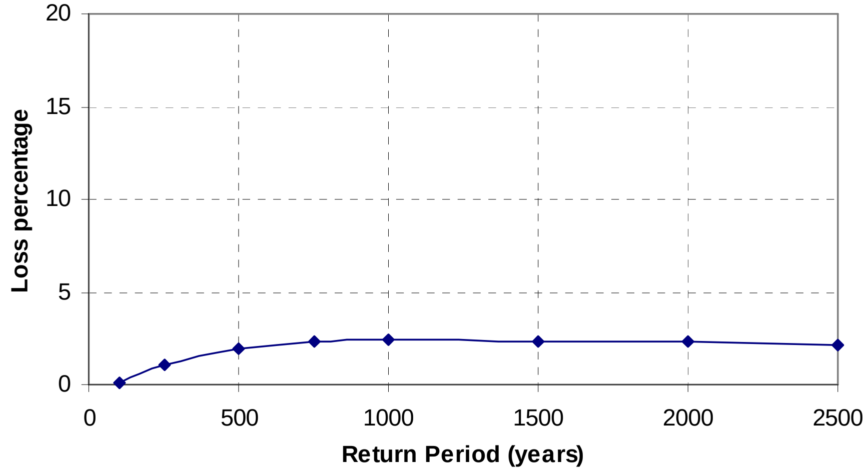
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.1	PL_{500}
0.4	PL_{750}
0.9	PL_{1000}
1.7	PL_{1500}
2.4	PL_{2000}
3.0	PL_{2500}
0.003	EAL

Figure B- 45 Steel – Mid Rise - Soil type C – Ponce



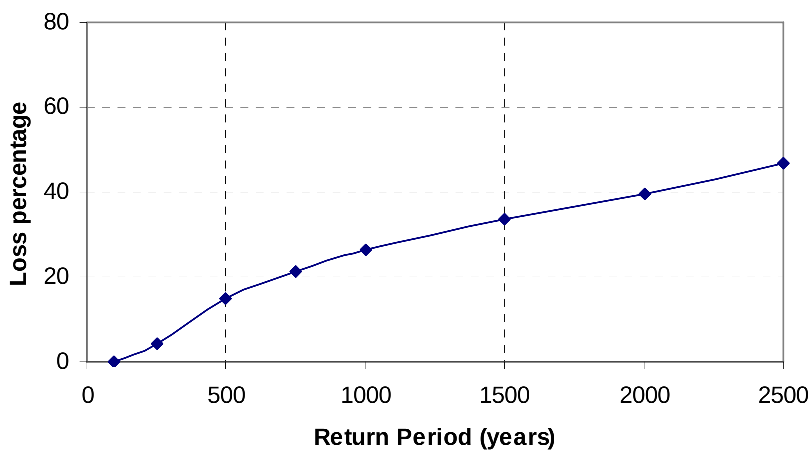
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.5	PL_{500}
1.1	PL_{750}
1.6	PL_{1000}
2.5	PL_{1500}
3.5	PL_{2000}
4.3	PL_{2500}
0.005	EAL

Figure B- 46 Steel – Mid Rise - Soil type D – Ponce



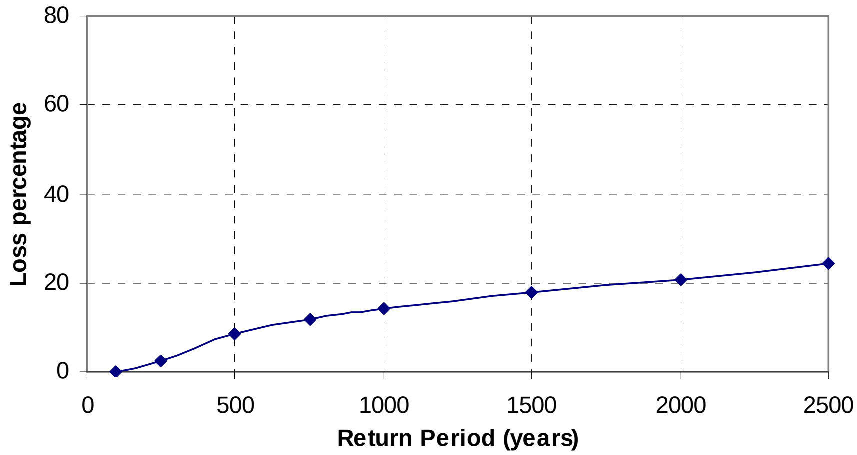
Probable Loss [%]	Name
0.1	PL_{100}
1.1	PL_{250}
1.9	PL_{500}
2.3	PL_{750}
2.5	PL_{1000}
2.3	PL_{1500}
2.3	PL_{2000}
2.1	PL_{2500}
0.011	EAL

Figure B- 47 Steel – Mid Rise - Soil type E – Ponce



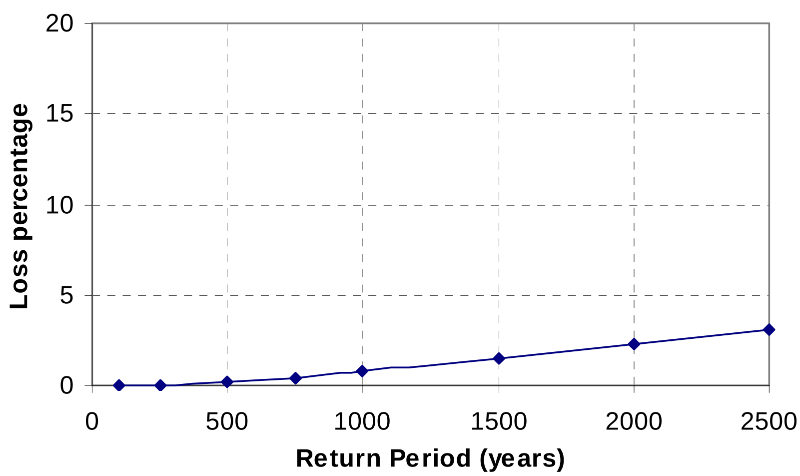
Probable Loss [%]	Name
0.1	PL_{100}
4.1	PL_{250}
15.0	PL_{500}
21.1	PL_{750}
26.2	PL_{1000}
33.7	PL_{1500}
39.4	PL_{2000}
46.9	PL_{2500}
0.091	EAL

Figure B- 48 Steel – Mid Rise - Soil type F (Shallow foundation) – Ponce



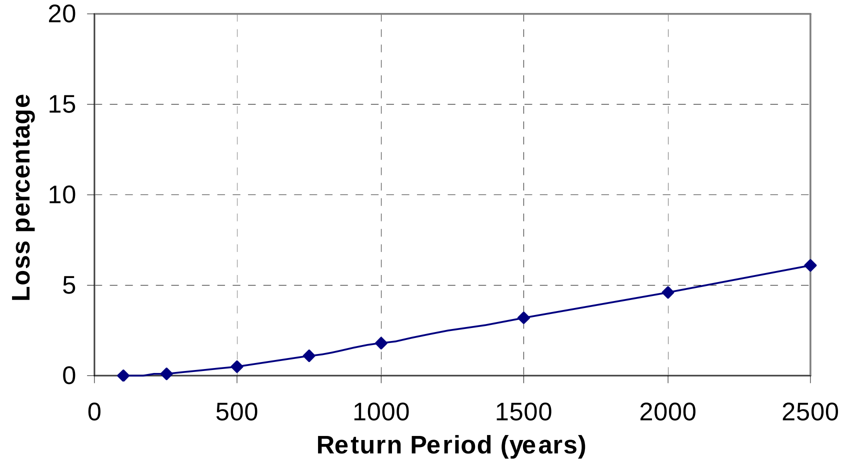
Probable Loss [%]	Name
0.1	PL_{100}
2.6	PL_{250}
8.4	PL_{500}
11.7	PL_{750}
14.4	PL_{1000}
18.0	PL_{1500}
20.9	PL_{2000}
24.5	PL_{2500}
0.051	EAL

Figure B- 49 Steel – Mid Rise - Soil type F (Deep foundation) – Ponce



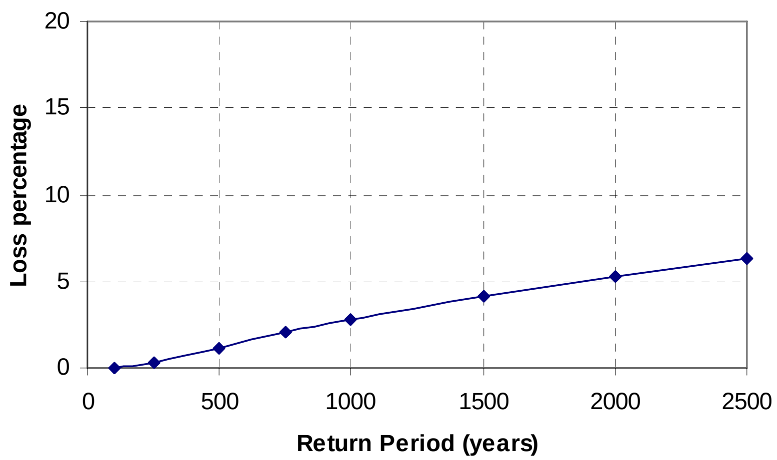
Probable Loss [%]	Name
0.00	PL_{100}
0.02	PL_{250}
0.18	PL_{500}
0.44	PL_{750}
0.78	PL_{1000}
1.51	PL_{1500}
2.28	PL_{2000}
3.05	PL_{2500}
0.003	EAL

Figure B- 50 Steel – High Rise - Soil type A – Ponce



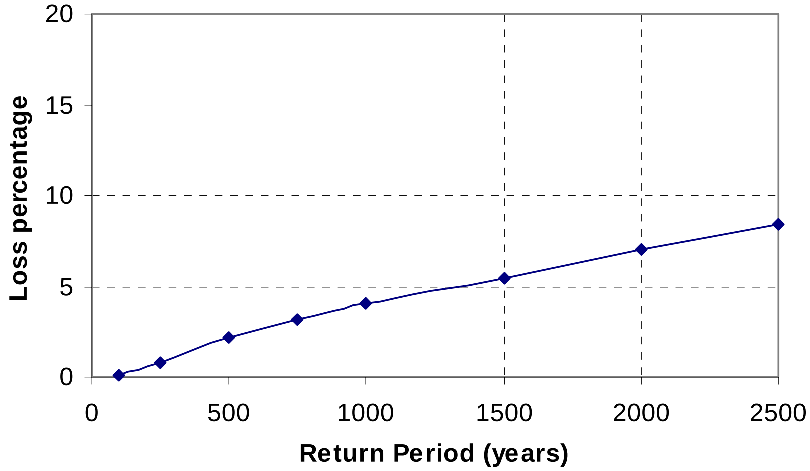
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.5	PL_{500}
1.1	PL_{750}
1.8	PL_{1000}
3.2	PL_{1500}
4.6	PL_{2000}
6.1	PL_{2500}
0.006	EAL

Figure B- 51 Steel – High Rise - Soil type B – Ponce



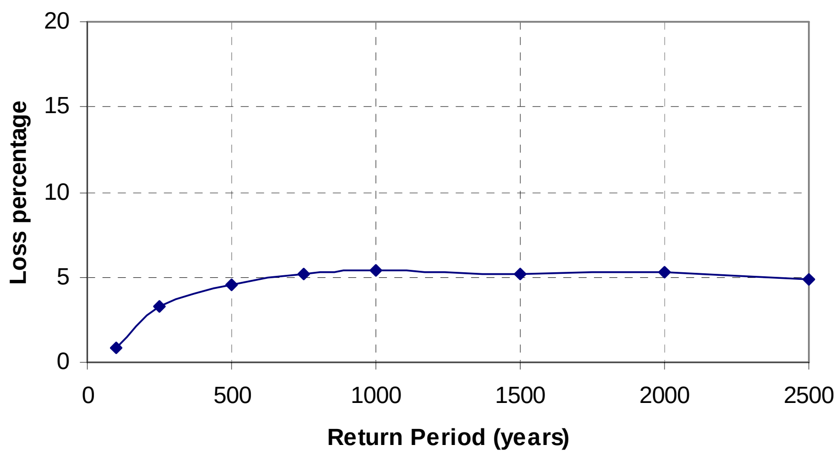
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.1	PL_{500}
2.0	PL_{750}
2.8	PL_{1000}
4.2	PL_{1500}
5.3	PL_{2000}
6.3	PL_{2500}
0.009	EAL

Figure B- 52 Steel – High Rise - Soil type C – Ponce



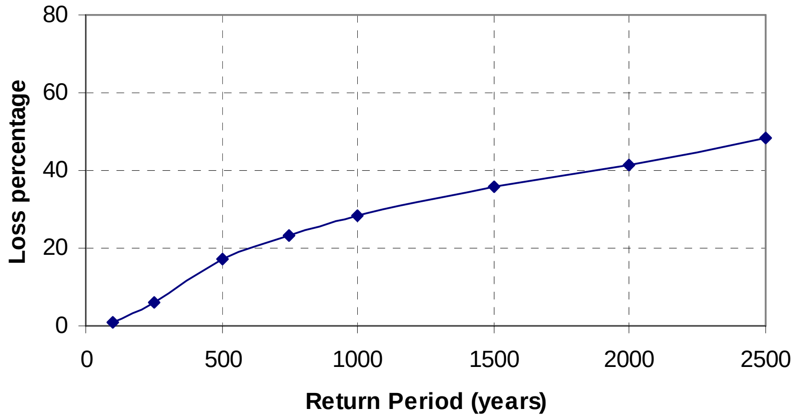
Probable Loss [%]	Name
0.1	PL_{100}
0.8	PL_{250}
2.1	PL_{500}
3.2	PL_{750}
4.1	PL_{1000}
5.5	PL_{1500}
7.1	PL_{2000}
8.4	PL_{2500}
0.016	EAL

Figure B- 53 Steel – High Rise - Soil type D – Ponce



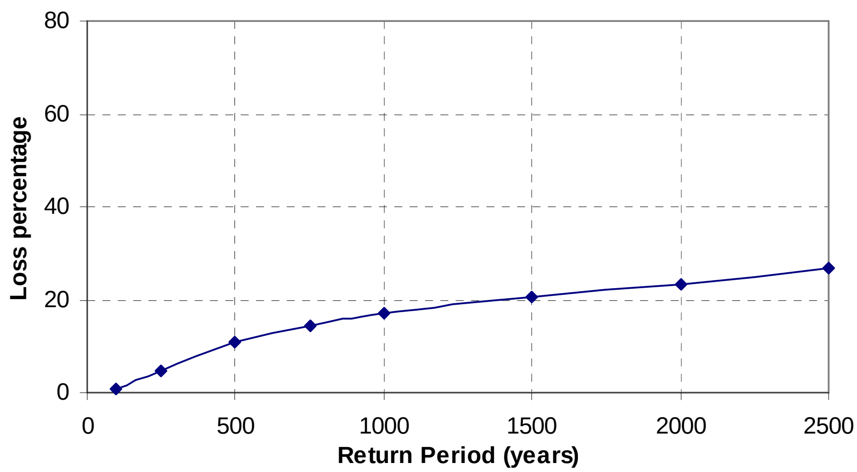
Probable Loss [%]	Name
0.9	PL_{100}
3.2	PL_{250}
4.6	PL_{500}
5.2	PL_{750}
5.4	PL_{1000}
5.2	PL_{1500}
5.3	PL_{2000}
4.9	PL_{2500}
0.030	EAL

Figure B- 54 Steel – High Rise - Soil type E – Ponce



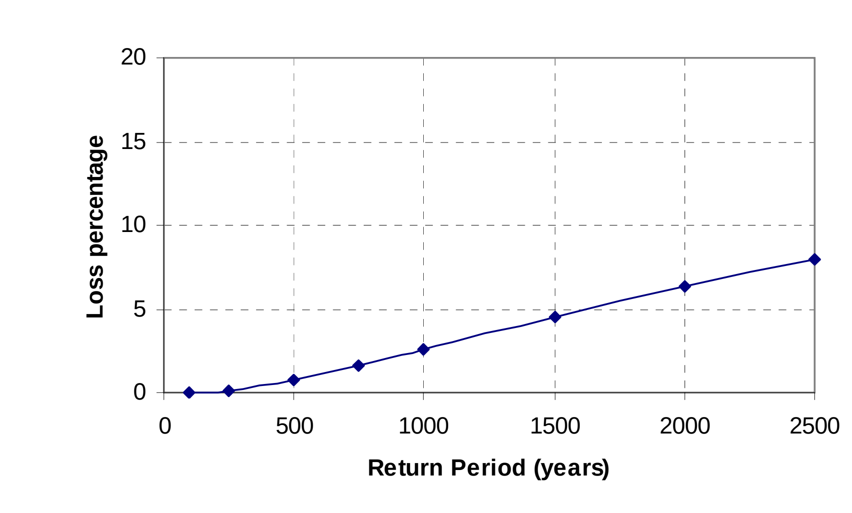
Probable Loss [%]	Name
1.0	PL_{100}
6.2	PL_{250}
17.3	PL_{500}
23.4	PL_{750}
28.5	PL_{1000}
35.7	PL_{1500}
41.2	PL_{2000}
48.5	PL_{2500}
0.108	EAL

Figure B- 55 Steel – High Rise - Soil type F (Shallow foundation) – Ponce



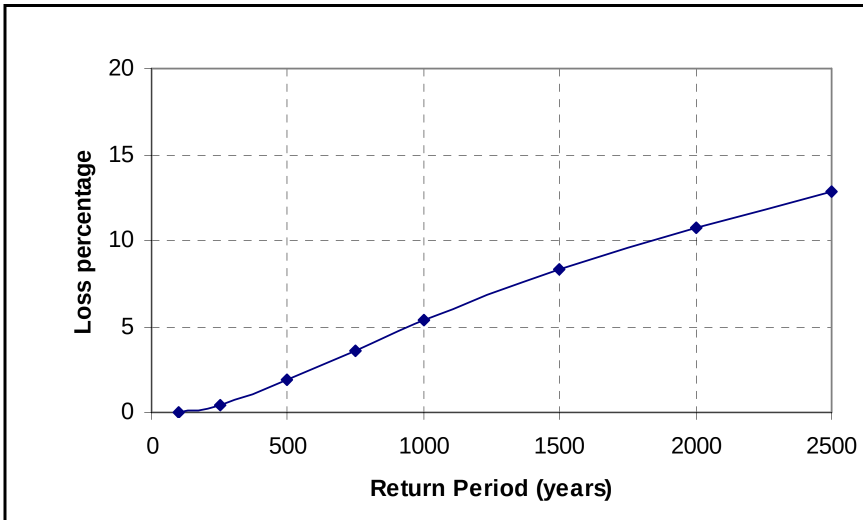
Probable Loss [%]	Name
0.9	PL_{100}
4.7	PL_{250}
10.9	PL_{500}
14.3	PL_{750}
17.0	PL_{1000}
20.4	PL_{1500}
23.2	PL_{2000}
26.7	PL_{2500}
0.069	EAL

Figure B- 56 Steel – High Rise - Soil type F (Deep foundation) – Ponce



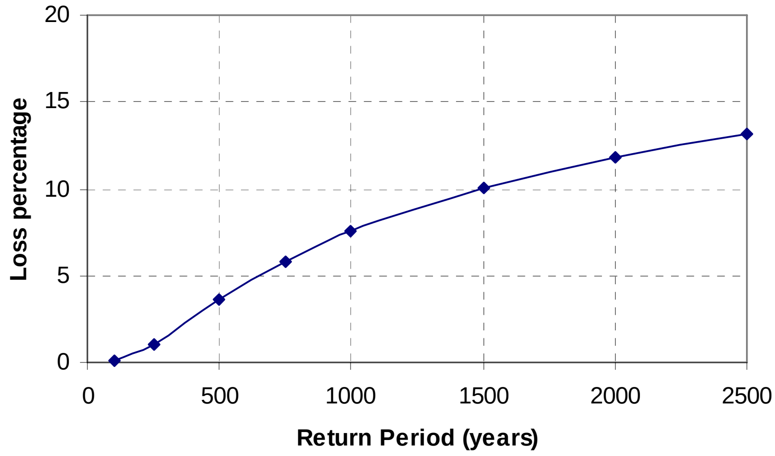
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.8	PL_{500}
1.6	PL_{750}
2.6	PL_{1000}
4.6	PL_{1500}
6.4	PL_{2000}
8.0	PL_{2500}
0.009	EAL

Figure B- 57 Steel – Industrial – 1 Story - Soil type A – Ponce



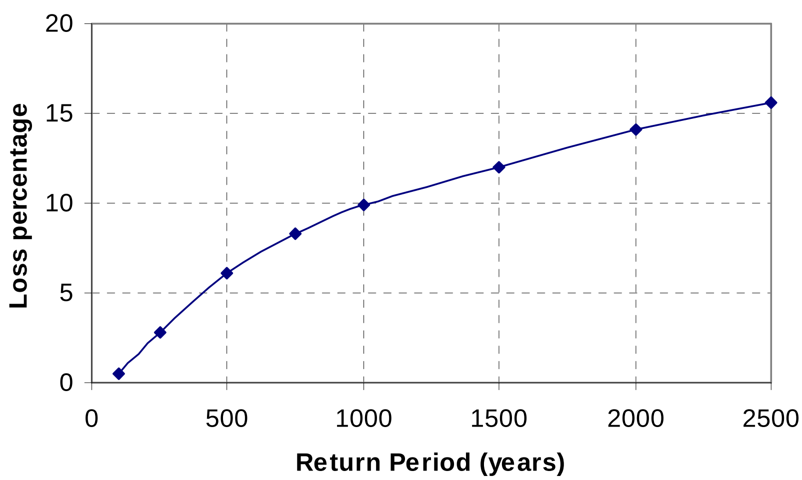
Probable Loss [%]	Name
0.0	PL_{100}
0.5	PL_{250}
1.9	PL_{500}
3.6	PL_{750}
5.3	PL_{1000}
8.3	PL_{1500}
10.8	PL_{2000}
12.9	PL_{2500}
0.017	EAL

Figure B- 58 Steel – Industrial – 1 Story - Soil type B – Ponce



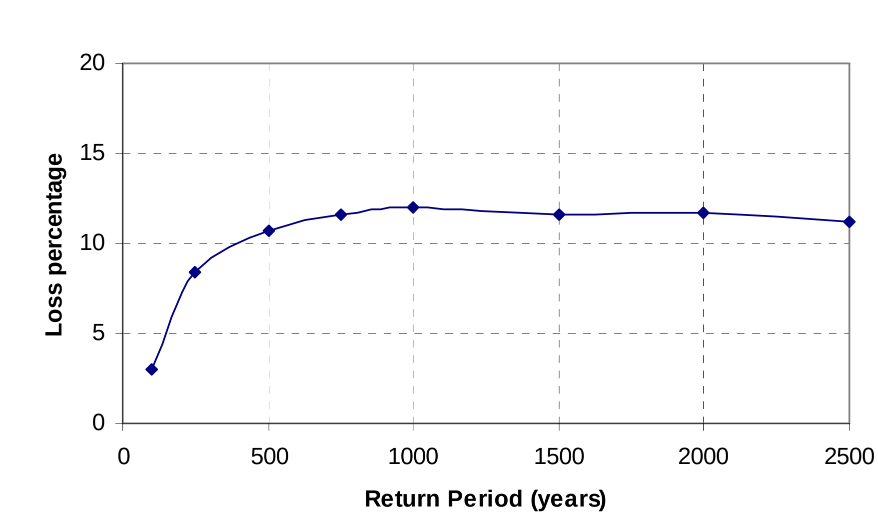
Probable Loss [%]	Name
0.1	PL_{100}
1.1	PL_{250}
3.6	PL_{500}
5.8	PL_{750}
7.6	PL_{1000}
10.0	PL_{1500}
11.8	PL_{2000}
13.1	PL_{2500}
0.025	EAL

Figure B- 59 Steel –Industrial – 1 Story - Soil type C – Ponce



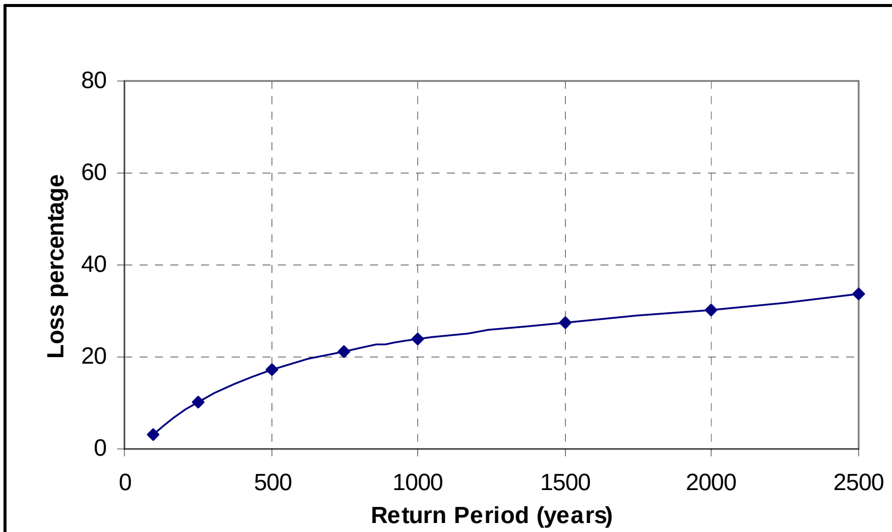
Probable Loss [%]	Name
0.5	PL_{100}
2.8	PL_{250}
6.1	PL_{500}
8.3	PL_{750}
9.9	PL_{1000}
12.0	PL_{1500}
14.1	PL_{2000}
15.6	PL_{2500}
0.040	EAL

Figure B- 60 Steel – Industrial – 1 Story - Soil type D – Ponce



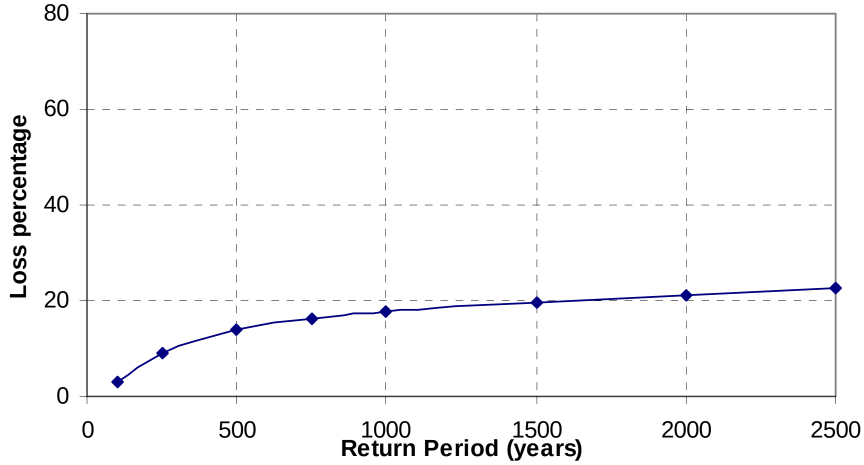
Probable Loss [%]	Name
3.0	PL_{100}
8.4	PL_{250}
10.7	PL_{500}
11.6	PL_{750}
12.0	PL_{1000}
11.6	PL_{1500}
11.7	PL_{2000}
11.2	PL_{2500}
0.076	EAL

Figure B- 61 Steel –Industrial – 1 Story - Soil type E – Ponce



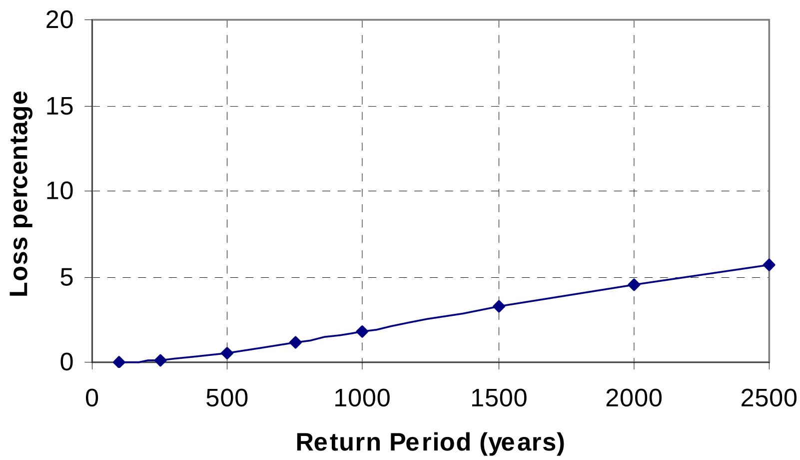
Probable Loss [%]	Name
3.0	PL_{100}
10.0	PL_{250}
17.4	PL_{500}
21.0	PL_{750}
23.8	PL_{1000}
27.3	PL_{1500}
30.2	PL_{2000}
33.8	PL_{2500}
0.117	EAL

Figure B- 62 Steel – Industrial – 1 Story - Soil type F (Shallow foundation) – Ponce



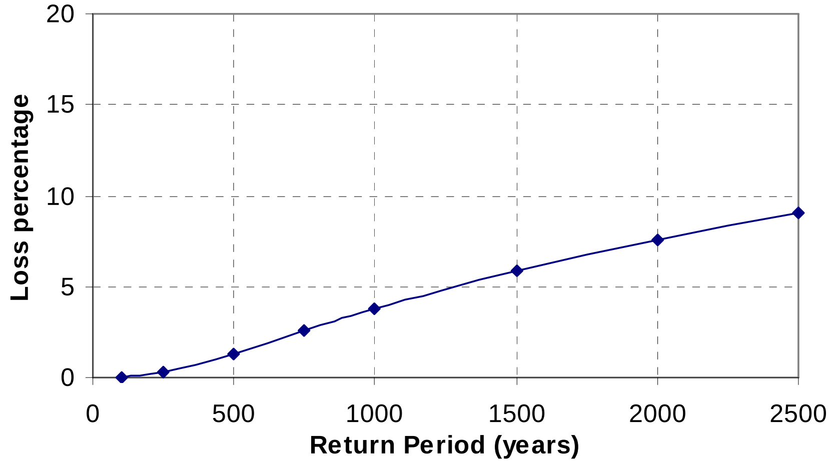
Probable Loss [%]	Name
3.0	PL_{100}
9.2	PL_{250}
14.1	PL_{500}
16.3	PL_{750}
17.9	PL_{1000}
19.5	PL_{1500}
21.0	PL_{2000}
22.5	PL_{2500}
0.096	EAL

Figure B- 63 Steel –Industrial – 1 Story - Soil type F (Deep foundation) – Ponce



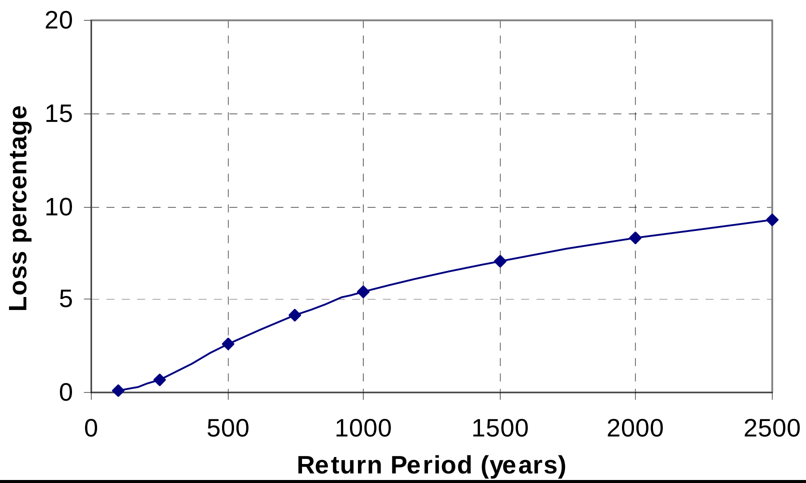
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.5	PL_{500}
1.1	PL_{750}
1.8	PL_{1000}
3.2	PL_{1500}
4.6	PL_{2000}
5.7	PL_{2500}
0.006	EAL

Figure B- 64 Steel – Industrial – 2 Story - Soil type A – Ponce



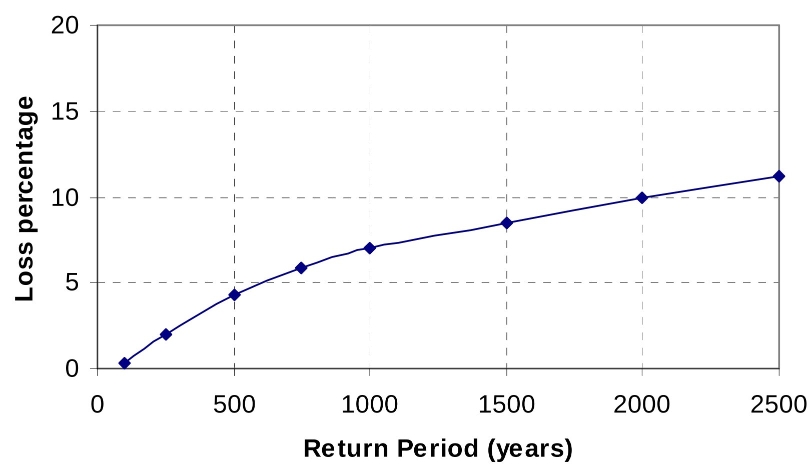
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.3	PL_{500}
2.5	PL_{750}
3.8	PL_{1000}
5.9	PL_{1500}
7.6	PL_{2000}
9.1	PL_{2500}
0.012	EAL

Figure B- 65 Steel – Industrial – 2 Story - Soil type B – Ponce



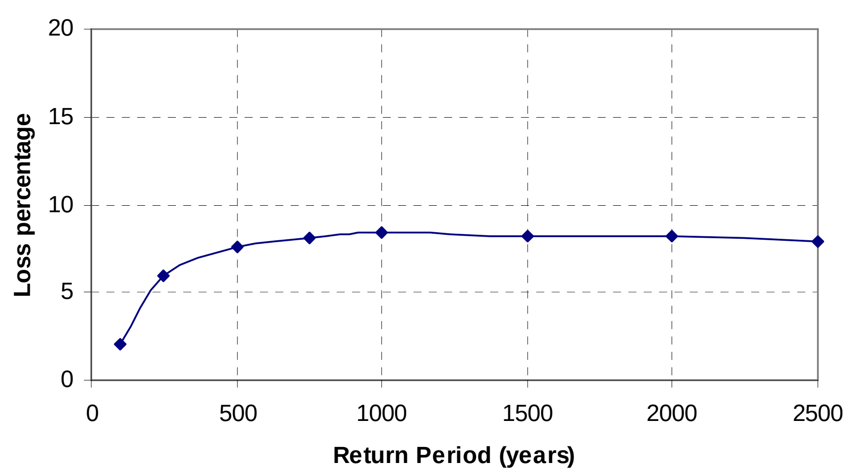
Probable Loss [%]	Name
0.1	PL_{100}
0.7	PL_{250}
2.6	PL_{500}
4.2	PL_{750}
5.4	PL_{1000}
7.1	PL_{1500}
8.3	PL_{2000}
9.2	PL_{2500}
0.017	EAL

Figure B- 66 Steel –Industrial – 2 Story - Soil type C – Ponce



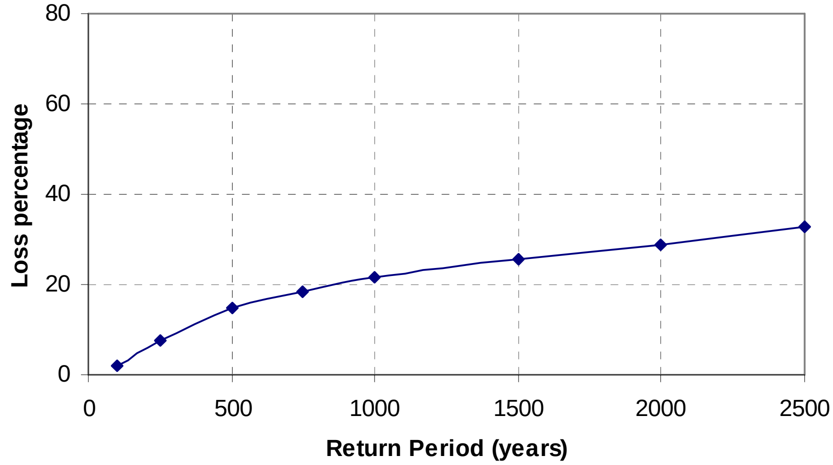
Probable Loss [%]	Name
0.3	PL_{100}
1.9	PL_{250}
4.3	PL_{500}
5.9	PL_{750}
7.0	PL_{1000}
8.5	PL_{1500}
10.0	PL_{2000}
11.2	PL_{2500}
0.028	EAL

Figure B- 67 Steel – Industrial – 2 Story - Soil type D – Ponce



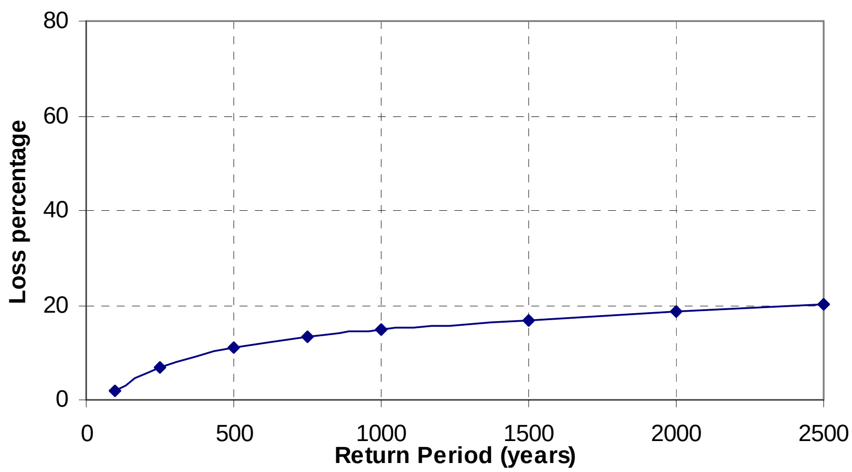
Probable Loss [%]	Name
2.1	PL_{100}
5.9	PL_{250}
7.6	PL_{500}
8.1	PL_{750}
8.4	PL_{1000}
8.2	PL_{1500}
8.2	PL_{2000}
7.9	PL_{2500}
0.054	EAL

Figure B- 68 Steel –Industrial – 2 Story - Soil type E – Ponce



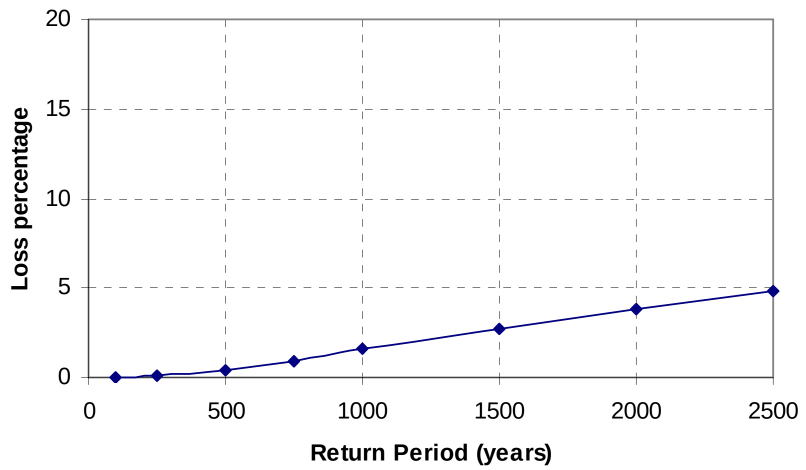
Probable Loss [%]	Name
2.1	PL_{100}
7.7	PL_{250}
14.9	PL_{500}
18.6	PL_{750}
21.5	PL_{1000}
25.6	PL_{1500}
28.7	PL_{2000}
32.9	PL_{2500}
0.098	EAL

Figure B- 69 Steel – Industrial – 2 Story - Soil type F (Shallow foundation) – Ponce



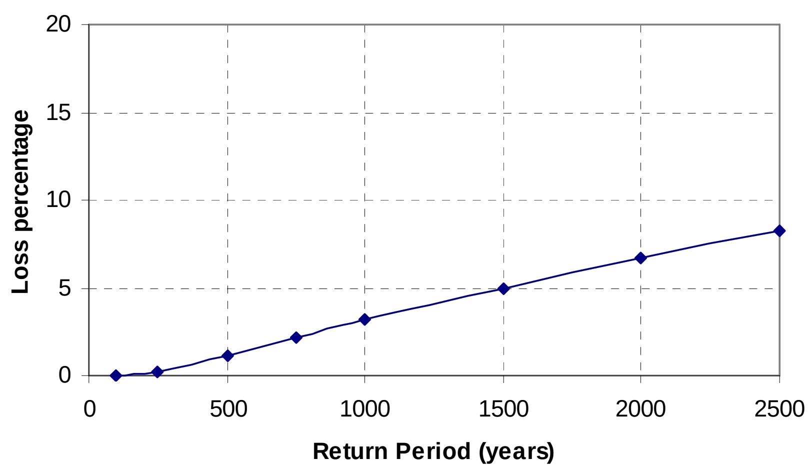
Probable Loss [%]	Name
2.1	PL_{100}
6.8	PL_{250}
11.2	PL_{500}
13.4	PL_{750}
15.0	PL_{1000}
16.9	PL_{1500}
18.5	PL_{2000}
20.4	PL_{2500}
0.076	EAL

Figure B- 70 Steel –Industrial – 2 Story - Soil type F (Deep foundation) – Ponce



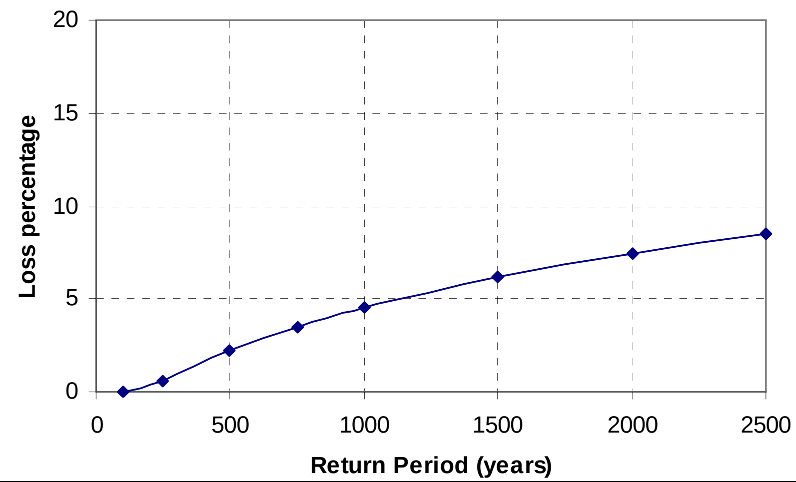
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.4	PL_{500}
1.0	PL_{750}
1.6	PL_{1000}
2.7	PL_{1500}
3.8	PL_{2000}
4.8	PL_{2500}
0.005	EAL

Figure B- 71 Steel – Commercial – 2 Story - Soil type A – Ponce



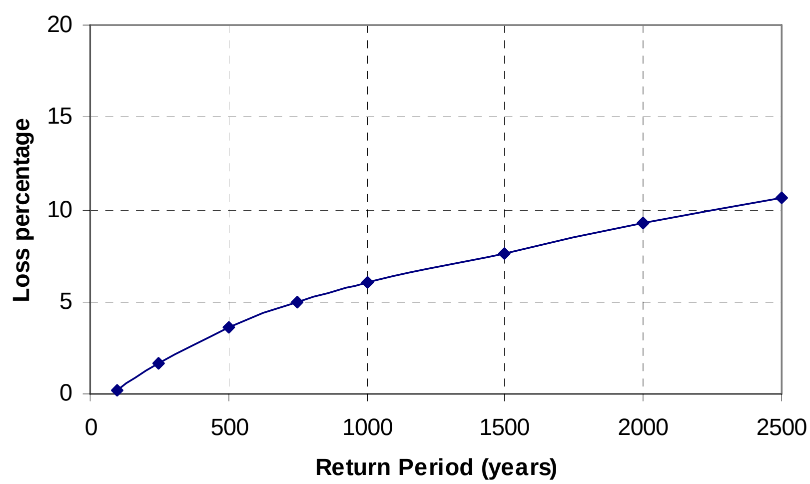
Probable Loss [%]	Name
0.0	PL_{100}
0.2	PL_{250}
1.1	PL_{500}
2.2	PL_{750}
3.2	PL_{1000}
5.0	PL_{1500}
6.7	PL_{2000}
8.3	PL_{2500}
0.010	EAL

Figure B- 72 Steel – Commercial – 2 Story - Soil type B – Ponce



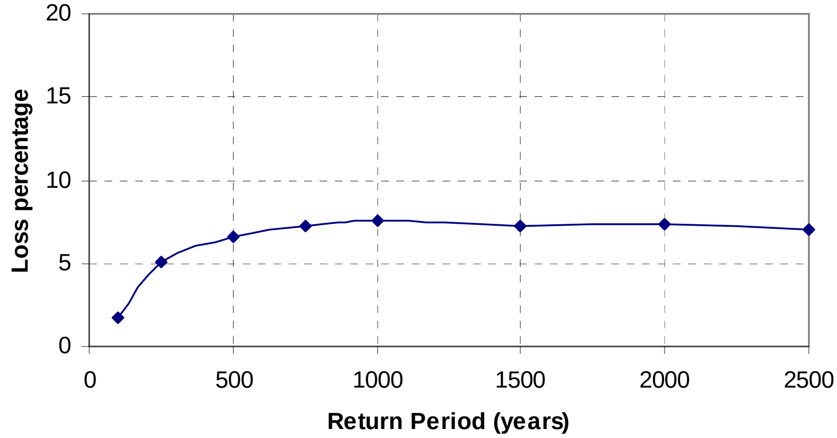
Probable Loss [%]	Name
0.0	PL_{100}
0.6	PL_{250}
2.2	PL_{500}
3.5	PL_{750}
4.6	PL_{1000}
6.2	PL_{1500}
7.4	PL_{2000}
8.5	PL_{2500}
0.015	EAL

Figure B- 73 Steel –Commercial– 2 Story - Soil type C – Ponce



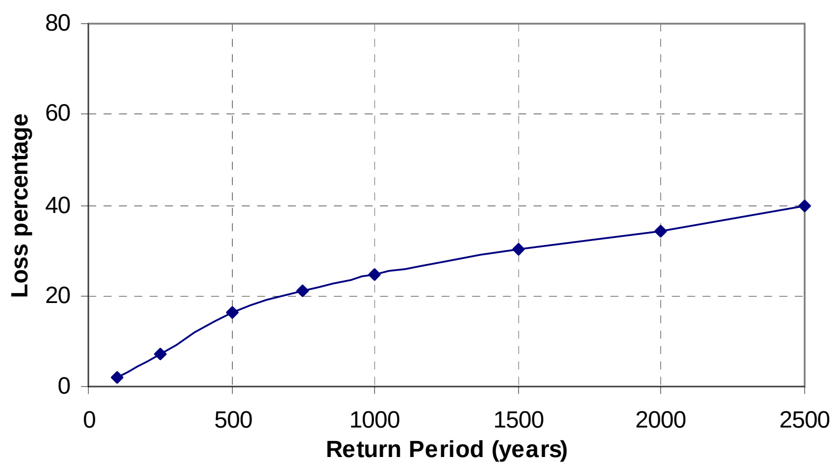
Probable Loss [%]	Name
0.2	PL_{100}
1.7	PL_{250}
3.6	PL_{500}
5.0	PL_{750}
6.1	PL_{1000}
7.6	PL_{1500}
9.3	PL_{2000}
10.6	PL_{2500}
0.025	EAL

Figure B- 74 Steel – Commercial – 2 Story - Soil type D – Ponce



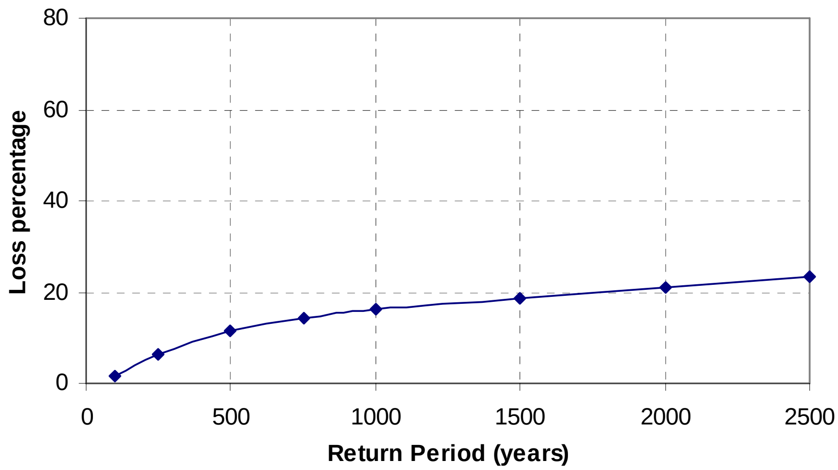
Probable Loss [%]	Name
1.8	PL_{100}
5.1	PL_{250}
6.6	PL_{500}
7.3	PL_{750}
7.6	PL_{1000}
7.3	PL_{1500}
7.4	PL_{2000}
7.0	PL_{2500}
0.046	EAL

Figure B- 75 Steel –Commercial – 2 Story - Soil type E – Ponce



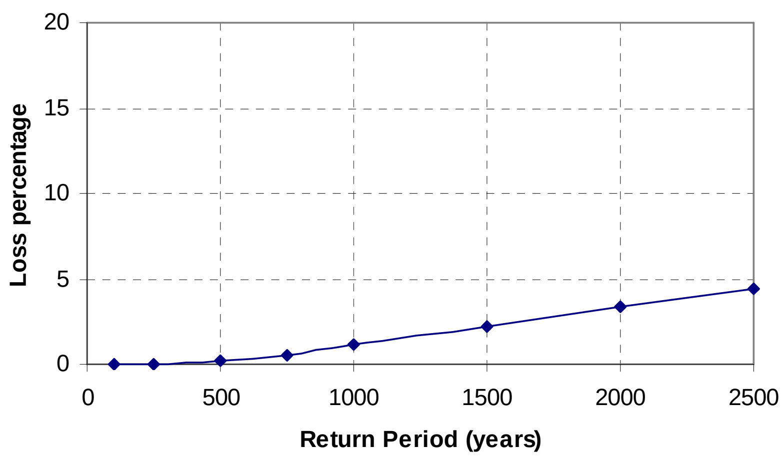
Probable Loss [%]	Name
1.8	PL_{100}
7.3	PL_{250}
16.2	PL_{500}
21.0	PL_{750}
24.8	PL_{1000}
30.2	PL_{1500}
34.3	PL_{2000}
39.7	PL_{2500}
0.105	EAL

Figure B- 76 Steel – Commercial – 2 Story - Soil type F (Shallow foundation) – Ponce



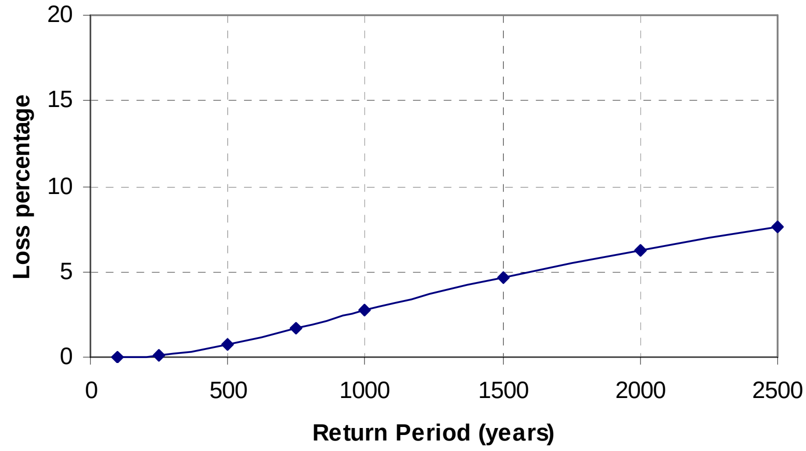
Probable Loss [%]	Name
1.8	PL_{100}
6.2	PL_{250}
11.4	PL_{500}
14.1	PL_{750}
16.2	PL_{1000}
18.7	PL_{1500}
20.8	PL_{2000}
23.4	PL_{2500}
0.076	EAL

Figure B- 77 Steel –Commercial – 2 Story - Soil type F (Deep foundation) – Ponce



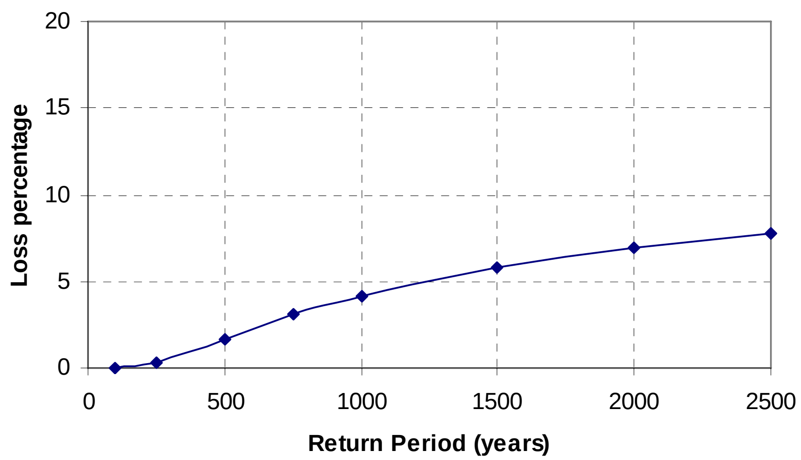
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.2	PL_{500}
0.6	PL_{750}
1.1	PL_{1000}
2.3	PL_{1500}
3.4	PL_{2000}
4.4	PL_{2500}
0.004	EAL

Figure B- 78 Steel – Commercial – 3 Story - Soil type A – Ponce



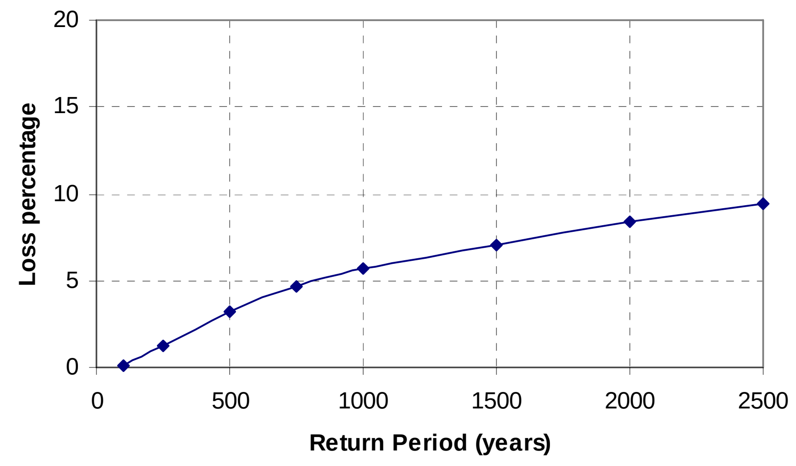
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.7	PL_{500}
1.7	PL_{750}
2.7	PL_{1000}
4.6	PL_{1500}
6.2	PL_{2000}
7.6	PL_{2500}
0.008	EAL

Figure B- 79 Steel – Commercial – 3 Story - Soil type B – Ponce



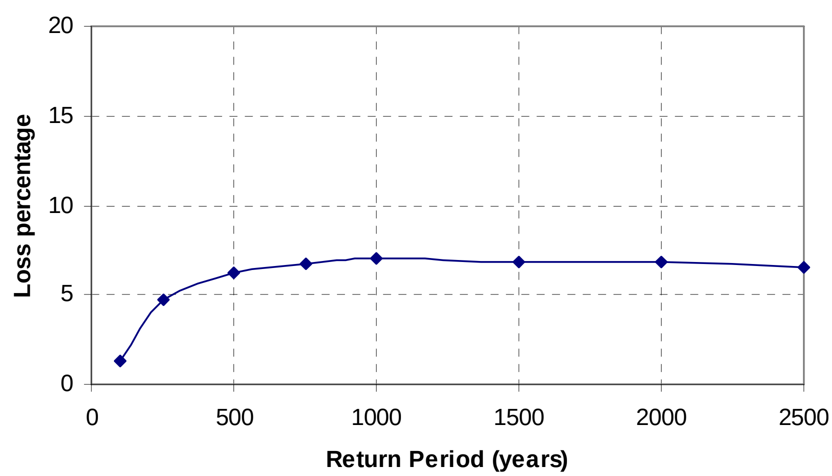
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.7	PL_{500}
3.1	PL_{750}
4.2	PL_{1000}
5.8	PL_{1500}
6.9	PL_{2000}
7.8	PL_{2500}
0.012	EAL

Figure B- 80 Steel –Commercial– 3 Story - Soil type C – Ponce



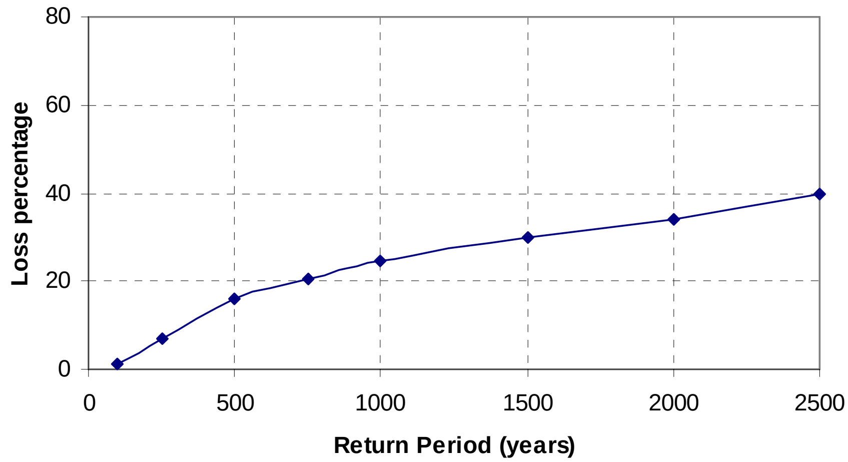
Probable Loss [%]	Name
0.1	PL_{100}
1.2	PL_{250}
3.2	PL_{500}
4.6	PL_{750}
5.7	PL_{1000}
7.1	PL_{1500}
8.4	PL_{2000}
9.4	PL_{2500}
0.021	EAL

Figure B- 81 Steel – Commercial – 3 Story - Soil type D – Ponce



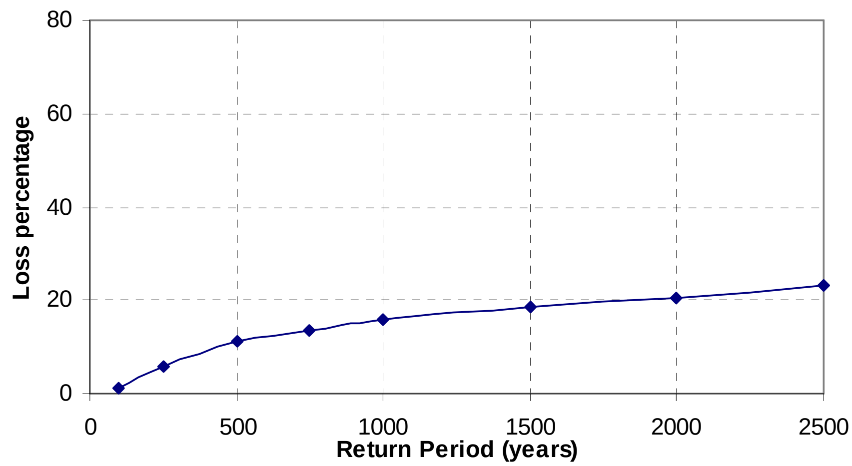
Probable Loss [%]	Name
1.3	PL_{100}
4.7	PL_{250}
6.2	PL_{500}
6.8	PL_{750}
7.0	PL_{1000}
6.8	PL_{1500}
6.9	PL_{2000}
6.5	PL_{2500}
0.042	EAL

Figure B- 82 Steel –Commercial – 3 Story - Soil type E – Ponce



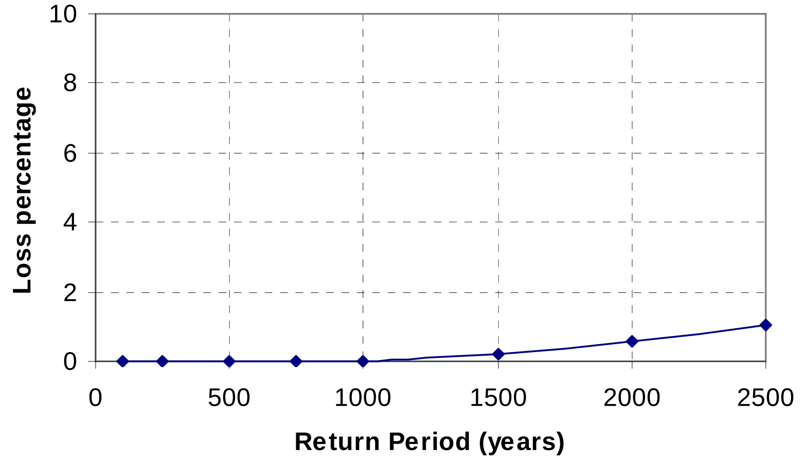
Probable Loss [%]	Name
1.3	PL_{100}
7.0	PL_{250}
15.9	PL_{500}
20.6	PL_{750}
24.5	PL_{1000}
29.9	PL_{1500}
34.1	PL_{2000}
39.6	PL_{2500}
0.101	EAL

Figure B- 83 Steel – Commercial – 3 Story - Soil type F (Shallow foundation) – Ponce



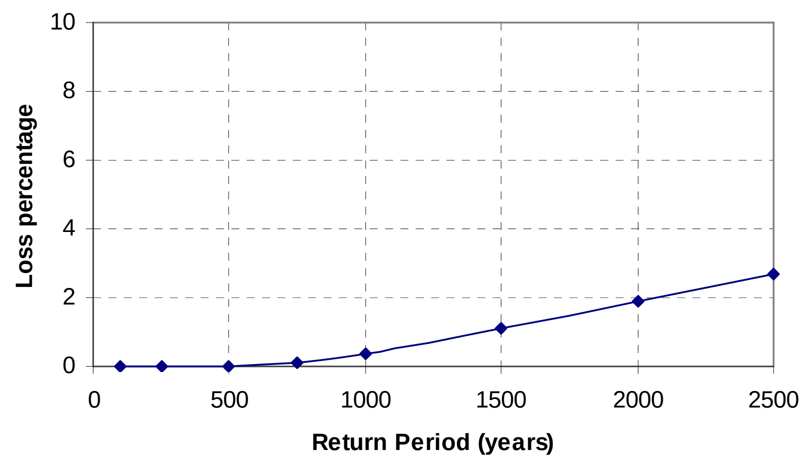
Probable Loss [%]	Name
1.3	PL_{100}
5.8	PL_{250}
11.0	PL_{500}
13.7	PL_{750}
15.8	PL_{1000}
18.4	PL_{1500}
20.5	PL_{2000}
23.1	PL_{2500}
0.072	EAL

Figure B- 84 Steel –Commercial – 3 Story - Soil type F (Deep foundation) – Ponce



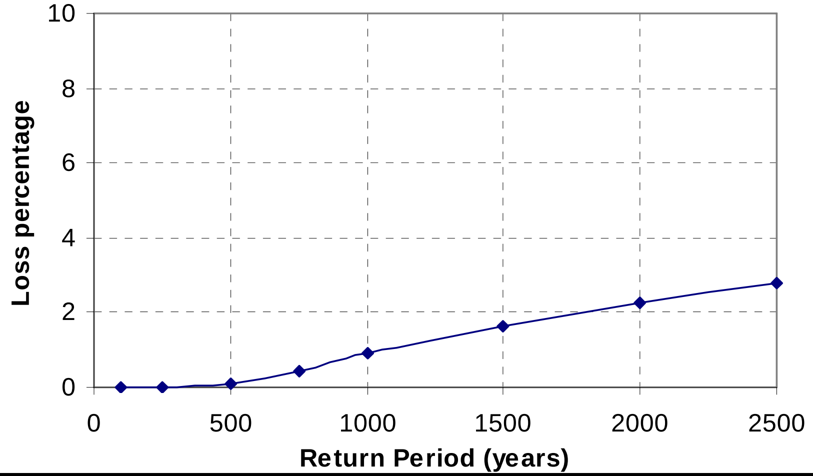
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.0	PL_{750}
0.0	PL_{1000}
0.2	PL_{1500}
0.6	PL_{2000}
1.0	PL_{2500}
0.001	EAL

Figure B- 85 Steel – Commercial – 4 Story - Soil type A – Ponce



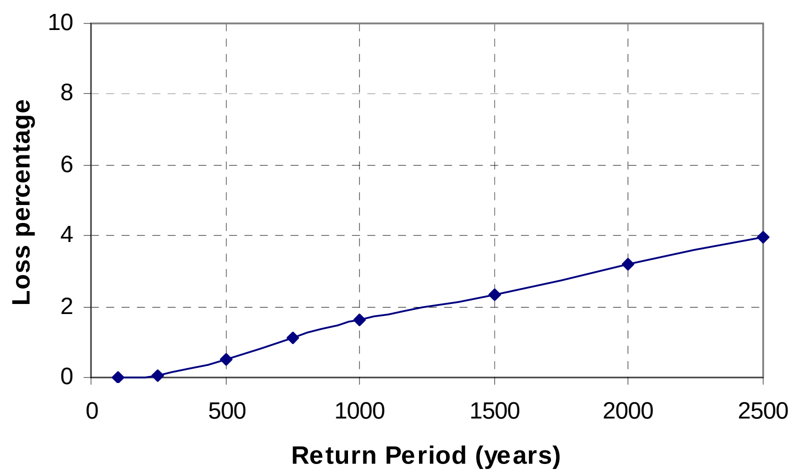
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.1	PL_{750}
0.3	PL_{1000}
1.1	PL_{1500}
1.9	PL_{2000}
2.7	PL_{2500}
0.002	EAL

Figure B- 86 Steel – Commercial – 4 Story - Soil type B – Ponce



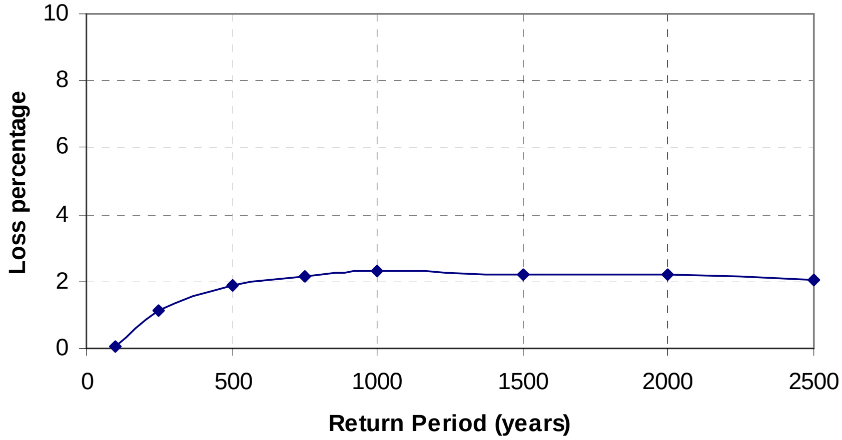
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.1	PL_{500}
0.5	PL_{750}
0.9	PL_{1000}
1.6	PL_{1500}
2.3	PL_{2000}
2.8	PL_{2500}
0.003	EAL

Figure B- 87 Steel –Commercial– 4 Story - Soil type C – Ponce



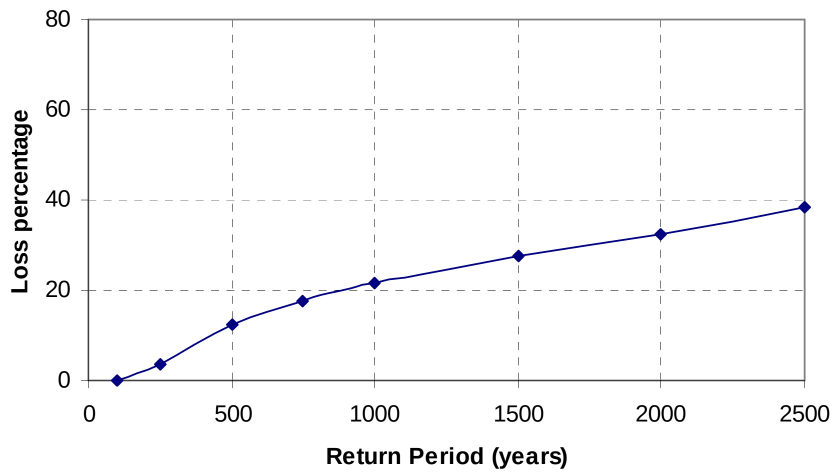
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.5	PL_{500}
1.1	PL_{750}
1.6	PL_{1000}
2.3	PL_{1500}
3.2	PL_{2000}
4.0	PL_{2500}
0.005	EAL

Figure B- 88 Steel – Commercial – 4 Story - Soil type D – Ponce



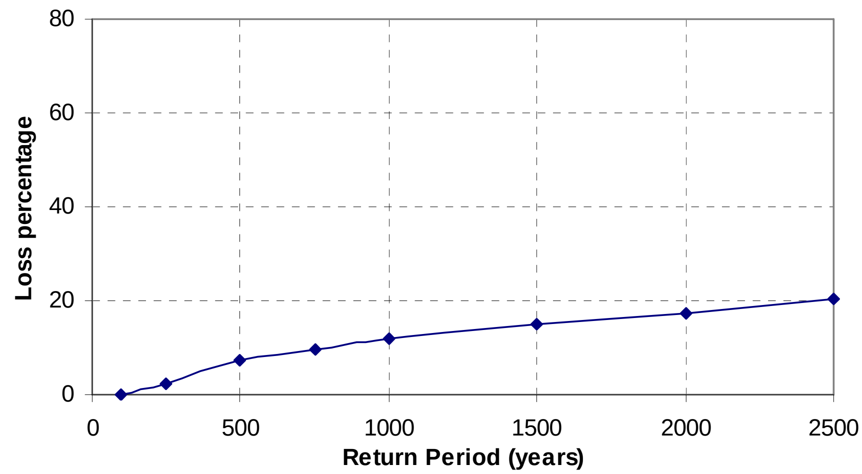
Probable Loss [%]	Name
0.0	PL_{100}
1.1	PL_{250}
1.9	PL_{500}
2.2	PL_{750}
2.3	PL_{1000}
2.2	PL_{1500}
2.2	PL_{2000}
2.0	PL_{2500}
0.011	EAL

Figure B- 89 Steel –Commercial – 4 Story - Soil type E – Ponce



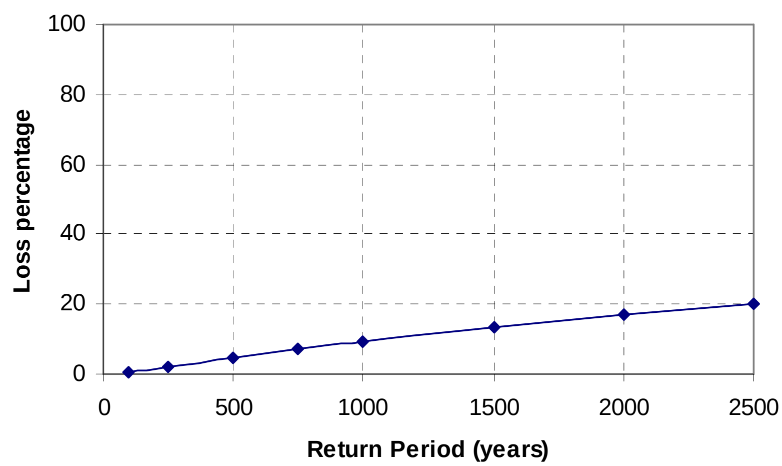
Probable Loss [%]	Name
0.1	PL_{100}
3.6	PL_{250}
12.4	PL_{500}
17.4	PL_{750}
21.6	PL_{1000}
27.7	PL_{1500}
32.3	PL_{2000}
38.4	PL_{2500}
0.076	EAL

Figure B- 90 Steel – Commercial – 4 Story - Soil type F (Shallow foundation) – Ponce



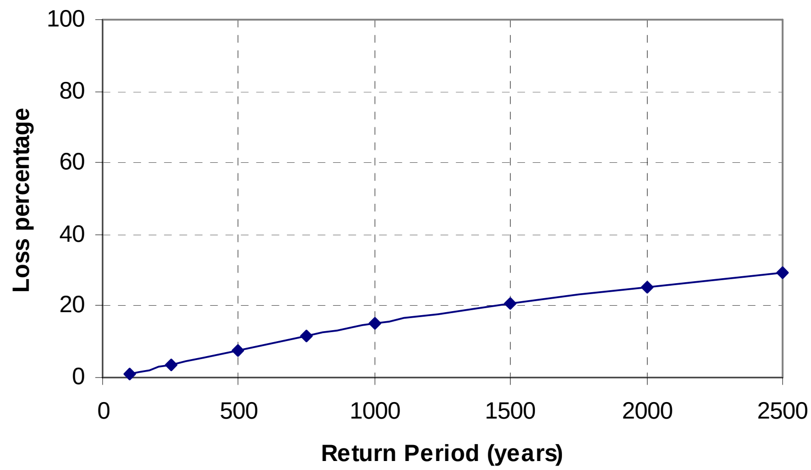
Probable Loss [%]	Name
0.0	PL_{100}
2.4	PL_{250}
7.2	PL_{500}
9.8	PL_{750}
12.0	PL_{1000}
14.9	PL_{1500}
17.2	PL_{2000}
20.2	PL_{2500}
0.043	EAL

Figure B- 91 Steel –Commercial – 4 Story - Soil type F (Deep foundation) – Ponce



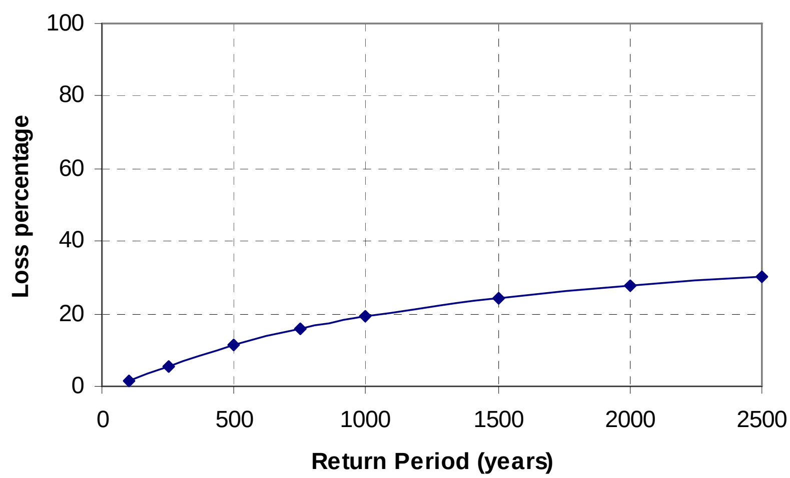
Probable Loss [%]	Name
0.4	PL_{100}
1.9	PL_{250}
4.5	PL_{500}
7.0	PL_{750}
9.4	PL_{1000}
13.5	PL_{1500}
17.1	PL_{2000}
20.2	PL_{2500}
0.036	EAL

Figure B- 92 Wood House - Soil type A – Ponce



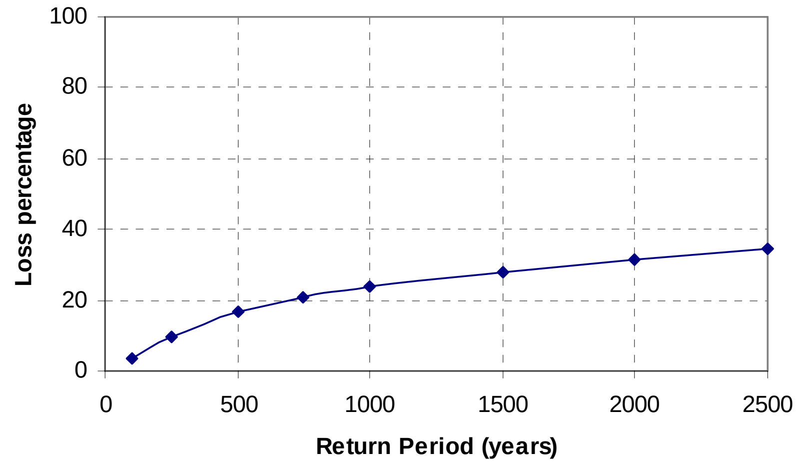
Probable Loss [%]	Name
0.9	PL_{100}
3.4	PL_{250}
7.7	PL_{500}
11.6	PL_{750}
15.1	PL_{1000}
20.7	PL_{1500}
25.5	PL_{2000}
29.5	PL_{2500}
0.059	EAL

Figure B- 93 Wood House - Soil type B – Ponce



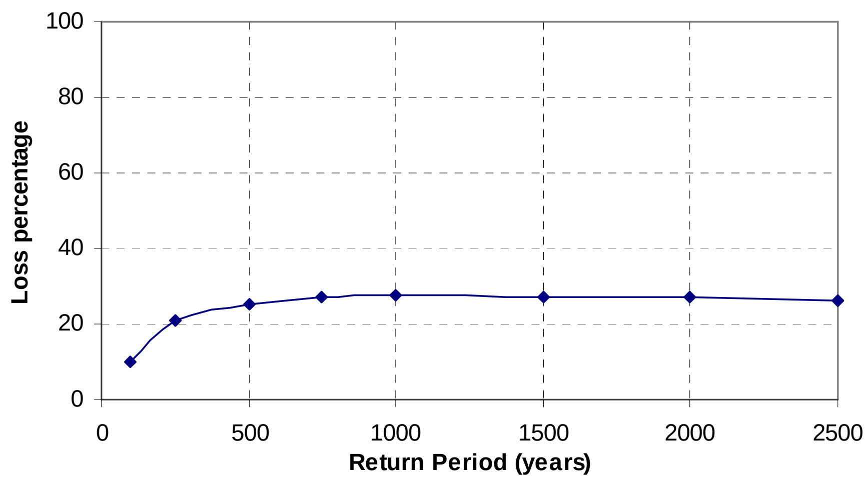
Probable Loss [%]	Name
1.5	PL_{100}
5.5	PL_{250}
11.6	PL_{500}
16.0	PL_{750}
19.4	PL_{1000}
24.1	PL_{1500}
27.5	PL_{2000}
30.0	PL_{2500}
0.080	EAL

Figure B- 94 Wood House - Soil type C – Ponce



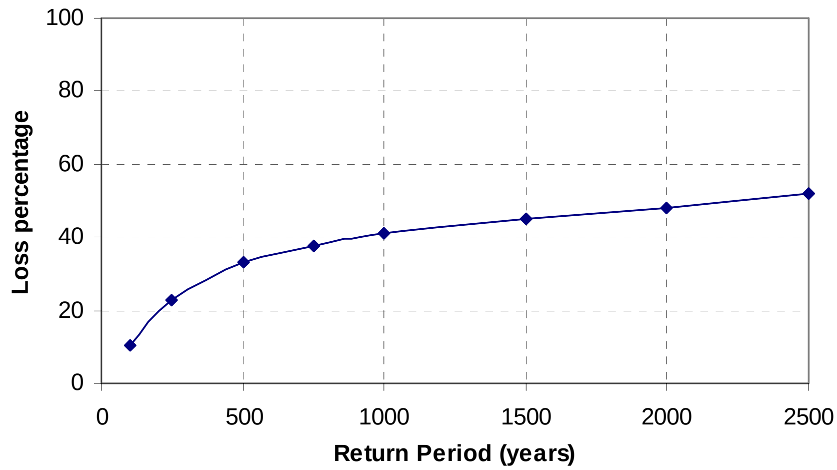
Probable Loss [%]	Name
3.5	PL_{100}
9.8	PL_{250}
16.5	PL_{500}
20.8	PL_{750}
23.9	PL_{1000}
27.9	PL_{1500}
31.7	PL_{2000}
34.5	PL_{2500}
0.116	EAL

Figure B- 95 Wood House - Soil type D – Ponce



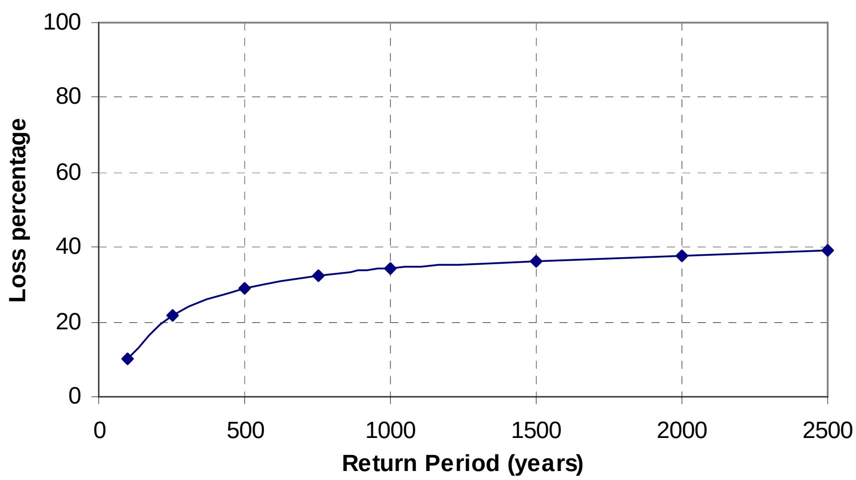
Probable Loss [%]	Name
10.1	PL_{100}
20.9	PL_{250}
25.4	PL_{500}
27.1	PL_{750}
27.8	PL_{1000}
27.1	PL_{1500}
27.3	PL_{2000}
26.4	PL_{2500}
0.193	EAL

Figure B- 96 Wood House - Soil type E – Ponce



Probable Loss [%]	Name
10.2	PL_{100}
22.8	PL_{250}
33.0	PL_{500}
37.7	PL_{750}
41.1	PL_{1000}
44.9	PL_{1500}
48.2	PL_{2000}
52.0	PL_{2500}
0.239	EAL

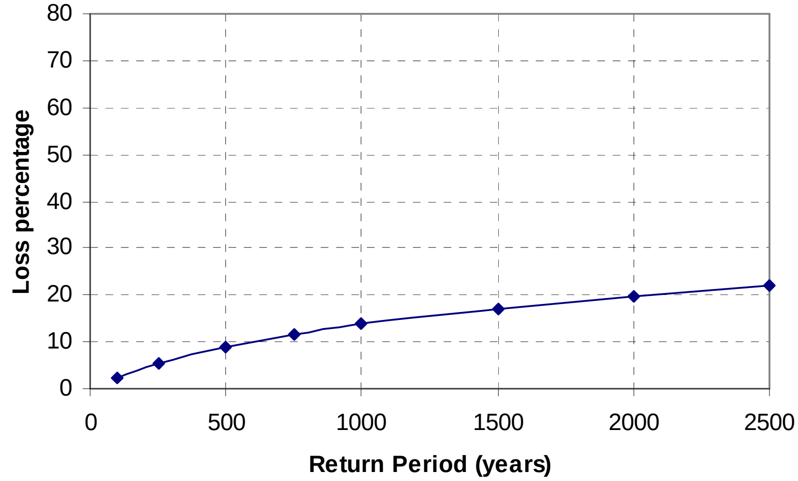
Figure B- 97 Wood House - Soil type F (Shallow foundation) – Ponce



Probable Loss [%]	Name
10.1	PL_{100}
21.9	PL_{250}
29.2	PL_{500}
32.4	PL_{750}
34.5	PL_{1000}
36.0	PL_{1500}
37.8	PL_{2000}
39.2	PL_{2500}
0.216	EAL

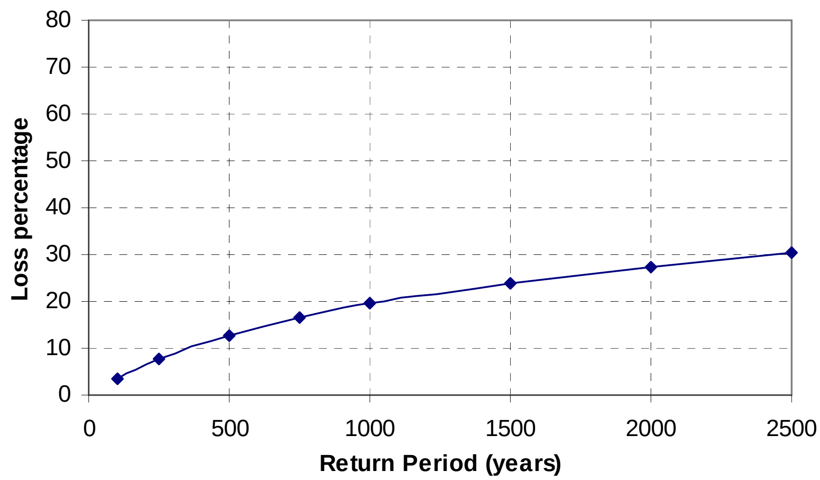
Figure B- 98 Wood House - Soil type F (Deep foundation) – Ponce

Appendix C Earthquake Loss Curves for San Juan



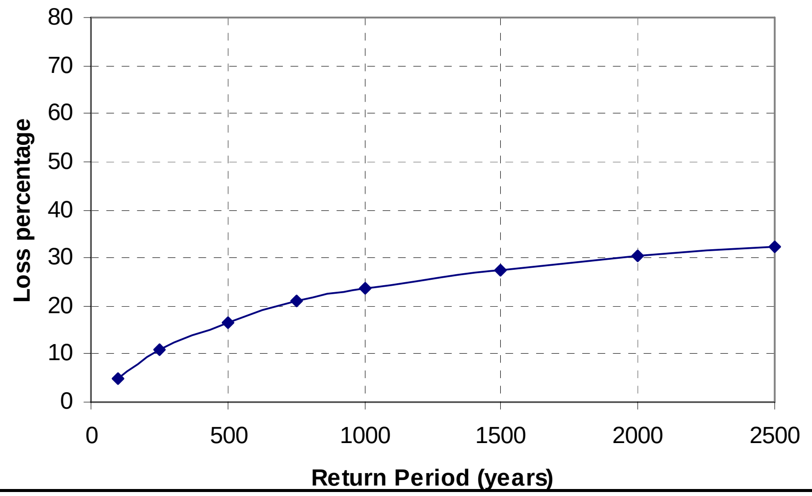
Probable Loss [%]	Name
2.3	PL_{100}
5.5	PL_{250}
9.3	PL_{500}
12.2	PL_{750}
14.5	PL_{1000}
18.0	PL_{1500}
20.9	PL_{2000}
23.3	PL_{2500}
0.070	EAL

Figure C- 1 Concrete Moment Resistant Frame – 1 Story - Soil type A – San Juan



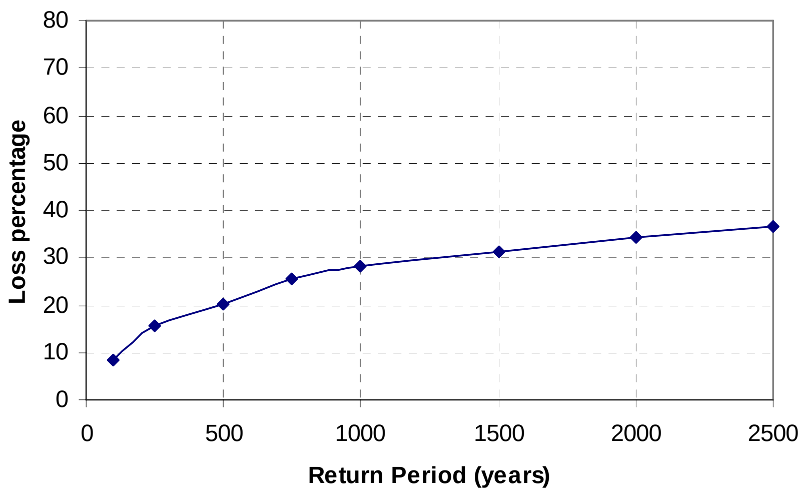
Probable Loss [%]	Name
3.6	PL_{100}
8.2	PL_{250}
13.6	PL_{500}
17.4	PL_{750}
20.5	PL_{1000}
25.1	PL_{1500}
28.8	PL_{2000}
31.8	PL_{2500}
0.102	EAL

Figure C- 2 Concrete Moment Resistant Frame – 1 Story - Soil type B – San Juan



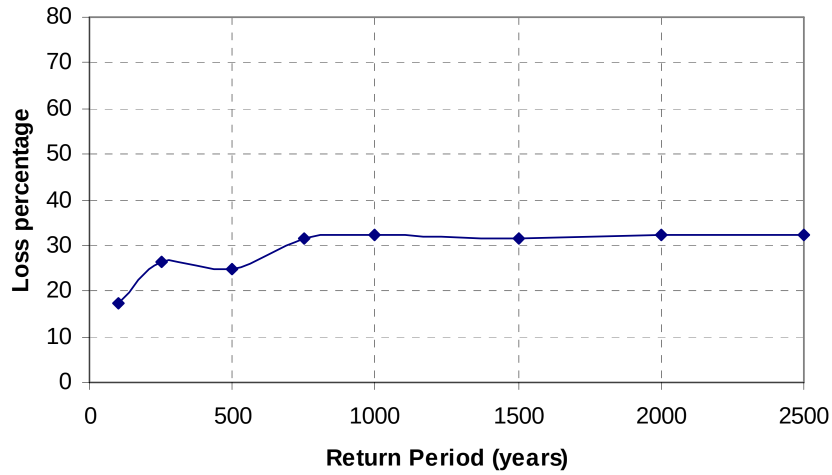
Probable Loss [%]	Name
5.2	PL_{100}
11.3	PL_{250}
17.3	PL_{500}
22.2	PL_{750}
25.0	PL_{1000}
28.9	PL_{1500}
31.7	PL_{2000}
33.9	PL_{2500}
0.130	EAL

Figure C- 3 Concrete Moment Resistant Frame – 1 Story - Soil type C – San Juan



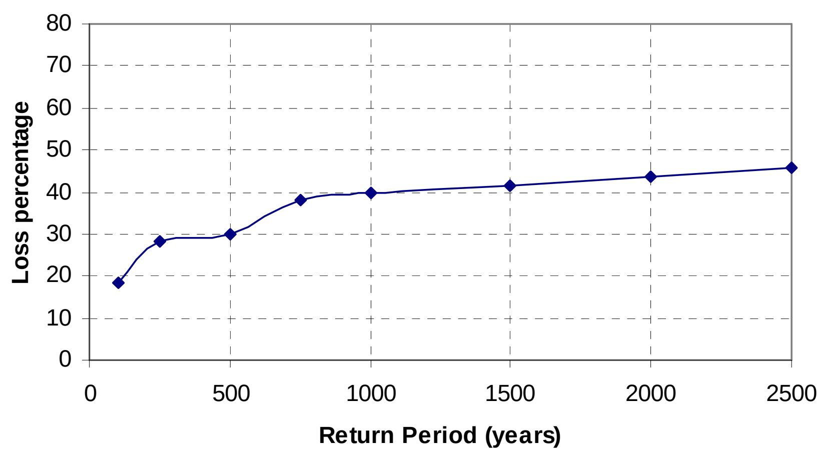
Probable Loss [%]	Name
8.7	PL_{100}
16.5	PL_{250}
21.2	PL_{500}
27.0	PL_{750}
29.5	PL_{1000}
32.6	PL_{1500}
35.6	PL_{2000}
38.0	PL_{2500}
0.174	EAL

Figure C- 4 Concrete Moment Resistant Frame – 1 Story - Soil type D – San Juan



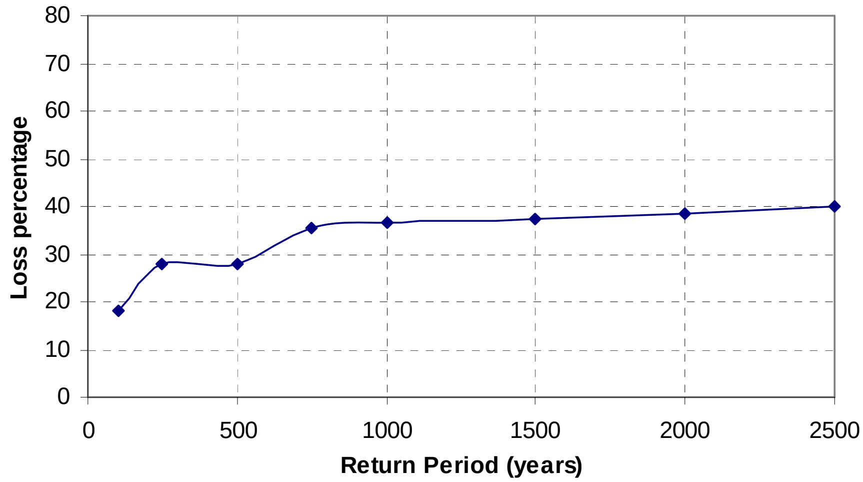
Probable Loss [%]	Name
18.3	PL_{100}
27.8	PL_{250}
26.0	PL_{500}
33.0	PL_{750}
33.6	PL_{1000}
33.1	PL_{1500}
33.6	PL_{2000}
33.7	PL_{2500}
0.256	EAL

Figure C- 5 Concrete Moment Resistant Frame – 1 Story - Soil type E – San Juan



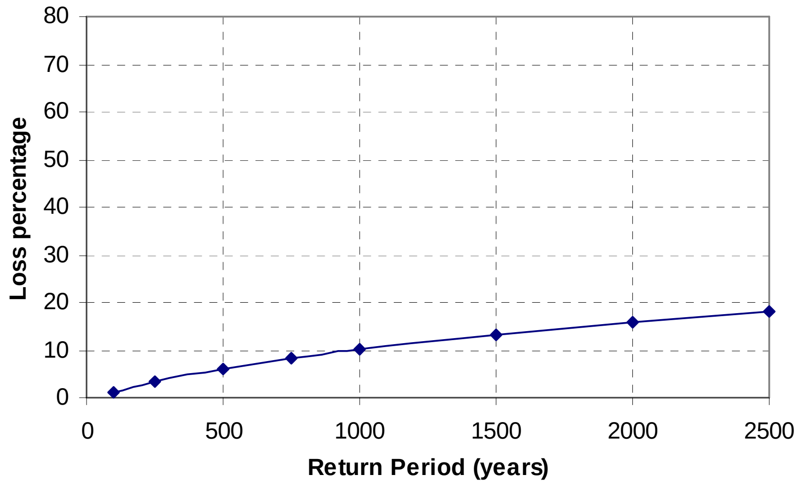
Probable Loss [%]	Name
18.3	PL_{100}
28.4	PL_{250}
29.8	PL_{500}
38.0	PL_{750}
39.9	PL_{1000}
41.5	PL_{1500}
43.5	PL_{2000}
45.9	PL_{2500}
0.277	EAL

Figure C- 6 Concrete Moment Resistant Frame – 1 Story - Soil type F (Shallow Foundation) – San Juan



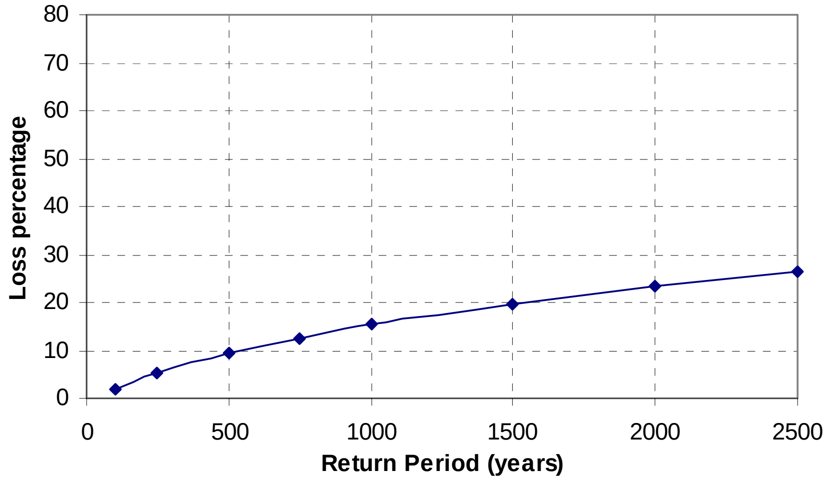
Probable Loss [%]	Name
18.3	PL_{100}
28.1	PL_{250}
27.9	PL_{500}
35.5	PL_{750}
36.7	PL_{1000}
37.3	PL_{1500}
38.6	PL_{2000}
39.8	PL_{2500}
0.267	EAL

Figure C- 7 Concrete Moment Resistant Frame – 1 Story - Soil type F (Deep Foundation) – San Juan



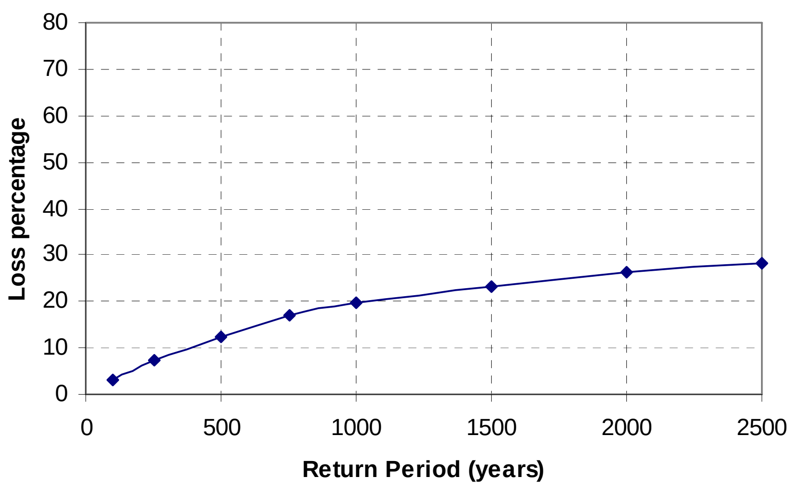
Probable Loss [%]	Name
1.0	PL_{100}
3.2	PL_{250}
6.0	PL_{500}
8.2	PL_{750}
10.1	PL_{1000}
13.1	PL_{1500}
15.7	PL_{2000}
17.9	PL_{2500}
0.045	EAL

Figure C- 8 Concrete Moment Resistant Frame – 2 Stories - Soil type A – San Juan



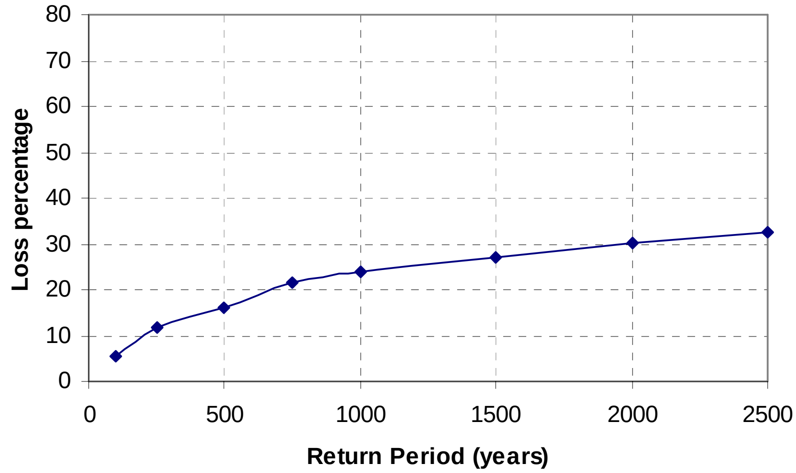
Probable Loss [%]	Name
1.9	PL_{100}
5.2	PL_{250}
9.3	PL_{500}
12.5	PL_{750}
15.3	PL_{1000}
19.6	PL_{1500}
23.2	PL_{2000}
26.3	PL_{2500}
0.070	EAL

