Ain Shams University

Faculty of Engineering

Structural Engineering Department

FRAGILITY CURVES FOR REINFORCED CONCRETE & MASONRY SHEAR WALLS

A thesis submitted in partial fulfillment of

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Engineering in Structural Engineering.

The work included in this thesis has been carried out by the author in the Department of Structural Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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To (my lovely mother)

Abstract

Fragility curves are one of the methods which are used for evaluating the performance of RC and Rm shear walls.

Itis a relation between drift and probability forincidence a specific damage state for wall under loading of earthquake.

We have four damage states varying between cracking of the wall to the complete failure.

Benefit of fragility curves is not in using individual curves for each wall, it is in creating little curves showing fragility curves for a group of walls have similar engineering properties and have changes in other properties this curves created with reasonable dispersion value, it had been taken in this report ≤ 5%.

We have 34 walls had been tested and we extracted drifts values for the four damage states and we used these values in creating fragility curve for each wall.

There are various engineering properties can affect fragility curves simply as it can affect the wall behavior such as vertical reinforcement ratio, axial load ratio, aspect ratio, diagonal reinforcement ratio and type of wall`s material.

We studied the effect of varying each engineering property in fragility curves for each two walls have the same properties but have changes in a specific property by statistical operation and if total variance or dispersion calculated was in the accepted range we created a curve form the values of drift for two walls shows fragility curves for any wall has the same properties.

We had a summarizing processes later to study more than one change in one property by using statistical operation also and comparing between the dispersion of curves which belong to each wall used in statistical operation and when we find dispersion value ≤ 5 % for a group of walls we use all values of walls to create a new curve describes fragility curve for any wall has engineering properties are in the same range for these walls.

Finally, we had created 6 curves only from all statistical operations

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Chapter One

Introduction

1 .1 Earthquake

As general; an **earthquake** is a sudden vibration or trembling in the Earth. More than 150,000 tremors strong enough to be felt by humans occur each year worldwide. Earthquake motion is caused by the quick release of stored potential energy into the kinetic energy of motion.

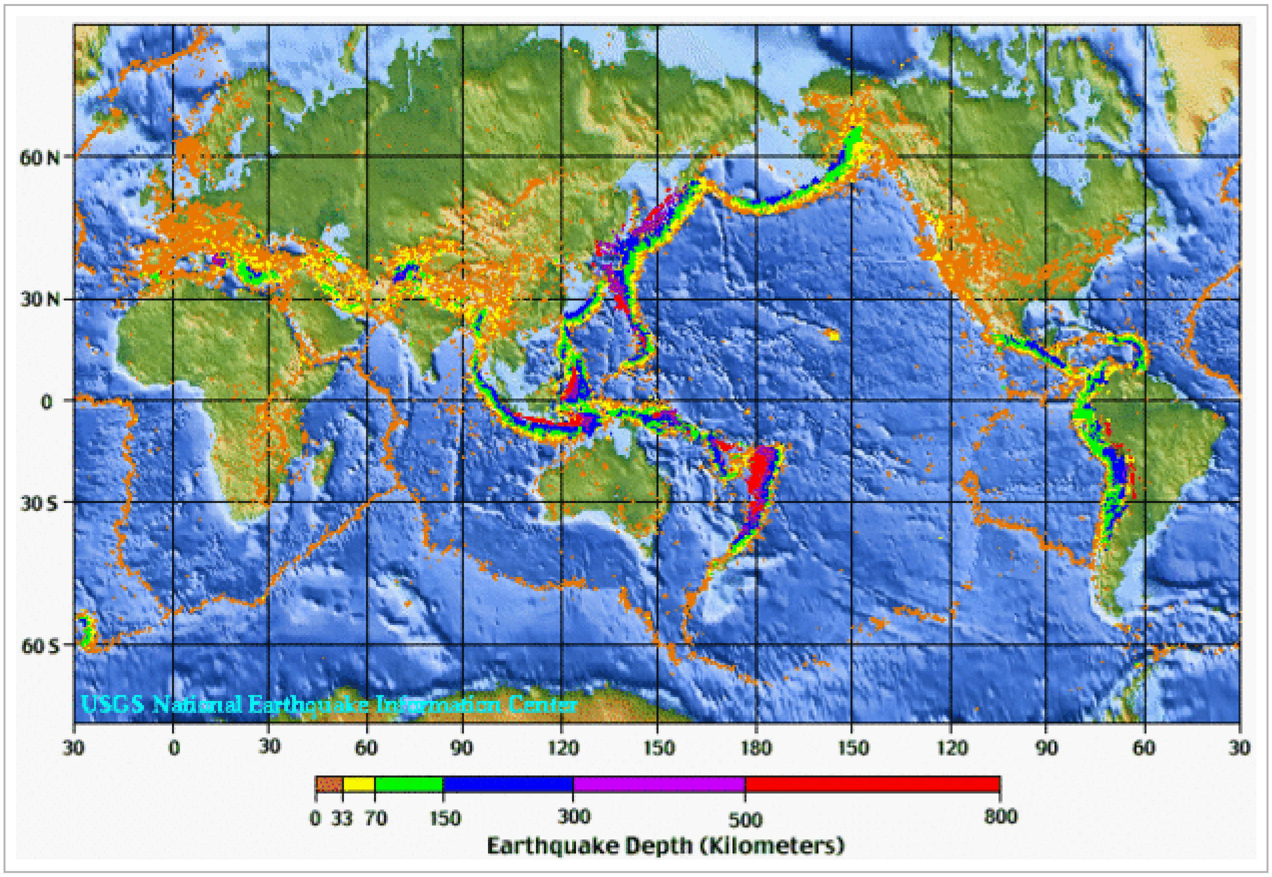


Figure 1.1-Distributions of earthquakes

The study of geotechnical earthquake engineering requires an understanding of the various processes by which earthquakes occur and their effects on ground motion. The field of seismology developed from a need to understand the internal structure and behavior of the earth particularly as they relate to earthquake phenomena.