Figure C- 9 Concrete Moment Resistant Frame – 2 Stories - Soil type B – San Juan



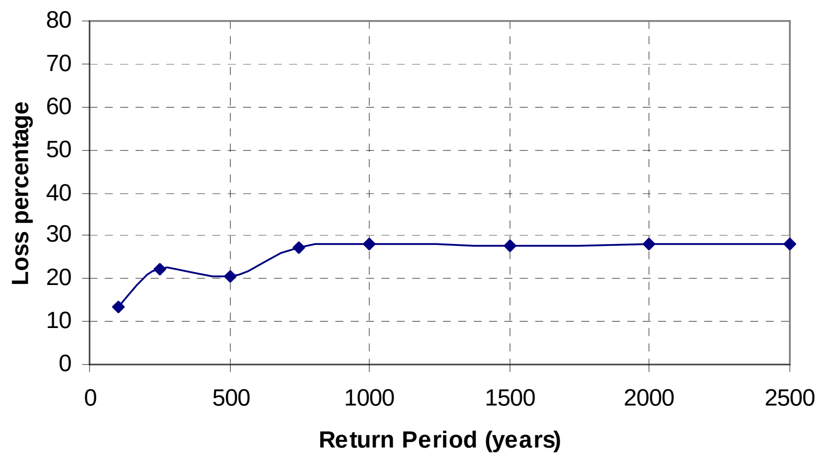
Probable Loss [%]	Name
3.0	PL_{100}
7.5	PL_{250}
12.5	PL_{500}
16.8	PL_{750}
19.5	PL_{1000}
23.3	PL_{1500}
26.1	PL_{2000}
28.3	PL_{2500}
0.093	EAL

Figure C- 10 Concrete Moment Resistant Frame – 2 Stories - Soil type C – San Juan



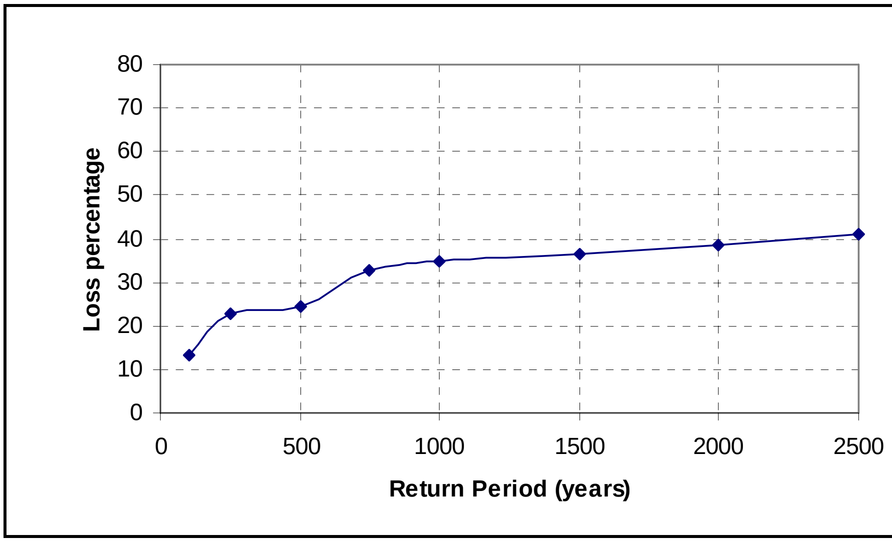
Probable Loss [%]	Name
5.6	PL_{100}
11.7	PL_{250}
16.0	PL_{500}
21.4	PL_{750}
23.9	PL_{1000}
27.0	PL_{1500}
30.0	PL_{2000}
32.5	PL_{2500}
0.129	EAL

Figure C- 11 Concrete Moment Resistant Frame – 2 Stories - Soil type D – San Juan



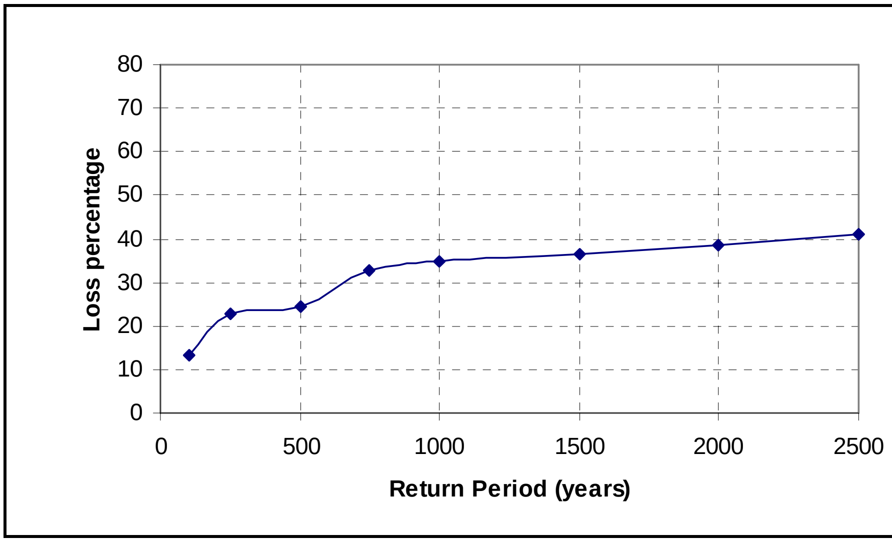
Probable Loss [%]	Name
13.3	PL_{100}
22.2	PL_{250}
20.5	PL_{500}
27.4	PL_{750}
28.0	PL_{1000}
27.6	PL_{1500}
28.0	PL_{2000}
28.1	PL_{2500}
0.203	EAL

Figure C- 12 Concrete Moment Resistant Frame – 2 Stories - Soil type E – San Juan



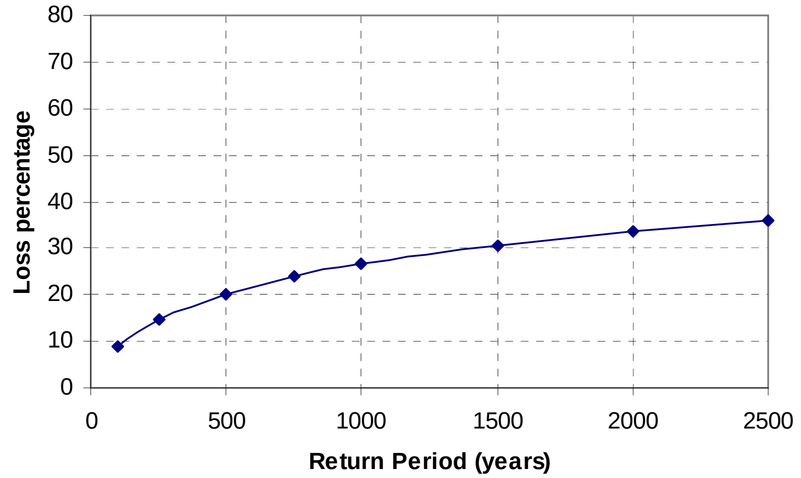
Probable Loss [%]	Name
13.3	PL_{100}
22.9	PL_{250}
24.6	PL_{500}
32.7	PL_{750}
34.6	PL_{1000}
36.3	PL_{1500}
38.4	PL_{2000}
40.9	PL_{2500}
0.225	EAL

Figure C- 13 Concrete Moment Resistant Frame – 2 Story - Soil type F (Shallow Foundation) – San Juan



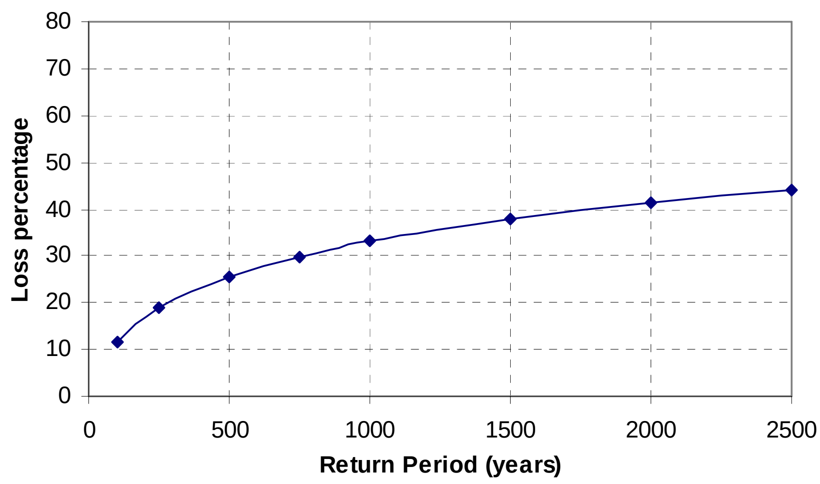
Probable Loss [%]	Name
13.3	PL_{100}
22.6	PL_{250}
22.6	PL_{500}
30.0	PL_{750}
31.3	PL_{1000}
31.9	PL_{1500}
33.2	PL_{2000}
34.5	PL_{2500}
0.214	EAL

Figure C- 14 Concrete Moment Resistant Frame – 2 Story - Soil type F (Deep Foundation) – San Juan



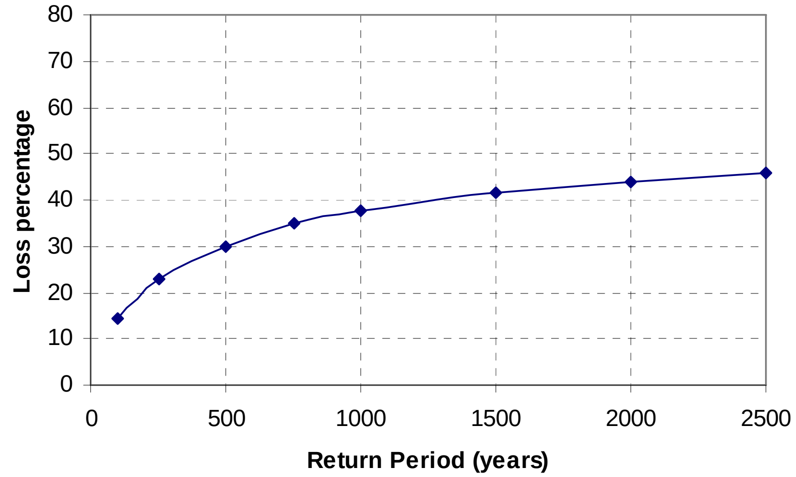
Probable Loss [%]	Name
9.0	PL_{100}
14.7	PL_{250}
20.2	PL_{500}
23.8	PL_{750}
26.6	PL_{1000}
30.5	PL_{1500}
33.6	PL_{2000}
36.1	PL_{2500}
0.162	EAL

Figure C- 15 Concrete Shear Wall – 1 Stories - Soil type A – San Juan



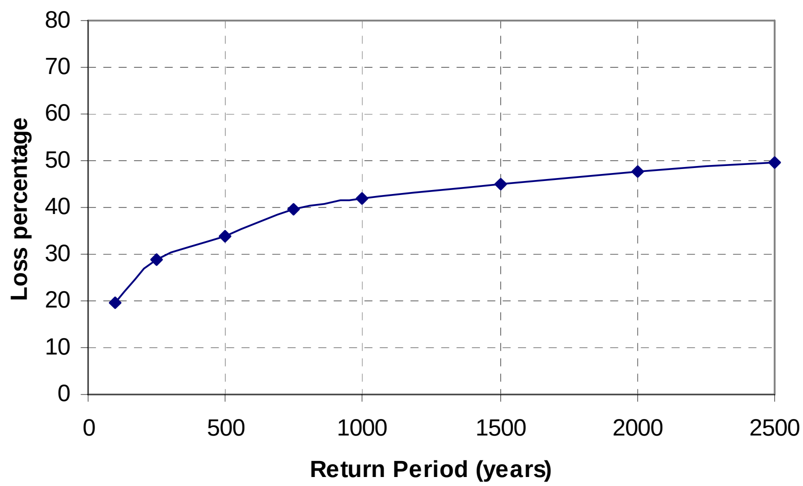
Probable Loss [%]	Name
11.6	PL_{100}
18.7	PL_{250}
25.5	PL_{500}
29.9	PL_{750}
33.2	PL_{1000}
37.8	PL_{1500}
41.4	PL_{2000}
44.2	PL_{2500}
0.205	EAL

Figure C- 16 Concrete Shear Wall – 1 Story - Soil type B – San Juan



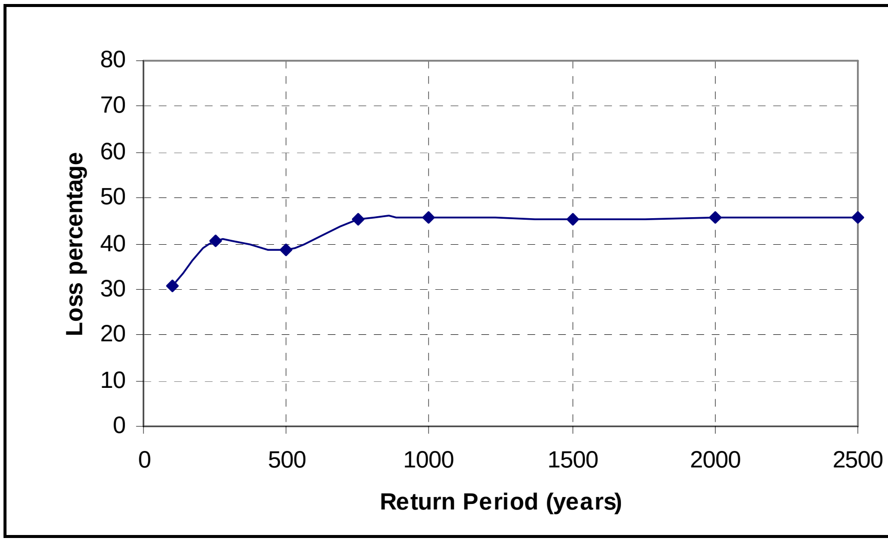
Probable Loss [%]	Name
14.2	PL_{100}
22.7	PL_{250}
29.8	PL_{500}
34.9	PL_{750}
37.7	PL_{1000}
41.4	PL_{1500}
44.0	PL_{2000}
46.0	PL_{2500}
0.240	EAL

Figure C- 17 Concrete Shear Wall – 1 Stories - Soil type C – San Juan



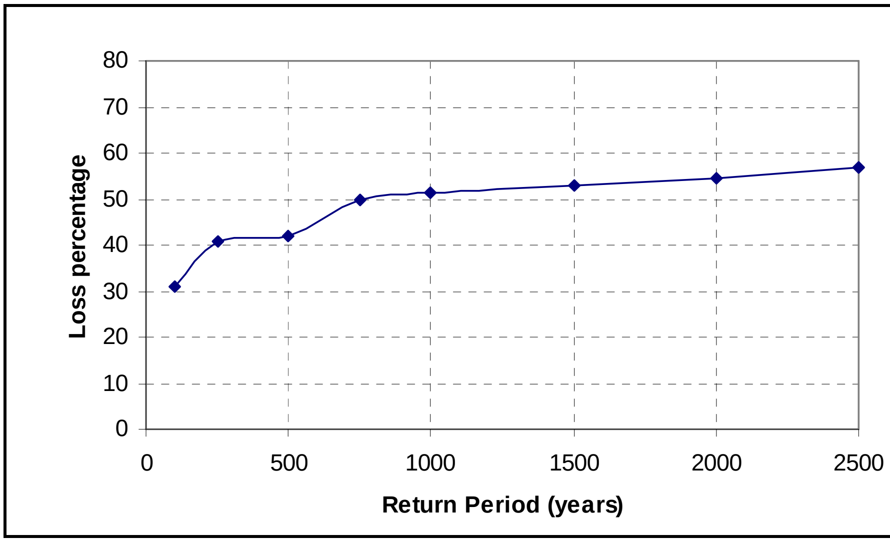
Probable Loss [%]	Name
19.5	PL_{100}
28.8	PL_{250}
33.9	PL_{500}
39.6	PL_{750}
42.0	PL_{1000}
44.9	PL_{1500}
47.5	PL_{2000}
49.6	PL_{2500}
0.293	EAL

Figure C- 18 Concrete Shear Wall – 1 Stories - Soil type D – San Juan



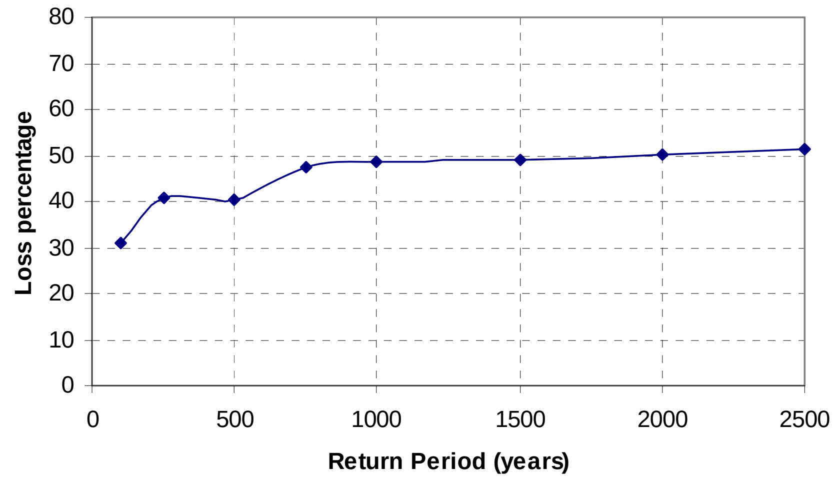
Probable Loss [%]	Name
30.8	PL_{100}
40.4	PL_{250}
38.7	PL_{500}
45.2	PL_{750}
45.7	PL_{1000}
45.3	PL_{1500}
45.7	PL_{2000}
45.9	PL_{2500}
0.382	EAL

Figure C- 19 Concrete Shear Wall – 1 Stories - Soil type E – San Juan



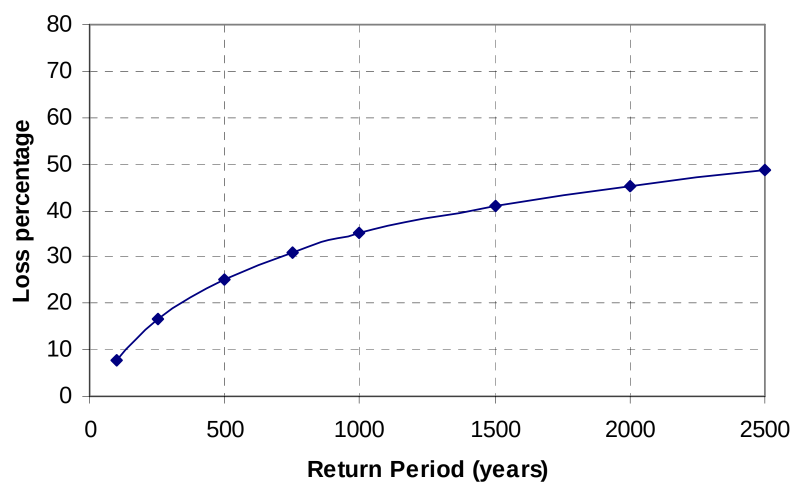
Probable Loss [%]	Name
30.8	PL_{100}
40.9	PL_{250}
42.0	PL_{500}
49.7	PL_{750}
51.4	PL_{1000}
52.8	PL_{1500}
54.6	PL_{2000}
56.8	PL_{2500}
0.400	EAL

Figure C- 20 Concrete Shear Wall – 1 Story - Soil type F (Shallow Foundation) – San Juan



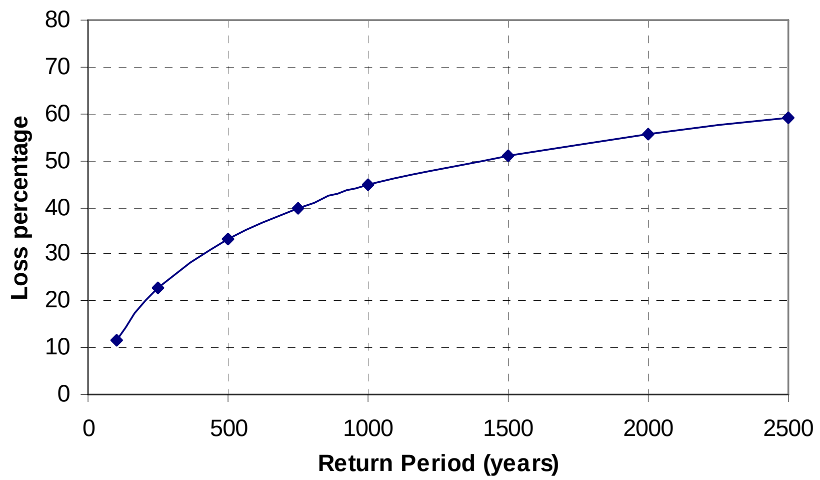
Probable Loss [%]	Name
30.8	PL_{100}
40.7	PL_{250}
40.4	PL_{500}
47.4	PL_{750}
48.5	PL_{1000}
49.1	PL_{1500}
50.2	PL_{2000}
51.3	PL_{2500}
0.391	EAL

Figure C- 21 Concrete Shear Wall – 1 Story - Soil type F (Deep Foundation) – San Juan



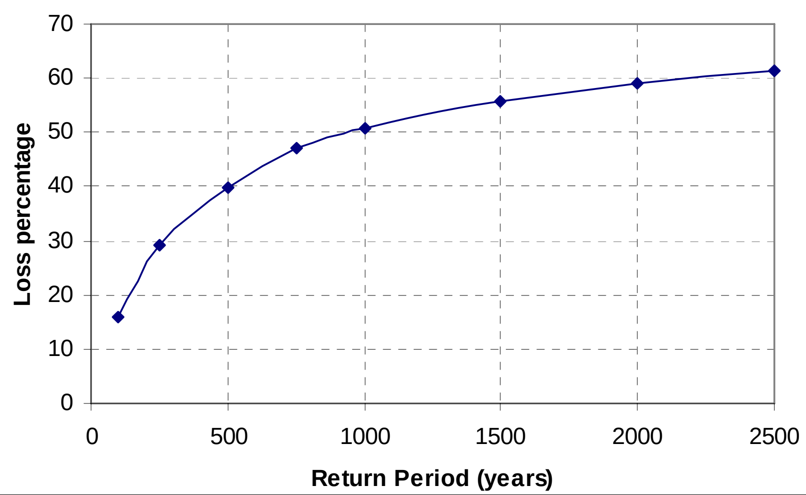
Probable Loss [%]	Name
7.8	PL_{100}
16.6	PL_{250}
25.2	PL_{500}
30.9	PL_{750}
35.1	PL_{1000}
40.9	PL_{1500}
45.2	PL_{2000}
48.6	PL_{2500}
0.189	EAL

Figure C- 22 Concrete Shear Wall – 2 Stories - Soil type A – San Juan



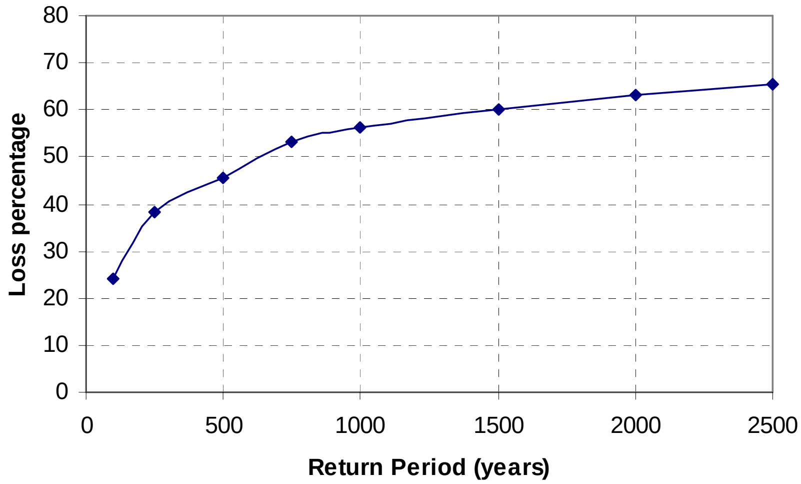
Probable Loss [%]	Name
11.7	PL_{100}
23.0	PL_{250}
33.4	PL_{500}
39.9	PL_{750}
44.7	PL_{1000}
51.0	PL_{1500}
55.6	PL_{2000}
59.1	PL_{2500}
0.253	EAL

Figure C- 23 Concrete Shear Wall – 2 Story - Soil type B – San Juan



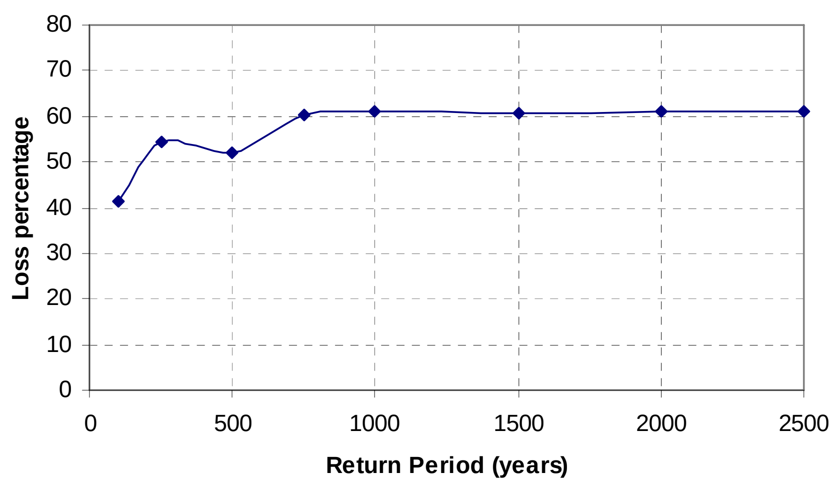
Probable Loss [%]	Name
15.8	PL_{100}
29.2	PL_{250}
39.8	PL_{500}
47.0	PL_{750}
50.8	PL_{1000}
55.7	PL_{1500}
59.0	PL_{2000}
61.3	PL_{2500}
0.307	EAL

Figure C- 24 Concrete Shear Wall – 2 Stories - Soil type C – San Juan



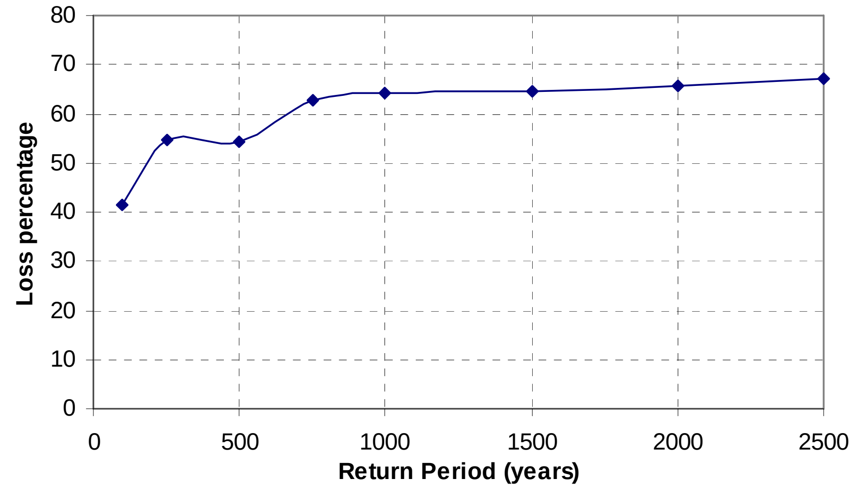
Probable Loss [%]	Name
24.1	PL_{100}
38.4	PL_{250}
45.7	PL_{500}
53.3	PL_{750}
56.4	PL_{1000}
59.9	PL_{1500}
63.1	PL_{2000}
65.5	PL_{2500}
0.385	EAL

Figure C- 25 Concrete Shear Wall – 2 Stories - Soil type D – San Juan



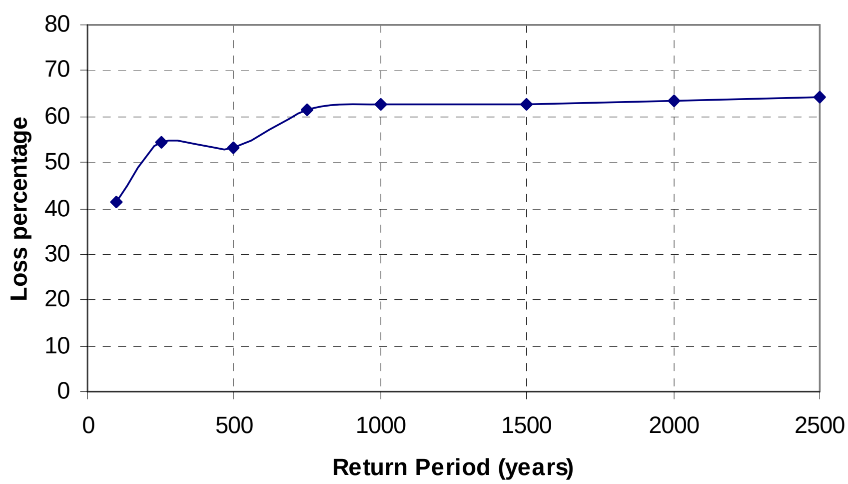
Probable Loss [%]	Name
41.3	PL_{100}
54.4	PL_{250}
52.1	PL_{500}
60.3	PL_{750}
61.0	PL_{1000}
60.5	PL_{1500}
61.0	PL_{2000}
61.2	PL_{2500}
0.512	EAL

Figure C- 26 Concrete Shear Wall – 2 Stories - Soil type E – San Juan



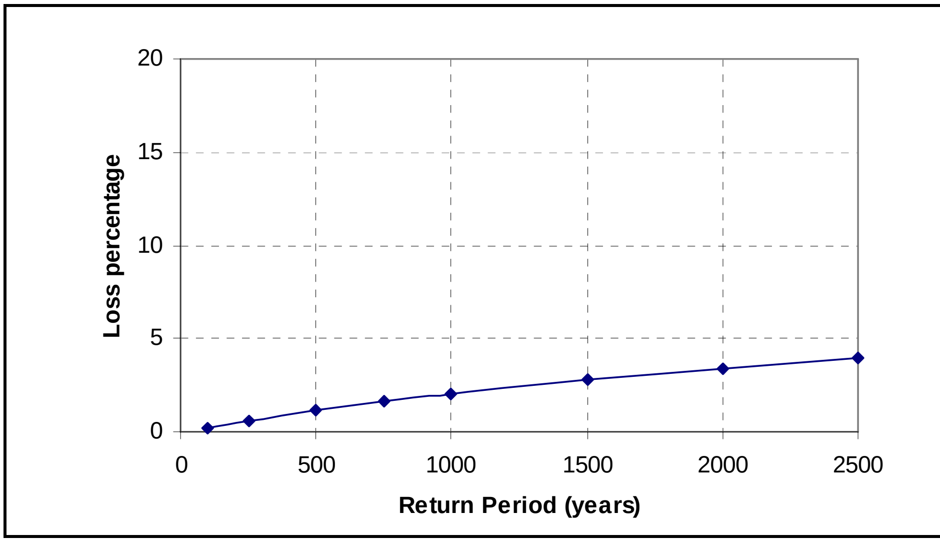
Probable Loss [%]	Name
41.3	PL_{100}
54.7	PL_{250}
54.2	PL_{500}
62.8	PL_{750}
64.1	PL_{1000}
64.6	PL_{1500}
65.8	PL_{2000}
67.1	PL_{2500}
0.523	EAL

Figure C- 27 Concrete Shear Wall – 2 Stories - Soil type F (Shallow Foundation) – San Juan



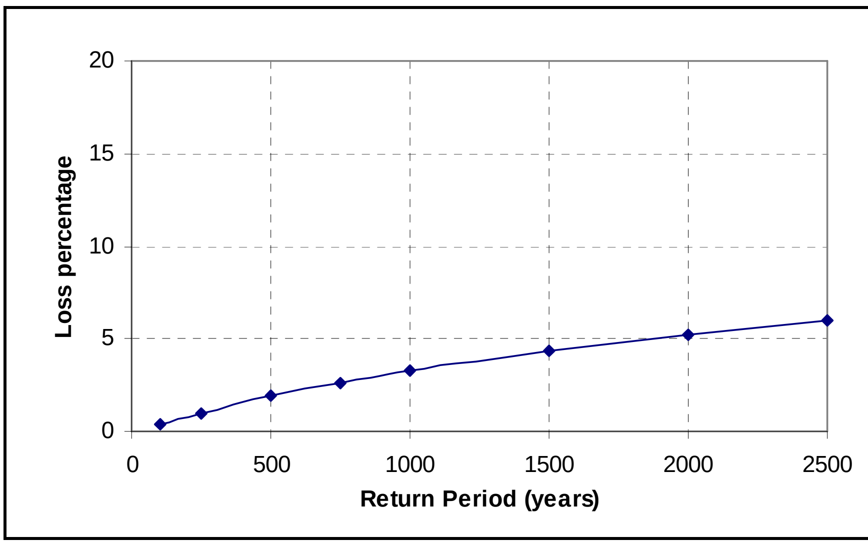
Probable Loss [%]	Name
41.3	PL_{100}
54.5	PL_{250}
53.2	PL_{500}
61.6	PL_{750}
62.5	PL_{1000}
62.6	PL_{1500}
63.4	PL_{2000}
64.1	PL_{2500}
0.517	EAL

Figure C- 28 Concrete Shear Wall – 2 Stories - Soil type F (Deep Foundation) – San Juan



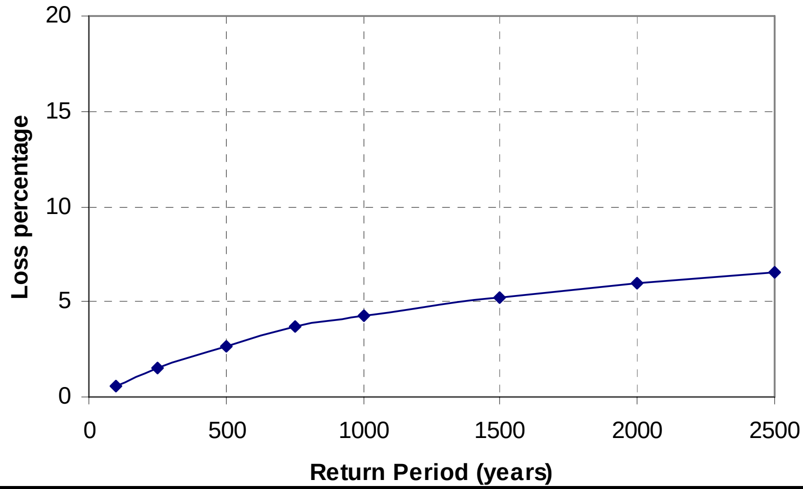
Probable Loss [%]	Name
0.2	PL_{100}
0.6	PL_{250}
1.2	PL_{500}
1.6	PL_{750}
2.1	PL_{1000}
2.8	PL_{1500}
3.4	PL_{2000}
3.9	PL_{2500}
0.009	EAL

Figure C- 29 Concrete - Multistory - Soil type A – San Juan



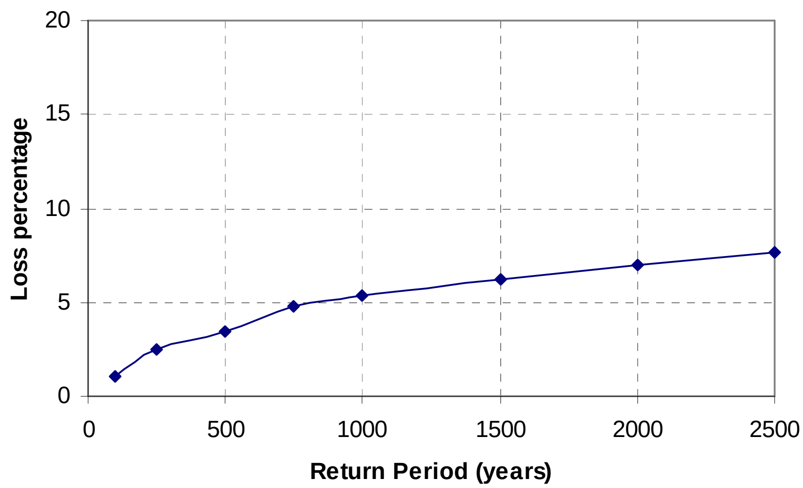
Probable Loss [%]	Name
0.3	PL_{100}
1.0	PL_{250}
1.9	PL_{500}
2.6	PL_{750}
3.3	PL_{1000}
4.3	PL_{1500}
5.2	PL_{2000}
6.0	PL_{2500}
0.014	EAL

Figure C- 30 Concrete - Multistory - Soil type B – San Juan



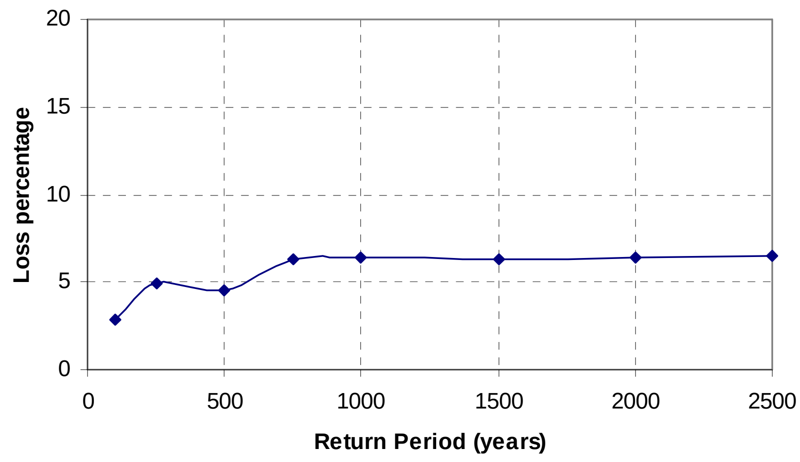
Probable Loss [%]	Name
0.5	PL_{100}
1.5	PL_{250}
2.6	PL_{500}
3.7	PL_{750}
4.3	PL_{1000}
5.2	PL_{1500}
6.0	PL_{2000}
6.5	PL_{2500}
0.019	EAL

Figure C- 31 Concrete - Multistory - Soil type C – San Juan



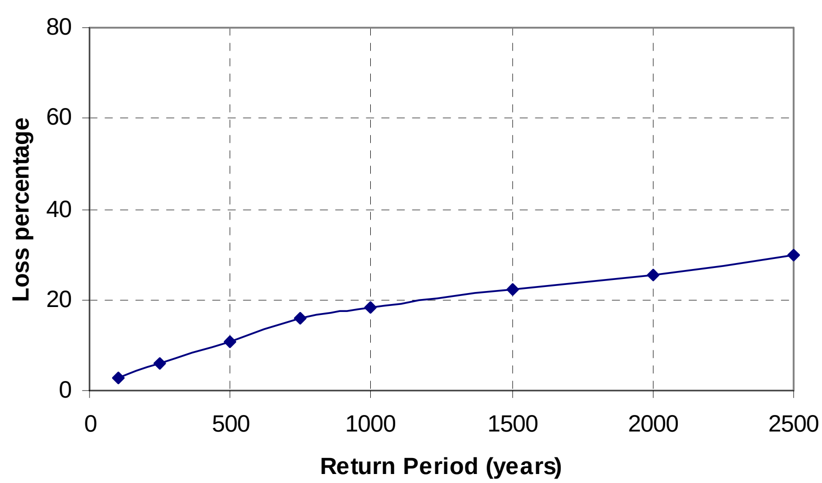
Probable Loss [%]	Name
1.1	PL_{100}
2.5	PL_{250}
3.5	PL_{500}
4.8	PL_{750}
5.4	PL_{1000}
6.2	PL_{1500}
7.0	PL_{2000}
7.7	PL_{2500}
0.028	EAL

Figure C- 32 Concrete - Multistory - Soil type D – San Juan



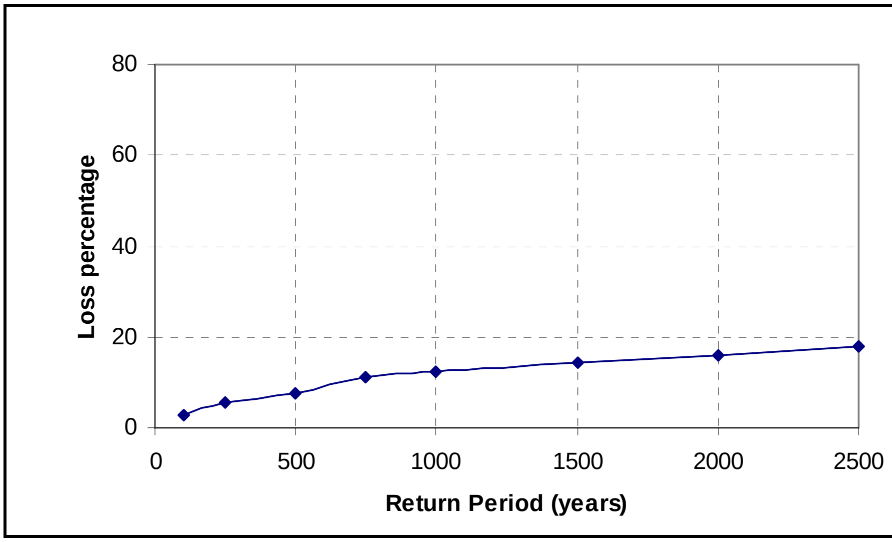
Probable Loss [%]	Name
2.8	PL_{100}
5.0	PL_{250}
4.5	PL_{500}
6.3	PL_{750}
6.4	PL_{1000}
6.3	PL_{1500}
6.5	PL_{2000}
6.5	PL_{2500}
0.045	EAL

Figure C- 33 Concrete - Multistory - Soil type E – San Juan



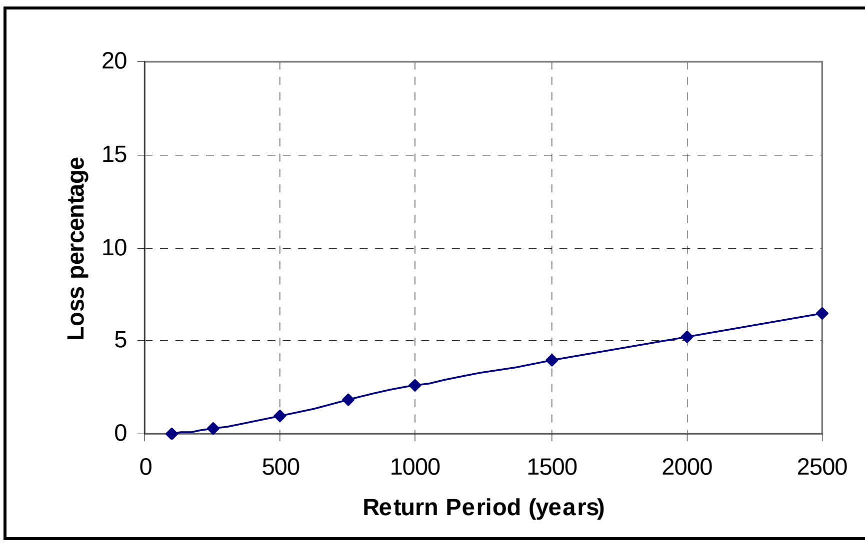
Probable Loss [%]	Name
2.8	PL_{100}
6.0	PL_{250}
10.9	PL_{500}
15.8	PL_{750}
18.5	PL_{1000}
22.1	PL_{1500}
25.3	PL_{2000}
29.7	PL_{2500}
0.083	EAL

Figure C- 34 Concrete - Multistory - Soil type F (Shallow foundation) – San Juan



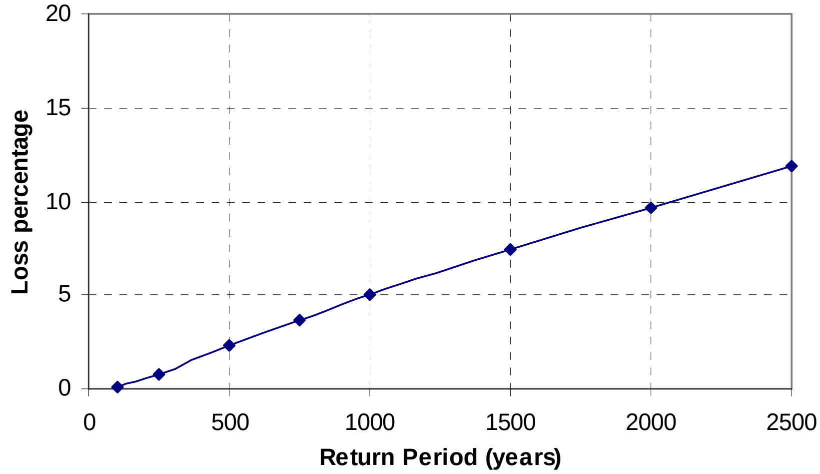
Probable Loss [%]	Name
2.8	PL_{100}
5.5	PL_{250}
7.7	PL_{500}
11.0	PL_{750}
12.5	PL_{1000}
14.2	PL_{1500}
15.9	PL_{2000}
18.1	PL_{2500}
0.064	EAL

Figure C- 35 Concrete - Multistory - Soil type F (Deep foundation) – San Juan



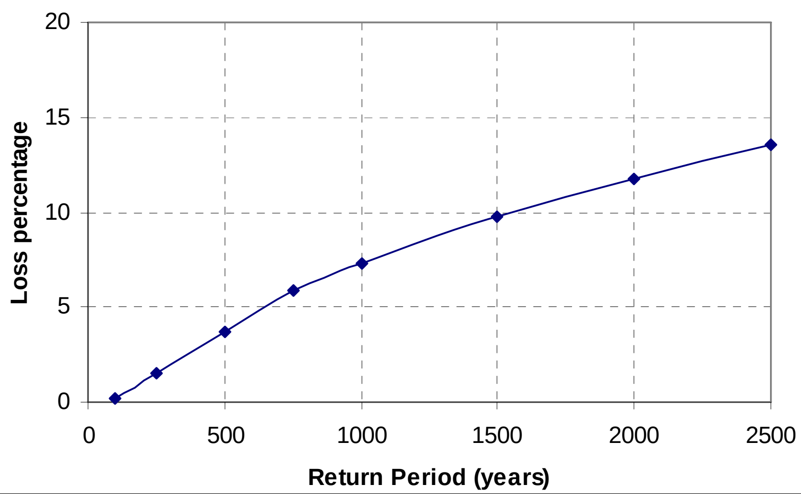
Probable Loss [%]	Name
0.0	PL_{100}
0.2	PL_{250}
1.0	PL_{500}
1.8	PL_{750}
2.6	PL_{1000}
4.0	PL_{1500}
5.2	PL_{2000}
6.4	PL_{2500}
0.009	EAL

Figure C- 36 Steel – Low Rise - Soil type A – San Juan



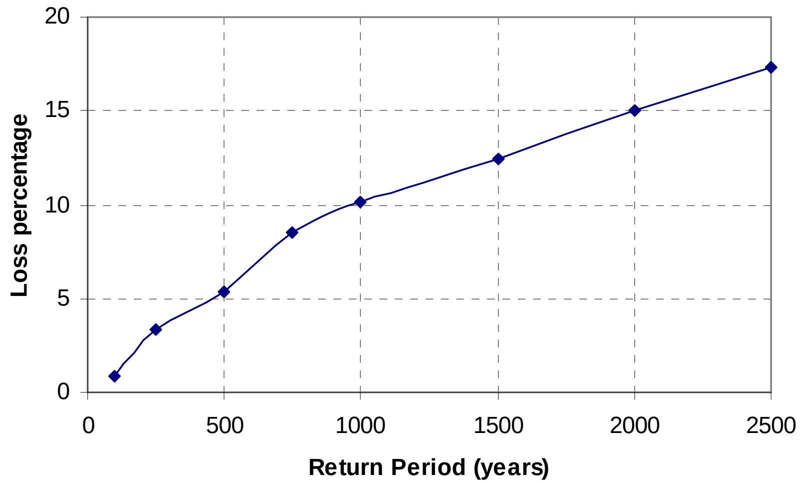
Probable Loss [%]	Name
0.1	PL_{100}
0.7	PL_{250}
2.3	PL_{500}
3.7	PL_{750}
5.1	PL_{1000}
7.4	PL_{1500}
9.7	PL_{2000}
11.9	PL_{2500}
0.018	EAL

Figure C- 37 Steel – Low Rise - Soil type B – San Juan



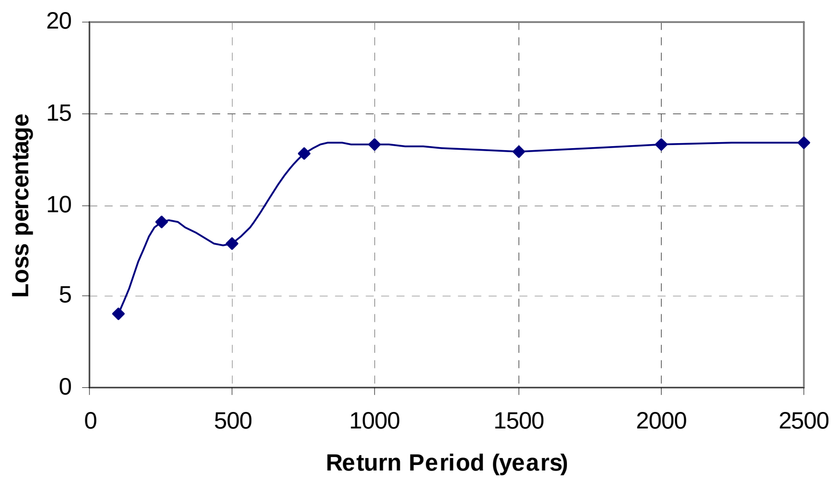
Probable Loss [%]	Name
0.2	PL_{100}
1.5	PL_{250}
3.7	PL_{500}
5.8	PL_{750}
7.3	PL_{1000}
9.7	PL_{1500}
11.8	PL_{2000}
13.5	PL_{2500}
0.027	EAL

Figure C- 38 Steel – Low Rise - Soil type C – San Juan



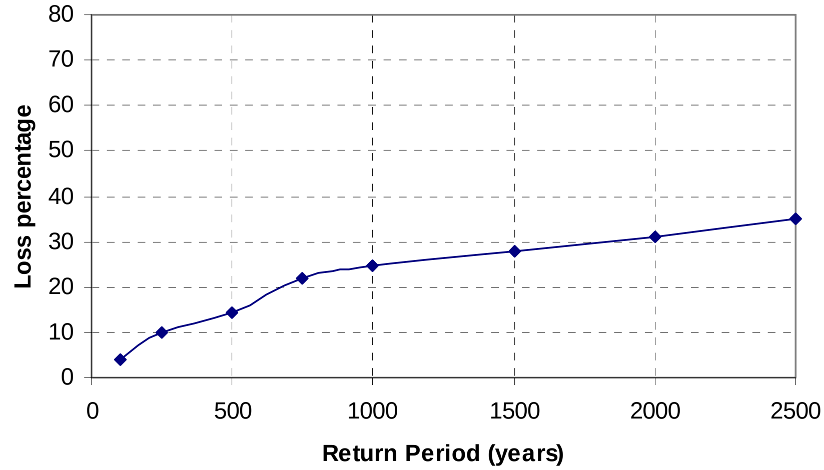
Probable Loss [%]	Name
0.9	PL_{100}
3.3	PL_{250}
5.4	PL_{500}
8.5	PL_{750}
10.2	PL_{1000}
12.5	PL_{1500}
15.0	PL_{2000}
17.3	PL_{2500}
0.044	EAL

Figure C- 39 Steel – Low Rise - Soil type D – San Juan



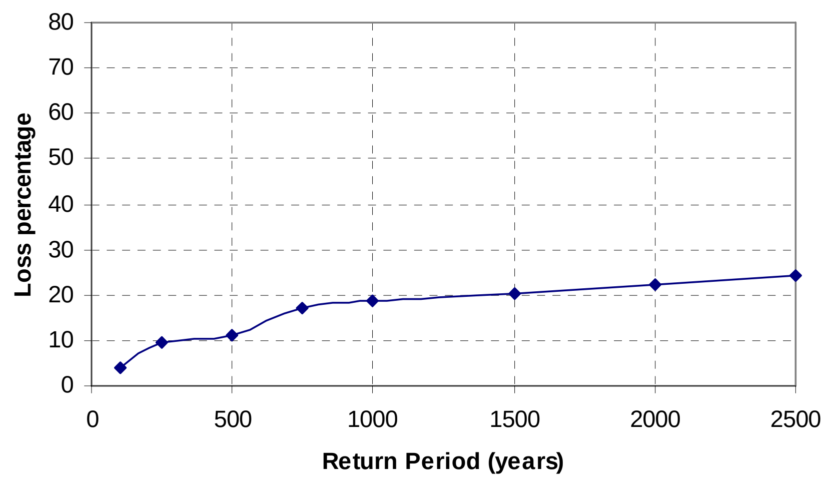
Probable Loss [%]	Name
4.1	PL_{100}
9.0	PL_{250}
7.9	PL_{500}
12.8	PL_{750}
13.3	PL_{1000}
12.9	PL_{1500}
13.3	PL_{2000}
13.4	PL_{2500}
0.081	EAL

Figure C- 40 Steel – Low Rise - Soil type E – San Juan



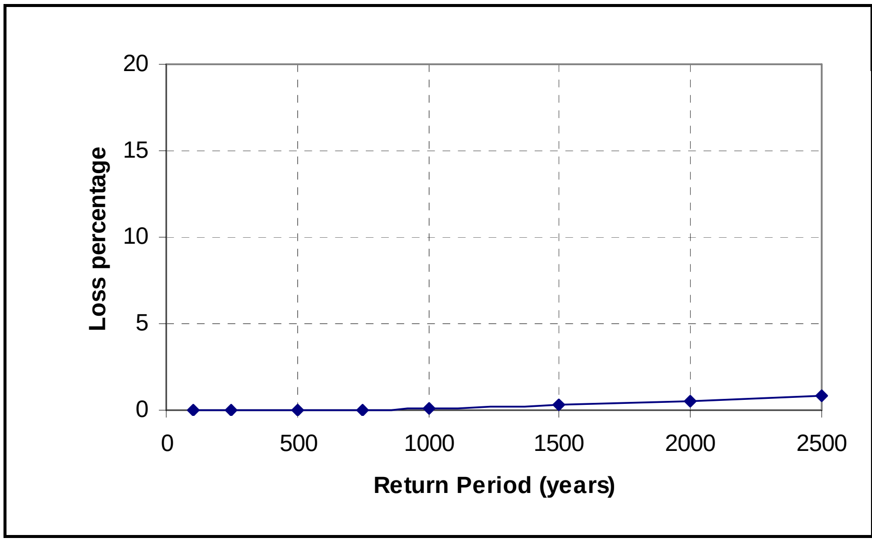
Probable Loss [%]	Name
4.1	PL_{100}
10.0	PL_{250}
14.3	PL_{500}
21.7	PL_{750}
24.5	PL_{1000}
27.7	PL_{1500}
30.9	PL_{2000}
35.1	PL_{2500}
0.117	EAL

Figure C- 41 Steel – Low Rise - Soil type F (Shallow foundation) – San Juan



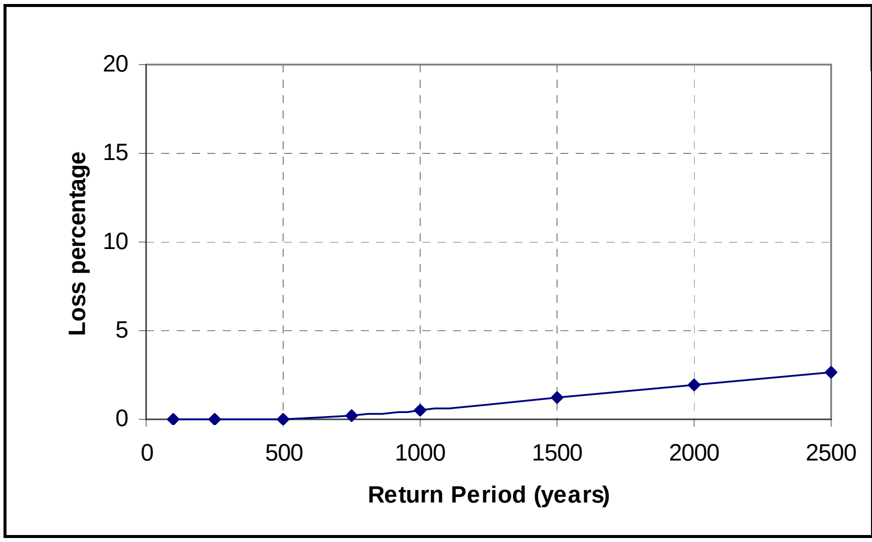
Probable Loss [%]	Name
4.1	PL_{100}
9.5	PL_{250}
11.1	PL_{500}
17.2	PL_{750}
18.9	PL_{1000}
20.3	PL_{1500}
22.1	PL_{2000}
24.2	PL_{2500}
0.099	EAL

Figure C- 42 Steel – Low Rise - Soil type F (Deep foundation) – San Juan



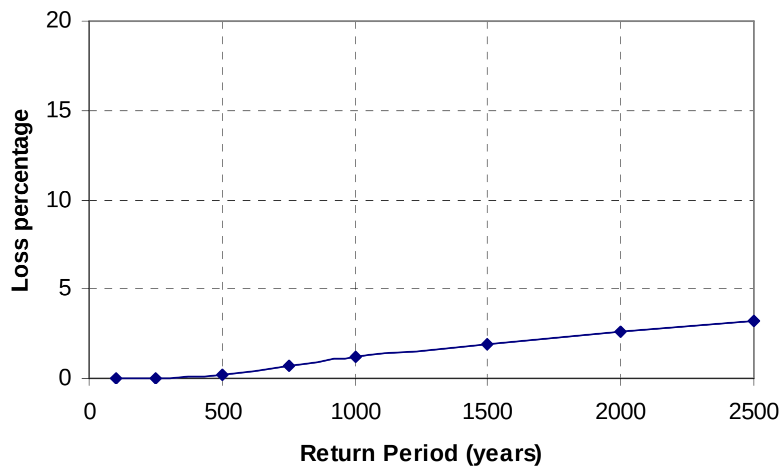
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.0	PL_{750}
0.1	PL_{1000}
0.3	PL_{1500}
0.5	PL_{2000}
0.9	PL_{2500}
0.001	EAL

Figure C- 43 Steel – Mid Rise - Soil type A – San Juan



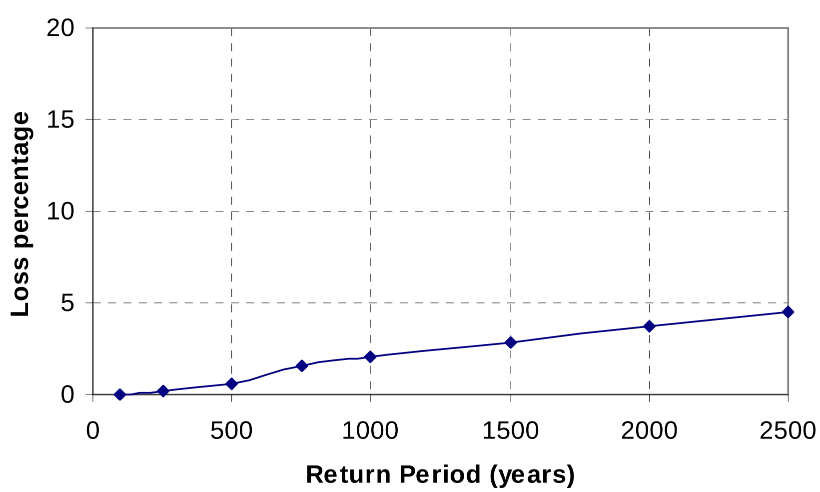
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.2	PL_{750}
0.5	PL_{1000}
1.2	PL_{1500}
1.9	PL_{2000}
2.7	PL_{2500}
0.002	EAL

Figure C- 44 Steel – Mid Rise - Soil type B – San Juan



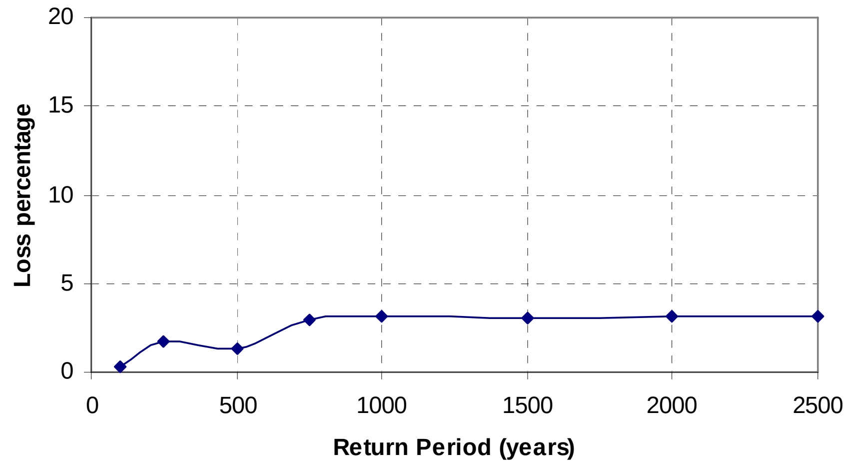
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.2	PL_{500}
0.7	PL_{750}
1.2	PL_{1000}
1.9	PL_{1500}
2.6	PL_{2000}
3.2	PL_{2500}
0.003	EAL

Figure C- 45 Steel – Mid Rise - Soil type C – San Juan



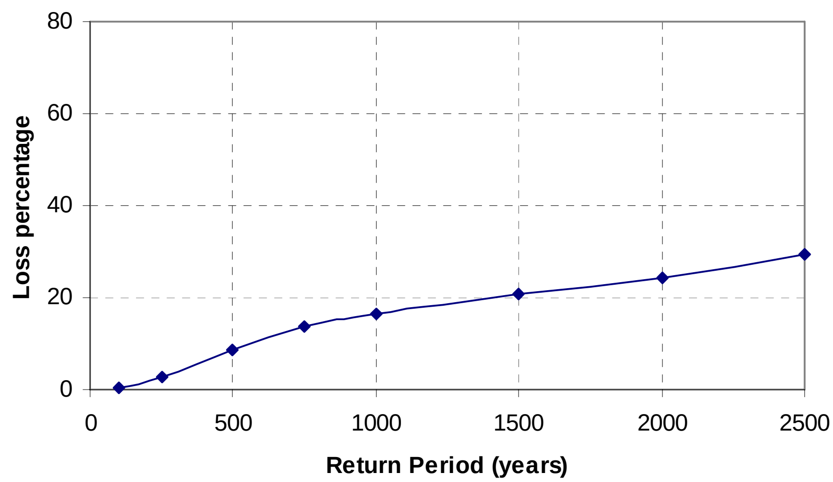
Probable Loss [%]	Name
0.0	PL_{100}
0.2	PL_{250}
0.6	PL_{500}
1.5	PL_{750}
2.1	PL_{1000}
2.9	PL_{1500}
3.7	PL_{2000}
4.5	PL_{2500}
0.006	EAL

Figure C- 46 Steel – Mid Rise - Soil type D – San Juan



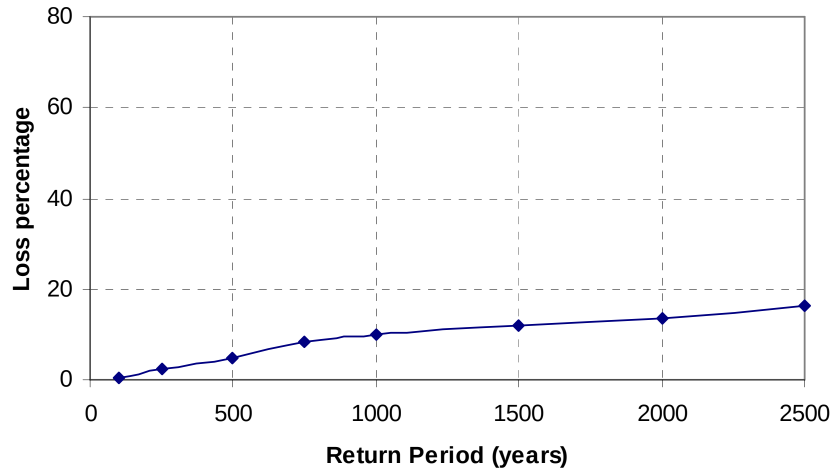
Probable Loss [%]	Name
0.3	PL_{100}
1.7	PL_{250}
1.3	PL_{500}
3.0	PL_{750}
3.1	PL_{1000}
3.0	PL_{1500}
3.2	PL_{2000}
3.2	PL_{2500}
0.015	EAL

Figure C- 47 Steel – Mid Rise - Soil type E – San Juan



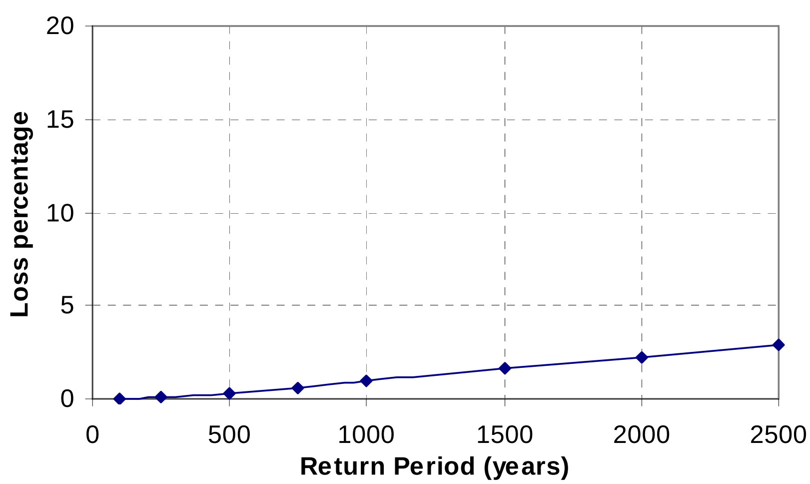
Probable Loss [%]	Name
0.3	PL_{100}
2.9	PL_{250}
8.5	PL_{500}
13.6	PL_{750}
16.7	PL_{1000}
20.7	PL_{1500}
24.3	PL_{2000}
29.2	PL_{2500}
0.058	EAL

Figure C- 48 Steel – Mid Rise - Soil type F (Shallow foundation) – San Juan



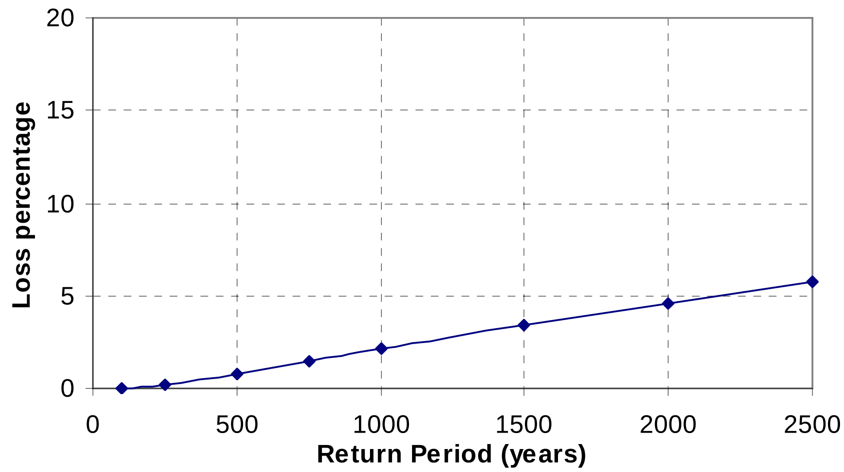
Probable Loss [%]	Name
0.3	PL_{100}
2.3	PL_{250}
4.9	PL_{500}
8.3	PL_{750}
9.9	PL_{1000}
11.9	PL_{1500}
13.7	PL_{2000}
16.2	PL_{2500}
0.036	EAL

Figure C- 49 Steel – Mid Rise - Soil type F (Deep foundation) – San Juan



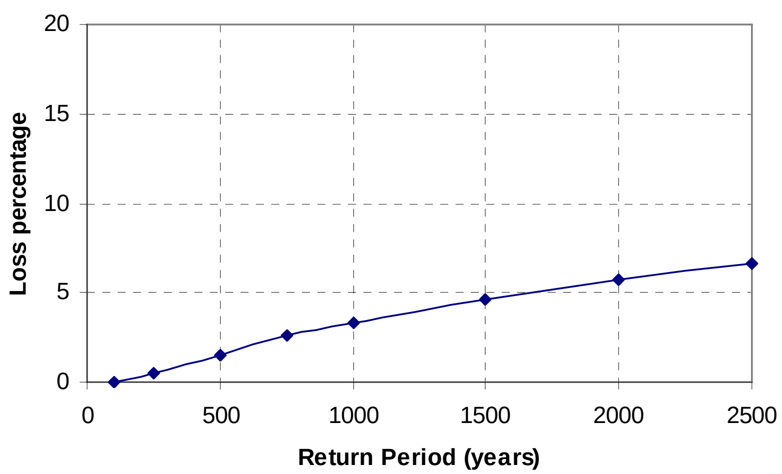
Probable Loss [%]	Name
0.00	PL_{100}
0.06	PL_{250}
0.29	PL_{500}
0.61	PL_{750}
0.96	PL_{1000}
1.62	PL_{1500}
2.27	PL_{2000}
2.89	PL_{2500}
0.003	EAL

Figure C- 50 Steel – High Rise - Soil type A – San Juan



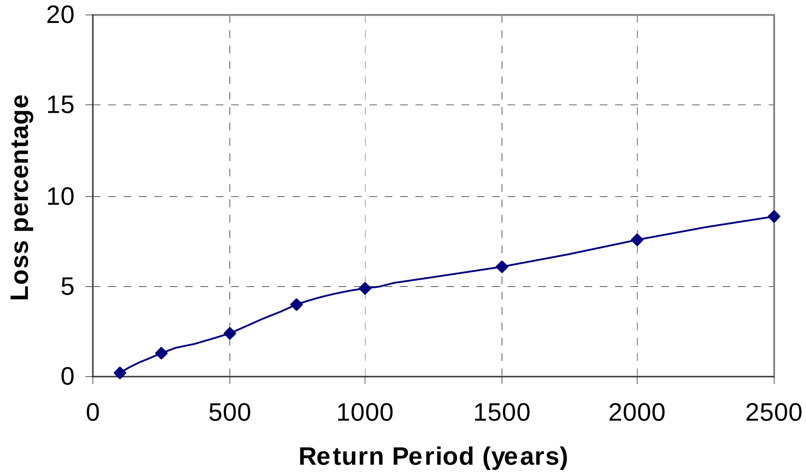
Probable Loss [%]	Name
0.0	PL_{100}
0.2	PL_{250}
0.8	PL_{500}
1.5	PL_{750}
2.2	PL_{1000}
3.4	PL_{1500}
4.6	PL_{2000}
5.8	PL_{2500}
0.007	EAL

Figure C- 51 Steel – High Rise - Soil type B – San Juan



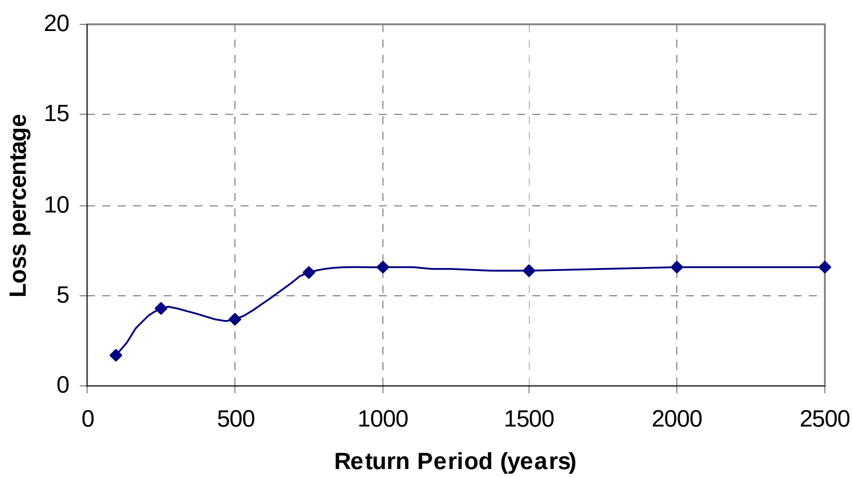
Probable Loss [%]	Name
0.0	PL_{100}
0.5	PL_{250}
1.5	PL_{500}
2.6	PL_{750}
3.4	PL_{1000}
4.6	PL_{1500}
5.7	PL_{2000}
6.7	PL_{2500}
0.011	EAL

Figure C- 52 Steel – High Rise - Soil type C – San Juan



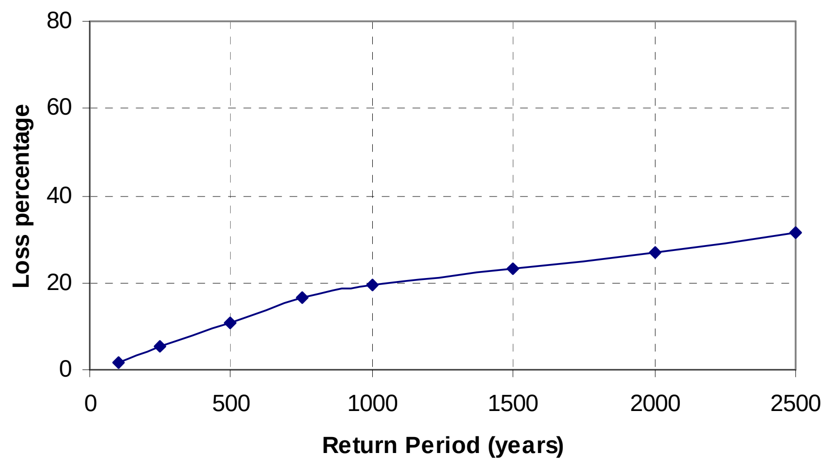
Probable Loss [%]	Name
0.2	PL_{100}
1.3	PL_{250}
2.3	PL_{500}
4.0	PL_{750}
4.8	PL_{1000}
6.1	PL_{1500}
7.5	PL_{2000}
8.9	PL_{2500}
0.019	EAL

Figure C- 53 Steel – High Rise - Soil type D – San Juan



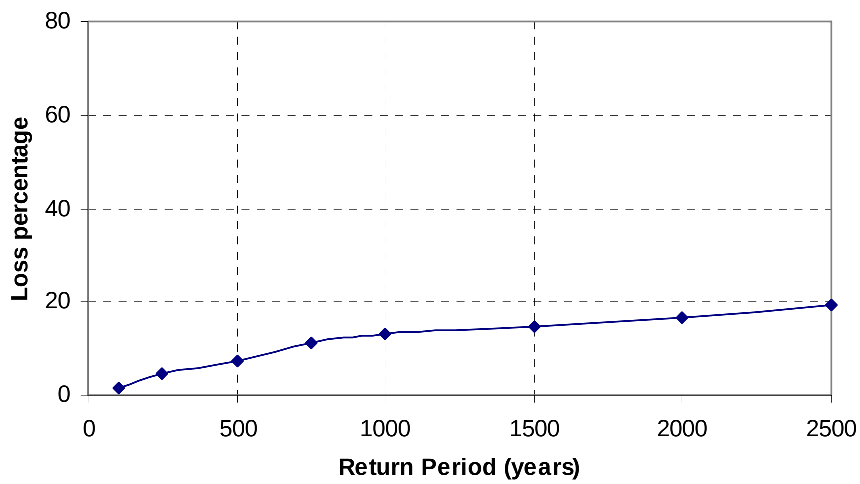
Probable Loss [%]	Name
1.7	PL_{100}
4.2	PL_{250}
3.7	PL_{500}
6.3	PL_{750}
6.5	PL_{1000}
6.3	PL_{1500}
6.6	PL_{2000}
6.6	PL_{2500}
0.038	EAL

Figure C- 54 Steel – High Rise - Soil type E – San Juan



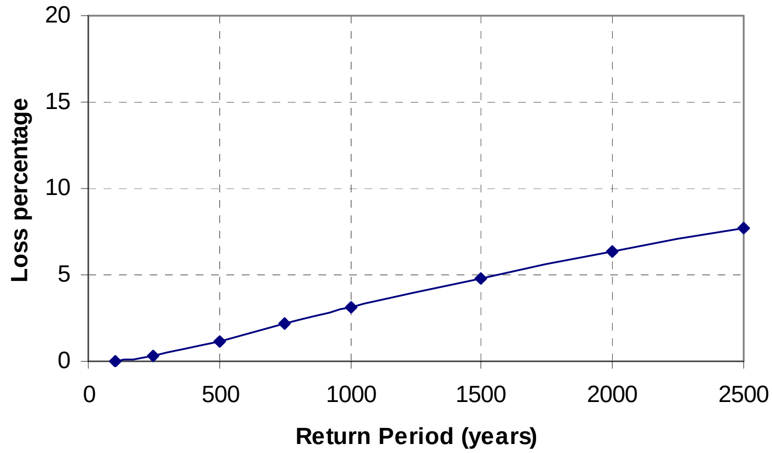
Probable Loss [%]	Name
1.7	PL_{100}
5.4	PL_{250}
10.6	PL_{500}
16.5	PL_{750}
19.6	PL_{1000}
23.4	PL_{1500}
26.9	PL_{2000}
31.7	PL_{2500}
0.079	EAL

Figure C- 55 Steel – High Rise - Soil type F (Shallow foundation) – San Juan



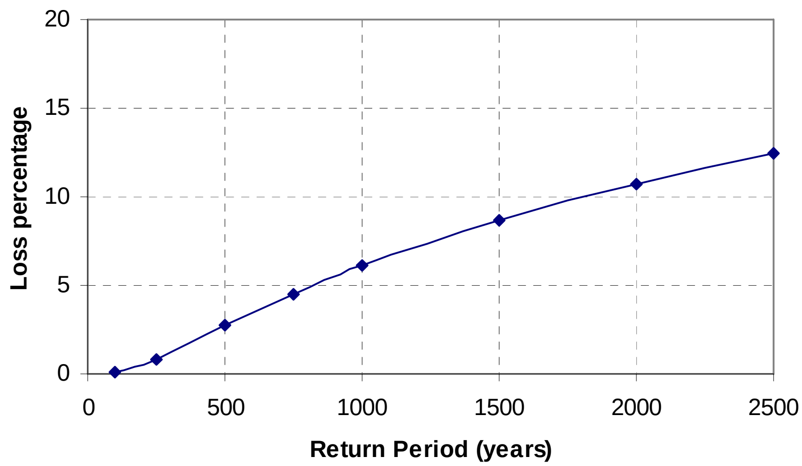
Probable Loss [%]	Name
1.7	PL_{100}
4.8	PL_{250}
7.2	PL_{500}
11.4	PL_{750}
13.0	PL_{1000}
14.9	PL_{1500}
16.7	PL_{2000}
19.1	PL_{2500}
0.058	EAL

Figure C- 56 Steel – High Rise - Soil type F (Deep foundation) – San Juan



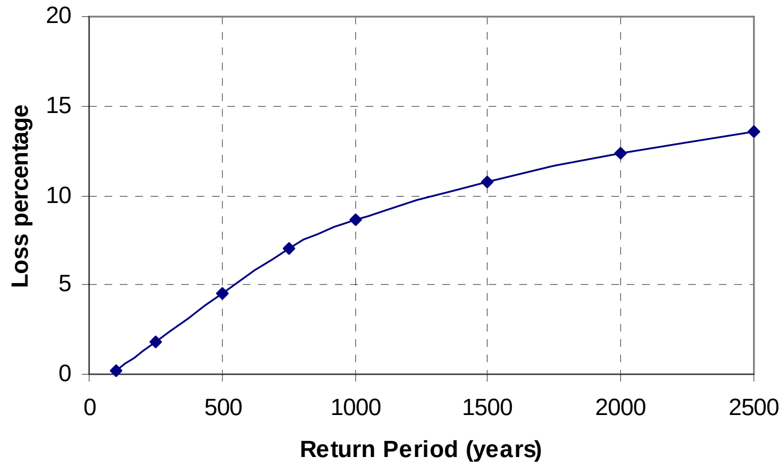
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.2	PL_{500}
2.1	PL_{750}
3.1	PL_{1000}
4.8	PL_{1500}
6.4	PL_{2000}
7.7	PL_{2500}
0.010	EAL

Figure C- 57 Steel – Industrial – 1 Story - Soil type A – San Juan



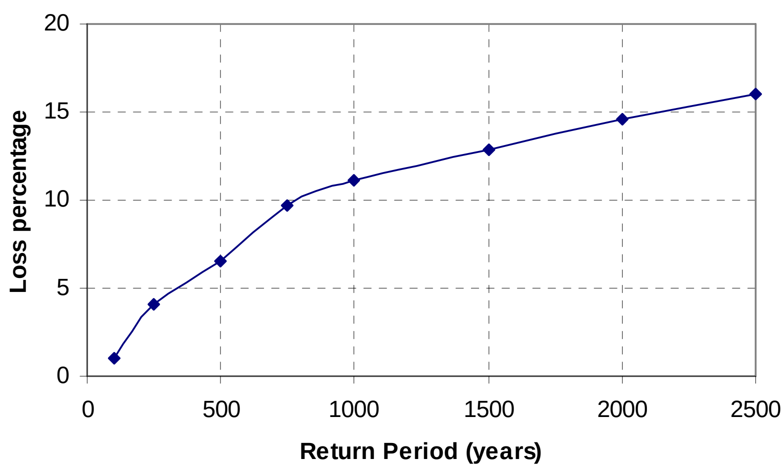
Probable Loss [%]	Name
0.1	PL_{100}
0.9	PL_{250}
2.7	PL_{500}
4.5	PL_{750}
6.1	PL_{1000}
8.7	PL_{1500}
10.7	PL_{2000}
12.5	PL_{2500}
0.021	EAL

Figure C- 58 Steel – Industrial – 1 Story - Soil type B – San Juan



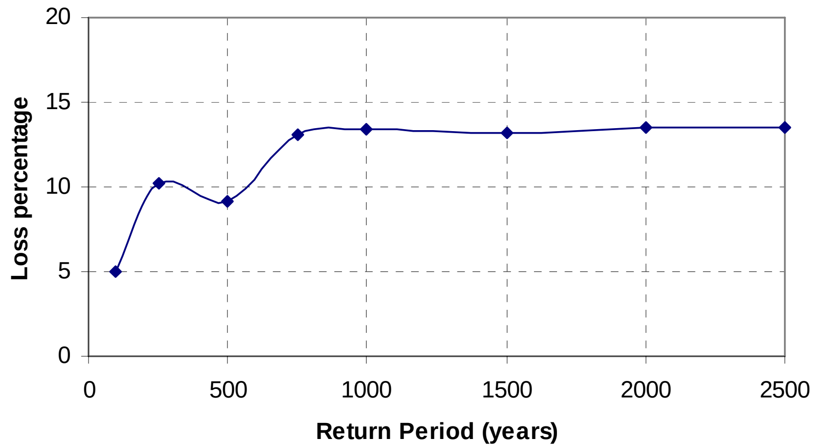
Probable Loss [%]	Name
0.2	PL_{100}
1.8	PL_{250}
4.5	PL_{500}
7.0	PL_{750}
8.6	PL_{1000}
10.8	PL_{1500}
12.4	PL_{2000}
13.6	PL_{2500}
0.031	EAL

Figure C- 59 Steel –Industrial – 1 Story - Soil type C – San Juan



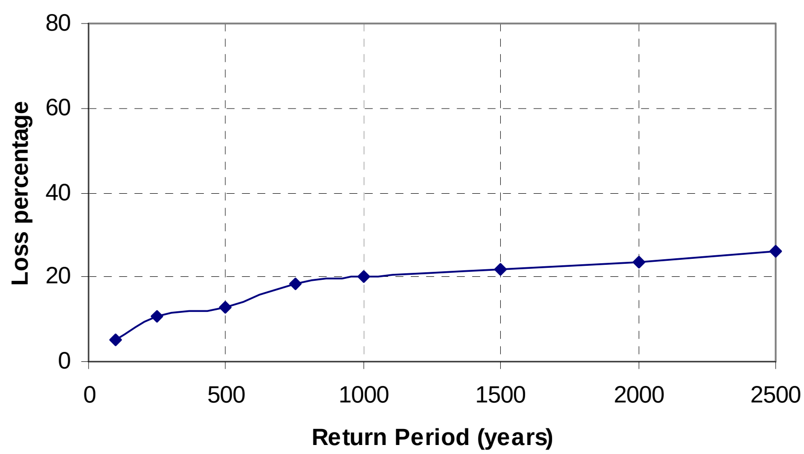
Probable Loss [%]	Name
1.0	PL_{100}
4.1	PL_{250}
6.5	PL_{500}
9.7	PL_{750}
11.1	PL_{1000}
12.9	PL_{1500}
14.6	PL_{2000}
16.1	PL_{2500}
0.049	EAL

Figure C- 60 Steel – Industrial – 1 Story - Soil type D – San Juan



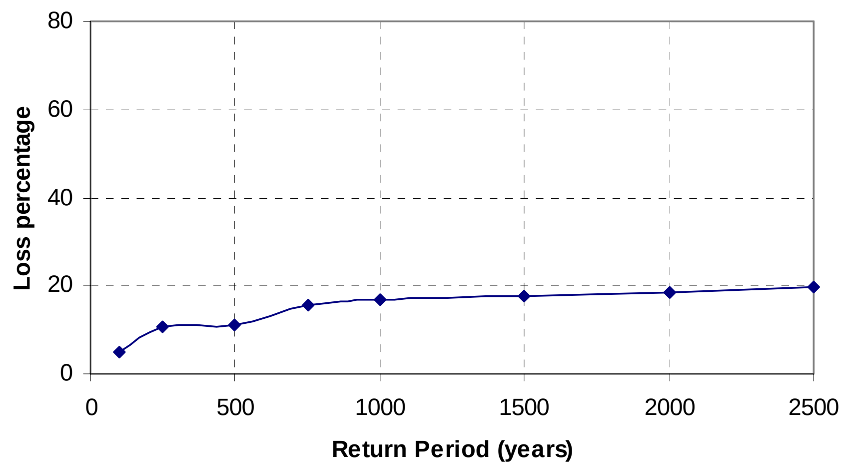
Probable Loss [%]	Name
5.0	PL_{100}
10.2	PL_{250}
9.2	PL_{500}
13.1	PL_{750}
13.4	PL_{1000}
13.2	PL_{1500}
13.5	PL_{2000}
13.5	PL_{2500}
0.090	EAL

Figure C- 61 Steel –Industrial – 1 Story - Soil type E – San Juan



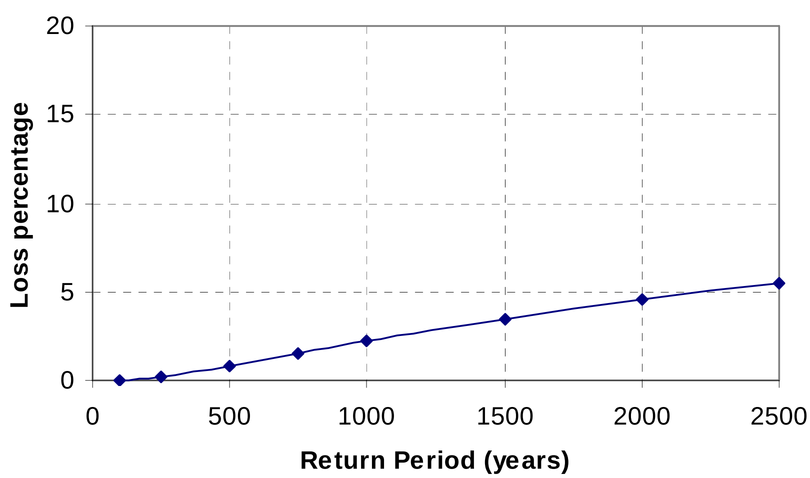
Probable Loss [%]	Name
5.0	PL_{100}
10.8	PL_{250}
12.9	PL_{500}
18.2	PL_{750}
19.9	PL_{1000}
21.7	PL_{1500}
23.6	PL_{2000}
26.0	PL_{2500}
0.111	EAL

Figure C- 62 Steel – Industrial – 1 Story - Soil type F (Shallow foundation) – San Juan



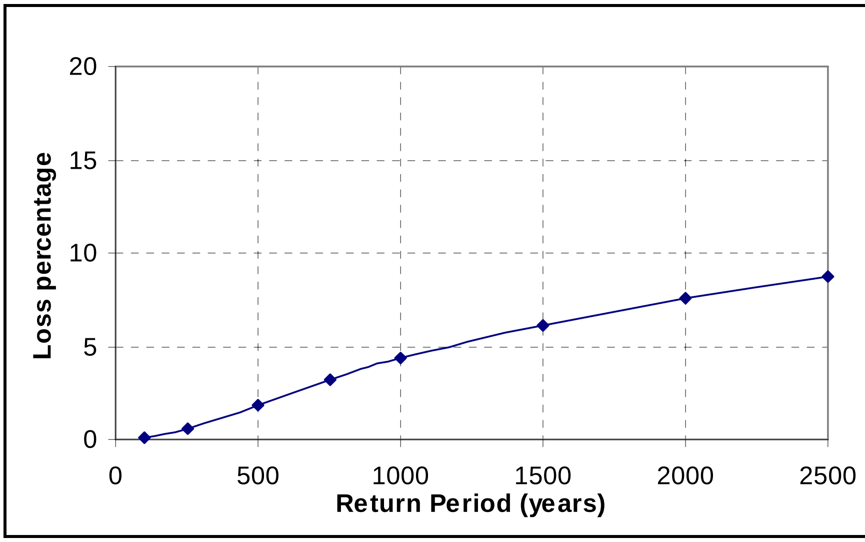
Probable Loss [%]	Name
5.0	PL_{100}
10.5	PL_{250}
11.1	PL_{500}
15.7	PL_{750}
16.7	PL_{1000}
17.5	PL_{1500}
18.5	PL_{2000}
19.8	PL_{2500}
0.101	EAL

Figure C- 63 Steel –Industrial – 1 Story - Soil type F (Deep foundation) – San Juan



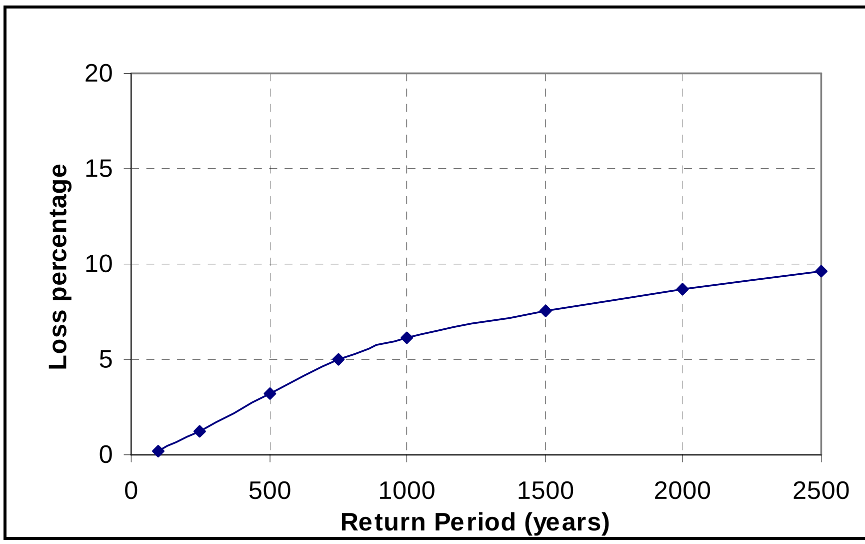
Probable Loss [%]	Name
0.0	PL_{100}
0.2	PL_{250}
0.8	PL_{500}
1.5	PL_{750}
2.2	PL_{1000}
3.4	PL_{1500}
4.5	PL_{2000}
5.5	PL_{2500}
0.007	EAL

Figure C- 64 Steel – Industrial – 2 Story - Soil type A – San Juan



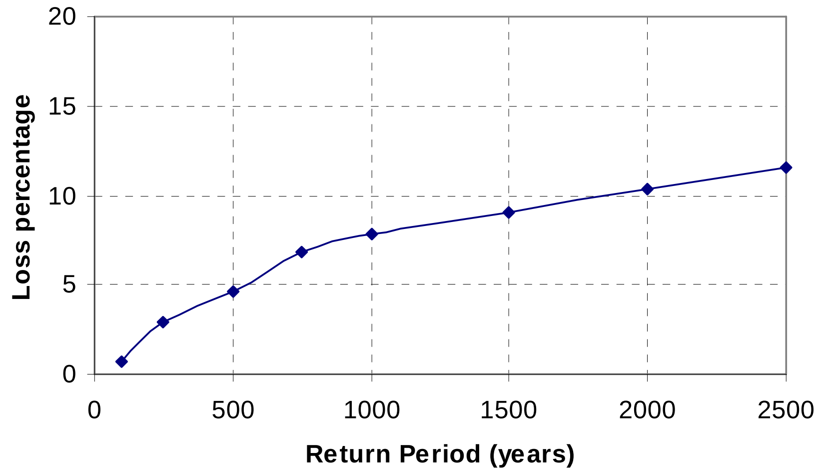
Probable Loss [%]	Name
0.0	PL_{100}
0.6	PL_{250}
1.9	PL_{500}
3.2	PL_{750}
4.4	PL_{1000}
6.1	PL_{1500}
7.6	PL_{2000}
8.8	PL_{2500}
0.014	EAL

Figure C- 65 Steel – Industrial – 2 Story - Soil type B – San Juan



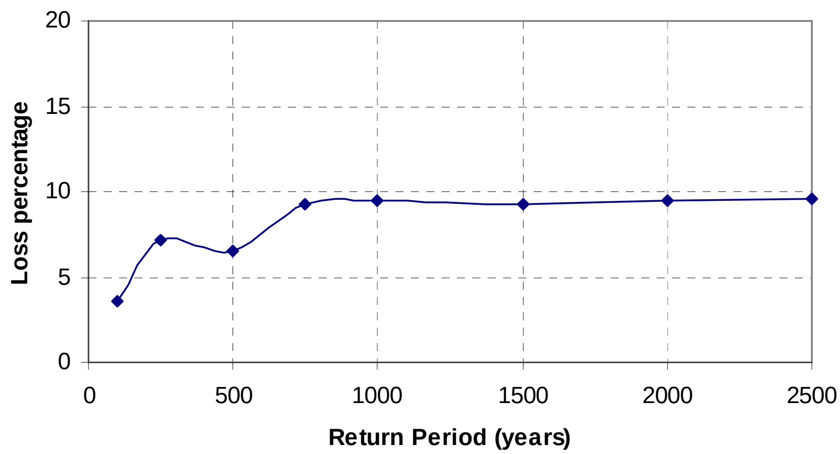
Probable Loss [%]	Name
0.2	PL_{100}
1.2	PL_{250}
3.2	PL_{500}
5.0	PL_{750}
6.1	PL_{1000}
7.6	PL_{1500}
8.7	PL_{2000}
9.6	PL_{2500}
0.022	EAL

Figure C- 66 Steel –Industrial – 2 Story - Soil type C – San Juan



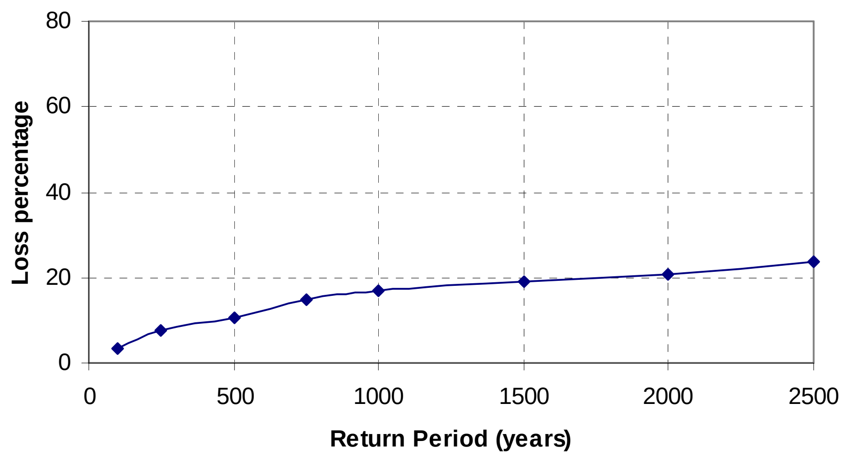
Probable Loss [%]	Name
0.7	PL_{100}
2.9	PL_{250}
4.7	PL_{500}
6.9	PL_{750}
7.8	PL_{1000}
9.1	PL_{1500}
10.4	PL_{2000}
11.6	PL_{2500}
0.035	EAL

Figure C- 67 Steel – Industrial – 2 Story - Soil type D – San Juan



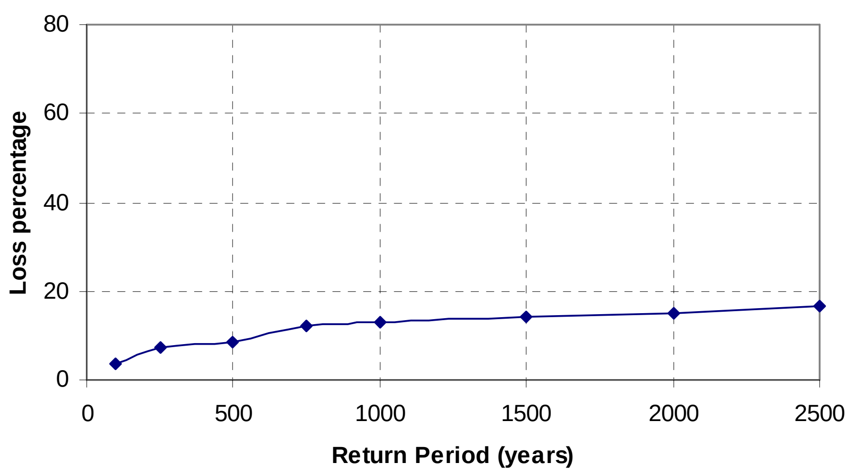
Probable Loss [%]	Name
3.5	PL_{100}
7.2	PL_{250}
6.5	PL_{500}
9.2	PL_{750}
9.5	PL_{1000}
9.3	PL_{1500}
9.5	PL_{2000}
9.5	PL_{2500}
0.064	EAL

Figure C- 68 Steel –Industrial – 2 Story - Soil type E – San Juan



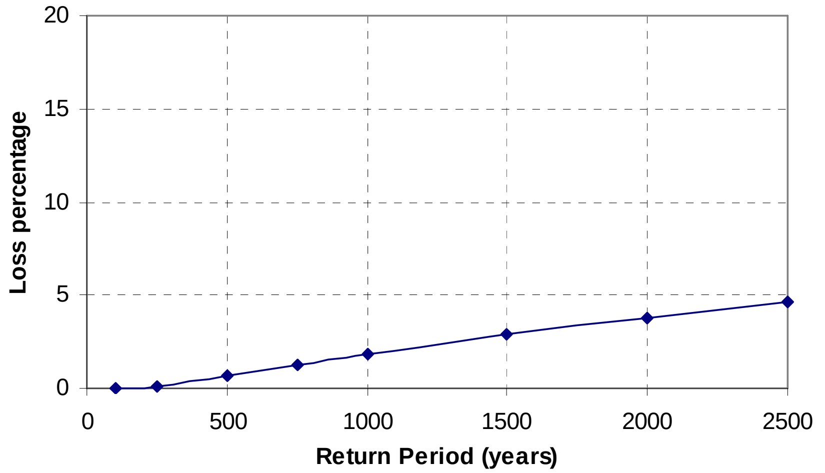
Probable Loss [%]	Name
3.5	PL_{100}
7.8	PL_{250}
10.6	PL_{500}
15.0	PL_{750}
16.8	PL_{1000}
18.9	PL_{1500}
20.9	PL_{2000}
23.6	PL_{2500}
0.087	EAL

Figure C- 69 Steel – Industrial – 2 Story - Soil type F (Shallow foundation) – San Juan