1.2 Earth internal structure

1-crust

2- Mantle

3- Outer core

4- Inner core

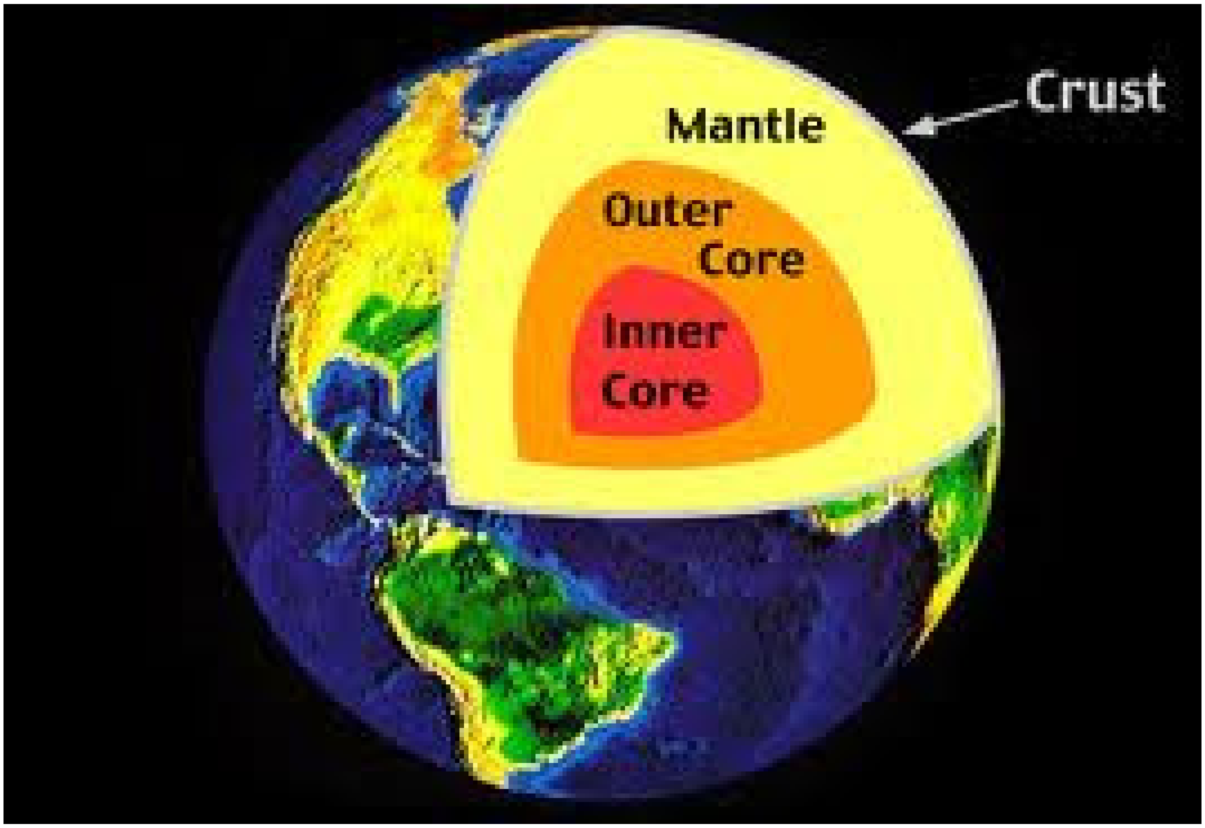


Figure 1.2- earth internal structures

1- The Crust

- **Thickness**

  About 25 to 40 KM in thickness beneath the continents, 60 to 70 KM under some young mountain and about 5 KM beneath the oceans.

- **Internal structure**

  Basaltic layer which overlain by a granite layer at continental locations.

- **Specific gravity**

  Up to 3.2

2- The Mantle

- **Thickness**

About 2850 KM in thickness.

- **Internal structure**

The mantle is cooler near the crust than the greater depths. Its average temperature is 4000 F. as aresult; the mantle materials are in viscous, semi molten state. They behave as a solid when subjected to rapidly applied stresses (seismic waves), but can slowly flow like a fluid in response to long term stresses.

- **Specific gravity**

About 4 to 5

3- Outer core

The outer core or liquid core about 2260 KM in thickness. As aliquid, it cannot transmit S-waves. The S- wave's velocity drops to zero at the core mantle boundary.

4- Inner core

The inner core or solid core: it is a very dense, solid nickel-iron material compressed under tremendous pressures. The temperature of the inner core is estimated to be relatively uniform at over 5000F.

1.3 Seismic waves

1- Body waves

- Primary waves (P-waves).
- Second waves (s-waves).

2- Surface waves

- Rayleigh waves (R-waves).
- Love waves (L-waves).

1- Body waves

- **Primary waves (P-waves)**

P-waves, also known as primary, compressional or longitudinal waves, involve successive compression and rarefaction of the materials through which they pass. They are analogous to sound waves; the motion of an individual particle that a P-wave travels through is parallel to the direction of travel.

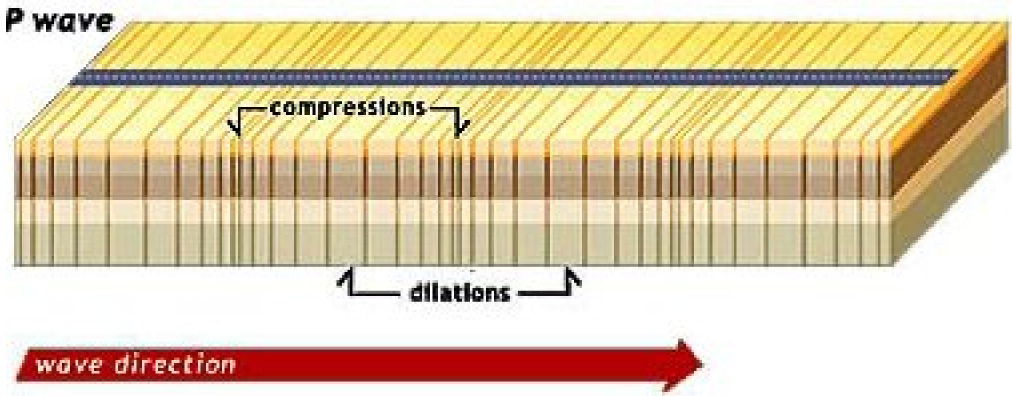


Figure 1.3- (P- waves)

- **Secondary waves (S-waves)**

S-waves, also known as secondary, shear or transverse waves cause shearing deformations as they travel through a materials. The motion of an individual particle is perpendicular to the direction of S-waves travel.

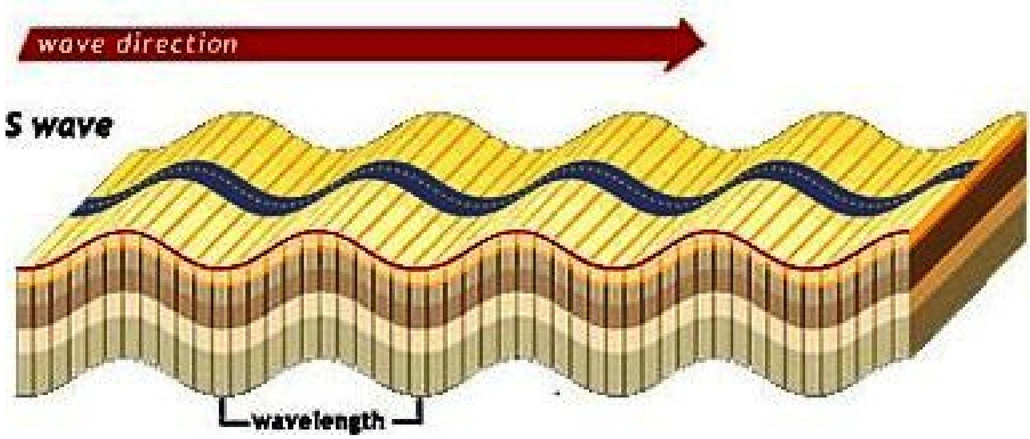


Figure 1.4- (S- waves)

The direction of particle movement can be used to divide S-waves into two components:

1- SV (vertical plane movement).
2- SH (horizontal plane movement).

Since geologic materials are stiffest in compression, P-waves travel faster than the other seismic waves and are therefore the first to arrive at a particular site. Fluids, which have not shear strength, cannot sustain shear waves.

2- Surface waves

Surface waves results from the interaction between body waves at the surface and the surficial layers of the earth. They travel along the earth`s surface with amplitudes that decrease roughly exponentially with depth. The most important surface waves, for engineering purposes, are Rayleigh waves and Love waves.

- **Rayleigh waves**

They produces by interaction of P-and SV-waves with the earth`s surface, involve both vertical and horizontal particle motion.

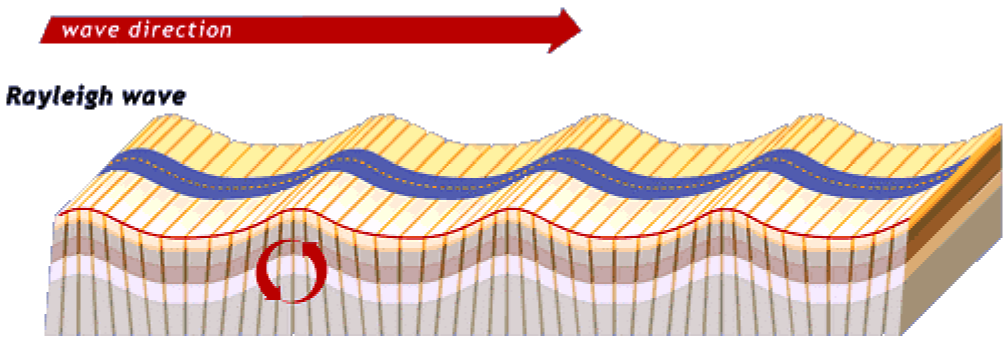


Figure 1.5- Rayleigh waves

- **Love waves**

They results from the interaction of SH-waves with a soft surficial layer and have no vertical component of particle motion.