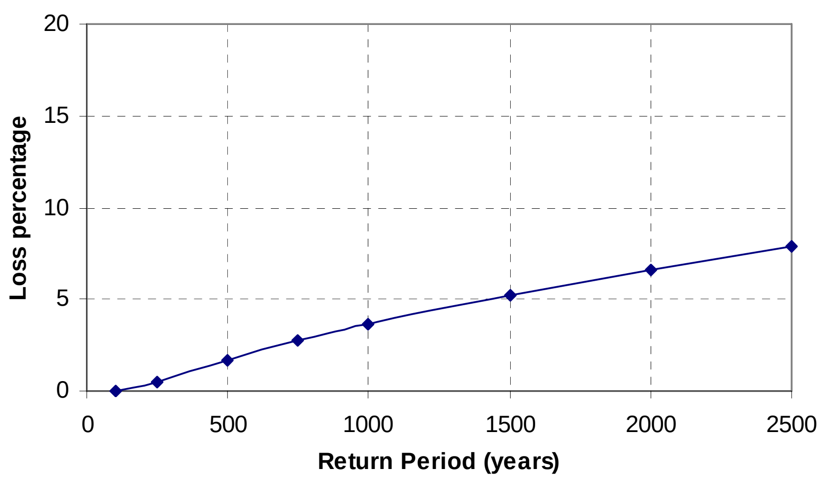
Probable Loss [%]	Name
3.5	PL_{100}
7.5	PL_{250}
8.5	PL_{500}
12.1	PL_{750}
13.1	PL_{1000}
14.1	PL_{1500}
15.2	PL_{2000}
16.6	PL_{2500}
0.075	EAL

Figure C- 70 Steel –Industrial – 2 Story - Soil type F (Deep foundation) – San Juan



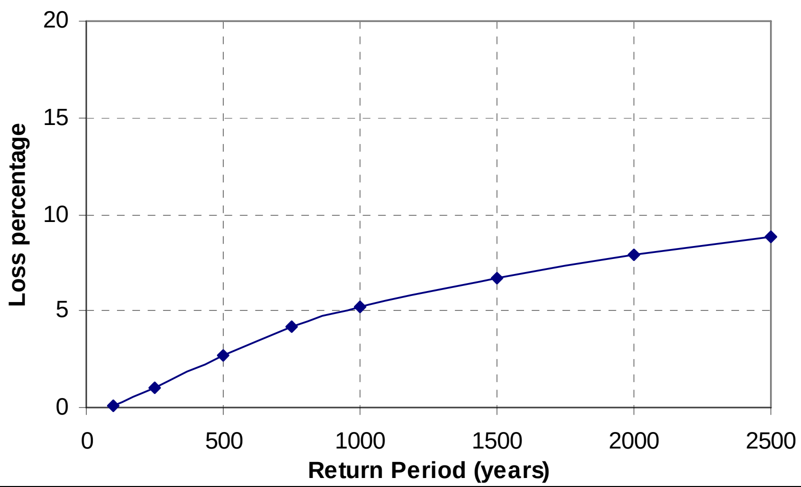
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.6	PL_{500}
1.3	PL_{750}
1.9	PL_{1000}
2.9	PL_{1500}
3.8	PL_{2000}
4.6	PL_{2500}
0.006	EAL

Figure C- 71 Steel – Commercial – 2 Story - Soil type A – San Juan



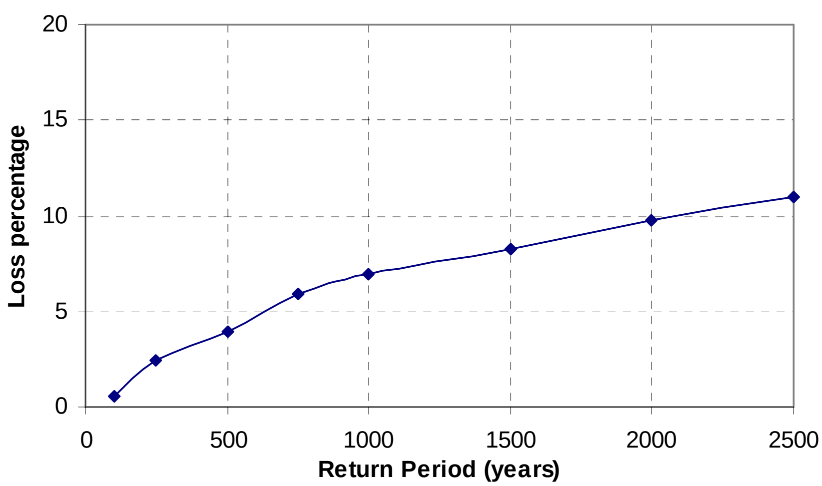
Probable Loss [%]	Name
0.0	PL_{100}
0.5	PL_{250}
1.6	PL_{500}
2.7	PL_{750}
3.7	PL_{1000}
5.2	PL_{1500}
6.6	PL_{2000}
7.9	PL_{2500}
0.012	EAL

Figure C- 72 Steel – Commercial – 2 Story - Soil type B – San Juan



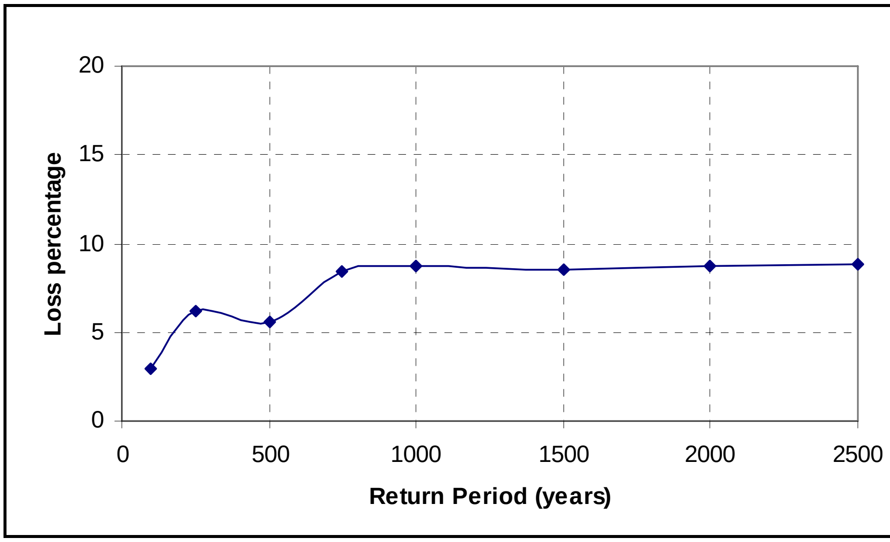
Probable Loss [%]	Name
0.1	PL_{100}
1.1	PL_{250}
2.7	PL_{500}
4.2	PL_{750}
5.2	PL_{1000}
6.7	PL_{1500}
7.9	PL_{2000}
8.9	PL_{2500}
0.019	EAL

Figure C- 73 Steel –Commercial– 2 Story - Soil type C – San Juan



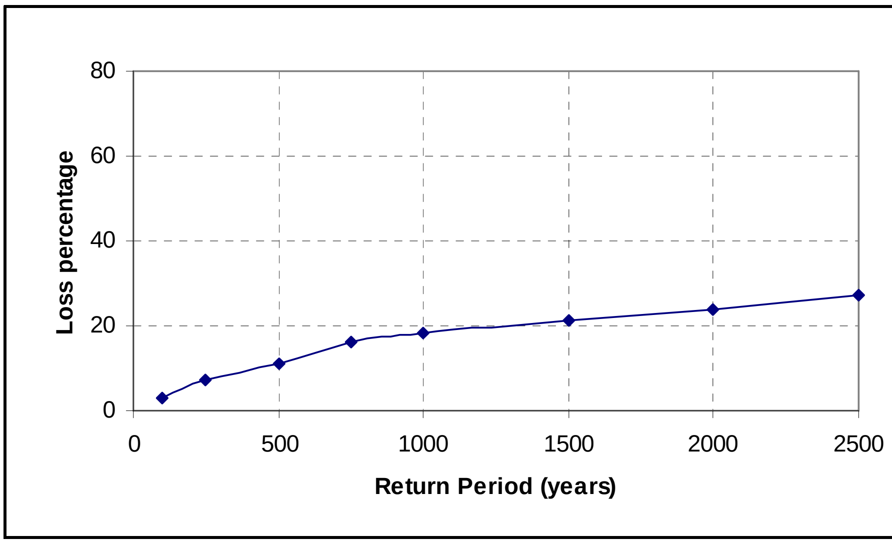
Probable Loss [%]	Name
0.6	PL_{100}
2.4	PL_{250}
3.9	PL_{500}
5.9	PL_{750}
6.9	PL_{1000}
8.3	PL_{1500}
9.7	PL_{2000}
11.0	PL_{2500}
0.030	EAL

Figure C- 74 Steel – Commercial – 2 Story - Soil type D – San Juan



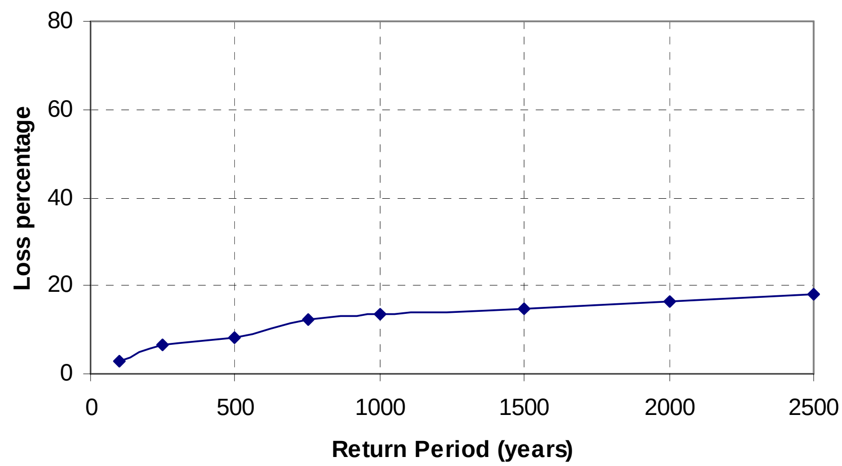
Probable Loss [%]	Name
3.0	PL_{100}
6.2	PL_{250}
5.6	PL_{500}
8.4	PL_{750}
8.7	PL_{1000}
8.5	PL_{1500}
8.7	PL_{2000}
8.8	PL_{2500}
0.056	EAL

Figure C- 75 Steel –Commercial – 2 Story - Soil type E – San Juan



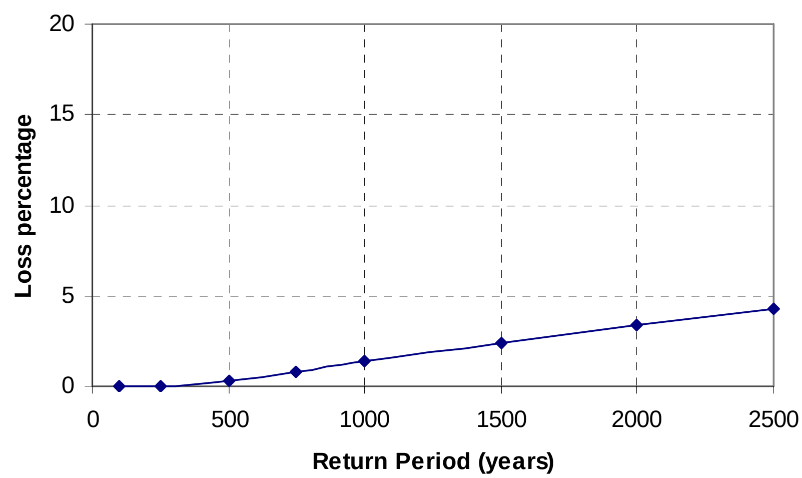
Probable Loss [%]	Name
3.0	PL_{100}
7.1	PL_{250}
10.9	PL_{500}
16.1	PL_{750}
18.4	PL_{1000}
21.2	PL_{1500}
23.9	PL_{2000}
27.4	PL_{2500}
0.087	EAL

Figure C- 76 Steel – Commercial – 2 Story - Soil type F (Shallow foundation) – San Juan



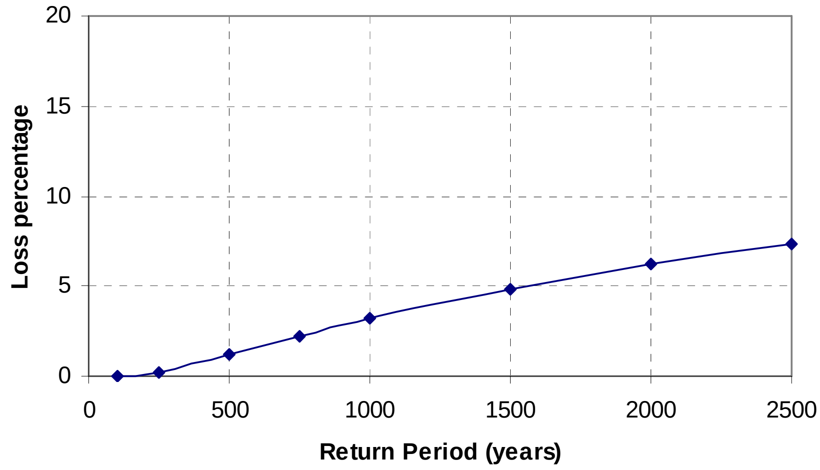
Probable Loss [%]	Name
3.0	PL_{100}
6.7	PL_{250}
8.2	PL_{500}
12.3	PL_{750}
13.6	PL_{1000}
14.9	PL_{1500}
16.3	PL_{2000}
18.1	PL_{2500}
0.071	EAL

Figure C- 77 Steel –Commercial – 2 Story - Soil type F (Deep foundation) – San Juan



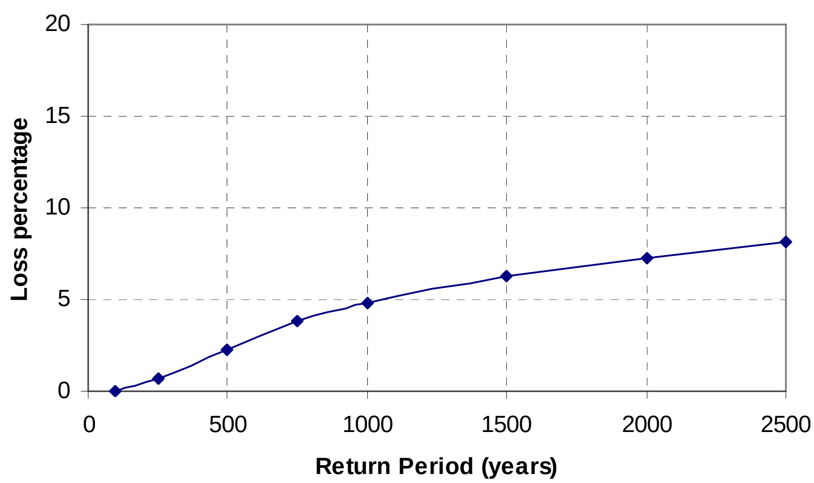
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.3	PL_{500}
0.8	PL_{750}
1.4	PL_{1000}
2.4	PL_{1500}
3.4	PL_{2000}
4.2	PL_{2500}
0.004	EAL

Figure C- 78 Steel – Commercial – 3 Story - Soil type A – San Juan



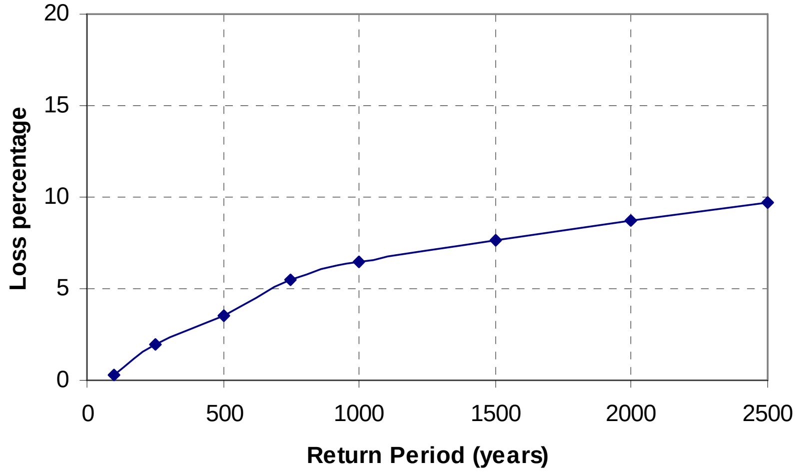
Probable Loss [%]	Name
0.0	PL_{100}
0.2	PL_{250}
1.2	PL_{500}
2.2	PL_{750}
3.2	PL_{1000}
4.9	PL_{1500}
6.2	PL_{2000}
7.3	PL_{2500}
0.010	EAL

Figure C- 79 Steel – Commercial – 3 Story - Soil type B – San Juan



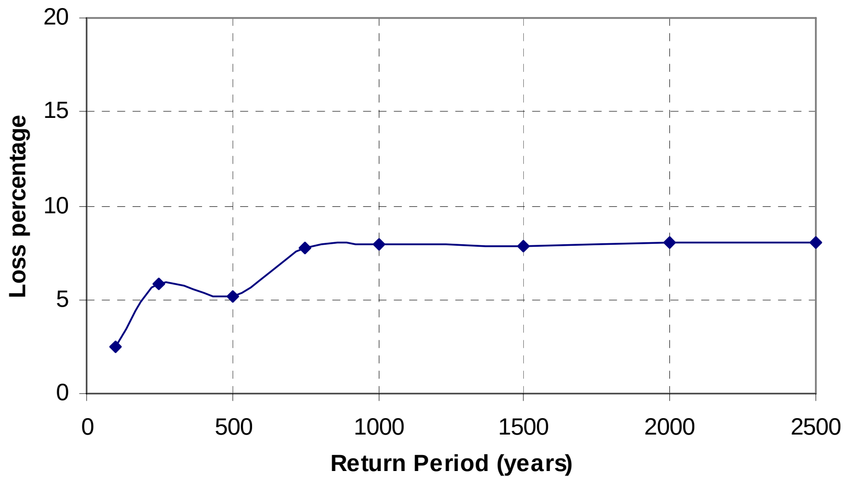
Probable Loss [%]	Name
0.0	PL_{100}
0.7	PL_{250}
2.2	PL_{500}
3.8	PL_{750}
4.8	PL_{1000}
6.2	PL_{1500}
7.3	PL_{2000}
8.1	PL_{2500}
0.015	EAL

Figure C- 80 Steel –Commercial– 3 Story - Soil type C – San Juan



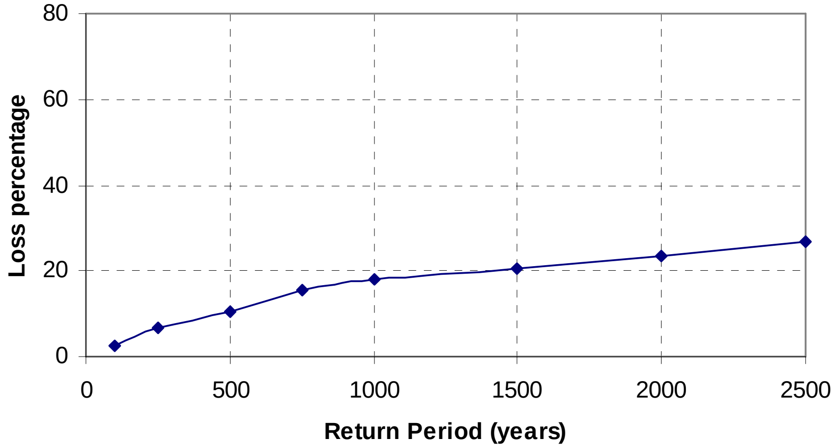
Probable Loss [%]	Name
0.3	PL_{100}
2.0	PL_{250}
3.5	PL_{500}
5.5	PL_{750}
6.5	PL_{1000}
7.6	PL_{1500}
8.8	PL_{2000}
9.7	PL_{2500}
0.026	EAL

Figure C- 81 Steel – Commercial – 3 Story - Soil type D – San Juan



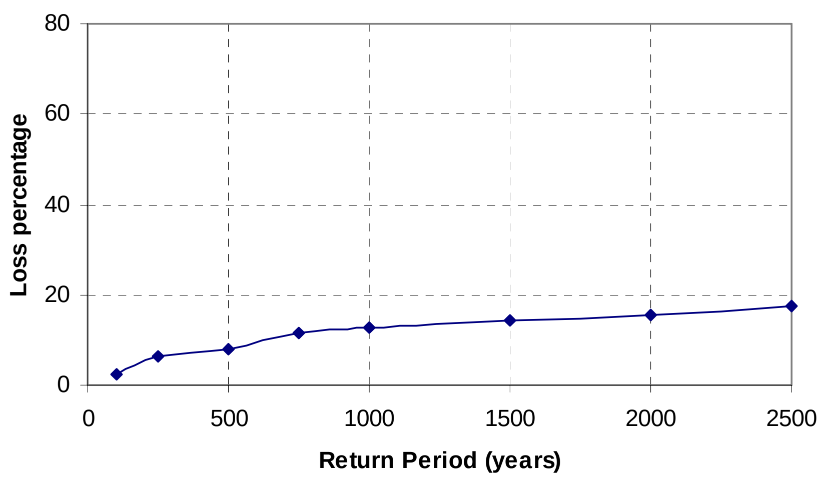
Probable Loss [%]	Name
2.5	PL_{100}
5.8	PL_{250}
5.2	PL_{500}
7.8	PL_{750}
8.0	PL_{1000}
7.8	PL_{1500}
8.0	PL_{2000}
8.0	PL_{2500}
0.051	EAL

Figure C- 82 Steel –Commercial – 3 Story - Soil type E – San Juan



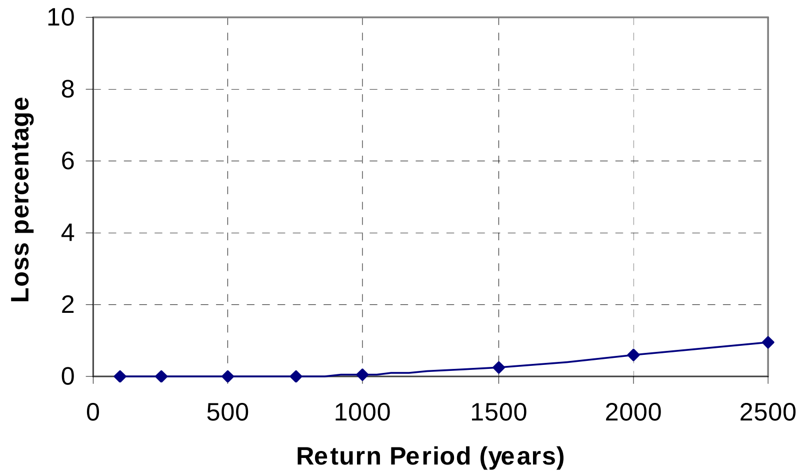
Probable Loss [%]	Name
2.5	PL_{100}
6.7	PL_{250}
10.5	PL_{500}
15.5	PL_{750}
17.8	PL_{1000}
20.7	PL_{1500}
23.4	PL_{2000}
27.0	PL_{2500}
0.083	EAL

Figure C- 83 Steel – Commercial – 3 Story - Soil type F (Shallow foundation) – San Juan



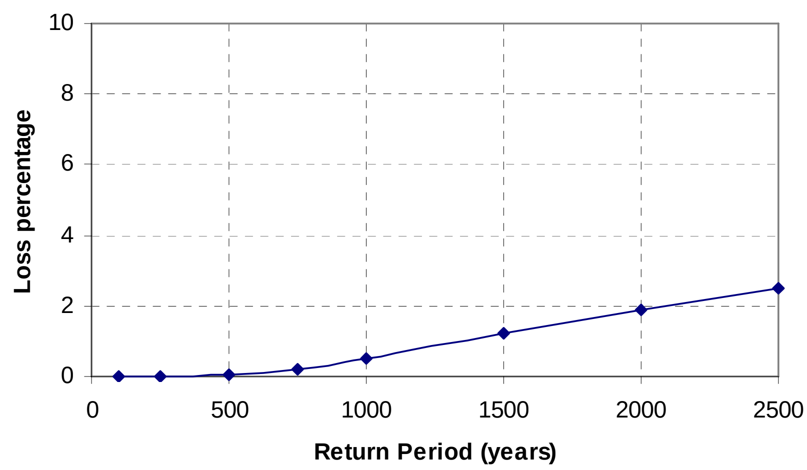
Probable Loss [%]	Name
2.5	PL_{100}
6.3	PL_{250}
7.9	PL_{500}
11.6	PL_{750}
12.9	PL_{1000}
14.3	PL_{1500}
15.7	PL_{2000}
17.5	PL_{2500}
0.067	EAL

Figure C- 84 Steel –Commercial – 3 Story - Soil type F (Deep foundation) – San Juan



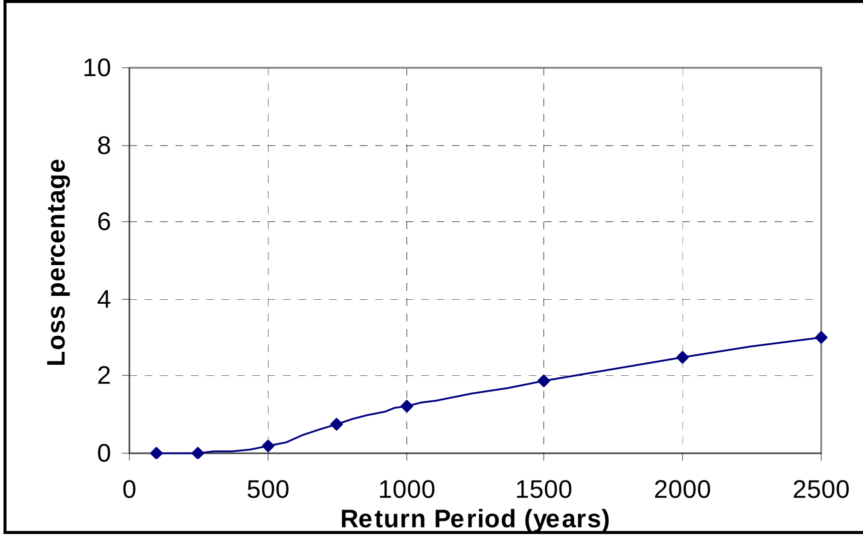
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.0	PL_{750}
0.1	PL_{1000}
0.3	PL_{1500}
0.6	PL_{2000}
0.9	PL_{2500}
0.001	EAL

Figure C- 85 Steel – Commercial – 4 Story - Soil type A – San Juan



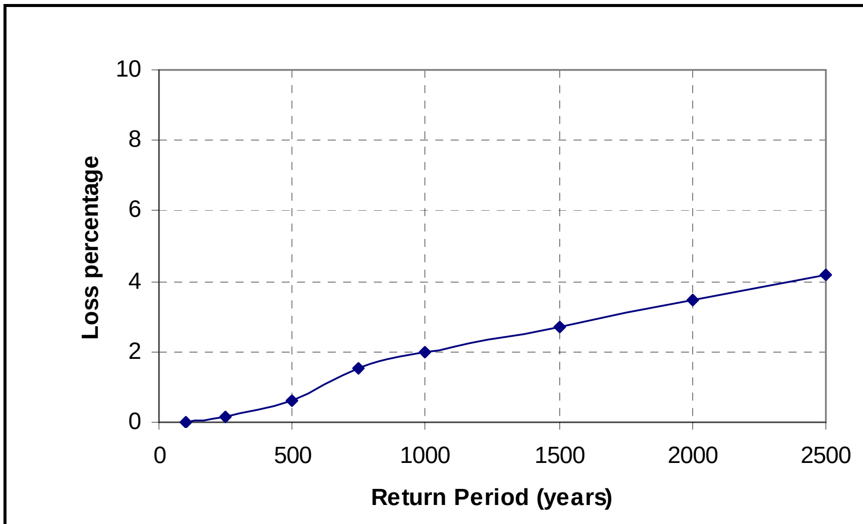
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.2	PL_{750}
0.5	PL_{1000}
1.2	PL_{1500}
1.9	PL_{2000}
2.5	PL_{2500}
0.002	EAL

Figure C- 86 Steel – Commercial – 4 Story - Soil type B – San Juan



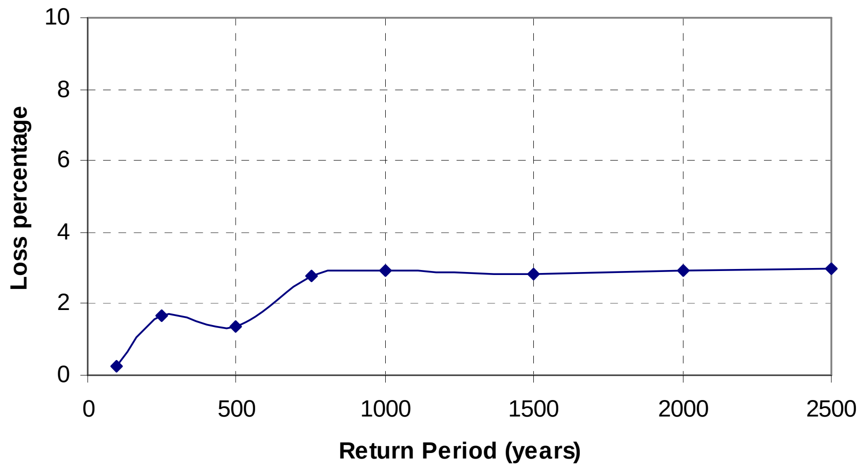
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.2	PL_{500}
0.8	PL_{750}
1.2	PL_{1000}
1.9	PL_{1500}
2.5	PL_{2000}
3.0	PL_{2500}
0.003	EAL

Figure C- 87 Steel –Commercial– 4 Story - Soil type C – San Juan



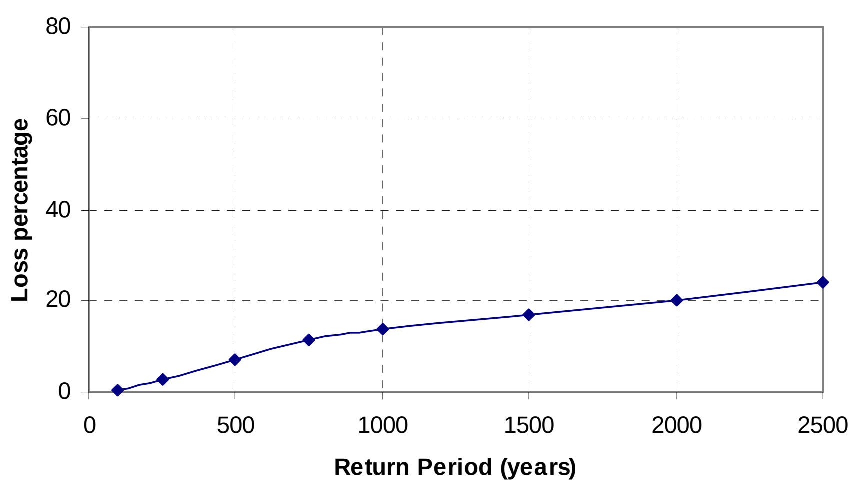
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.6	PL_{500}
1.5	PL_{750}
2.0	PL_{1000}
2.7	PL_{1500}
3.5	PL_{2000}
4.2	PL_{2500}
0.006	EAL

Figure C- 88 Steel – Commercial – 4 Story - Soil type D – San Juan



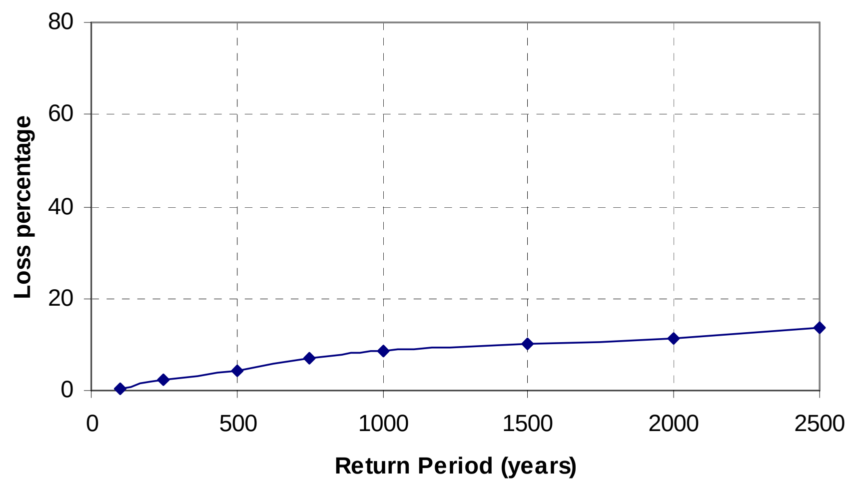
Probable Loss [%]	Name
0.3	PL_{100}
1.7	PL_{250}
1.4	PL_{500}
2.8	PL_{750}
2.9	PL_{1000}
2.8	PL_{1500}
2.9	PL_{2000}
3.0	PL_{2500}
0.014	EAL

Figure C- 89 Steel –Commercial – 4 Story - Soil type E – San Juan



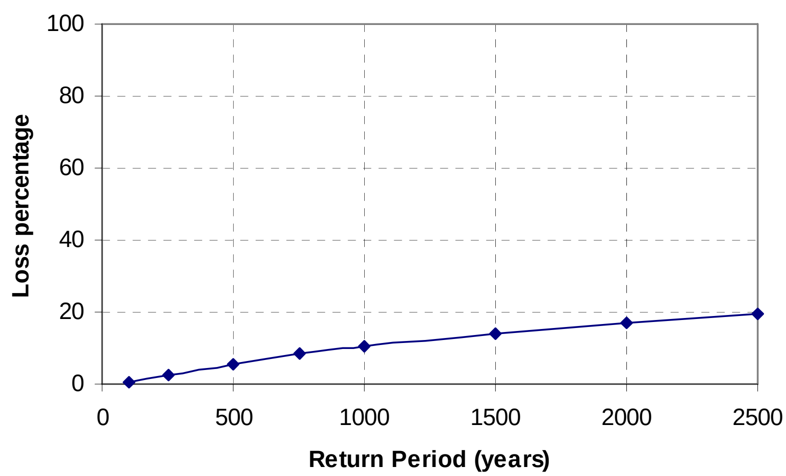
Probable Loss [%]	Name
0.3	PL_{100}
2.6	PL_{250}
7.2	PL_{500}
11.4	PL_{750}
13.9	PL_{1000}
17.1	PL_{1500}
20.1	PL_{2000}
24.1	PL_{2500}
0.049	EAL

Figure C- 90 Steel – Commercial – 4 Story - Soil type F (Shallow foundation) – San Juan



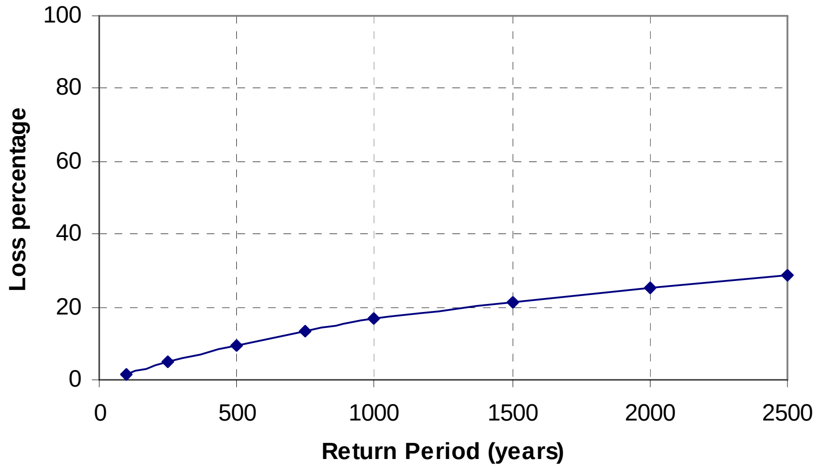
Probable Loss [%]	Name
0.3	PL_{100}
2.2	PL_{250}
4.3	PL_{500}
7.1	PL_{750}
8.4	PL_{1000}
10.0	PL_{1500}
11.5	PL_{2000}
13.5	PL_{2500}
0.032	EAL

Figure C- 91 Steel – Commercial – 4 Story - Soil type F (Deep foundation) – San Juan



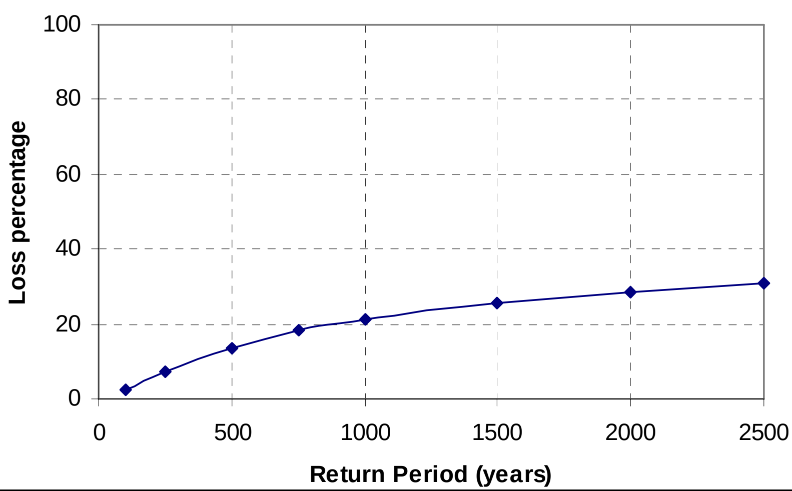
Probable Loss [%]	Name
0.7	PL_{100}
2.7	PL_{250}
5.7	PL_{500}
8.3	PL_{750}
10.5	PL_{1000}
14.0	PL_{1500}
17.0	PL_{2000}
19.6	PL_{2500}
0.043	EAL

Figure C- 92 Wood House - Soil type A – San Juan



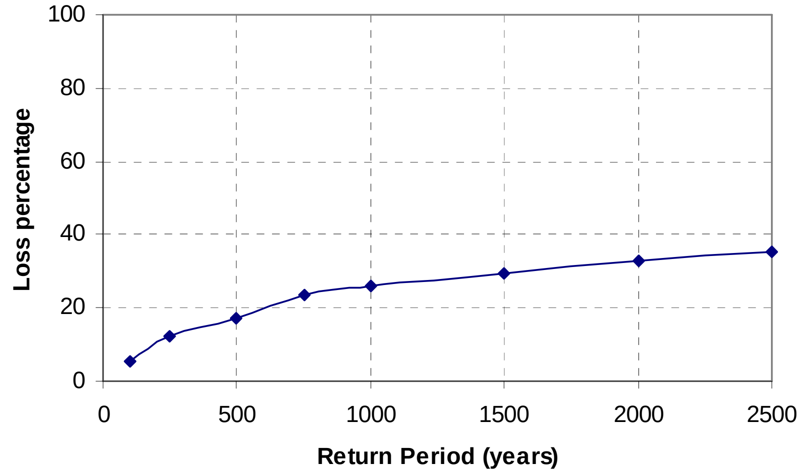
Probable Loss [%]	Name
1.5	PL_{100}
4.8	PL_{250}
9.6	PL_{500}
13.4	PL_{750}
16.6	PL_{1000}
21.5	PL_{1500}
25.4	PL_{2000}
28.7	PL_{2500}
0.070	EAL

Figure C- 93 Wood House - Soil type B – San Juan



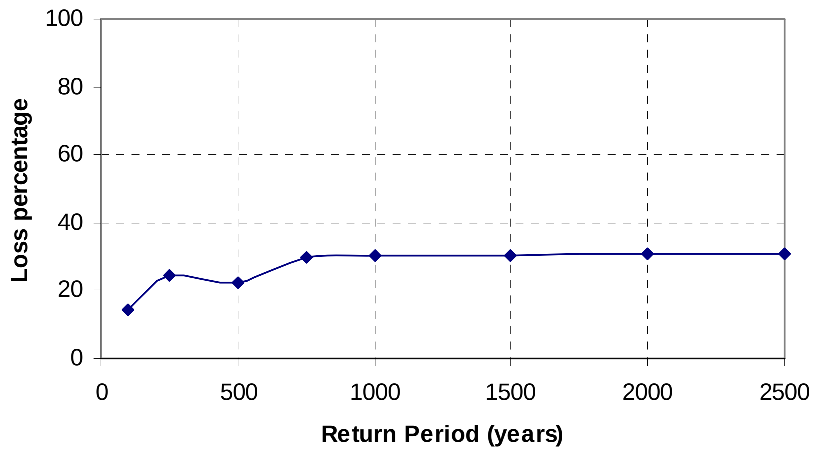
Probable Loss [%]	Name
2.5	PL_{100}
7.5	PL_{250}
13.3	PL_{500}
18.3	PL_{750}
21.4	PL_{1000}
25.5	PL_{1500}
28.6	PL_{2000}
30.9	PL_{2500}
0.096	EAL

Figure C- 94 Wood House - Soil type C – San Juan



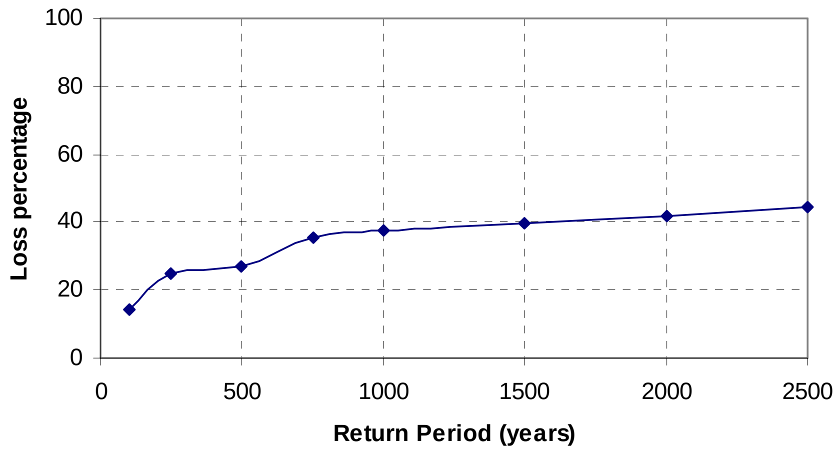
Probable Loss [%]	Name
5.3	PL_{100}
12.5	PL_{250}
17.4	PL_{500}
23.4	PL_{750}
26.2	PL_{1000}
29.5	PL_{1500}
32.7	PL_{2000}
35.3	PL_{2500}
0.137	EAL

Figure C- 95 Wood House - Soil type D – San Juan



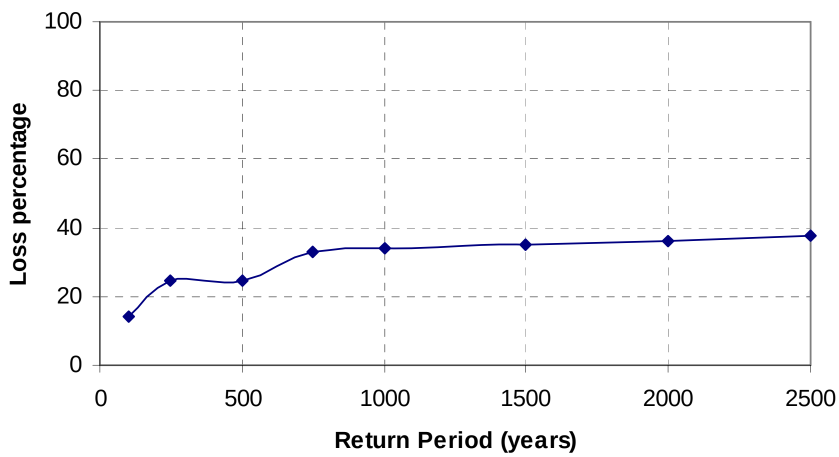
Probable Loss [%]	Name
14.3	PL_{100}
24.3	PL_{250}
22.4	PL_{500}
29.9	PL_{750}
30.5	PL_{1000}
30.1	PL_{1500}
30.6	PL_{2000}
30.7	PL_{2500}
0.221	EAL

Figure C- 96 Wood House - Soil type E – San Juan



Probable Loss [%]	Name
14.3	PL_{100}
25.0	PL_{250}
26.8	PL_{500}
35.7	PL_{750}
37.8	PL_{1000}
39.7	PL_{1500}
42.0	PL_{2000}
44.7	PL_{2500}
0.245	EAL

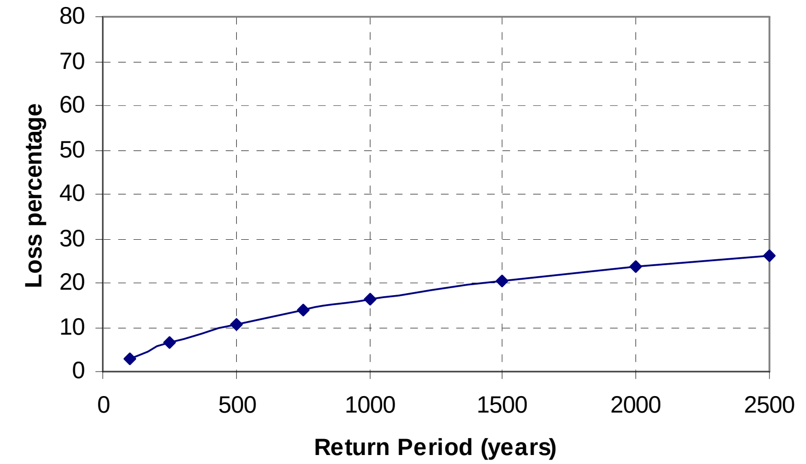
Figure C- 97 Wood House - Soil type F (Shallow foundation) – San Juan



Probable Loss [%]	Name
14.3	PL_{100}
24.7	PL_{250}
24.6	PL_{500}
32.8	PL_{750}
34.2	PL_{1000}
34.9	PL_{1500}
36.3	PL_{2000}
37.7	PL_{2500}
0.233	EAL

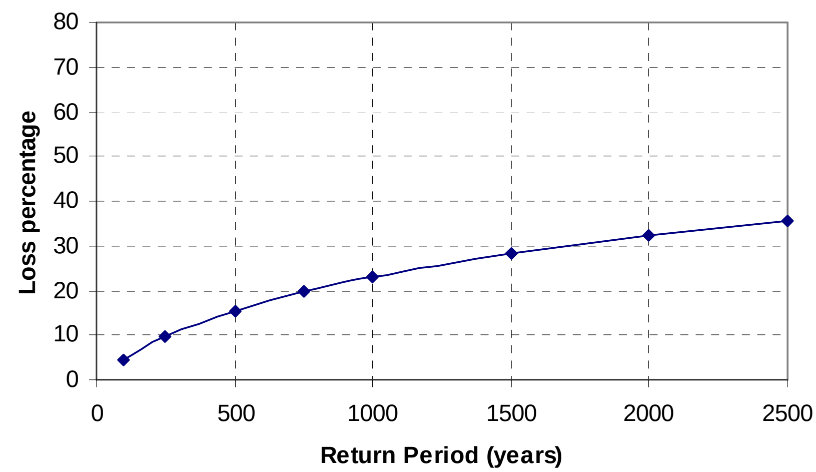
Figure C- 98 Wood House - Soil type F (Deep foundation) – San Juan

Appendix D Earthquake Loss Curves for Arecibo



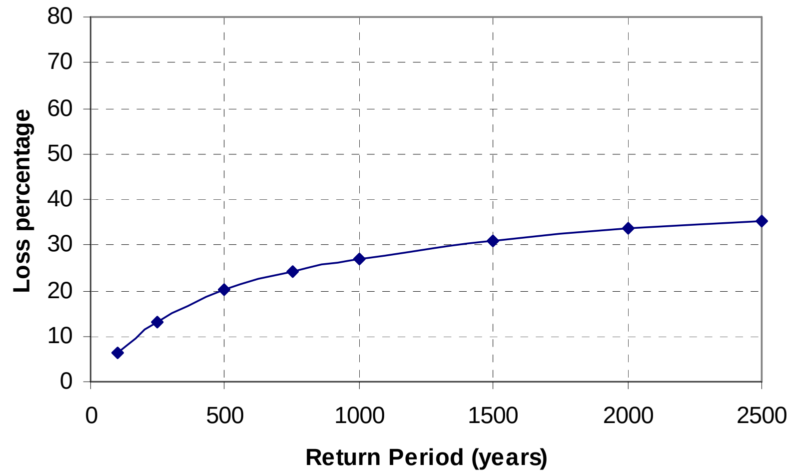
Probable Loss [%]	Name
2.8	PL_{100}
6.4	PL_{250}
10.7	PL_{500}
14.0	PL_{750}
16.5	PL_{1000}
20.6	PL_{1500}
23.8	PL_{2000}
26.3	PL_{2500}
0.081	EAL

Figure D- 1 Concrete Moment Resistant Frame – 1 Story - Soil type A – Arecibo



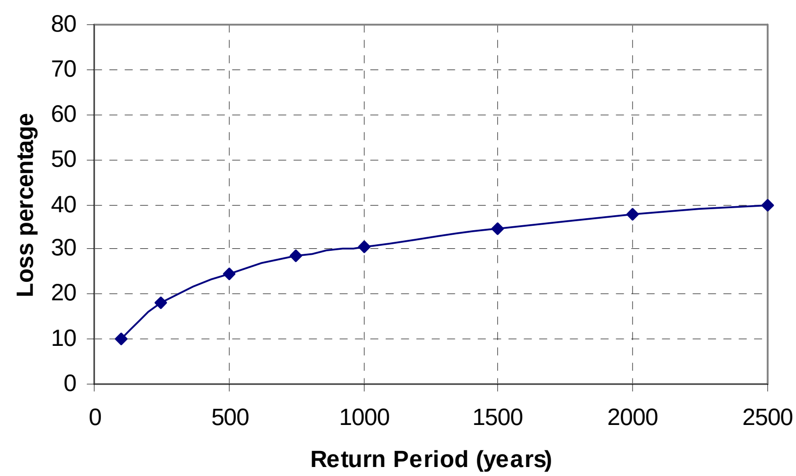
Probable Loss [%]	Name
4.3	PL_{100}
9.6	PL_{250}
15.5	PL_{500}
19.9	PL_{750}
23.1	PL_{1000}
28.4	PL_{1500}
32.4	PL_{2000}
35.4	PL_{2500}
0.117	EAL

Figure D- 2 Concrete Moment Resistant Frame – 1 Story - Soil type B – Arecibo



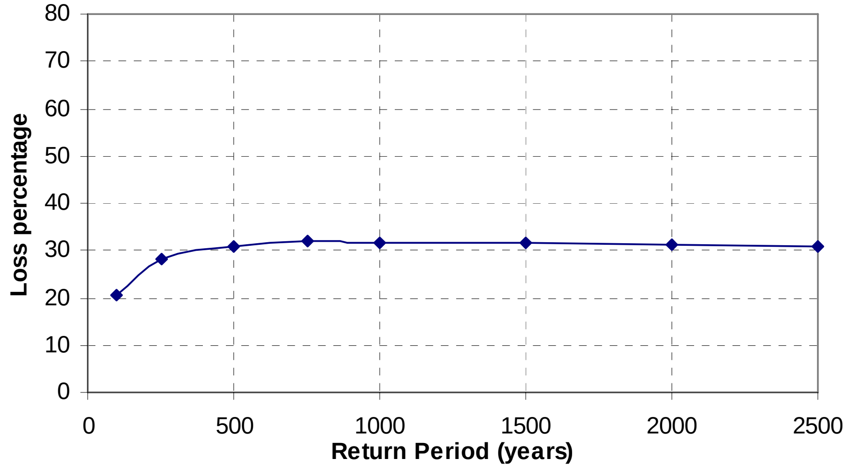
Probable Loss [%]	Name
6.1	PL_{100}
13.1	PL_{250}
20.0	PL_{500}
24.1	PL_{750}
26.8	PL_{1000}
30.8	PL_{1500}
33.5	PL_{2000}
35.4	PL_{2500}
0.147	EAL

Figure D- 3 Concrete Moment Resistant Frame – 1 Story - Soil type C – Arecibo



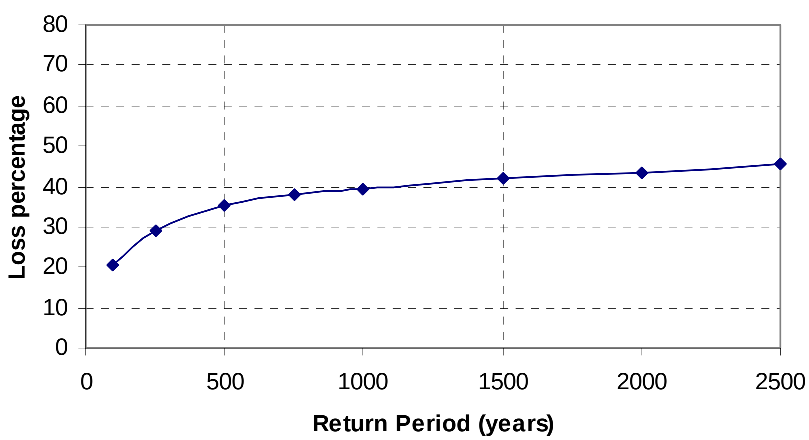
Probable Loss [%]	Name
10.2	PL_{100}
18.1	PL_{250}
24.7	PL_{500}
28.3	PL_{750}
30.6	PL_{1000}
34.7	PL_{1500}
37.7	PL_{2000}
39.7	PL_{2500}
0.192	EAL

Figure D- 4 Concrete Moment Resistant Frame – 1 Story - Soil type D – Arecibo



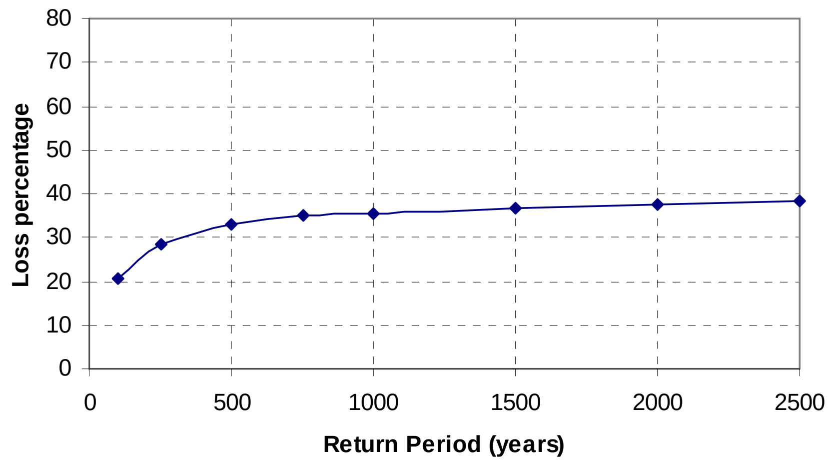
Probable Loss [%]	Name
20.6	PL_{100}
28.1	PL_{250}
30.9	PL_{500}
31.9	PL_{750}
31.5	PL_{1000}
31.8	PL_{1500}
31.3	PL_{2000}
30.9	PL_{2500}
0.268	EAL

Figure D- 5 Concrete Moment Resistant Frame – 1 Story - Soil type E – Arecibo



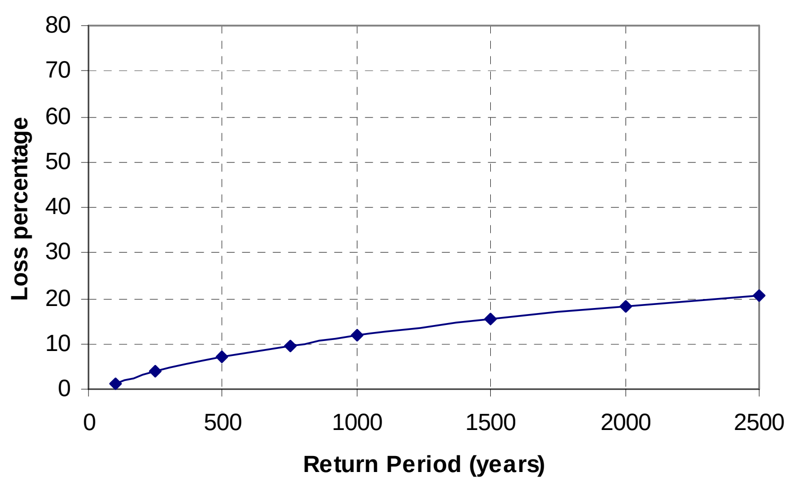
Probable Loss [%]	Name
20.6	PL_{100}
29.1	PL_{250}
35.2	PL_{500}
38.2	PL_{750}
39.3	PL_{1000}
41.9	PL_{1500}
43.5	PL_{2000}
45.5	PL_{2500}
0.294	EAL

Figure D- 6 Concrete Moment Resistant Frame – 1 Story - Soil type F (Shallow Foundation) – Arecibo



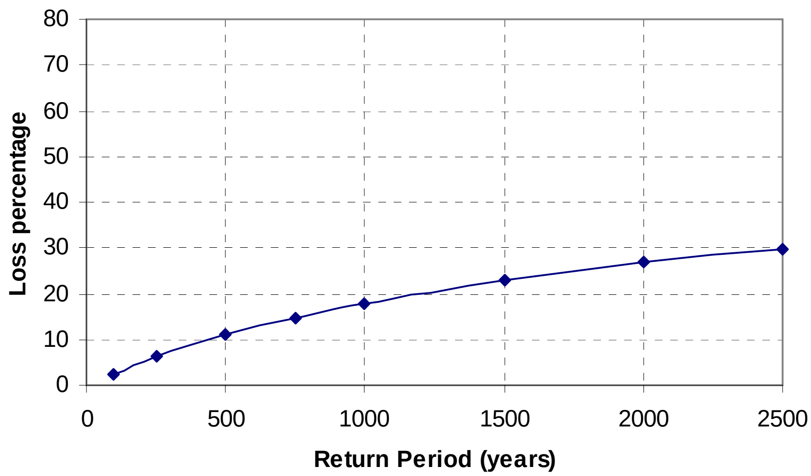
Probable Loss [%]	Name
20.6	PL_{100}
28.6	PL_{250}
33.0	PL_{500}
35.0	PL_{750}
35.4	PL_{1000}
36.8	PL_{1500}
37.4	PL_{2000}
38.2	PL_{2500}
0.281	EAL

Figure D- 7 Concrete Moment Resistant Frame – 1 Story - Soil type F (Deep Foundation) – Arecibo



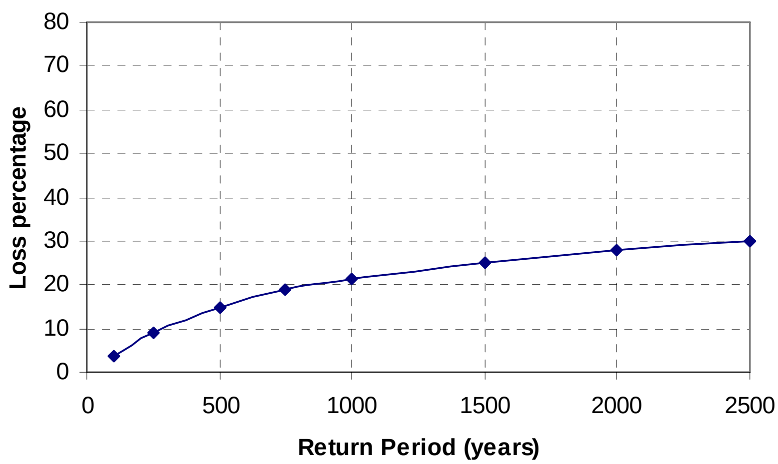
Probable Loss [%]	Name
1.3	PL_{100}
4.0	PL_{250}
7.1	PL_{500}
9.7	PL_{750}
11.7	PL_{1000}
15.4	PL_{1500}
18.4	PL_{2000}
20.7	PL_{2500}
0.054	EAL

Figure D- 8 Concrete Moment Resistant Frame – 2 Stories - Soil type A – Arecibo



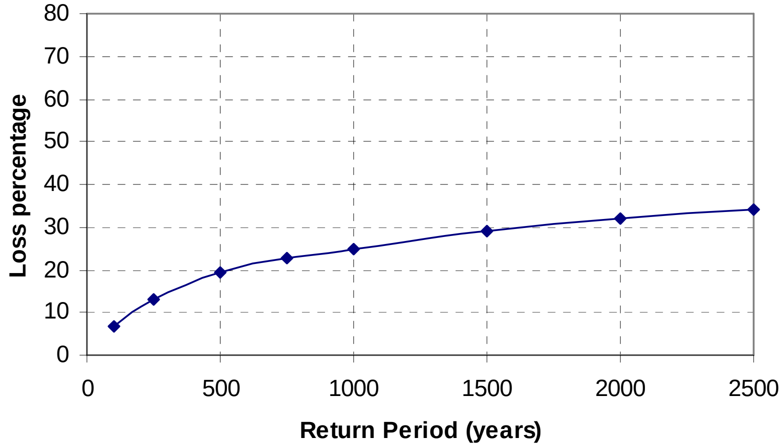
Probable Loss [%]	Name
2.4	PL_{100}
6.3	PL_{250}
10.9	PL_{500}
14.7	PL_{750}
17.8	PL_{1000}
22.8	PL_{1500}
26.8	PL_{2000}
29.9	PL_{2500}
0.083	EAL

Figure D- 9 Concrete Moment Resistant Frame – 2 Stories - Soil type B – Arecibo



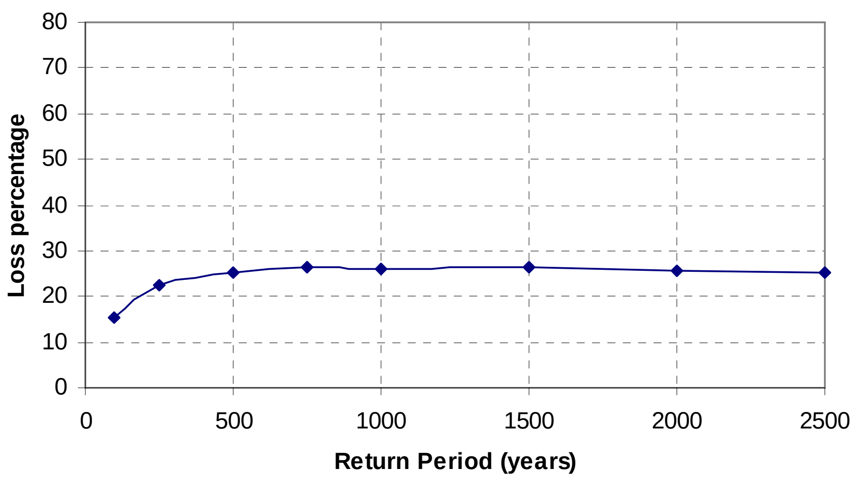
Probable Loss [%]	Name
3.7	PL_{100}
8.9	PL_{250}
14.9	PL_{500}
18.7	PL_{750}
21.3	PL_{1000}
25.2	PL_{1500}
27.9	PL_{2000}
29.9	PL_{2500}
0.107	EAL

Figure D- 10 Concrete Moment Resistant Frame – 2 Stories - Soil type C – Arecibo



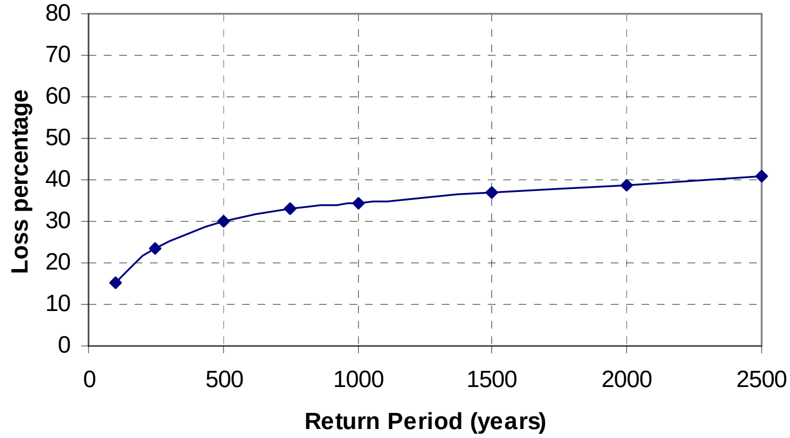
Probable Loss [%]	Name
6.7	PL_{100}
13.1	PL_{250}
19.2	PL_{500}
22.8	PL_{750}
25.0	PL_{1000}
29.1	PL_{1500}
32.1	PL_{2000}
34.2	PL_{2500}
0.145	EAL

Figure D- 11 Concrete Moment Resistant Frame – 2 Stories - Soil type D – Arecibo



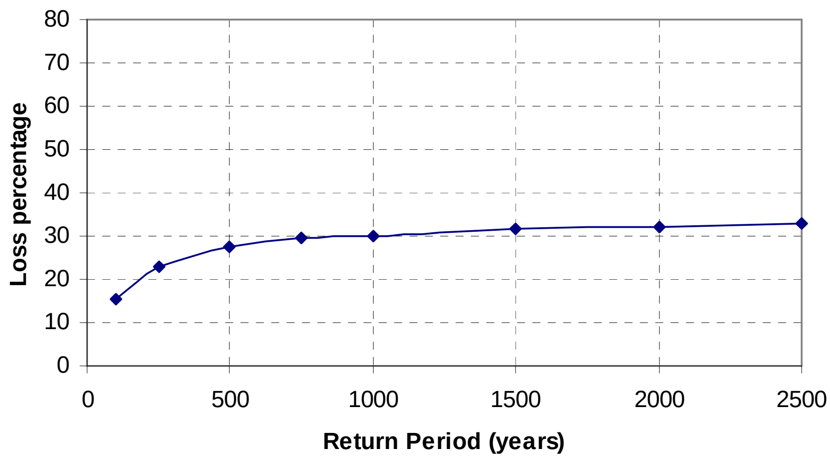
Probable Loss [%]	Name
15.4	PL_{100}
22.5	PL_{250}
25.3	PL_{500}
26.3	PL_{750}
25.9	PL_{1000}
26.2	PL_{1500}
25.8	PL_{2000}
25.3	PL_{2500}
0.213	EAL

Figure D- 12 Concrete Moment Resistant Frame – 2 Stories - Soil type E – Arecibo



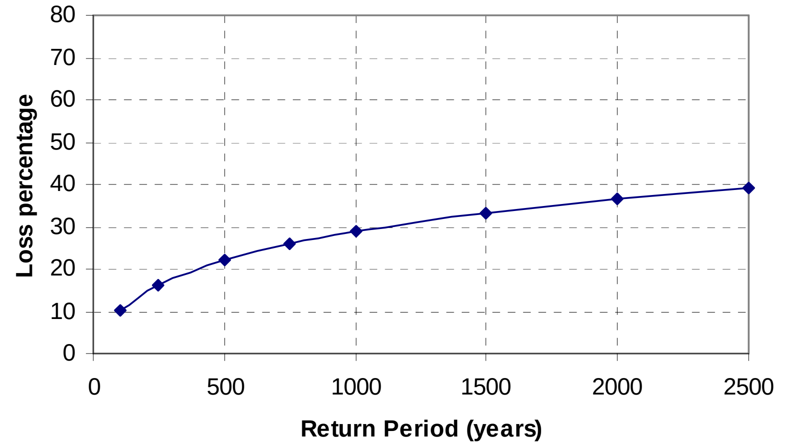
Probable Loss [%]	Name
15.4	PL_{100}
23.6	PL_{250}
29.9	PL_{500}
33.0	PL_{750}
34.2	PL_{1000}
36.9	PL_{1500}
38.6	PL_{2000}
40.8	PL_{2500}
0.241	EAL

Figure D- 13 Concrete Moment Resistant Frame – 2 Story - Soil type F (Shallow Foundation) – Arecibo



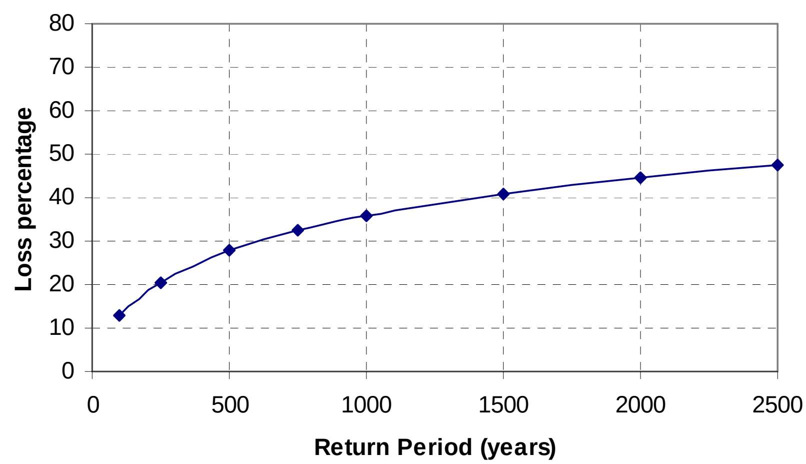
Probable Loss [%]	Name
15.4	PL_{100}
23.1	PL_{250}
27.6	PL_{500}
29.6	PL_{750}
30.1	PL_{1000}
31.5	PL_{1500}
32.2	PL_{2000}
33.1	PL_{2500}
0.227	EAL

Figure D- 14 Concrete Moment Resistant Frame – 2 Story - Soil type F (Deep Foundation) – Arecibo



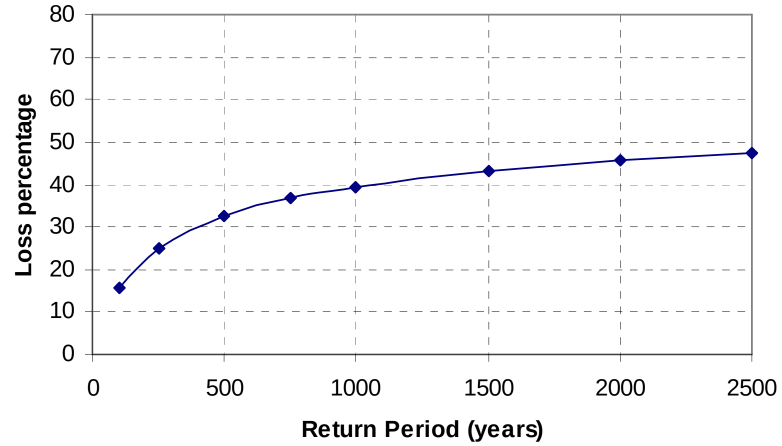
Probable Loss [%]	Name
10.0	PL_{100}
16.2	PL_{250}
22.0	PL_{500}
26.0	PL_{750}
28.9	PL_{1000}
33.2	PL_{1500}
36.5	PL_{2000}
38.9	PL_{2500}
0.178	EAL

Figure D- 15 Concrete Shear Wall – 1 Stories - Soil type A – Arecibo



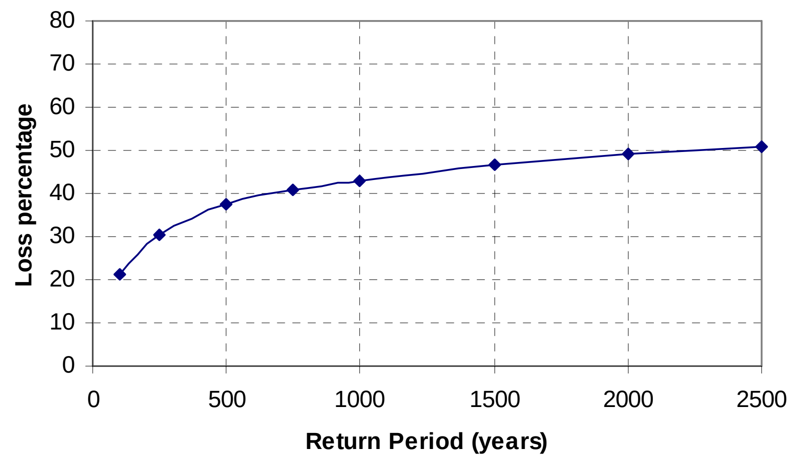
Probable Loss [%]	Name
12.9	PL_{100}
20.6	PL_{250}
27.7	PL_{500}
32.5	PL_{750}
35.9	PL_{1000}
40.9	PL_{1500}
44.7	PL_{2000}
47.3	PL_{2500}
0.224	EAL

Figure D- 16 Concrete Shear Wall – 1 Story - Soil type B – Arecibo



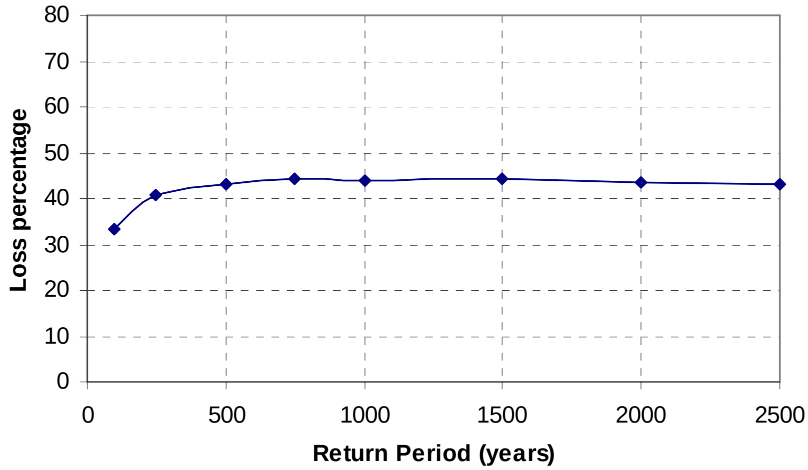
Probable Loss [%]	Name
15.8	PL_{100}
24.9	PL_{250}
32.7	PL_{500}
36.8	PL_{750}
39.5	PL_{1000}
43.2	PL_{1500}
45.6	PL_{2000}
47.3	PL_{2500}
0.260	EAL

Figure D- 17 Concrete Shear Wall – 1 Stories - Soil type C – Arecibo



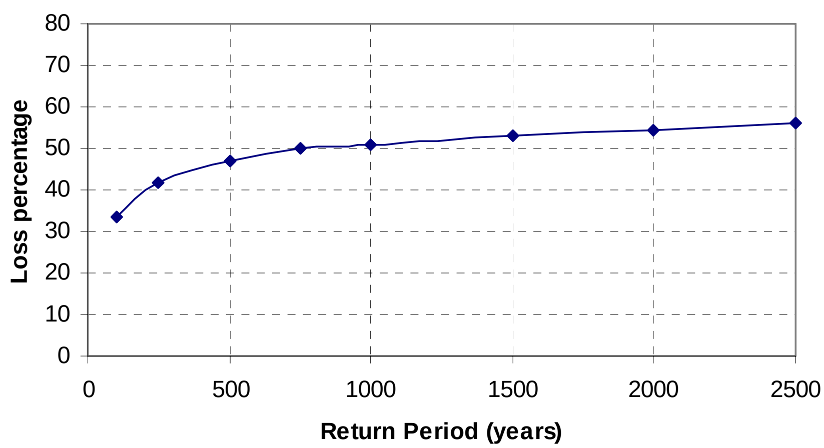
Probable Loss [%]	Name
21.3	PL_{100}
30.6	PL_{250}
37.4	PL_{500}
40.9	PL_{750}
43.0	PL_{1000}
46.7	PL_{1500}
49.3	PL_{2000}
51.0	PL_{2500}
0.312	EAL

Figure D- 18 Concrete Shear Wall – 1 Stories - Soil type D – Arecibo



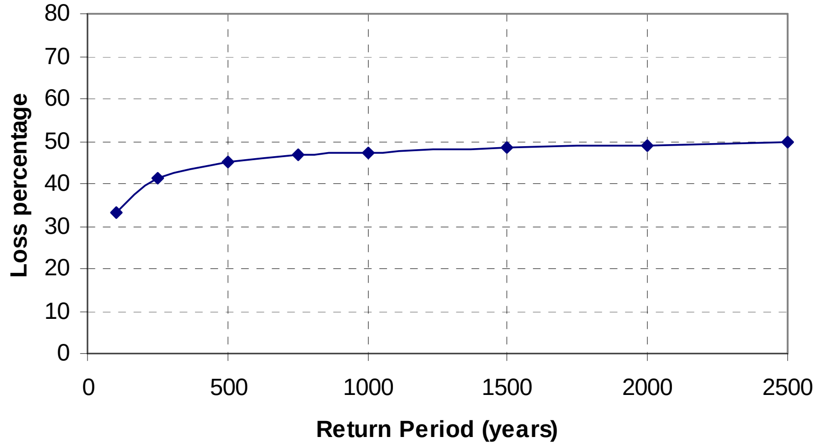
Probable Loss [%]	Name
33.3	PL_{100}
40.7	PL_{250}
43.3	PL_{500}
44.2	PL_{750}
43.9	PL_{1000}
44.1	PL_{1500}
43.7	PL_{2000}
43.3	PL_{2500}
0.393	EAL

Figure D- 19 Concrete Shear Wall – 1 Stories - Soil type E – Arecibo



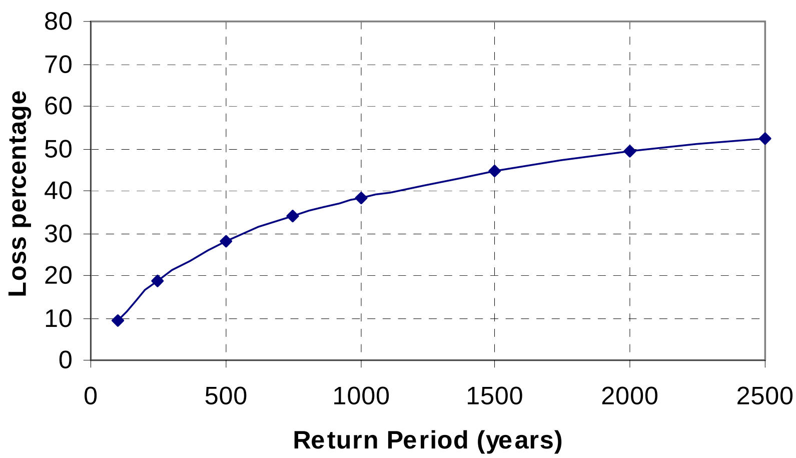
Probable Loss [%]	Name
33.3	PL_{100}
41.6	PL_{250}
47.1	PL_{500}
49.8	PL_{750}
50.8	PL_{1000}
53.1	PL_{1500}
54.5	PL_{2000}
56.3	PL_{2500}
0.417	EAL

Figure D- 20 Concrete Shear Wall – 1 Story - Soil type F (Shallow Foundation) – Arecibo



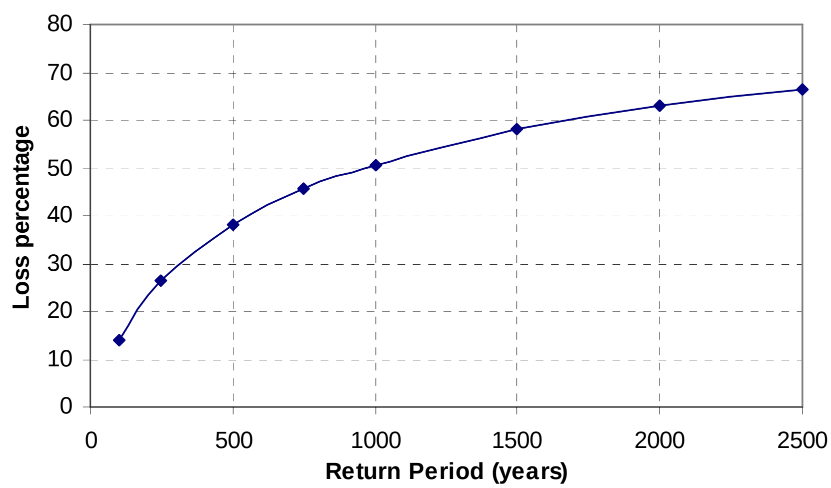
Probable Loss [%]	Name
33.3	PL_{100}
41.1	PL_{250}
45.2	PL_{500}
47.0	PL_{750}
47.3	PL_{1000}
48.6	PL_{1500}
49.1	PL_{2000}
49.8	PL_{2500}
0.405	EAL

Figure D- 21 Concrete Shear Wall – 1 Story - Soil type F (Deep Foundation) – Arecibo



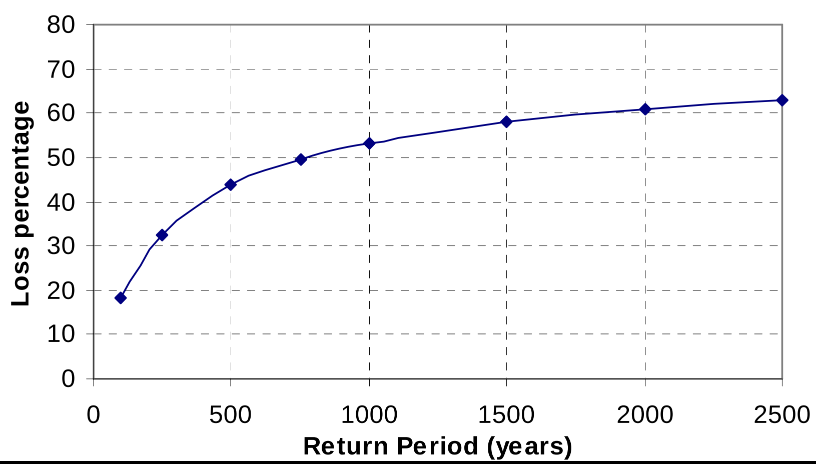
Probable Loss [%]	Name
9.3	PL_{100}
18.9	PL_{250}
28.1	PL_{500}
34.2	PL_{750}
38.4	PL_{1000}
44.7	PL_{1500}
49.2	PL_{2000}
52.4	PL_{2500}
0.212	EAL

Figure D- 22 Concrete Shear Wall – 2 Stories - Soil type A – Arecibo



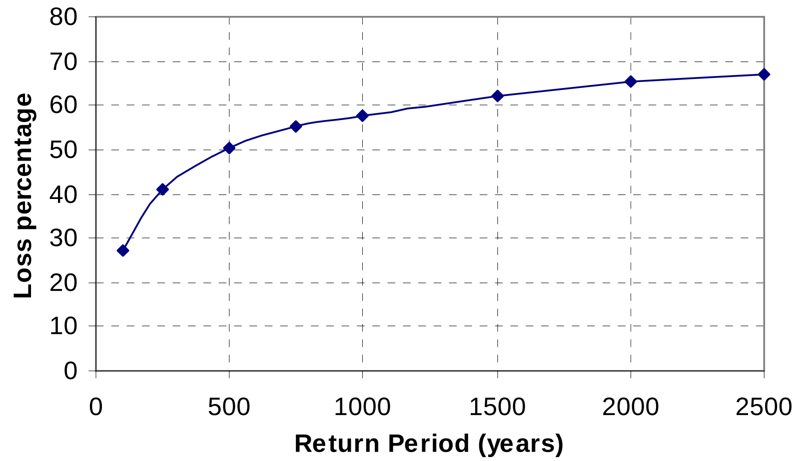
Probable Loss [%]	Name
13.7	PL_{100}
25.9	PL_{250}
36.8	PL_{500}
43.7	PL_{750}
48.3	PL_{1000}
55.1	PL_{1500}
59.7	PL_{2000}
62.9	PL_{2500}
0.282	EAL

Figure D- 23 Concrete Shear Wall – 2 Story - Soil type B – Arecibo



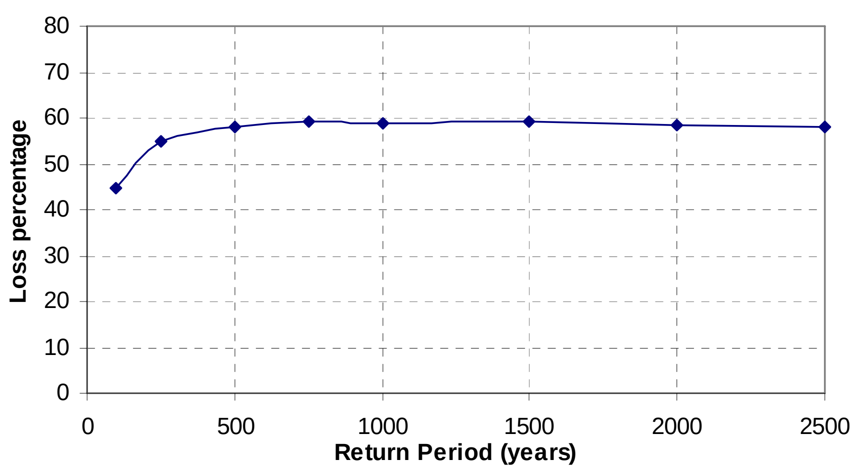
Probable Loss [%]	Name
18.2	PL_{100}
32.6	PL_{250}
43.9	PL_{500}
49.7	PL_{750}
53.2	PL_{1000}
57.9	PL_{1500}
60.9	PL_{2000}
62.9	PL_{2500}
0.337	EAL

Figure D- 24 Concrete Shear Wall – 2 Story - Soil type C – Arecibo



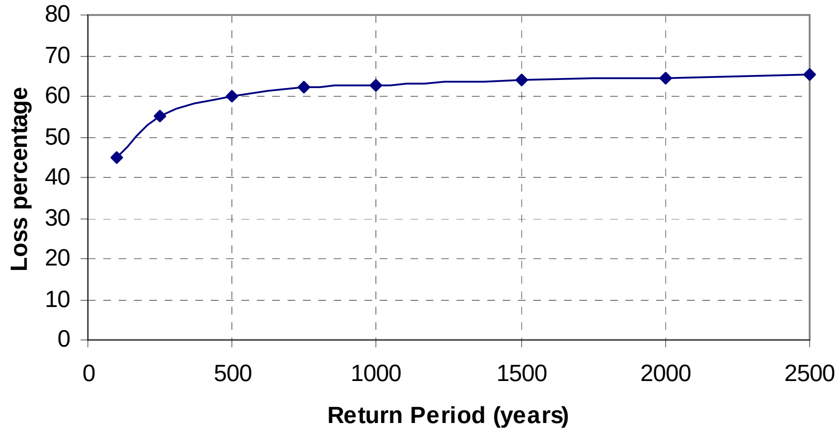
Probable Loss [%]	Name
27.0	PL_{100}
41.0	PL_{250}
50.4	PL_{500}
55.0	PL_{750}
57.6	PL_{1000}
62.1	PL_{1500}
65.2	PL_{2000}
67.1	PL_{2500}
0.414	EAL

Figure D- 25 Concrete Shear Wall – 2 Stories - Soil type D – Arecibo



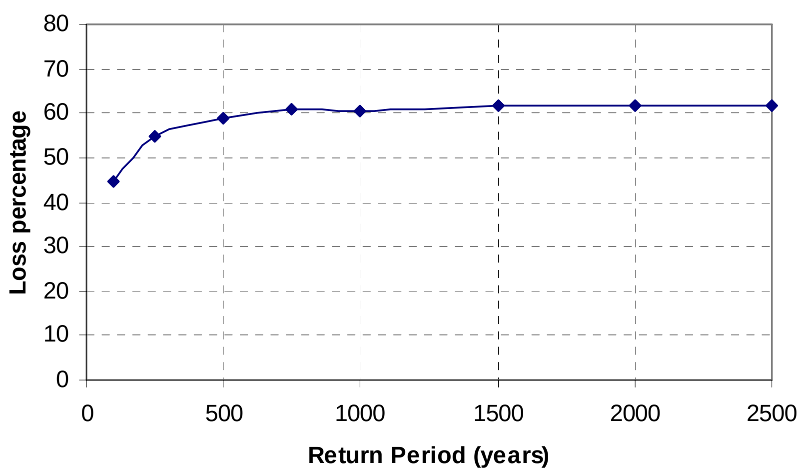
Probable Loss [%]	Name
44.8	PL_{100}
54.7	PL_{250}
58.0	PL_{500}
59.1	PL_{750}
58.7	PL_{1000}
59.0	PL_{1500}
58.5	PL_{2000}
58.0	PL_{2500}
0.528	EAL

Figure D- 26 Concrete Shear Wall – 2 Stories - Soil type E – Arecibo



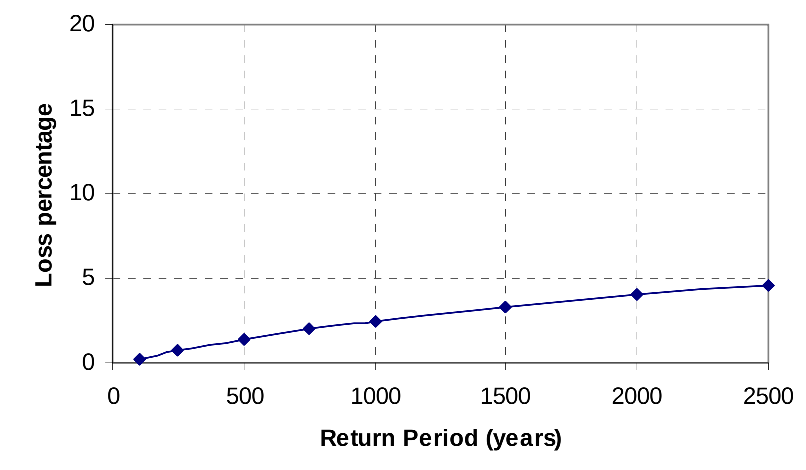
Probable Loss [%]	Name
44.8	PL_{100}
55.3	PL_{250}
60.2	PL_{500}
62.3	PL_{750}
62.6	PL_{1000}
64.1	PL_{1500}
64.6	PL_{2000}
65.4	PL_{2500}
0.542	EAL

Figure D- 27 Concrete Shear Wall – 2 Stories - Soil type F (Shallow Foundation) – Arecibo



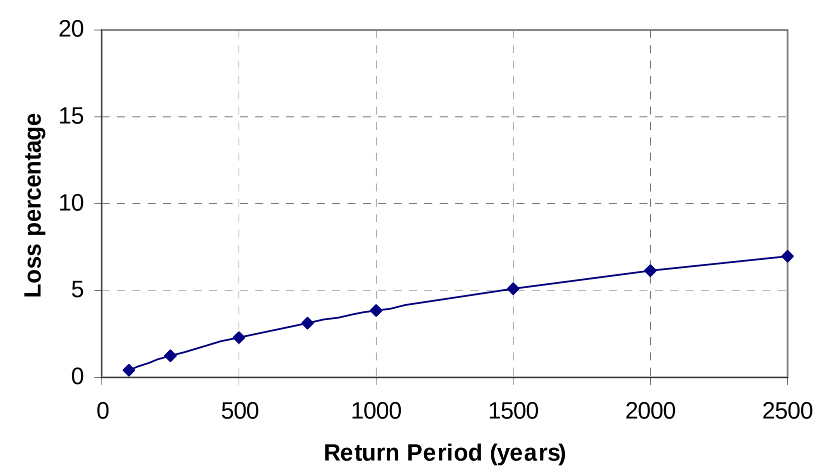
Probable Loss [%]	Name
44.8	PL_{100}
55.0	PL_{250}
59.1	PL_{500}
60.7	PL_{750}
60.7	PL_{1000}
61.6	PL_{1500}
61.6	PL_{2000}
61.7	PL_{2500}
0.535	EAL

Figure D- 28 Concrete Shear Wall – 2 Stories - Soil type F (Deep Foundation) – Arecibo



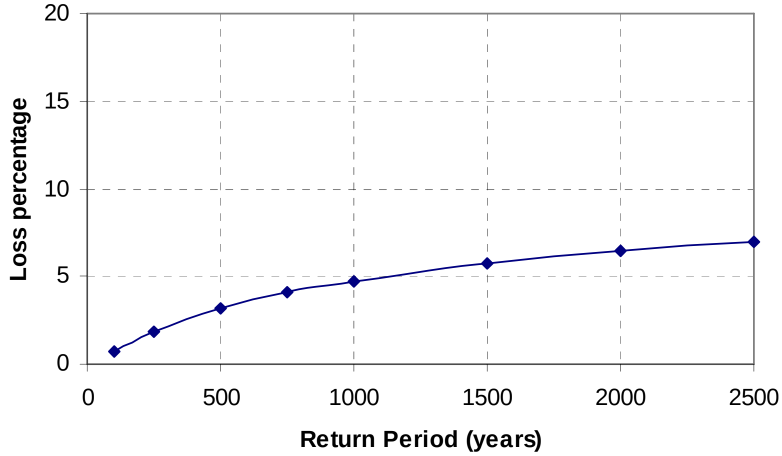
Probable Loss [%]	Name
0.2	PL_{100}
0.7	PL_{250}
1.4	PL_{500}
2.0	PL_{750}
2.5	PL_{1000}
3.3	PL_{1500}
4.0	PL_{2000}
4.6	PL_{2500}
0.011	EAL

Figure D- 29 Concrete - Multistory - Soil type A – Arecibo



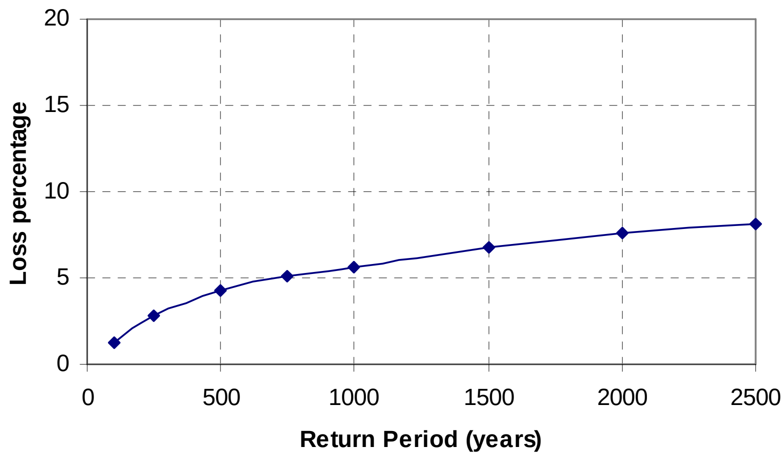
Probable Loss [%]	Name
0.4	PL_{100}
1.2	PL_{250}
2.3	PL_{500}
3.2	PL_{750}
3.9	PL_{1000}
5.1	PL_{1500}
6.1	PL_{2000}
6.9	PL_{2500}
0.017	EAL

Figure D- 30 Concrete - Multistory - Soil type B – Arecibo



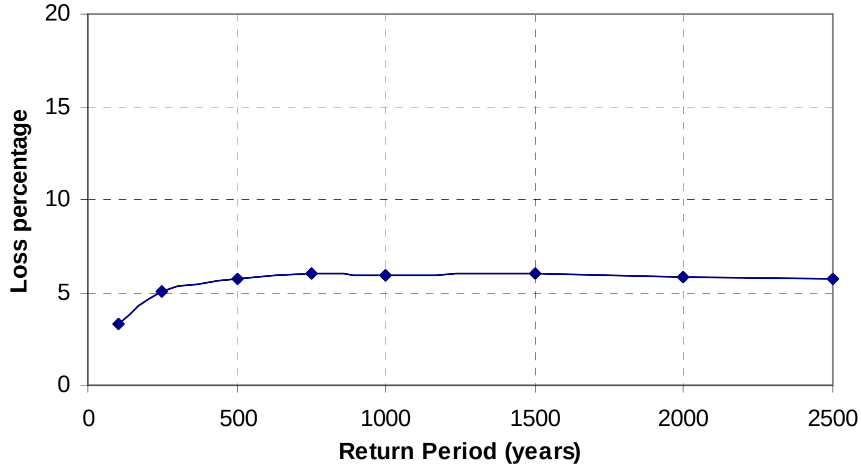
Probable Loss [%]	Name
0.7	PL_{100}
1.8	PL_{250}
3.2	PL_{500}
4.1	PL_{750}
4.7	PL_{1000}
5.7	PL_{1500}
6.4	PL_{2000}
6.9	PL_{2500}
0.023	EAL

Figure D- 31 Concrete - Multistory - Soil type C – Arecibo



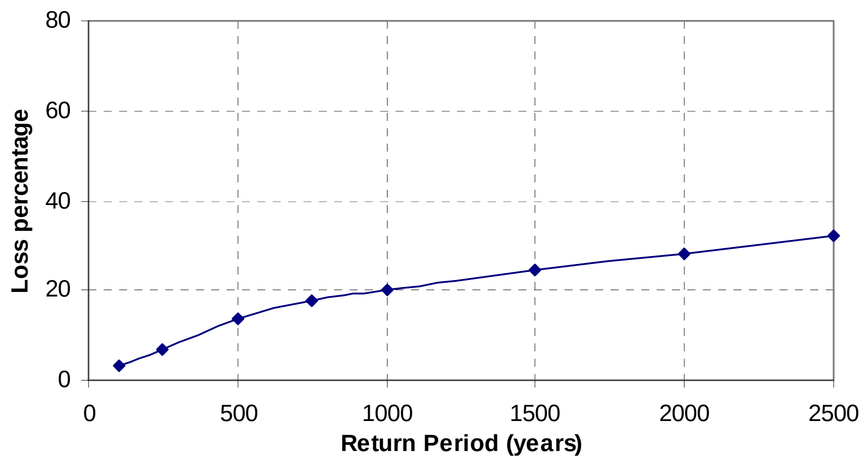
Probable Loss [%]	Name
1.3	PL_{100}
2.8	PL_{250}
4.2	PL_{500}
5.1	PL_{750}
5.7	PL_{1000}
6.7	PL_{1500}
7.6	PL_{2000}
8.1	PL_{2500}
0.031	EAL

Figure D- 32 Concrete - Multistory - Soil type D – Arecibo



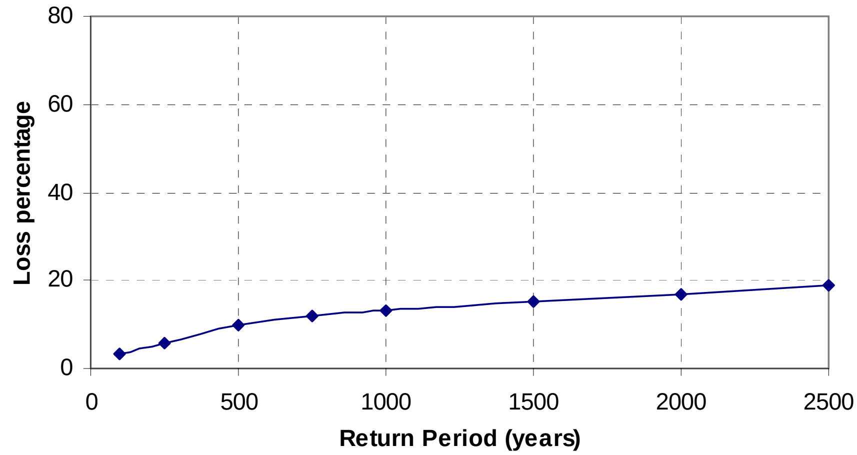
Probable Loss [%]	Name
3.3	PL_{100}
5.0	PL_{250}
5.7	PL_{500}
6.0	PL_{750}
5.9	PL_{1000}
6.0	PL_{1500}
5.9	PL_{2000}
5.7	PL_{2500}
0.048	EAL

Figure D- 33 Concrete - Multistory - Soil type E – Arecibo



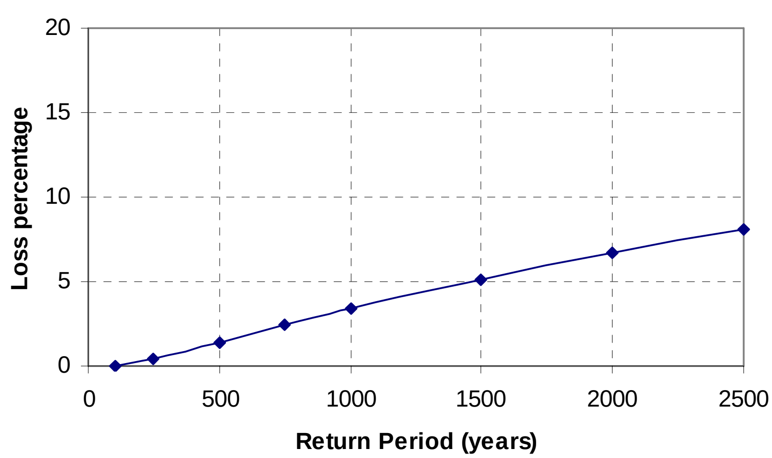
Probable Loss [%]	Name
3.3	PL_{100}
6.8	PL_{250}
13.6	PL_{500}
17.6	PL_{750}
20.2	PL_{1000}
24.6	PL_{1500}
28.1	PL_{2000}
32.3	PL_{2500}
0.095	EAL