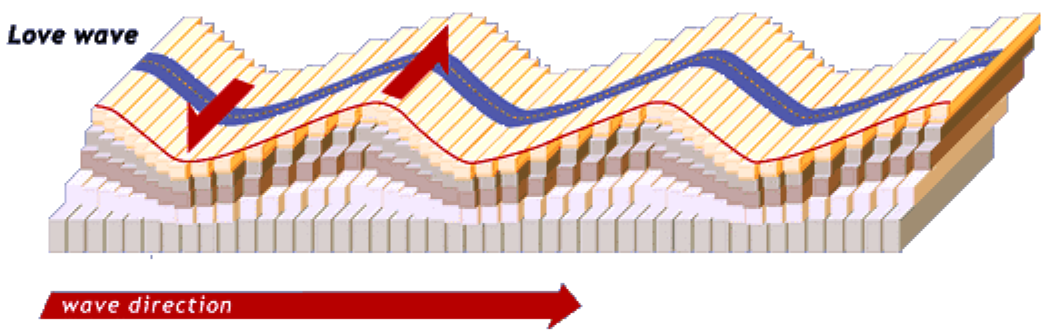


Figure 1.6- Rayleigh waves

1.4 Transmission of earthquake from earth to structure

Earthquake causes shaking of the ground. So a building resting on it will face motion at its base. From Newton's First Law of Motion, even though the base of the building moves with the ground, the roof has a tendency to stay in its original position. But since the walls and columns are connected to it, they drag the roof along with them. This is much like the situation that you face when the bus you are standing in suddenly starts; your feet move with the bus, but your upper body tends to stay back making you fall backwards!! This tendency to continue to remain in the previous position is known as inertia. In the building, since the walls or columns are flexible, the motion of the roof is different from that of the ground.

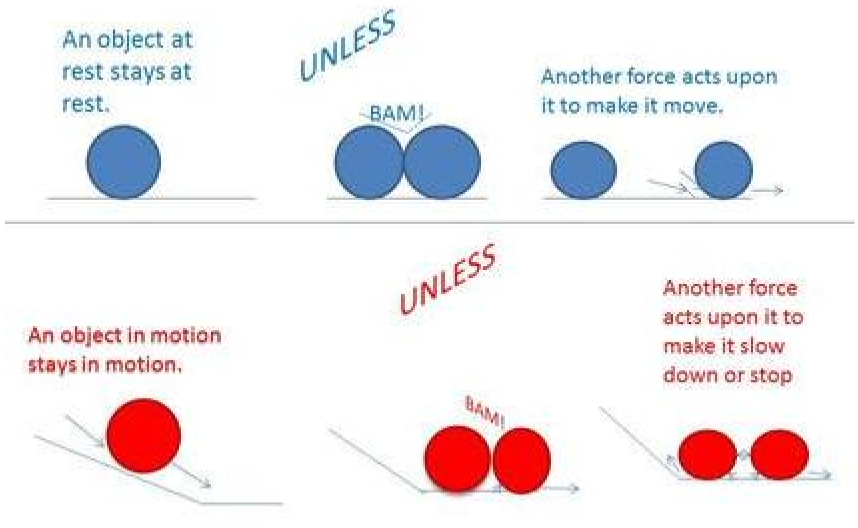
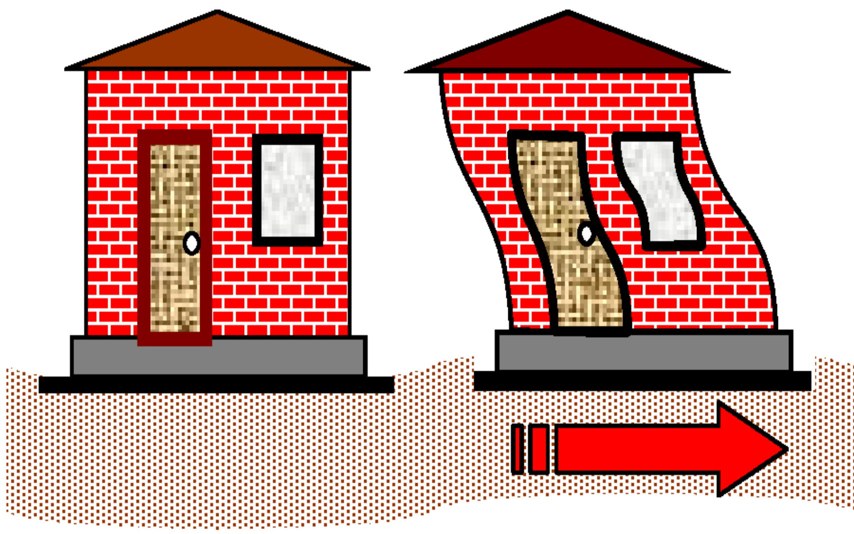


Figure 1.7- Newton's first law of motion



Effect of earthquakeon a building when shaken at its base

Figure 1.8- Effect of earthquake on buildings

- ## Inertia Forces in Structures

When the ground moves, even the building is thrown backwards, and the roof faces a force, called inertia force. If the roof has a mass (M)and faces an acceleration (a), then from Newton's Second Law of Motion, the inertia force (FI)is mass (M) times acceleration (a), and its direction is opposite to that of the acceleration. Clearly, more mass means higher inertia force. Therefore, lighter buildings sustain the earthquake shaking better.

$$F_{\text{net external}} = ma$$

Net force on object = mass of object x acceleration

Figure 1.9- Newton`s second law of motion

- ## Effect of Deformations in Structures

The inertia force experienced by the roof is transferred to the ground via the columns, causing forces in columns. These forces generated in the columns can also be understood in another way. During earthquake shaking, the columns undergo relative movement between their ends. In Figure 1.10, this movement is shown as quantity (u) between the roof and the ground. But, given a free option, columnswould like to come back to the straight verticalposition, i.e., columns resist deformations. In the straight vertical position, the columns carry no horizontal earthquake force through them. But, when forced to bend, they develop internal forces. The larger is the relative horizontal displacement (u) between the top and bottom of the column, the larger this internal force in columns. Also, the stiffer the columns are (i.e., bigger is the column size), larger is this force. For this reason, these internal forces in the columns are called stiffness forces. In fact, the stiffness force in a column is the column stiffness times the relative displacement between its ends.