Figure D- 34 Concrete - Multistory - Soil type F (Shallow foundation) – Arecibo



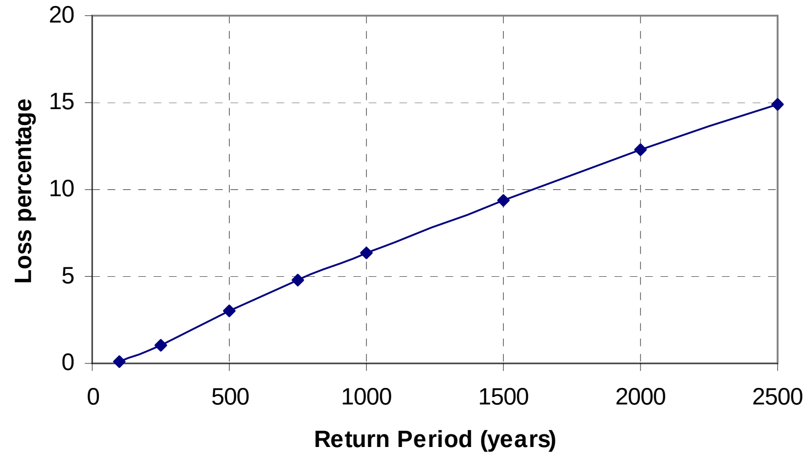
Probable Loss [%]	Name
3.3	PL_{100}
5.9	PL_{250}
9.7	PL_{500}
11.8	PL_{750}
13.1	PL_{1000}
15.3	PL_{1500}
17.0	PL_{2000}
19.0	PL_{2500}
0.071	EAL

Figure D- 35 Concrete - Multistory - Soil type F (Deep foundation) – Arecibo



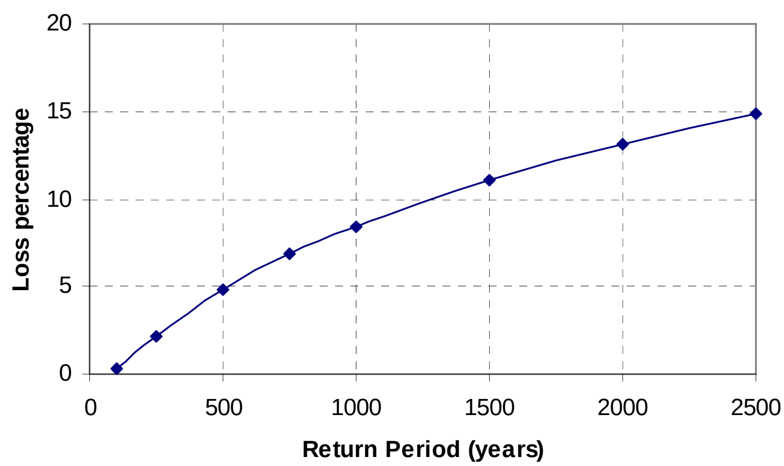
Probable Loss [%]	Name
0.0	PL_{100}
0.4	PL_{250}
1.4	PL_{500}
2.4	PL_{750}
3.4	PL_{1000}
5.1	PL_{1500}
6.7	PL_{2000}
8.1	PL_{2500}
0.012	EAL

Figure D- 36 Steel – Low Rise - Soil type A – Arecibo



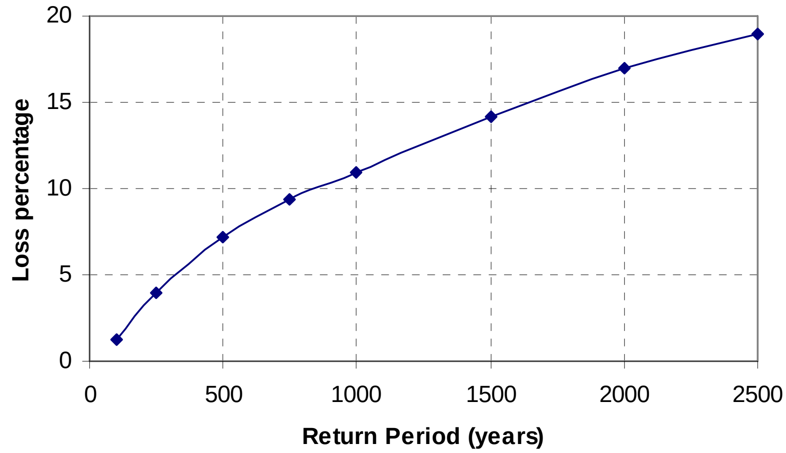
Probable Loss [%]	Name
0.1	PL_{100}
1.1	PL_{250}
3.0	PL_{500}
4.8	PL_{750}
6.3	PL_{1000}
9.4	PL_{1500}
12.3	PL_{2000}
14.9	PL_{2500}
0.024	EAL

Figure D- 37 Steel – Low Rise - Soil type B – Arecibo



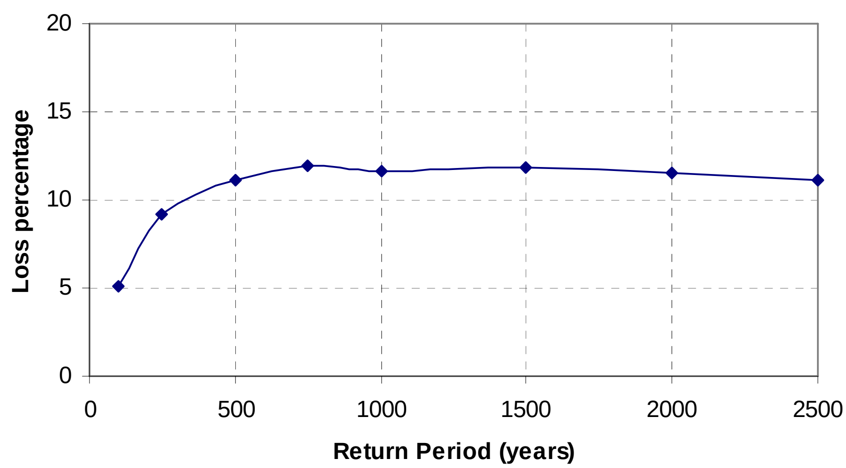
Probable Loss [%]	Name
0.3	PL_{100}
2.1	PL_{250}
4.8	PL_{500}
6.8	PL_{750}
8.4	PL_{1000}
11.1	PL_{1500}
13.2	PL_{2000}
14.9	PL_{2500}
0.033	EAL

Figure D- 38 Steel – Low Rise - Soil type C – Arecibo



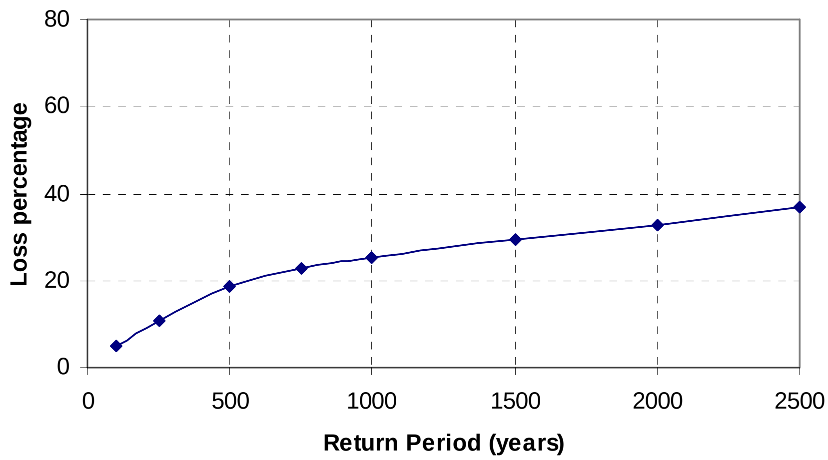
Probable Loss [%]	Name
1.2	PL_{100}
4.0	PL_{250}
7.2	PL_{500}
9.4	PL_{750}
10.9	PL_{1000}
14.2	PL_{1500}
16.9	PL_{2000}
18.9	PL_{2500}
0.052	EAL

Figure D- 39 Steel – Low Rise - Soil type D – Arecibo



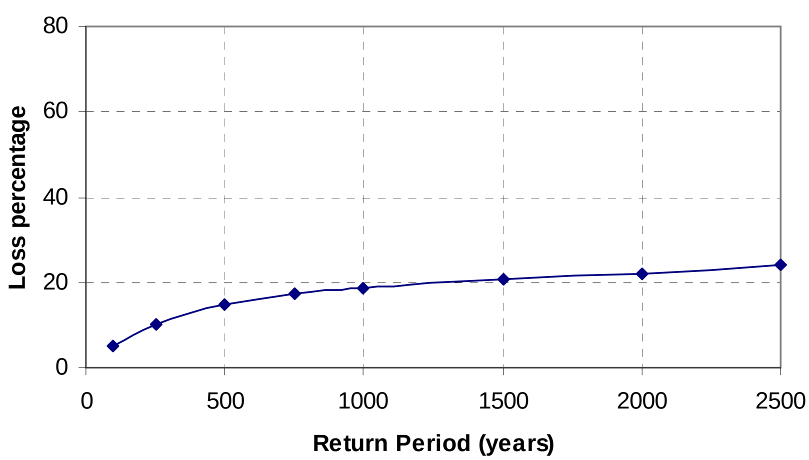
Probable Loss [%]	Name
5.1	PL_{100}
9.2	PL_{250}
11.1	PL_{500}
11.9	PL_{750}
11.6	PL_{1000}
11.8	PL_{1500}
11.5	PL_{2000}
11.1	PL_{2500}
0.086	EAL

Figure D- 40 Steel – Low Rise - Soil type E – Arecibo



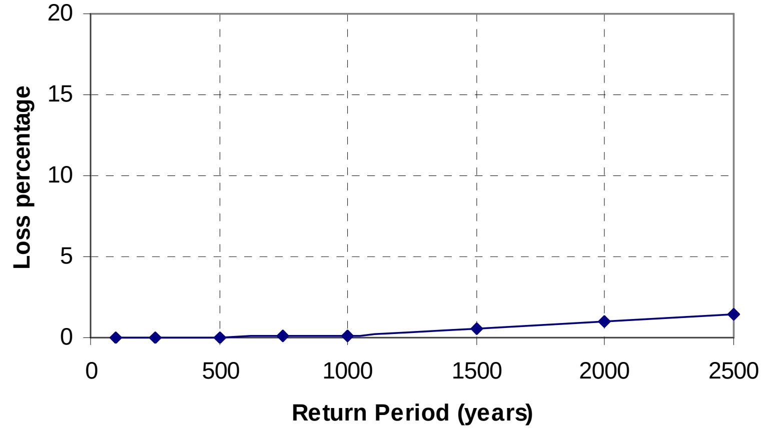
Probable Loss [%]	Name
5.1	PL_{100}
10.9	PL_{250}
18.7	PL_{500}
23.0	PL_{750}
25.3	PL_{1000}
29.6	PL_{1500}
32.8	PL_{2000}
36.7	PL_{2500}
0.132	EAL

Figure D- 41 Steel – Low Rise - Soil type F (Shallow foundation) – Arecibo



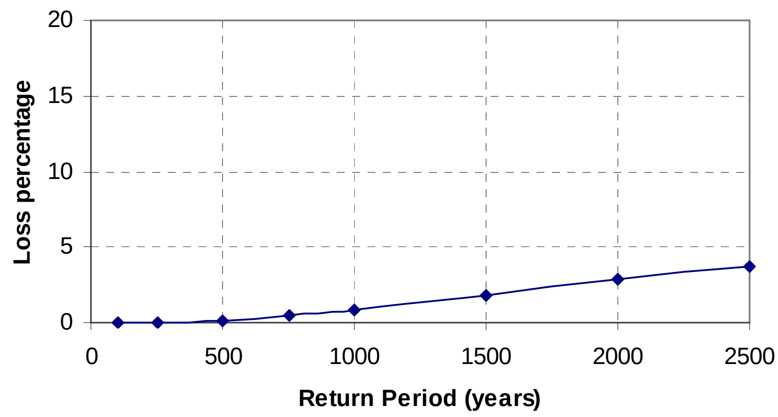
Probable Loss [%]	Name
5.1	PL_{100}
10.1	PL_{250}
14.9	PL_{500}
17.4	PL_{750}
18.5	PL_{1000}
20.7	PL_{1500}
22.1	PL_{2000}
23.9	PL_{2500}
0.109	EAL

Figure D- 42 Steel – Low Rise - Soil type F (Deep foundation) – Arecibo



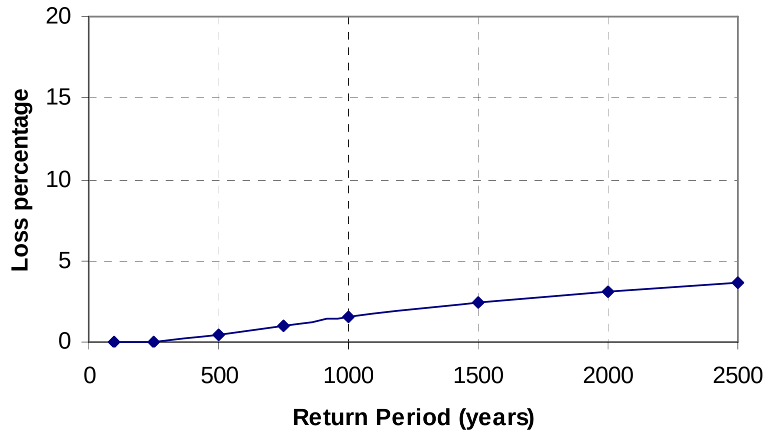
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.1	PL_{750}
0.2	PL_{1000}
0.5	PL_{1500}
1.0	PL_{2000}
1.4	PL_{2500}
0.001	EAL

Figure D- 43 Steel – Mid Rise - Soil type A – Arecibo



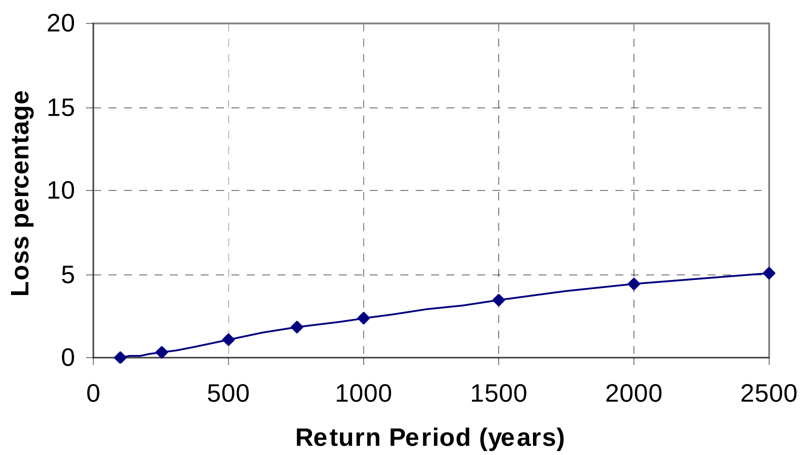
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.1	PL_{500}
0.4	PL_{750}
0.9	PL_{1000}
1.8	PL_{1500}
2.8	PL_{2000}
3.7	PL_{2500}
0.003	EAL

Figure D- 44 Steel – Mid Rise - Soil type B – Arecibo



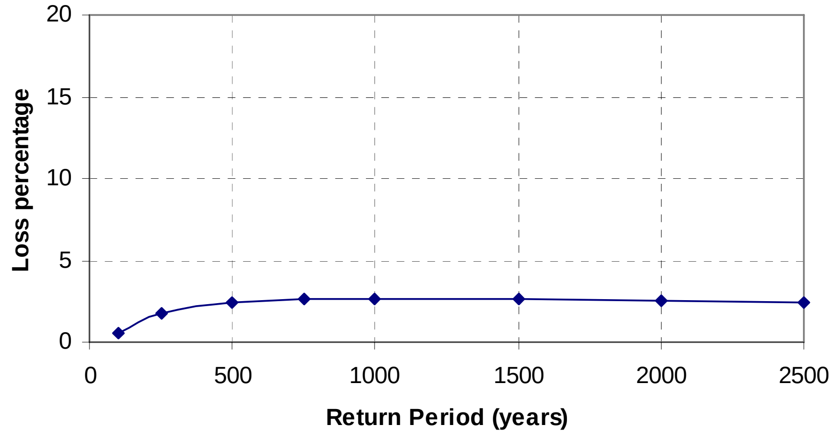
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.5	PL_{500}
1.0	PL_{750}
1.5	PL_{1000}
2.4	PL_{1500}
3.1	PL_{2000}
3.7	PL_{2500}
0.004	EAL

Figure D- 45 Steel – Mid Rise - Soil type C – Arecibo



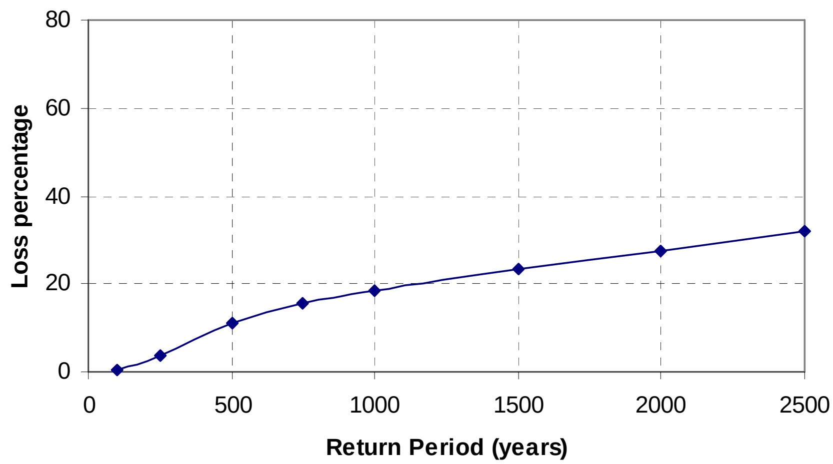
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.1	PL_{500}
1.8	PL_{750}
2.3	PL_{1000}
3.5	PL_{1500}
4.4	PL_{2000}
5.1	PL_{2500}
0.008	EAL

Figure D- 46 Steel – Mid Rise - Soil type D – Arecibo



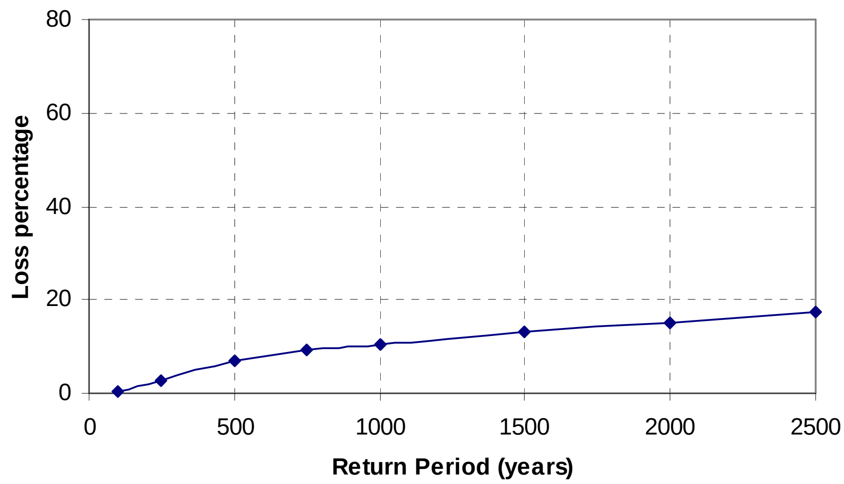
Probable Loss [%]	Name
0.5	PL_{100}
1.8	PL_{250}
2.4	PL_{500}
2.7	PL_{750}
2.6	PL_{1000}
2.7	PL_{1500}
2.5	PL_{2000}
2.4	PL_{2500}
0.016	EAL

Figure D- 47 Steel – Mid Rise - Soil type E – Arecibo



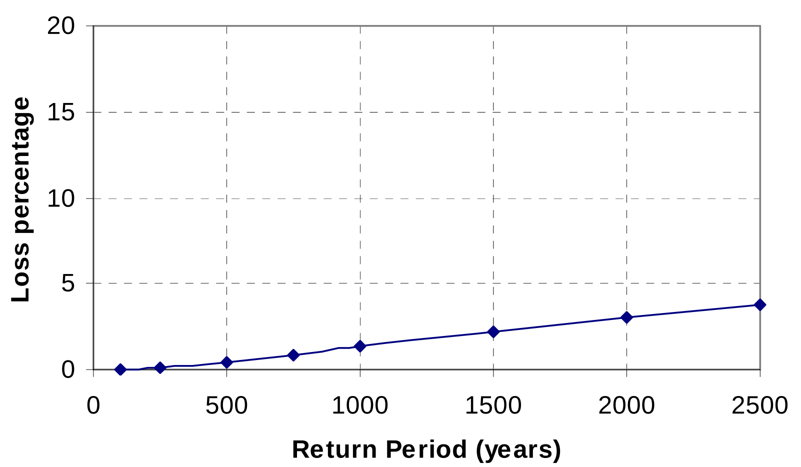
Probable Loss [%]	Name
0.5	PL_{100}
3.7	PL_{250}
11.3	PL_{500}
15.7	PL_{750}
18.6	PL_{1000}
23.5	PL_{1500}
27.4	PL_{2000}
32.2	PL_{2500}
0.070	EAL

Figure D- 48 Steel – Mid Rise - Soil type F (Shallow foundation) – Arecibo



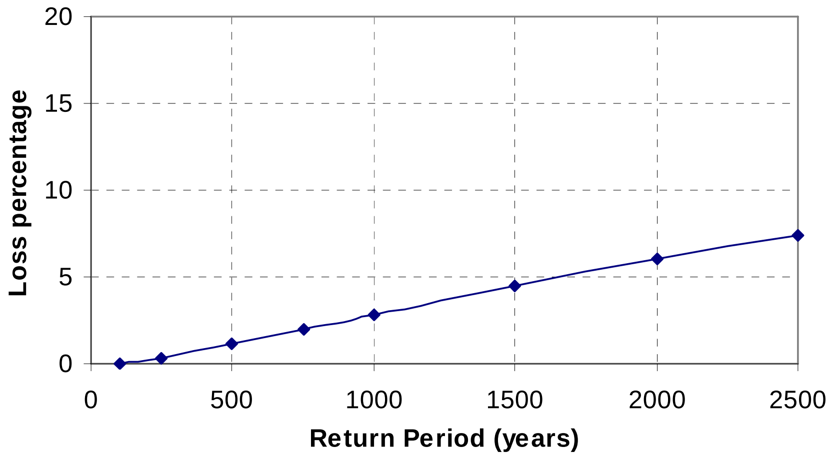
Probable Loss [%]	Name
0.5	PL_{100}
2.7	PL_{250}
6.8	PL_{500}
9.2	PL_{750}
10.6	PL_{1000}
13.1	PL_{1500}
15.0	PL_{2000}
17.3	PL_{2500}
0.043	EAL

Figure D- 49 Steel – Mid Rise - Soil type F (Deep foundation) – Arecibo



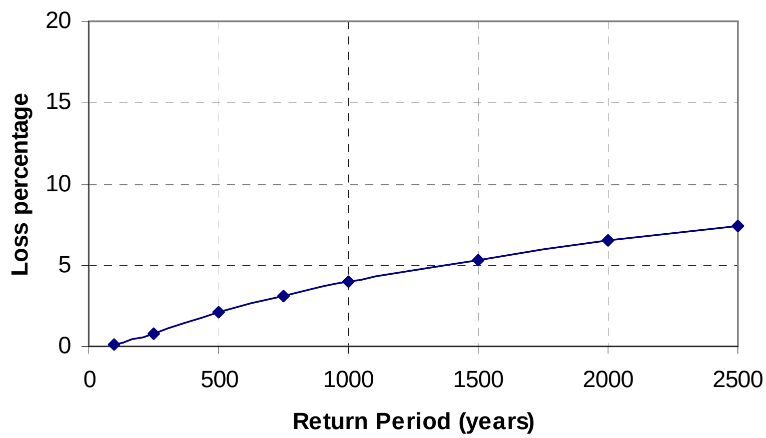
Probable Loss [%]	Name
0.00	PL_{100}
0.09	PL_{250}
0.44	PL_{500}
0.88	PL_{750}
1.31	PL_{1000}
2.18	PL_{1500}
3.01	PL_{2000}
3.74	PL_{2500}
0.004	EAL

Figure D- 50 Steel – High Rise - Soil type A – Arecibo



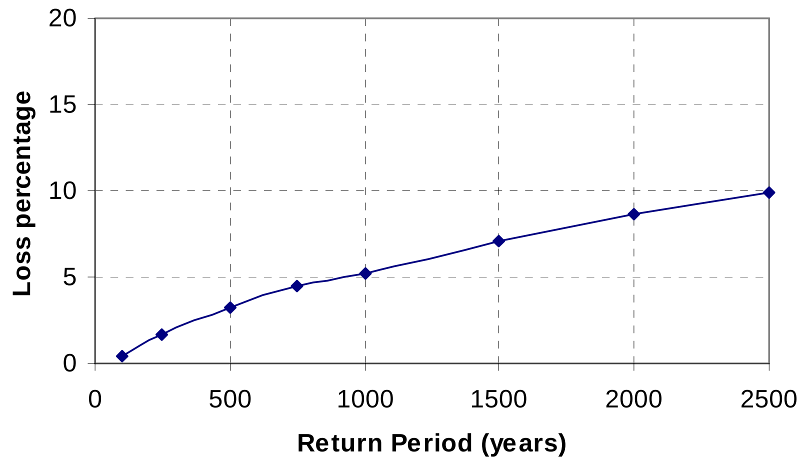
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.1	PL_{500}
2.0	PL_{750}
2.8	PL_{1000}
4.4	PL_{1500}
6.0	PL_{2000}
7.4	PL_{2500}
0.010	EAL

Figure D- 51 Steel – High Rise - Soil type B – Arecibo



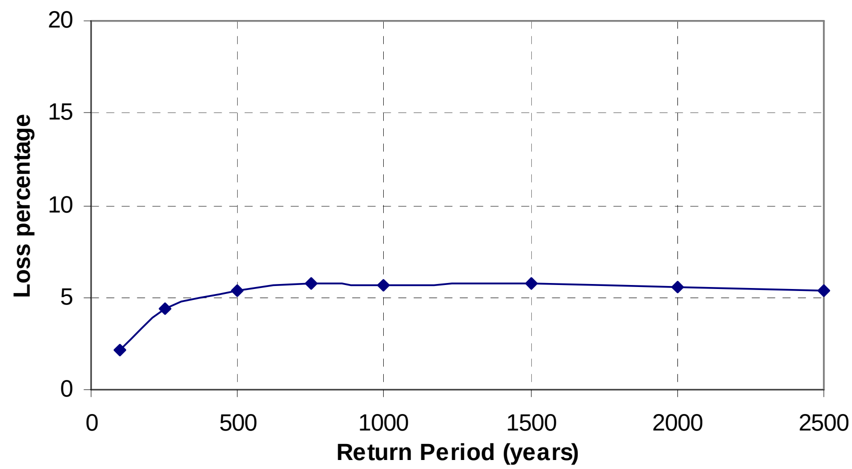
Probable Loss [%]	Name
0.1	PL_{100}
0.7	PL_{250}
2.1	PL_{500}
3.1	PL_{750}
3.9	PL_{1000}
5.4	PL_{1500}
6.5	PL_{2000}
7.4	PL_{2500}
0.014	EAL

Figure D- 52 Steel – High Rise - Soil type C – Arecibo



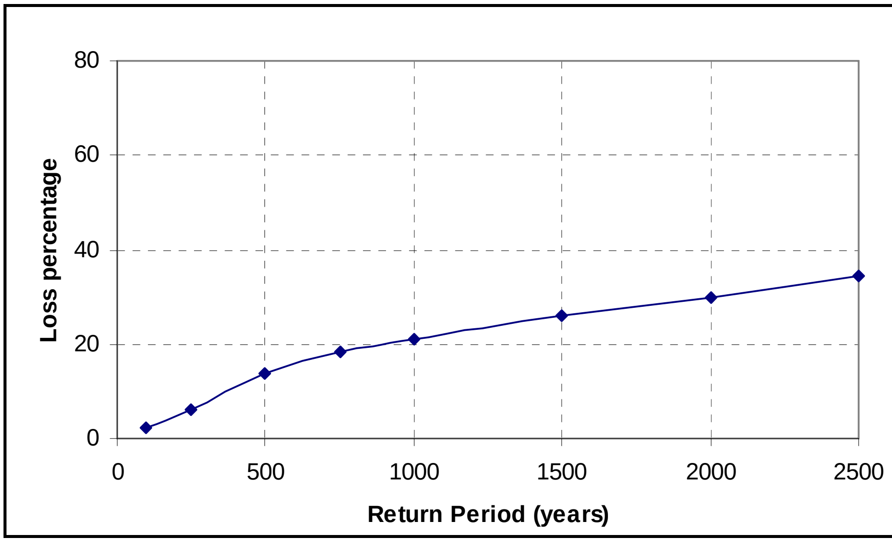
Probable Loss [%]	Name
0.4	PL_{100}
1.6	PL_{250}
3.3	PL_{500}
4.4	PL_{750}
5.2	PL_{1000}
7.1	PL_{1500}
8.7	PL_{2000}
9.9	PL_{2500}
0.023	EAL

Figure D- 53 Steel – High Rise - Soil type D – Arecibo



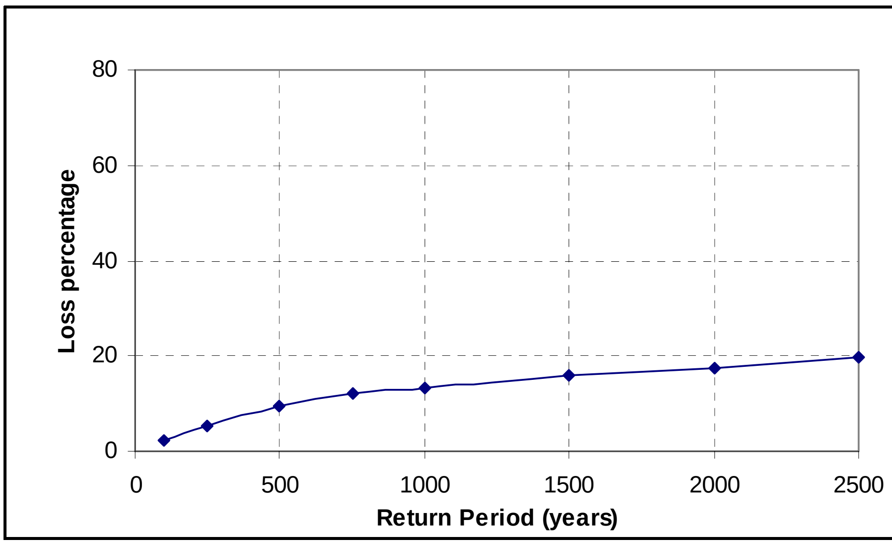
Probable Loss [%]	Name
2.2	PL_{100}
4.3	PL_{250}
5.4	PL_{500}
5.8	PL_{750}
5.6	PL_{1000}
5.8	PL_{1500}
5.6	PL_{2000}
5.4	PL_{2500}
0.041	EAL

Figure D- 54 Steel – High Rise - Soil type E – Arecibo



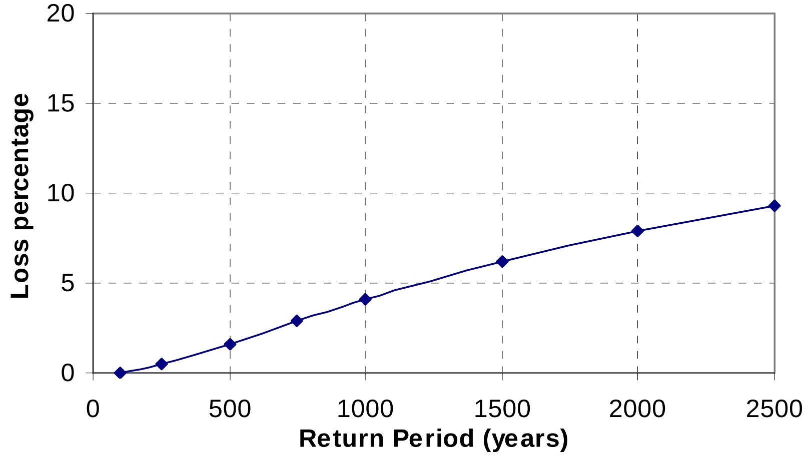
Probable Loss [%]	Name
2.2	PL_{100}
6.3	PL_{250}
13.9	PL_{500}
18.4	PL_{750}
21.2	PL_{1000}
25.9	PL_{1500}
29.7	PL_{2000}
34.3	PL_{2500}
0.092	EAL

Figure D- 55 Steel – High Rise - Soil type F (Shallow foundation) – Arecibo



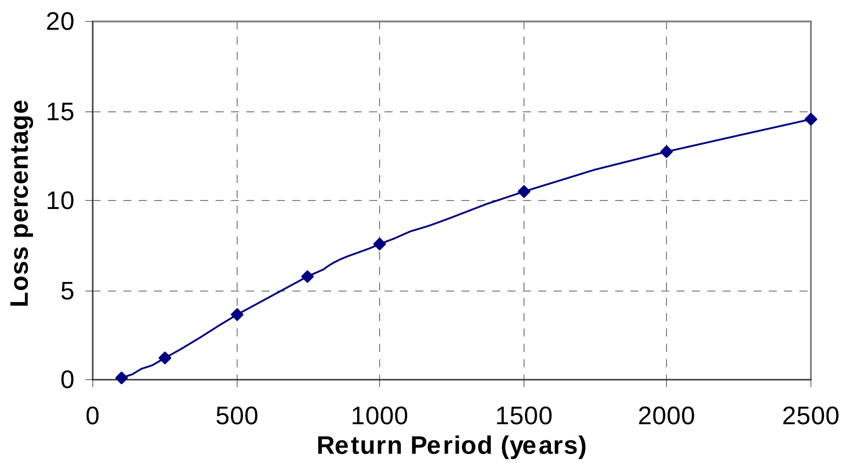
Probable Loss [%]	Name
2.2	PL_{100}
5.3	PL_{250}
9.7	PL_{500}
12.1	PL_{750}
13.4	PL_{1000}
15.8	PL_{1500}
17.6	PL_{2000}
19.8	PL_{2500}
0.066	EAL

Figure D- 56 Steel – High Rise - Soil type F (Deep foundation) – Arecibo



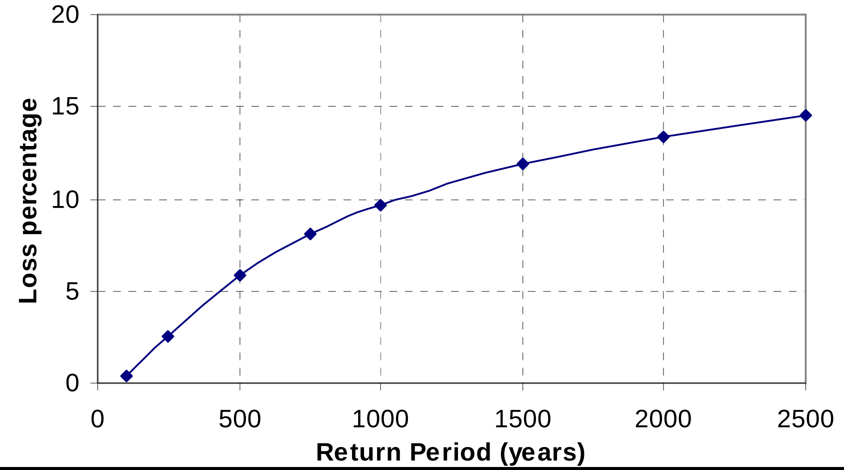
Probable Loss [%]	Name
0.0	PL_{100}
0.5	PL_{250}
1.6	PL_{500}
2.9	PL_{750}
4.1	PL_{1000}
6.2	PL_{1500}
7.9	PL_{2000}
9.3	PL_{2500}
0.014	EAL

Figure D- 57 Steel – Industrial – 1 Story - Soil type A – Arecibo



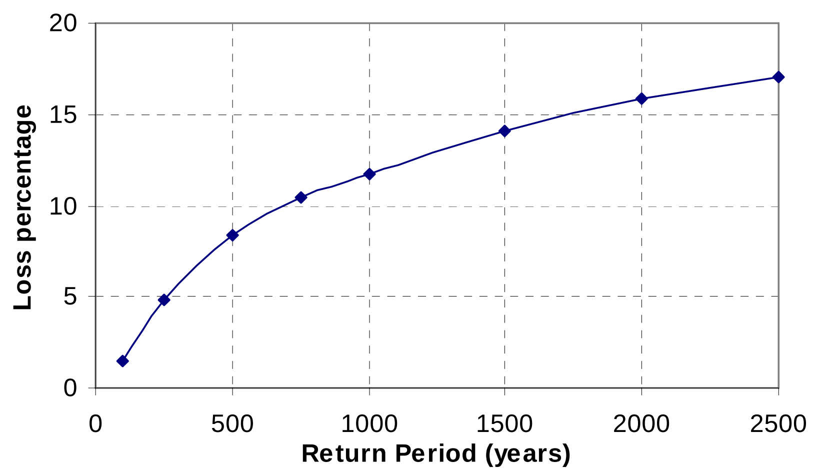
Probable Loss [%]	Name
0.1	PL_{100}
1.3	PL_{250}
3.6	PL_{500}
5.8	PL_{750}
7.6	PL_{1000}
10.5	PL_{1500}
12.8	PL_{2000}
14.5	PL_{2500}
0.027	EAL

Figure D- 58 Steel – Industrial – 1 Story - Soil type B – Arecibo



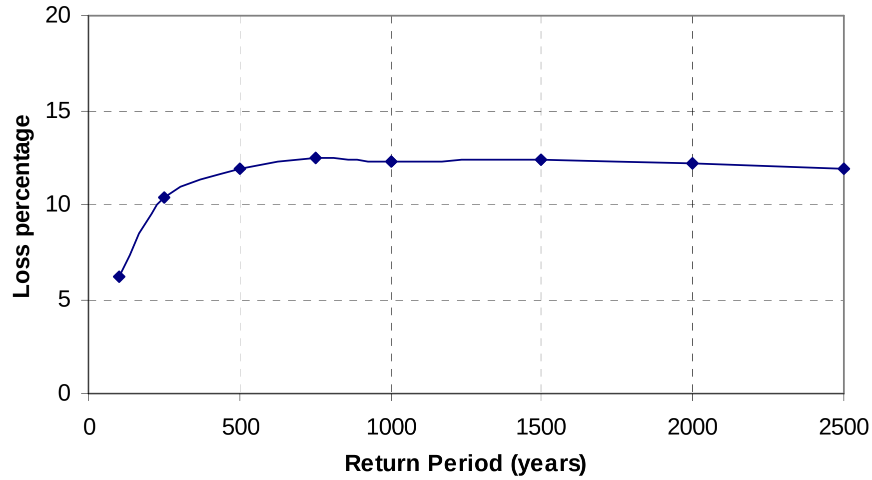
Probable Loss [%]	Name
0.4	PL_{100}
2.5	PL_{250}
5.9	PL_{500}
8.1	PL_{750}
9.6	PL_{1000}
11.9	PL_{1500}
13.4	PL_{2000}
14.5	PL_{2500}
0.038	EAL

Figure D- 59 Steel –Industrial – 1 Story - Soil type C – Arecibo



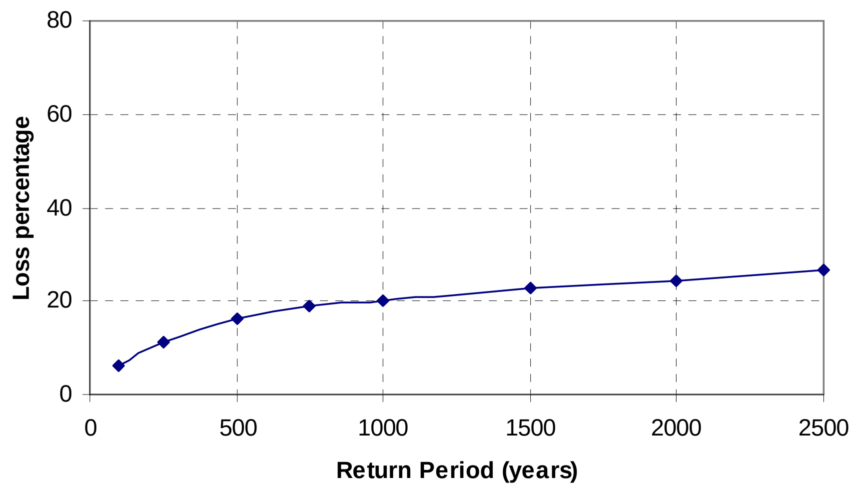
Probable Loss [%]	Name
1.4	PL_{100}
4.9	PL_{250}
8.4	PL_{500}
10.5	PL_{750}
11.7	PL_{1000}
14.1	PL_{1500}
15.8	PL_{2000}
17.1	PL_{2500}
0.057	EAL

Figure D- 60 Steel – Industrial – 1 Story - Soil type D – Arecibo



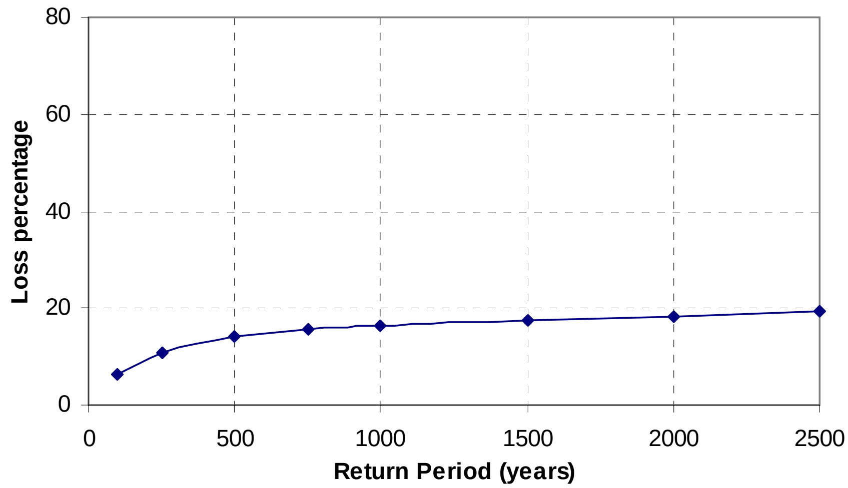
Probable Loss [%]	Name
6.2	PL_{100}
10.3	PL_{250}
11.9	PL_{500}
12.5	PL_{750}
12.3	PL_{1000}
12.4	PL_{1500}
12.2	PL_{2000}
11.9	PL_{2500}
0.096	EAL

Figure D- 61 Steel –Industrial – 1 Story - Soil type E – Arecibo



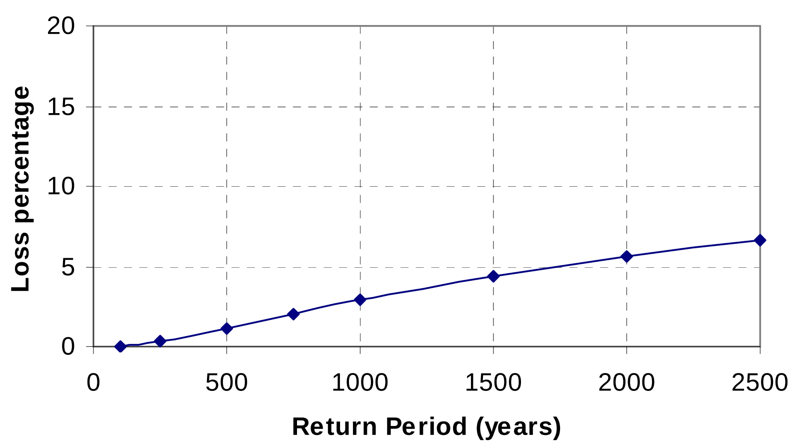
Probable Loss [%]	Name
6.2	PL_{100}
11.3	PL_{250}
16.3	PL_{500}
18.9	PL_{750}
20.2	PL_{1000}
22.7	PL_{1500}
24.5	PL_{2000}
26.7	PL_{2500}
0.123	EAL

Figure D- 62 Steel – Industrial – 1 Story - Soil type F (Shallow foundation) – Arecibo



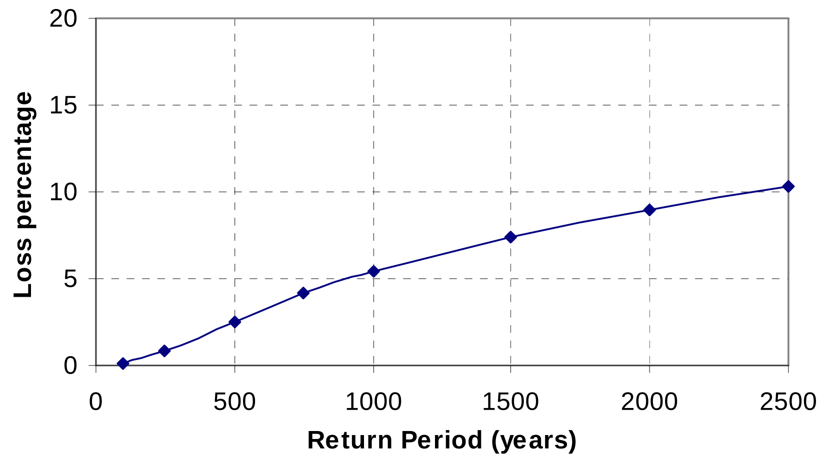
Probable Loss [%]	Name
6.2	PL_{100}
10.8	PL_{250}
14.1	PL_{500}
15.7	PL_{750}
16.2	PL_{1000}
17.5	PL_{1500}
18.3	PL_{2000}
19.3	PL_{2500}
0.109	EAL

Figure D- 63 Steel –Industrial – 1 Story - Soil type F (Deep foundation) – Arecibo



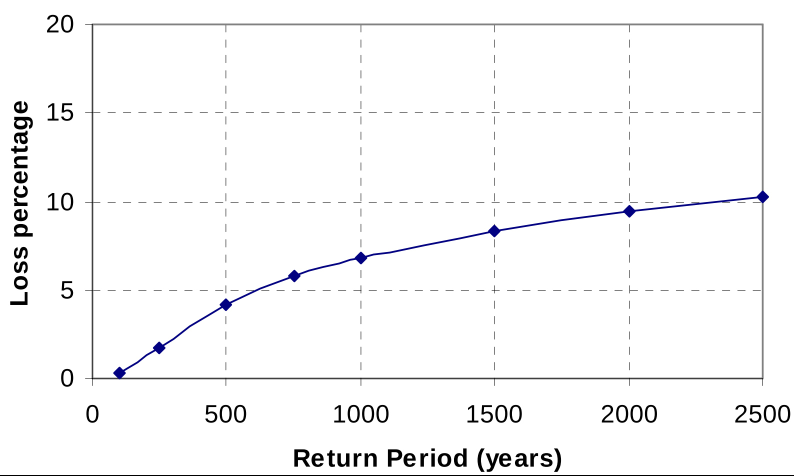
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.1	PL_{500}
2.0	PL_{750}
2.9	PL_{1000}
4.4	PL_{1500}
5.6	PL_{2000}
6.6	PL_{2500}
0.009	EAL

Figure D- 64 Steel – Industrial – 2 Story - Soil type A – Arecibo



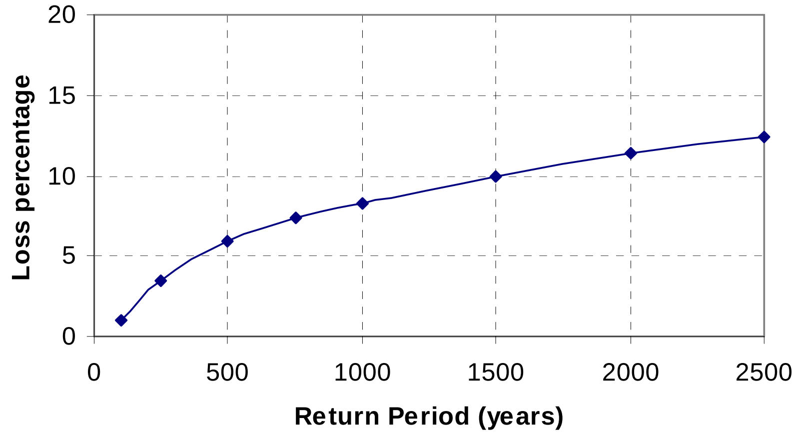
Probable Loss [%]	Name
0.1	PL_{100}
0.8	PL_{250}
2.5	PL_{500}
4.1	PL_{750}
5.4	PL_{1000}
7.4	PL_{1500}
9.0	PL_{2000}
10.3	PL_{2500}
0.019	EAL

Figure D- 65 Steel – Industrial – 2 Story - Soil type B – Arecibo



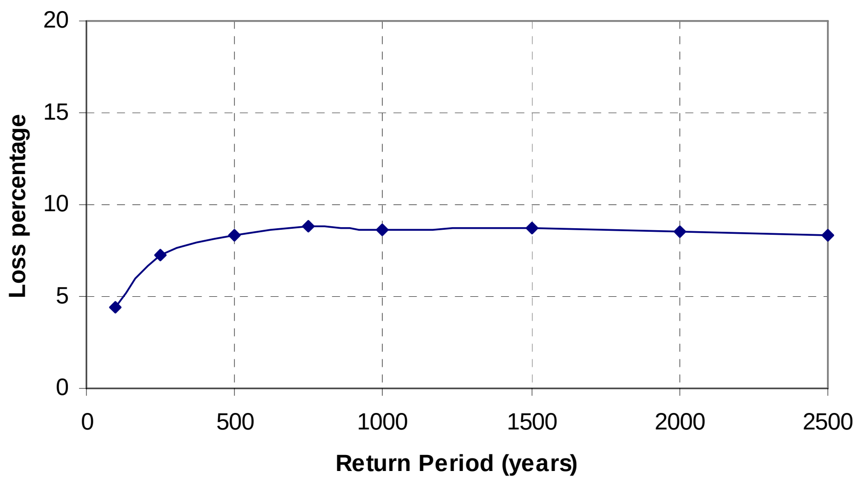
Probable Loss [%]	Name
0.3	PL_{100}
1.7	PL_{250}
4.2	PL_{500}
5.8	PL_{750}
6.8	PL_{1000}
8.3	PL_{1500}
9.4	PL_{2000}
10.3	PL_{2500}
0.026	EAL

Figure D- 66 Steel –Industrial – 2 Story - Soil type C – Arecibo



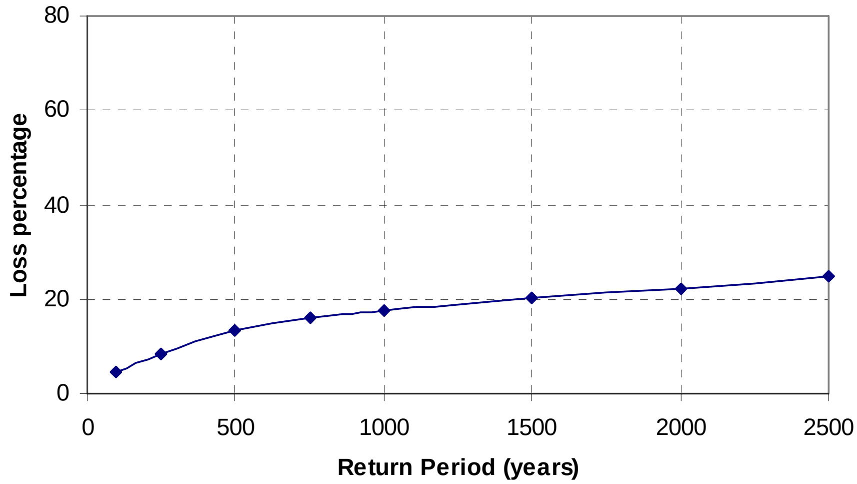
Probable Loss [%]	Name
1.0	PL_{100}
3.5	PL_{250}
6.0	PL_{500}
7.4	PL_{750}
8.2	PL_{1000}
10.0	PL_{1500}
11.4	PL_{2000}
12.5	PL_{2500}
0.041	EAL

Figure D- 67 Steel – Industrial – 2 Story - Soil type D – Arecibo



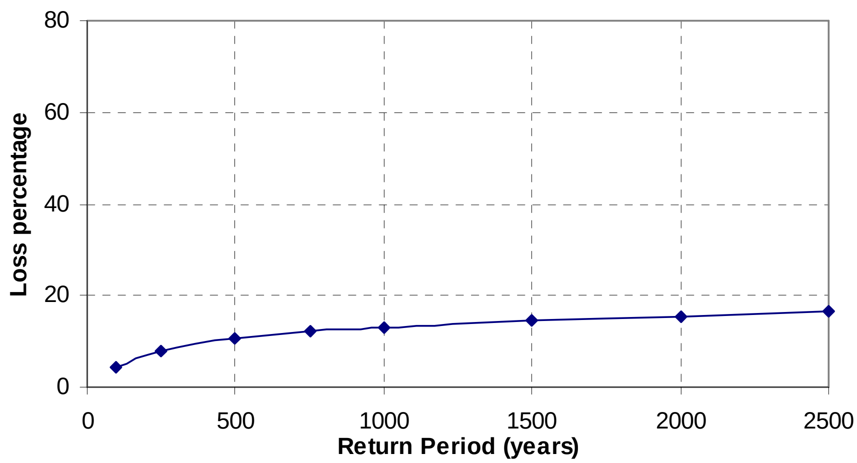
Probable Loss [%]	Name
4.4	PL_{100}
7.3	PL_{250}
8.4	PL_{500}
8.8	PL_{750}
8.6	PL_{1000}
8.7	PL_{1500}
8.6	PL_{2000}
8.4	PL_{2500}
0.068	EAL

Figure D- 68 Steel –Industrial – 2 Story - Soil type E – Arecibo



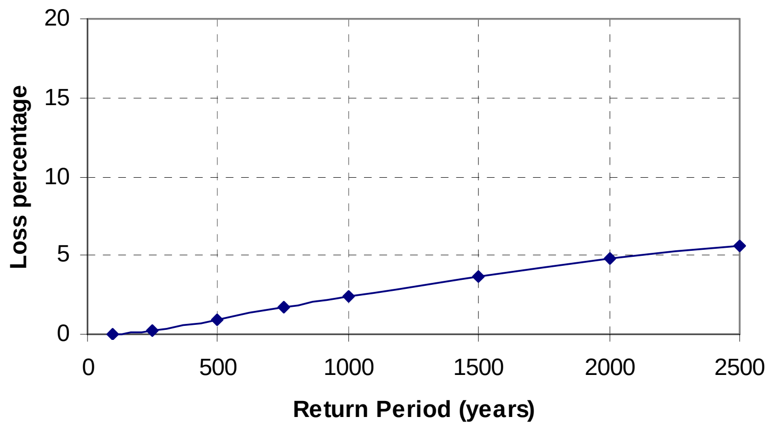
Probable Loss [%]	Name
4.4	PL_{100}
8.4	PL_{250}
13.2	PL_{500}
15.9	PL_{750}
17.4	PL_{1000}
20.2	PL_{1500}
22.3	PL_{2000}
24.8	PL_{2500}
0.097	EAL

Figure D- 69 Steel – Industrial – 2 Story - Soil type F (Shallow foundation) – Arecibo



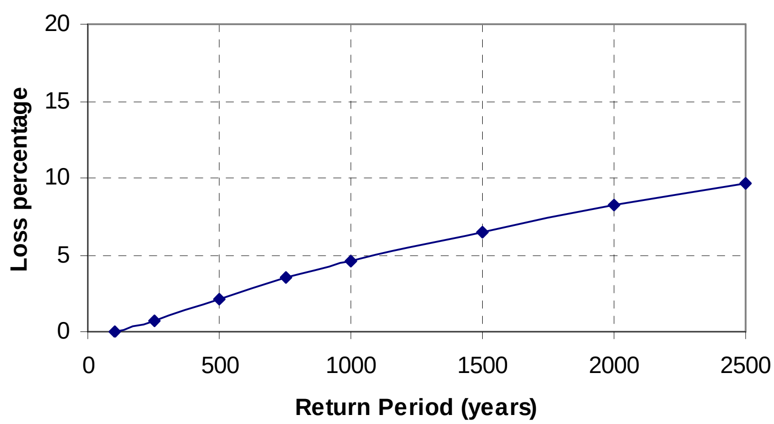
Probable Loss [%]	Name
4.4	PL_{100}
7.8	PL_{250}
10.8	PL_{500}
12.3	PL_{750}
13.0	PL_{1000}
14.5	PL_{1500}
15.4	PL_{2000}
16.6	PL_{2500}
0.083	EAL

Figure D- 70 Steel –Industrial – 2 Story - Soil type F (Deep foundation) – Arecibo



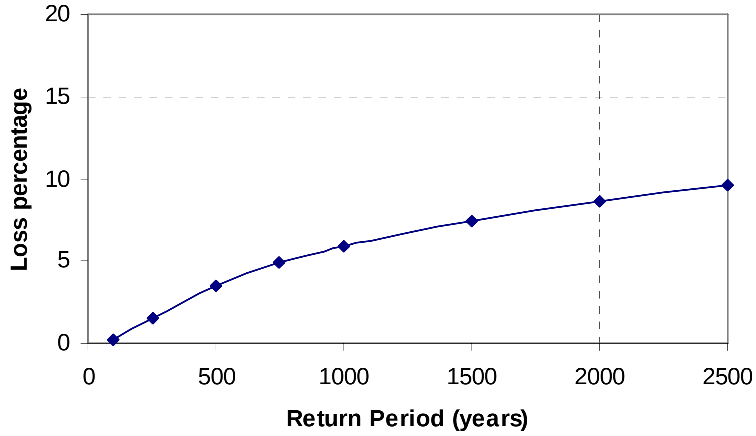
Probable Loss [%]	Name
0.0	PL_{100}
0.2	PL_{250}
0.9	PL_{500}
1.8	PL_{750}
2.4	PL_{1000}
3.7	PL_{1500}
4.8	PL_{2000}
5.7	PL_{2500}
0.008	EAL

Figure D- 71 Steel – Commercial – 2 Story - Soil type A – Arecibo



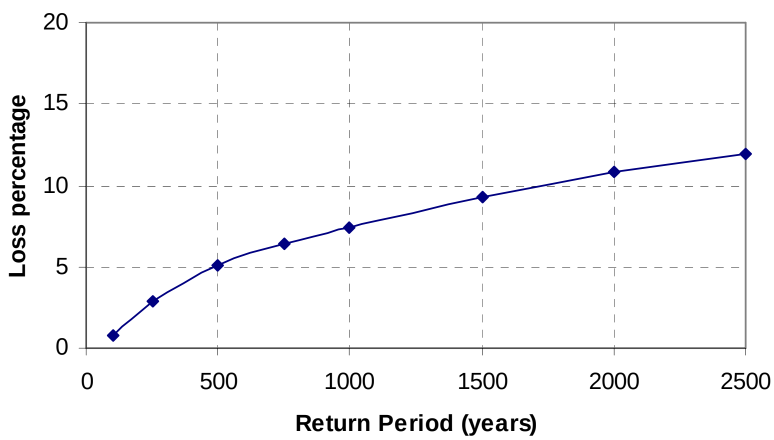
Probable Loss [%]	Name
0.1	PL_{100}
0.7	PL_{250}
2.2	PL_{500}
3.5	PL_{750}
4.5	PL_{1000}
6.5	PL_{1500}
8.2	PL_{2000}
9.6	PL_{2500}
0.016	EAL

Figure D- 72 Steel – Commercial – 2 Story - Soil type B – Arecibo



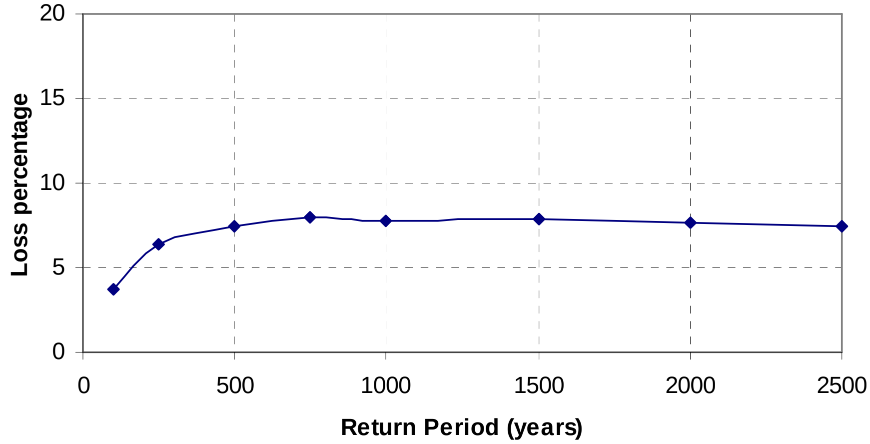
Probable Loss [%]	Name
0.2	PL_{100}
1.5	PL_{250}
3.5	PL_{500}
4.9	PL_{750}
5.9	PL_{1000}
7.5	PL_{1500}
8.7	PL_{2000}
9.6	PL_{2500}
0.023	EAL

Figure D- 73 Steel –Commercial– 2 Story - Soil type C – Arecibo



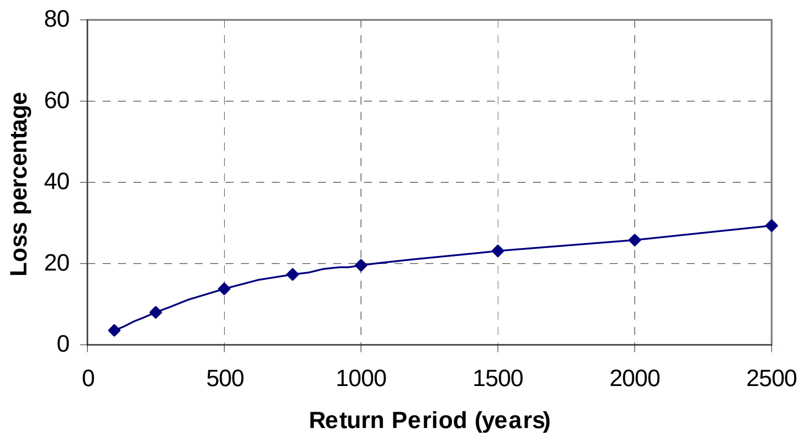
Probable Loss [%]	Name
0.8	PL_{100}
2.9	PL_{250}
5.1	PL_{500}
6.5	PL_{750}
7.4	PL_{1000}
9.3	PL_{1500}
10.8	PL_{2000}
12.0	PL_{2500}
0.036	EAL

Figure D- 74 Steel – Commercial – 2 Story - Soil type D – Arecibo



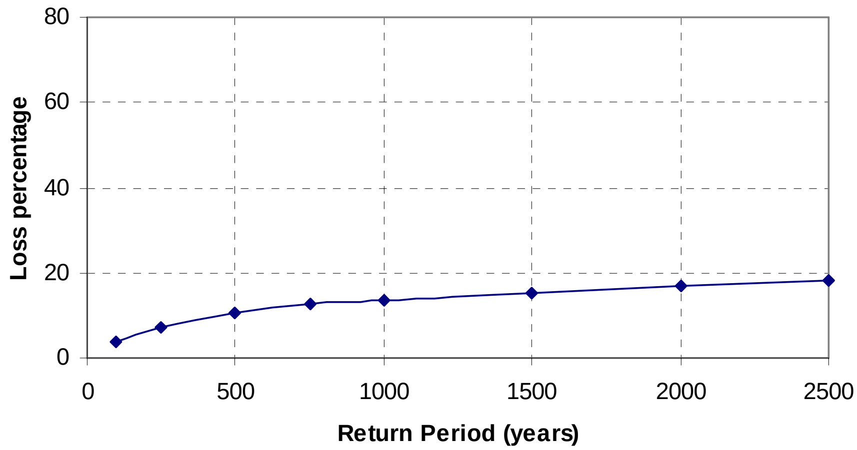
Probable Loss [%]	Name
3.7	PL_{100}
6.4	PL_{250}
7.5	PL_{500}
7.9	PL_{750}
7.8	PL_{1000}
7.9	PL_{1500}
7.7	PL_{2000}
7.5	PL_{2500}
0.060	EAL

Figure D- 75 Steel –Commercial – 2 Story - Soil type E – Arecibo



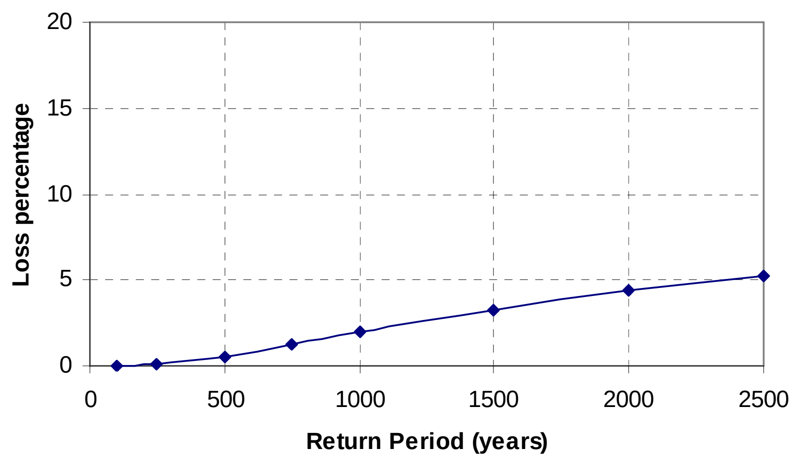
Probable Loss [%]	Name
3.7	PL_{100}
7.8	PL_{250}
13.9	PL_{500}
17.4	PL_{750}
19.4	PL_{1000}
23.0	PL_{1500}
25.7	PL_{2000}
29.1	PL_{2500}
0.098	EAL

Figure D- 76 Steel – Commercial – 2 Story - Soil type F (Shallow foundation) – Arecibo



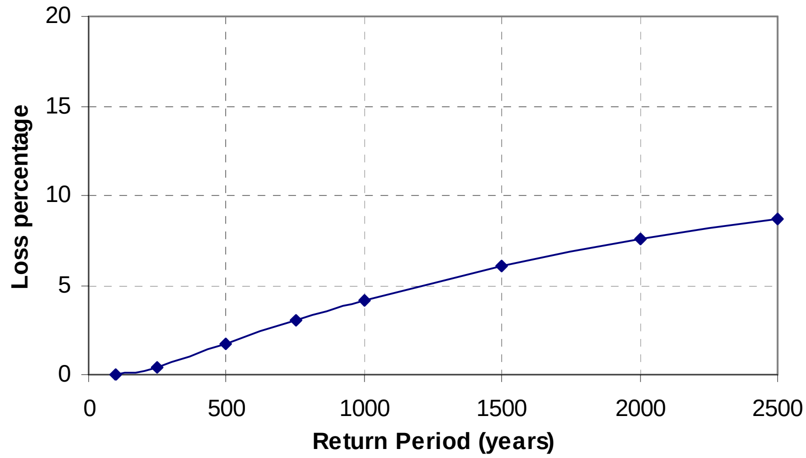
Probable Loss [%]	Name
3.7	PL_{100}
7.1	PL_{250}
10.7	PL_{500}
12.7	PL_{750}
13.6	PL_{1000}
15.4	PL_{1500}
16.7	PL_{2000}
18.3	PL_{2500}
0.079	EAL

Figure D- 77 Steel –Commercial – 2 Story - Soil type F (Deep foundation) – Arecibo



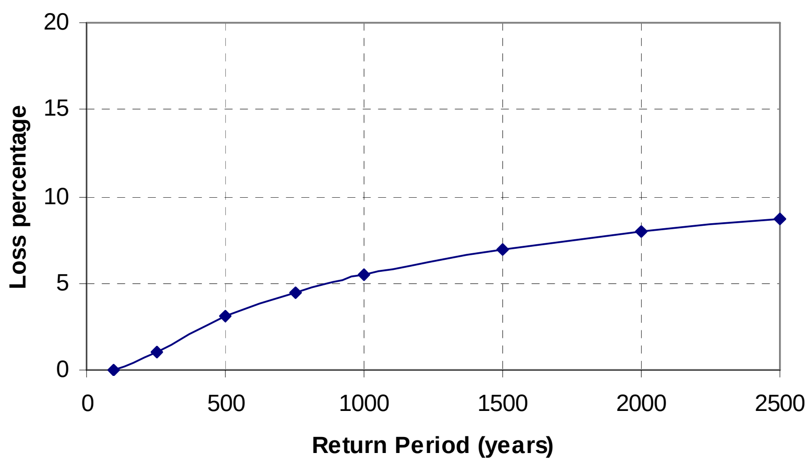
Probable Loss [%]	Name
0.0	PL_{100}
0.1	PL_{250}
0.6	PL_{500}
1.3	PL_{750}
2.0	PL_{1000}
3.3	PL_{1500}
4.4	PL_{2000}
5.3	PL_{2500}
0.006	EAL

Figure D- 78 Steel – Commercial – 3 Story - Soil type A – Arecibo



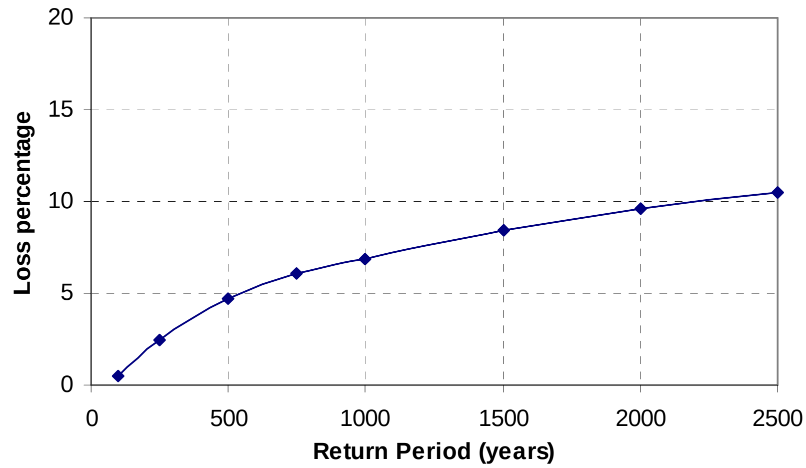
Probable Loss [%]	Name
0.0	PL_{100}
0.4	PL_{250}
1.7	PL_{500}
3.0	PL_{750}
4.2	PL_{1000}
6.1	PL_{1500}
7.5	PL_{2000}
8.7	PL_{2500}
0.013	EAL

Figure D- 79 Steel – Commercial – 3 Story - Soil type B – Arecibo



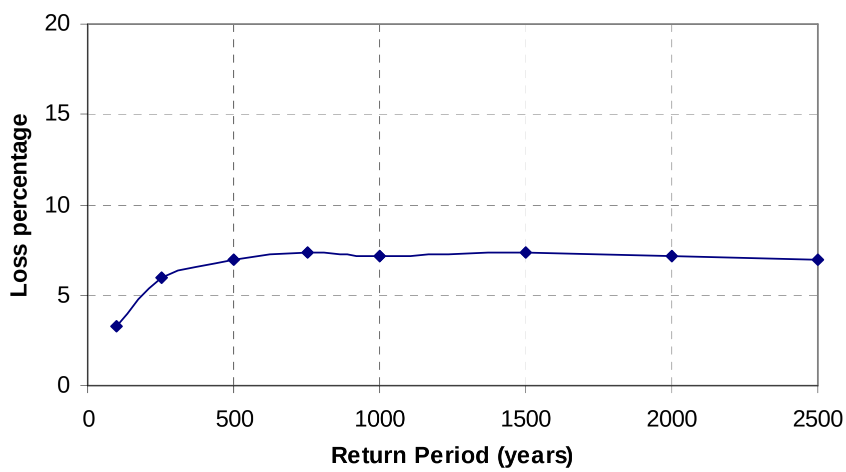
Probable Loss [%]	Name
0.1	PL_{100}
1.0	PL_{250}
3.1	PL_{500}
4.5	PL_{750}
5.5	PL_{1000}
6.9	PL_{1500}
7.9	PL_{2000}
8.7	PL_{2500}
0.019	EAL

Figure D- 80 Steel –Commercial– 3 Story - Soil type C – Arecibo



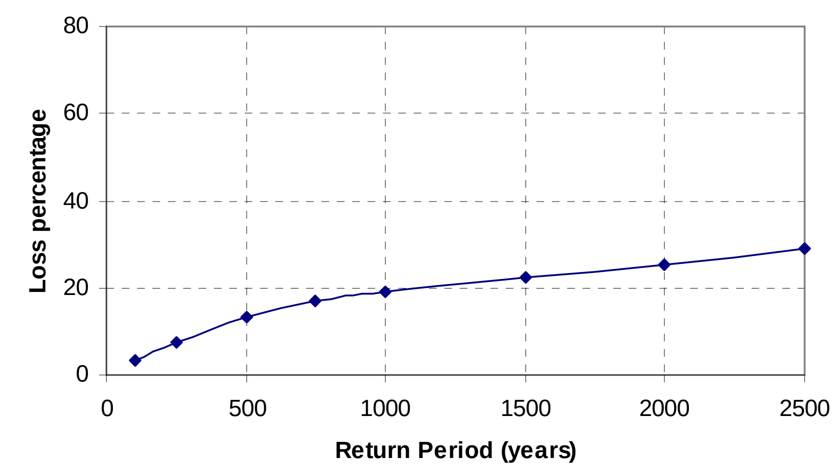
Probable Loss [%]	Name
0.5	PL_{100}
2.5	PL_{250}
4.7	PL_{500}
6.0	PL_{750}
6.9	PL_{1000}
8.4	PL_{1500}
9.6	PL_{2000}
10.5	PL_{2500}
0.031	EAL

Figure D- 81 Steel – Commercial – 3 Story - Soil type D – Arecibo



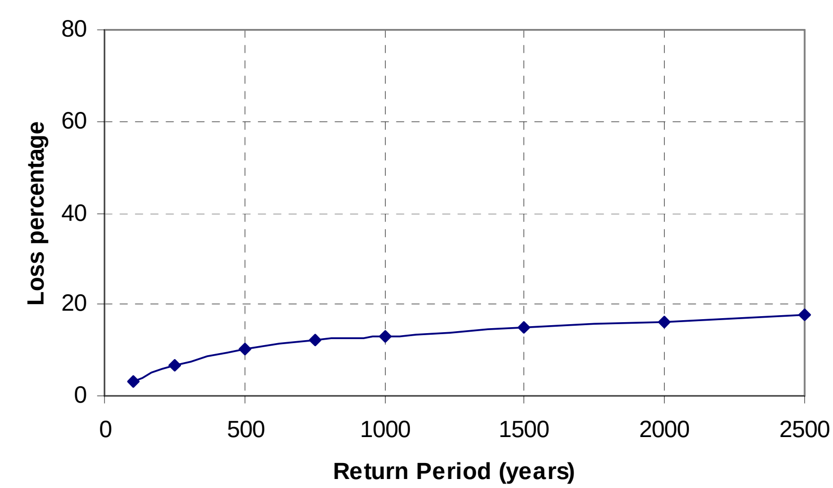
Probable Loss [%]	Name
3.3	PL_{100}
6.0	PL_{250}
7.0	PL_{500}
7.4	PL_{750}
7.2	PL_{1000}
7.3	PL_{1500}
7.2	PL_{2000}
7.0	PL_{2500}
0.055	EAL

Figure D- 82 Steel –Commercial – 3 Story - Soil type E – Arecibo



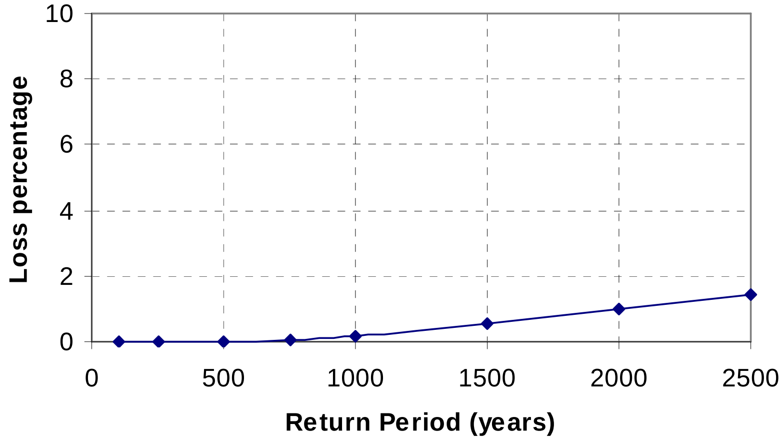
Probable Loss [%]	Name
3.3	PL_{100}
7.4	PL_{250}
13.5	PL_{500}
16.9	PL_{750}
19.0	PL_{1000}
22.6	PL_{1500}
25.4	PL_{2000}
28.9	PL_{2500}
0.094	EAL

Figure D- 83 Steel – Commercial – 3 Story - Soil type F (Shallow foundation) – Arecibo



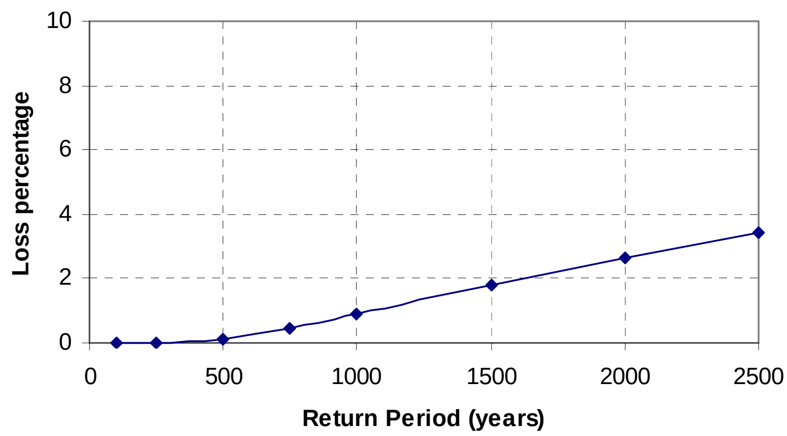
Probable Loss [%]	Name
3.3	PL_{100}
6.7	PL_{250}
10.2	PL_{500}
12.1	PL_{750}
13.1	PL_{1000}
15.0	PL_{1500}
16.3	PL_{2000}
17.9	PL_{2500}
0.075	EAL

Figure D- 84 Steel –Commercial – 3 Story - Soil type F (Deep foundation) – Arecibo



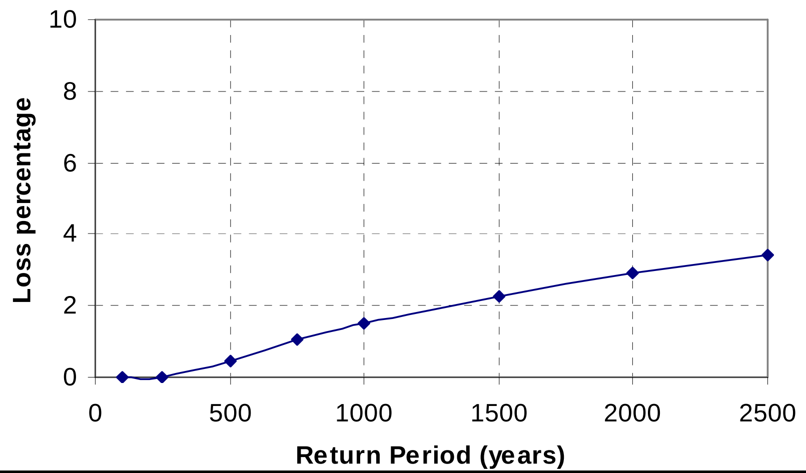
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.0	PL_{500}
0.0	PL_{750}
0.1	PL_{1000}
0.5	PL_{1500}
1.0	PL_{2000}
1.4	PL_{2500}
0.001	EAL

Figure D- 85 Steel – Commercial – 4 Story - Soil type A – Arecibo



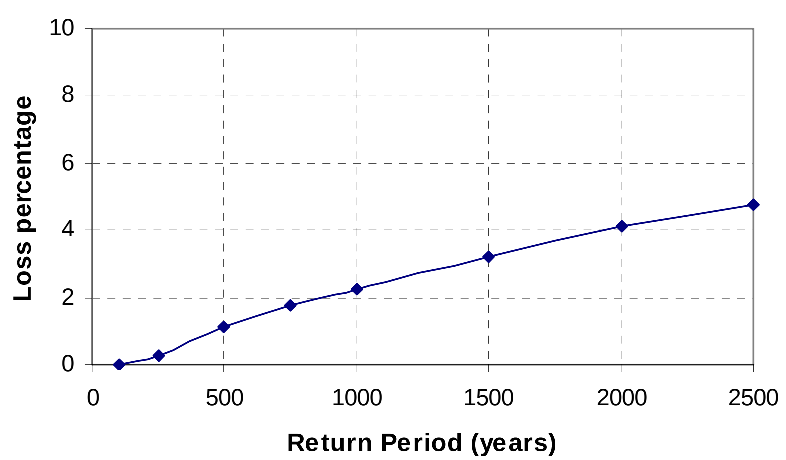
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.1	PL_{500}
0.4	PL_{750}
0.9	PL_{1000}
1.8	PL_{1500}
2.6	PL_{2000}
3.4	PL_{2500}
0.003	EAL

Figure D- 86 Steel – Commercial – 4 Story - Soil type B – Arecibo



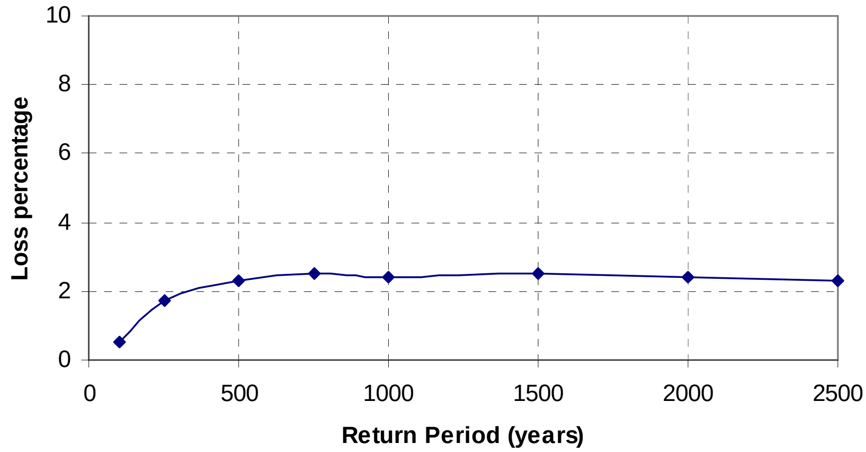
Probable Loss [%]	Name
0.0	PL_{100}
0.0	PL_{250}
0.5	PL_{500}
1.1	PL_{750}
1.5	PL_{1000}
2.3	PL_{1500}
2.9	PL_{2000}
3.4	PL_{2500}
0.004	EAL

Figure D- 87 Steel –Commercial– 4 Story - Soil type C – Arecibo



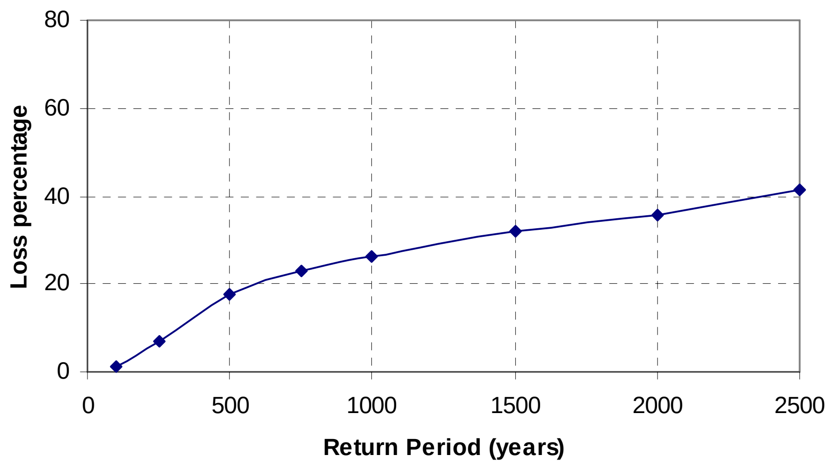
Probable Loss [%]	Name
0.0	PL_{100}
0.3	PL_{250}
1.1	PL_{500}
1.8	PL_{750}
2.2	PL_{1000}
3.2	PL_{1500}
4.1	PL_{2000}
4.7	PL_{2500}
0.008	EAL

Figure D- 88 Steel – Commercial – 4 Story - Soil type D – Arecibo



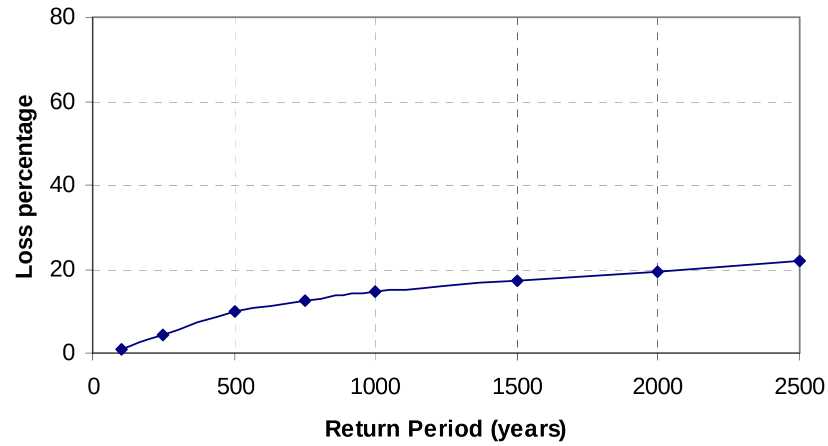
Probable Loss [%]	Name
0.5	PL_{100}
1.7	PL_{250}
2.3	PL_{500}
2.5	PL_{750}
2.4	PL_{1000}
2.5	PL_{1500}
2.4	PL_{2000}
2.3	PL_{2500}
0.016	EAL

Figure D- 89 Steel –Commercial – 4 Story - Soil type E – Arecibo



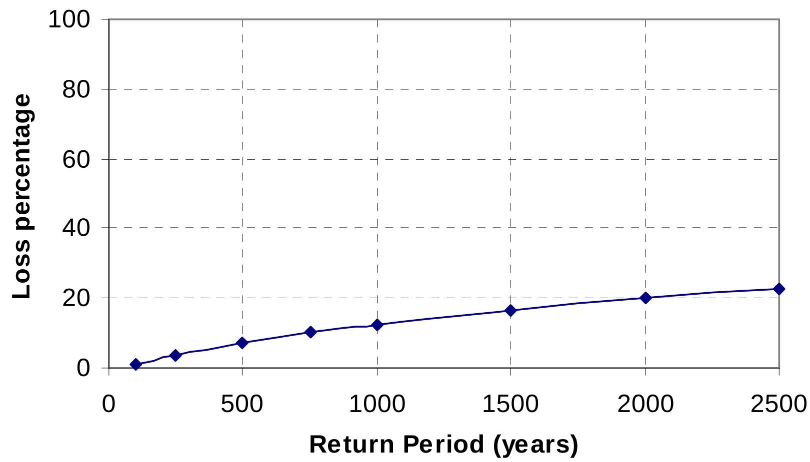
Probable Loss [%]	Name
1.2	PL_{100}
7.1	PL_{250}
17.5	PL_{500}
22.8	PL_{750}
26.4	PL_{1000}
31.9	PL_{1500}
35.9	PL_{2000}
41.6	PL_{2500}
0.107	EAL

Figure D- 90 Steel – Commercial – 4 Story - Soil type F (Shallow foundation) – Arecibo



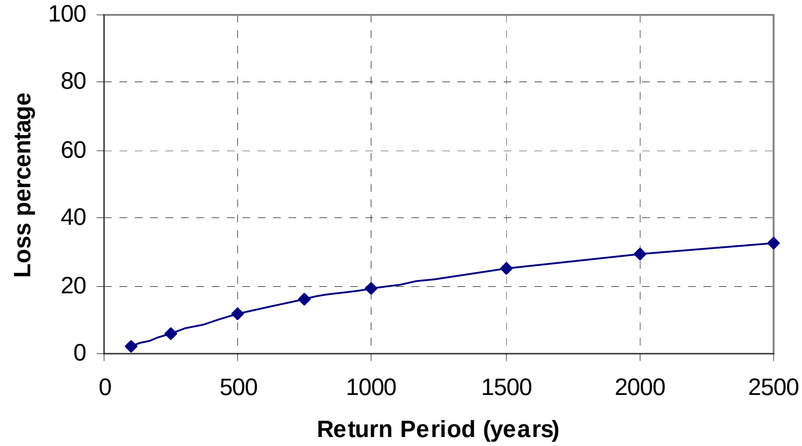
Probable Loss [%]	Name
0.9	PL_{100}
4.4	PL_{250}
9.9	PL_{500}
12.7	PL_{750}
14.4	PL_{1000}
17.2	PL_{1500}
19.1	PL_{2000}
21.9	PL_{2500}
0.061	EAL

Figure D- 91 Steel –Commercial – 4 Story - Soil type F (Deep foundation) – Arecibo



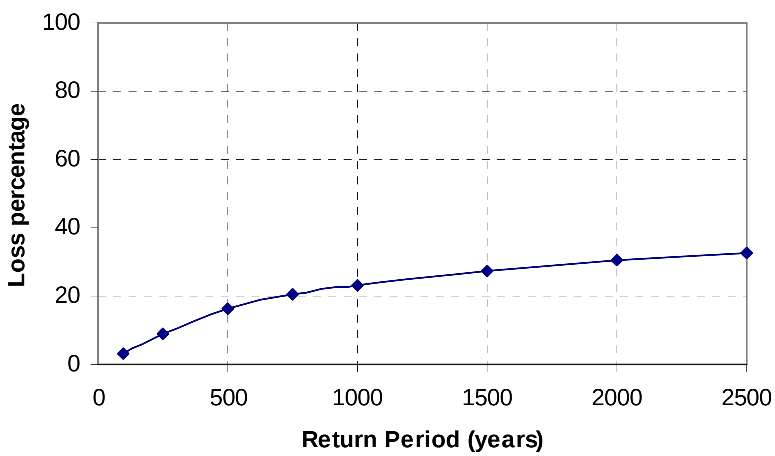
Probable Loss [%]	Name
1.0	PL_{100}
3.4	PL_{250}
7.0	PL_{500}
10.1	PL_{750}
12.5	PL_{1000}
16.7	PL_{1500}
20.1	PL_{2000}
22.7	PL_{2500}
0.052	EAL

Figure D- 92 Wood House - Soil type A – Arecibo



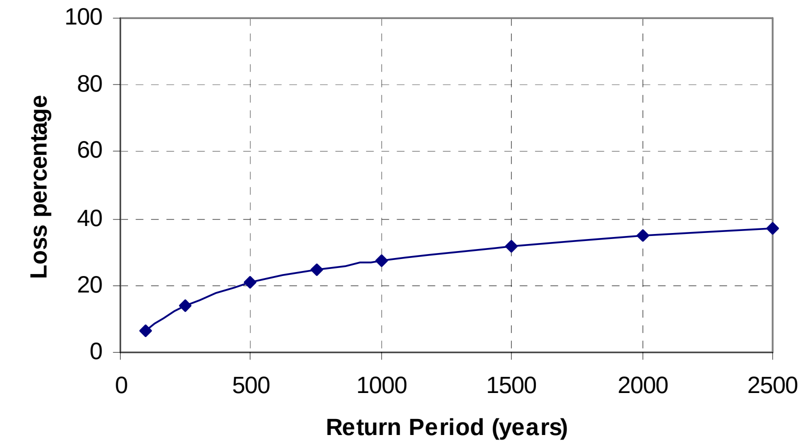
Probable Loss [%]	Name
1.9	PL_{100}
6.0	PL_{250}
11.5	PL_{500}
16.0	PL_{750}
19.4	PL_{1000}
25.0	PL_{1500}
29.3	PL_{2000}
32.5	PL_{2500}
0.084	EAL

Figure D- 93 Wood House - Soil type B – Arecibo



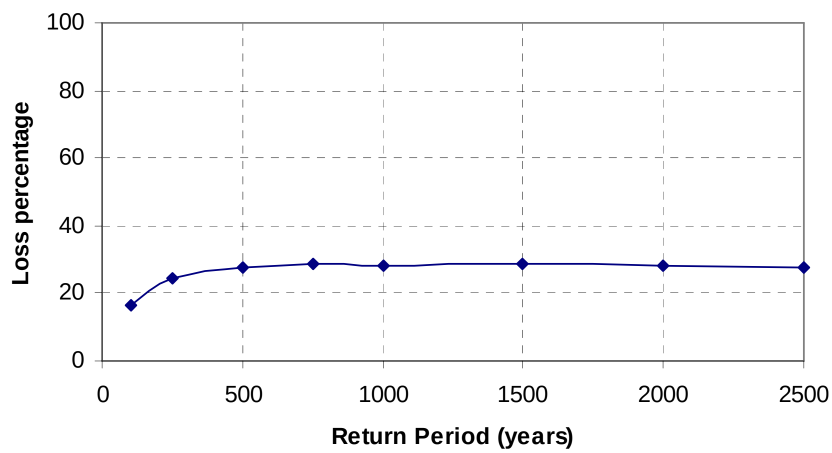
Probable Loss [%]	Name
3.2	PL_{100}
9.1	PL_{250}
16.1	PL_{500}
20.4	PL_{750}
23.3	PL_{1000}
27.6	PL_{1500}
30.4	PL_{2000}
32.5	PL_{2500}
0.111	EAL

Figure D- 94 Wood House - Soil type C – Arecibo



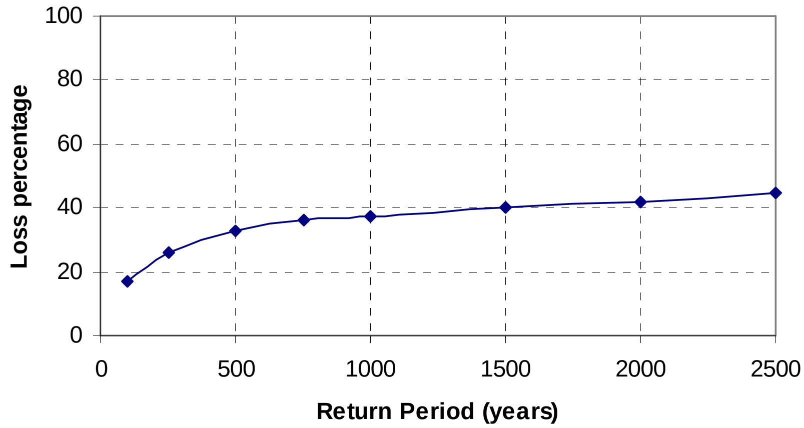
Probable Loss [%]	Name
6.5	PL_{100}
14.1	PL_{250}
21.0	PL_{500}
24.9	PL_{750}
27.3	PL_{1000}
31.7	PL_{1500}
35.0	PL_{2000}
37.1	PL_{2500}
0.155	EAL

Figure D- 95 Wood House - Soil type D – Arecibo



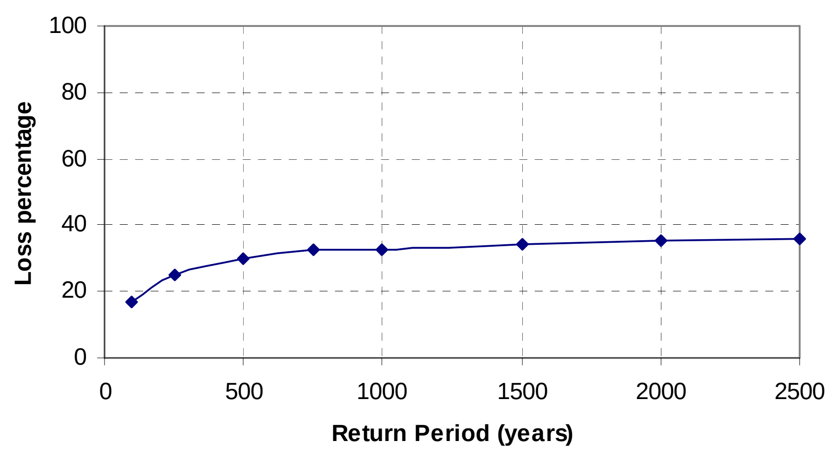
Probable Loss [%]	Name
16.7	PL_{100}
24.7	PL_{250}
27.6	PL_{500}
28.7	PL_{750}
28.3	PL_{1000}
28.7	PL_{1500}
28.2	PL_{2000}
27.6	PL_{2500}
0.233	EAL

Figure D- 96 Wood House - Soil type E – Arecibo



Probable Loss [%]	Name
16.7	PL_{100}
25.8	PL_{250}
32.6	PL_{500}
35.9	PL_{750}
37.3	PL_{1000}
40.2	PL_{1500}
42.0	PL_{2000}
44.4	PL_{2500}
0.263	EAL

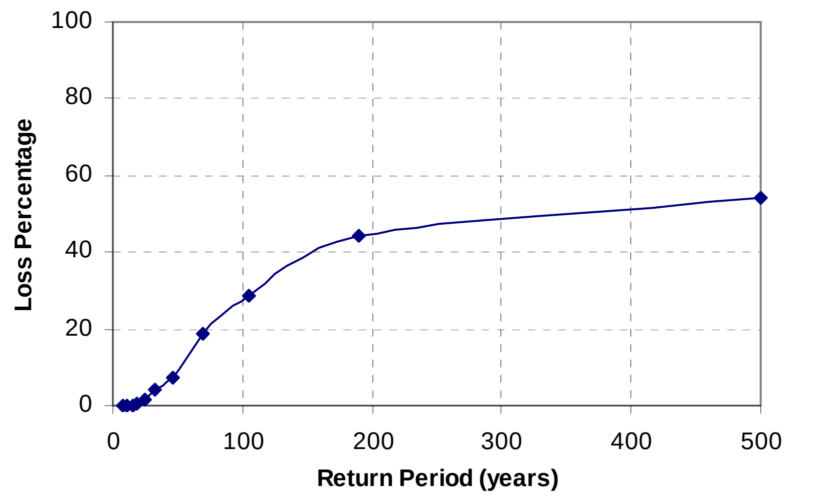
Figure D- 97 Wood House - Soil type F (Shallow foundation) – Arecibo



Probable Loss [%]	Name
16.7	PL_{100}
25.2	PL_{250}
30.1	PL_{500}
32.3	PL_{750}
32.8	PL_{1000}
34.4	PL_{1500}
35.1	PL_{2000}
36.0	PL_{2500}
0.248	EAL

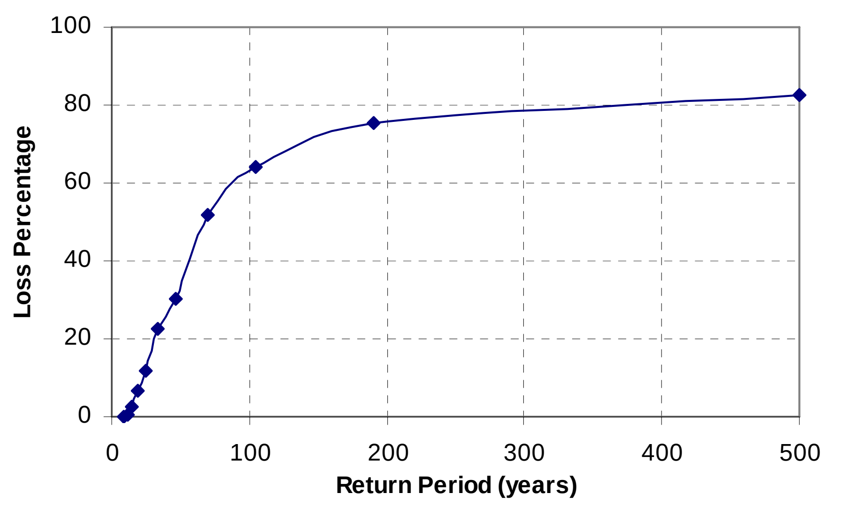
Figure D- 98 Wood House - Soil type F (Deep foundation) – Arecibo