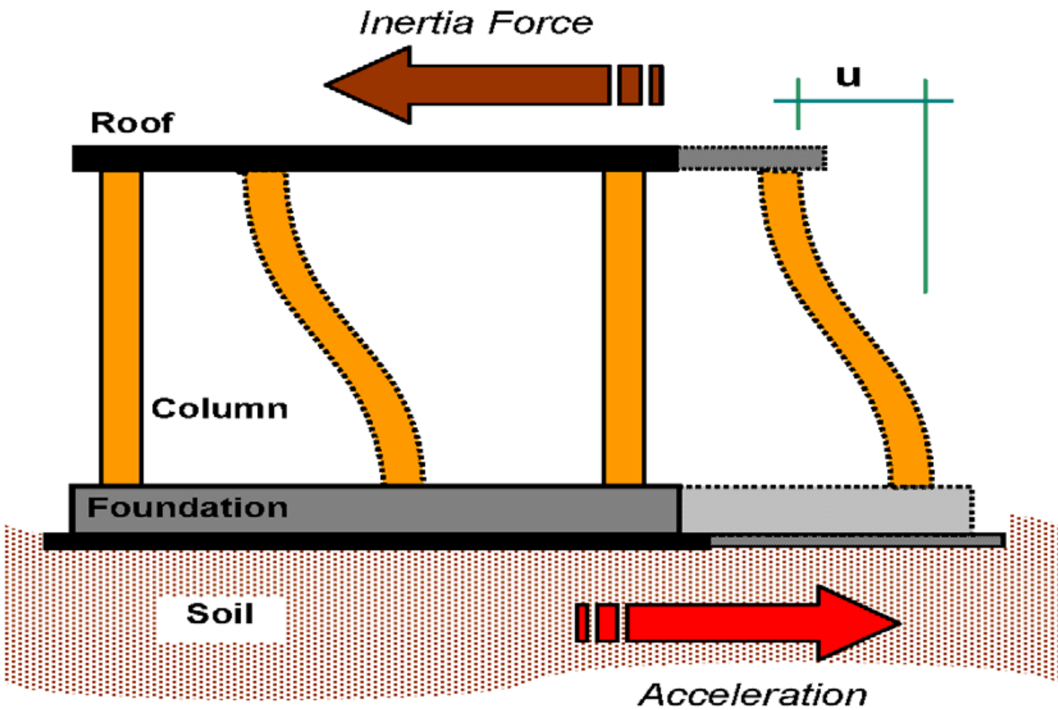


Figure 1.10- Inertia force and relative motion within a building

- ## Horizontal and Vertical Shaking

Earthquake causes shaking of the ground in all three directions – along the two horizontal directions (X and Y), and the vertical direction (Z) (Figure 3). Also, during the earthquake, the ground shakes randomly back and forth (- and +)along each of these X, Y and Z directions. All structures are primarily designed to carry the gravity loads, i.e., they are designed for a force equal to the mass (M) (this includes mass due to own weight and imposed loads) times the acceleration due to gravity (g)acting in the vertical downward direction (-Z). The downward force (Mg)is called the gravity load. The vertical acceleration during ground shaking either adds to or subtracts from the acceleration due to gravity. Since factors of safety are used in the design of structures to resist the gravity loads, usually most structures tend to be adequate against vertical shaking.
However, horizontal shaking along X and Y directions (both + and – directions of each) remains a concern. Structures designed for gravity loads, in general, may not be able to safely sustain the effects of horizontal earthquake shaking. Hence, it is necessary to ensure adequacy of the structures against horizontal earthquake effects.

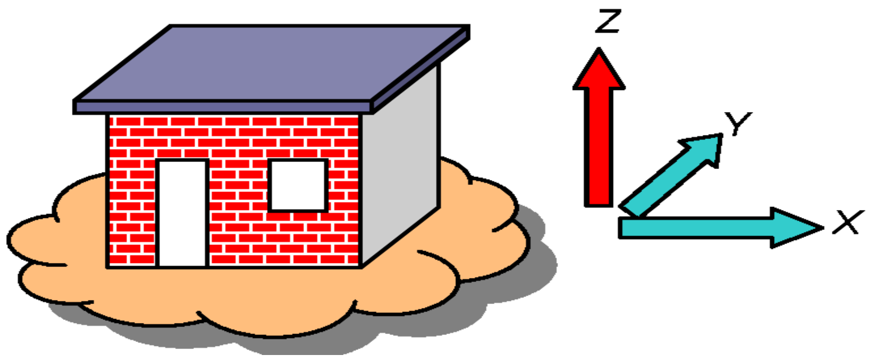


Figure 1.11- Principal directions of a building

- ## Flow of Inertia Forces to Foundations

Under horizontal shaking of the ground, horizontal inertia forces are generated at level of the mass of the structure (usually situated at the floor levels). These lateral inertia forces are transferred by the floor slab to the walls or columns, to the foundations, and finally to the soil system underneath (Figure 4). So, each of these structural elements (floor slabs, walls, columns, and foundations) and the connections between them must be designed to safely transfer these inertia forces through them.

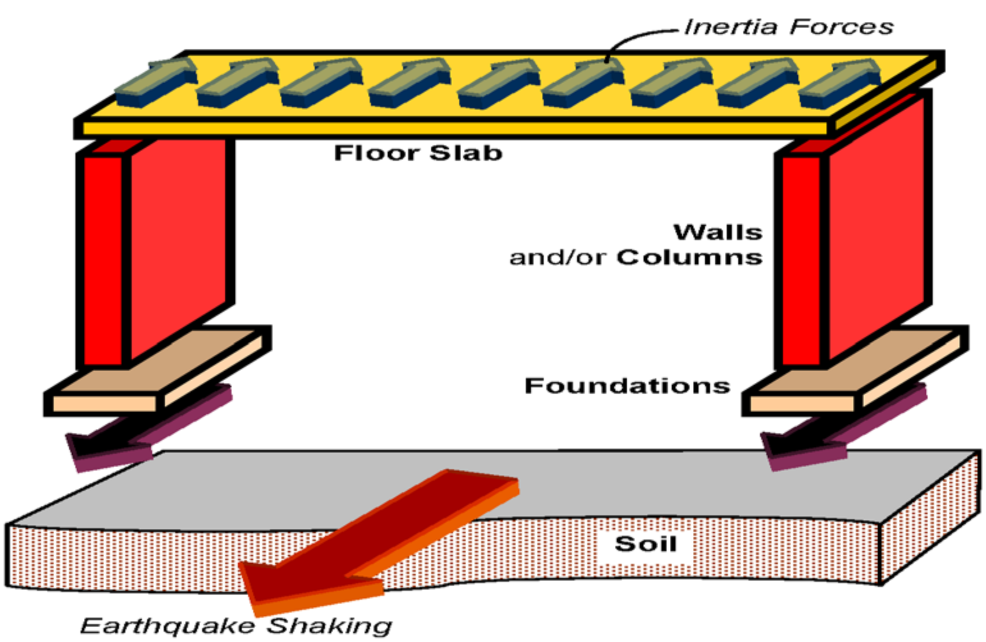


Figure 1.12- Flow of seismic inertia forces through all structural components.

Walls or columns are the most critical elements in transferring the inertia forces. But, in traditional construction, floor slabs and beams receive more care and attention during design and construction, than walls and columns. Walls are relatively thin and often made of brittle material like masonry. They are poor in carrying horizontal earthquake inertia forces along the direction of their thickness. Failures of masonry wallshave been observed in many earthquakes in the past. Similarly, poorly designed and constructed reinforced concrete columns can be disastrous.

1.5 Examples of destructive effect of earthquake on structures

There were various examples of earth quakes failures because of lake or weakness of the elements resisting the lateral forces.

Figure 1.13-Partial collapse of stone masonry walls during 1991 Uttarkashi (India) earthquake.

Figure 1.14- Collapse of reinforced concrete columns (and building) during 2001 Bhuj (India) earthquake.

Figure 1.15- Catastrophic earthquake damage to the Alto Rio building, Conception, Chile due to the February 27, 2010 M8.8 Earthquake

Figure 1.16- New-Zealand-building

Figure 1.17- Bending of building, Kobe earthquake. (Photo from: The January 17, 1995 Kobe Earthquake.

1.6 Elements resisting earthquake loads

Reinforced concrete (RC) walls are structural elements frequently used in buildings to provide lateral stiffness and strength against wind and earthquake actions. In regions of moderate and high seismicity such walls are typically designed and detailed according to capacity-design principles. Nevertheless, significant structural differences can be observed: In regions with a high seismic hazard, walls with purely rectangular cross sections are seldom used because the strength and ductility required against strong earthquake actions is better achieved by walls with boundary elements. If, as an exception, walls with a rectangular cross section are used, they often need large reinforcement ratios. Therefore, in countries with high seismicity, research and experimental testing focus on RC structural walls featuring these characteristics. On the contrary, in regions of moderate seismicity, such as e.g. Switzerland, wall sections are typically purely rectangular and often a total reinforcement ratio of less than 1% is sufficient to provide the required lateral stiffness and strength to the structure. Moreover, in most countries of Central Europe the number of stories of office and factory buildings is limited and therefore the axial load ratio of the structural walls is relatively low.(Alessandro Daizo, Kartin Bayer, Hugo Bachmann, 2009), Important differences exist also with respect to the mechanical properties of the reinforcement. Particularly in Central Europe the importance of the ductility properties of the longitudinal reinforcement on the displacement capacity of the walls was for a long time undervalued and reinforcing steel was merely rated for its strength rather than its deformation capacity. As a consequence a portion of the existing RC wall buildings was constructed with reinforcing steel possessing inferior ductility properties. For these reasons, experiments were conducted to investigate the effects of the particularities of structural walls.

On the other side,in regions of low seismic activity, masonry still remained a popular and economical option as a building material, particularly for low-rise construction. Regions of high seismic activity demanded more ductile and earthquake resistant structures, and as a result reinforced masonry was developed. In general, the seismic design of all masonry structures is highly conservative due to the historically poor performance of unreinforced masonry in past earthquakes. However, properly detailed and well-constructed reinforced masonry has consistently preformed well and provided adequate safety during seismic events. Masonry has been a popular construction material for millennia. It has been used to build notable historical structures such as the Egyptian pyramids, the Roman coliseum, medieval castles and many more. The prevalence of masonry construction throughout the world can be attributed to its relative versatility, its durability and ability to withstand the natural elements, its cost effectiveness, and its ease of construction.

1.7 Failure Modes of Shear Walls

Reinforced shear walls located in high seismic regions need to simultaneously resist in-plane and out-of-plane lateral loads as well as vertical loads. Various loading conditions may cause four distinct failure mechanisms, or a combination thereof, to arise. These failure mechanisms, depicted in include rocking, sliding, flexure and shear. Rocking and sliding can be prevented with adequate anchorage, leaving flexure and shear as the dominant failure mechanisms. Wall behavior is dependent upon the height-to-length aspect ratio of the wall, the magnitude of the applied axial load, and the amount and distribution of horizontal and vertical reinforcement.

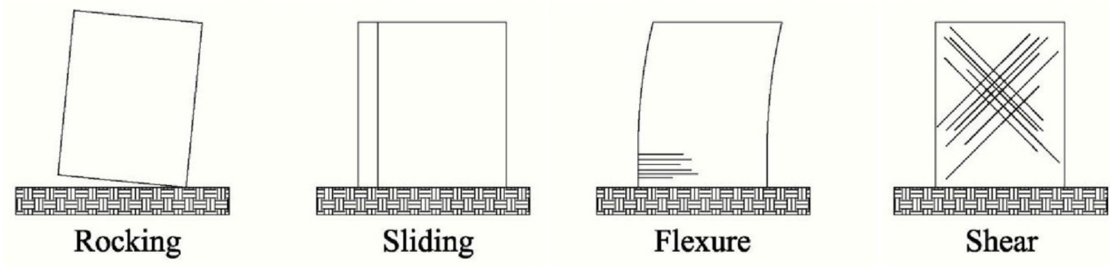


Figure 1.18- Shear Wall Failure Modes (adapted from Eikanas, 2003)

- **Flexural failure**

It is typically characterized by tensile yielding of the vertical reinforcement, the formation of a plastic hinge zone and crushing of masonry at critical wall sections (for masonry shear walls) (Shedid et al., 2008; Shing et al., 1989). Crushing of the masonry is often accompanied by vertical splitting of the masonry in the toe regions. At increased displacements, face shell spalling and eventual crushing of the grout also occur in the toe regions (Shedid et al, 2008). Flexural wall behavior is negatively affected by high vertical reinforcement ratios which correspond to decreased levels of drift and ductility and can result in more brittle failures (Eikanas, 2003; Sherman, 2011). The flexural strength increases as the magnitude of applied axial stress increases (Shing et al., 1989). Walls with height-to-length aspect ratios greater than 1.5 exhibit more flexure-dominated behavior than shear-dominated behavior. Shear walls are typically designed to fail in flexure to ensure a ductile response.

Flexure is the preferred type of failure because of its ductile nature and effectiveness at dissipating energy.

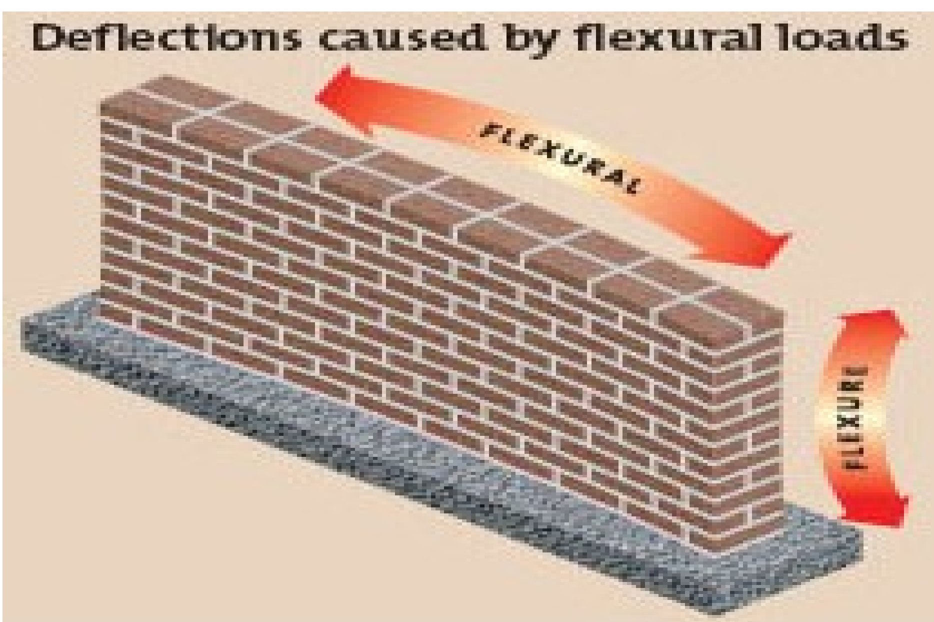


Figure 1.19- Deformations caused by flexural loads.

Flexure failure is divided into four categories according to a predefined method of repair (**Banting, Bennett[1]; El-Dakhakhni, Wael[2],2012),** Insignificant, Slight, Moderate and Extreme. These damage states have been identified to coincide with a certain level of remediation (i.e. epoxy injection of cracks).

- **Damage States for shear walls failing under flexure**

Designation	Damage State Criteria	Method of Repair	Experimental Observation
DS1 (Insignificant)	Initiation of Flexural Cracks Initiation of Shear Cracks Cracks < 1.6 mm wide	Cosmetic	Occurrence of first visible cracks (flexure/shear) (Lateral load ≈ 75% Fy)
DS2 (Slight)	Cracks < 3.2 mm Insignificant residual displacement	Injection	First instance of flexural yielding of reinforcement (Lateral load ≈ 80% Fu)
DS3 (Moderate)	Cracks < 3.2 mm Moderate spalling/vertical cracking in compression toes Insignificant residual displacement	Remove and patch spalled masonry	Point at which peak loading is sustained to (i.e. until a significant deviation from peak occurs)
DS4 (Extreme)	Fracture of extreme tension reinforcement, buckling between lateral ties, crushing of confined core, replacement or enhancement required	Replacement or enhancement of wall	Wall sustained a drop in resistance to 50% Fu or visual confirmation of damage sate criteria

Table 1.1- Damage states for shear walls failing under flexure

Figure 1.20- Typical flexural failure for reinforced concrete shear wall. Specimen (2) (Felipe Cifelli, 2011) before testing began (Face A). Right: Specimen after loss of lateral load capacity.