Appendix E Hurricane Loss Curves for Mayagüez



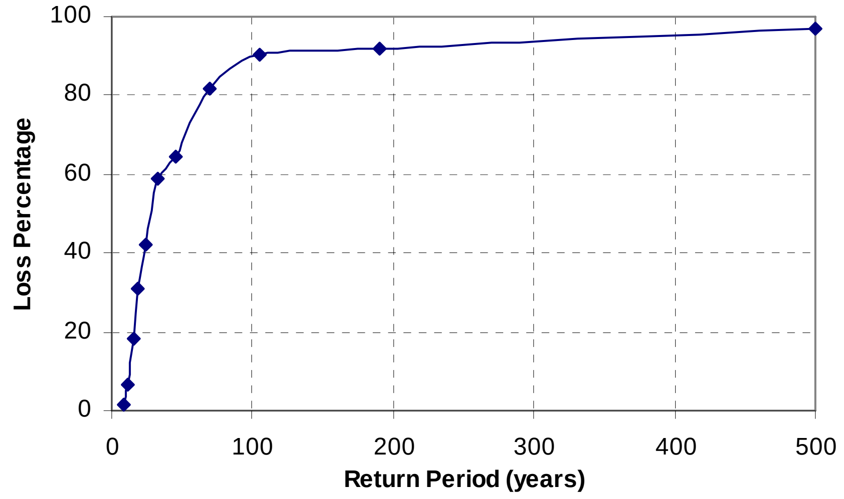
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.2	PL_{15}
0.6	PL_{19}
1.4	PL_{24}
4.2	PL_{33}
7.4	PL_{46}
18.5	PL_{70}
28.9	PL_{105}
44.0	PL_{190}
54.3	PL_{500}
0.697	EAL

Figure E- 1 Wood-Zinc House – 1 Story – Mayagüez – Exposure B



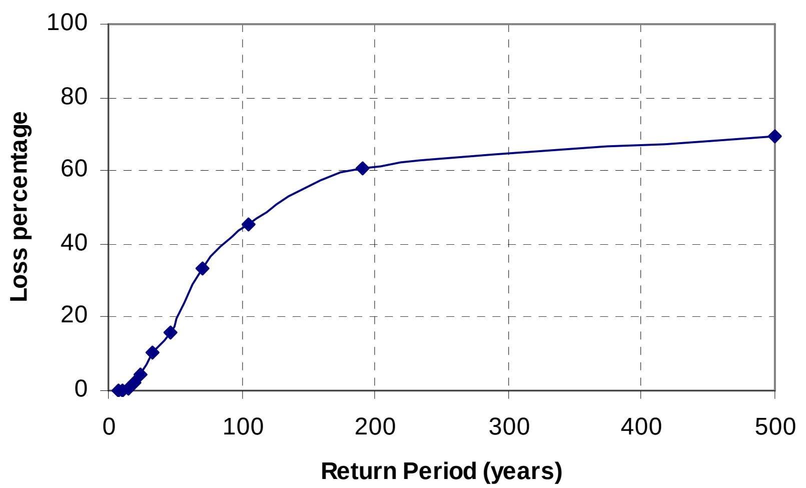
Probable Loss [%]	Name
0.0	PL_8
0.5	PL_{11}
2.7	PL_{15}
6.8	PL_{19}
11.6	PL_{24}
22.5	PL_{33}
30.3	PL_{46}
51.7	PL_{70}
63.9	PL_{105}
75.1	PL_{190}
82.8	PL_{500}
1.909	EAL

Figure E- 2 Wood-Zinc House – 1 Story – Mayagüez – Exposure B – Minimum Topographic effect



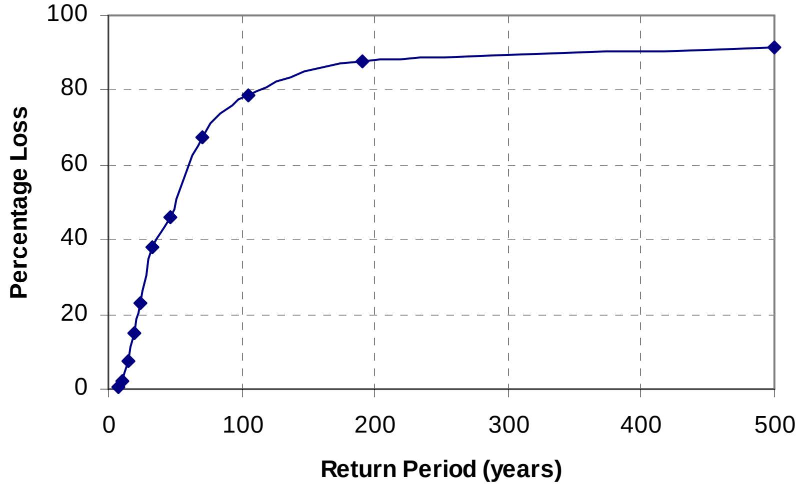
Probable Loss [%]	Name
1.5	PL_8
6.8	PL_{11}
18.3	PL_{15}
31.1	PL_{19}
42.0	PL_{24}
58.7	PL_{33}
64.2	PL_{46}
81.5	PL_{70}
90.4	PL_{105}
91.6	PL_{190}
96.9	PL_{500}
4.115	EAL

Figure E- 3 Wood-Zinc House – 1 Story – Mayagüez – Exposure B – Maximum Topographic effect



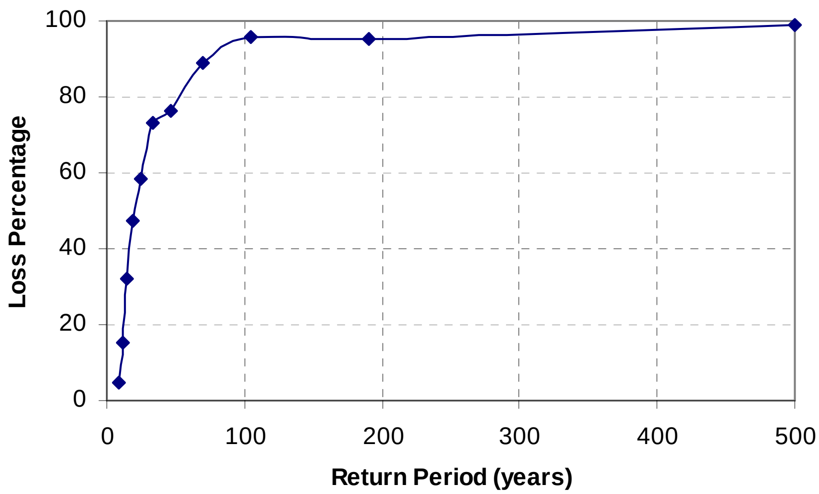
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.7	PL_{15}
2.2	PL_{19}
4.4	PL_{24}
10.4	PL_{33}
16.0	PL_{46}
33.1	PL_{70}
45.4	PL_{105}
60.6	PL_{190}
69.6	PL_{500}
1.180	EAL

Figure E- 4 Wood-Zinc House – 1 Story – Mayagüez – Exposure C



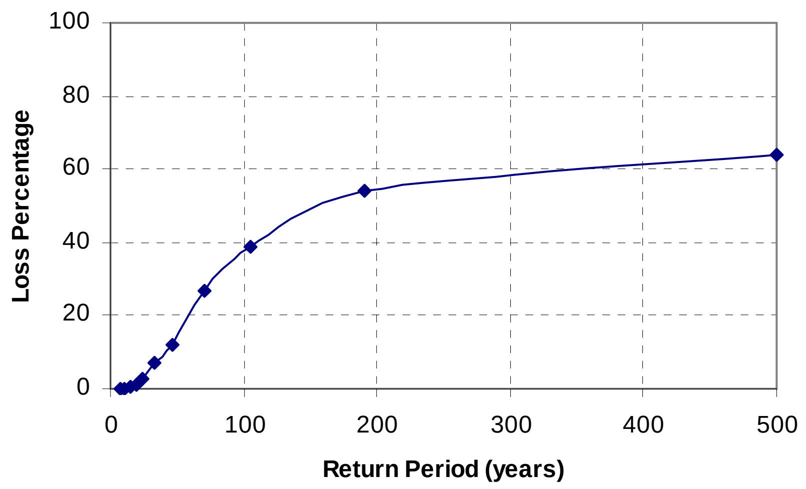
Probable Loss [%]	Name
0.3	PL_{8}
2.0	PL_{11}
7.3	PL_{15}
15.1	PL_{19}
23.1	PL_{24}
38.2	PL_{33}
46.1	PL_{46}
67.5	PL_{70}
78.4	PL_{105}
87.6	PL_{190}
91.2	PL_{500}
2.812	EAL

Figure E- 5 Wood-Zinc House – 1 Story – Mayagüez – Exposure C - Minimum Topographic effect



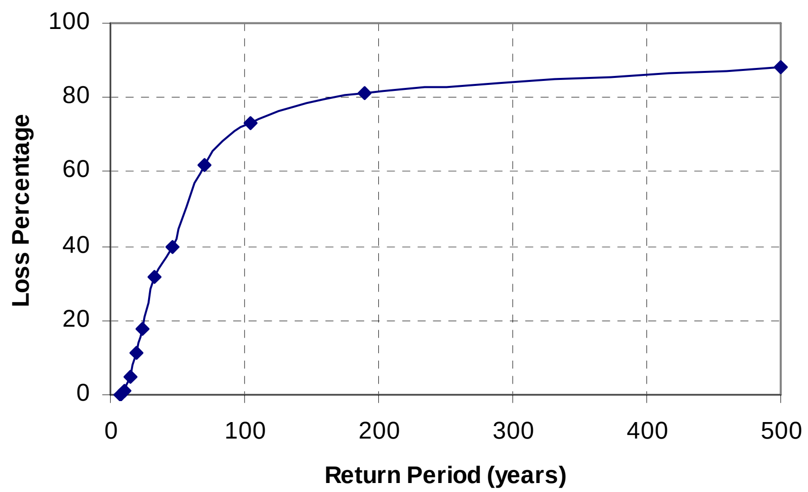
Probable Loss [%]	Name
4.6	PL_{8}
15.2	PL_{11}
32.3	PL_{15}
47.2	PL_{19}
58.4	PL_{24}
73.4	PL_{33}
76.2	PL_{46}
88.9	PL_{70}
95.9	PL_{105}
95.4	PL_{190}
98.9	PL_{500}
5.406	EAL

Figure E- 6 Wood-Zinc House – 1 Story – Mayagüez – Exposure C - Maximum Topographic effect



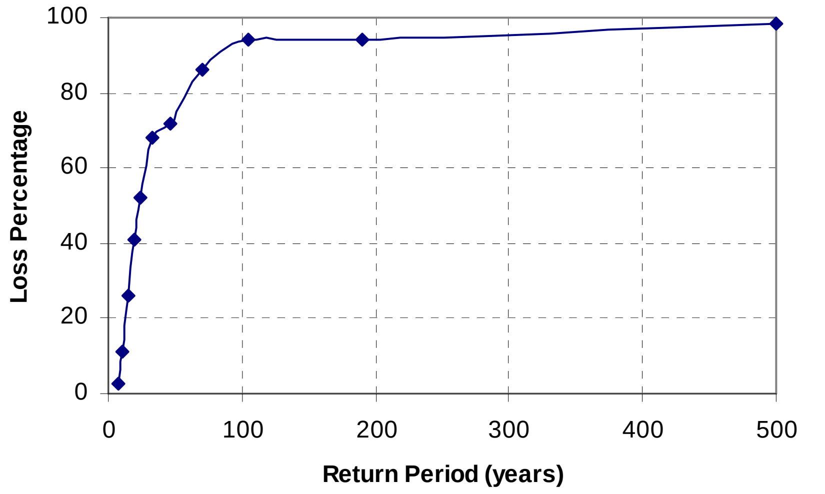
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.3	PL_{15}
1.2	PL_{19}
2.6	PL_{24}
7.1	PL_{33}
11.8	PL_{46}
26.8	PL_{70}
38.6	PL_{105}
54.3	PL_{190}
63.9	PL_{500}
0.956	EAL

Figure E- 7 Wood-Zinc House – 2 Story – Mayagüez – Exposure B



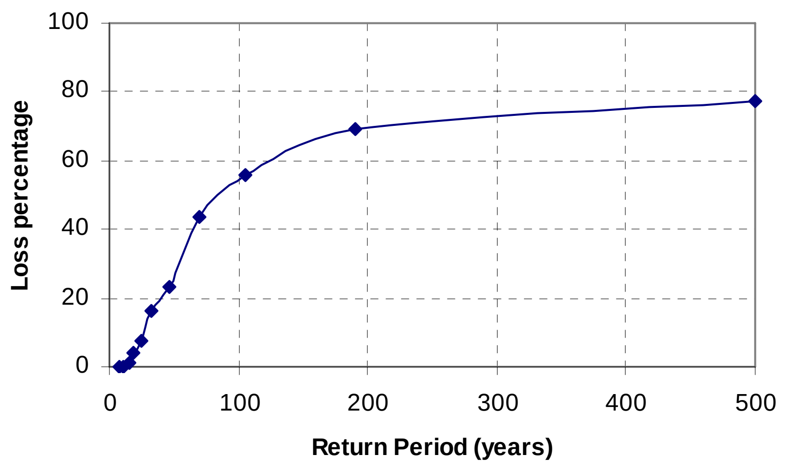
Probable Loss [%]	Name
0.1	PL_{8}
1.0	PL_{11}
4.8	PL_{15}
11.0	PL_{19}
17.8	PL_{24}
31.5	PL_{33}
39.7	PL_{46}
61.7	PL_{70}
73.2	PL_{105}
81.2	PL_{190}
88.4	PL_{500}
2.399	EAL

Figure E- 8 Wood-Zinc House – 2 Story – Mayagüez – Exposure B – Minimum Topographic Effect



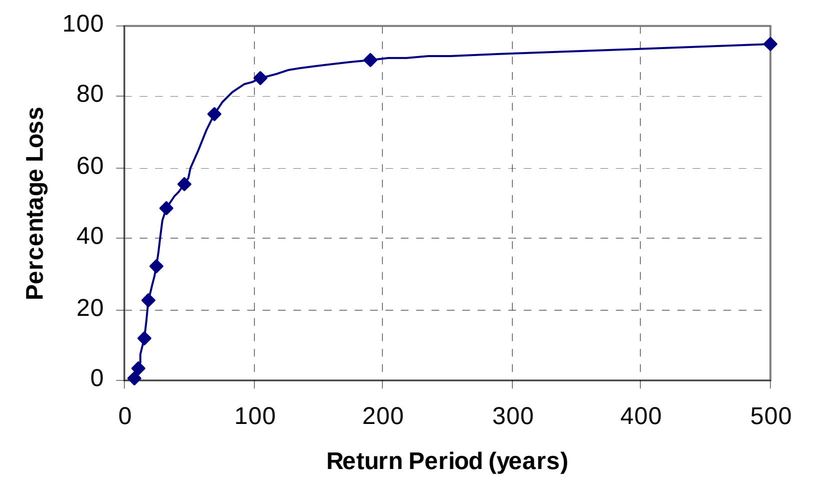
Probable Loss [%]	Name
2.8	PL_8
11.1	PL_{11}
26.2	PL_{15}
40.8	PL_{19}
52.1	PL_{24}
68.1	PL_{33}
71.9	PL_{46}
86.4	PL_{70}
94.2	PL_{105}
94.2	PL_{190}
98.4	PL_{500}
4.867	EAL

Figure E- 9 Wood-Zinc House – 2 Story – Mayagüez – Exposure B - Maximum Topographic Effect



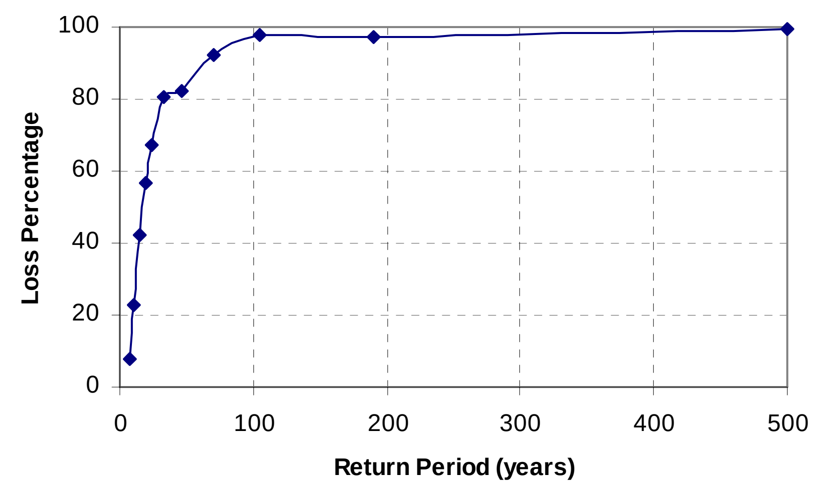
Probable Loss [%]	Name
0.0	PL_8
0.2	PL_{11}
1.3	PL_{15}
4.0	PL_{19}
7.5	PL_{24}
16.2	PL_{33}
23.2	PL_{46}
43.4	PL_{70}
55.9	PL_{105}
69.3	PL_{190}
77.5	PL_{500}
1.542	EAL

Figure E- 10 Wood-Zinc House – 2 Story – Mayagüez – Exposure C



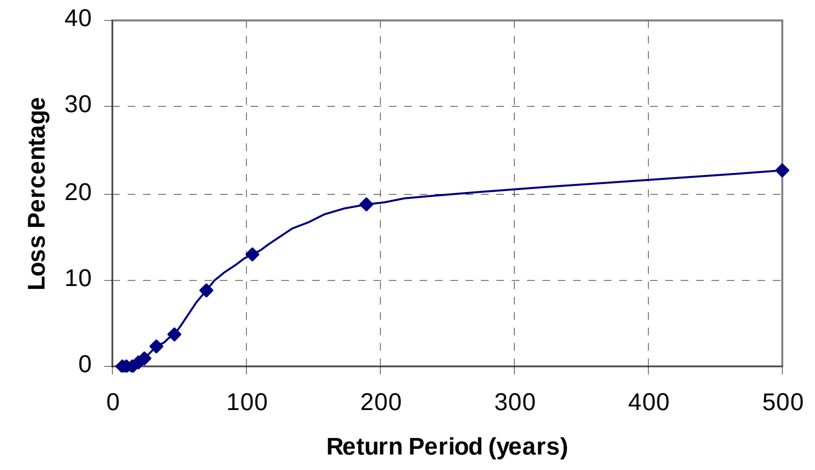
Probable Loss [%]	Name
0.6	PL_8
3.5	PL_{11}
11.7	PL_{15}
22.4	PL_{19}
32.1	PL_{24}
48.7	PL_{33}
55.6	PL_{46}
75.4	PL_{70}
85.3	PL_{105}
90.7	PL_{190}
94.6	PL_{500}
3.421	EAL

Figure E- 11 Wood-Zinc House – 2 Story – Mayagüez – Exposure C – Minimum Topographic effect



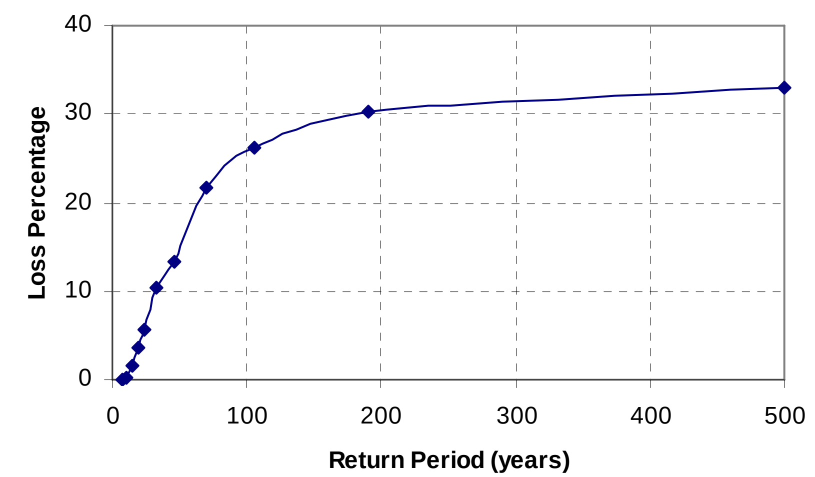
Probable Loss [%]	Name
7.7	PL_8
22.5	PL_{11}
42.0	PL_{15}
56.8	PL_{19}
67.4	PL_{24}
80.3	PL_{33}
82.0	PL_{46}
92.0	PL_{70}
97.8	PL_{105}
97.1	PL_{190}
99.5	PL_{500}
6.230	EAL

Figure E- 12 Wood-Zinc House – 2 Story – Mayagüez – Exposure C – Maximum Topographic effect



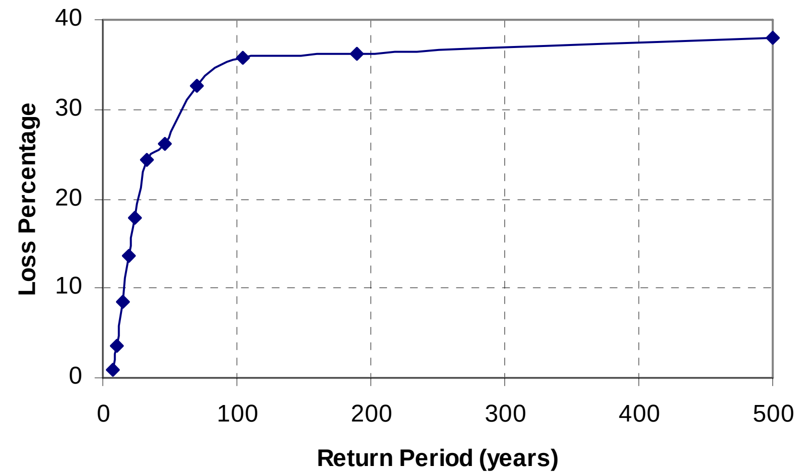
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.1	PL_{15}
0.4	PL_{19}
0.9	PL_{24}
2.3	PL_{33}
3.8	PL_{46}
8.7	PL_{70}
12.9	PL_{105}
18.7	PL_{190}
22.7	PL_{500}
0.320	EAL

Figure E- 13 Mixed House – 2 Story – Mayagüez – Exposure B



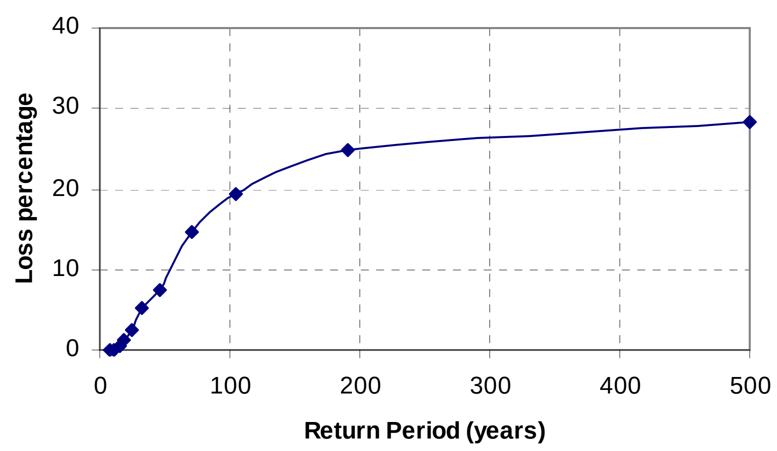
Probable Loss [%]	Name
0.0	PL_8
0.3	PL_{11}
1.6	PL_{15}
3.6	PL_{19}
5.7	PL_{24}
10.3	PL_{33}
13.3	PL_{46}
21.7	PL_{70}
26.3	PL_{105}
30.2	PL_{190}
33.1	PL_{500}
0.833	EAL

Figure E- 14 Mixed House – 2 Story – Mayagüez – Exposure B - Minimum Topographic Effect



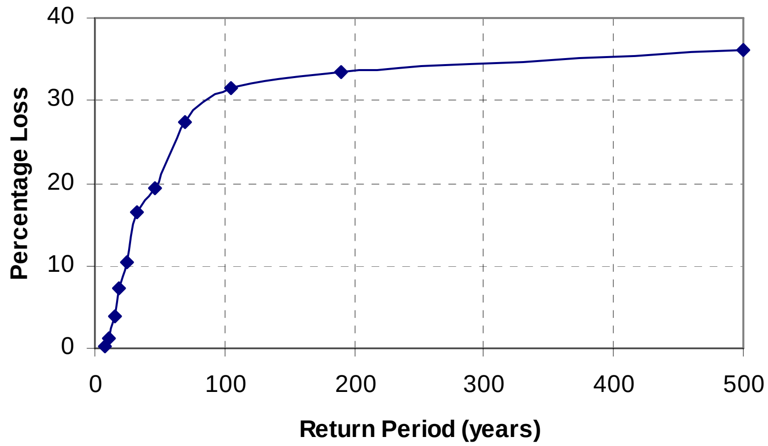
Probable Loss [%]	Name
0.9	PL_8
3.6	PL_{11}
8.5	PL_{15}
13.7	PL_{19}
17.9	PL_{24}
24.3	PL_{33}
26.2	PL_{46}
32.5	PL_{70}
35.8	PL_{105}
36.1	PL_{190}
38.0	PL_{500}
1.733	EAL

Figure E- 15 Mixed House – 2 Story – Mayagüez – Exposure B - Maximum Topographic Effect



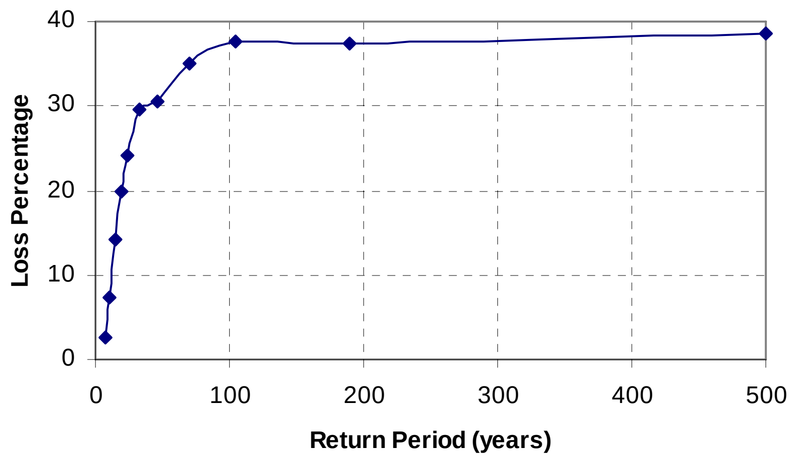
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.4	PL_{15}
1.3	PL_{19}
2.4	PL_{24}
5.2	PL_{33}
7.5	PL_{46}
14.6	PL_{70}
19.4	PL_{105}
24.9	PL_{190}
28.3	PL_{500}
0.526	EAL

Figure E- 16 Mixed House – 2 Story – Mayagüez – Exposure C



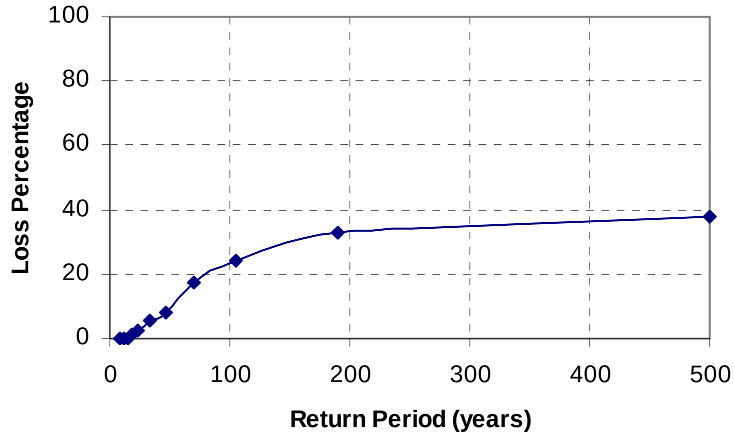
Probable Loss [%]	Name
0.2	PL_{8}
1.2	PL_{11}
3.8	PL_{15}
7.2	PL_{19}
10.5	PL_{24}
16.5	PL_{33}
19.4	PL_{46}
27.5	PL_{70}
31.6	PL_{105}
33.5	PL_{190}
36.1	PL_{500}
1.196	EAL

Figure E- 17 Mixed House – 2 Story – Mayagüez – Exposure C - Minimum Topographic Effect



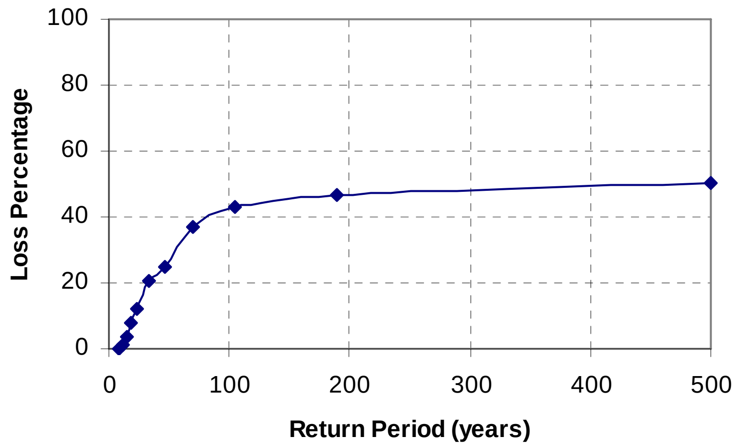
Probable Loss [%]	Name
2.5	PL_{8}
7.3	PL_{11}
14.1	PL_{15}
19.9	PL_{19}
24.1	PL_{24}
29.6	PL_{33}
30.6	PL_{46}
35.1	PL_{70}
37.7	PL_{105}
37.5	PL_{190}
38.7	PL_{500}
2.245	EAL

Figure E- 18 Mixed House – 2 Story – Mayagüez – Exposure C - Maximum Topographic Effect



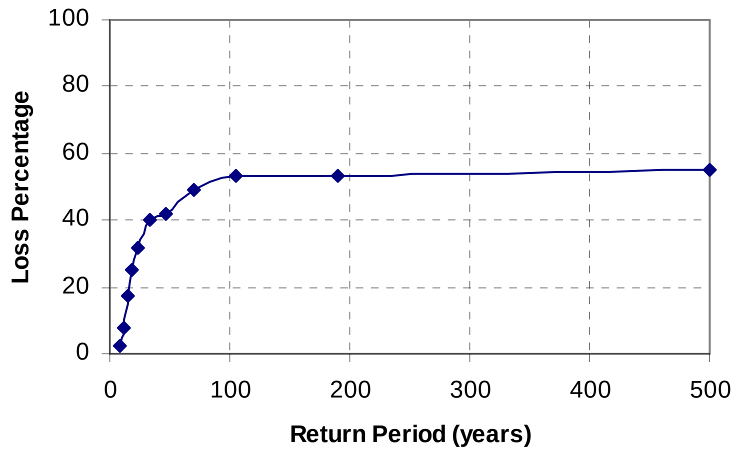
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.3	PL_{15}
1.0	PL_{19}
2.2	PL_{24}
5.3	PL_{33}
8.3	PL_{46}
17.6	PL_{70}
24.4	PL_{105}
32.9	PL_{190}
38.0	PL_{500}
0.624	EAL

Figure E- 19 Mixed House – 3 Story – Mayagüez – Exposure B



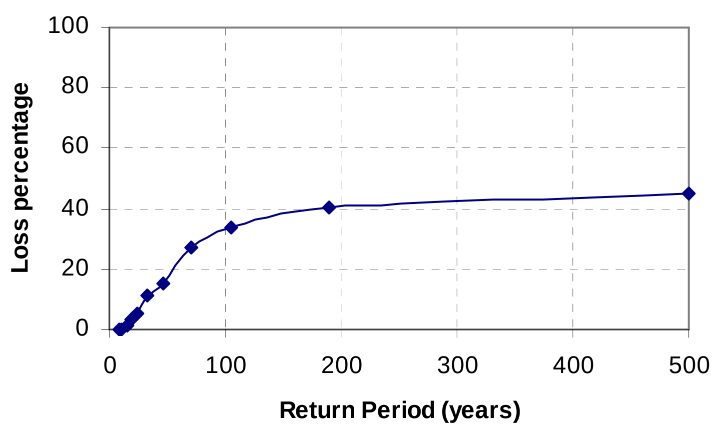
Probable Loss [%]	Name
0.1	PL_8
0.9	PL_{11}
3.7	PL_{15}
7.9	PL_{19}
12.1	PL_{24}
20.3	PL_{33}
24.8	PL_{46}
36.8	PL_{70}
43.0	PL_{105}
46.8	PL_{190}
50.6	PL_{500}
1.499	EAL

Figure E- 20 Mixed House – 3 Story – Mayagüez – Exposure B - Minimum Topographic Effect



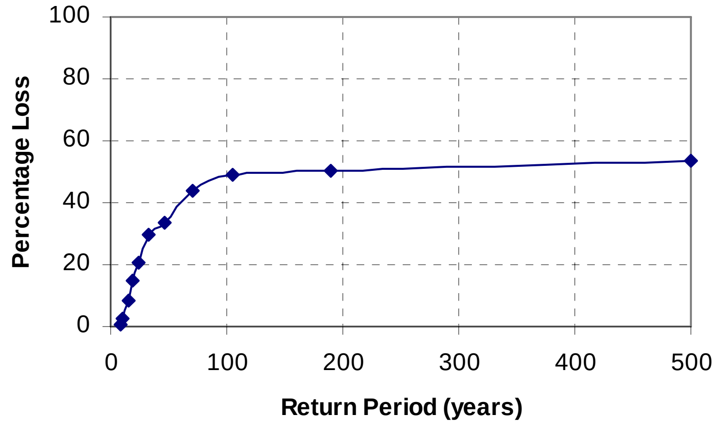
Probable Loss [%]	Name
2.2	PL_8
7.9	PL_{11}
17.1	PL_{15}
25.4	PL_{19}
31.7	PL_{24}
40.2	PL_{33}
42.0	PL_{46}
49.4	PL_{70}
53.4	PL_{105}
53.2	PL_{190}
55.3	PL_{500}
2.942	EAL

Figure E- 21 Mixed House – 3 Story – Mayagüez – Exposure B - Maximum Topographic Effect



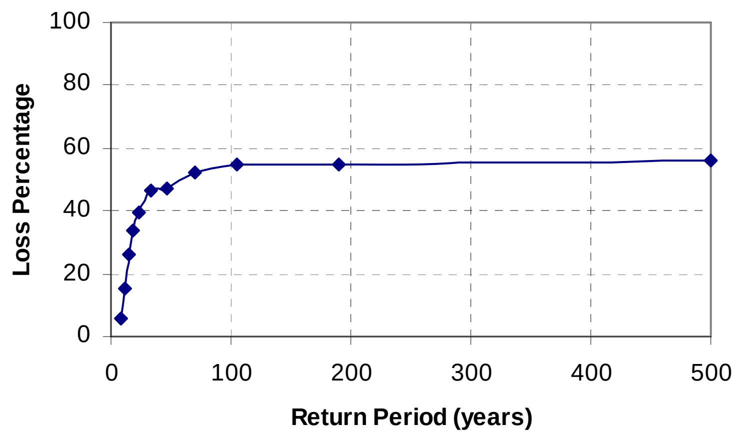
Probable Loss [%]	Name
0.0	PL_8
0.2	PL_{11}
1.2	PL_{15}
3.2	PL_{19}
5.6	PL_{24}
11.2	PL_{33}
15.3	PL_{46}
27.0	PL_{70}
33.9	PL_{105}
40.7	PL_{190}
45.1	PL_{500}
0.983	EAL

Figure E- 22 Mixed House – 3 Story – Mayagüez – Exposure C



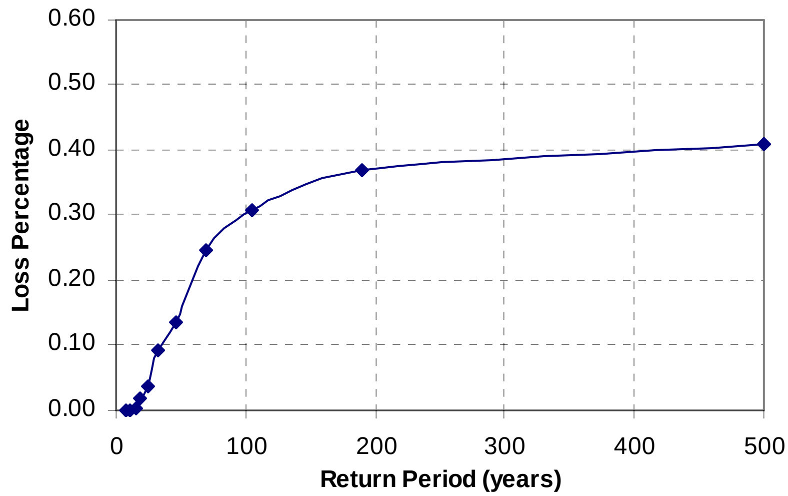
Probable Loss [%]	Name
0.5	PL_8
2.8	PL_{11}
8.3	PL_{15}
14.9	PL_{19}
20.6	PL_{24}
29.9	PL_{33}
33.4	PL_{46}
43.9	PL_{70}
49.1	PL_{105}
50.4	PL_{190}
53.6	PL_{500}
2.094	EAL

Figure E- 23 Mixed House – 3 Story – Mayagüez – Exposure C - Minimum Topographic Effect



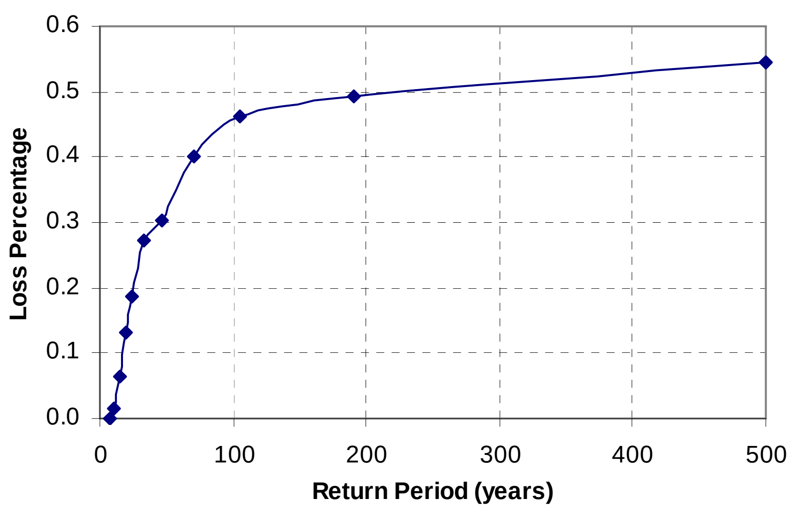
Probable Loss [%]	Name
5.7	PL_8
15.0	PL_{11}
26.0	PL_{15}
34.0	PL_{19}
39.7	PL_{24}
46.4	PL_{33}
47.1	PL_{46}
52.1	PL_{70}
55.1	PL_{105}
54.7	PL_{190}
55.8	PL_{500}
3.712	EAL

Figure E- 24 Mixed House – 3 Story – Mayagüez – Exposure C - Maximum Topographic Effect



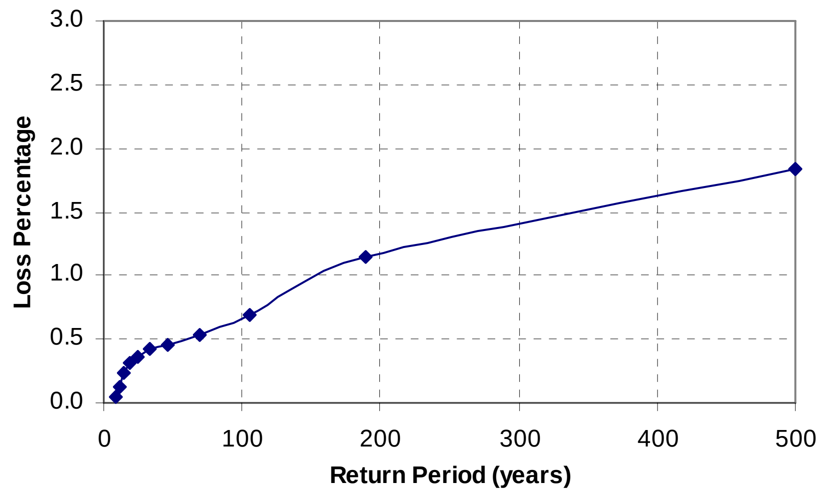
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.02	PL_{19}
0.04	PL_{24}
0.09	PL_{33}
0.14	PL_{46}
0.25	PL_{70}
0.31	PL_{105}
0.37	PL_{190}
0.41	PL_{500}
0.008	EAL

Figure E- 25 Concrete House – 1-3 Story – Mayagüez – Exposure B



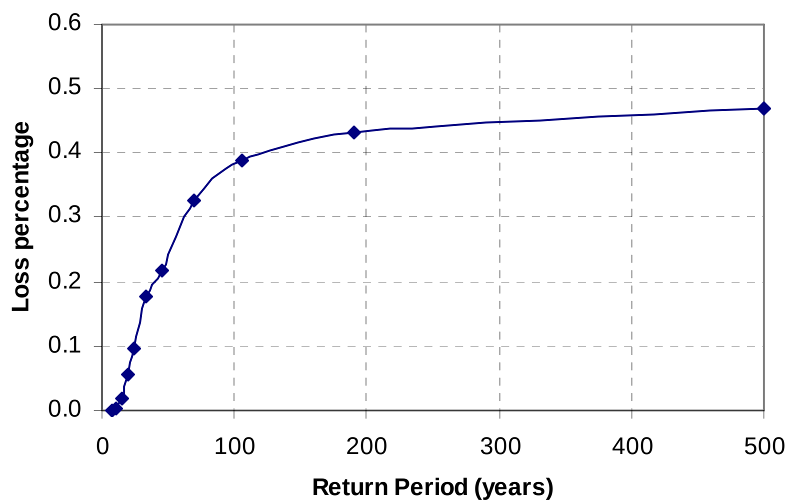
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.1	PL_{15}
0.1	PL_{19}
0.2	PL_{24}
0.3	PL_{33}
0.3	PL_{46}
0.4	PL_{70}
0.5	PL_{105}
0.5	PL_{190}
0.5	PL_{500}
0.019	EAL

Figure E- 26 Concrete House – 1-3 Story – Mayagüez – Exposure B – Minimum Topographic Effect



Probable Loss [%]	Name
0.0	PL_{8}
0.1	PL_{11}
0.2	PL_{15}
0.3	PL_{19}
0.4	PL_{24}
0.4	PL_{33}
0.4	PL_{46}
0.5	PL_{70}
0.7	PL_{105}
1.1	PL_{190}
1.8	PL_{500}
0.040	EAL

Figure E- 27 Concrete House – 1-3 Story – Mayagüez – Exposure B – Maximum Topographic Effect

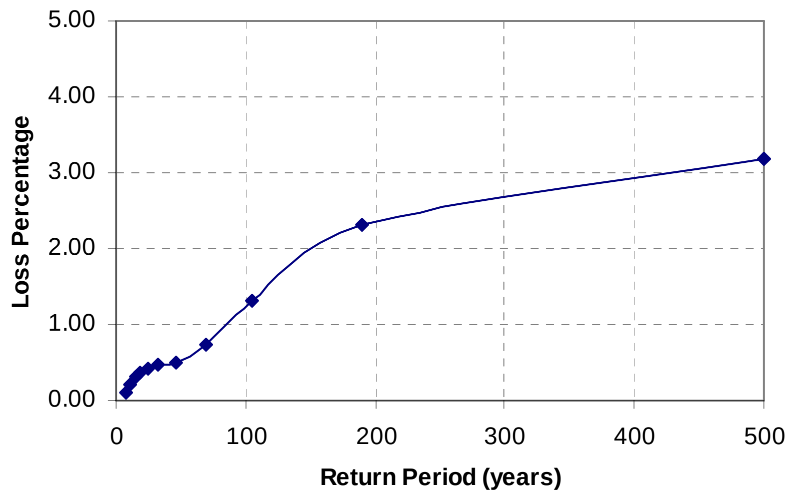


Probable Loss [%]	Name
0.00	PL_{8}
0.00	PL_{11}
0.02	PL_{15}
0.06	PL_{19}
0.10	PL_{24}
0.18	PL_{33}
0.22	PL_{46}
0.33	PL_{70}
0.39	PL_{105}
0.43	PL_{190}
0.47	PL_{500}
0.013	EAL

Figure E- 28 Concrete House – 1-3 Story – Mayagüez – Exposure C

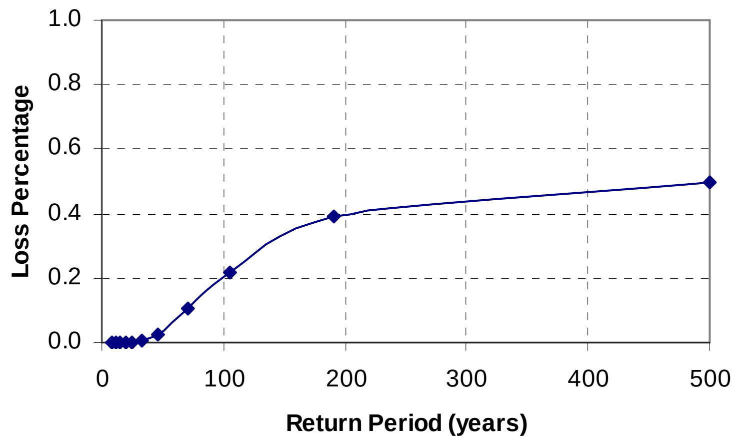
Probable Loss [%]	Name
0.01	PL_{8}
0.05	PL_{11}
0.14	PL_{15}
0.22	PL_{19}
0.27	PL_{24}
0.35	PL_{33}
0.37	PL_{46}
0.46	PL_{70}
0.52	PL_{105}
0.58	PL_{190}
0.81	PL_{500}
0.026	EAL

Figure E- 29 Concrete House – 1-3 Story – Mayagüez – Exposure C – Minimum Topographic Effect



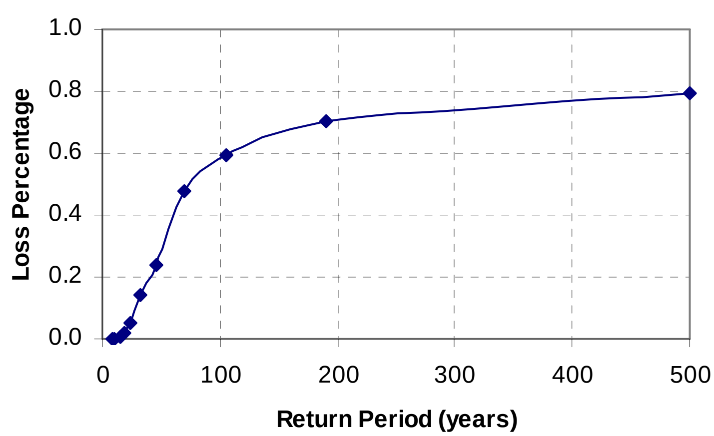
Probable Loss [%]	Name
0.10	PL_{8}
0.22	PL_{11}
0.31	PL_{15}
0.37	PL_{19}
0.42	PL_{24}
0.49	PL_{33}
0.51	PL_{46}
0.74	PL_{70}
1.30	PL_{105}
2.33	PL_{190}
3.19	PL_{500}
0.060	EAL

Figure E- 30 Concrete House – 1-3 Story – Mayagüez – Exposure C – Maximum Topographic Effect



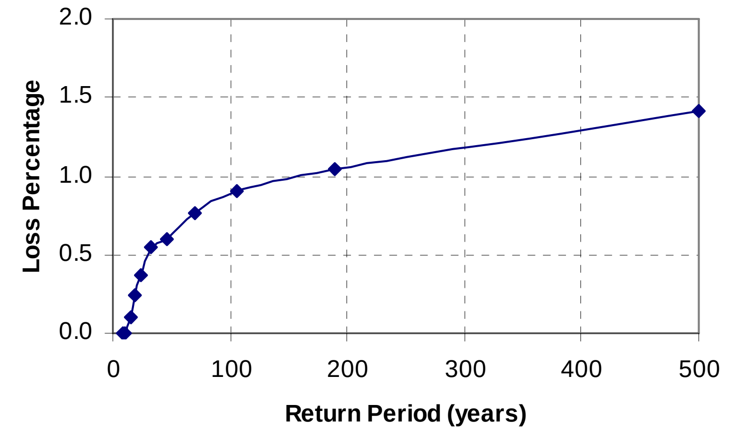
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.00	PL_{19}
0.00	PL_{24}
0.01	PL_{33}
0.02	PL_{46}
0.10	PL_{70}
0.22	PL_{105}
0.39	PL_{190}
0.49	PL_{500}
0.005	EAL

Figure E- 31 Multistory Concrete – 4-7 Story – Mayagüez – Exposure B



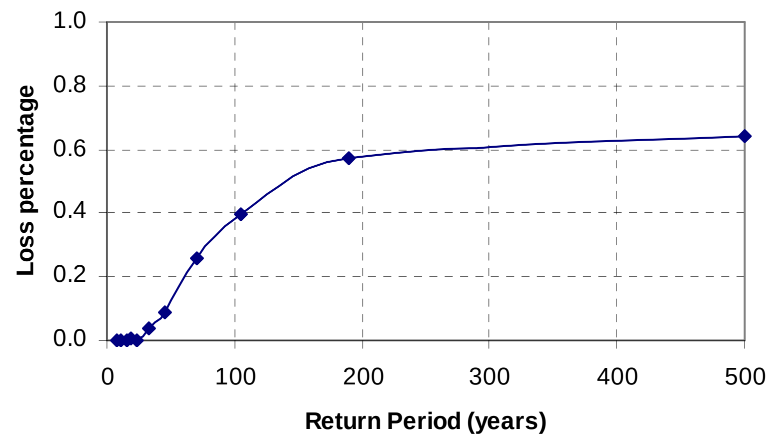
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.02	PL_{19}
0.05	PL_{24}
0.14	PL_{33}
0.24	PL_{46}
0.48	PL_{70}
0.59	PL_{105}
0.71	PL_{190}
0.79	PL_{500}
0.015	EAL

Figure E- 32 Multistory Concrete – 4-7 Story – Mayagüez – Exposure B – Minimum Topographic Effect



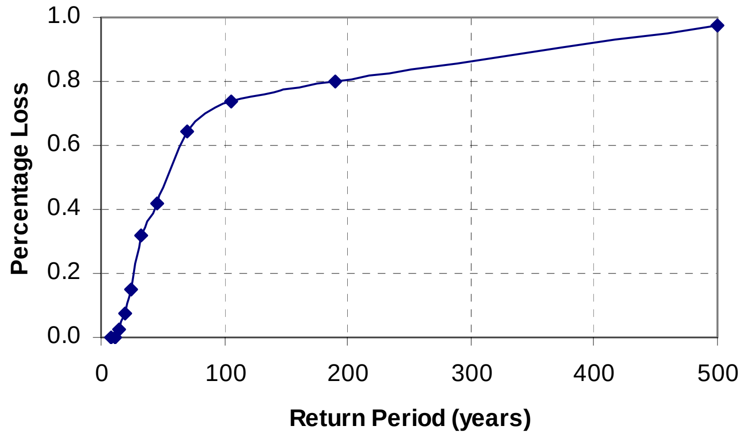
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.11	PL_{15}
0.25	PL_{19}
0.37	PL_{24}
0.55	PL_{33}
0.60	PL_{46}
0.77	PL_{70}
0.91	PL_{105}
1.05	PL_{190}
1.41	PL_{500}
0.036	EAL

Figure E- 33 Multistory Concrete – 4-7 Story – Mayagüez – Exposure B – Maximum Topographic Effect



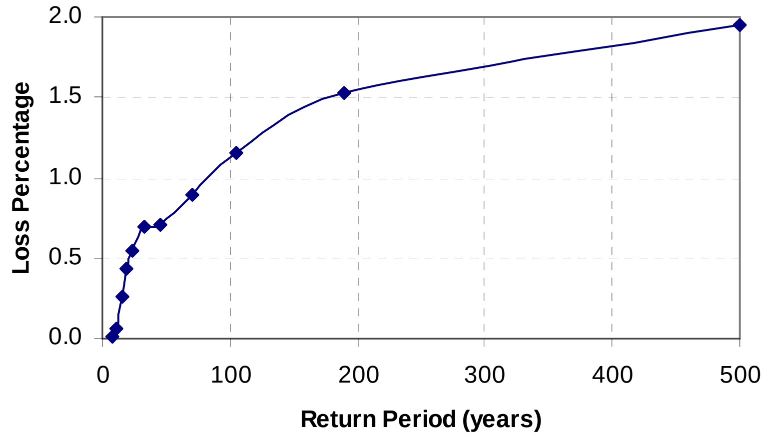
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.3	PL_{15}
0.4	PL_{19}
0.6	PL_{24}
0.7	PL_{33}
0.7	PL_{46}
0.9	PL_{70}
1.2	PL_{105}
1.5	PL_{190}
2.0	PL_{500}
0.053	EAL

Figure E- 34 Multistory Concrete – 4-7 Story – Mayagüez – Exposure C



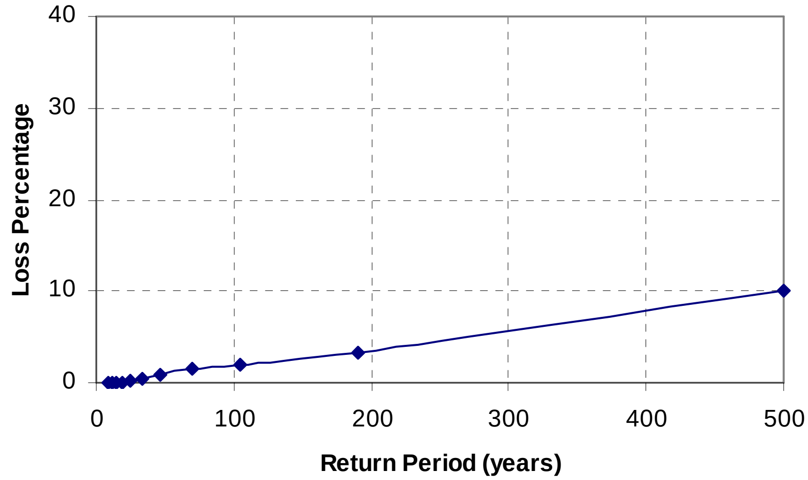
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.02	PL_{15}
0.08	PL_{19}
0.15	PL_{24}
0.32	PL_{33}
0.42	PL_{46}
0.64	PL_{70}
0.74	PL_{105}
0.80	PL_{190}
0.97	PL_{500}
0.023	EAL

Figure E- 35 Multistory Concrete – 4-7 Story – Mayagüez – Exposure C – Minimum Topographic Effect



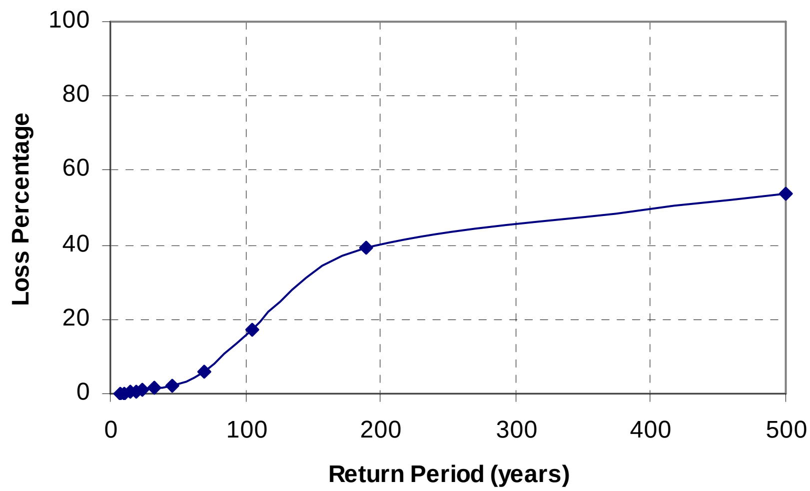
Probable Loss [%]	Name
0.01	PL_8
0.06	PL_{11}
0.26	PL_{15}
0.44	PL_{19}
0.55	PL_{24}
0.69	PL_{33}
0.71	PL_{46}
0.89	PL_{70}
1.15	PL_{105}
1.53	PL_{190}
1.95	PL_{500}
0.053	EAL

Figure E- 36 Multistory Concrete – 4-7 Story – Mayagüez – Exposure C – Maximum Topographic Effect



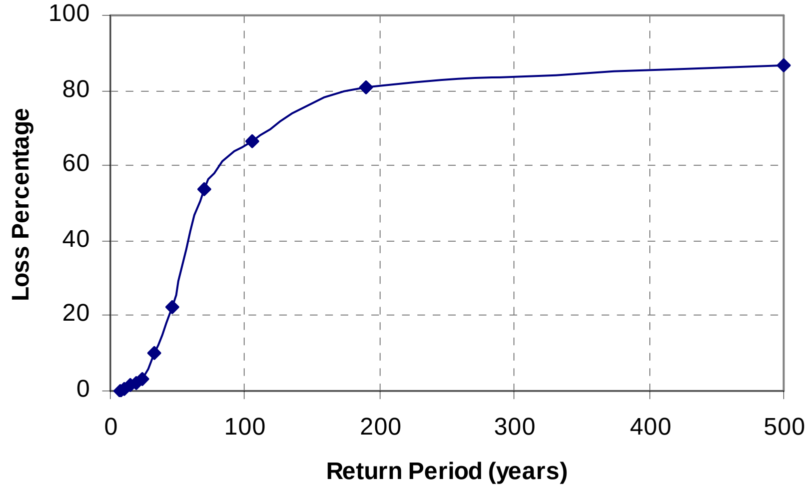
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.0	PL_{19}
0.1	PL_{24}
0.5	PL_{33}
0.8	PL_{46}
1.5	PL_{70}
2.0	PL_{105}
3.3	PL_{190}
10.1	PL_{500}
0.056	EAL

Figure E- 37 Small Institutional – Mayagüez – Exposure B



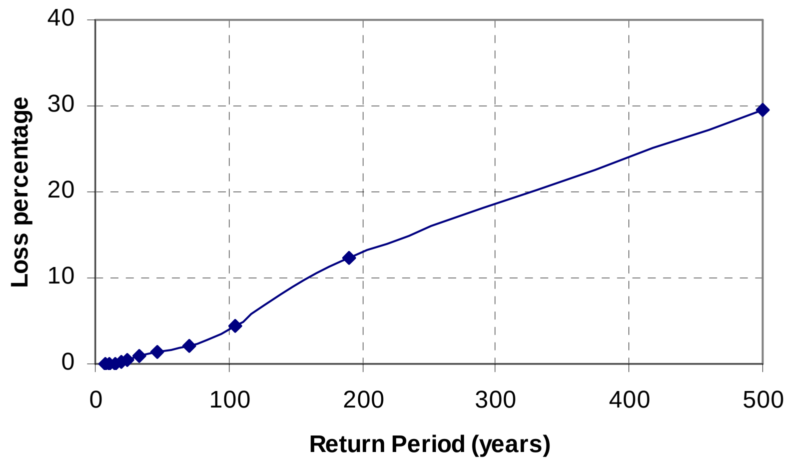
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.3	PL_{15}
0.7	PL_{19}
1.1	PL_{24}
1.7	PL_{33}
2.0	PL_{46}
5.8	PL_{70}
17.4	PL_{105}
39.2	PL_{190}
53.8	PL_{500}
0.466	EAL

Figure E- 38 Small Institutional – Mayagüez – Exposure B – Minimum Topographic Effect



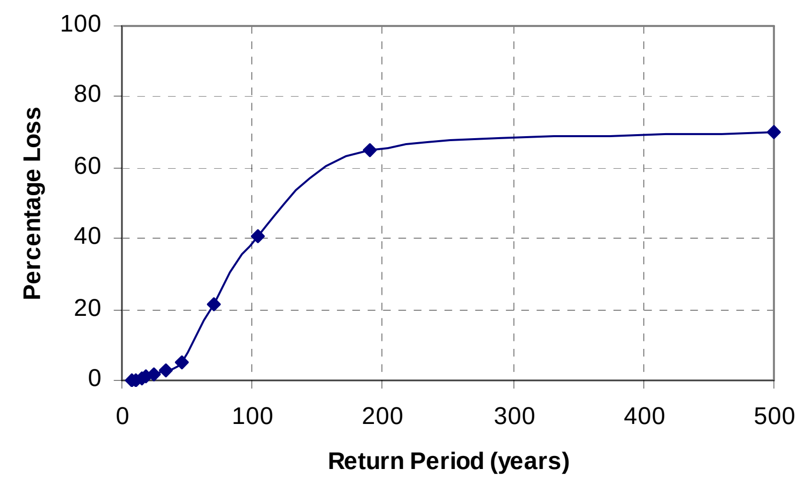
Probable Loss [%]	Name
0.2	PL_{8}
0.7	PL_{11}
1.5	PL_{15}
2.0	PL_{19}
3.2	PL_{24}
10.4	PL_{33}
22.3	PL_{46}
53.7	PL_{70}
66.3	PL_{105}
80.7	PL_{190}
86.9	PL_{500}
1.619	EAL

Figure E- 39 Small Institutional – Mayagüez – Exposure B – Maximum Topographic Effect



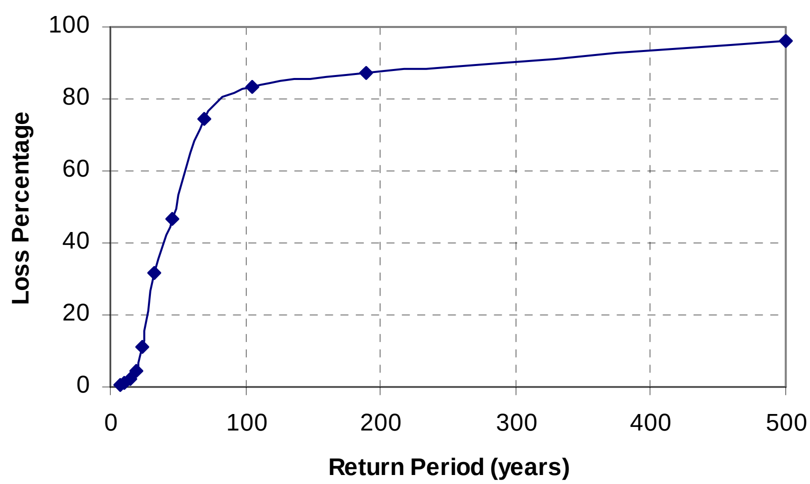
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.1	PL_{15}
0.2	PL_{19}
0.5	PL_{24}
1.0	PL_{33}
1.3	PL_{46}
2.2	PL_{70}
4.4	PL_{105}
12.2	PL_{190}
29.6	PL_{500}
0.154	EAL

Figure E- 40 Small Institutional – Mayagüez – Exposure C



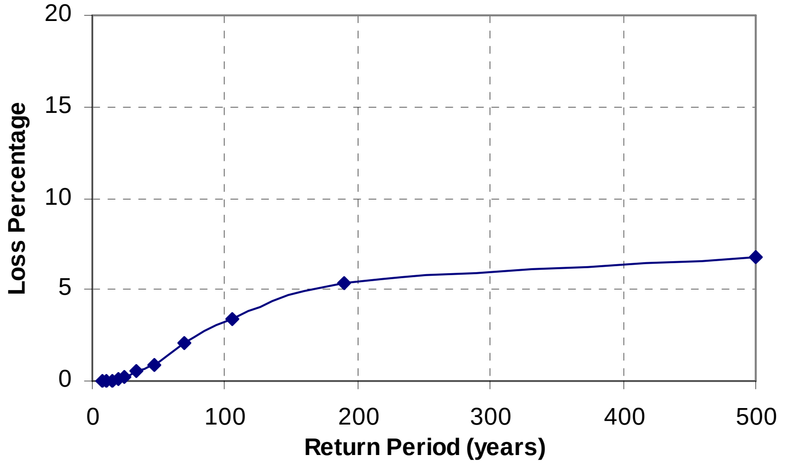
Probable Loss [%]	Name
0.0	PL_{8}
0.2	PL_{11}
0.8	PL_{15}
1.3	PL_{19}
1.7	PL_{24}
2.6	PL_{33}
5.1	PL_{46}
21.3	PL_{70}
40.7	PL_{105}
64.8	PL_{190}
70.1	PL_{500}
0.916	EAL

Figure E- 41 Small Institutional – Mayagüez – Exposure C – Minimum Topographic Effect



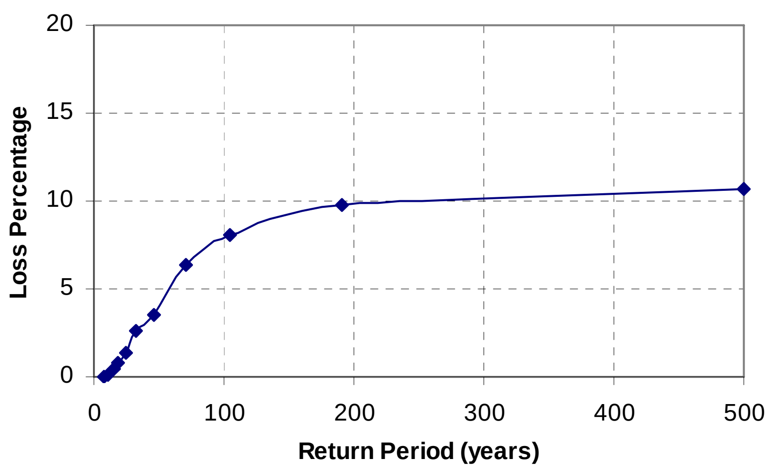
Probable Loss [%]	Name
0.5	PL_{8}
1.3	PL_{11}
2.1	PL_{15}
4.7	PL_{19}
11.3	PL_{24}
31.9	PL_{33}
46.5	PL_{46}
74.3	PL_{70}
83.3	PL_{105}
87.2	PL_{190}
96.2	PL_{500}
2.437	EAL

Figure E- 42 Small Institutional – Mayagüez – Exposure C – Maximum Topographic Effect



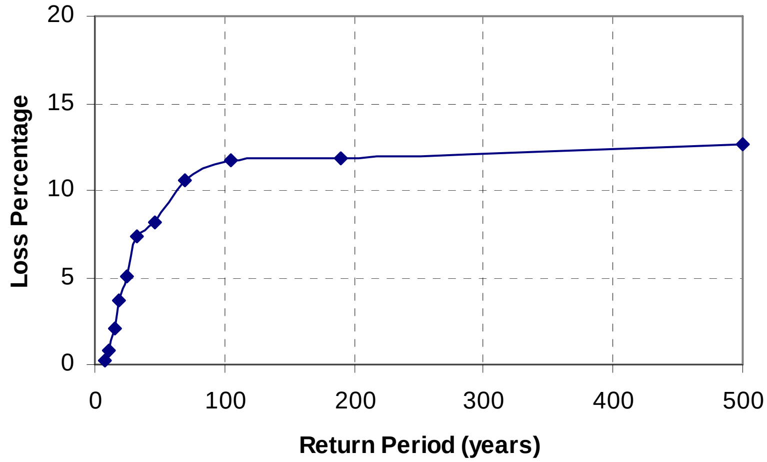
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.0	PL_{15}
0.1	PL_{19}
0.2	PL_{24}
0.6	PL_{33}
0.9	PL_{46}
2.1	PL_{70}
3.4	PL_{105}
5.3	PL_{190}
6.8	PL_{500}
0.085	EAL

Figure E- 43 Large Institutional – Mayagüez – Exposure B



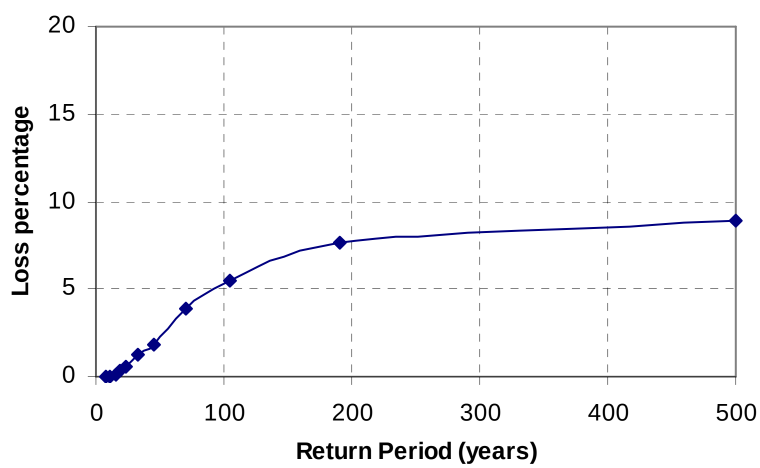
Probable Loss [%]	Name
0.0	PL_{8}
0.1	PL_{11}
0.4	PL_{15}
0.9	PL_{19}
1.4	PL_{24}
2.6	PL_{33}
3.5	PL_{46}
6.4	PL_{70}
8.1	PL_{105}
9.7	PL_{190}
10.7	PL_{500}
0.238	EAL

Figure E- 44 Large Institutional – Mayagüez – Exposure B – Minimum Topographic Effect



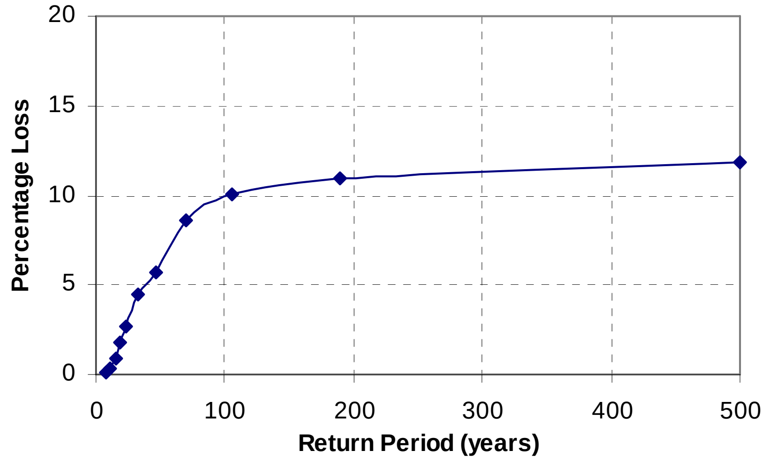
Probable Loss [%]	Name
0.2	PL_8
0.9	PL_{11}
2.1	PL_{15}
3.6	PL_{19}
5.1	PL_{24}
7.4	PL_{33}
8.2	PL_{46}
10.6	PL_{70}
11.8	PL_{105}
11.9	PL_{190}
12.6	PL_{500}
0.516	EAL

Figure E- 45 Large Institutional – Mayagüez – Exposure B – Maximum Topographic Effect



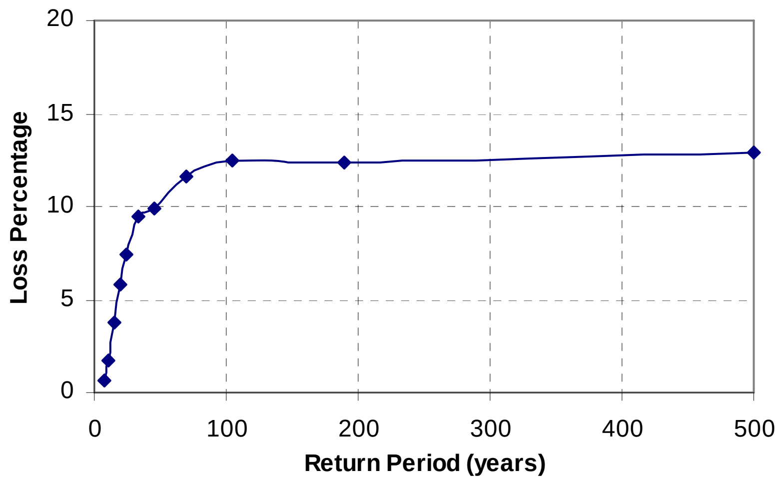
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.1	PL_{15}
0.3	PL_{19}
0.6	PL_{24}
1.2	PL_{33}
1.8	PL_{46}
3.9	PL_{70}
5.5	PL_{105}
7.7	PL_{190}
8.9	PL_{500}
0.146	EAL

Figure E- 46 Large Institutional – Mayagüez – Exposure C



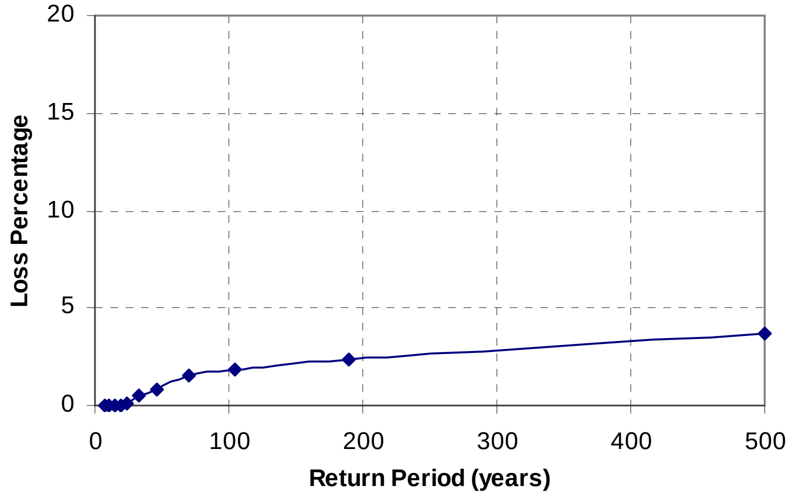
Probable Loss [%]	Name
0.1	PL_8
0.3	PL_{11}
0.9	PL_{15}
1.7	PL_{19}
2.6	PL_{24}
4.5	PL_{33}
5.7	PL_{46}
8.6	PL_{70}
10.1	PL_{105}
11.0	PL_{190}
11.9	PL_{500}
0.348	EAL

Figure E- 47 Large Institutional – Mayagüez – Exposure C – Minimum Topographic Effect



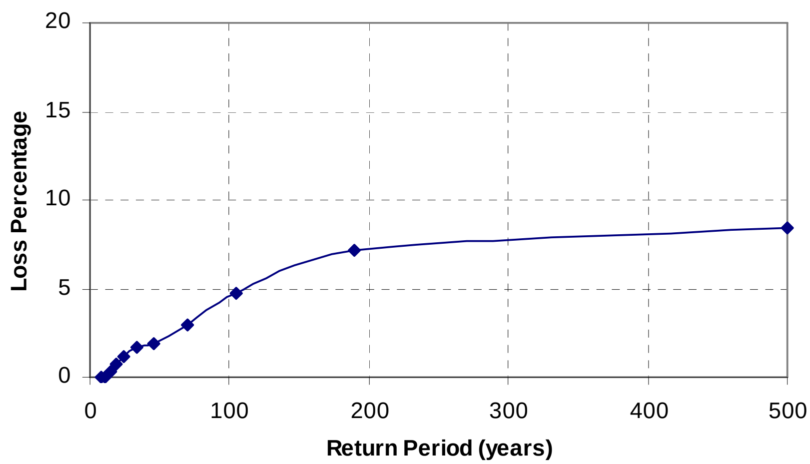
Probable Loss [%]	Name
0.6	PL_8
1.8	PL_{11}
3.8	PL_{15}
5.8	PL_{19}
7.4	PL_{24}
9.5	PL_{33}
9.9	PL_{46}
11.6	PL_{70}
12.5	PL_{105}
12.4	PL_{190}
12.9	PL_{500}
0.681	EAL

Figure E- 48 Large Institutional – Mayagüez – Exposure C – Maximum Topographic Effect



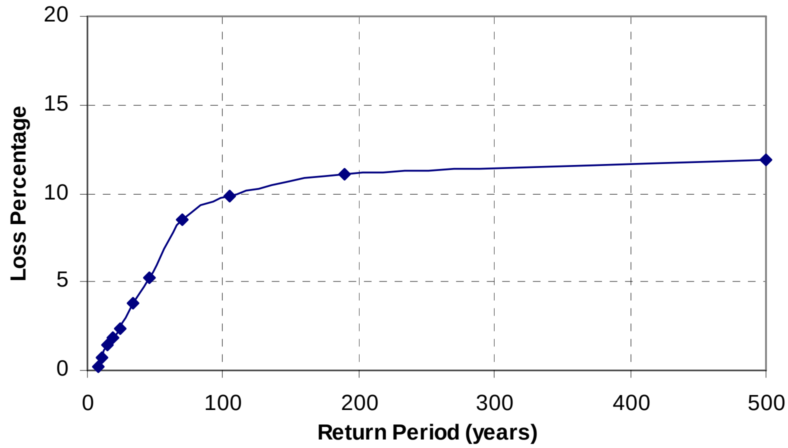
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.0	PL_{19}
0.1	PL_{24}
0.5	PL_{33}
0.8	PL_{46}
1.5	PL_{70}
1.9	PL_{105}
2.4	PL_{190}
3.7	PL_{500}
0.049	EAL

Figure E- 49 Mixed Institutional – Mayagüez – Exposure B



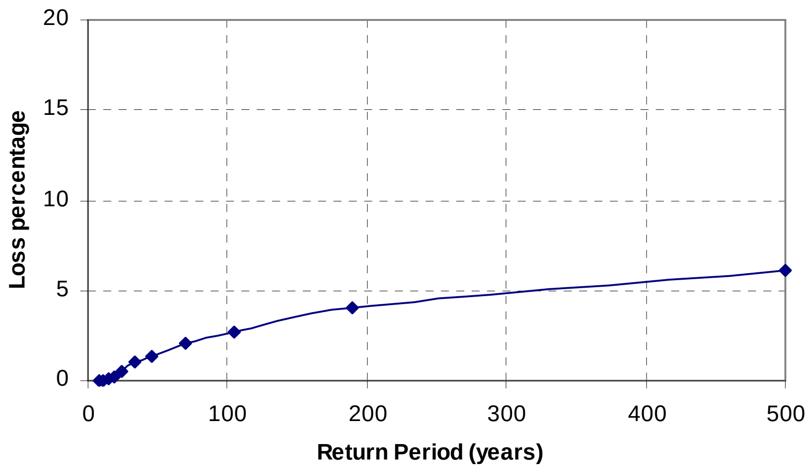
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.3	PL_{15}
0.8	PL_{19}
1.1	PL_{24}
1.7	PL_{33}
1.9	PL_{46}
3.0	PL_{70}
4.8	PL_{105}
7.2	PL_{190}
8.4	PL_{500}
0.153	EAL

Figure E- 50 Mixed Institutional – Mayagüez – Exposure B – Minimum Topographic Effect



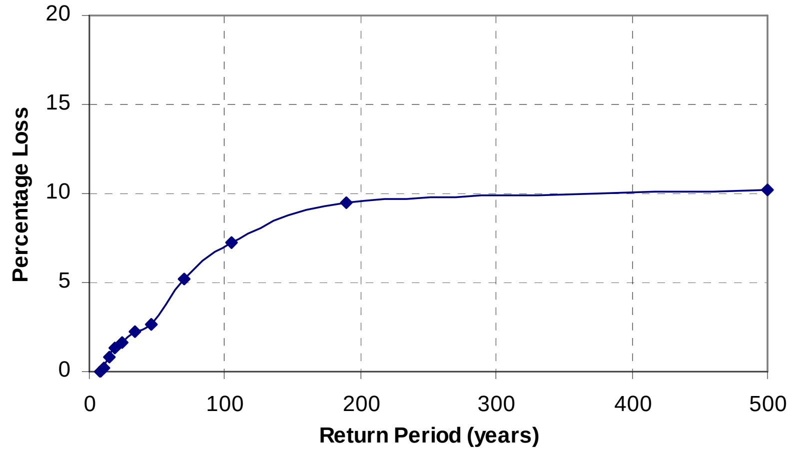
Probable Loss [%]	Name
0.2	PL_8
0.8	PL_{11}
1.5	PL_{15}
1.9	PL_{19}
2.3	PL_{24}
3.8	PL_{33}
5.2	PL_{46}
8.5	PL_{70}
9.8	PL_{105}
11.1	PL_{190}
11.9	PL_{500}
0.360	EAL

Figure E- 51 Mixed Institutional – Mayagüez – Exposure B – Maximum Topographic Effect



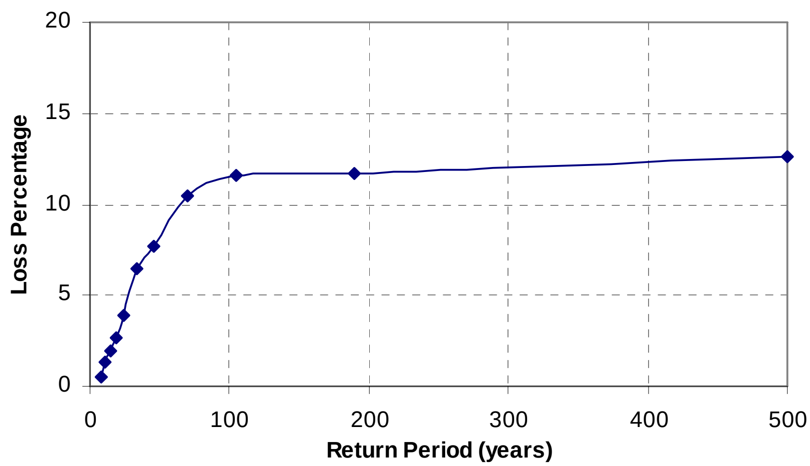
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.1	PL_{15}
0.3	PL_{19}
0.5	PL_{24}
1.0	PL_{33}
1.3	PL_{46}
2.0	PL_{70}
2.7	PL_{105}
4.0	PL_{190}
6.1	PL_{500}
0.085	EAL

Figure E- 52 Mixed Institutional – Mayagüez – Exposure C



Probable Loss [%]	Name
0.0	PL_{8}
0.2	PL_{11}
0.8	PL_{15}
1.3	PL_{19}
1.7	PL_{24}
2.2	PL_{33}
2.7	PL_{46}
5.2	PL_{70}
7.2	PL_{105}
9.5	PL_{190}
10.2	PL_{500}
0.235	EAL

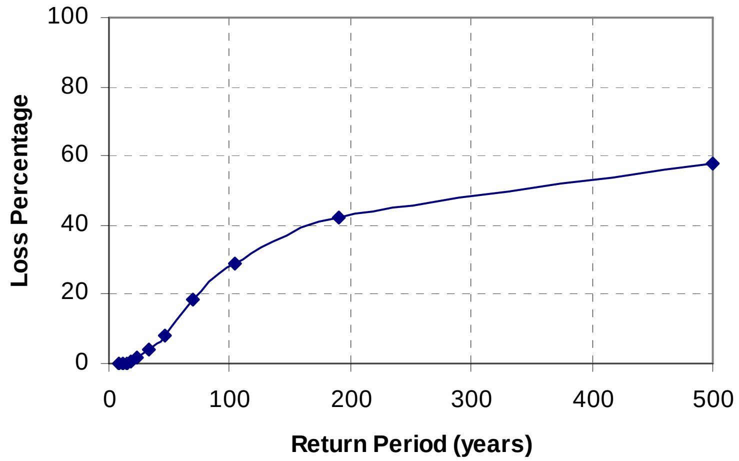
Figure E- 53 Mixed Institutional – Mayagüez – Exposure C – Minimum Topographic Effect



Probable Loss [%]	Name
0.5	PL_{8}
1.3	PL_{11}
1.9	PL_{15}
2.6	PL_{19}
3.8	PL_{24}
6.4	PL_{33}
7.7	PL_{46}
10.5	PL_{70}
11.5	PL_{105}
11.7	PL_{190}
12.7	PL_{500}
0.489	EAL

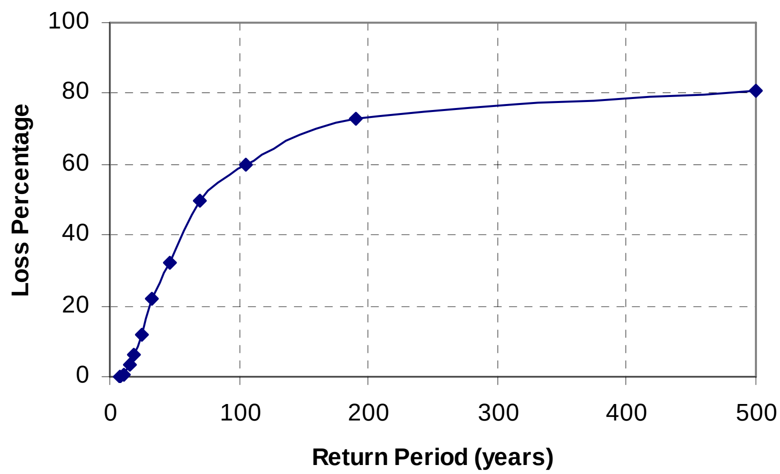
Figure E- 54 Mixed Institutional – Mayagüez – Exposure C – Maximum Topographic Effect

Appendix F Hurricane Loss Curves for Ponce



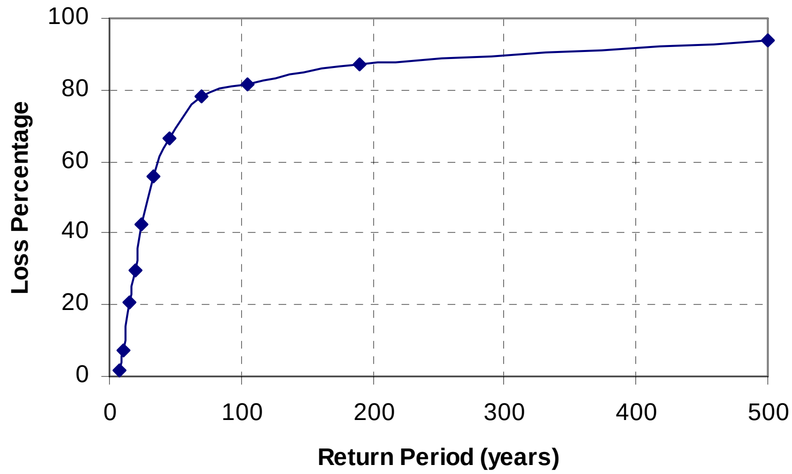
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.2	PL_{15}
0.6	PL_{19}
1.5	PL_{24}
4.3	PL_{33}
8.1	PL_{46}
18.2	PL_{70}
28.6	PL_{105}
42.4	PL_{190}
57.7	PL_{500}
0.689	EAL

Figure F- 1 Wood-Zinc House – 1 Story – Ponce – Exposure B



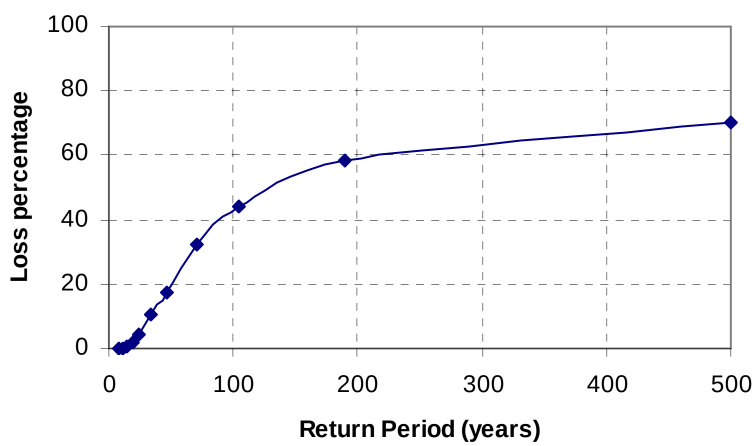
Probable Loss [%]	Name
0.1	PL_8
0.6	PL_{11}
3.1	PL_{15}
6.2	PL_{19}
11.9	PL_{24}
22.2	PL_{33}
32.2	PL_{46}
49.5	PL_{70}
59.7	PL_{105}
72.7	PL_{190}
80.6	PL_{500}
1.876	EAL

Figure F- 2 Wood-Zinc House – 1 Story – Ponce – Exposure B – Minimum Topographic effect



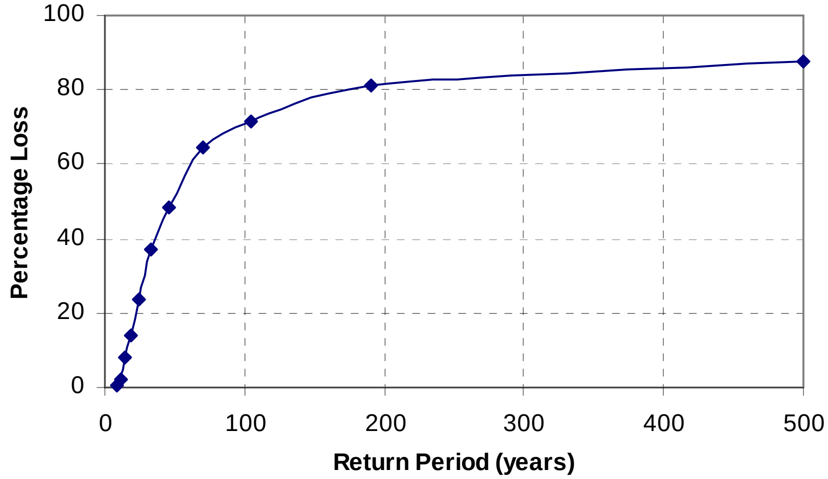
Probable Loss [%]	Name
1.8	PL_8
7.1	PL_{11}
20.6	PL_{15}
29.5	PL_{19}
42.2	PL_{24}
55.9	PL_{33}
66.4	PL_{46}
78.0	PL_{70}
81.4	PL_{105}
87.1	PL_{190}
93.7	PL_{500}
4.046	EAL

Figure F- 3 Wood-Zinc House – 1 Story – Ponce – Exposure B – Maximum Topographic effect



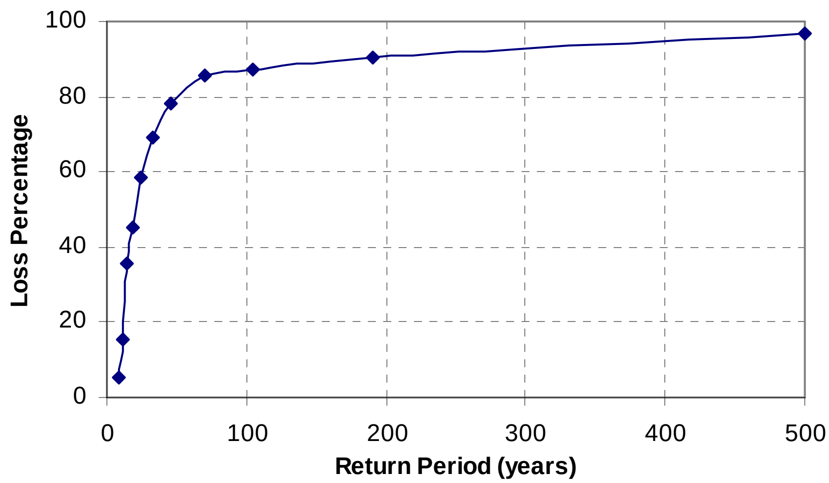
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.8	PL_{15}
2.0	PL_{19}
4.6	PL_{24}
10.4	PL_{33}
17.3	PL_{46}
32.1	PL_{70}
43.9	PL_{105}
58.7	PL_{190}
70.4	PL_{500}
1.165	EAL

Figure F- 4 Wood-Zinc House – 1 Story – Ponce – Exposure C



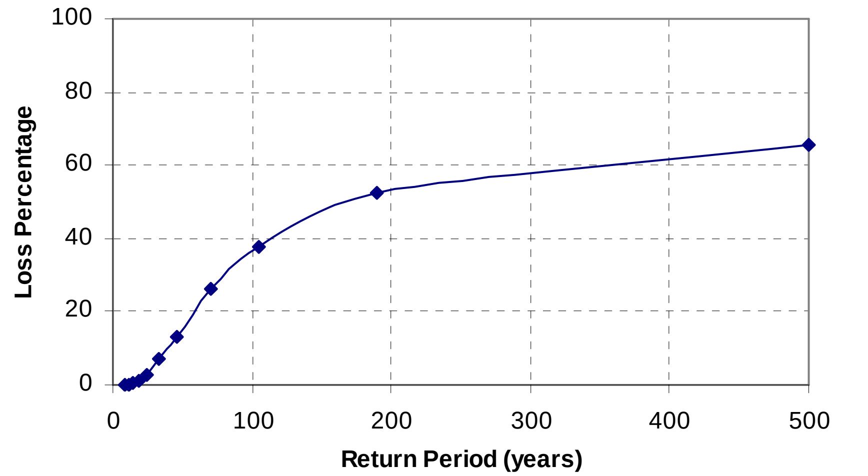
Probable Loss [%]	Name
0.3	PL_8
2.1	PL_{11}
8.3	PL_{15}
14.1	PL_{19}
23.5	PL_{24}
37.0	PL_{33}
48.3	PL_{46}
64.3	PL_{70}
71.4	PL_{105}
81.1	PL_{190}
87.6	PL_{500}
2.733	EAL

Figure F- 5 Wood-Zinc House – 1 Story – Ponce – Exposure C - Minimum Topographic effect



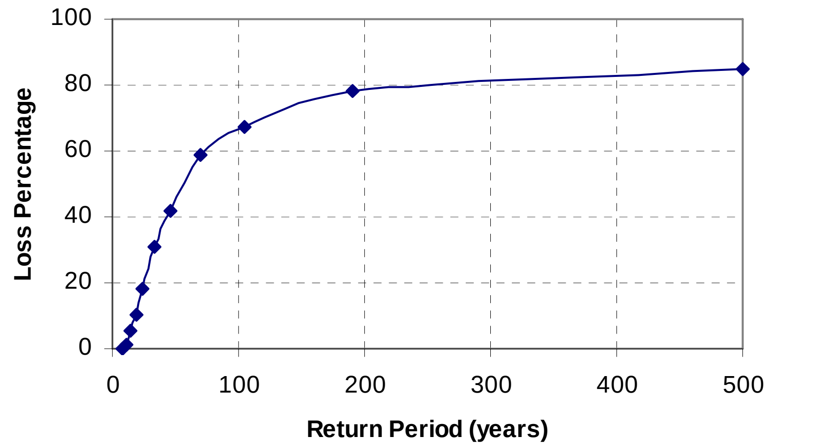
Probable Loss [%]	Name
5.2	PL_8
15.6	PL_{11}
35.9	PL_{15}
45.4	PL_{19}
58.4	PL_{24}
69.4	PL_{33}
78.1	PL_{46}
85.9	PL_{70}
87.3	PL_{105}
90.7	PL_{190}
97.0	PL_{500}
5.356	EAL

Figure F- 6 Wood-Zinc House – 1 Story – Ponce – Exposure C - Maximum Topographic effect



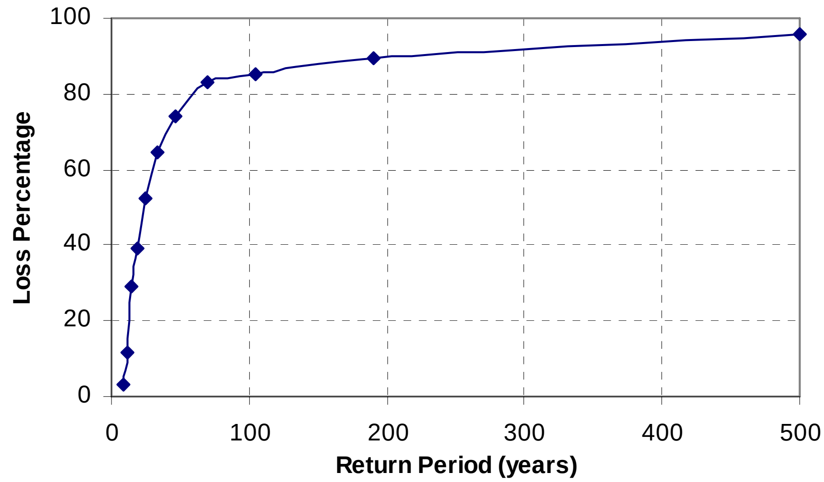
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.4	PL_{15}
1.1	PL_{19}
2.7	PL_{24}
7.2	PL_{33}
12.9	PL_{46}
26.1	PL_{70}
37.7	PL_{105}
52.5	PL_{190}
65.8	PL_{500}
0.945	EAL

Figure F- 7 Wood-Zinc House – 2 Story – Ponce – Exposure B



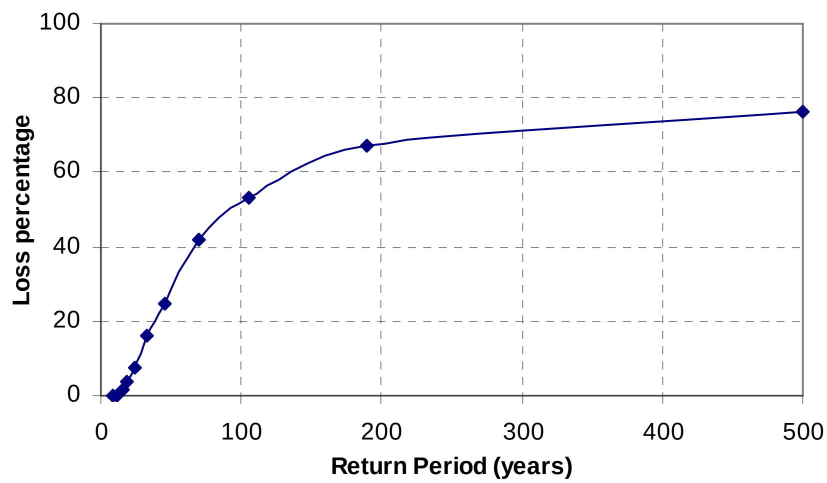
Probable Loss [%]	Name
0.1	PL_{8}
1.1	PL_{11}
5.4	PL_{15}
10.2	PL_{19}
18.2	PL_{24}
30.8	PL_{33}
41.9	PL_{46}
58.8	PL_{70}
67.2	PL_{105}
78.2	PL_{190}
85.1	PL_{500}
2.351	EAL

Figure F- 8 Wood-Zinc House – 2 Story – Ponce – Exposure B – Minimum Topographic Effect



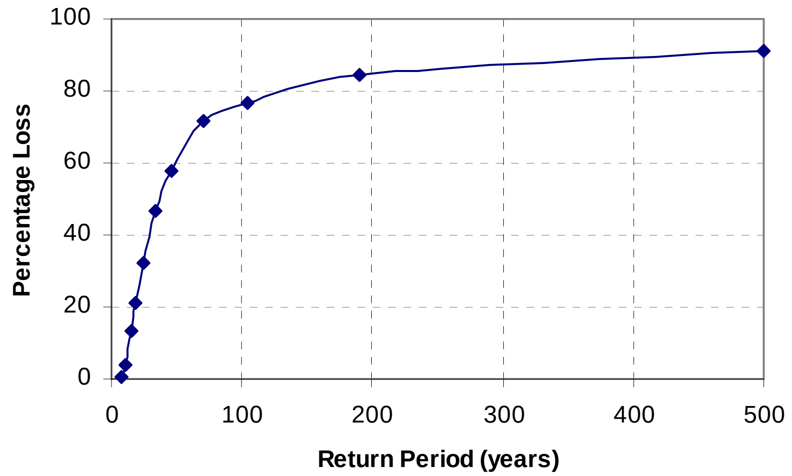
Probable Loss [%]	Name
3.2	PL_8
11.4	PL_{11}
29.3	PL_{15}
39.0	PL_{19}
52.2	PL_{24}
64.4	PL_{33}
73.9	PL_{46}
83.1	PL_{70}
85.1	PL_{105}
89.4	PL_{190}
95.9	PL_{500}
4.805	EAL

Figure F- 9 Wood-Zinc House – 2 Story – Ponce – Exposure B - Maximum Topographic Effect



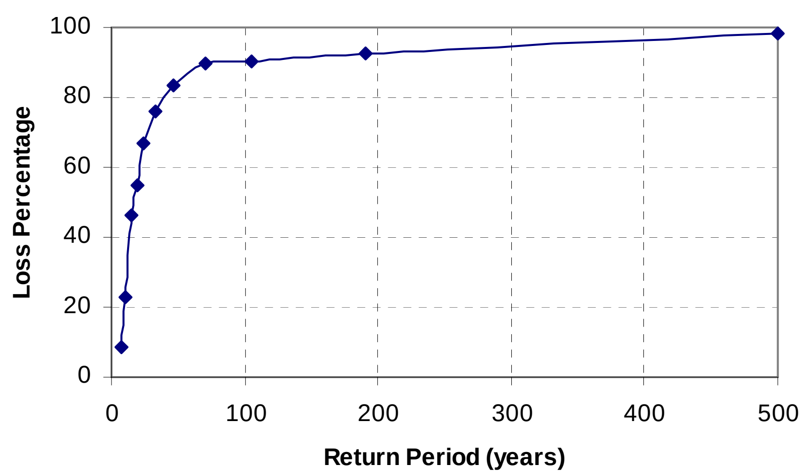
Probable Loss [%]	Name
0.0	PL_8
0.2	PL_{11}
1.6	PL_{15}
3.6	PL_{19}
7.7	PL_{24}
16.1	PL_{33}
24.9	PL_{46}
41.7	PL_{70}
53.0	PL_{105}
67.1	PL_{190}
76.5	PL_{500}
1.518	EAL

Figure F- 10 Wood-Zinc House – 2 Story – Ponce – Exposure C



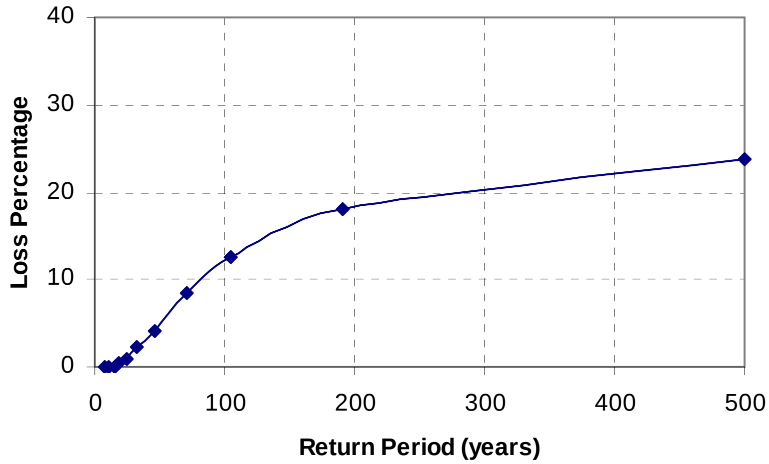
Probable Loss [%]	Name
0.7	PL_8
3.7	PL_{11}
13.3	PL_{15}
20.9	PL_{19}
32.5	PL_{24}
46.7	PL_{33}
57.9	PL_{46}
71.8	PL_{70}
76.9	PL_{105}
84.5	PL_{190}
91.0	PL_{500}
3.337	EAL

Figure F- 11 Wood-Zinc House – 2 Story – Ponce – Exposure C – Minimum Topographic effect



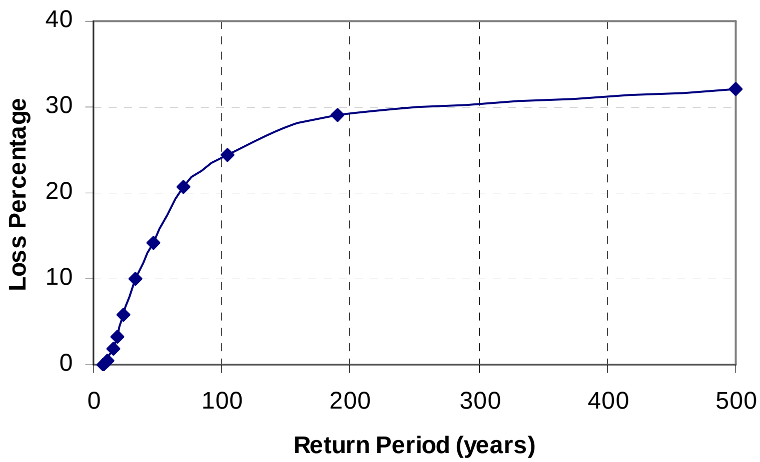
Probable Loss [%]	Name
8.7	PL_8
22.9	PL_{11}
46.4	PL_{15}
55.1	PL_{19}
67.0	PL_{24}
76.0	PL_{33}
83.5	PL_{46}
89.5	PL_{70}
90.1	PL_{105}
92.5	PL_{190}
98.2	PL_{500}
6.205	EAL

Figure F- 12 Wood-Zinc House – 2 Story – Ponce – Exposure C – Maximum Topographic effect



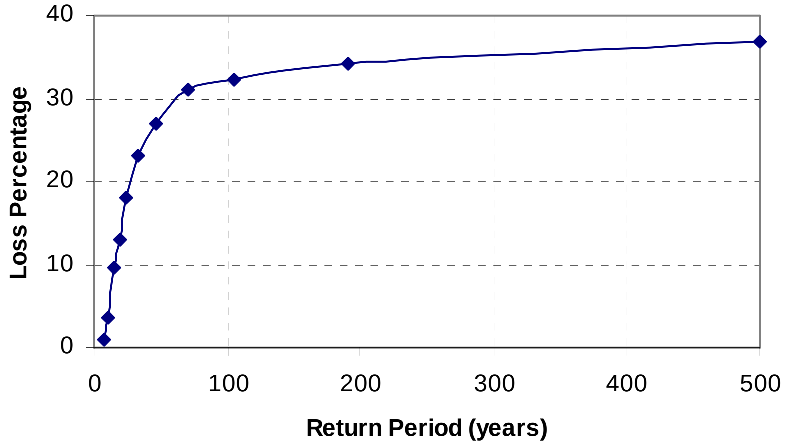
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.1	PL_{15}
0.3	PL_{19}
0.9	PL_{24}
2.3	PL_{33}
4.2	PL_{46}
8.5	PL_{70}
12.6	PL_{105}
18.1	PL_{190}
23.7	PL_{500}
0.316	EAL

Figure F- 13 Mixed House – 2 Story – Ponce – Exposure B



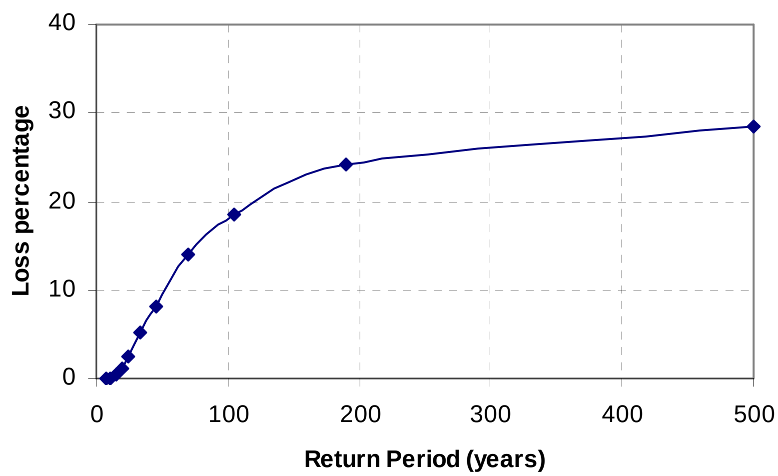
Probable Loss [%]	Name
0.0	PL_8
0.4	PL_{11}
1.8	PL_{15}
3.3	PL_{19}
5.8	PL_{24}
10.1	PL_{33}
14.1	PL_{46}
20.7	PL_{70}
24.4	PL_{105}
29.2	PL_{190}
32.1	PL_{500}
0.818	EAL

Figure F- 14 Mixed House – 2 Story – Ponce – Exposure B - Minimum Topographic Effect



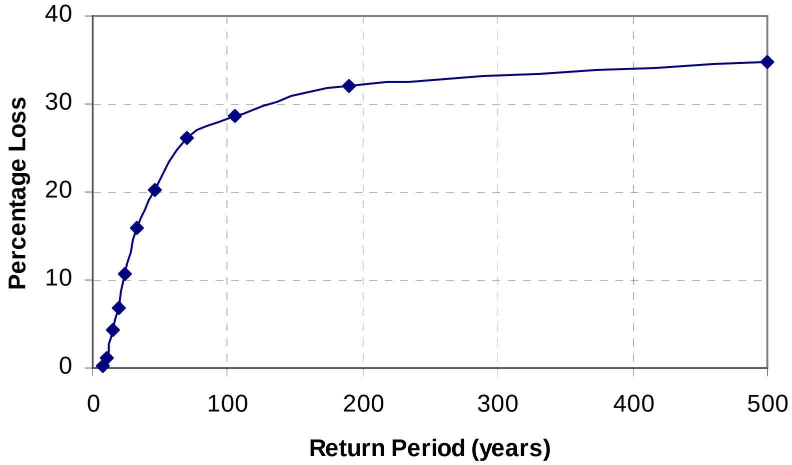
Probable Loss [%]	Name
1.0	PL_8
3.7	PL_{11}
9.5	PL_{15}
13.0	PL_{19}
18.0	PL_{24}
23.1	PL_{33}
27.0	PL_{46}
31.2	PL_{70}
32.3	PL_{105}
34.3	PL_{190}
36.9	PL_{500}
1.709	EAL

Figure F- 15 Mixed House – 2 Story – Ponce – Exposure B - Maximum Topographic Effect



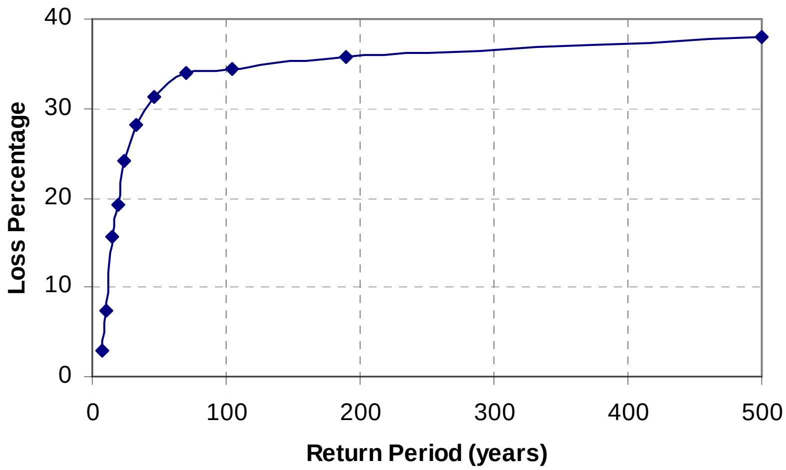
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.5	PL_{15}
1.2	PL_{19}
2.5	PL_{24}
5.2	PL_{33}
8.1	PL_{46}
14.1	PL_{70}
18.5	PL_{105}
24.1	PL_{190}
28.4	PL_{500}
0.519	EAL

Figure F- 16 Mixed House – 2 Story – Ponce – Exposure C



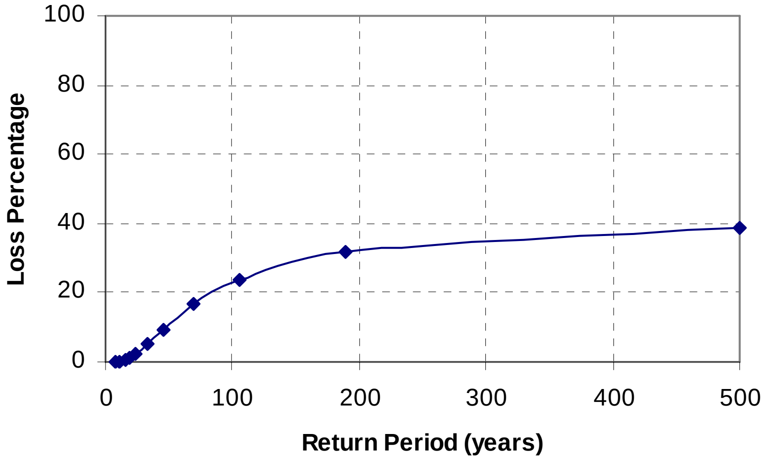
Probable Loss [%]	Name
0.2	PL_{8}
1.2	PL_{11}
4.3	PL_{15}
6.8	PL_{19}
10.7	PL_{24}
15.9	PL_{33}
20.3	PL_{46}
26.2	PL_{70}
28.7	PL_{105}
32.1	PL_{190}
34.7	PL_{500}
1.173	EAL

Figure F- 17 Mixed House – 2 Story – Ponce – Exposure C - Minimum Topographic Effect



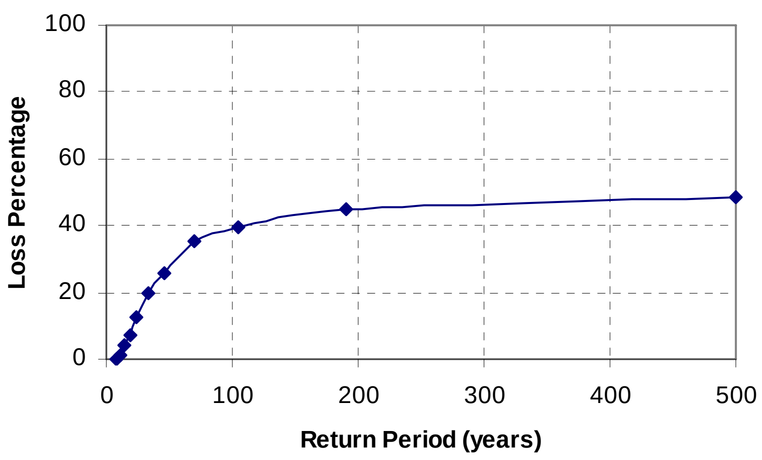
Probable Loss [%]	Name
2.8	PL_{8}
7.4	PL_{11}
15.6	PL_{15}
19.2	PL_{19}
24.1	PL_{24}
28.1	PL_{33}
31.3	PL_{46}
34.0	PL_{70}
34.5	PL_{105}
35.7	PL_{190}
38.0	PL_{500}
2.229	EAL

Figure F- 18 Mixed House – 2 Story – Ponce – Exposure C - Maximum Topographic Effect



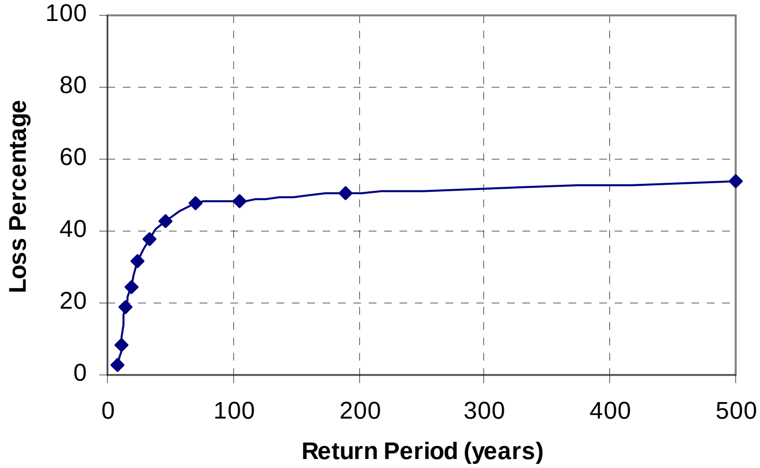
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.2	PL_{15}
0.8	PL_{19}
1.8	PL_{24}
5.2	PL_{33}
10.6	PL_{46}
15.1	PL_{70}
22.4	PL_{105}
26.2	PL_{190}
36.0	PL_{500}
0.597	EAL

Figure F- 19 Mixed House – 3 Story – Ponce – Exposure B



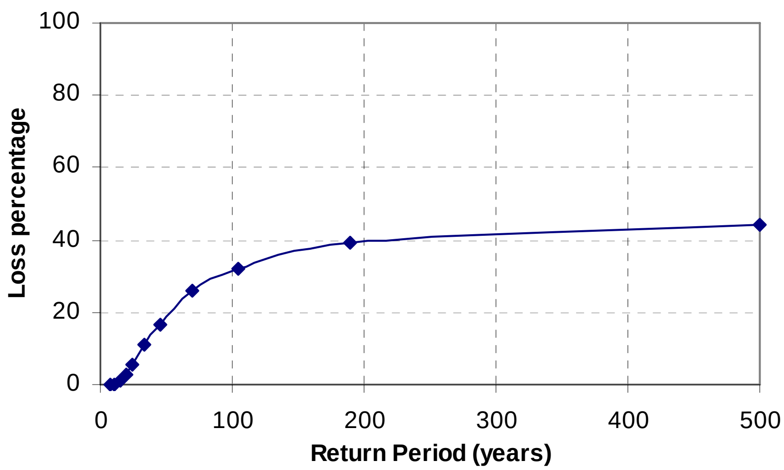
Probable Loss [%]	Name
0.1	PL_8
1.5	PL_{11}
2.8	PL_{15}
6.3	PL_{19}
10.6	PL_{24}
20.1	PL_{33}
29.1	PL_{46}
32.9	PL_{70}
39.8	PL_{105}
39.9	PL_{190}
47.8	PL_{500}
1.433	EAL

Figure F- 20 Mixed House – 3 Story – Ponce – Exposure B - Minimum Topographic Effect



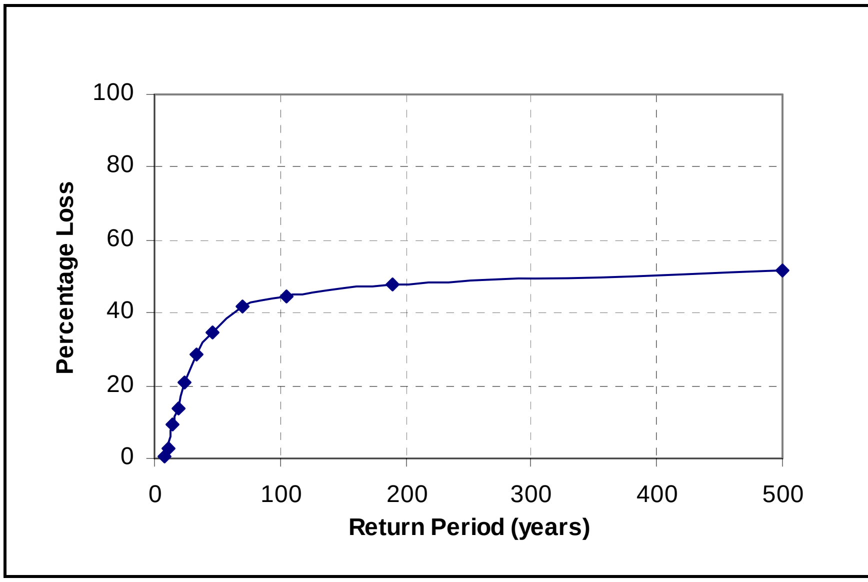
Probable Loss [%]	Name
2.0	PL_{8}
9.8	PL_{11}
13.3	PL_{15}
22.4	PL_{19}
29.3	PL_{24}
40.1	PL_{33}
46.1	PL_{46}
46.3	PL_{70}
50.1	PL_{105}
48.5	PL_{190}
54.0	PL_{500}
2.838	EAL

Figure F- 21 Mixed House – 3 Story – Ponce – Exposure B - Maximum Topographic Effect



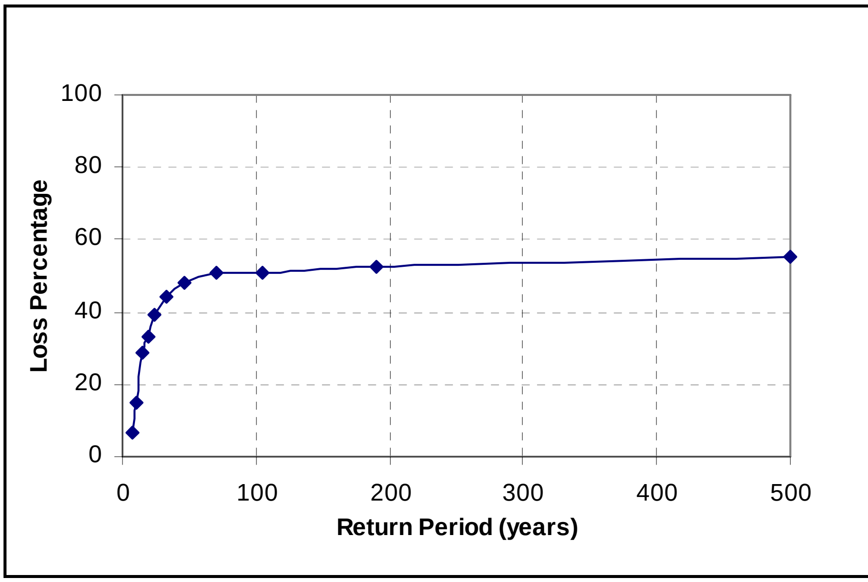
Probable Loss [%]	Name
0.0	PL_{8}
0.4	PL_{11}
0.9	PL_{15}
2.4	PL_{19}
4.8	PL_{24}
11.0	PL_{33}
18.8	PL_{46}
23.6	PL_{70}
31.3	PL_{105}
33.6	PL_{190}
42.5	PL_{500}
0.939	EAL

Figure F- 22 Mixed House – 3 Story – Ponce – Exposure C



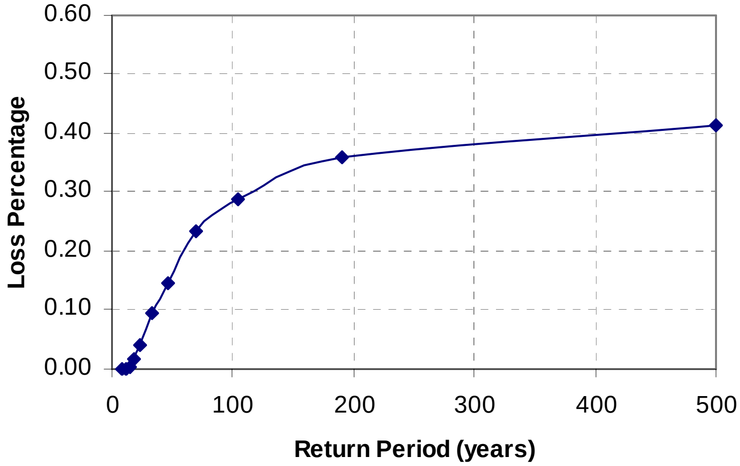
Probable Loss [%]	Name
0.4	PL_8
4.0	PL_{11}
6.3	PL_{15}
12.5	PL_{19}
18.4	PL_{24}
29.7	PL_{33}
38.1	PL_{46}
40.0	PL_{70}
45.6	PL_{105}
44.3	PL_{190}
51.3	PL_{500}
2.010	EAL

Figure F- 23 Mixed House – 3 Story – Ponce – Exposure C - Minimum Topographic Effect



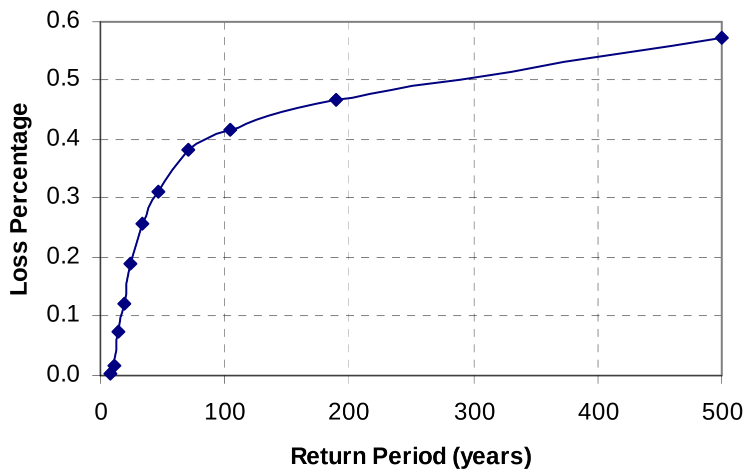
Probable Loss [%]	Name
5.0	PL_8
17.4	PL_{11}
20.8	PL_{15}
31.3	PL_{19}
37.8	PL_{24}
46.6	PL_{33}
50.3	PL_{46}
49.9	PL_{70}
52.4	PL_{105}
51.3	PL_{190}
55.2	PL_{500}
3.606	EAL

Figure F- 24 Mixed House – 3 Story – Ponce – Exposure C - Maximum Topographic Effect



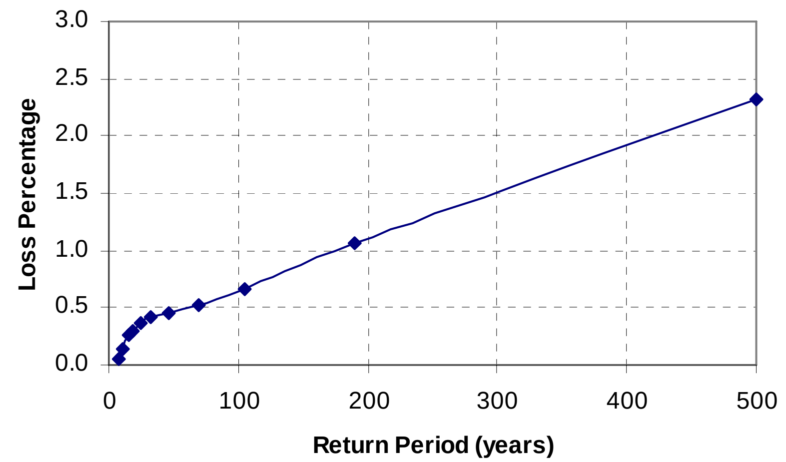
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.01	PL_{15}
0.02	PL_{19}
0.04	PL_{24}
0.09	PL_{33}
0.15	PL_{46}
0.24	PL_{70}
0.29	PL_{105}
0.36	PL_{190}
0.41	PL_{500}
0.008	EAL

Figure F- 25 Concrete House – 1-3 Story – Ponce – Exposure B



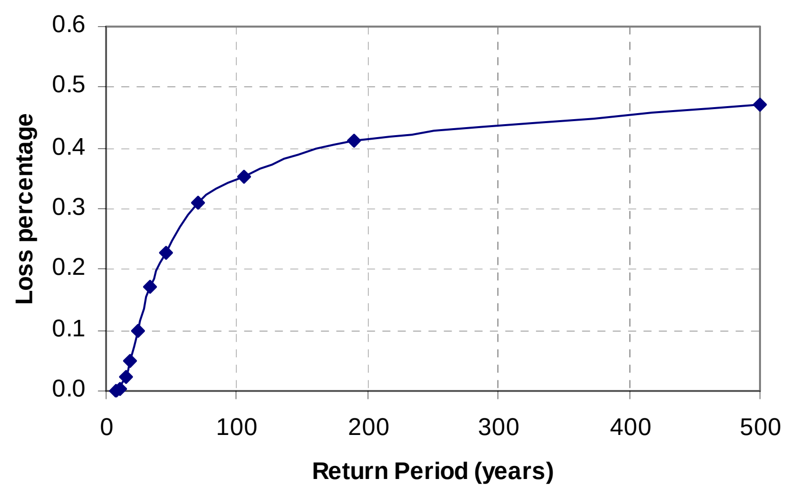
Probable Loss [%]	Name
0.00	PL_8
0.02	PL_{11}
0.07	PL_{15}
0.12	PL_{19}
0.19	PL_{24}
0.26	PL_{33}
0.31	PL_{46}
0.38	PL_{70}
0.42	PL_{105}
0.47	PL_{190}
0.57	PL_{500}
0.019	EAL

Figure F- 26 Concrete House – 1-3 Story – Ponce – Exposure B – Minimum Topographic Effect



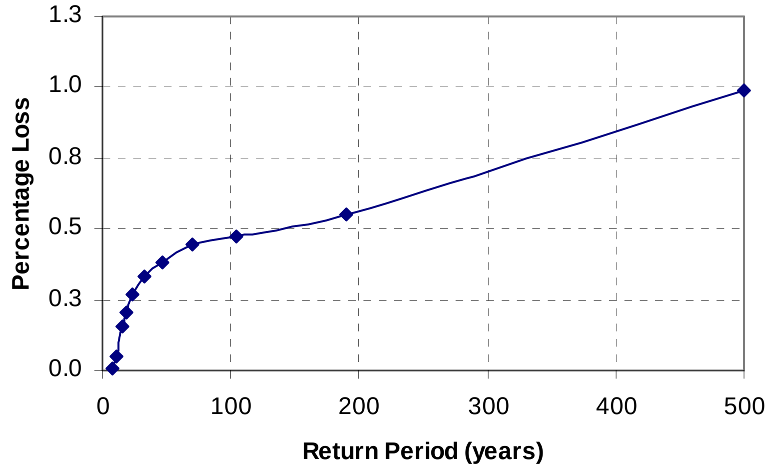
Probable Loss [%]	Name
0.05	PL_8
0.13	PL_{11}
0.26	PL_{15}
0.30	PL_{19}
0.36	PL_{24}
0.41	PL_{33}
0.46	PL_{46}
0.52	PL_{70}
0.66	PL_{105}
1.06	PL_{190}
2.32	PL_{500}
0.044	EAL

Figure F- 27 Concrete House – 1-3 Story – Ponce – Exposure B – Maximum Topographic Effect



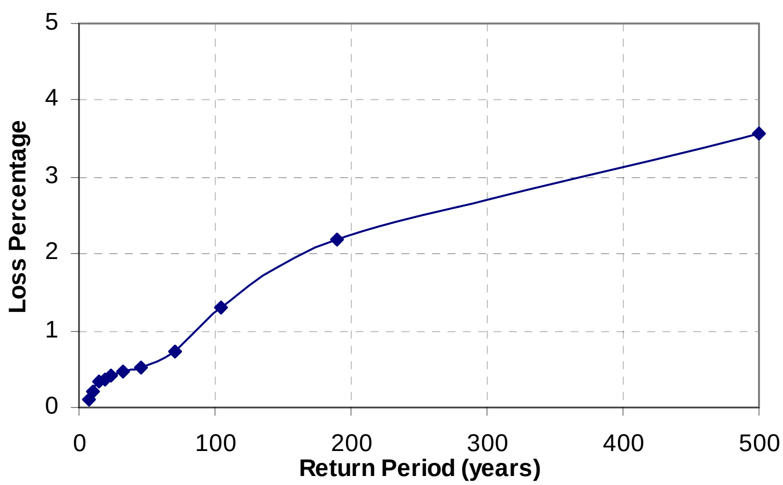
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.02	PL_{15}
0.05	PL_{19}
0.10	PL_{24}
0.17	PL_{33}
0.23	PL_{46}
0.31	PL_{70}
0.35	PL_{105}
0.41	PL_{190}
0.47	PL_{500}
0.013	EAL

Figure F- 28 Concrete House – 1-3 Story – Ponce – Exposure C



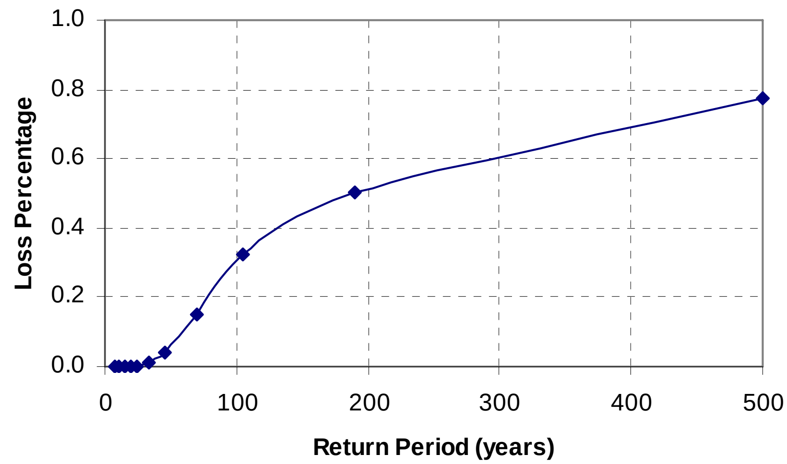
Probable Loss [%]	Name
0.01	PL_8
0.05	PL_{11}
0.15	PL_{15}
0.21	PL_{19}
0.27	PL_{24}
0.33	PL_{33}
0.38	PL_{46}
0.45	PL_{70}
0.47	PL_{105}
0.55	PL_{190}
0.99	PL_{500}
0.027	EAL

Figure F- 29 Concrete House – 1-3 Story – Ponce – Exposure C – Minimum Topographic Effect



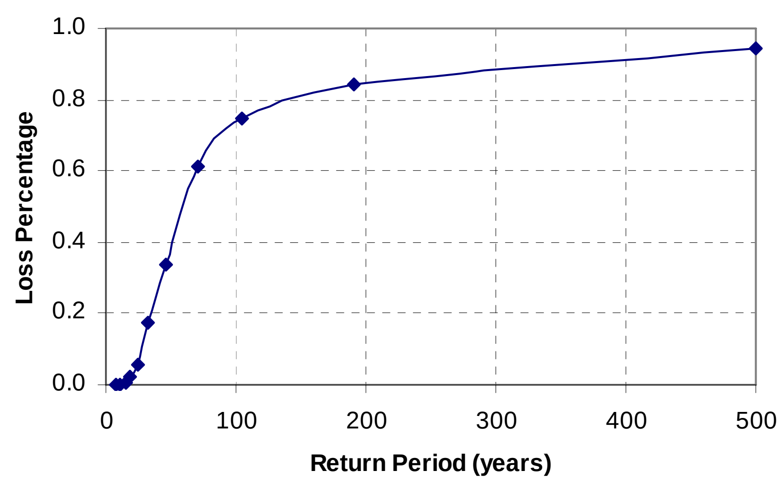
Probable Loss [%]	Name
0.11	PL_8
0.22	PL_{11}
0.34	PL_{15}
0.37	PL_{19}
0.42	PL_{24}
0.47	PL_{33}
0.52	PL_{46}
0.74	PL_{70}
1.31	PL_{105}
2.19	PL_{190}
3.57	PL_{500}
0.065	EAL

Figure F- 30 Concrete House – 1-3 Story – Ponce – Exposure C – Maximum Topographic Effect



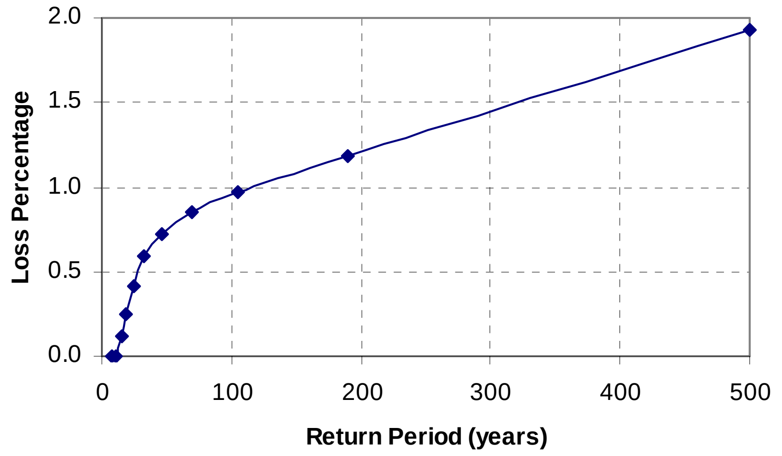
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.00	PL_{19}
0.00	PL_{24}
0.01	PL_{33}
0.04	PL_{46}
0.15	PL_{70}
0.32	PL_{105}
0.50	PL_{190}
0.77	PL_{500}
0.007	EAL

Figure F- 31 Multistory Concrete – 4-7 Story – Ponce – Exposure B



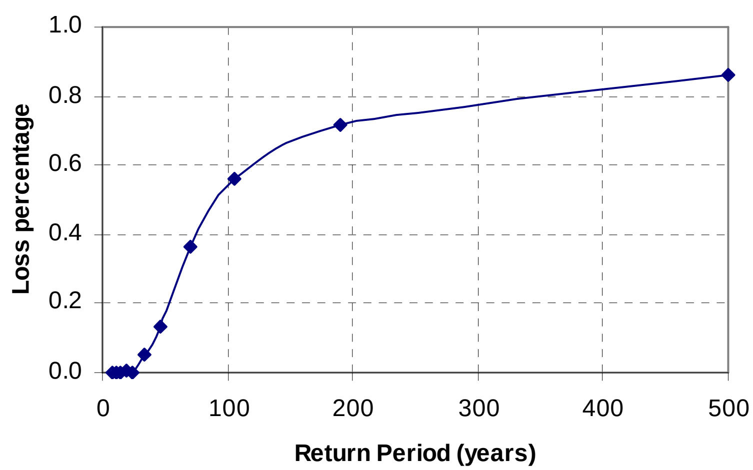
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.01	PL_{15}
0.02	PL_{19}
0.06	PL_{24}
0.17	PL_{33}
0.34	PL_{46}
0.61	PL_{70}
0.75	PL_{105}
0.85	PL_{190}
0.94	PL_{500}
0.019	EAL

Figure F- 32 Multistory Concrete – 4-7 Story – Ponce – Exposure B – Minimum Topographic Effect



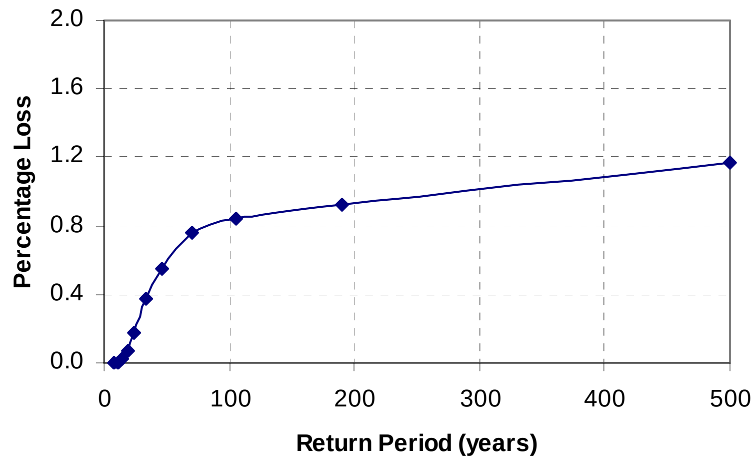
Probable Loss [%]	Name
0.00	PL_{8}
0.00	PL_{11}
0.12	PL_{15}
0.24	PL_{19}
0.42	PL_{24}
0.59	PL_{33}
0.72	PL_{46}
0.86	PL_{70}
0.98	PL_{105}
1.18	PL_{190}
1.93	PL_{500}
0.040	EAL

Figure F- 33 Multistory Concrete – 4-7 Story – Ponce – Exposure B – Maximum Topographic Effect



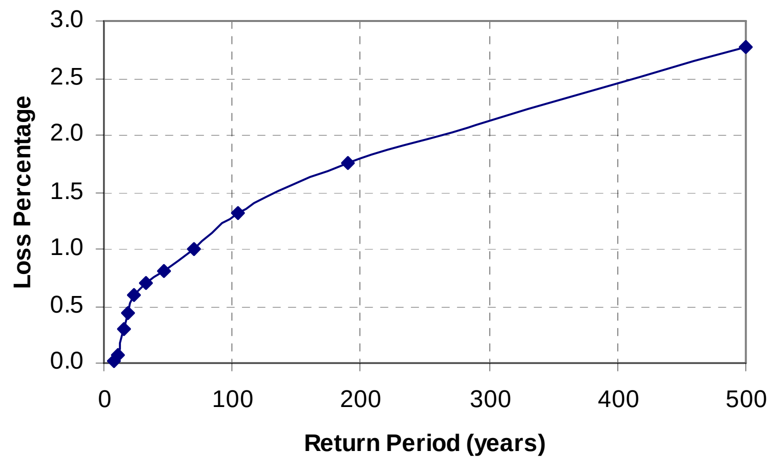
Probable Loss [%]	Name
0.00	PL_{8}
0.00	PL_{11}
0.00	PL_{15}
0.00	PL_{19}
0.00	PL_{24}
0.05	PL_{33}
0.13	PL_{46}
0.36	PL_{70}
0.56	PL_{105}
0.72	PL_{190}
0.86	PL_{500}
0.012	EAL

Figure F- 34 Multistory Concrete – 4-7 Story – Ponce – Exposure C



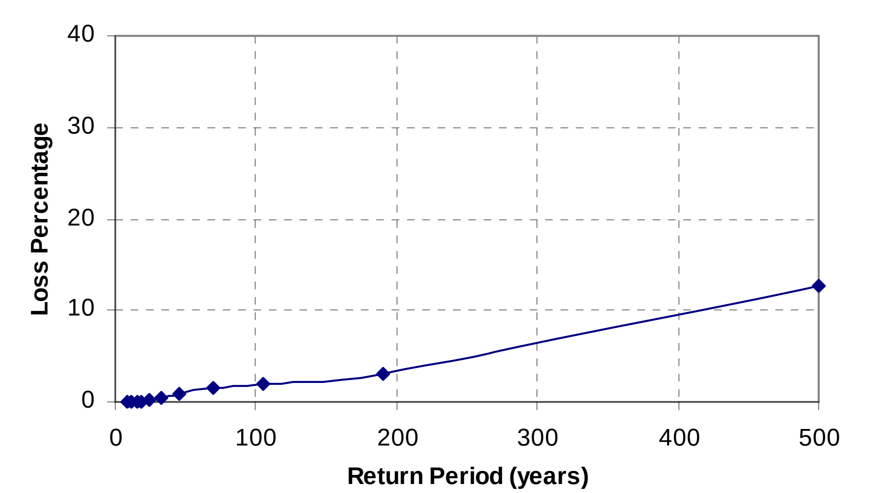
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.03	PL_{15}
0.08	PL_{19}
0.18	PL_{24}
0.37	PL_{33}
0.55	PL_{46}
0.76	PL_{70}
0.84	PL_{105}
0.92	PL_{190}
1.17	PL_{500}
0.027	EAL

Figure F- 35 Multistory Concrete – 4-7 Story – Ponce – Exposure C – Minimum Topographic Effect



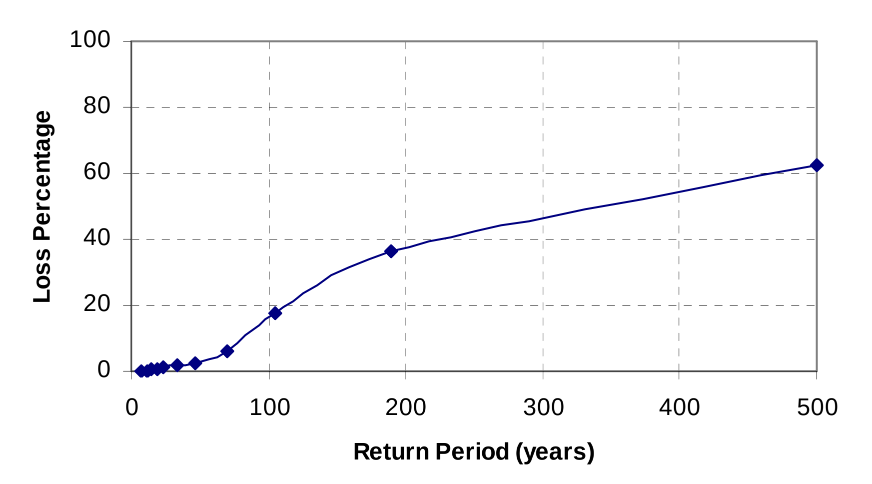
Probable Loss [%]	Name
0.01	PL_8
0.07	PL_{11}
0.29	PL_{15}
0.44	PL_{19}
0.60	PL_{24}
0.71	PL_{33}
0.82	PL_{46}
1.00	PL_{70}
1.31	PL_{105}
1.75	PL_{190}
2.78	PL_{500}
0.058	EAL

Figure F- 36 Multistory Concrete – 4-7 Story – Ponce – Exposure C – Maximum Topographic Effect



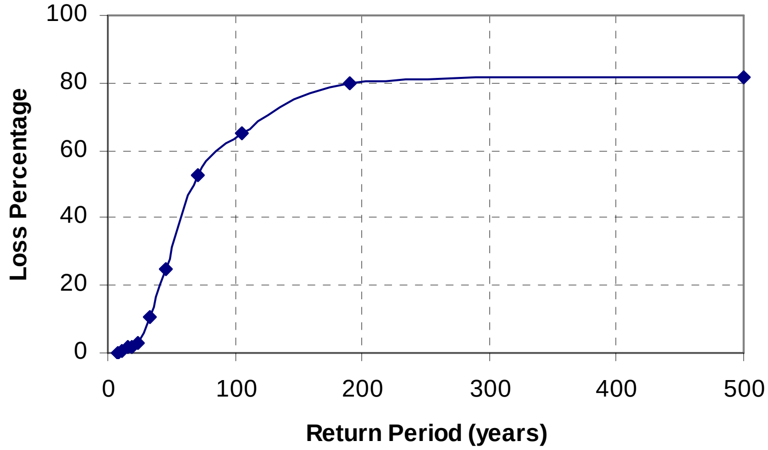
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.0	PL_{19}
0.1	PL_{24}
0.5	PL_{33}
1.0	PL_{46}
1.3	PL_{70}
1.8	PL_{105}
2.5	PL_{190}
10.0	PL_{500}
0.076	EAL

Figure F- 37 Small Institutional – Ponce – Exposure B



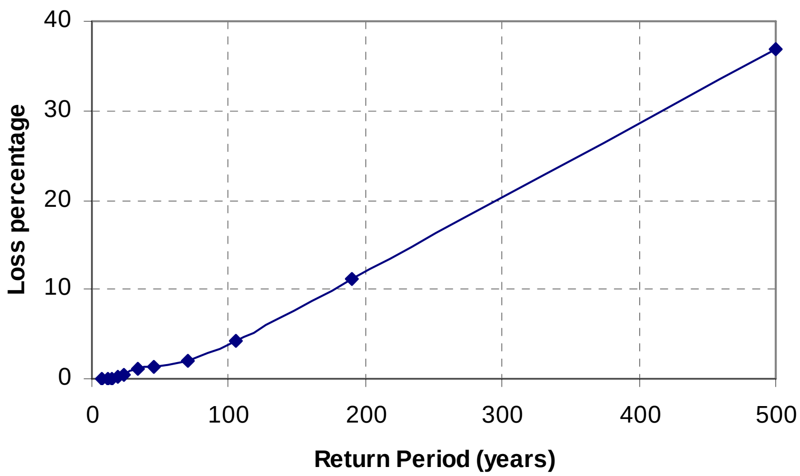
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.2	PL_{15}
0.6	PL_{19}
1.0	PL_{24}
1.7	PL_{33}
2.5	PL_{46}
5.0	PL_{70}
15.3	PL_{105}
27.5	PL_{190}
53.8	PL_{500}
0.460	EAL

Figure F- 38 Small Institutional – Ponce – Exposure B – Minimum Topographic Effect



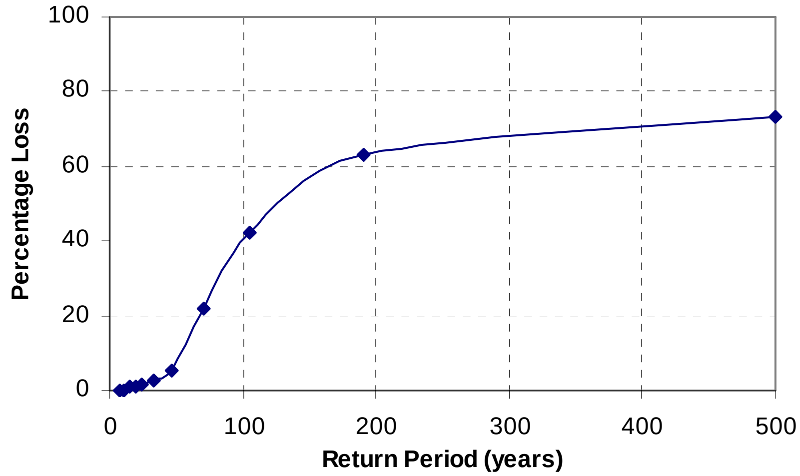
Probable Loss [%]	Name
0.1	PL_8
0.9	PL_{11}
1.1	PL_{15}
1.8	PL_{19}
2.9	PL_{24}
10.1	PL_{33}
28.5	PL_{46}
45.9	PL_{70}
62.3	PL_{105}
67.7	PL_{190}
79.3	PL_{500}
1.539	EAL

Figure F- 39 Small Institutional – Ponce – Exposure B – Maximum Topographic Effect



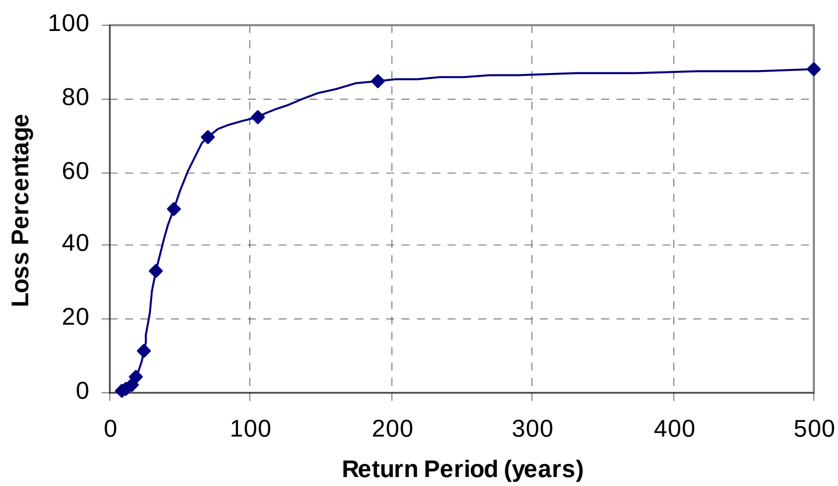
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.2	PL_{19}
0.4	PL_{24}
1.0	PL_{33}
1.6	PL_{46}
1.9	PL_{70}
3.9	PL_{105}
8.4	PL_{190}
29.5	PL_{500}
0.199	EAL

Figure F- 40 Small Institutional – Ponce – Exposure C



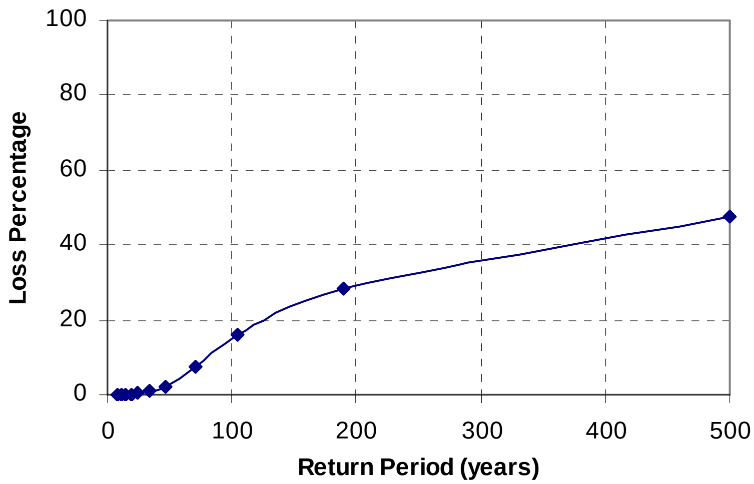
Probable Loss [%]	Name
0.0	PL_8
0.3	PL_{11}
0.6	PL_{15}
1.1	PL_{19}
1.5	PL_{24}
2.6	PL_{33}
7.0	PL_{46}
17.9	PL_{70}
37.1	PL_{105}
49.6	PL_{190}
67.4	PL_{500}
0.842	EAL

Figure F- 41 Small Institutional – Ponce – Exposure C – Minimum Topographic Effect



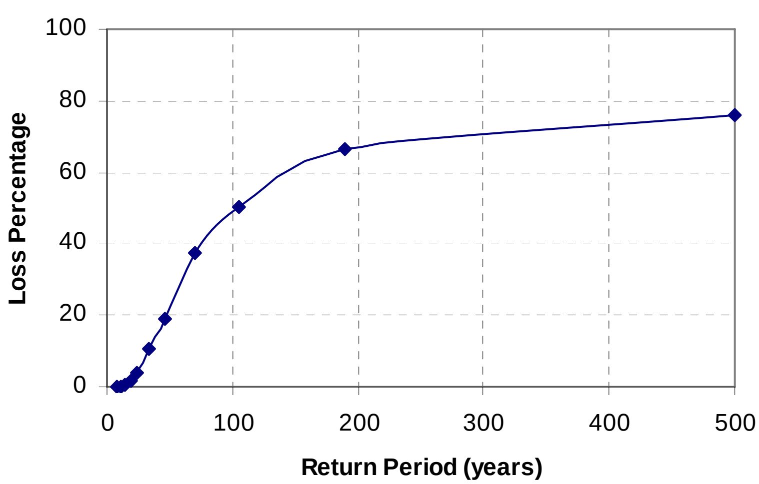
Probable Loss [%]	Name
0.5	PL_8
1.6	PL_{11}
1.7	PL_{15}
3.7	PL_{19}
9.6	PL_{24}
31.3	PL_{33}
57.0	PL_{46}
65.0	PL_{70}
77.2	PL_{105}
74.1	PL_{190}
88.5	PL_{500}
2.356	EAL

Figure F- 42 Small Institutional – Ponce – Exposure C – Maximum Topographic Effect



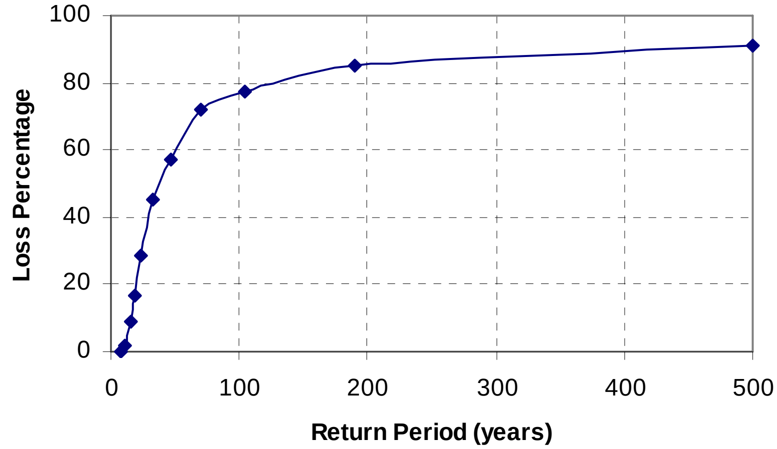
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.1	PL_{19}
0.3	PL_{24}
1.0	PL_{33}
3.0	PL_{46}
6.5	PL_{70}
22.9	PL_{105}
21.9	PL_{190}
41.1	PL_{500}
0.413	EAL

Figure F- 43 Large Institutional – Ponce – Exposure B



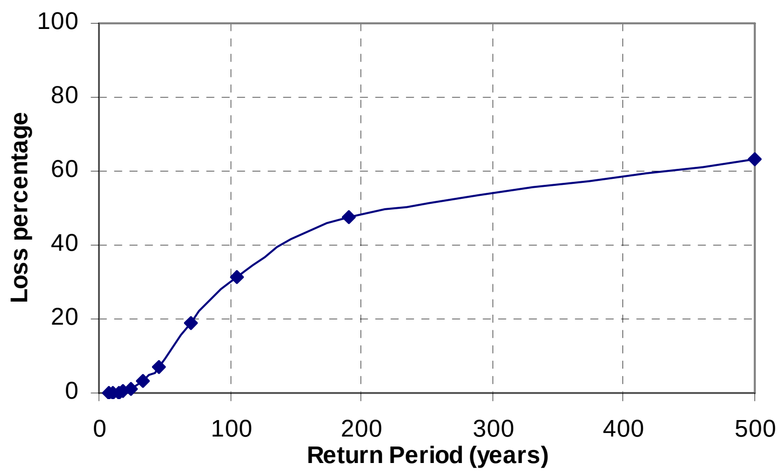
Probable Loss [%]	Name
0.0	PL_8
0.2	PL_{11}
0.4	PL_{15}
1.4	PL_{19}
3.3	PL_{24}
10.1	PL_{33}
21.9	PL_{46}
32.8	PL_{70}
48.1	PL_{105}
55.1	PL_{190}
71.6	PL_{500}
1.230	EAL

Figure F- 44 Large Institutional – Ponce – Exposure B – Minimum Topographic Effect



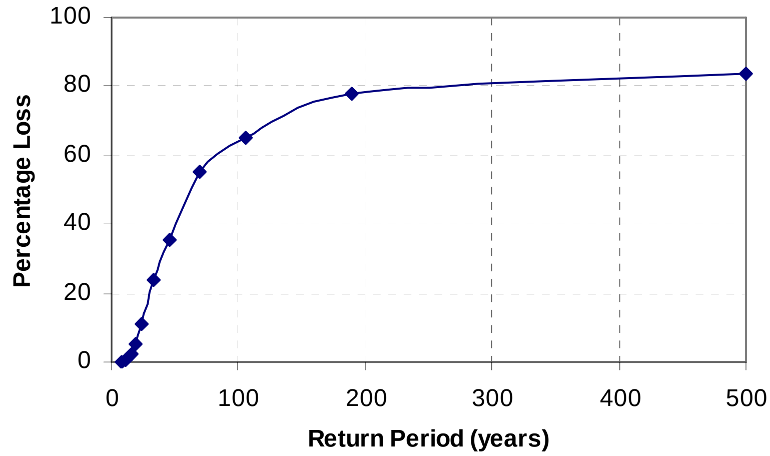
Probable Loss [%]	Name
0.3	PL_{8}
3.2	PL_{11}
5.8	PL_{15}
14.1	PL_{19}
24.3	PL_{24}
45.9	PL_{33}
63.9	PL_{46}
68.6	PL_{70}
79.8	PL_{105}
76.9	PL_{190}
90.6	PL_{500}
3.022	EAL

Figure F- 45 Large Institutional – Ponce – Exposure B – Maximum Topographic Effect



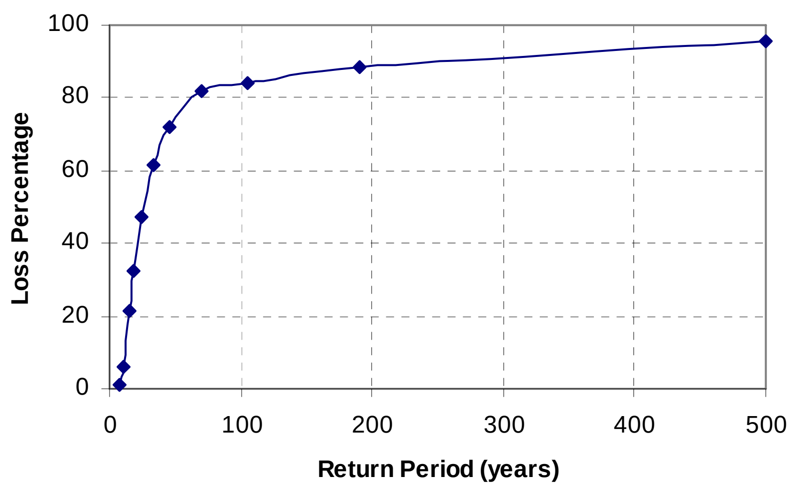
Probable Loss [%]	Name
0.0	PL_{8}
0.1	PL_{11}
0.1	PL_{15}
0.4	PL_{19}
0.9	PL_{24}
3.2	PL_{33}
8.8	PL_{46}
16.0	PL_{70}
28.7	PL_{105}
37.9	PL_{190}
57.4	PL_{500}
0.699	EAL

Figure F- 46 Large Institutional – Ponce – Exposure C



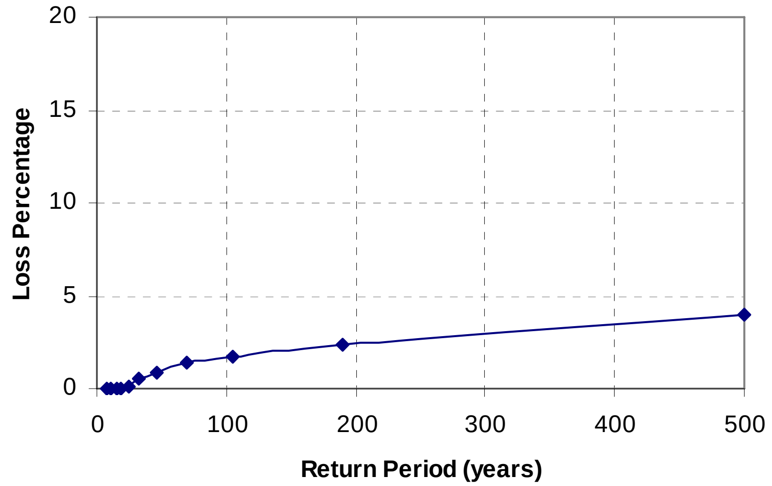
Probable Loss [%]	Name
0.1	PL_{8}
0.8	PL_{11}
1.5	PL_{15}
4.4	PL_{19}
9.3	PL_{24}
23.2	PL_{33}
40.4	PL_{46}
50.5	PL_{70}
64.9	PL_{105}
67.1	PL_{190}
81.6	PL_{500}
1.918	EAL

Figure F- 47 Large Institutional – Ponce – Exposure C – Minimum Topographic Effect



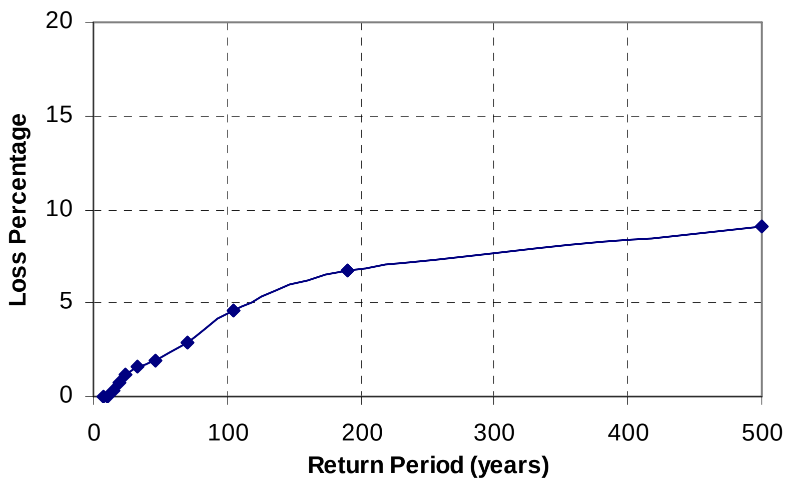
Probable Loss [%]	Name
1.0	PL_{8}
8.7	PL_{11}
14.2	PL_{15}
28.7	PL_{19}
42.2	PL_{24}
64.7	PL_{33}
78.8	PL_{46}
79.2	PL_{70}
87.6	PL_{105}
83.6	PL_{190}
95.5	PL_{500}
4.188	EAL

Figure F- 48 Large Institutional – Ponce – Exposure C – Maximum Topographic Effect



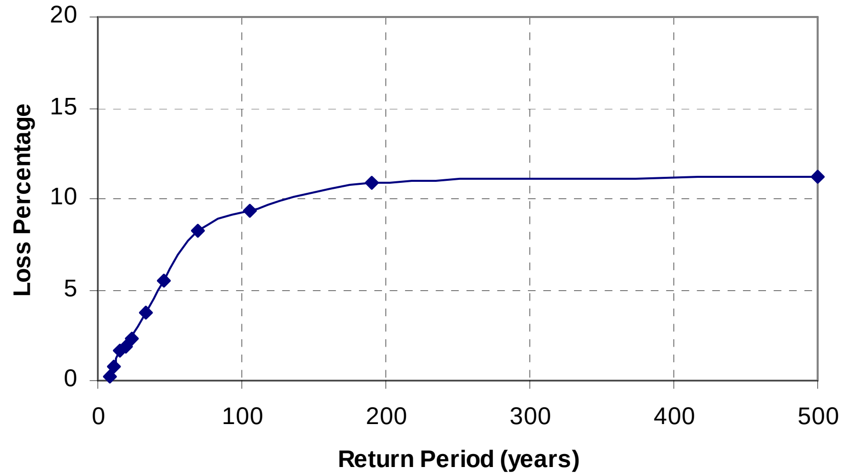
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.0	PL_{15}
0.0	PL_{19}
0.2	PL_{24}
0.5	PL_{33}
0.9	PL_{46}
1.4	PL_{70}
1.8	PL_{105}
2.3	PL_{190}
4.0	PL_{500}
0.054	EAL

Figure F- 49 Mixed Institutional – Ponce – Exposure B



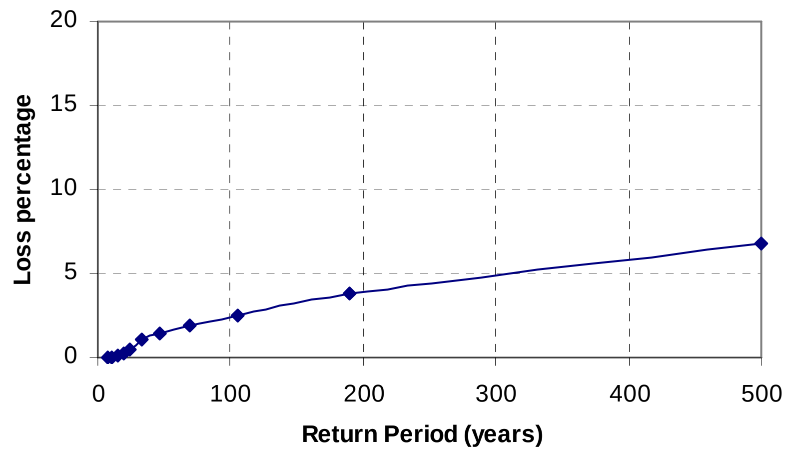
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.4	PL_{15}
0.7	PL_{19}
1.1	PL_{24}
1.6	PL_{33}
1.9	PL_{46}
2.9	PL_{70}
4.6	PL_{105}
6.7	PL_{190}
9.1	PL_{500}
0.158	EAL

Figure F- 50 Mixed Institutional – Ponce – Exposure B – Minimum Topographic Effect



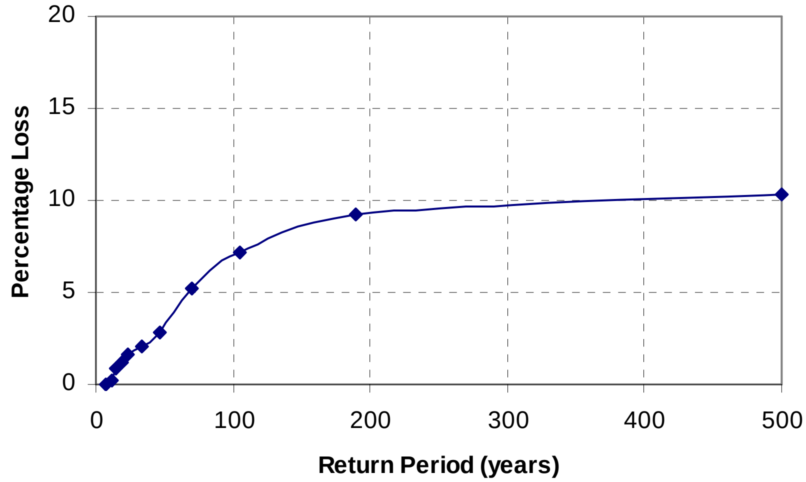
Probable Loss [%]	Name
0.2	PL_{8}
0.8	PL_{11}
1.6	PL_{15}
1.8	PL_{19}
2.3	PL_{24}
3.7	PL_{33}
5.5	PL_{46}
8.2	PL_{70}
9.3	PL_{105}
10.8	PL_{190}
11.2	PL_{500}
0.361	EAL

Figure F- 51 Mixed Institutional – Ponce – Exposure B – Maximum Topographic Effect



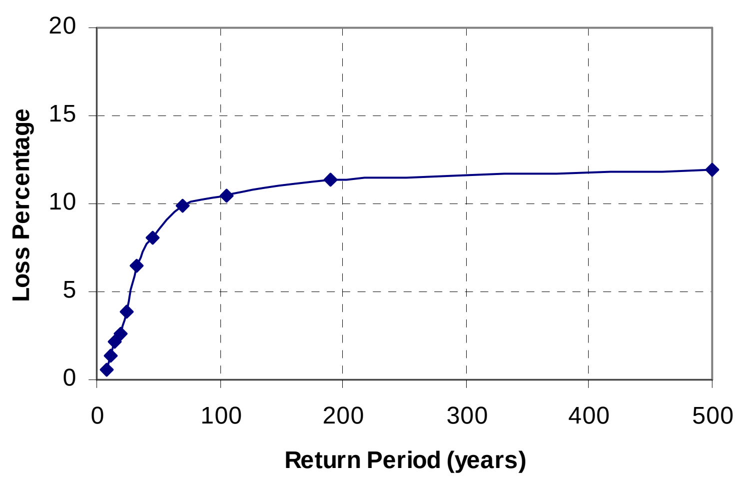
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.1	PL_{15}
0.2	PL_{19}
0.5	PL_{24}
1.0	PL_{33}
1.4	PL_{46}
1.9	PL_{70}
2.5	PL_{105}
3.8	PL_{190}
6.8	PL_{500}
0.093	EAL

Figure F- 52 Mixed Institutional – Ponce – Exposure C



Probable Loss [%]	Name
0.0	PL_8
0.2	PL_{11}
0.9	PL_{15}
1.2	PL_{19}
1.7	PL_{24}
2.1	PL_{33}
2.8	PL_{46}
5.2	PL_{70}
7.1	PL_{105}
9.2	PL_{190}
10.3	PL_{500}
0.238	EAL

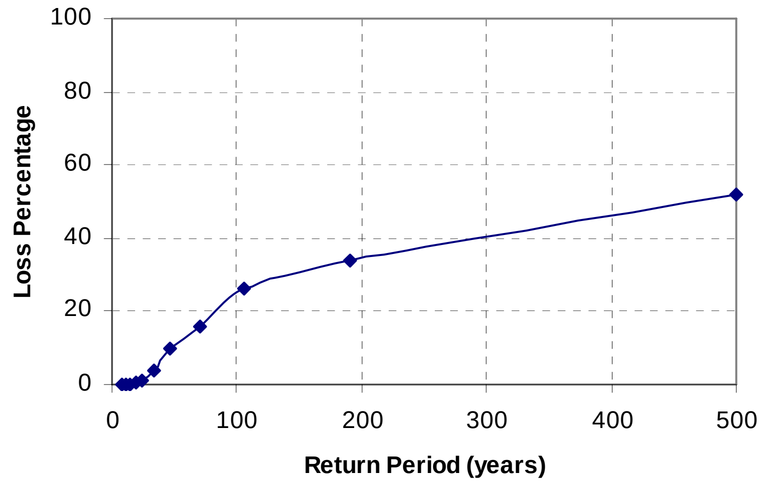
Figure F- 53 Mixed Institutional – Ponce – Exposure C – Minimum Topographic Effect



Probable Loss [%]	Name
0.6	PL_8
1.3	PL_{11}
2.1	PL_{15}
2.6	PL_{19}
3.9	PL_{24}
6.4	PL_{33}
8.0	PL_{46}
9.9	PL_{70}
10.4	PL_{105}
11.3	PL_{190}
11.9	PL_{500}
0.487	EAL

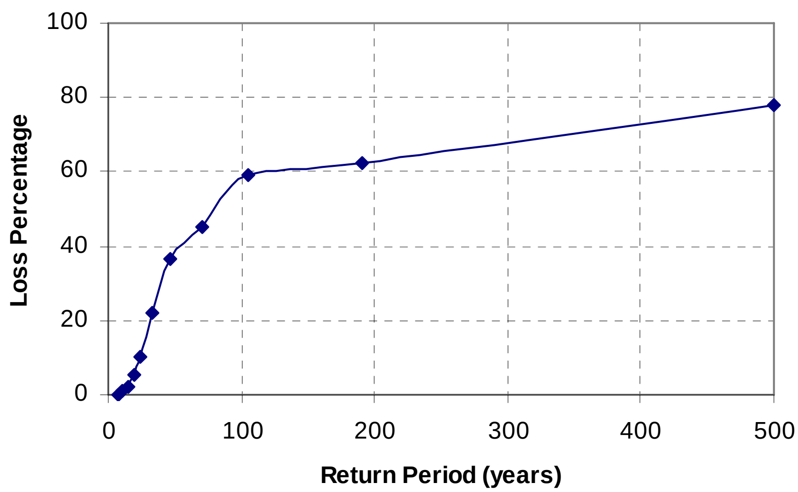
Figure F- 54 Mixed Institutional – Ponce – Exposure C – Maximum Topographic Effect

Appendix G Hurricane Loss Curves for San Juan



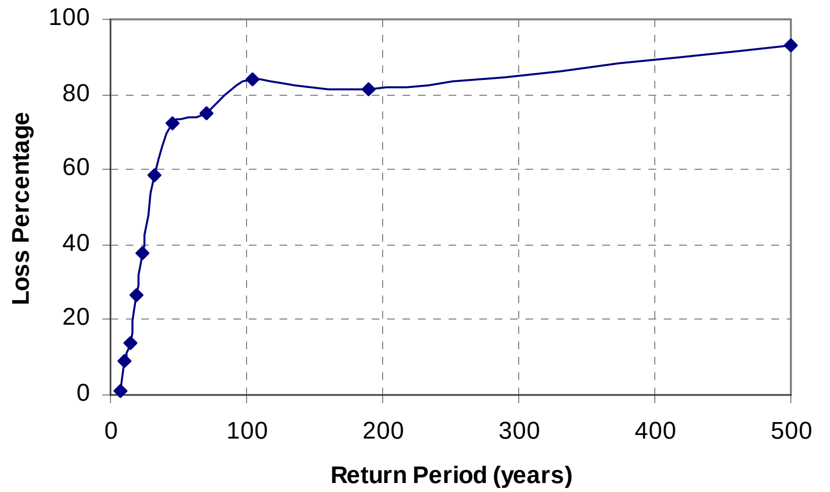
Probable Loss [%]	Name
0.0	PL_{8}
0.1	PL_{11}
0.1	PL_{15}
0.4	PL_{19}
1.2	PL_{24}
4.1	PL_{33}
9.7	PL_{46}
15.8	PL_{70}
26.5	PL_{105}
34.0	PL_{190}
52.1	PL_{500}
0.609	EAL

Figure G- 1 Wood-Zinc House – 1 Story – San Juan – Exposure B



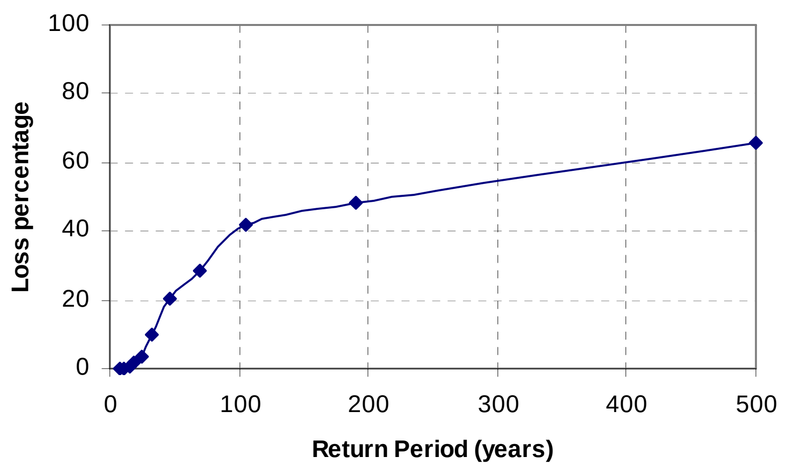
Probable Loss [%]	Name
0.0	PL_{8}
1.0	PL_{11}
2.0	PL_{15}
5.3	PL_{19}
10.0	PL_{24}
22.1	PL_{33}
36.5	PL_{46}
45.4	PL_{70}
59.1	PL_{105}
62.4	PL_{190}
77.9	PL_{500}
1.765	EAL

Figure G- 2 Wood-Zinc House – 1 Story – San Juan – Exposure B – Minimum Topographic effect



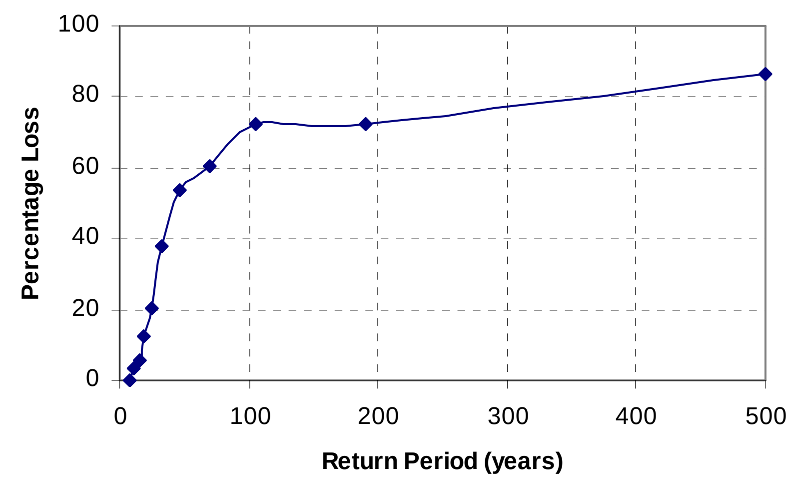
Probable Loss [%]	Name
1.3	PL_{8}
9.2	PL_{11}
14.0	PL_{15}
26.5	PL_{19}
37.9	PL_{24}
58.3	PL_{33}
72.4	PL_{46}
75.0	PL_{70}
84.1	PL_{105}
81.4	PL_{190}
93.3	PL_{500}
3.911	EAL

Figure G- 3 Wood-Zinc House – 1 Story – San Juan – Exposure B – Maximum Topographic effect



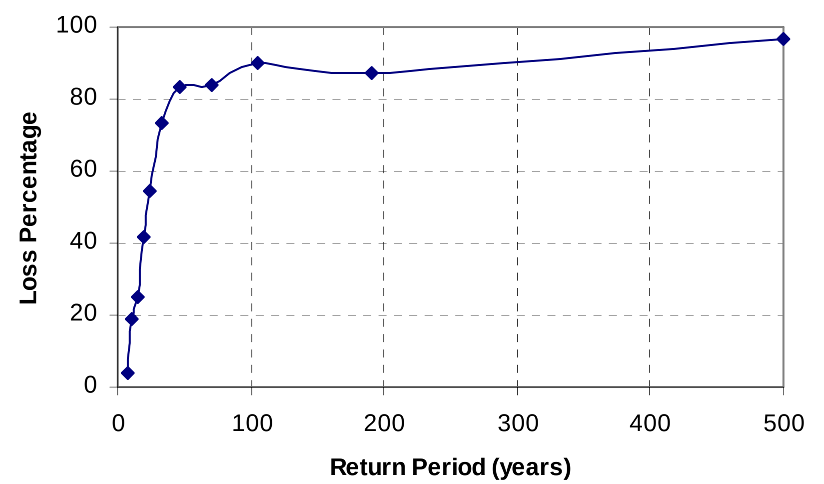
Probable Loss [%]	Name
0.0	PL_{8}
0.3	PL_{11}
0.5	PL_{15}
1.7	PL_{19}
3.8	PL_{24}
10.2	PL_{33}
20.3	PL_{46}
28.6	PL_{70}
41.9	PL_{105}
48.5	PL_{190}
65.8	PL_{500}
1.066	EAL

Figure G- 4 Wood-Zinc House – 1 Story – San Juan – Exposure C



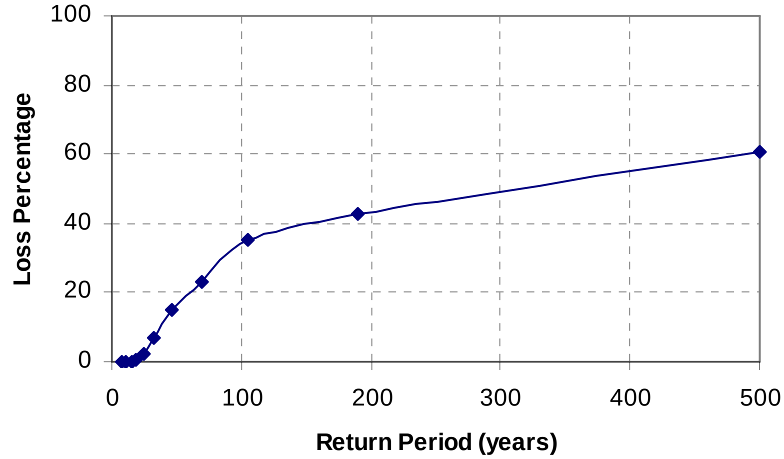
Probable Loss [%]	Name
0.2	PL_8
3.1	PL_{11}
5.5	PL_{15}
12.3	PL_{19}
20.3	PL_{24}
37.7	PL_{33}
53.9	PL_{46}
60.4	PL_{70}
72.6	PL_{105}
72.3	PL_{190}
86.3	PL_{500}
2.617	EAL

Figure G- 5 Wood-Zinc House – 1 Story – San Juan – Exposure C - Minimum Topographic effect



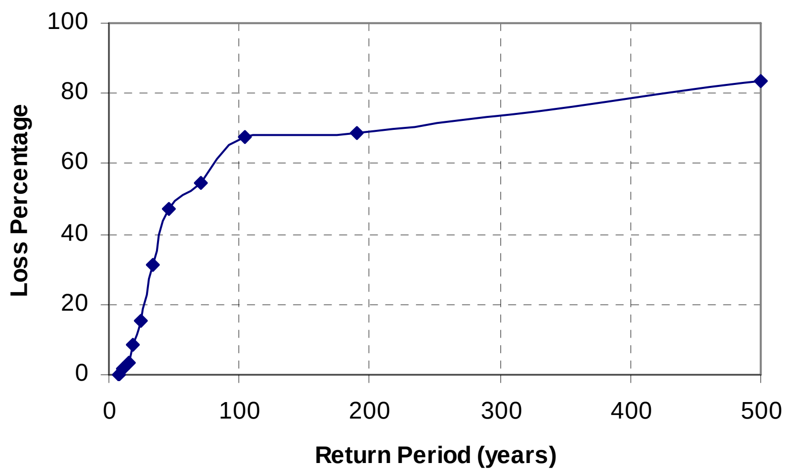
Probable Loss [%]	Name
4.0	PL_8
18.9	PL_{11}
25.1	PL_{15}
41.9	PL_{19}
54.4	PL_{24}
73.3	PL_{33}
83.6	PL_{46}
83.6	PL_{70}
90.1	PL_{105}
87.3	PL_{190}
96.8	PL_{500}
5.195	EAL

Figure G- 6 Wood-Zinc House – 1 Story – San Juan – Exposure C - Maximum Topographic effect



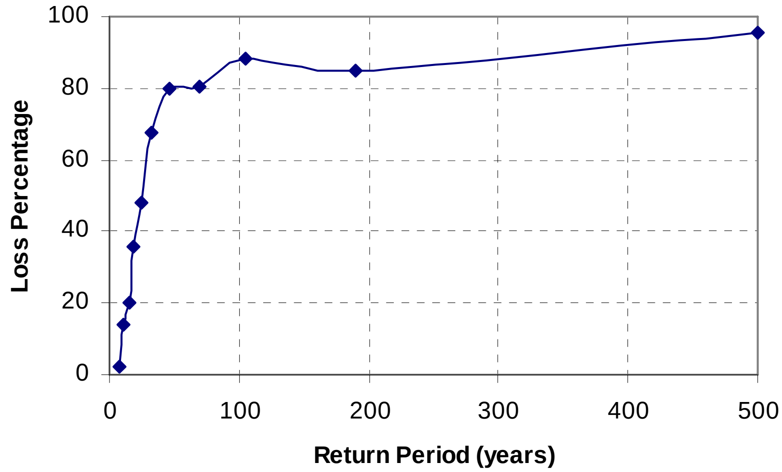
Probable Loss [%]	Name
0.0	PL_{8}
0.1	PL_{11}
0.2	PL_{15}
0.9	PL_{19}
2.2	PL_{24}
6.9	PL_{33}
15.2	PL_{46}
22.9	PL_{70}
35.5	PL_{105}
42.9	PL_{190}
60.7	PL_{500}
0.852	EAL

Figure G- 7 Wood-Zinc House – 2 Story – San Juan – Exposure B



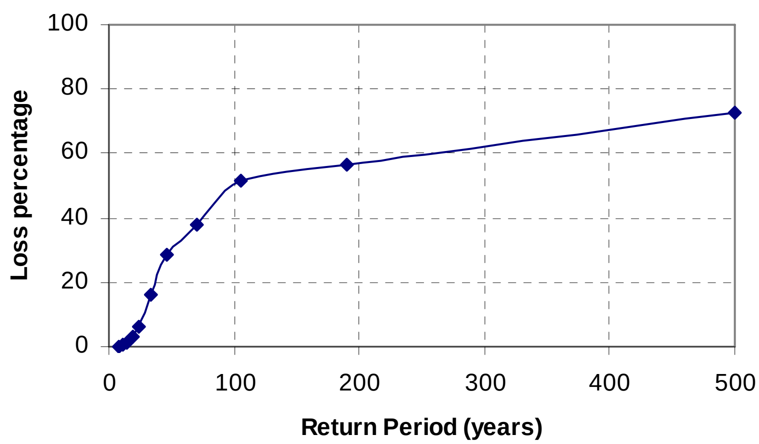
Probable Loss [%]	Name
0.1	PL_{8}
1.9	PL_{11}
3.5	PL_{15}
8.7	PL_{19}
15.4	PL_{24}
31.1	PL_{33}
47.0	PL_{46}
54.7	PL_{70}
67.7	PL_{105}
68.7	PL_{190}
83.3	PL_{500}
2.239	EAL

Figure G- 8 Wood-Zinc House – 2 Story – San Juan – Exposure B – Minimum Topographic Effect



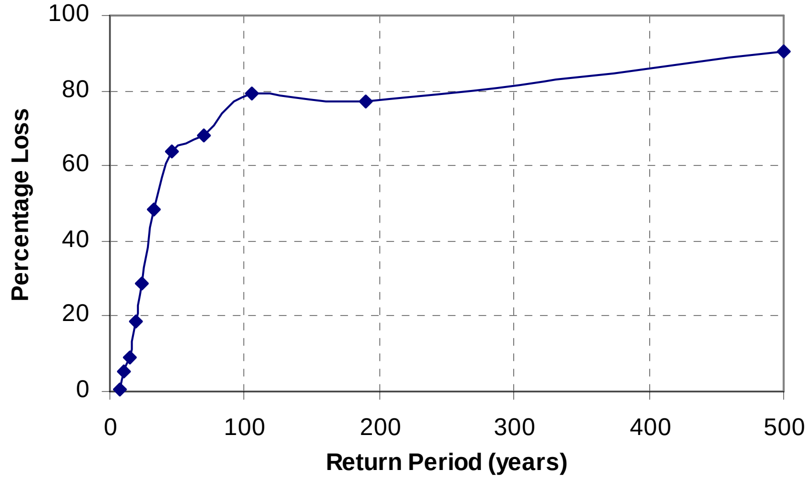
Probable Loss [%]	Name
2.4	PL_8
14.1	PL_{11}
20.2	PL_{15}
35.5	PL_{19}
47.8	PL_{24}
67.9	PL_{33}
79.6	PL_{46}
80.6	PL_{70}
88.1	PL_{105}
85.1	PL_{190}
95.7	PL_{500}
4.650	EAL

Figure G- 9 Wood-Zinc House – 2 Story – San Juan – Exposure B - Maximum Topographic Effect



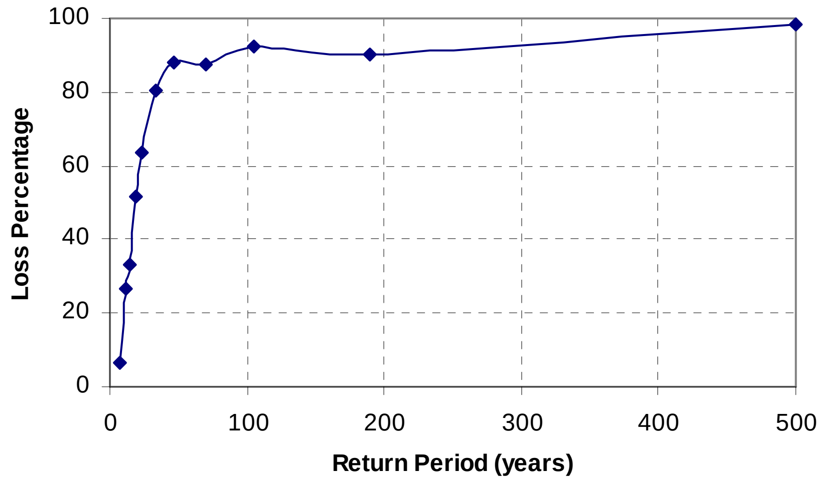
Probable Loss [%]	Name
0.0	PL_8
0.5	PL_{11}
1.0	PL_{15}
3.0	PL_{19}
6.4	PL_{24}
15.8	PL_{33}
28.9	PL_{46}
37.7	PL_{70}
51.7	PL_{105}
56.6	PL_{190}
72.9	PL_{500}
1.414	EAL

Figure G- 10 Wood-Zinc House – 2 Story – San Juan – Exposure C



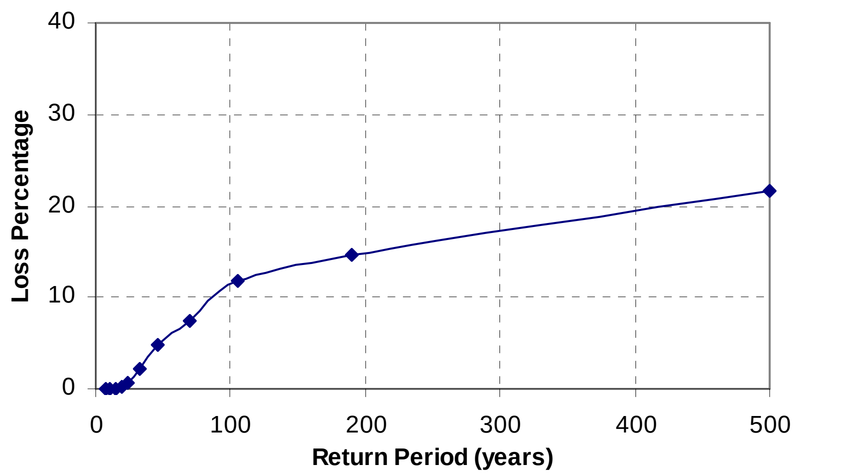
Probable Loss [%]	Name
0.5	PL_{8}
5.2	PL_{11}
8.9	PL_{15}
18.5	PL_{19}
28.5	PL_{24}
48.2	PL_{33}
63.9	PL_{46}
68.3	PL_{70}
79.0	PL_{105}
77.2	PL_{190}
90.2	PL_{500}
3.216	EAL

Figure G- 11 Wood-Zinc House – 2 Story – San Juan – Exposure C – Minimum Topographic effect



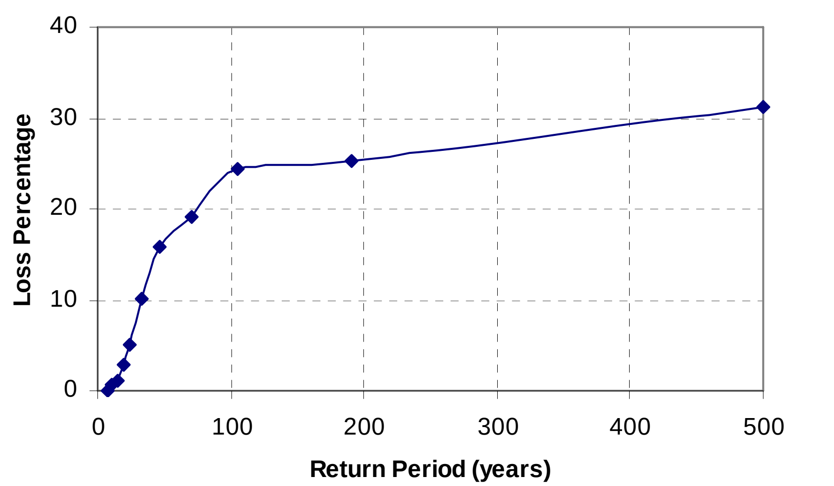
Probable Loss [%]	Name
6.7	PL_{8}
26.7	PL_{11}
33.2	PL_{15}
51.6	PL_{19}
63.7	PL_{24}
80.6	PL_{33}
88.2	PL_{46}
87.6	PL_{70}
92.6	PL_{105}
90.4	PL_{190}
98.1	PL_{500}
6.016	EAL

Figure G- 12 Wood-Zinc House – 2 Story – San Juan – Exposure C – Maximum Topographic effect



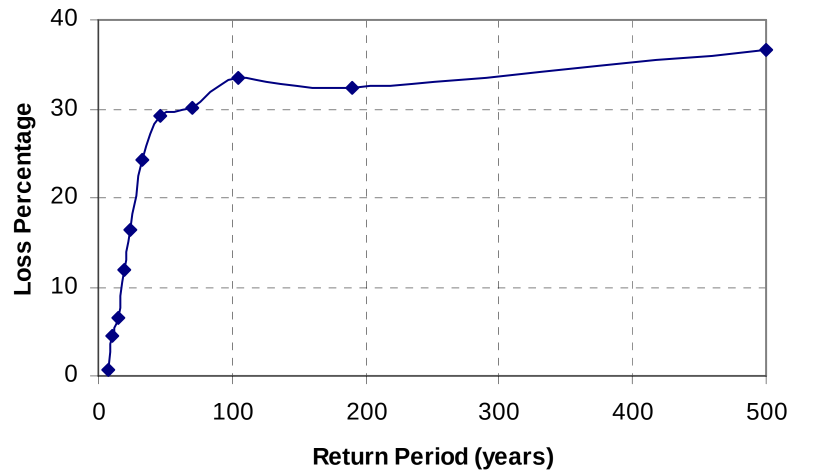
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.1	PL_{15}
0.3	PL_{19}
0.7	PL_{24}
2.3	PL_{33}
4.9	PL_{46}
7.5	PL_{70}
11.8	PL_{105}
14.7	PL_{190}
21.7	PL_{500}
0.283	EAL

Figure G- 13 Mixed House – 2 Story – San Juan – Exposure B



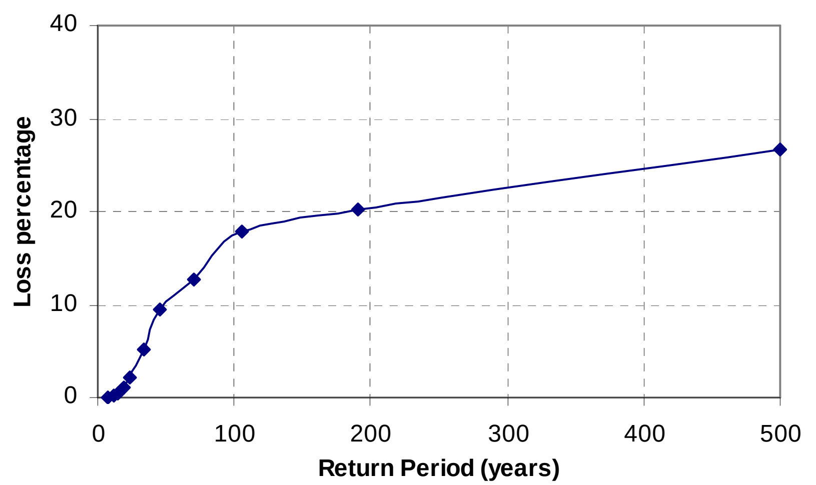
Probable Loss [%]	Name
0.0	PL_8
0.6	PL_{11}
1.2	PL_{15}
2.8	PL_{19}
5.0	PL_{24}
10.2	PL_{33}
15.9	PL_{46}
19.1	PL_{70}
24.3	PL_{105}
25.3	PL_{190}
31.2	PL_{500}
0.773	EAL

Figure G- 14 Mixed House – 2 Story – San Juan – Exposure B - Minimum Topographic Effect



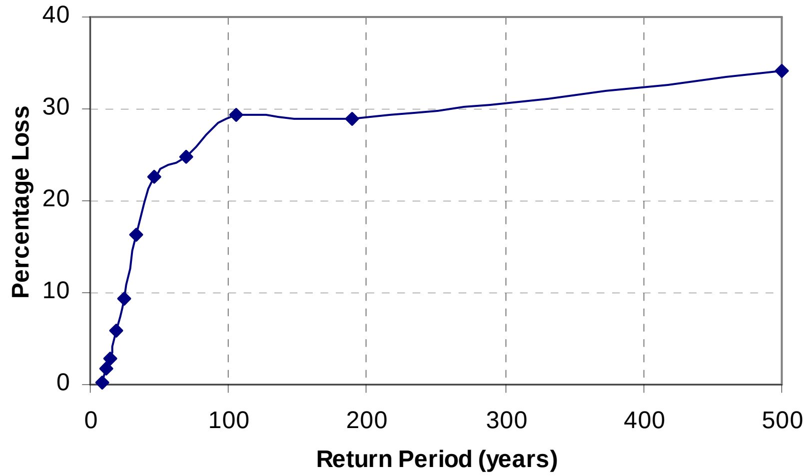
Probable Loss [%]	Name
0.8	PL_8
4.6	PL_{11}
6.6	PL_{15}
11.8	PL_{19}
16.3	PL_{24}
24.2	PL_{33}
29.3	PL_{46}
30.1	PL_{70}
33.4	PL_{105}
32.3	PL_{190}
36.7	PL_{500}
1.652	EAL

Figure G- 15 Mixed House – 2 Story – San Juan – Exposure B - Maximum Topographic Effect



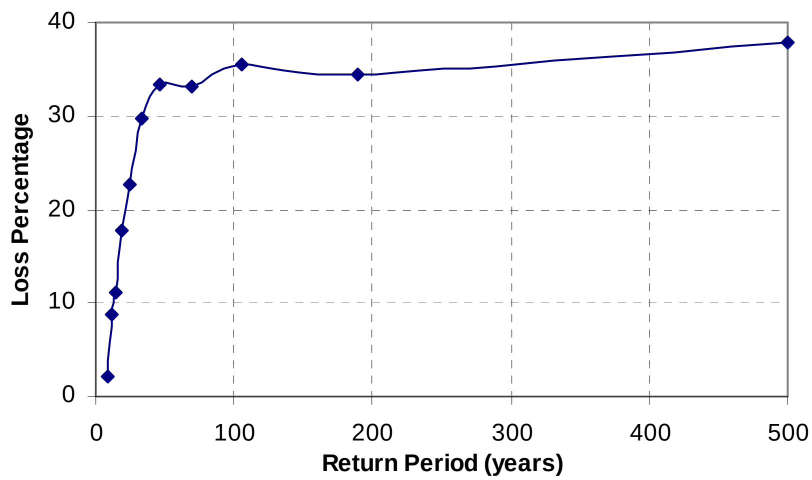
Probable Loss [%]	Name
0.0	PL_8
0.2	PL_{11}
0.3	PL_{15}
1.0	PL_{19}
2.1	PL_{24}
5.1	PL_{33}
9.4	PL_{46}
12.6	PL_{70}
17.9	PL_{105}
20.1	PL_{190}
26.8	PL_{500}
0.479	EAL

Figure G- 16 Mixed House – 2 Story – San Juan – Exposure C



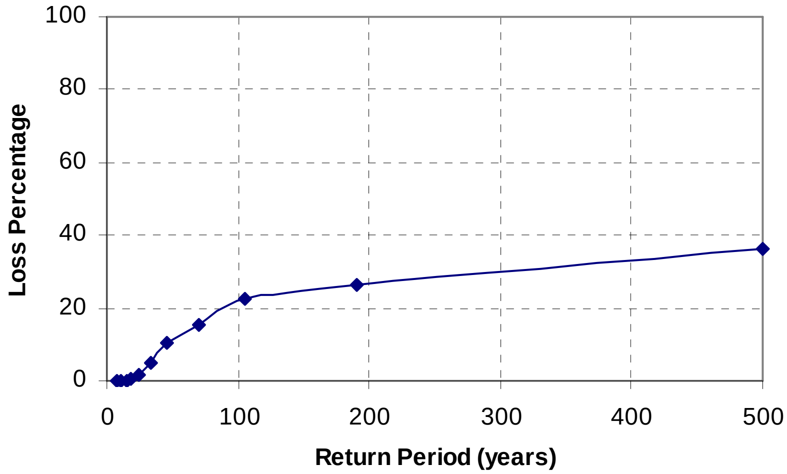
Probable Loss [%]	Name
0.2	PL_{8}
1.7	PL_{11}
2.9	PL_{15}
6.0	PL_{19}
9.3	PL_{24}
16.4	PL_{33}
22.5	PL_{46}
24.8	PL_{70}
29.2	PL_{105}
29.0	PL_{190}
34.2	PL_{500}
1.126	EAL

Figure G- 17 Mixed House – 2 Story – San Juan – Exposure C - Minimum Topographic Effect