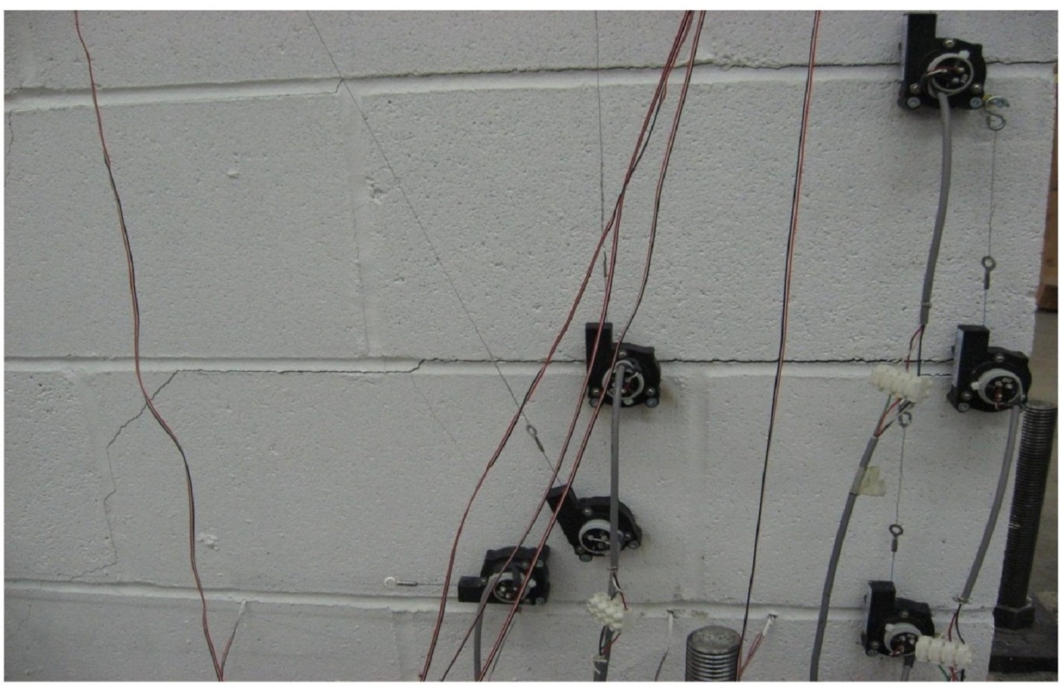


Figure 1.21-Development of flexure cracks, (Dg1). (Wall 2, C-Kapoi, 2012).

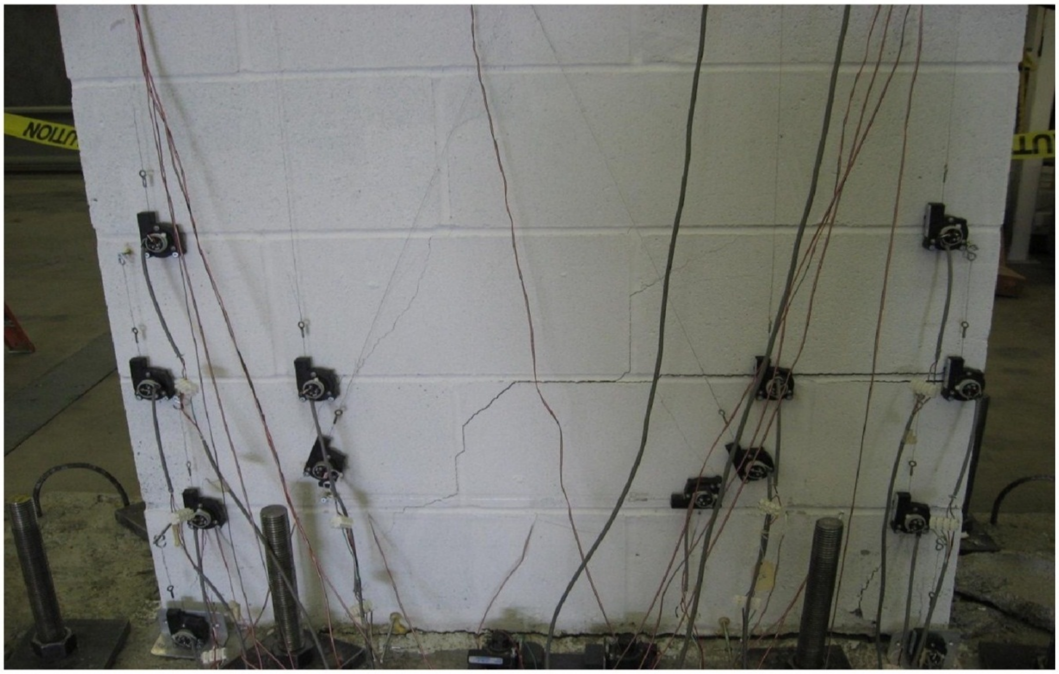


Figure 1.22- Further Development of flexure cracks, (Dg2). (Wall 2, C-Kapoi, 2012)

Figure 1.23- Progression of cracks, (Dg3). (Wall 6, C-Kapoi, 2012)

Figure 1.24- (Dg4).Specimen (2) (Felipe Cifelli, 2011)

- **Shear failure**

Shear failures are undesirable because they exhibit more brittle behavior and “rapid strength degradation soon after the maximum strength is reached” (Voon and Ingham, 2006). They are characterized by diagonal tensile cracking that often starts as horizontal flexural cracks that develop into wide-open diagonal cracks and extend throughout the wall. Walls with height-to-length aspect ratios less than 1.0 are often dominated by shear behavior. The shear resistance of a masonry shear wall comes from the “tension of shear reinforcement, dowel-action of vertical reinforcement, applied axial stress and aggregate interlocking” (Shing et. al., 1989). Shear strength can be increased by evenly distributing the horizontal reinforcement up the height of the wall which helps distribute the stresses (Voon and Ingham, 2006). This can also change the wall’s behavior from a brittle failure to a more ductile failure. Larger amounts of vertical reinforcement reduce the size and amount of crack openings which enhances the aggregate-interlock system (Shing et. al., 1989). Lastly, larger magnitudes of applied axial load increase the shear strength by delaying the initiation of cracking and enhancing the aggregate-interlock system (Ibrahim and Suter, 1999; Voon and Ingham, 2006).

Figure 1.25- Typical shear failure, Chi-Chi Earthquake in Taiwan

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Figure 1.26- Shear Failure, Specimen (1) (Felipe Cifelli, 2011)

Figure 1.27- Lower right side of specimen after failure, Specimen (1) (Felipe Cifelli, 2011).

Over the past 40 years, major changes regarding seismic design procedures have occurred. Historically, seismic design procedures were based primarily on forces and the strength necessary to resist them largely because that is what dead and live loads are traditionally designed for. It was believed that the strength of a structure was synonymous with the performance of a structure (Priestley, 2000). Research conducted during the 1970's and 1980's focused on determining the ductility of structural systems and incorporating this into the design requirements, but the overall design methods were still based on resisting forces. In the 1990's, a new design method based on desired levels of displacements, instead of forces, was introduced and has been the focus of research since then (Priestley et al., 2007).

The new design method, referred to as performance-based design, was developed to overcome shortcomings in the previous force-based design methodology.
Force-based design methods are based on the elastic behavior of shear walls while performance-based design methods recognize that the inelastic behavior of shear walls is a more accurate representation of their performance. This is incorporated into the design method by taking the stiffness of a shear wall as the secant stiffness obtained at maximum displacement. Performance-based design provides a more consistent and realistic prediction of shear wall behavior and may also result in more economical designs than the force-based design method.