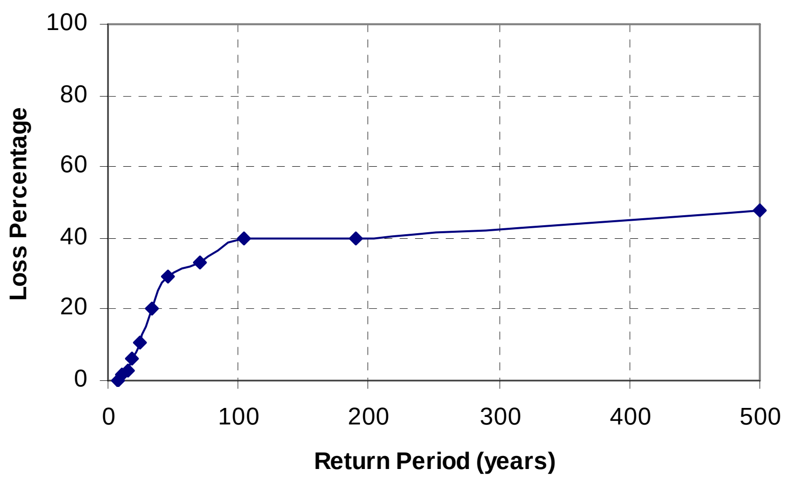
Probable Loss [%]	Name
2.2	PL_{8}
8.8	PL_{11}
11.1	PL_{15}
17.8	PL_{19}
22.6	PL_{24}
29.7	PL_{33}
33.3	PL_{46}
33.2	PL_{70}
35.5	PL_{105}
34.5	PL_{190}
37.9	PL_{500}
2.162	EAL

Figure G- 18 Mixed House – 2 Story – San Juan – Exposure C - Maximum Topographic Effect



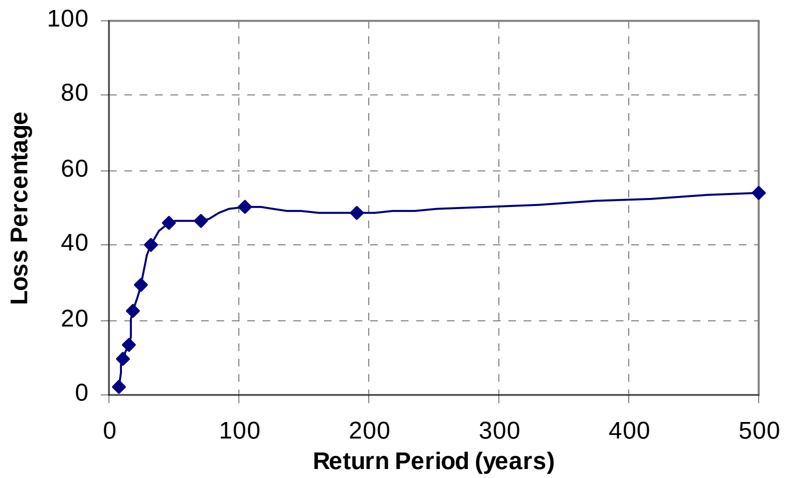
Probable Loss [%]	Name
0.0	PL_{8}
0.1	PL_{11}
0.2	PL_{15}
0.8	PL_{19}
1.8	PL_{24}
5.2	PL_{33}
10.6	PL_{46}
15.1	PL_{70}
22.4	PL_{105}
26.2	PL_{190}
36.0	PL_{500}
0.597	EAL

Figure G- 19 Mixed House – 3 Story – San Juan – Exposure B



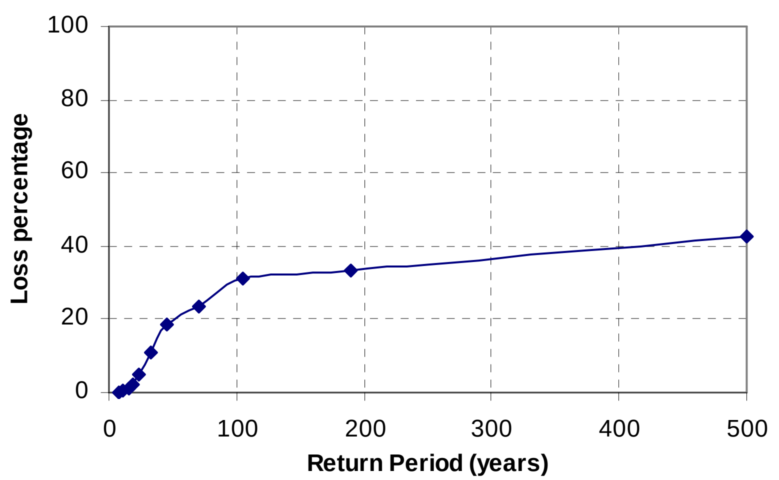
Probable Loss [%]	Name
0.1	PL_{8}
1.5	PL_{11}
2.8	PL_{15}
6.3	PL_{19}
10.6	PL_{24}
20.1	PL_{33}
29.1	PL_{46}
32.9	PL_{70}
39.8	PL_{105}
39.9	PL_{190}
47.8	PL_{500}
1.433	EAL

Figure G- 20 Mixed House – 3 Story – San Juan – Exposure B - Minimum Topographic Effect



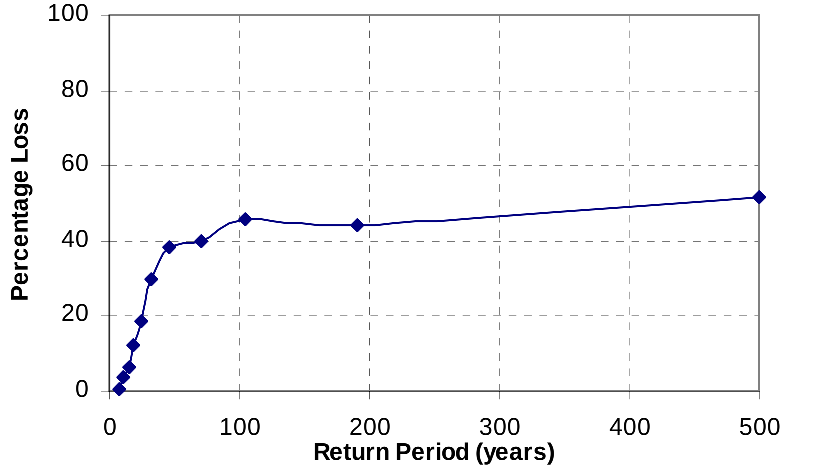
Probable Loss [%]	Name
2.0	PL_{8}
9.8	PL_{11}
13.3	PL_{15}
22.4	PL_{19}
29.3	PL_{24}
40.1	PL_{33}
46.1	PL_{46}
46.3	PL_{70}
50.1	PL_{105}
48.5	PL_{190}
54.0	PL_{500}
2.838	EAL

Figure G- 21 Mixed House – 3 Story – San Juan – Exposure B - Maximum Topographic Effect



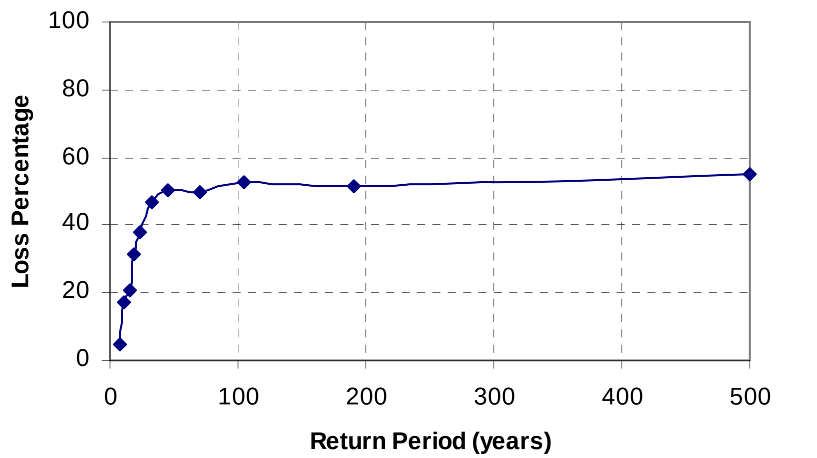
Probable Loss [%]	Name
0.0	PL_{8}
0.4	PL_{11}
0.9	PL_{15}
2.4	PL_{19}
4.8	PL_{24}
11.0	PL_{33}
18.8	PL_{46}
23.6	PL_{70}
31.3	PL_{105}
33.6	PL_{190}
42.5	PL_{500}
0.939	EAL

Figure G- 22 Mixed House – 3 Story – San Juan – Exposure C



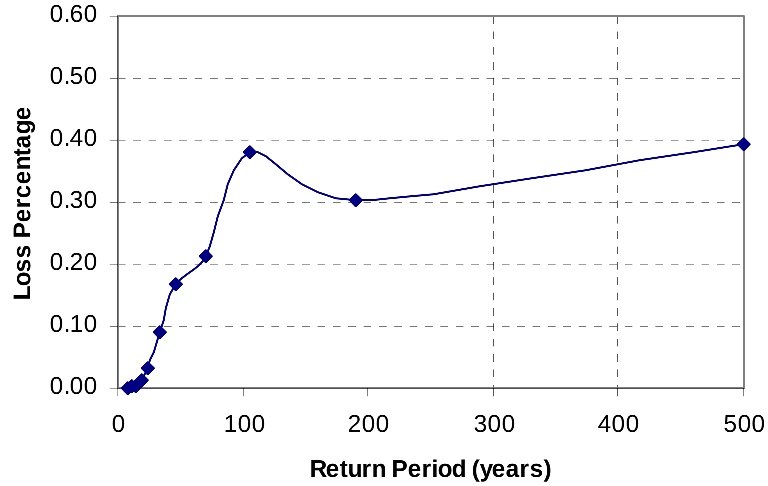
Probable Loss [%]	Name
0.4	PL_8
4.0	PL_{11}
6.3	PL_{15}
12.5	PL_{19}
18.4	PL_{24}
29.7	PL_{33}
38.1	PL_{46}
40.0	PL_{70}
45.6	PL_{105}
44.3	PL_{190}
51.3	PL_{500}
2.010	EAL

Figure G- 23 Mixed House – 3 Story – San Juan – Exposure C - Minimum Topographic Effect



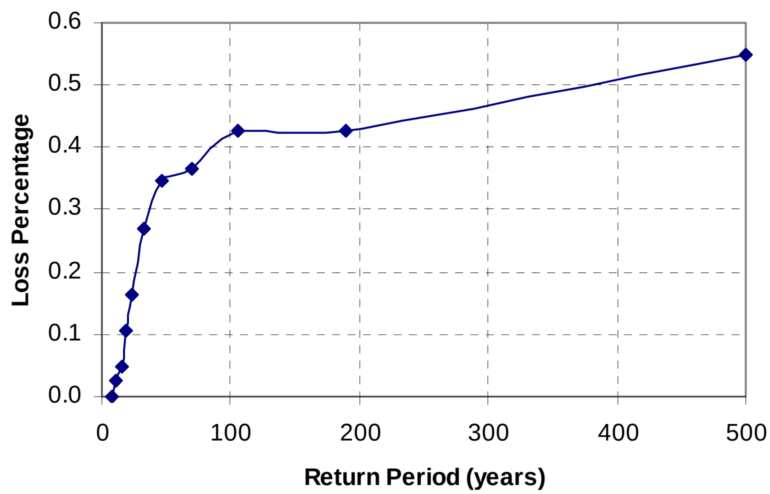
Probable Loss [%]	Name
5.0	PL_8
17.4	PL_{11}
20.8	PL_{15}
31.3	PL_{19}
37.8	PL_{24}
46.6	PL_{33}
50.3	PL_{46}
49.9	PL_{70}
52.4	PL_{105}
51.3	PL_{190}
55.2	PL_{500}
3.606	EAL

Figure G- 24 Mixed House – 3 Story – San Juan – Exposure C - Maximum Topographic Effect



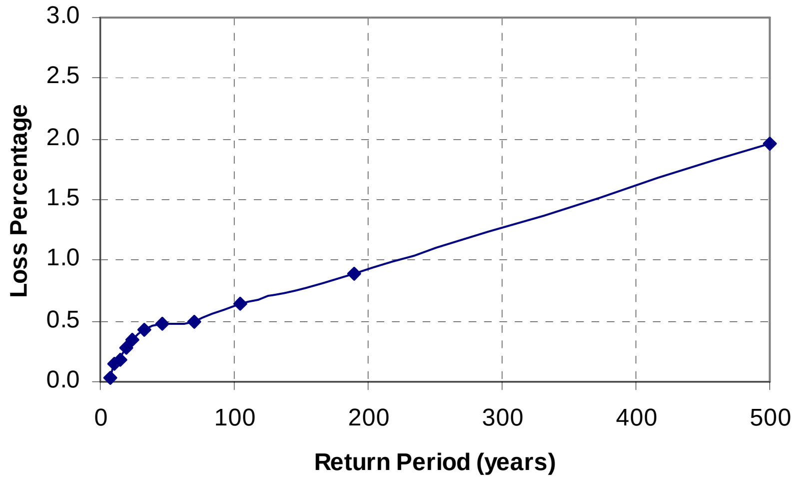
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.01	PL_{19}
0.03	PL_{24}
0.09	PL_{33}
0.17	PL_{46}
0.21	PL_{70}
0.38	PL_{105}
0.30	PL_{190}
0.39	PL_{500}
0.008	EAL

Figure G- 25 Concrete House – 1-3 Story – San Juan – Exposure B



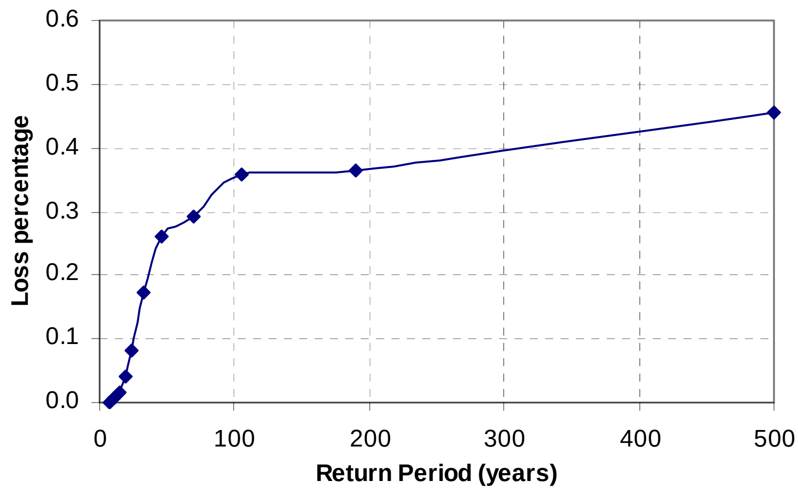
Probable Loss [%]	Name
0.00	PL_8
0.03	PL_{11}
0.05	PL_{15}
0.11	PL_{19}
0.16	PL_{24}
0.27	PL_{33}
0.35	PL_{46}
0.37	PL_{70}
0.43	PL_{105}
0.43	PL_{190}
0.55	PL_{500}
0.018	EAL

Figure G- 26 Concrete House – 1-3 Story – San Juan – Exposure B – Minimum Topographic Effect



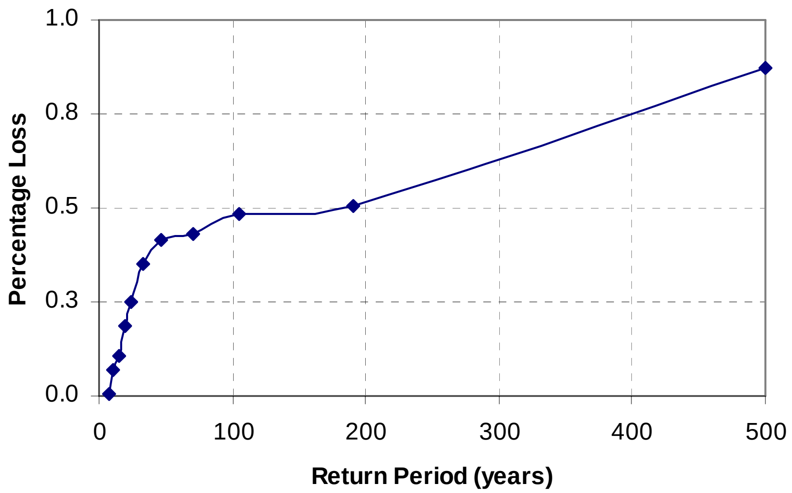
Probable Loss [%]	Name
0.03	PL_8
0.15	PL_{11}
0.19	PL_{15}
0.28	PL_{19}
0.34	PL_{24}
0.43	PL_{33}
0.48	PL_{46}
0.50	PL_{70}
0.64	PL_{105}
0.90	PL_{190}
1.97	PL_{500}
0.041	EAL

Figure G- 27 Concrete House – 1-3 Story – San Juan – Exposure B – Maximum Topographic Effect



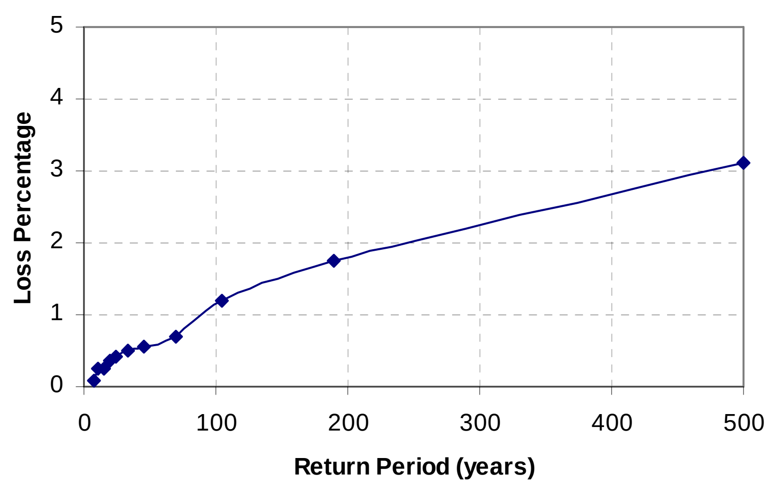
Probable Loss [%]	Name
0.00	PL_8
0.01	PL_{11}
0.01	PL_{15}
0.04	PL_{19}
0.08	PL_{24}
0.17	PL_{33}
0.26	PL_{46}
0.29	PL_{70}
0.36	PL_{105}
0.36	PL_{190}
0.46	PL_{500}
0.012	EAL

Figure G- 28 Concrete House – 1-3 Story – San Juan – Exposure C



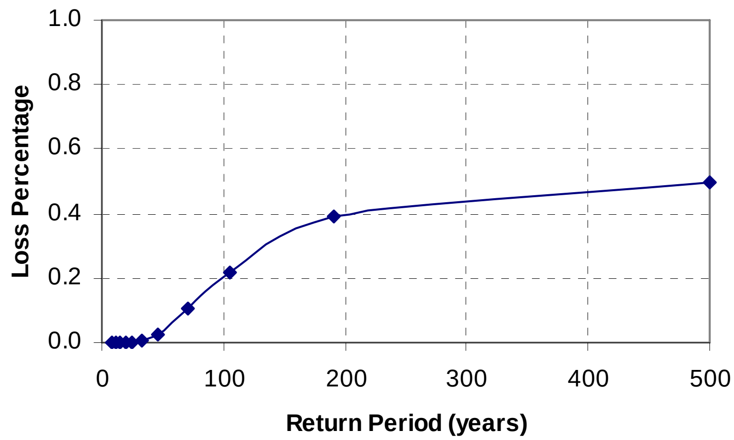
Probable Loss [%]	Name
0.01	PL_{8}
0.07	PL_{11}
0.10	PL_{15}
0.19	PL_{19}
0.25	PL_{24}
0.35	PL_{33}
0.41	PL_{46}
0.43	PL_{70}
0.48	PL_{105}
0.51	PL_{190}
0.87	PL_{500}
0.026	EAL

Figure G- 29 Concrete House – 1-3 Story – San Juan – Exposure C – Minimum Topographic Effect



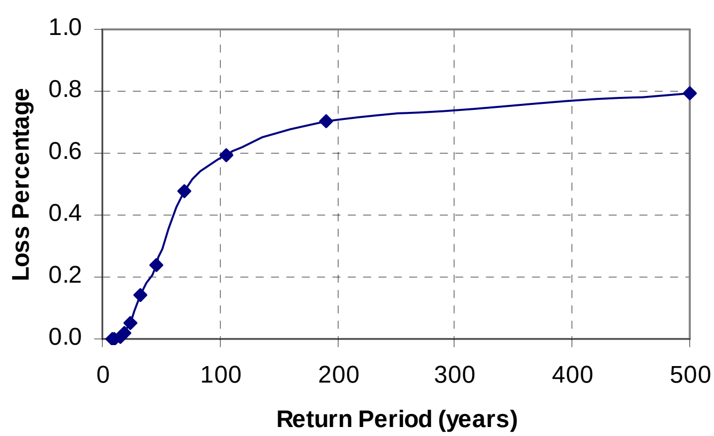
Probable Loss [%]	Name
0.09	PL_{8}
0.24	PL_{11}
0.26	PL_{15}
0.35	PL_{19}
0.41	PL_{24}
0.49	PL_{33}
0.55	PL_{46}
0.69	PL_{70}
1.19	PL_{105}
1.76	PL_{190}
3.12	PL_{500}
0.059	EAL

Figure G- 30 Concrete House – 1-3 Story – San Juan – Exposure C – Maximum Topographic Effect



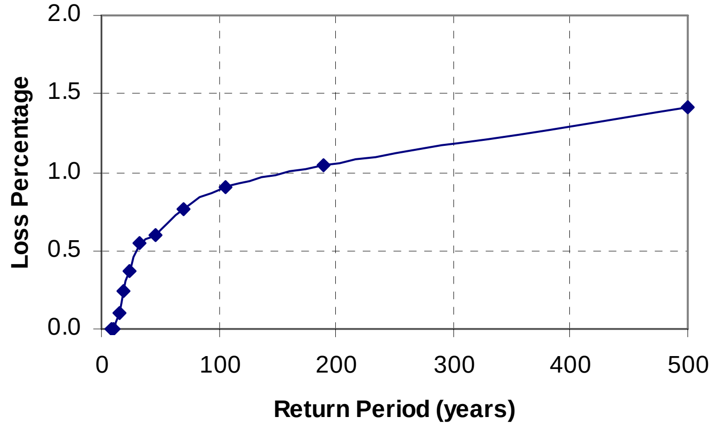
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.00	PL_{19}
0.00	PL_{24}
0.01	PL_{33}
0.02	PL_{46}
0.10	PL_{70}
0.22	PL_{105}
0.39	PL_{190}
0.49	PL_{500}
0.005	EAL

Figure G- 31 Multistory Concrete – 4-7 Story – San Juan – Exposure B



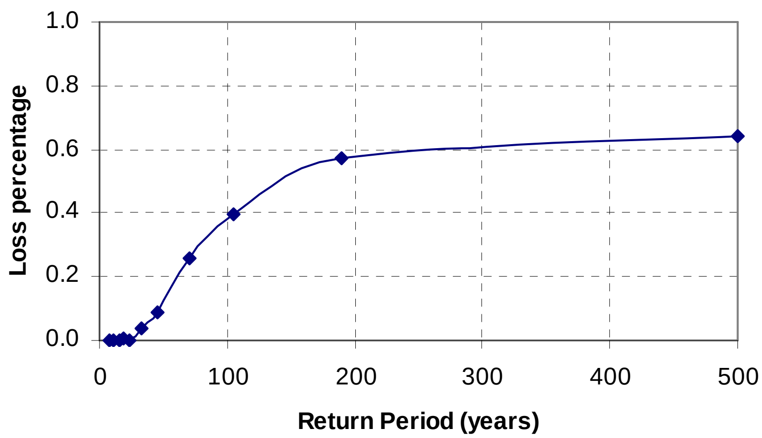
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.02	PL_{19}
0.05	PL_{24}
0.14	PL_{33}
0.24	PL_{46}
0.48	PL_{70}
0.59	PL_{105}
0.71	PL_{190}
0.79	PL_{500}
0.015	EAL

Figure G- 32 Multistory Concrete – 4-7 Story – San Juan – Exposure B – Minimum Topographic Effect



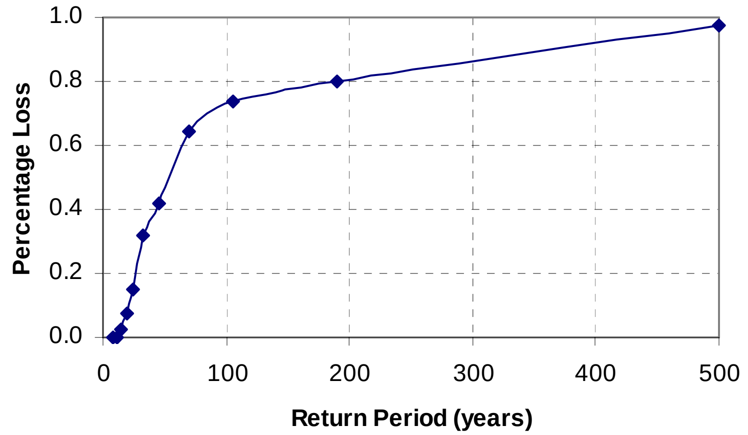
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.11	PL_{15}
0.25	PL_{19}
0.37	PL_{24}
0.55	PL_{33}
0.60	PL_{46}
0.77	PL_{70}
0.91	PL_{105}
1.05	PL_{190}
1.41	PL_{500}
0.036	EAL

Figure G- 33 Multistory Concrete – 4-7 Story – San Juan – Exposure B – Maximum Topographic Effect



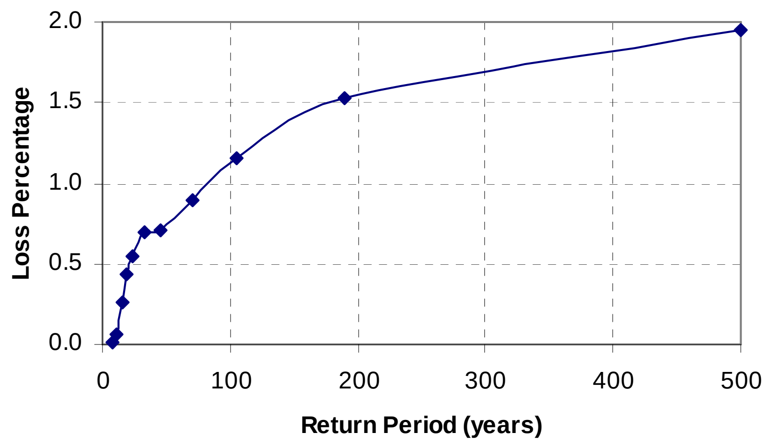
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.3	PL_{15}
0.4	PL_{19}
0.6	PL_{24}
0.7	PL_{33}
0.7	PL_{46}
0.9	PL_{70}
1.2	PL_{105}
1.5	PL_{190}
2.0	PL_{500}
0.053	EAL

Figure G- 34 Multistory Concrete – 4-7 Story – San Juan – Exposure C



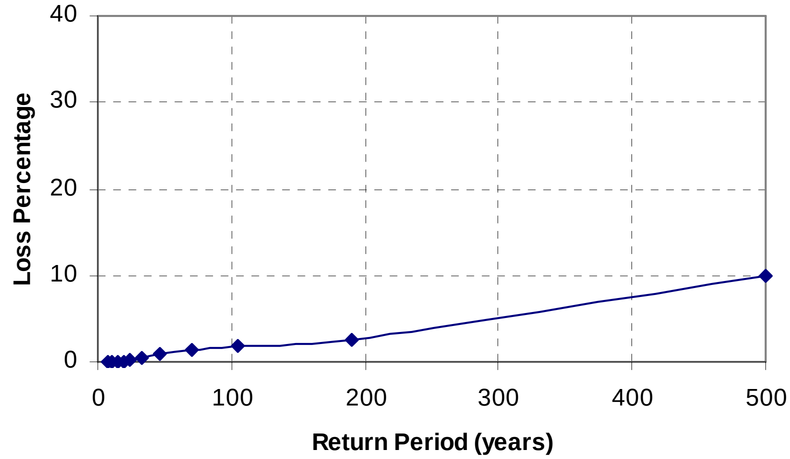
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.02	PL_{15}
0.08	PL_{19}
0.15	PL_{24}
0.32	PL_{33}
0.42	PL_{46}
0.64	PL_{70}
0.74	PL_{105}
0.80	PL_{190}
0.97	PL_{500}
0.023	EAL

Figure G- 35 Multistory Concrete – 4-7 Story – San Juan – Exposure C – Minimum Topographic Effect



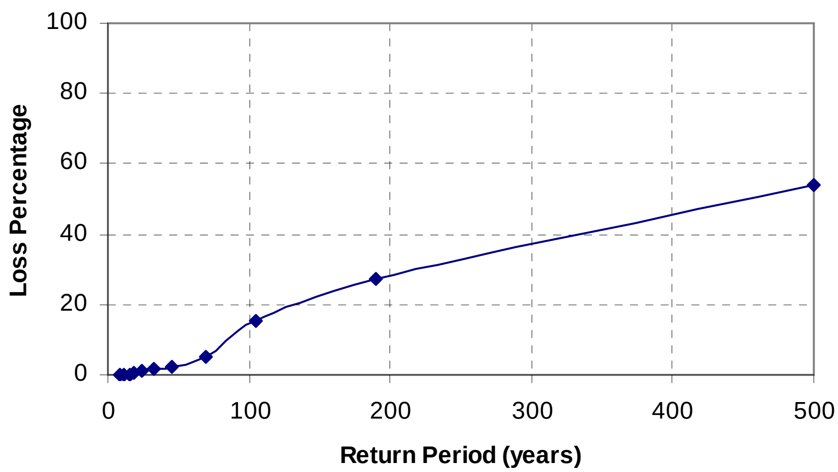
Probable Loss [%]	Name
0.01	PL_8
0.06	PL_{11}
0.26	PL_{15}
0.44	PL_{19}
0.55	PL_{24}
0.69	PL_{33}
0.71	PL_{46}
0.89	PL_{70}
1.15	PL_{105}
1.53	PL_{190}
1.95	PL_{500}
0.053	EAL

Figure G- 36 Multistory Concrete – 4-7 Story – San Juan – Exposure C – Maximum Topographic Effect



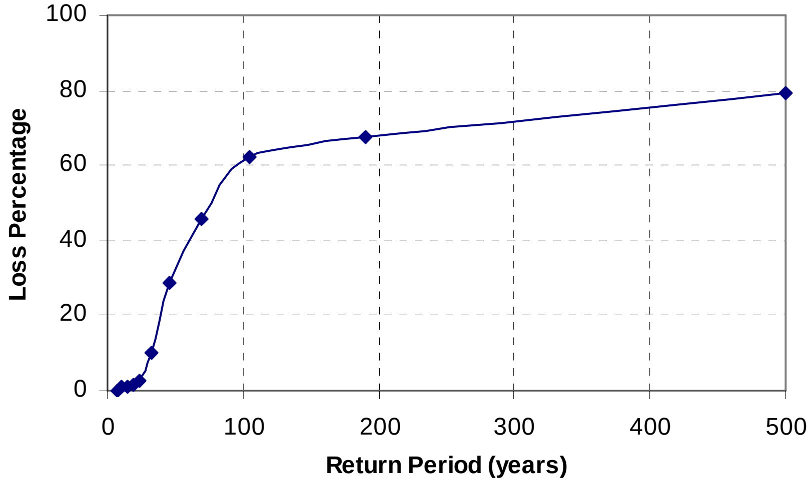
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.0	PL_{19}
0.1	PL_{24}
0.5	PL_{33}
1.0	PL_{46}
1.3	PL_{70}
1.8	PL_{105}
2.5	PL_{190}
10.0	PL_{500}
0.076	EAL

Figure G- 37 Small Institutional – San Juan – Exposure B



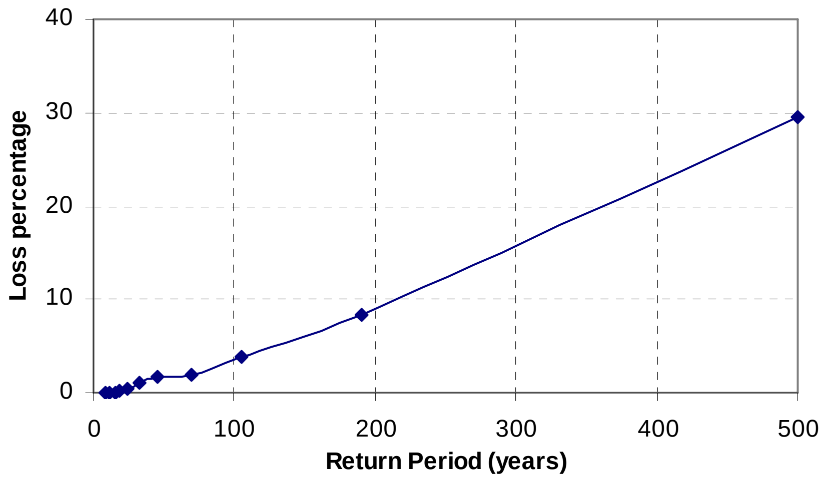
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.2	PL_{15}
0.6	PL_{19}
1.0	PL_{24}
1.7	PL_{33}
2.5	PL_{46}
5.0	PL_{70}
15.3	PL_{105}
27.5	PL_{190}
53.8	PL_{500}
0.460	EAL

Figure G- 38 Small Institutional – San Juan – Exposure B – Minimum Topographic Effect



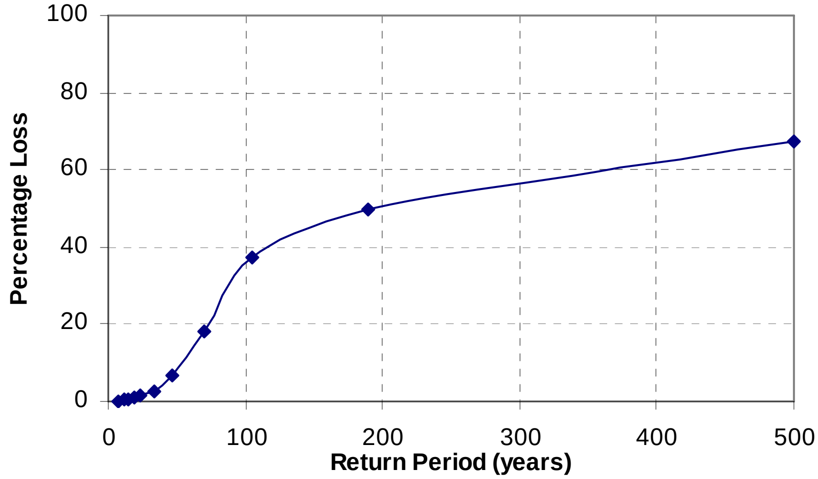
Probable Loss [%]	Name
0.1	PL_{8}
0.9	PL_{11}
1.1	PL_{15}
1.8	PL_{19}
2.9	PL_{24}
10.1	PL_{33}
28.5	PL_{46}
45.9	PL_{70}
62.3	PL_{105}
67.7	PL_{190}
79.3	PL_{500}
1.539	EAL

Figure G- 39 Small Institutional – San Juan – Exposure B – Maximum Topographic Effect



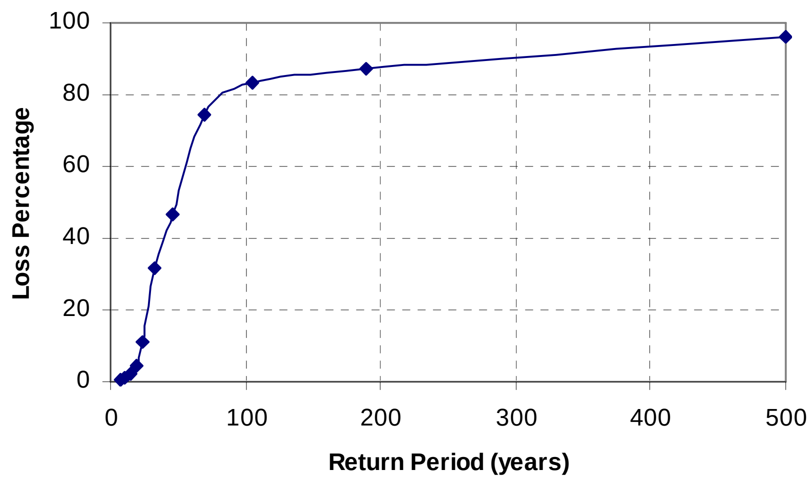
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.0	PL_{15}
0.2	PL_{19}
0.4	PL_{24}
1.0	PL_{33}
1.6	PL_{46}
1.9	PL_{70}
3.9	PL_{105}
8.4	PL_{190}
29.5	PL_{500}
0.199	EAL

Figure G- 40 Small Institutional – San Juan – Exposure C



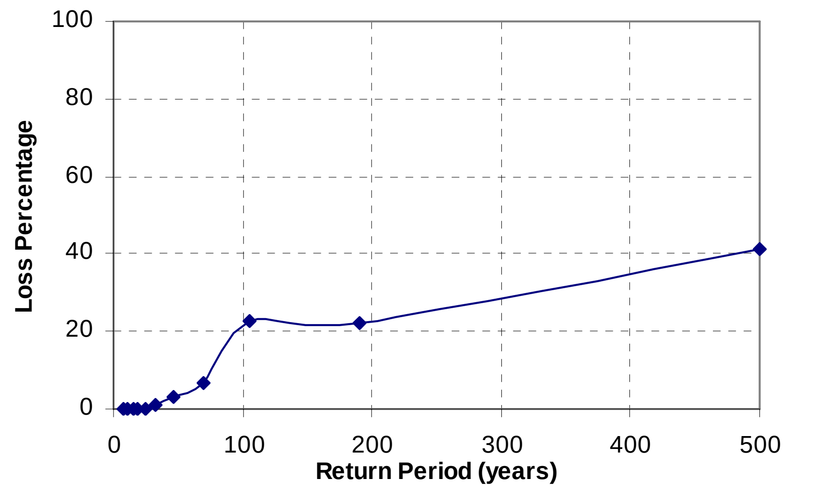
Probable Loss [%]	Name
0.0	PL_{8}
0.3	PL_{11}
0.6	PL_{15}
1.1	PL_{19}
1.5	PL_{24}
2.6	PL_{33}
7.0	PL_{46}
17.9	PL_{70}
37.1	PL_{105}
49.6	PL_{190}
67.4	PL_{500}
0.842	EAL

Figure G- 41 Small Institutional – San Juan – Exposure C – Minimum Topographic Effect



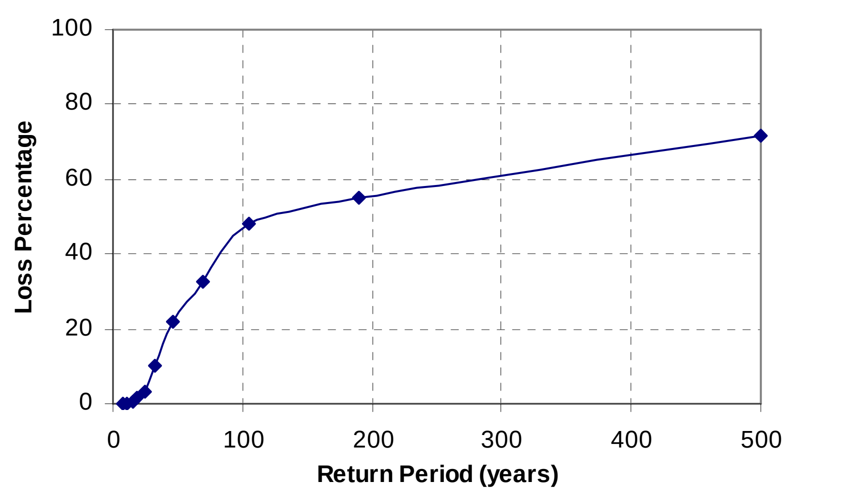
Probable Loss [%]	Name
0.5	PL_{8}
1.6	PL_{11}
1.7	PL_{15}
3.7	PL_{19}
9.6	PL_{24}
31.3	PL_{33}
57.0	PL_{46}
65.0	PL_{70}
77.2	PL_{105}
74.1	PL_{190}
88.5	PL_{500}
2.356	EAL

Figure G- 42 Small Institutional – San Juan – Exposure C – Maximum Topographic Effect



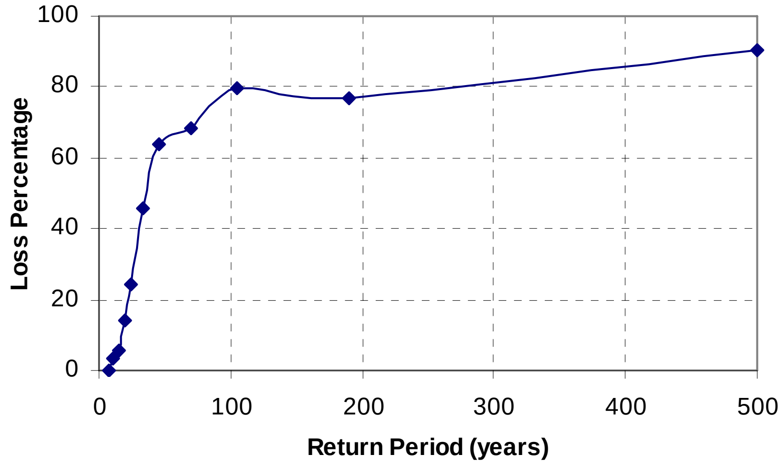
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.1	PL_{19}
0.3	PL_{24}
1.0	PL_{33}
3.0	PL_{46}
6.5	PL_{70}
22.9	PL_{105}
21.9	PL_{190}
41.1	PL_{500}
0.413	EAL

Figure G- 43 Large Institutional – San Juan – Exposure B



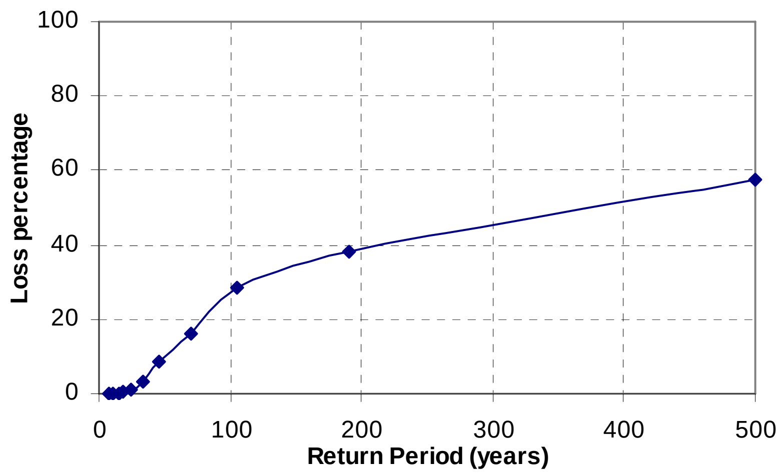
Probable Loss [%]	Name
0.0	PL_8
0.2	PL_{11}
0.4	PL_{15}
1.4	PL_{19}
3.3	PL_{24}
10.1	PL_{33}
21.9	PL_{46}
32.8	PL_{70}
48.1	PL_{105}
55.1	PL_{190}
71.6	PL_{500}
1.230	EAL

Figure G- 44 Large Institutional – San Juan – Exposure B – Minimum Topographic Effect



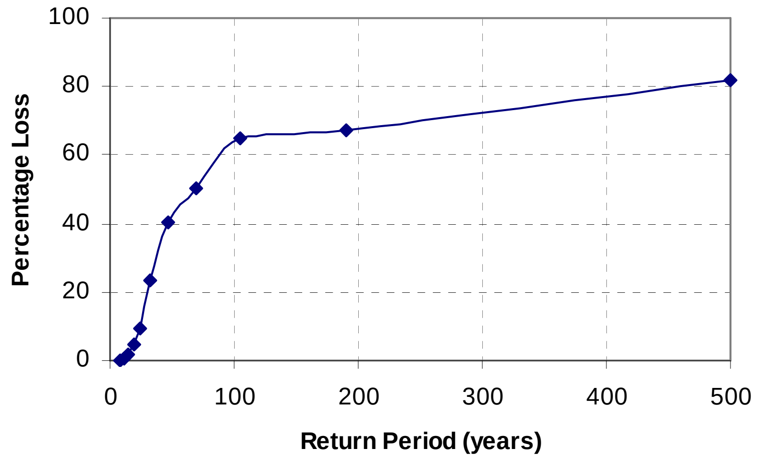
Probable Loss [%]	Name
0.3	PL_8
3.2	PL_{11}
5.8	PL_{15}
14.1	PL_{19}
24.3	PL_{24}
45.9	PL_{33}
63.9	PL_{46}
68.6	PL_{70}
79.8	PL_{105}
76.9	PL_{190}
90.6	PL_{500}
3.022	EAL

Figure G- 45 Large Institutional – San Juan – Exposure B – Maximum Topographic Effect



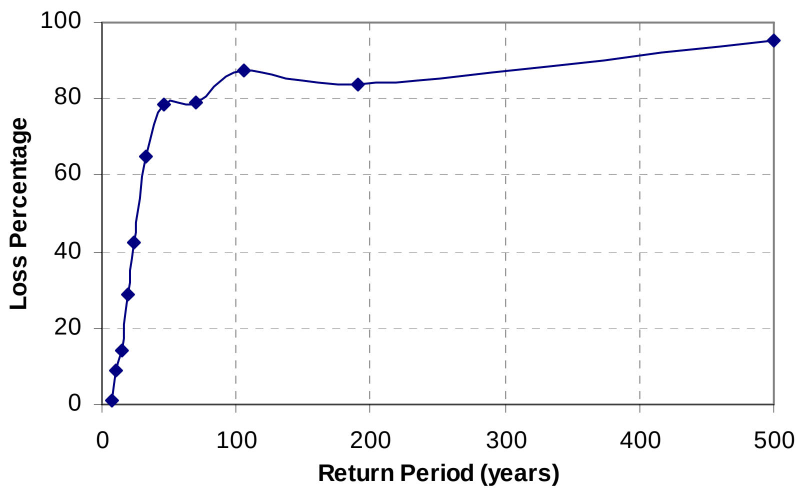
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.1	PL_{15}
0.4	PL_{19}
0.9	PL_{24}
3.2	PL_{33}
8.8	PL_{46}
16.0	PL_{70}
28.7	PL_{105}
37.9	PL_{190}
57.4	PL_{500}
0.699	EAL

Figure G- 46 Large Institutional – San Juan – Exposure C



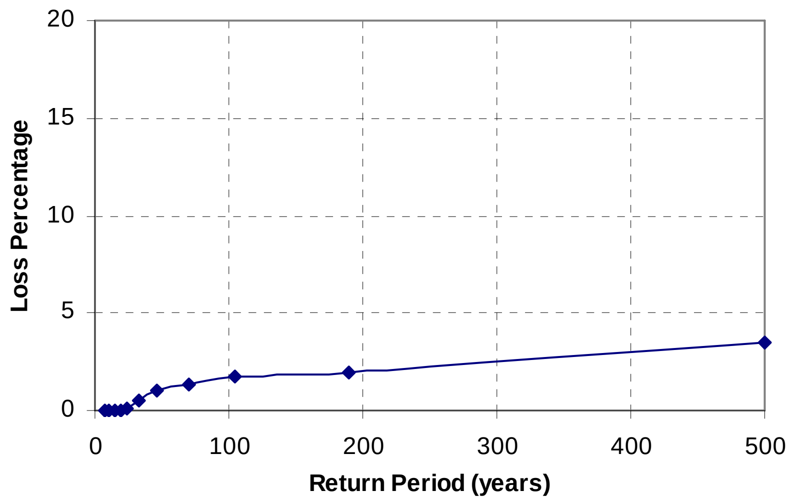
Probable Loss [%]	Name
0.1	PL_{8}
0.8	PL_{11}
1.5	PL_{15}
4.4	PL_{19}
9.3	PL_{24}
23.2	PL_{33}
40.4	PL_{46}
50.5	PL_{70}
64.9	PL_{105}
67.1	PL_{190}
81.6	PL_{500}
1.918	EAL

Figure G- 47 Large Institutional – San Juan – Exposure C – Minimum Topographic Effect



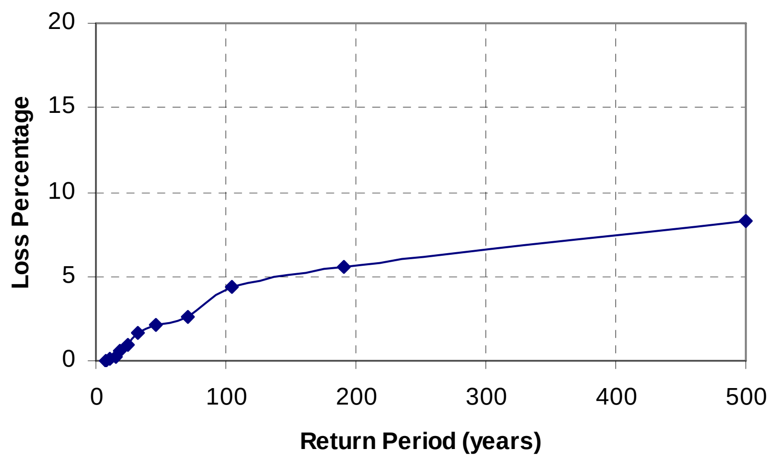
Probable Loss [%]	Name
1.0	PL_{8}
8.7	PL_{11}
14.2	PL_{15}
28.7	PL_{19}
42.2	PL_{24}
64.7	PL_{33}
78.8	PL_{46}
79.2	PL_{70}
87.6	PL_{105}
83.6	PL_{190}
95.5	PL_{500}
4.188	EAL

Figure G- 48 Large Institutional – San Juan – Exposure C – Maximum Topographic Effect



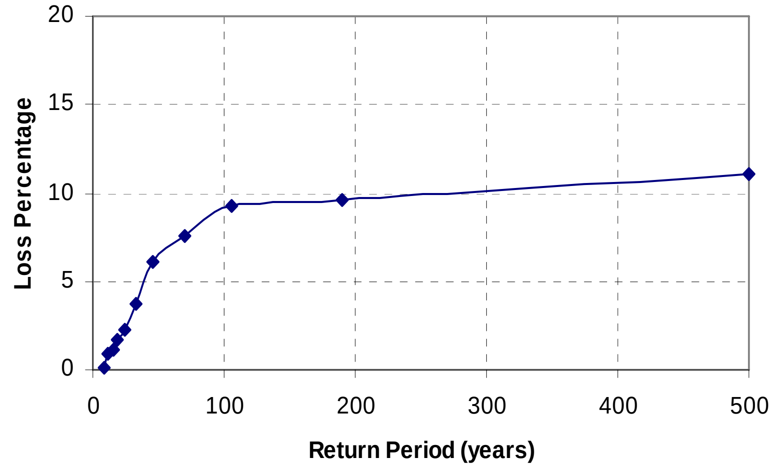
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.0	PL_{19}
0.1	PL_{24}
0.5	PL_{33}
1.0	PL_{46}
1.3	PL_{70}
1.7	PL_{105}
1.9	PL_{190}
3.5	PL_{500}
0.050	EAL

Figure G- 49 Mixed Institutional – San Juan – Exposure B



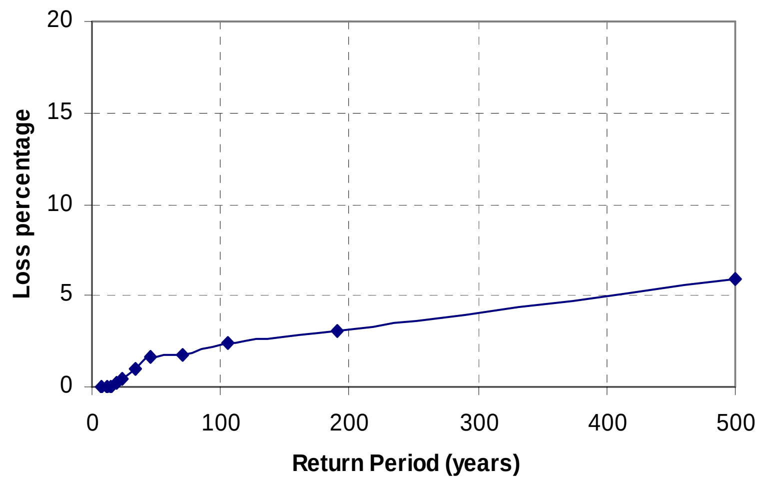
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.2	PL_{15}
0.6	PL_{19}
1.0	PL_{24}
1.7	PL_{33}
2.2	PL_{46}
2.6	PL_{70}
4.3	PL_{105}
5.5	PL_{190}
8.3	PL_{500}
0.146	EAL

Figure G- 50 Mixed Institutional – San Juan – Exposure B – Minimum Topographic Effect



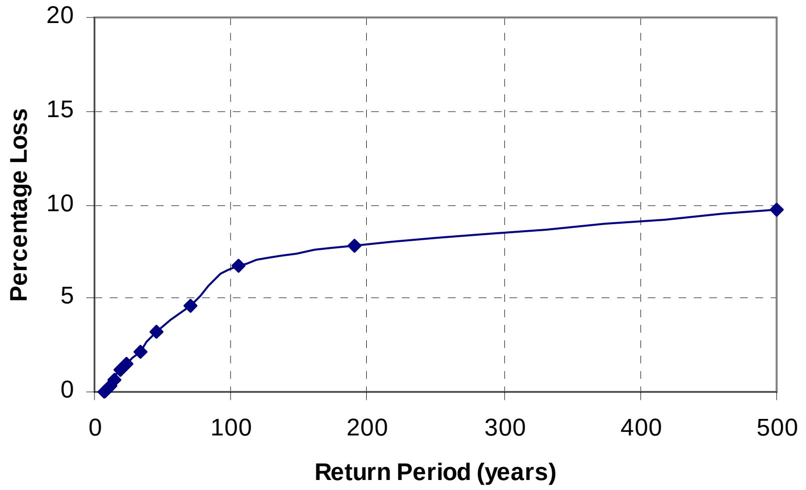
Probable Loss [%]	Name
0.1	PL_8
0.9	PL_{11}
1.1	PL_{15}
1.7	PL_{19}
2.2	PL_{24}
3.7	PL_{33}
6.1	PL_{46}
7.6	PL_{70}
9.3	PL_{105}
9.6	PL_{190}
11.1	PL_{500}
0.346	EAL

Figure G- 51 Mixed Institutional – San Juan – Exposure B – Maximum Topographic Effect



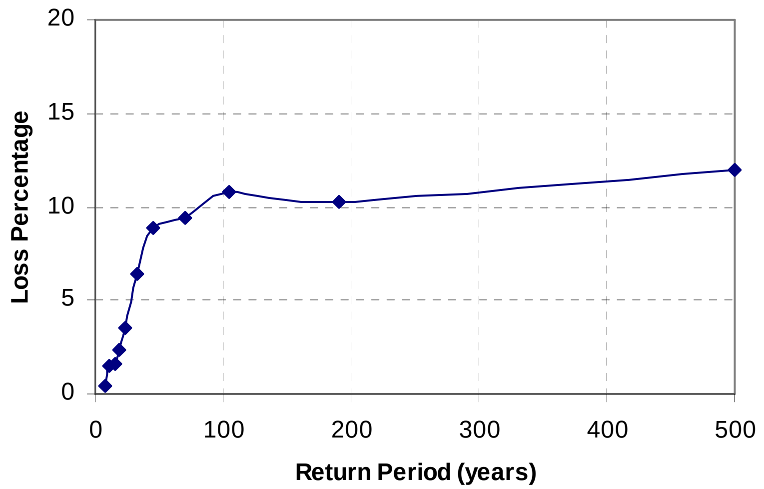
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.2	PL_{19}
0.4	PL_{24}
1.0	PL_{33}
1.6	PL_{46}
1.8	PL_{70}
2.4	PL_{105}
3.1	PL_{190}
5.9	PL_{500}
0.087	EAL

Figure G- 52 Mixed Institutional – San Juan – Exposure C



Probable Loss [%]	Name
0.0	PL_8
0.3	PL_{11}
0.6	PL_{15}
1.1	PL_{19}
1.5	PL_{24}
2.2	PL_{33}
3.2	PL_{46}
4.6	PL_{70}
6.7	PL_{105}
7.8	PL_{190}
9.7	PL_{500}
0.222	EAL

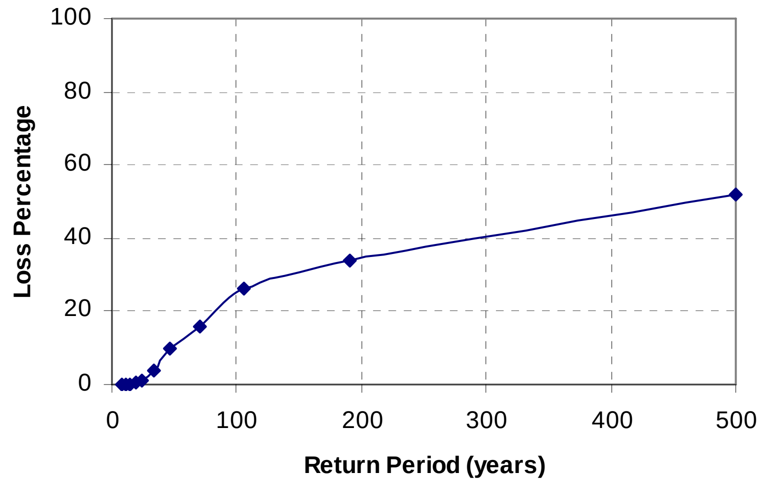
Figure G- 53 Mixed Institutional – San Juan – Exposure C – Minimum Topographic Effect



Probable Loss [%]	Name
0.5	PL_8
1.5	PL_{11}
1.6	PL_{15}
2.4	PL_{19}
3.6	PL_{24}
6.4	PL_{33}
8.9	PL_{46}
9.5	PL_{70}
10.8	PL_{105}
10.3	PL_{190}
11.9	PL_{500}
0.474	EAL

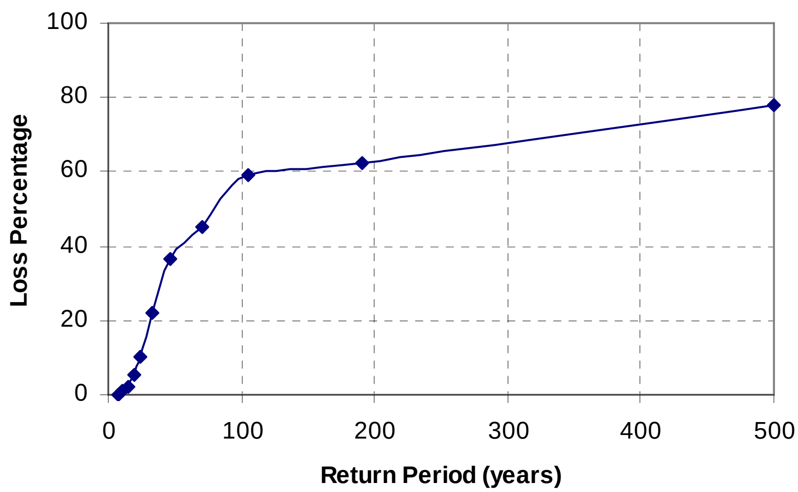
Figure G- 54 Mixed Institutional – San Juan – Exposure C – Maximum Topographic Effect

Appendix H Hurricane Loss Curves for Arecibo



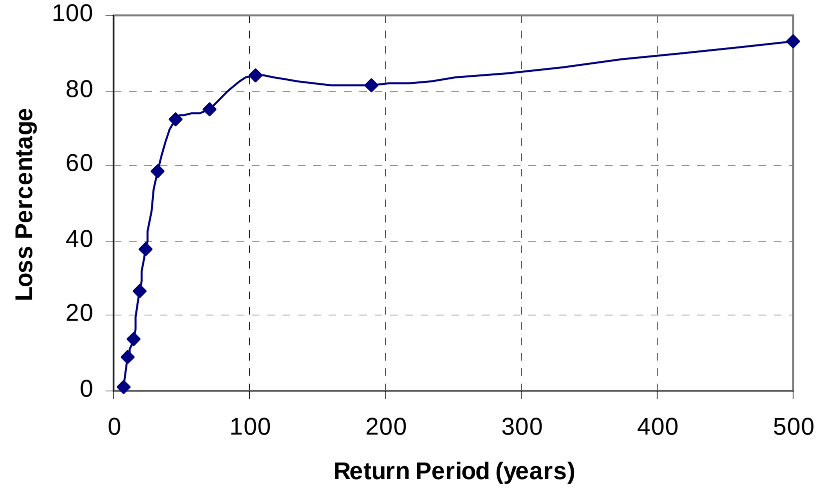
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.1	PL_{15}
0.4	PL_{19}
1.2	PL_{24}
4.1	PL_{33}
9.7	PL_{46}
15.8	PL_{70}
26.5	PL_{105}
34.0	PL_{190}
52.1	PL_{500}
0.609	EAL

Figure H- 1 Wood-Zinc House – 1 Story – Arecibo – Exposure B



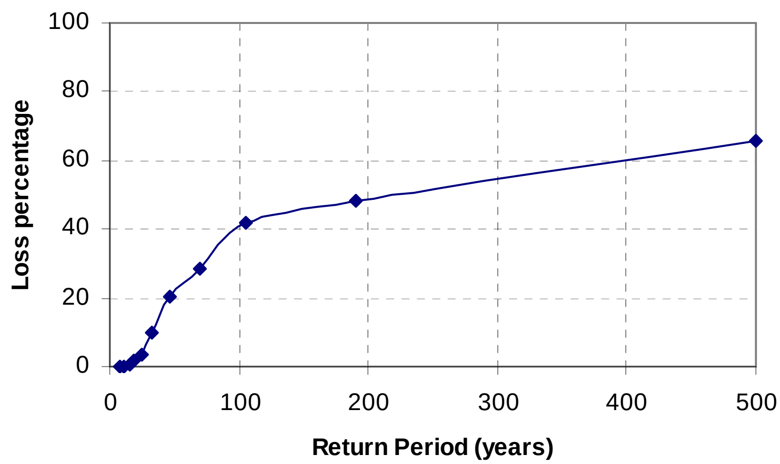
Probable Loss [%]	Name
0.0	PL_8
1.0	PL_{11}
2.0	PL_{15}
5.3	PL_{19}
10.0	PL_{24}
22.1	PL_{33}
36.5	PL_{46}
45.4	PL_{70}
59.1	PL_{105}
62.4	PL_{190}
77.9	PL_{500}
1.765	EAL

Figure H- 2 Wood-Zinc House – 1 Story – Arecibo – Exposure B – Minimum Topographic effect



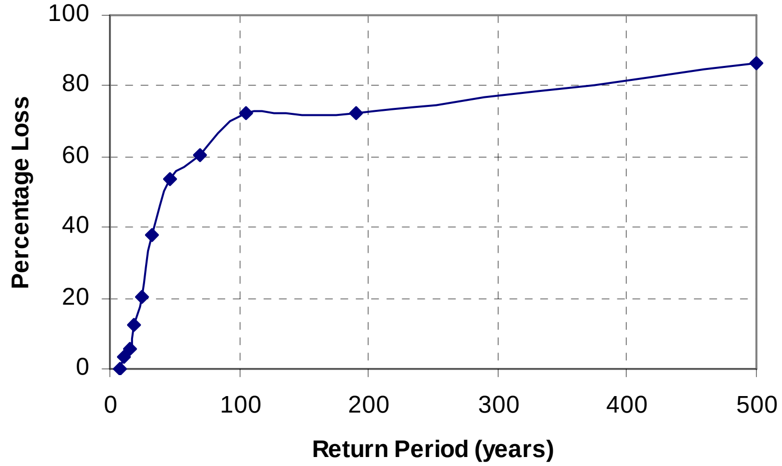
Probable Loss [%]	Name
1.3	PL_8
9.2	PL_{11}
14.0	PL_{15}
26.5	PL_{19}
37.9	PL_{24}
58.3	PL_{33}
72.4	PL_{46}
75.0	PL_{70}
84.1	PL_{105}
81.4	PL_{190}
93.3	PL_{500}
3.911	EAL

Figure H- 3 Wood-Zinc House – 1 Story – Arecibo – Exposure B – Maximum Topographic effect



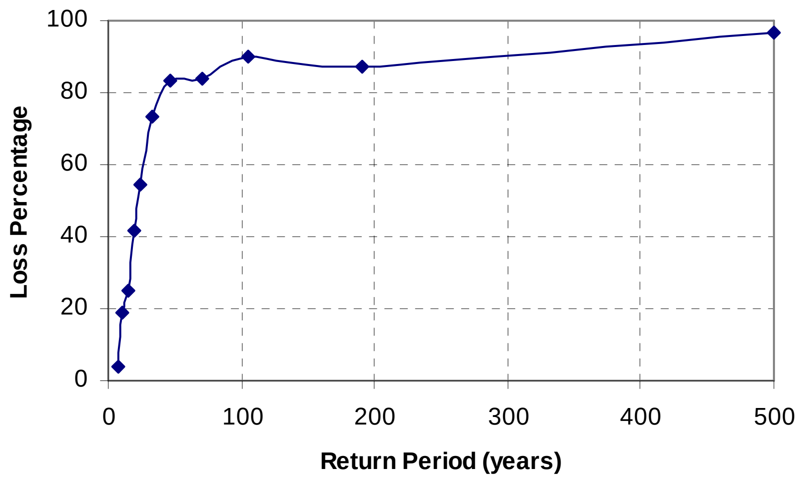
Probable Loss [%]	Name
0.0	PL_8
0.3	PL_{11}
0.5	PL_{15}
1.7	PL_{19}
3.8	PL_{24}
10.2	PL_{33}
20.3	PL_{46}
28.6	PL_{70}
41.9	PL_{105}
48.5	PL_{190}
65.8	PL_{500}
1.066	EAL

Figure H- 4 Wood-Zinc House – 1 Story – Arecibo – Exposure C



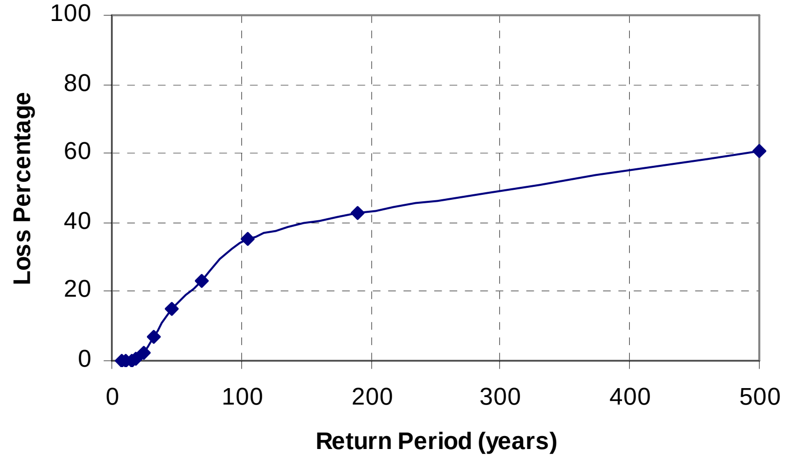
Probable Loss [%]	Name
0.2	PL_8
3.1	PL_{11}
5.5	PL_{15}
12.3	PL_{19}
20.3	PL_{24}
37.7	PL_{33}
53.9	PL_{46}
60.4	PL_{70}
72.6	PL_{105}
72.3	PL_{190}
86.3	PL_{500}
2.617	EAL

Figure H- 5 Wood-Zinc House – 1 Story – Arecibo – Exposure C - Minimum Topographic effect



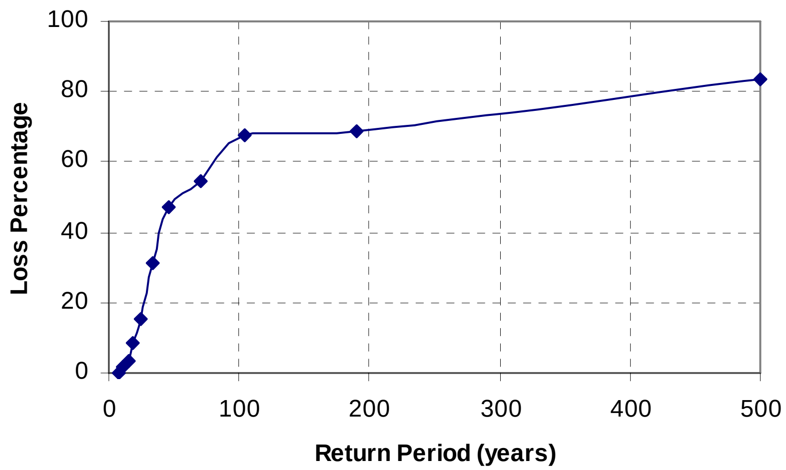
Probable Loss [%]	Name
4.0	PL_8
18.9	PL_{11}
25.1	PL_{15}
41.9	PL_{19}
54.4	PL_{24}
73.3	PL_{33}
83.6	PL_{46}
83.6	PL_{70}
90.1	PL_{105}
87.3	PL_{190}
96.8	PL_{500}
5.195	EAL

Figure H- 6 Wood-Zinc House – 1 Story – Arecibo – Exposure C - Maximum Topographic effect



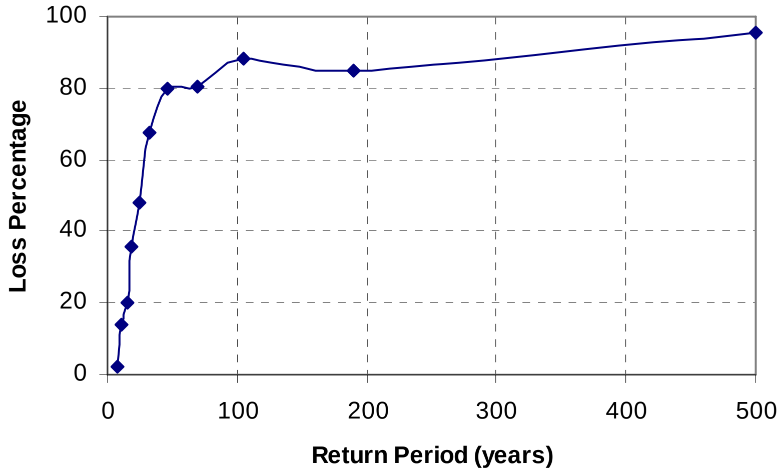
Probable Loss [%]	Name
0.0	PL_{8}
0.1	PL_{11}
0.2	PL_{15}
0.9	PL_{19}
2.2	PL_{24}
6.9	PL_{33}
15.2	PL_{46}
22.9	PL_{70}
35.5	PL_{105}
42.9	PL_{190}
60.7	PL_{500}
0.852	EAL

Figure H- 7 Wood-Zinc House – 2 Story – Arecibo – Exposure B



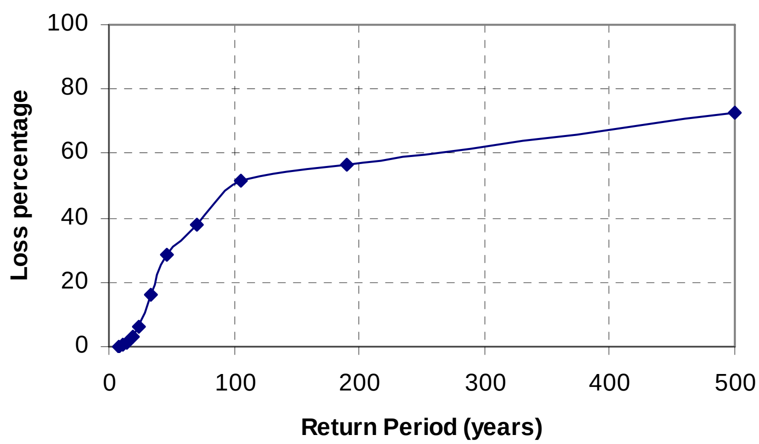
Probable Loss [%]	Name
0.1	PL_{8}
1.9	PL_{11}
3.5	PL_{15}
8.7	PL_{19}
15.4	PL_{24}
31.1	PL_{33}
47.0	PL_{46}
54.7	PL_{70}
67.7	PL_{105}
68.7	PL_{190}
83.3	PL_{500}
2.239	EAL

Figure H- 8 Wood-Zinc House – 2 Story – Arecibo – Exposure B – Minimum Topographic Effect



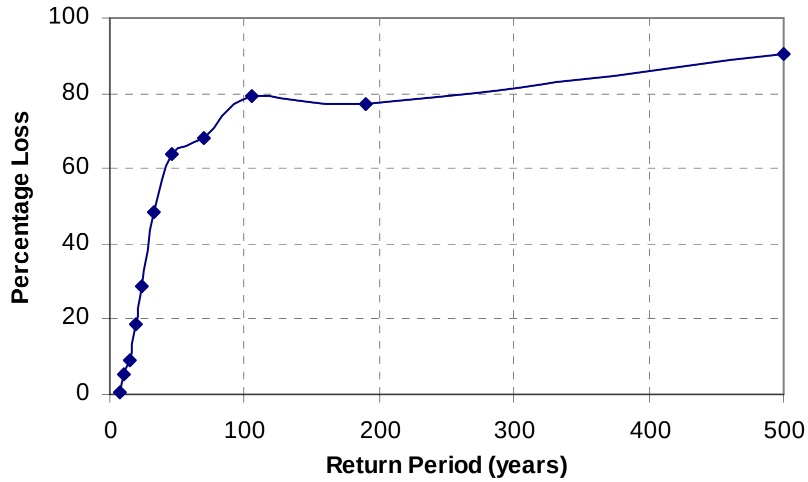
Probable Loss [%]	Name
2.4	PL_8
14.1	PL_{11}
20.2	PL_{15}
35.5	PL_{19}
47.8	PL_{24}
67.9	PL_{33}
79.6	PL_{46}
80.6	PL_{70}
88.1	PL_{105}
85.1	PL_{190}
95.7	PL_{500}
4.650	EAL

Figure H- 9 Wood-Zinc House – 2 Story – Arecibo – Exposure B - Maximum Topographic Effect



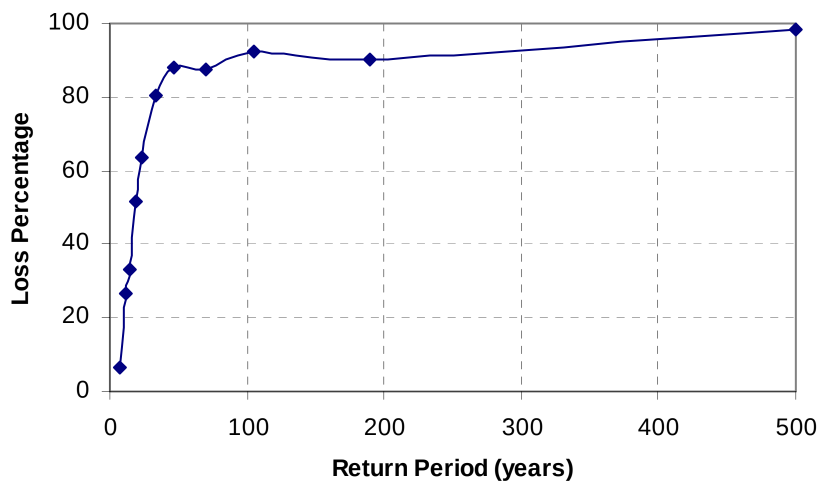
Probable Loss [%]	Name
0.0	PL_8
0.5	PL_{11}
1.0	PL_{15}
3.0	PL_{19}
6.4	PL_{24}
15.8	PL_{33}
28.9	PL_{46}
37.7	PL_{70}
51.7	PL_{105}
56.6	PL_{190}
72.9	PL_{500}
1.414	EAL

Figure H- 10 Wood-Zinc House – 2 Story – Arecibo – Exposure C



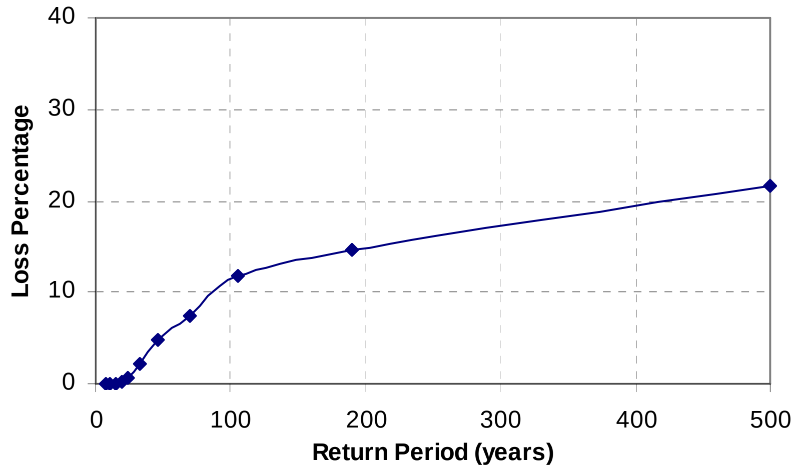
Probable Loss [%]	Name
0.5	PL_8
5.2	PL_{11}
8.9	PL_{15}
18.5	PL_{19}
28.5	PL_{24}
48.2	PL_{33}
63.9	PL_{46}
68.3	PL_{70}
79.0	PL_{105}
77.2	PL_{190}
90.2	PL_{500}
3.216	EAL

Figure H- 11 Wood-Zinc House – 2 Story – Arecibo – Exposure C – Minimum Topographic effect



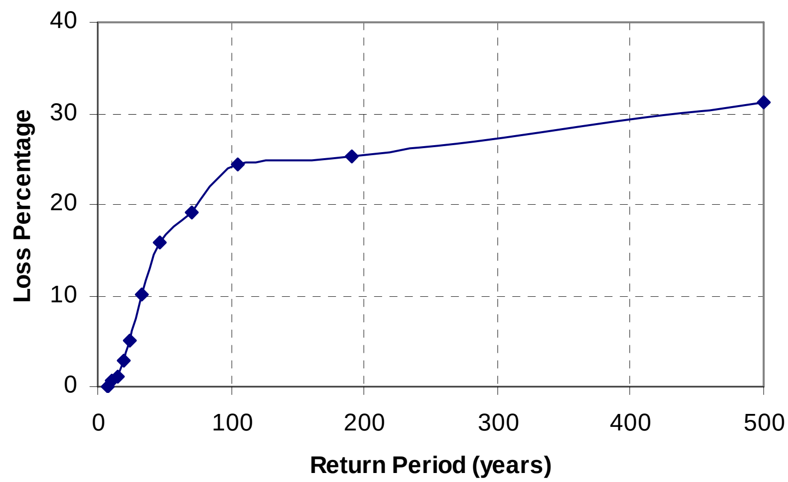
Probable Loss [%]	Name
6.7	PL_8
26.7	PL_{11}
33.2	PL_{15}
51.6	PL_{19}
63.7	PL_{24}
80.6	PL_{33}
88.2	PL_{46}
87.6	PL_{70}
92.6	PL_{105}
90.4	PL_{190}
98.1	PL_{500}
6.016	EAL

Figure H- 12 Wood-Zinc House – 2 Story – Arecibo – Exposure C – Maximum Topographic effect



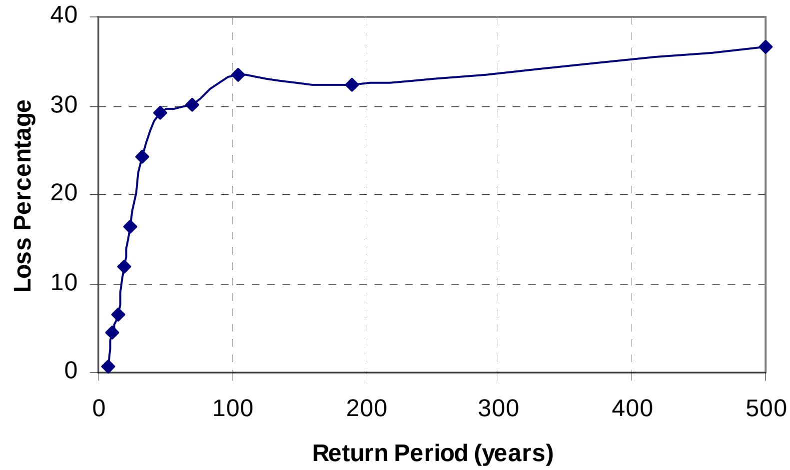
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.1	PL_{15}
0.3	PL_{19}
0.7	PL_{24}
2.3	PL_{33}
4.9	PL_{46}
7.5	PL_{70}
11.8	PL_{105}
14.7	PL_{190}
21.7	PL_{500}
0.283	EAL

Figure H- 13 Mixed House – 2 Story – Arecibo – Exposure B



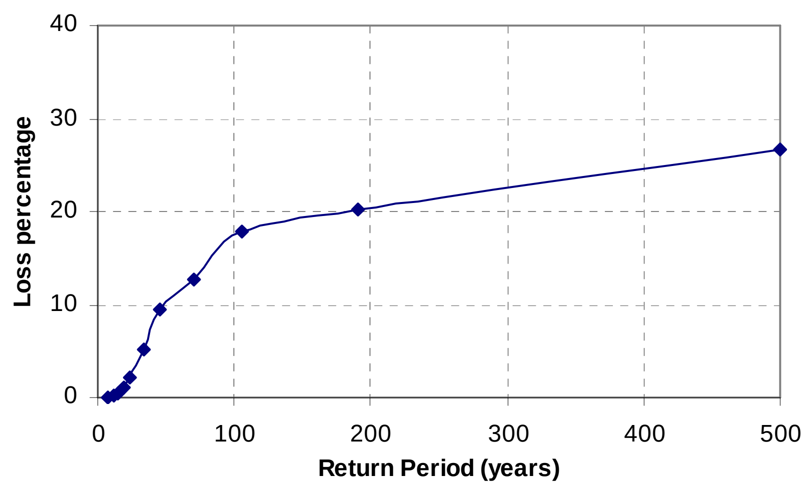
Probable Loss [%]	Name
0.0	PL_{8}
0.6	PL_{11}
1.2	PL_{15}
2.8	PL_{19}
5.0	PL_{24}
10.2	PL_{33}
15.9	PL_{46}
19.1	PL_{70}
24.3	PL_{105}
25.3	PL_{190}
31.2	PL_{500}
0.773	EAL

Figure H- 14 Mixed House – 2 Story – Arecibo – Exposure B - Minimum Topographic Effect



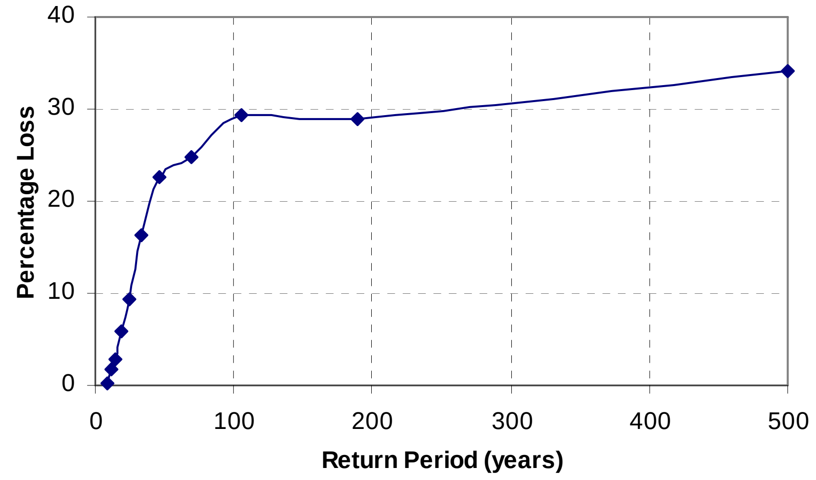
Probable Loss [%]	Name
0.8	PL_8
4.6	PL_{11}
6.6	PL_{15}
11.8	PL_{19}
16.3	PL_{24}
24.2	PL_{33}
29.3	PL_{46}
30.1	PL_{70}
33.4	PL_{105}
32.3	PL_{190}
36.7	PL_{500}
1.652	EAL

Figure H- 15 Mixed House – 2 Story – Arecibo – Exposure B - Maximum Topographic Effect



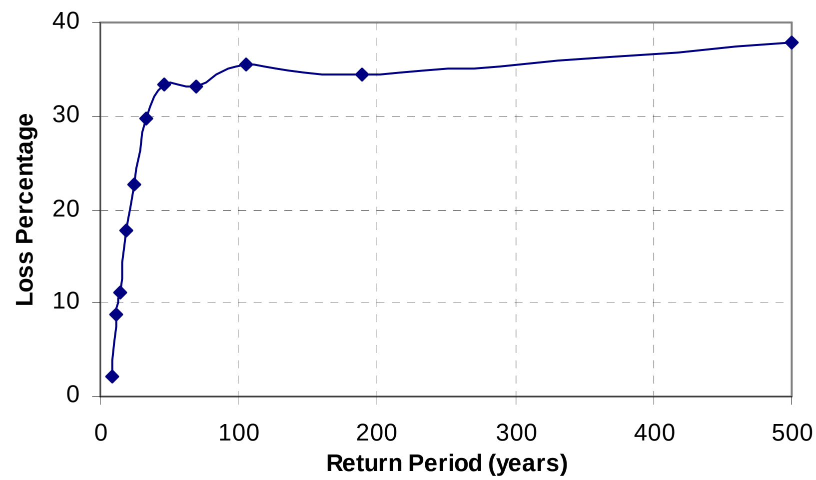
Probable Loss [%]	Name
0.0	PL_8
0.2	PL_{11}
0.3	PL_{15}
1.0	PL_{19}
2.1	PL_{24}
5.1	PL_{33}
9.4	PL_{46}
12.6	PL_{70}
17.9	PL_{105}
20.1	PL_{190}
26.8	PL_{500}
0.479	EAL

Figure H- 16 Mixed House – 2 Story – Arecibo – Exposure C



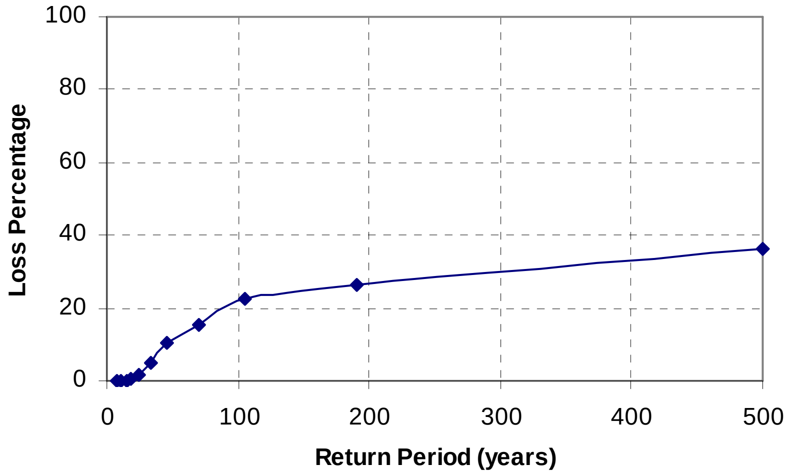
Probable Loss [%]	Name
0.2	PL_{8}
1.7	PL_{11}
2.9	PL_{15}
6.0	PL_{19}
9.3	PL_{24}
16.4	PL_{33}
22.5	PL_{46}
24.8	PL_{70}
29.2	PL_{105}
29.0	PL_{190}
34.2	PL_{500}
1.126	EAL

Figure H- 17 Mixed House – 2 Story – Arecibo – Exposure C - Minimum Topographic Effect



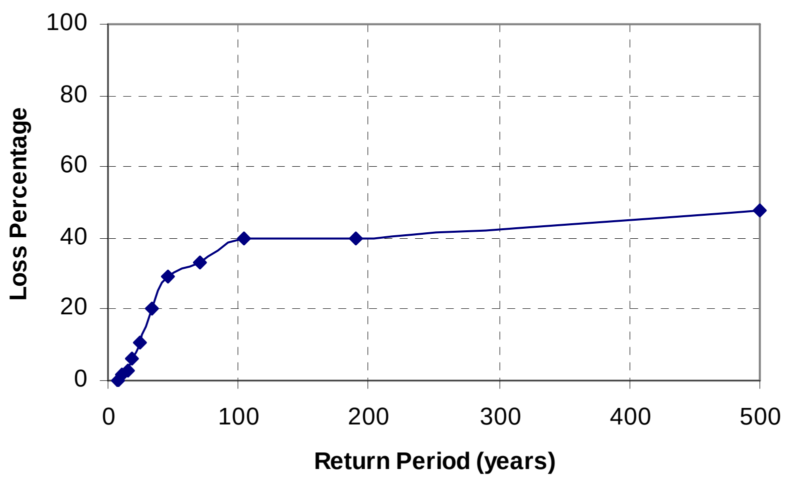
Probable Loss [%]	Name
2.2	PL_{8}
8.8	PL_{11}
11.1	PL_{15}
17.8	PL_{19}
22.6	PL_{24}
29.7	PL_{33}
33.3	PL_{46}
33.2	PL_{70}
35.5	PL_{105}
34.5	PL_{190}
37.9	PL_{500}
2.162	EAL

Figure H- 18 Mixed House – 2 Story – Arecibo – Exposure C - Maximum Topographic Effect



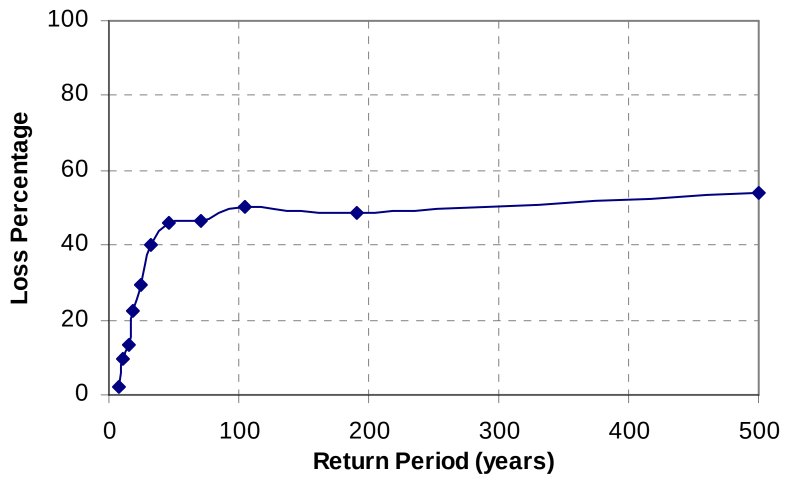
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.2	PL_{15}
0.8	PL_{19}
1.8	PL_{24}
5.2	PL_{33}
10.6	PL_{46}
15.1	PL_{70}
22.4	PL_{105}
26.2	PL_{190}
36.0	PL_{500}
0.597	EAL

Figure H- 19 Mixed House – 3 Story – Arecibo – Exposure B



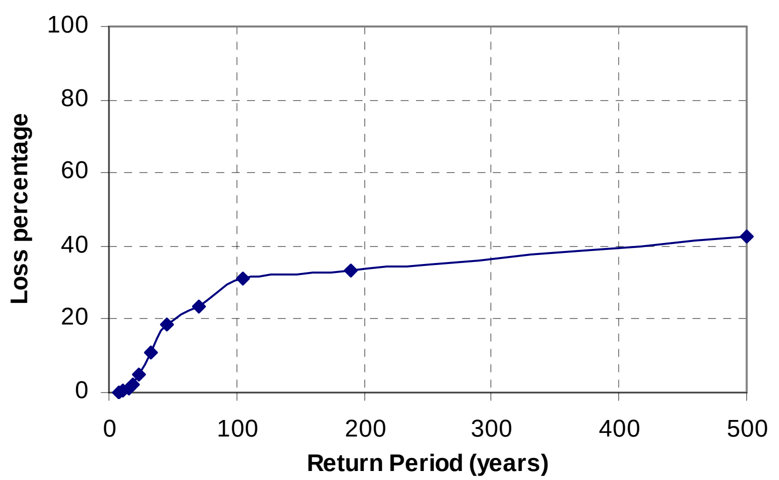
Probable Loss [%]	Name
0.1	PL_8
1.5	PL_{11}
2.8	PL_{15}
6.3	PL_{19}
10.6	PL_{24}
20.1	PL_{33}
29.1	PL_{46}
32.9	PL_{70}
39.8	PL_{105}
39.9	PL_{190}
47.8	PL_{500}
1.433	EAL

Figure H- 20 Mixed House – 3 Story – Arecibo – Exposure B - Minimum Topographic Effect



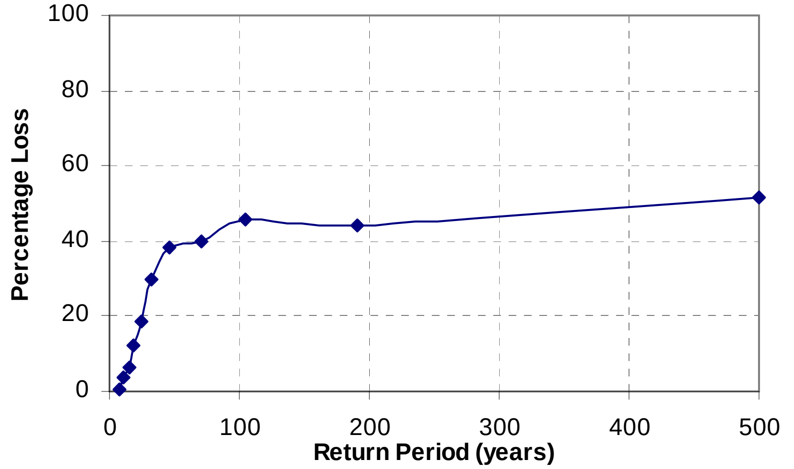
Probable Loss [%]	Name
2.0	PL_8
9.8	PL_{11}
13.3	PL_{15}
22.4	PL_{19}
29.3	PL_{24}
40.1	PL_{33}
46.1	PL_{46}
46.3	PL_{70}
50.1	PL_{105}
48.5	PL_{190}
54.0	PL_{500}
2.838	EAL

Figure H- 21 Mixed House – 3 Story – Arecibo – Exposure B - Maximum Topographic Effect



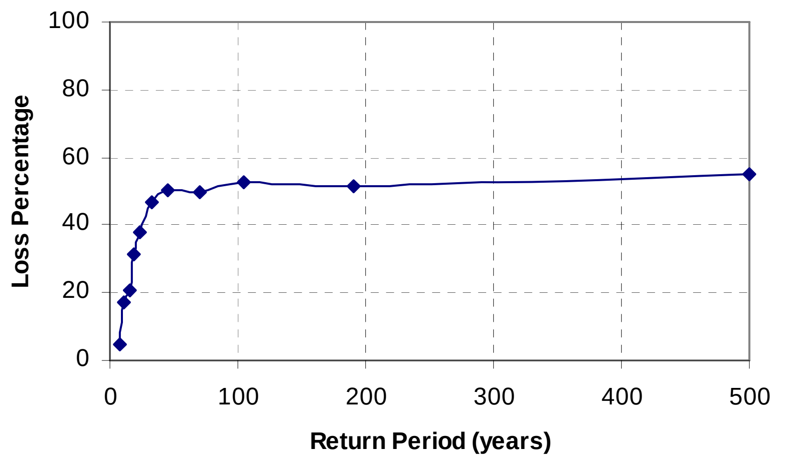
Probable Loss [%]	Name
0.0	PL_8
0.4	PL_{11}
0.9	PL_{15}
2.4	PL_{19}
4.8	PL_{24}
11.0	PL_{33}
18.8	PL_{46}
23.6	PL_{70}
31.3	PL_{105}
33.6	PL_{190}
42.5	PL_{500}
0.939	EAL

Figure H- 22 Mixed House – 3 Story – Arecibo – Exposure C



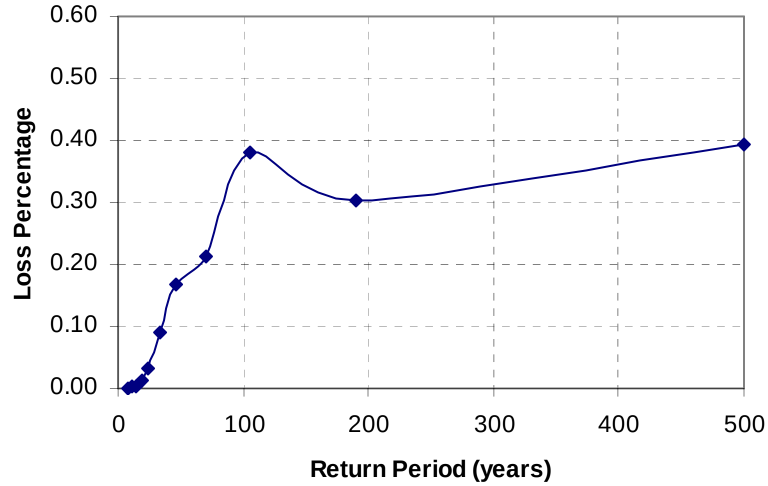
Probable Loss [%]	Name
0.4	PL_8
4.0	PL_{11}
6.3	PL_{15}
12.5	PL_{19}
18.4	PL_{24}
29.7	PL_{33}
38.1	PL_{46}
40.0	PL_{70}
45.6	PL_{105}
44.3	PL_{190}
51.3	PL_{500}
2.010	EAL

Figure H- 23 Mixed House – 3 Story – Arecibo – Exposure C - Minimum Topographic Effect



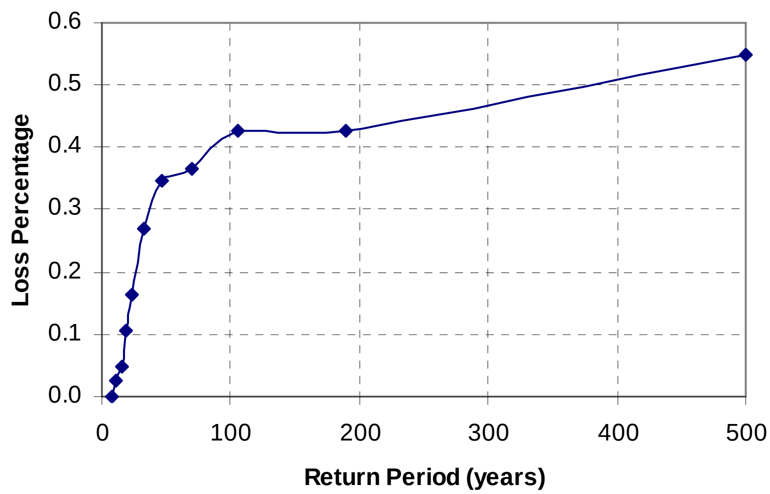
Probable Loss [%]	Name
5.0	PL_8
17.4	PL_{11}
20.8	PL_{15}
31.3	PL_{19}
37.8	PL_{24}
46.6	PL_{33}
50.3	PL_{46}
49.9	PL_{70}
52.4	PL_{105}
51.3	PL_{190}
55.2	PL_{500}
3.606	EAL

Figure H- 24 Mixed House – 3 Story – Arecibo – Exposure C - Maximum Topographic Effect



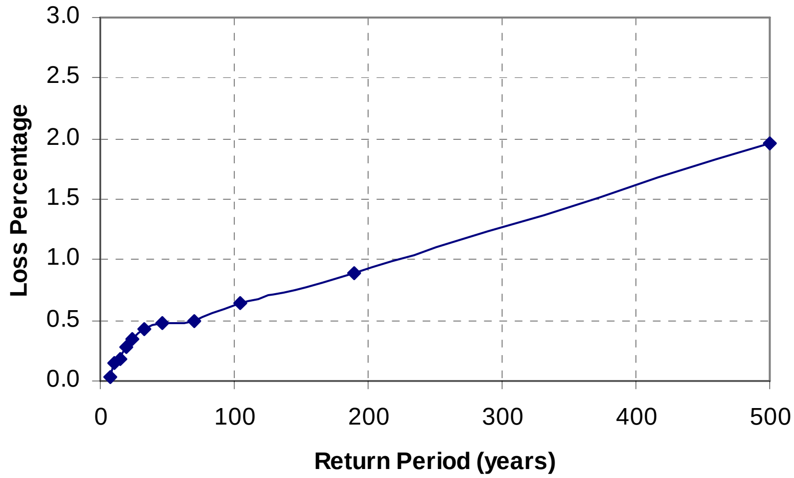
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.01	PL_{19}
0.03	PL_{24}
0.09	PL_{33}
0.17	PL_{46}
0.21	PL_{70}
0.38	PL_{105}
0.30	PL_{190}
0.39	PL_{500}
0.008	EAL