Through history, we had recognized that earthquakes caused in a big disasters to structures which hadn`t any elements to resist the horizontal force produced from quakes, as we said later, there is a concept in thedesign of structures that was seismic design conceptwas based primarily on forces and the strength necessary to resist them largely because that is what dead and live loads are traditionally designed for.
So, there was a need for developing the field of design ofreinforced concrete structure which will be subjected to lateral load specially earth quakes loads and develop the concept of design

ofshear walls and elements resisting lateral loads also, there was a need to evaluate the behavior of shear walls under earth quakes loading, predict the failure`s type of wall and the expected displacements or damage state which we will face under action of earth quake.

One of themethods used for evaluating the performance of RC and RM shear walls in earthquakes is the use of fragility curves.

1.8 Objectives of the report

1- Application of fragility curves analysis in various shear walls failing under flexure only.
2- Discovering the effect of various engineering parameter of shear walls on fragility curves.
3- Extracting simple united curves of fragility curves describes group of shear walls have common engineering parameters, but have a change in one or more than one of engineering parameters.

1.9 Outline of the report

- **Chapter Two:**

  1- Definition of fragility, why we use it?
  2- The methods of applying it.
  3- Definition of the used test data.
  4- Definition of demand parameter.

- **Chapter Three:**

  1- Fragility analysis in all walls.
  2- Studying the effect of changing in one engineering parameter of wall in fragility values and behavior of the wall.
  3- Summarizing all curves we had created to have a little no. of curves by studying the effect of changing in more than one engineering parameter of wall`s engineering parameters.

- **Chapter Four:**

  Conclusion

Chapter Two

Fragility Functions & Experiments walls data

2.1 Fragility curves

These diagrams show the probability of exceeding a specific state of damage versus seismic intensity parameters, such as (As), (ρv), cross section shape, (P) or any other demand parameters.

2.2 Whydo we create fragility curves?

Each year earthquakes occur in several countries, killing many people and causing extreme lossesso that, evaluating the seismic performance of buildings and proposing some effective methods to rehabilitate them against earthquakes is an essential step toward hazard mitigation and risk assessment.Developing fragility curves for a specific type of building is a probabilistic method to estimate the probability that the building will exceed a specific state of damage for a definite value of the seismic intensity parameter. This parameter can be taken as(As) for wall, (ρv)and(P) or any other demand or damage parameter related to wall or earth quake.

2.3 Types of fragility curves

Two classes of fragility curves have been developed. They are distinguished by the demand of parameters used. Class A curves use the story-drift ratio as the demand parameter, which is a common measure of seismic demand on a structure or structural component.
In this report we used Class A.

Class B fragility curves are based on these demand parameters.the demand parameters associated with flexural and shear damage are defined differently. The damage of flexure-dominated walls can be related to the level of flexural deformation, while that caused by diagonal shear is more related to the shear force demand as compared to the shear capacity because of the brittle and sudden nature of the latter.

2.4Methods of fragility curves

2.4.1 Lognormal Distribution

The lognormal distribution is a one-sided probability distribution of a random variable whose logarithm is normally distributed. This distribution is widely used for fragility studiesandits relationship with the normal or Gaussian distribution is:

$$F(\Delta) = \emptyset((\ln(\Delta/\theta i)/\beta i)$$

$$\beta i = \sqrt{\left(\frac{1}{n-1}\sum_{i-1}^{n}\left(\ln\left(\frac{\Delta i}{\theta i}\right)\right)^2\right.}$$

$$\theta i = e^{(1/n \sum_{i-1}^{n} \ln \Delta)}$$

F (Δ) →denotes the fragility function for damage state defined as the probability that the component reaches or exceeds a specific damage state.
(Φ) Denotes the standard normal (Gaussian) cumulative distribution function.
(β) Denotes the logarithmic standard deviation.
(Θ) Denotes the median value of the distribution.

2.4.2 Gamma Distribution

Similar to the lognormal distribution, the gamma distribution is also one-sided the gamma distribution uses two parameters, k andβ. The parameter k defines the shape of the distribution and β is a scale parameter. The probability density function for the gamma distribution is unimodal with its peak at x = 0 for k ≤ 1, and at x = (k -1) /β for k >1 [Soong (2004)].

$$fx(x) = \begin{cases} \frac{\beta^{K} x^{(K-1)} e^{-\beta\chi}}{\Gamma(k)} & \text{for } x \geqslant 0 \\ 0, \text{else where} \end{cases}$$

$$\Gamma(k) = \int u^{K-1} e^{-u} \, d\, u$$

Γ (k) is the gamma function.

2.4.3 Weibull Distribution

The Weibull distribution is an extreme value distribution presents the probability density function for the weibull distribution. Similar to the gamma distribution, k defines the shape of the distribution and λ is a scale parameter.

$$fx(x) = \frac{k}{\lambda}\left[\frac{x}{\lambda}\right]^{K-1} \exp[-\left[\frac{x}{\lambda}\right]^{K}]$$

2.4.4 Beta Distribution

The beta distribution is a versatile distribution defined on the interval [0, 1]. The probability Density function for the beta distribution is:

$$fx(x) = \begin{cases} \left[\frac{1}{B(\delta,\beta)}\right] x^{\delta-1}[1-x]^{\beta-1} \ \text{for } 0 \le x \le 1 \\ 0, \text{else where} \end{cases}$$

Where B is the beta function as calculated using Equation:

$$B(\delta,\beta) = \frac{[\Gamma(\delta)\,\Gamma(\beta)]}{\Gamma(\delta+\beta)}$$

The parameters δ & β are both shape parameters that take on positive values only. When δ, β>1, the density function is unimodal with the peak at (δ-1)/ (δ+β-2). The density function becomes U-shaped when δ, β < 1
J-shaped when δ ≥ 1, β < 1; reverse J-shaped when δ< 1, β≥ 1and uniformwhen δ = β =1(Soong 2004).

We used the lognormal distribution because it fits a variety of structural component failure data well, as well as nonstructural failure data; it has strong precedent in seismic risk analysis. Finally, there is a strong theoretical reason to use the lognormal: It has zero probability density at and below zero demand parameters.
We used the variance equations to create the curves with a known value for dispersion to reach the value of fragility with ± (specific value) %. In this research we took this specific value 5%.

2.5 Experiments Walls Data

34 RC & RM shear walls had been tested by (Jaime F. Hernandez, 2012), (Shedid,2008), (Shedid, 2010) (Alessandro Daizo, Kartin Bayer, Hugo Bachmann, 2009), (Thomas N., Salonikios, Andreas, J. Kappos, Lonnis A., Tegos&Georgios G., Penelis, 2000), (Shing, Lonnis D. Lefas, Michael D., Kotsovos, &Ambraseys, 1990) studied in these papers 29 walls had been tested cyclically and 5 walls had been tested monotonically, (As) was ranging between (1 to 2.28) %, (ρv) is ranging between (0.16 to 2.95) % and(P) is ranging between (0 to 1.5) %.

2.5.1 Walls tested by (Jaime F. Hernandez, 2012)

Jaime hernandez has tested three reinforced masonry shear-wall segment were constructed and tested at the Ferguson Structural Engineering Laboratory of the University of Texas at Austin. Specimens were 96-in. wide and 96-in. with high (As) which equals to 1.0 % and were tested with different combinations of (P) which varying from (zero and 0.10) % and (ρv) which varying from (0.33% and 0.16%). Specimens met the 2011 MSJC Code requirements for special reinforced masonry shear walls, and were tested under quasi-static in-plane reversed cyclic loads. The specimens exhibited predominantly flexural behavior. The specified compressive strength of masonry, fm` was taken as 2500 psi and the specified yield strength of reinforcement, fy, was taken as 60 ksi.