Figure H- 25 Concrete House – 1-3 Story – Arecibo – Exposure B



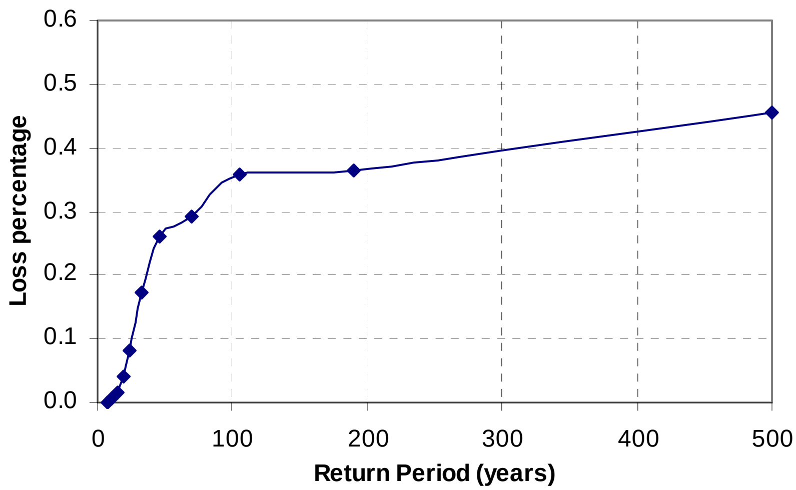
Probable Loss [%]	Name
0.00	PL_8
0.03	PL_{11}
0.05	PL_{15}
0.11	PL_{19}
0.16	PL_{24}
0.27	PL_{33}
0.35	PL_{46}
0.37	PL_{70}
0.43	PL_{105}
0.43	PL_{190}
0.55	PL_{500}
0.018	EAL

Figure H- 26 Concrete House – 1-3 Story – Arecibo – Exposure B – Minimum Topographic Effect



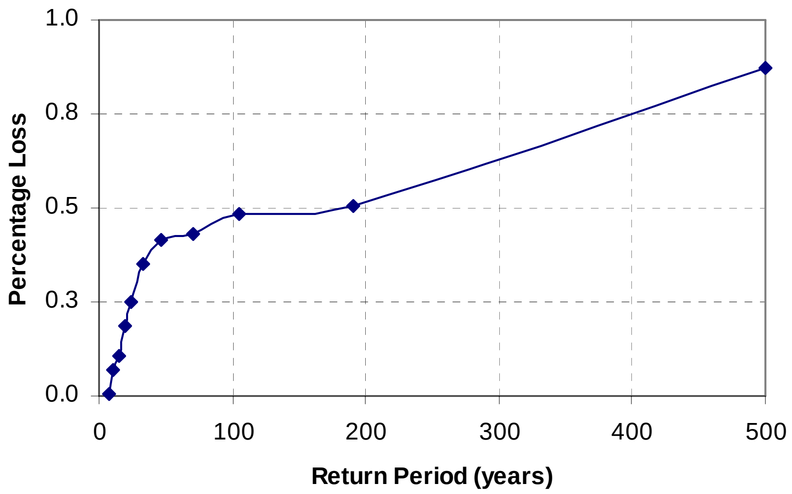
Probable Loss [%]	Name
0.03	PL_8
0.15	PL_{11}
0.19	PL_{15}
0.28	PL_{19}
0.34	PL_{24}
0.43	PL_{33}
0.48	PL_{46}
0.50	PL_{70}
0.64	PL_{105}
0.90	PL_{190}
1.97	PL_{500}
0.041	EAL

Figure H- 27 Concrete House – 1-3 Story – Arecibo – Exposure B – Maximum Topographic Effect



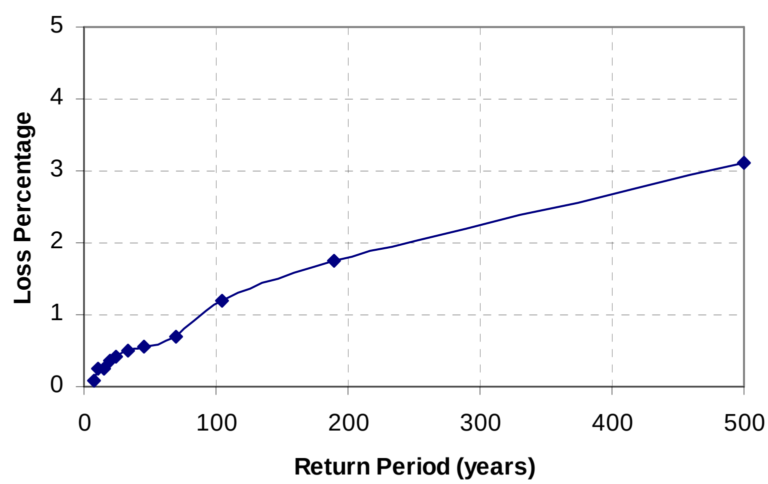
Probable Loss [%]	Name
0.00	PL_8
0.01	PL_{11}
0.01	PL_{15}
0.04	PL_{19}
0.08	PL_{24}
0.17	PL_{33}
0.26	PL_{46}
0.29	PL_{70}
0.36	PL_{105}
0.36	PL_{190}
0.46	PL_{500}
0.012	EAL

Figure H- 28 Concrete House – 1-3 Story – Arecibo – Exposure C



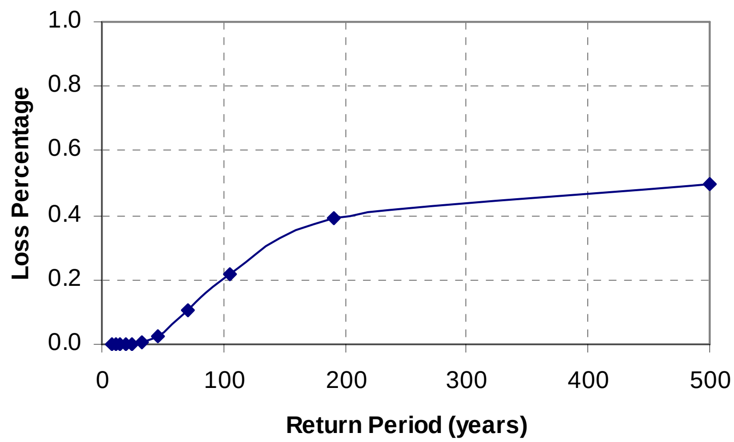
Probable Loss [%]	Name
0.01	PL_8
0.07	PL_{11}
0.10	PL_{15}
0.19	PL_{19}
0.25	PL_{24}
0.35	PL_{33}
0.41	PL_{46}
0.43	PL_{70}
0.48	PL_{105}
0.51	PL_{190}
0.87	PL_{500}
0.026	EAL

Figure H- 29 Concrete House – 1-3 Story – Arecibo – Exposure C – Minimum Topographic Effect



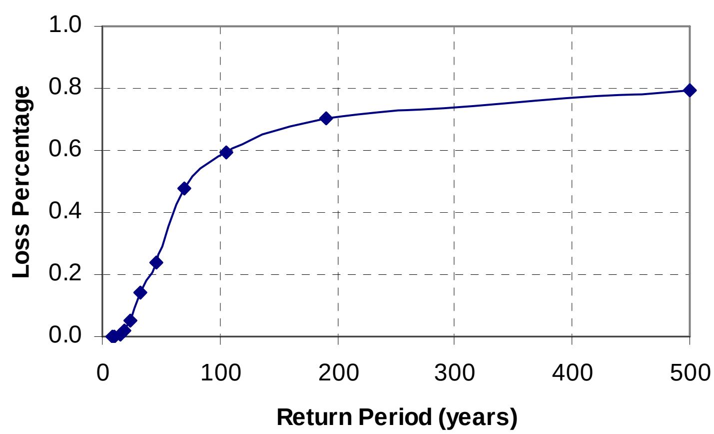
Probable Loss [%]	Name
0.09	PL_8
0.24	PL_{11}
0.26	PL_{15}
0.35	PL_{19}
0.41	PL_{24}
0.49	PL_{33}
0.55	PL_{46}
0.69	PL_{70}
1.19	PL_{105}
1.76	PL_{190}
3.12	PL_{500}
0.059	EAL

Figure H- 30 Concrete House – 1-3 Story – Arecibo – Exposure C – Maximum Topographic Effect



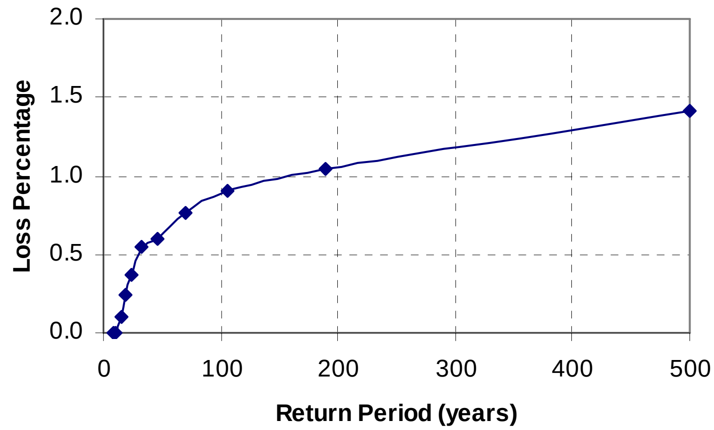
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.00	PL_{19}
0.00	PL_{24}
0.01	PL_{33}
0.02	PL_{46}
0.10	PL_{70}
0.22	PL_{105}
0.39	PL_{190}
0.49	PL_{500}
0.005	EAL

Figure H- 31 Multistory Concrete – 4-7 Story – Arecibo – Exposure B



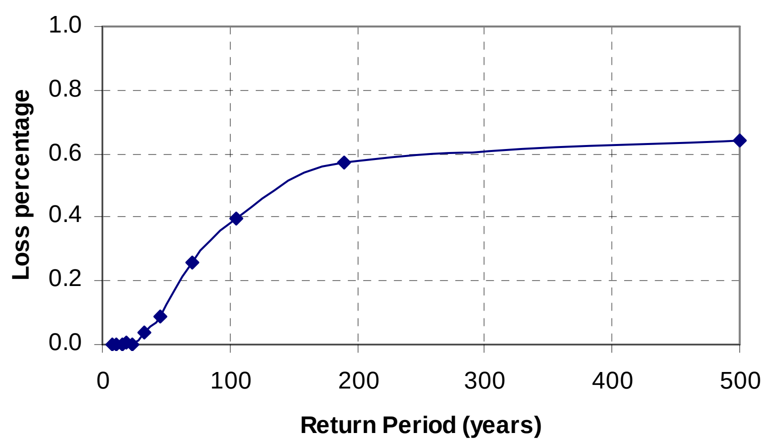
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.00	PL_{15}
0.02	PL_{19}
0.05	PL_{24}
0.14	PL_{33}
0.24	PL_{46}
0.48	PL_{70}
0.59	PL_{105}
0.71	PL_{190}
0.79	PL_{500}
0.015	EAL

Figure H- 32 Multistory Concrete – 4-7 Story – Arecibo – Exposure B – Minimum Topographic Effect



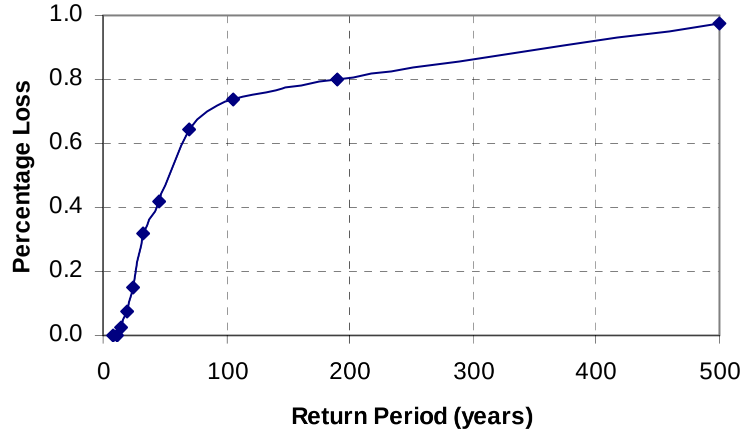
Probable Loss [%]	Name
0.00	PL_{8}
0.00	PL_{11}
0.11	PL_{15}
0.25	PL_{19}
0.37	PL_{24}
0.55	PL_{33}
0.60	PL_{46}
0.77	PL_{70}
0.91	PL_{105}
1.05	PL_{190}
1.41	PL_{500}
0.036	EAL

Figure H- 33 Multistory Concrete – 4-7 Story – Arecibo – Exposure B – Maximum Topographic Effect



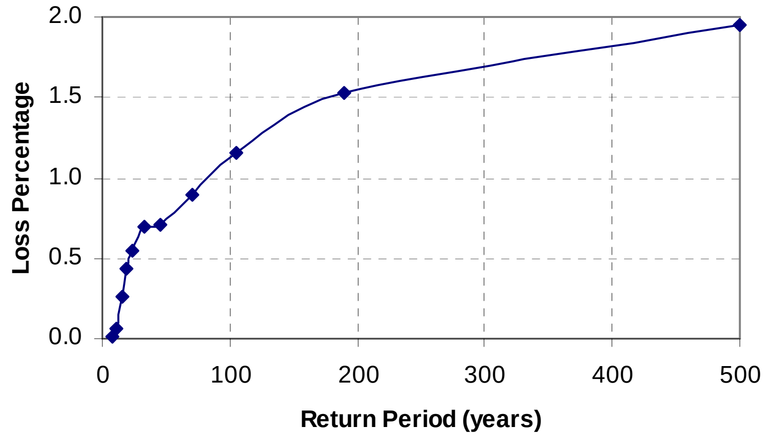
Probable Loss [%]	Name
0.0	PL_{8}
0.1	PL_{11}
0.3	PL_{15}
0.4	PL_{19}
0.6	PL_{24}
0.7	PL_{33}
0.7	PL_{46}
0.9	PL_{70}
1.2	PL_{105}
1.5	PL_{190}
2.0	PL_{500}
0.053	EAL

Figure H- 34 Multistory Concrete – 4-7 Story – Arecibo – Exposure C



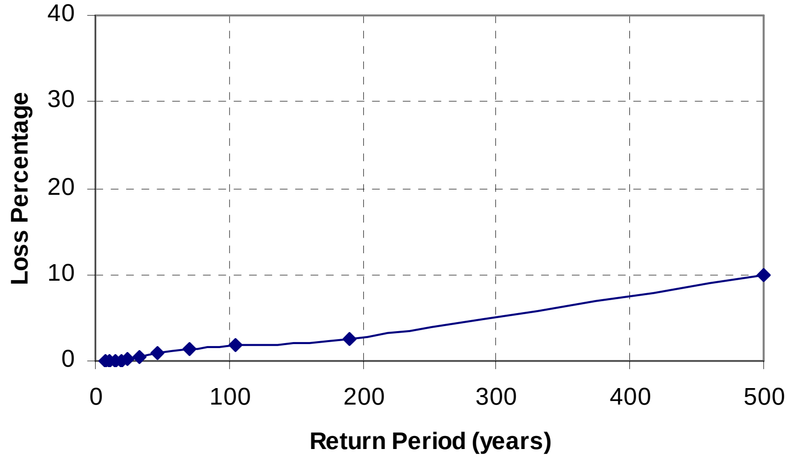
Probable Loss [%]	Name
0.00	PL_8
0.00	PL_{11}
0.02	PL_{15}
0.08	PL_{19}
0.15	PL_{24}
0.32	PL_{33}
0.42	PL_{46}
0.64	PL_{70}
0.74	PL_{105}
0.80	PL_{190}
0.97	PL_{500}
0.023	EAL

Figure H- 35 Multistory Concrete – 4-7 Story – Arecibo – Exposure C – Minimum Topographic Effect



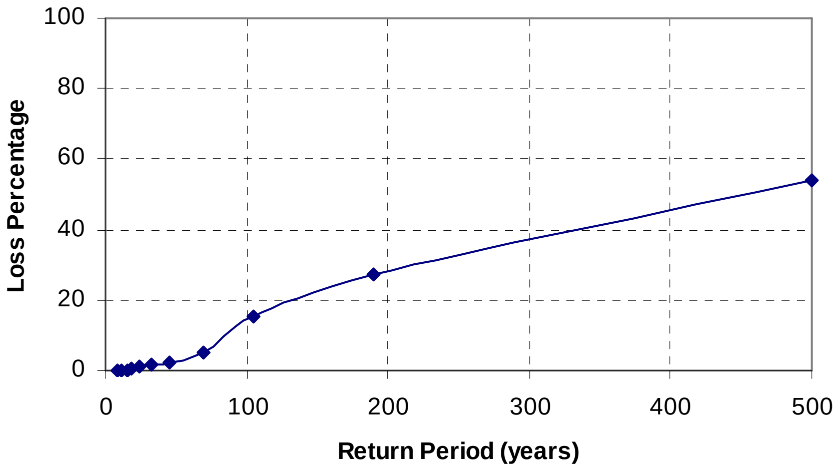
Probable Loss [%]	Name
0.01	PL_8
0.06	PL_{11}
0.26	PL_{15}
0.44	PL_{19}
0.55	PL_{24}
0.69	PL_{33}
0.71	PL_{46}
0.89	PL_{70}
1.15	PL_{105}
1.53	PL_{190}
1.95	PL_{500}
0.053	EAL

Figure H- 36 Multistory Concrete – 4-7 Story – Arecibo – Exposure C – Maximum Topographic Effect



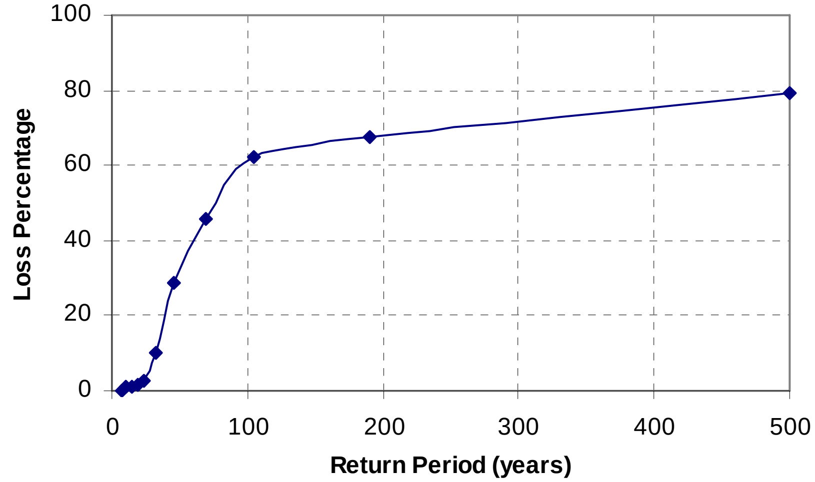
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.0	PL_{19}
0.1	PL_{24}
0.5	PL_{33}
1.0	PL_{46}
1.3	PL_{70}
1.8	PL_{105}
2.5	PL_{190}
10.0	PL_{500}
0.076	EAL

Figure H- 37 Small Institutional – Arecibo – Exposure B



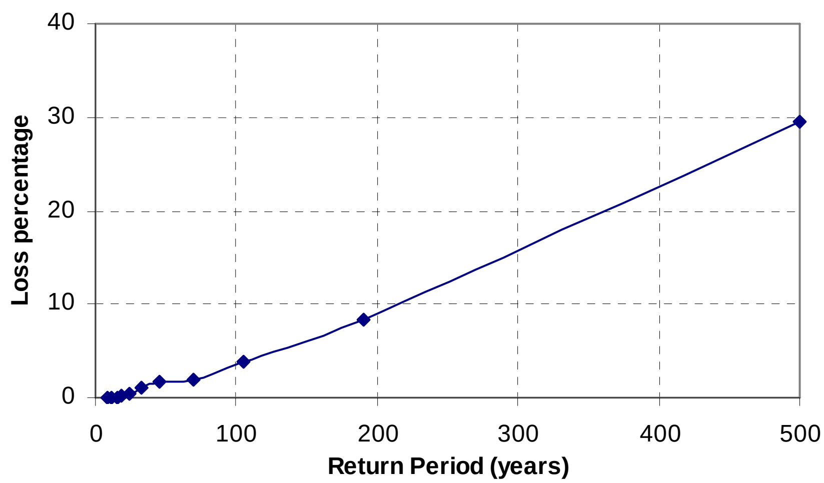
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.2	PL_{15}
0.6	PL_{19}
1.0	PL_{24}
1.7	PL_{33}
2.5	PL_{46}
5.0	PL_{70}
15.3	PL_{105}
27.5	PL_{190}
53.8	PL_{500}
0.460	EAL

Figure H- 38 Small Institutional – Arecibo – Exposure B – Minimum Topographic Effect



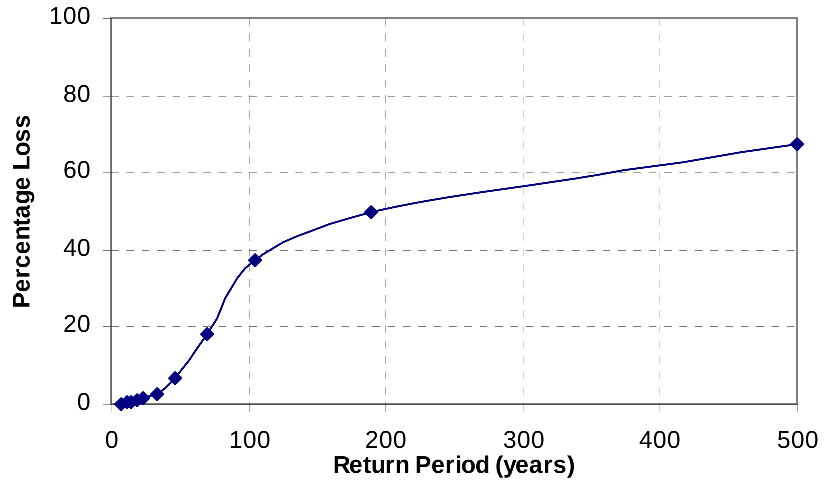
Probable Loss [%]	Name
0.1	PL_8
0.9	PL_{11}
1.1	PL_{15}
1.8	PL_{19}
2.9	PL_{24}
10.1	PL_{33}
28.5	PL_{46}
45.9	PL_{70}
62.3	PL_{105}
67.7	PL_{190}
79.3	PL_{500}
1.539	EAL

Figure H- 39 Small Institutional – Arecibo – Exposure B – Maximum Topographic Effect



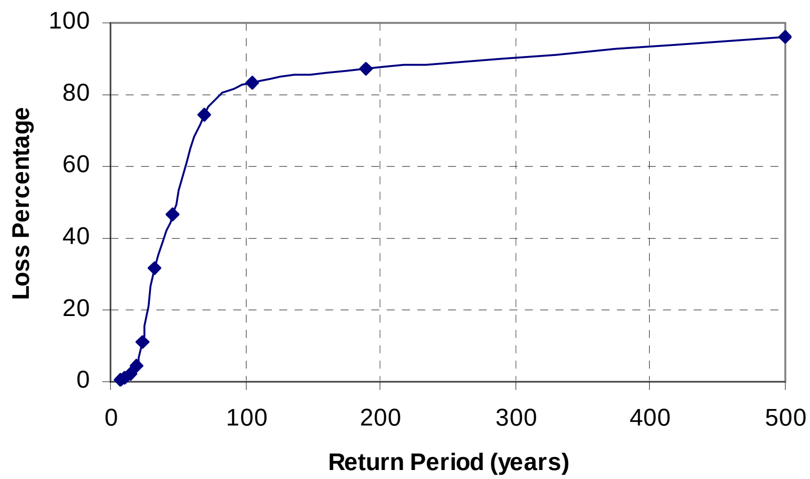
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.2	PL_{19}
0.4	PL_{24}
1.0	PL_{33}
1.6	PL_{46}
1.9	PL_{70}
3.9	PL_{105}
8.4	PL_{190}
29.5	PL_{500}
0.199	EAL

Figure H- 40 Small Institutional – Arecibo – Exposure C



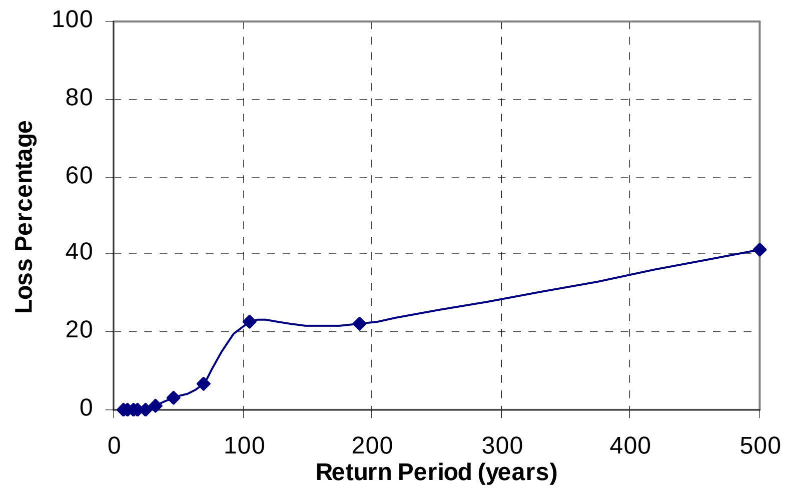
Probable Loss [%]	Name
0.0	PL_8
0.3	PL_{11}
0.6	PL_{15}
1.1	PL_{19}
1.5	PL_{24}
2.6	PL_{33}
7.0	PL_{46}
17.9	PL_{70}
37.1	PL_{105}
49.6	PL_{190}
67.4	PL_{500}
0.842	EAL

Figure H- 41 Small Institutional – Arecibo – Exposure C – Minimum Topographic Effect



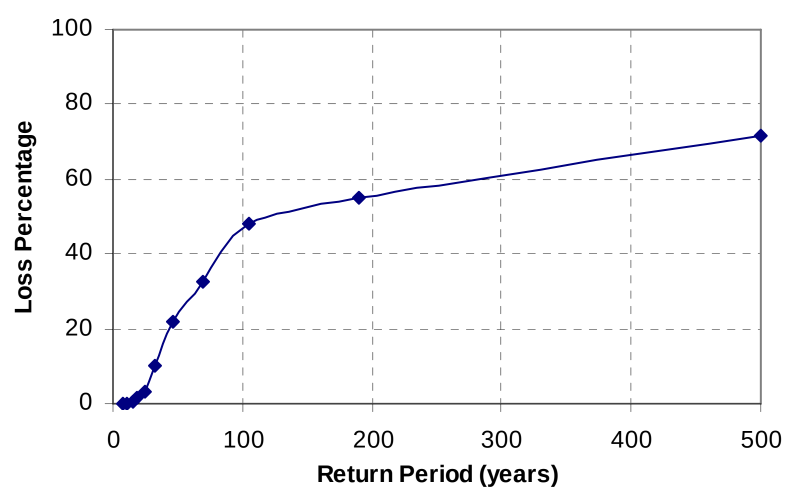
Probable Loss [%]	Name
0.5	PL_8
1.6	PL_{11}
1.7	PL_{15}
3.7	PL_{19}
9.6	PL_{24}
31.3	PL_{33}
57.0	PL_{46}
65.0	PL_{70}
77.2	PL_{105}
74.1	PL_{190}
88.5	PL_{500}
2.356	EAL

Figure H- 42 Small Institutional – Arecibo – Exposure C – Maximum Topographic Effect



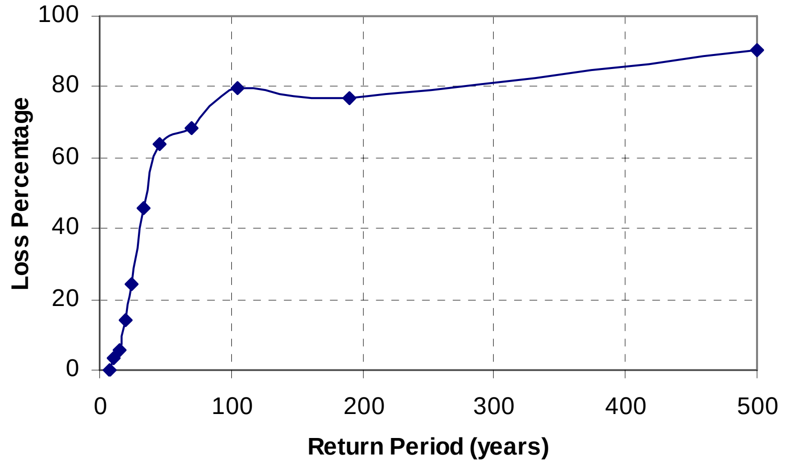
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.0	PL_{15}
0.1	PL_{19}
0.3	PL_{24}
1.0	PL_{33}
3.0	PL_{46}
6.5	PL_{70}
22.9	PL_{105}
21.9	PL_{190}
41.1	PL_{500}
0.413	EAL

Figure H- 43 Large Institutional – Arecibo – Exposure B



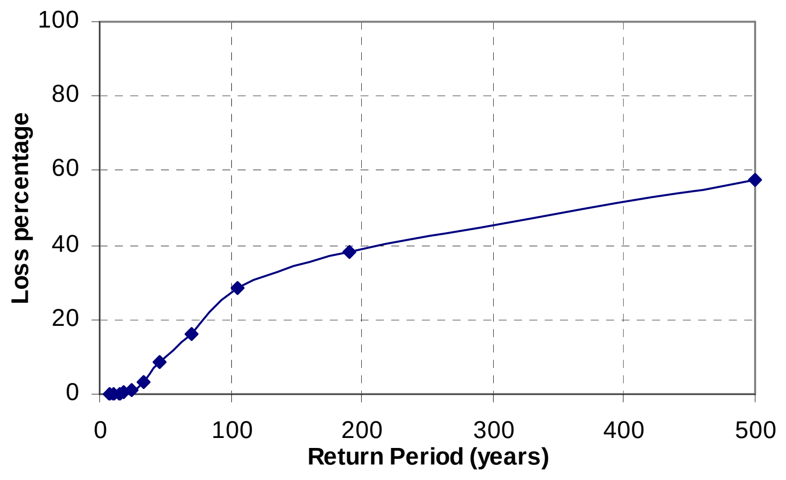
Probable Loss [%]	Name
0.0	PL_{8}
0.2	PL_{11}
0.4	PL_{15}
1.4	PL_{19}
3.3	PL_{24}
10.1	PL_{33}
21.9	PL_{46}
32.8	PL_{70}
48.1	PL_{105}
55.1	PL_{190}
71.6	PL_{500}
1.230	EAL

Figure H- 44 Large Institutional – Arecibo – Exposure B – Minimum Topographic Effect



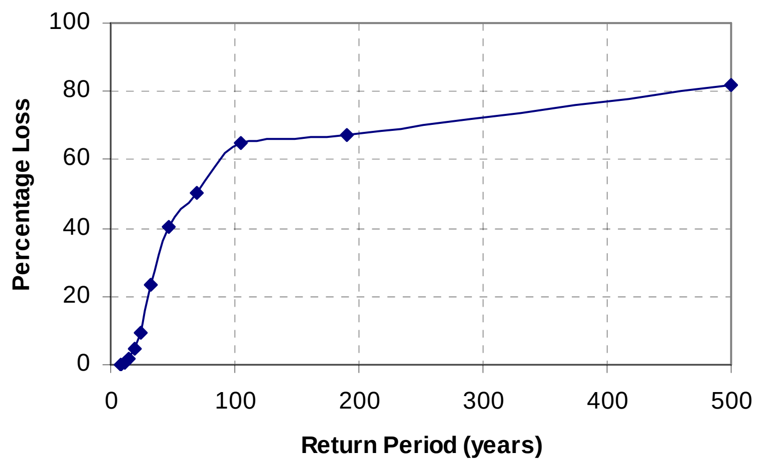
Probable Loss [%]	Name
0.3	PL_8
3.2	PL_{11}
5.8	PL_{15}
14.1	PL_{19}
24.3	PL_{24}
45.9	PL_{33}
63.9	PL_{46}
68.6	PL_{70}
79.8	PL_{105}
76.9	PL_{190}
90.6	PL_{500}
3.022	EAL

Figure H- 45 Large Institutional – Arecibo – Exposure B – Maximum Topographic Effect



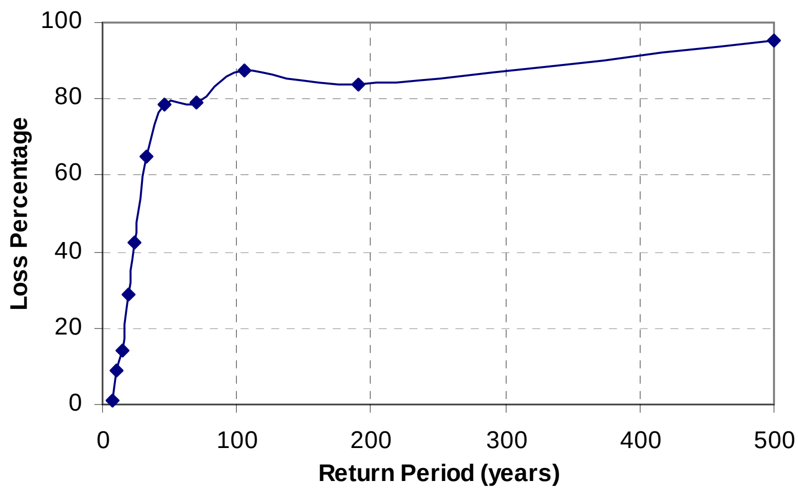
Probable Loss [%]	Name
0.0	PL_8
0.1	PL_{11}
0.1	PL_{15}
0.4	PL_{19}
0.9	PL_{24}
3.2	PL_{33}
8.8	PL_{46}
16.0	PL_{70}
28.7	PL_{105}
37.9	PL_{190}
57.4	PL_{500}
0.699	EAL

Figure H- 46 Large Institutional – Arecibo – Exposure C



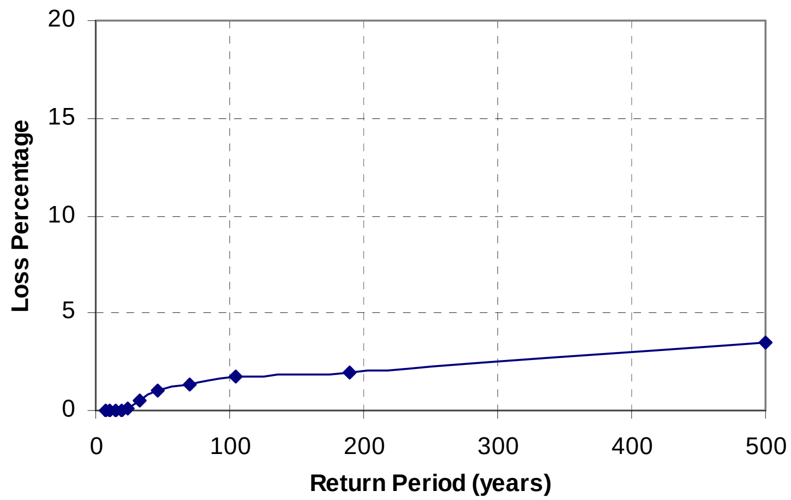
Probable Loss [%]	Name
0.1	PL_8
0.8	PL_{11}
1.5	PL_{15}
4.4	PL_{19}
9.3	PL_{24}
23.2	PL_{33}
40.4	PL_{46}
50.5	PL_{70}
64.9	PL_{105}
67.1	PL_{190}
81.6	PL_{500}
1.918	EAL

Figure H- 47 Large Institutional – Arecibo – Exposure C – Minimum Topographic Effect



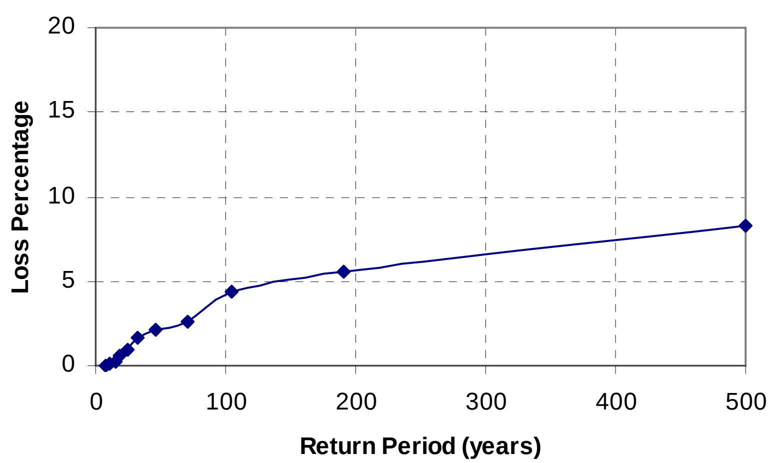
Probable Loss [%]	Name
1.0	PL_8
8.7	PL_{11}
14.2	PL_{15}
28.7	PL_{19}
42.2	PL_{24}
64.7	PL_{33}
78.8	PL_{46}
79.2	PL_{70}
87.6	PL_{105}
83.6	PL_{190}
95.5	PL_{500}
4.188	EAL

Figure H- 48 Large Institutional – Arecibo – Exposure C – Maximum Topographic Effect



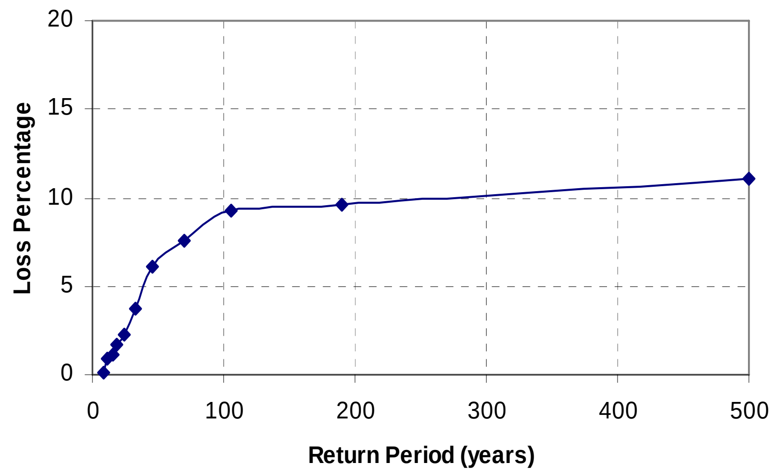
Probable Loss [%]	Name
0.0	PL_{8}
0.0	PL_{11}
0.0	PL_{15}
0.0	PL_{19}
0.1	PL_{24}
0.5	PL_{33}
1.0	PL_{46}
1.3	PL_{70}
1.7	PL_{105}
1.9	PL_{190}
3.5	PL_{500}
0.050	EAL

Figure H- 49 Mixed Institutional – Arecibo – Exposure B



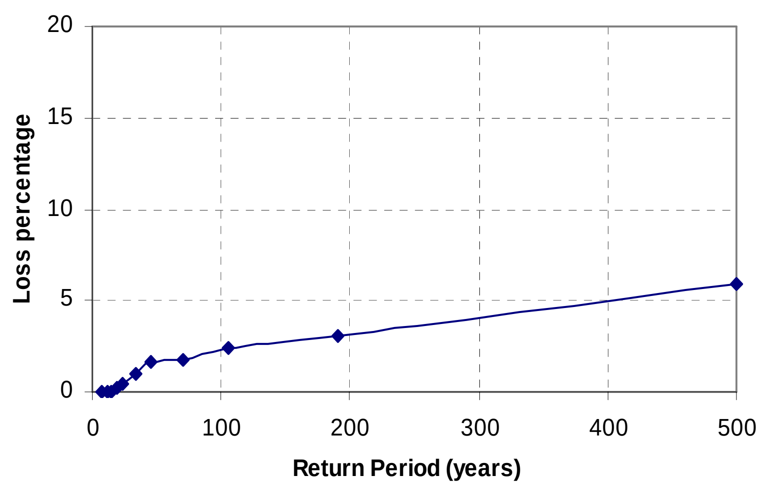
Probable Loss [%]	Name
0.0	PL_{8}
0.1	PL_{11}
0.2	PL_{15}
0.6	PL_{19}
1.0	PL_{24}
1.7	PL_{33}
2.2	PL_{46}
2.6	PL_{70}
4.3	PL_{105}
5.5	PL_{190}
8.3	PL_{500}
0.146	EAL

Figure H- 50 Mixed Institutional – Arecibo – Exposure B – Minimum Topographic Effect



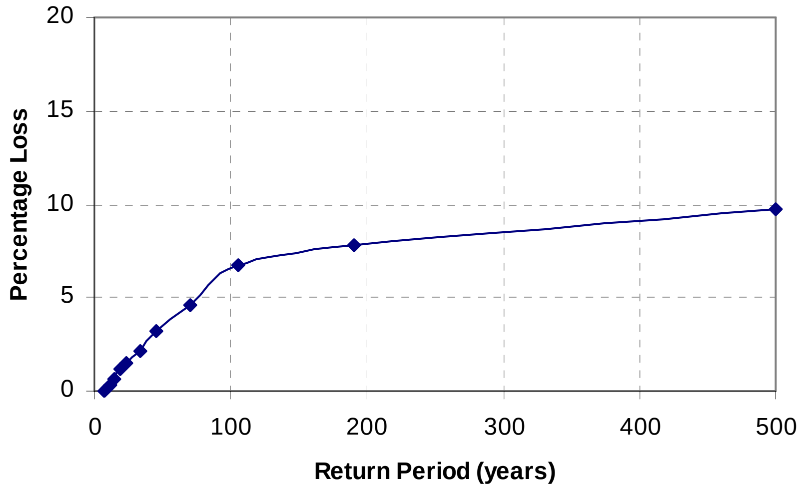
Probable Loss [%]	Name
0.1	PL_8
0.9	PL_{11}
1.1	PL_{15}
1.7	PL_{19}
2.2	PL_{24}
3.7	PL_{33}
6.1	PL_{46}
7.6	PL_{70}
9.3	PL_{105}
9.6	PL_{190}
11.1	PL_{500}
0.346	EAL

Figure H- 51 Mixed Institutional – Arecibo – Exposure B – Maximum Topographic Effect



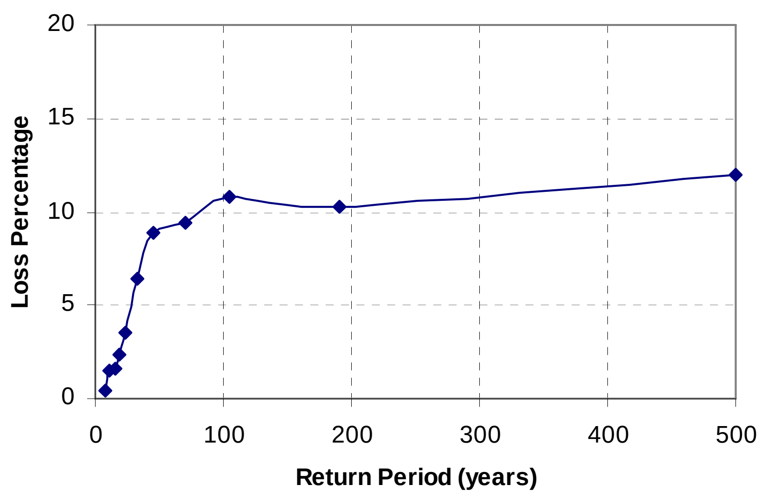
Probable Loss [%]	Name
0.0	PL_8
0.0	PL_{11}
0.0	PL_{15}
0.2	PL_{19}
0.4	PL_{24}
1.0	PL_{33}
1.6	PL_{46}
1.8	PL_{70}
2.4	PL_{105}
3.1	PL_{190}
5.9	PL_{500}
0.087	EAL

Figure H- 52 Mixed Institutional – Arecibo – Exposure C



Probable Loss [%]	Name
0.0	PL_{8}
0.3	PL_{11}
0.6	PL_{15}
1.1	PL_{19}
1.5	PL_{24}
2.2	PL_{33}
3.2	PL_{46}
4.6	PL_{70}
6.7	PL_{105}
7.8	PL_{190}
9.7	PL_{500}
0.222	EAL

Figure H- 53 Mixed Institutional – Arecibo – Exposure C – Minimum Topographic Effect



Probable Loss [%]	Name
0.5	PL_{8}
1.5	PL_{11}
1.6	PL_{15}
2.4	PL_{19}
3.6	PL_{24}
6.4	PL_{33}
8.9	PL_{46}
9.5	PL_{70}
10.8	PL_{105}
10.3	PL_{190}
11.9	PL_{500}
0.474	EAL

Figure H- 54 Mixed Institutional – Arecibo – Exposure C – Maximum Topographic Effect

Appendix I Damage states descriptions from HAZUS

Table I- 1 Structural damage states description for concrete MRF

Damage State	Description
Slight	Flexural or shear type hairline cracks in some beams and columns near joints or within joints
Moderate	Most beams and columns exhibit hairline cracks. In ductile frames some of the frame elements have reached yield capacity indicated by larger flexural cracks and some concrete spalling. Nonductile frames may exhibit larger shear cracks and spalling.
Extensive	Some of the frame elements have reached their ultimate capacity indicated in ductile frames by large flexural cracks, spalled concrete and buckled main reinforcement; nonductile frame elements may have suffered shear failures or bond failures at reinforcement splices, or broken ties or buckled main reinforcement in columns which may result in partial collapse.
Complete	Structure is collapsed or in imminent danger of collapse due to brittle failure of nonductile frame elements or loss of frame stability. Approximately 13%(low-rise), 10%(mid-rise) or 5%(high-rise) of the total area of C1 buildings with Complete damage is expected to be collapsed.

Table I- 2 Structural damage states description for steel MRF

Damage State	Description
Slight	Minor deformations in connections or hairline cracks in few welds.
Moderate	Some steel members have yielded exhibiting observable permanent rotations at connections; few welded connections may exhibit major cracks through welds or few bolted connections may exhibit broken bolts or enlarged bolt holes.
Extensive	Most steel members have exceeded their yield capacity, resulting in significant permanent lateral deformation of the structure. Some of the structural members or connections may have exceeded their ultimate capacity exhibited by major permanent member rotations at connections, buckled flanges and failed connections. Partial collapse of portions of structure is possible due to failed critical elements and/or connections.
Complete	Significant portion of the structural elements have exceeded their ultimate capacities or some critical structural elements or connections have failed resulting in dangerous permanent lateral displacement, partial collapse or collapse of the building. Approximately 8%(low-rise), 5%(mid-rise) or 3%(high-rise) of the total area of S1 buildings with Complete damage is expected to be collapsed.

Table I- 3 Structural damage states description for shear walls

Damage State	Description
Slight	Diagonal hairline cracks on most concrete shear wall surfaces; minor concrete spalling at few locations.
Moderate	Most shear wall surfaces exhibit diagonal cracks; some shear walls have exceeded yield capacity indicated by larger diagonal cracks and concrete spalling at wall ends.
Extensive	Most concrete shear walls have exceeded their yield capacities; some walls have exceeded their ultimate capacities indicated by large, through-the-wall diagonal cracks, extensive spalling around the cracks and visibly buckled wall reinforcement or rotation of narrow walls with inadequate foundations. Partial collapse may occur due to failure of nonductile columns not designed to resist lateral loads.
Complete	Structure has collapsed or is in imminent danger of collapse due to failure of most of the shear walls and failure of some critical beams or columns. Approximately 13%(low-rise), 10%(mid-rise) or 5%(high-rise) of the total area of C2 buildings with Complete damage is expected to be collapsed.

Table I- 4 Structural damage states description for wood light frame structures

Damage State	Description
Slight	Small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections.
Moderate	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels.
Extensive	Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of “room-over-garage” or other “soft-story” configurations; small foundations cracks.
Complete	Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks. Approximately 3% of the total area of W1 buildings with Complete damage is expected to be collapsed.

Appendix J Soil Maps

Figure J- 1 Soil class map of Arecibo

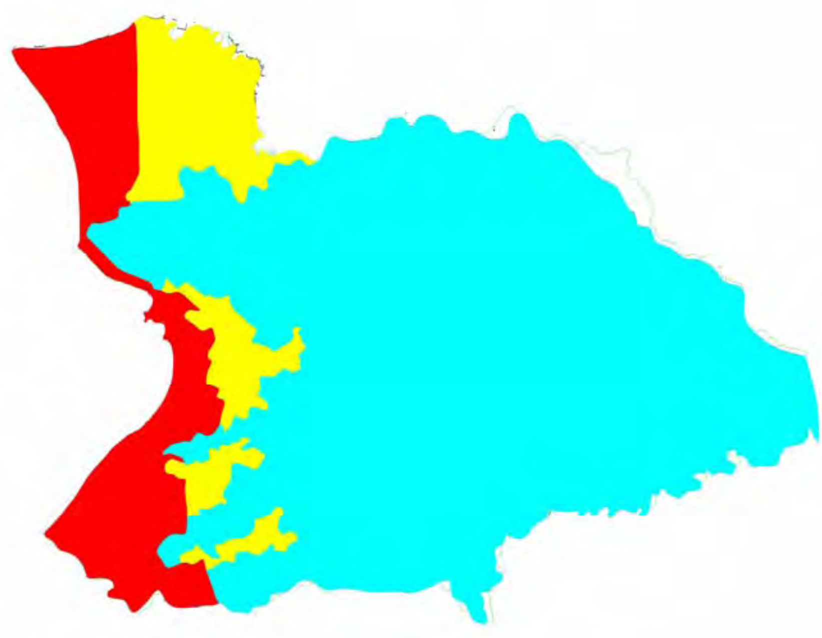


Figure J- 2 Soil class map of Mayagüez

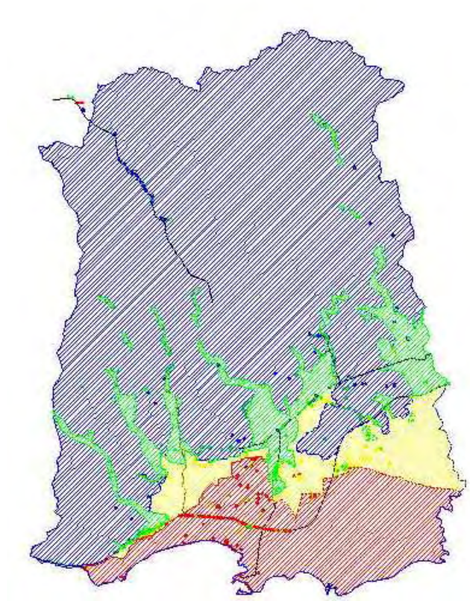


Figure J- 3 Soil class map of Ponce

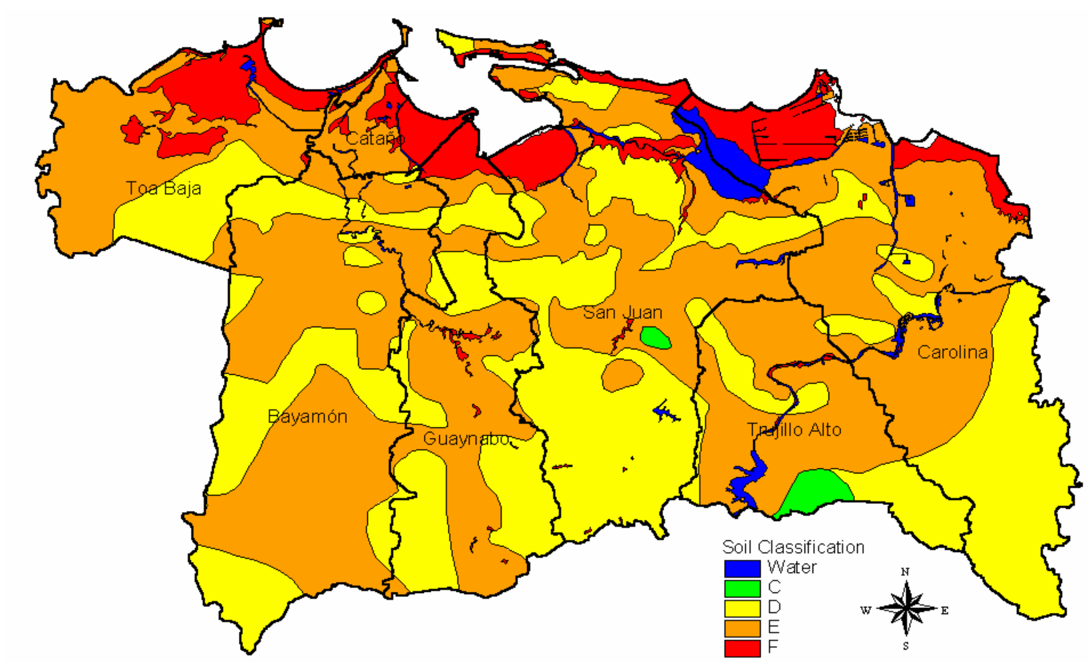


Figure J- 4 Soil class map of San Juan metropolitan area

Appendix K Wind Exposure Maps

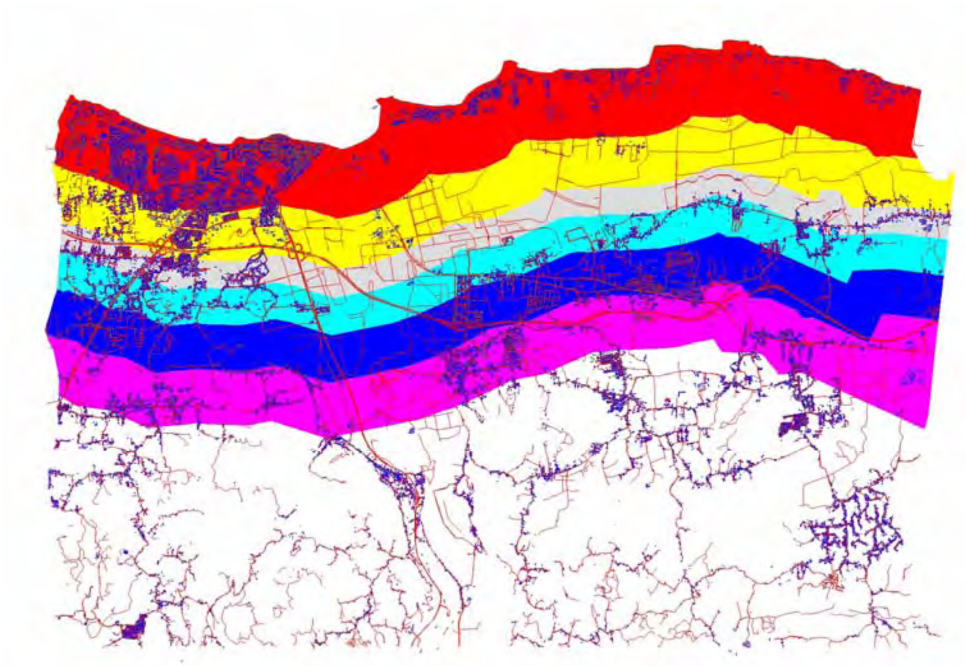


Figure K- 1 Wind exposure map of Arecibo

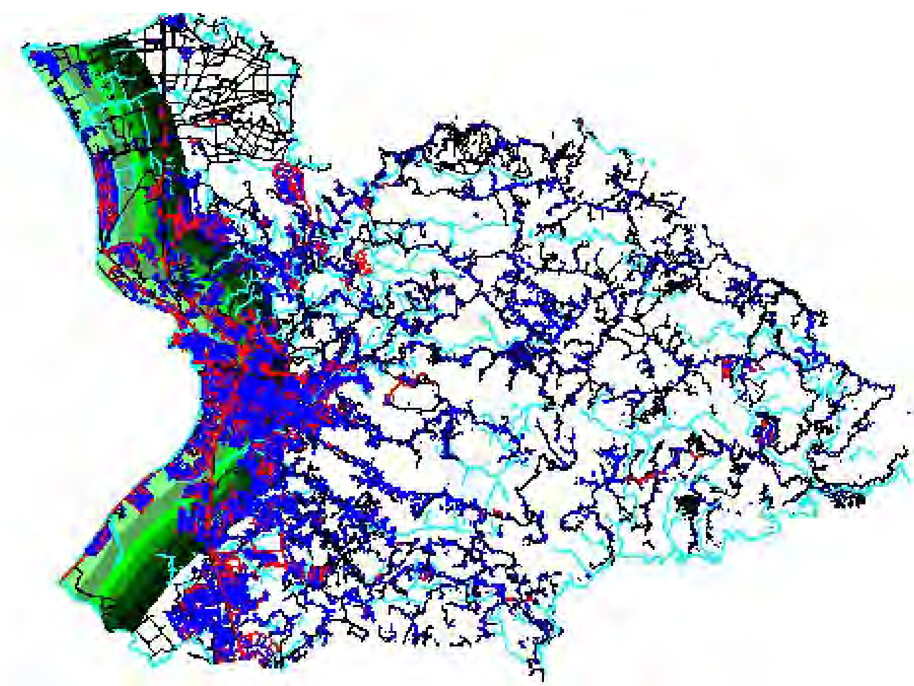


Figure K- 2 Wind exposure map of Mayagüez

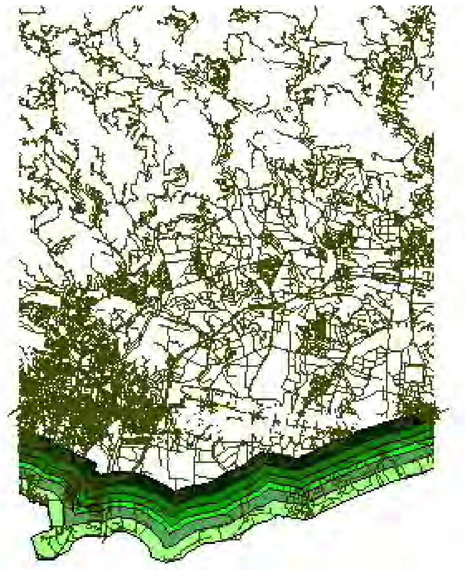


Figure K- 3 Wind exposure map of Ponce

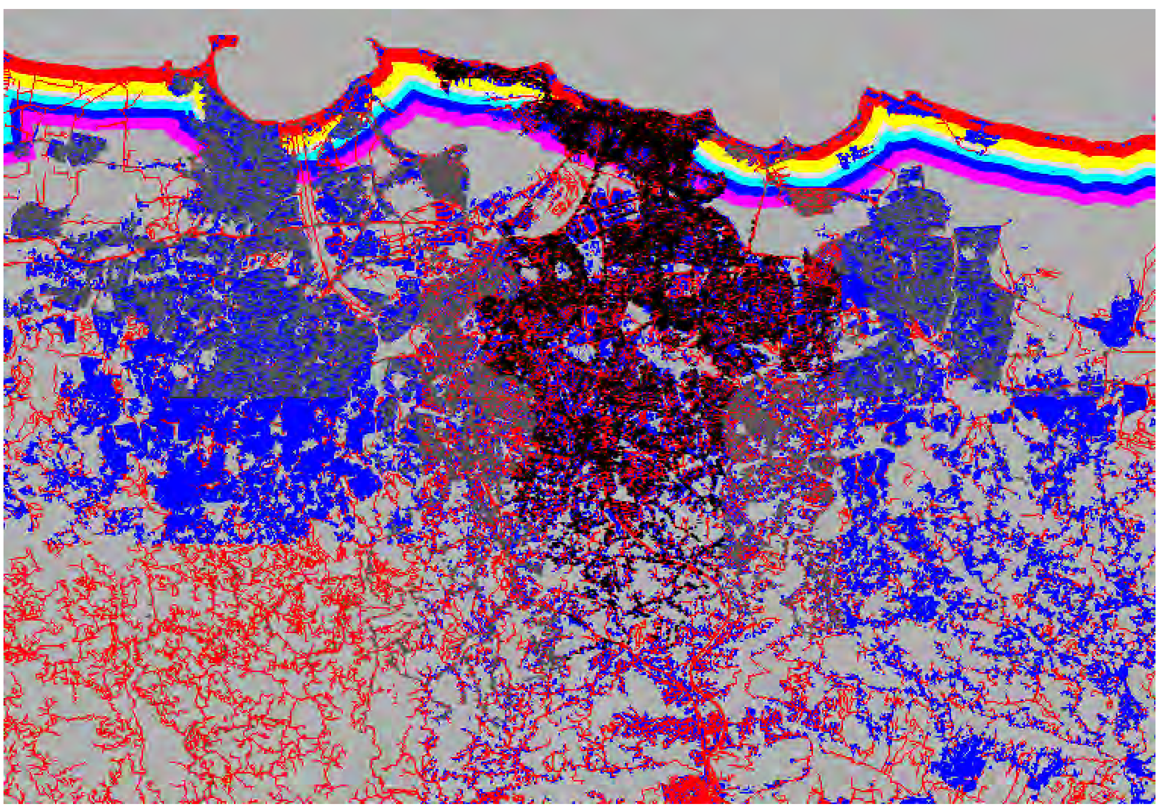


Figure K- 4 Wind exposure map of San Juan

Appendix L Topographic Effects Maps

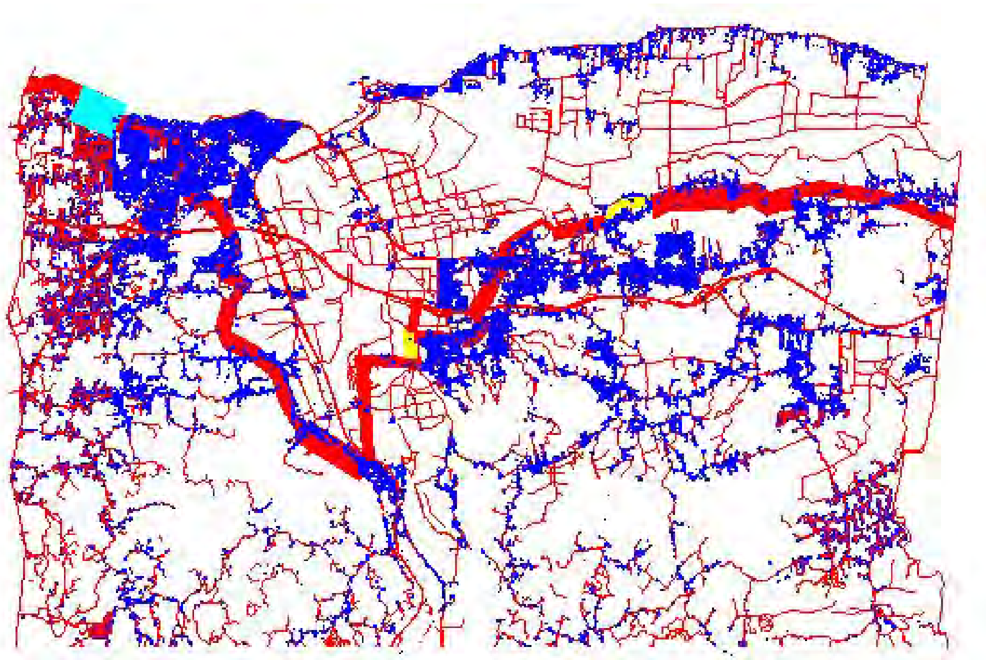


Figure L- 1 Topographic effects map of Arecibo

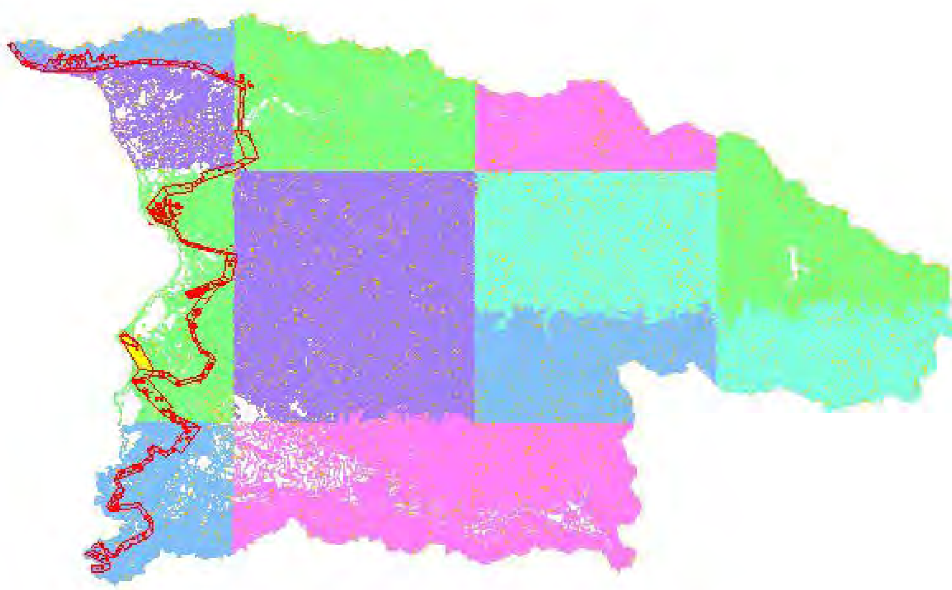


Figure L- 2 Topographic effects map of Mayagüez

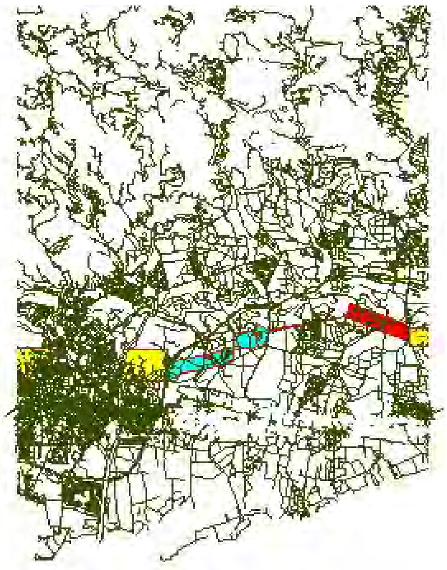


Figure L- 3 Topographic effects map of Ponce

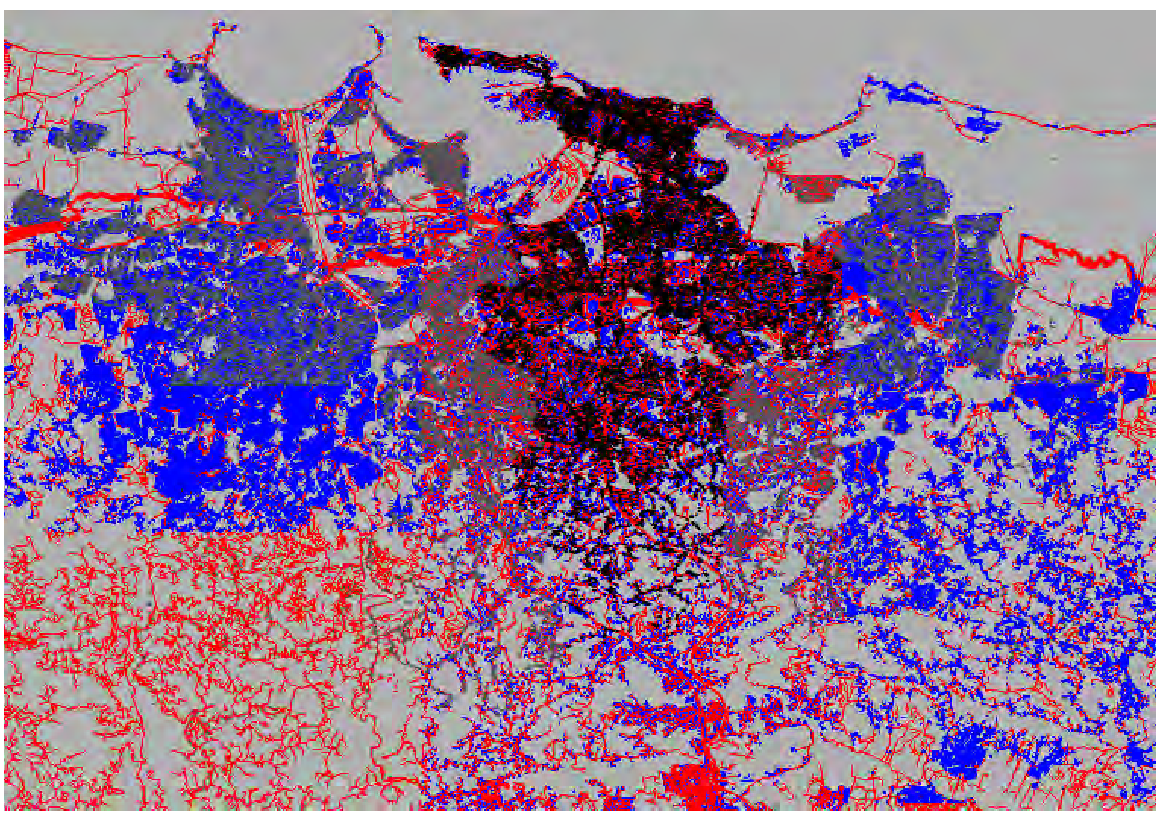
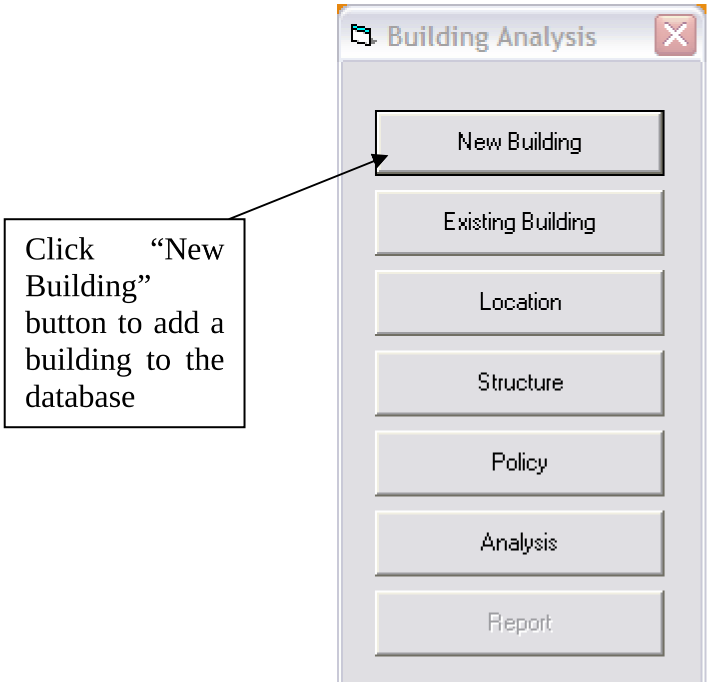


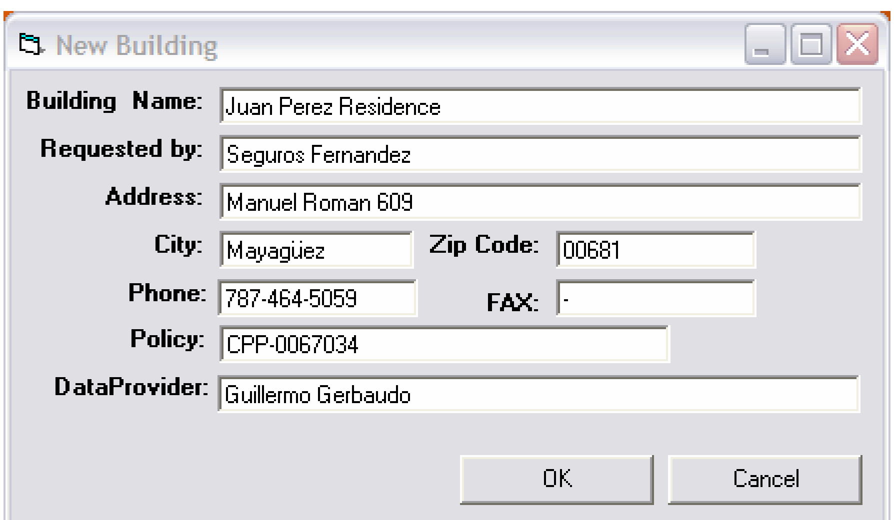
Figure L- 4 Topographic effects map of San Juan Metropolitan area

Appendix M Probable loss application examples

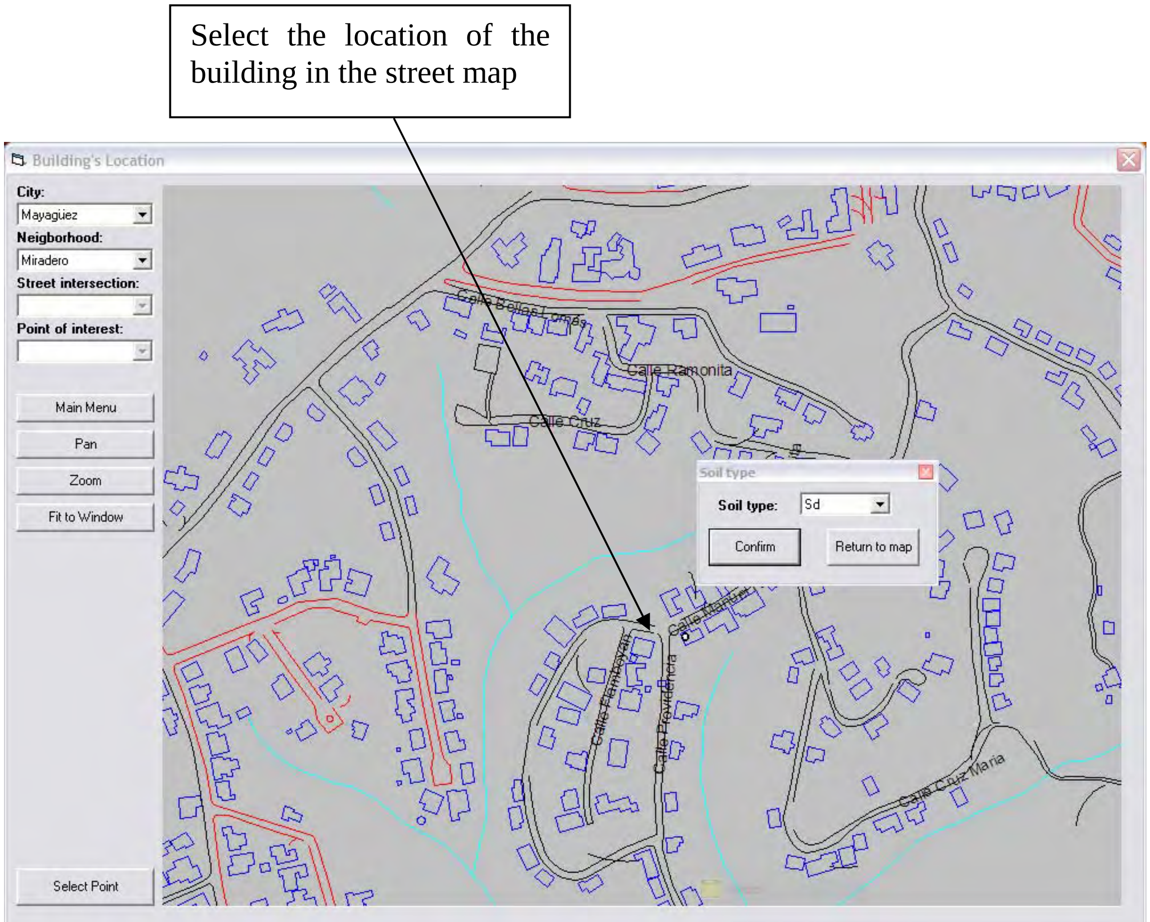
M.1 Concrete House Example



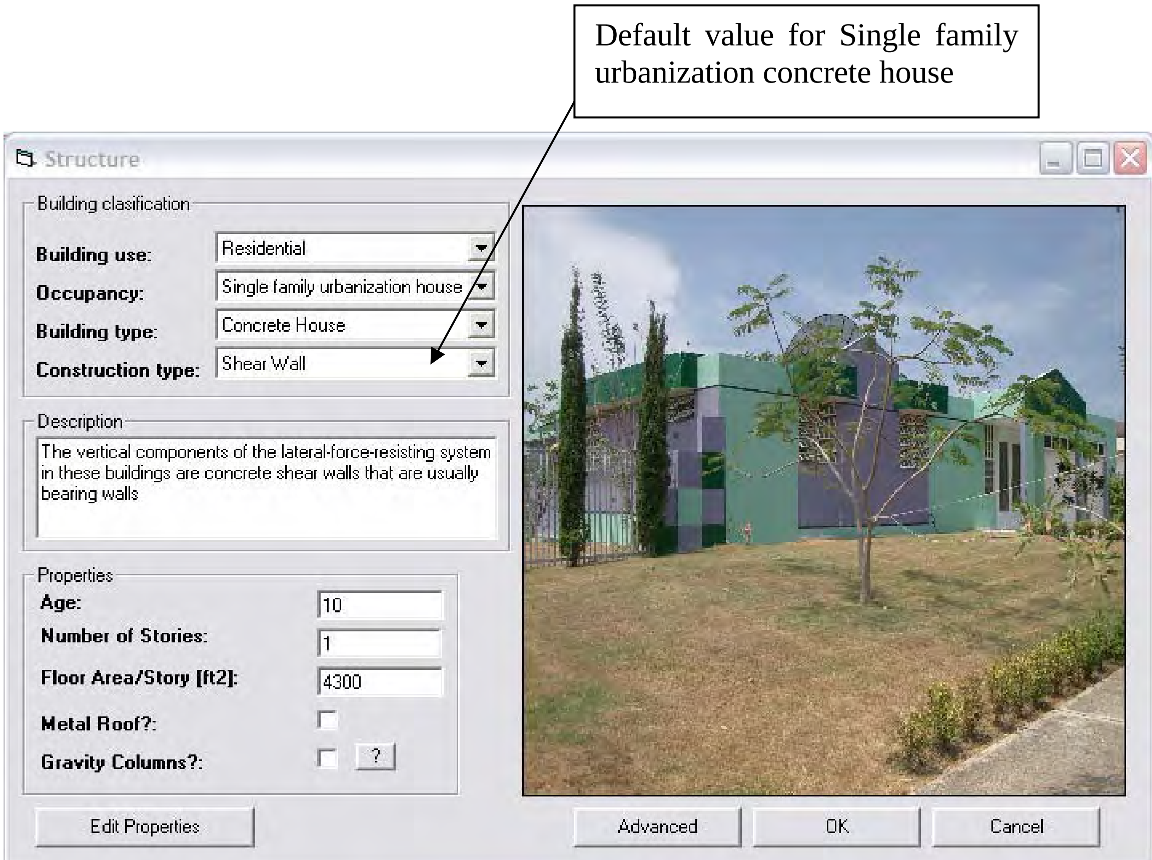
MAIN MENU



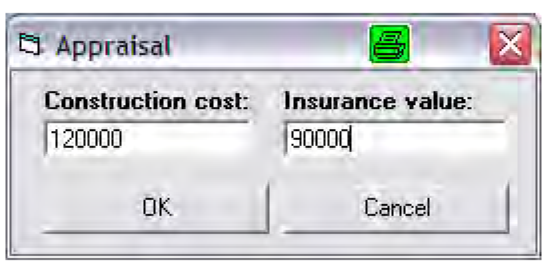
GENERAL INFORMATION


Select the location of the building in the street map
Building's Location
City:
Mayagüez
Neigborhood:
Miradero
Street intersection:
Point of interest:
Main Menu
Pan
Zoom
Fit to Window
Select Point
Calle Ramonita
Calle Cruz
Calle Providencia
Calle Cruz Maria
Soil type
Soil type:
Sd
Confirm
Return to map

LOCATION



STRUCTURE INFORMATION



APPRAISAL INFORMATION

LOSS ESTIMATION REPORT

Juan Perez residence

Manuel Roman 609 – Urb. Bellas Lomas
Mayagüez, PR

REQUESTED BY	:	Seguros Fernandez
DATA PROVIDED BY	:	Guillermo Gerbaudo
REPORT DATE	:	March 30, 2007

DATA DESCRIPTION

GENERAL INFORMATION

Building Name: Juan Perez Residence

Requested by: Juan Perez

Location: Manuel Roman 609

City: Mayagüez

Zip Code: 00681

Policy number: CPP-0067034

Report date: March 30, 2007

Phone: 787-464-5059

Fax: -

Data provided by: Guillermo M. Gerbaudo

SITE PROPERTIES

Soil classification: Type Sd according to NEHRP Provisions

Wind exposure: B

Topography: Flat

BUILDING CHARACTERISTICS

Building Use: Residential

Occupancy: Single family urbanization house

Construction type: Concrete Shear Wall (DefaultValue)

Age: 10 years

Number of Stories: 1

Floor Area: 4300 square feet

Roof type: Concrete (Assumed)

Gravity Columns: no

Advanced options: Not provided

BUILDING VALUE

Replacement value: US$ 120,000

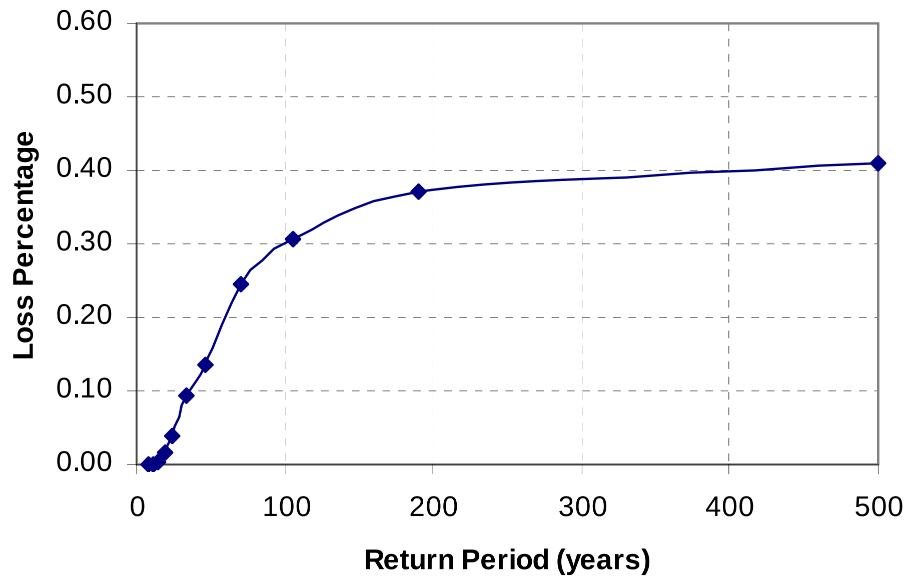
Insurance value: US$ 90,000

RESULTS

HURRICANE

Sustained Wind Speed [mph]	Hurricane	Return Period [YEARS]	Probable Loss [%]	[US$]
96	II	15	0.00	0
111	III	25	0.04	48
131	IV	45	0.14	168
156	V	110	0.31	372
170	V	190	0.37	444
185	V	500	0.41	492

Expected Annual Loss = 0.008 % (US$ 9.6)

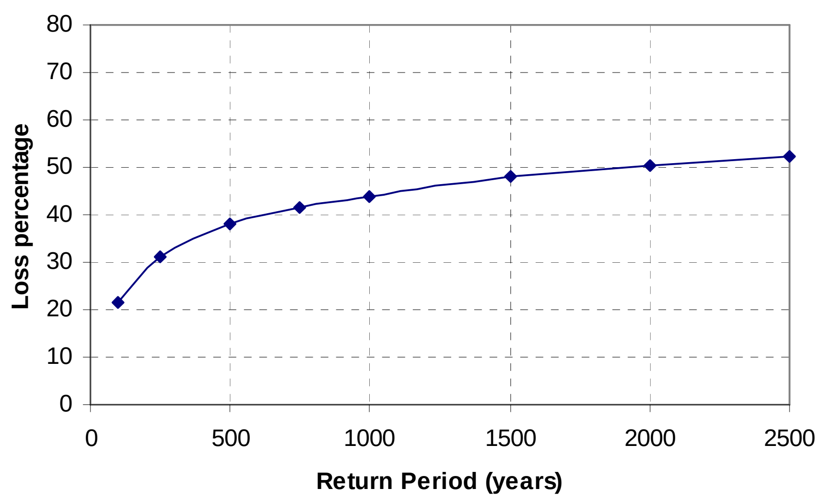


HURRICANE LOSS CURVE

EARTHQUAKE

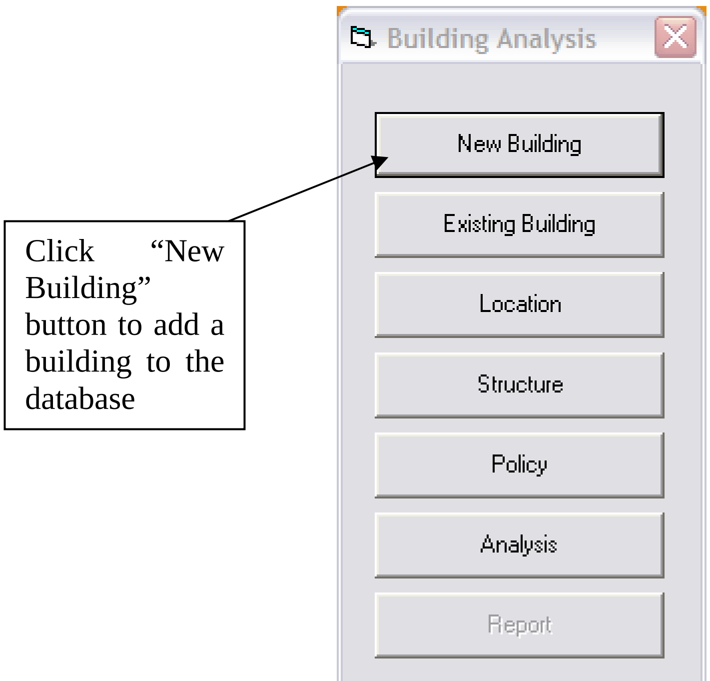
Peak Ground Acceleration [G]	Return Period [YEARS]	Probable Loss [%]	[US$]
0.12	100	21	25,200
0.19	250	31	37,200
0.25	500	38	45,600
0.30	750	41	49,200
0.34	100	44	51,800
0.39	1500	48	57,600
0.43	2000	50	60,000
0.47	2500	52	62,400

Expected Annual Loss = 0.316 % (US$ 379)

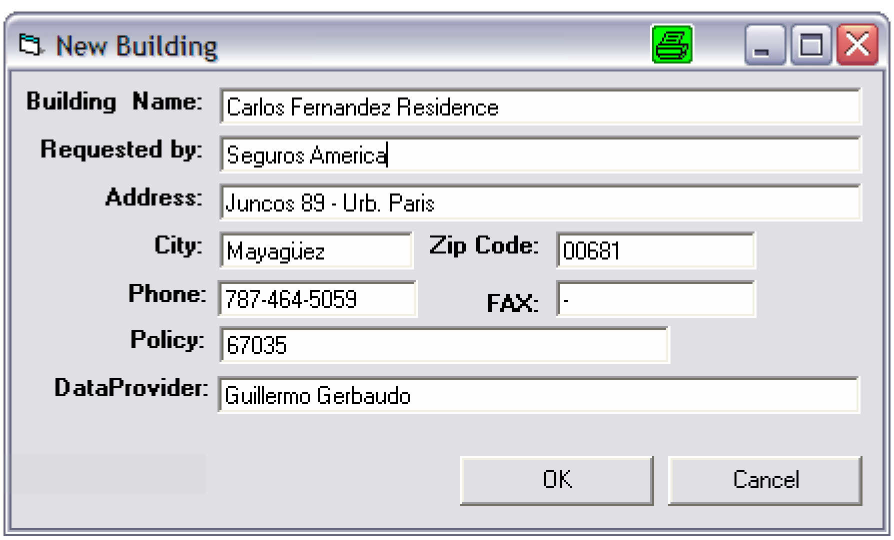


EARTHQUAKE LOSS CURVE

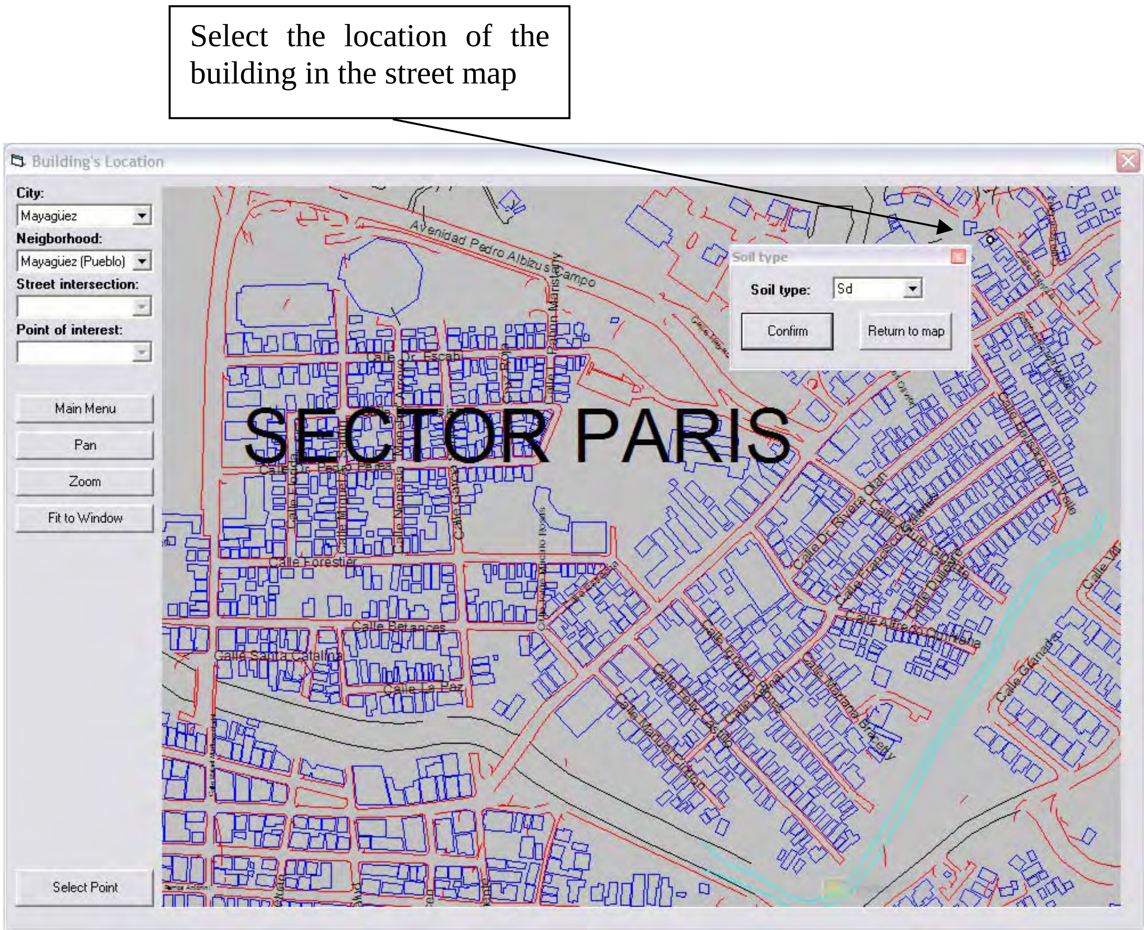
M.2 Wood House Example



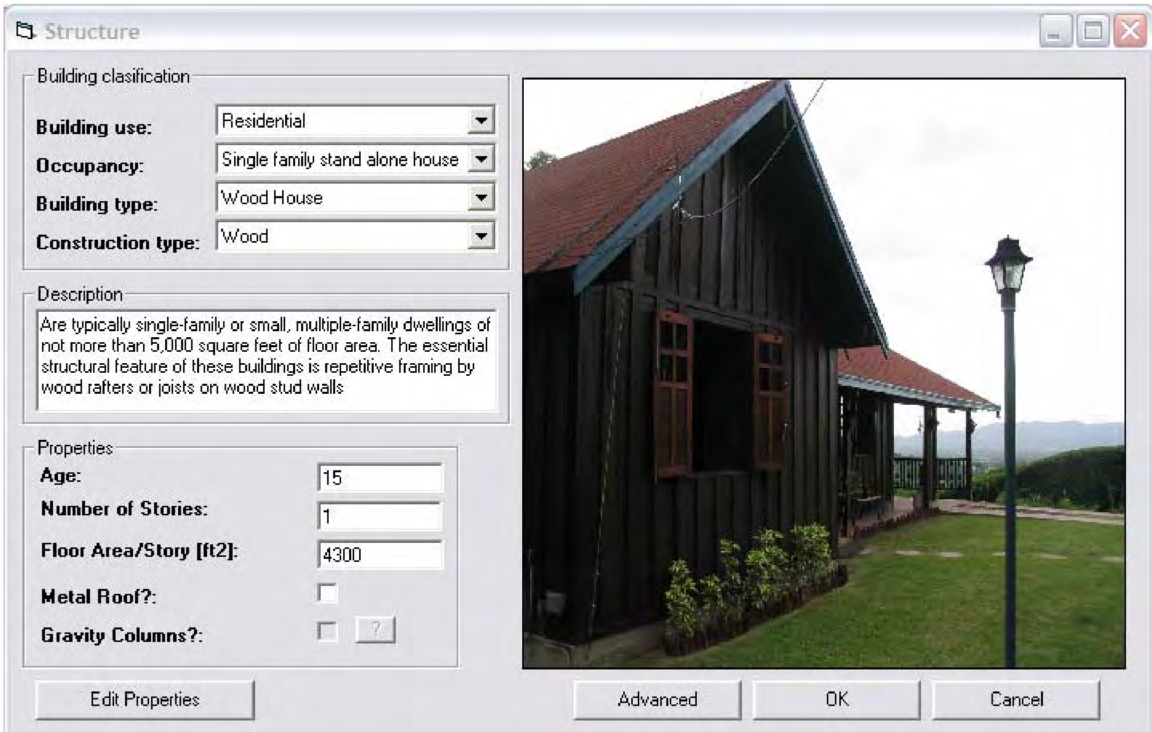
MAIN MENU



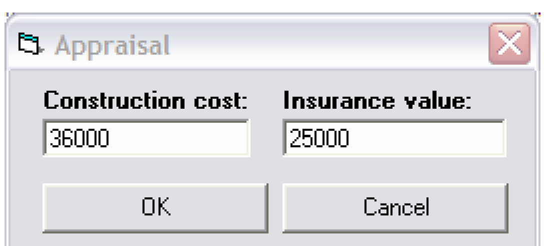
GENERAL INFORMATION


Select the location of the building in the street map
Building's Location
City:
Mayagüez
Neigborhood:
Mayagüez (Pueblo)
Street intersection:
Point of interest:
Main Menu
Pan
Zoom
Fit to Window
Select Point
Soil type
Soil type:
Sd
Confirm
Return to map
SECTOR PARIS
Calle Forestier
Calle Betances
Calle Santa Catalina
Calle La Paz

LOCATION



STRUCTURE INFORMATION



APPRAISAL INFORMATION

LOSS ESTIMATION REPORT

Carlos Fernandez Residence

Juncos 89 – Sector Paris
Mayagüez, PR

REQUESTED BY : Seguros America

DATA PROVIDED BY : Guillermo Gerbaudo

REPORT DATE : March 30, 2007

Data Description

General Information

Building Name: Carlos Fernandez Residence

Requested by: Seguros America

Location: Juncos 89 – Urb. Paris

City: Mayagüez

Zip Code: 00681

Policy number: CPP-0067035

Report date: March 30, 2007

Phone: 787-464-5059

Fax: -

Data provided by: Guillermo M. Gerbaudo

Site Properties

Soil classification: Type Sd according to NEHRP Provisions

Wind exposure: B

Topography: Flat

BUILDING CHARACTERISTICS

Building Use: Residential

Occupancy: Single family urbanization house

Construction type: Wood House

Age: 15 years

Number of Stories: 1

Floor Area: 4300 square feet

Roof type: Zinc

Gravity Columns: no

Advanced options: Not provided

BUILDING VALUE

Replacement value: US$ 36,000

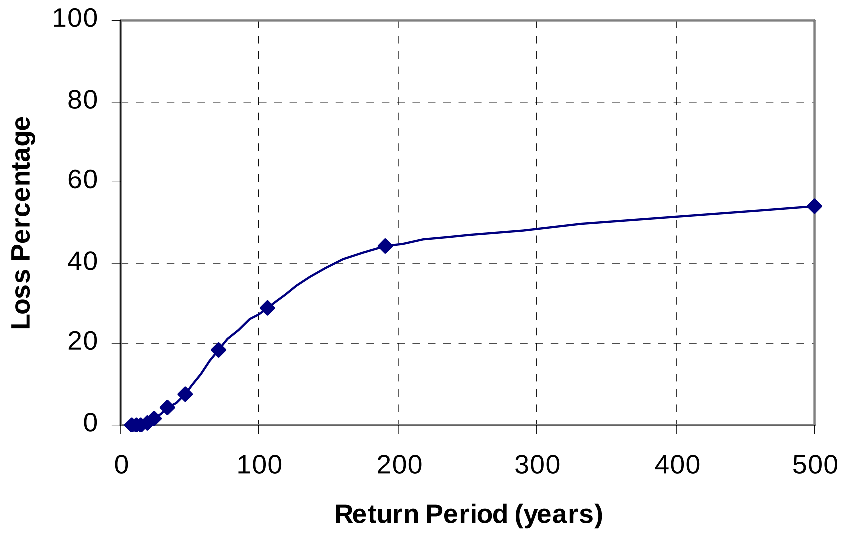
Insurance value: US$ 25,000

RESULTS

HURRICANE

Sustained Wind Speed [mph]	Hurricane [YEARS]	Return Period	Probable Loss [%]	[US$]
96	II	15	0.2	72
111	III	25	1.4	504
131	IV	45	7.4	2664
145	IV	70	18.5	6660
156	V	110	28.9	10404
170	V	190	44.0	15840
185	V	500	54.3	19548

Expected Annual Loss = 0.697 % (US$ 251)

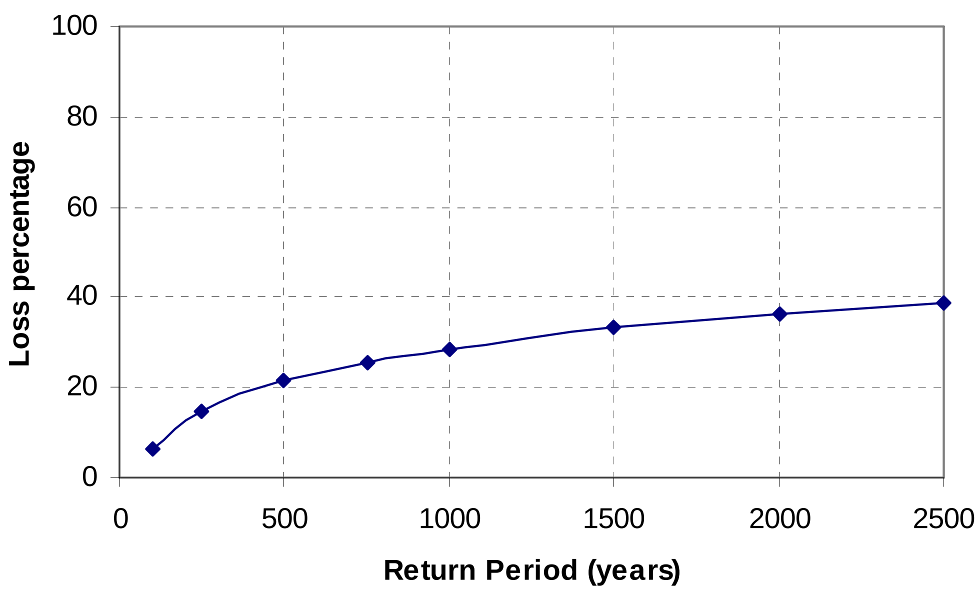


HURRICANE LOSS CURVE

EARTHQUAKE

Peak Ground Acceleration [G]	Return Period [YEARS]	Probable Loss [%]	[US$]
0.12	100	6.5	2,367
0.19	250	14	5,208
0.25	500	21	7,757
0.30	750	25	9,159
0.34	100	28	10,184
0.39	1500	33	11,995
0.43	2000	36	13,098
0.47	2500	39	13,900

Expected Annual Loss = 0.13 % (US$ 45)



EARTHQUAKE LOSS CURVE