No	Wall ID	Cross section	hw	lw	tw	Aspect %	ρv%	ρh%	ρd %	P%
1	PBS-3	Rectangular	96 (in)	96 (in)	7.625 (in)	1	0.33	0.33	0	0
2	PBS-4	Rectangular	96 (in)	96 (in)	7.625 (in)	1	0.16	0.16	0	0
3	PBS-11	Rectangular	96 (in)	96 (in)	7.625 (in)	1	0.33	0.33	0	0.10
4	PBS-12	Rectangular	96 (in)	96 (in)	7.625 (in)	1	0.16	0.16	0	0.10

Table 2.1- Jaime hernandez walls

2.5.2 Walls tested by (Shedid, 2008) Full scale

Shedid had tested five full-scale masonry walls to failure under reversed cyclic lateral loading. Specimens were 1.8 m. wide and 3.6 m with high (As) which equals to 2.0 % and were tested with different combinations of (P) which varying from (zero, 0.75 &1.5) % and (ρv)which varying from (0.29%, 0.78% &1.31%), compressive strength in walls was 17 MpaandThe average yield strength for the vertical reinforcementused in all walls was 502 MPa.

No	Wall ID	Cross section	hw	lw	tw	Aspect %	ρv%	ρh%	ρd %	P%
1	WALL1	Rectangular	3.6 (m)	1.8 (m)	19 (cm)	2	0.29	0.08	0	0
2	WALL2	Rectangular	3.6 (m)	1.8 (m)	19 (cm)	2	0.78	0.13	0	0
3	WALL4	Rectangular	3.6 (m)	1.8 (m)	19 (cm)	2	1.31	0.26	0	0
4	WALL5	Rectangular	3.6 (m)	1.8 (m)	19 (cm)	2	1.31	0.26	0	0.75
5	WALL6	Rectangular	3.6 (m)	1.8 (m)	19 (cm)	2	1.31	0.26	0	1.5

Table 2.2- (Shedid, 2008) Full Scale walls

2.5.3 Walls tested by (Shedid, 2010) Half scale

Shedid had tested two half-scale masonry walls to failure under reversed cyclic lateral loading. Specimens were 1.8 m. wide and 2.6 m & 4 m. with high (As) which is ranging between 1.47 & 2.21) and were tested with different combinations of (P) which equals to (1.05 & 1.09) and (ρv) which equals to (1.17) %,The average compressive strength in wallsfm`, was 16.4 MPa and the average yield strength ofthe bars of 495 MPa.

No	Wall ID	Cross section	hw	lw	tw	Aspect %	ρv%	ρh%	ρd %	P%
1	WALL1`	Rectangular	4 (m)	1.8 (m)	9 (cm)	2.22	1.17	0.3	0	1.09
2	WALL4`	Rectangular	2.6 (m)	1.8 (m)	9 (cm)	1.47	1.17	0.6	0	1.05

Table 2.3- (Shedid, 2010) Half Scale walls

2.5.4 Walls tested by (Alessandro Daizo, Kartin Bayer, Hugo Bachmann, 2009)

Six reinforced concrete walls had been subjected to quasi-static cyclic tests. Specimens were 2 m wide,the height of the test units was 4.56 m for WSH1 to WSH5 and 4.52 m for WSH6, (As) ranging from (2.26 to 2.28) % and were tested with different combinations of (P) which ranging between (0.051, 0.057, 0.058, 0.108 & 0.128) % and (ρv) which ranging between (0.39, 0.54 & 0.82) %, the cube strength fcw was 55 Mpa and the average yield strength of the bars of 495 MPa.

No	Wall ID	Cross section	hw	lw	tw	Aspect %	ρv%	ρh%	ρd %	P%
1	WSH1	Rectangular	4.56 (m)	2 (m)	15 (cm)	2.28	0.54	0.25	0	0.051
2	WSH2	Rectangular	4.56 (m)	2 (m)	15 (cm)	2.28	0.54	0.25	0	0.057
3	WSH3	Rectangular	4.56 (m)	2 (m)	15 (cm)	2.28	0.82	0.25	0	0.058
4	WSH4	Rectangular	4.56 (m)	2 (m)	15 (cm)	2.28	0.82	0.25	0	0.057
5	WSH5	Rectangular	4.56 (m)	2 (m)	15 (cm)	2.28	0.39	0.25	0	0.128
6	WSH6	Rectangular	4.52 (m)	2 (m)	15 (cm)	2.26	0.82	0.25	0	0.108

Table 2.4- Alessandro Daizo, Kartin Bayer & Hugo Bachmann Walls

2.5.5 Walls tested by (Thomas N., Salonikios, Andreas, J. Kappos, Lonnis A., Tegos&Georgios G., Penelis, 2000)

Eight reinforced concrete shear walls tested cyclically. Specimens were 1.2 m. wide, the height of the test units was 1.2 m and 1.8 m, (As) ranging between (1 to 1.5) % and were tested with different combinations of (P) which ranging between (0 & 0.07) and (ρv) which ranging between (0.68 & 1.02) %, the cube strength fcw was 25Mpa, average values of measured yield strengths of the Grade 500
[Specified strength fyk = 500 MPa].

No	**Wall ID**	**Cross section**	**hw**	**lw**	**tw**	**Aspect %**	**ρv%**	**ρh%**	**ρd %**	**P%**
1	LSW2	Rectangular	1.2 (m)	1.2 (m)	10 (cm)	1	0.68	0.277	0	0
2	LSW3	Rectangular	1.2 (m)	1.2 (m)	10 (cm)	1	0.68	0.277	0	0.07
3	LSW4	Rectangular	1.2 (m)	1.2 (m)	10 (cm)	1	0.68	0.277	0.42	0
4	LSW5	Rectangular	1.2 (m)	1.2 (m)	10 (cm)	1	0.68	0.277	0.42	0
5	MSW2	Rectangular	1.8 (m)	1.2 (m)	10 (cm)	1.5	0.68	0.277	0	0
6	MSW3	Rectangular	1.8 (m)	1.2 (m)	10 (cm)	1.5	0.68	0.277	0	0.07
7	MSW4	Rectangular	1.8 (m)	1.2 (m)	10 (cm)	1.5	0.68	0.277	0.42	0
8	MSW5	Rectangular	1.8 (m)	1.2 (m)	10 (cm)	1.5	1.02	0.277	0.42	0

Table 2.5- Thomas N. Salonikios, Andreas J. Kappos, Lonnis A. Tegos&Georgios G. Penelis Walls.

2.5.6 Walls tested by (Shing, 1990)

Four reinforced masonry clay shear walls had been tested cyclically. Specimens were 72- in. wide, the height of the test units was 72-in, (As)equals to 1 % and were tested with different combinations of (P) which ranging between (0.03, 0.07 & 0.09) % and (ρv) which ranging between (0.38 & 0.4) %.

No	**Wall ID**	**Cross section**	**hw**	**lw**	**tw**	**Aspect %**	**ρv%**	**ρh%**	**ρd %**	**P%**
1	WALL17	Rectangular	72 (in)	72 (in)	5.38 (in)	1	0.4	0.26	0	0.07
2	WALL18	Rectangular	72 (in)	72 (in)	5.38 (in)	1	0.4	0.26	0	0.07
3	WALL19	Rectangular	72 (in)	72 (in)	5.38 (in)	1	0.4	0.26	0	0.07

4	WALL20	Rectangular	72 (in)	72 (in)	5.38 (in)	1	0.4	0.26	0	0.07

Table 2.6- (Shing, Lonnis D. Lefas, Michael D., Kotsovos, &Ambraseys, 1990) Walls

2.5.7 Walls tested by (Lonnis D. Lefas, 1990)

Five reinforced concrete shear walls tested monotonically. Specimens were 1.3 m. wide, the height of the test units was 0.65 m., (As) equals to 2 % and were tested with different combinations of (P) which ranging between (0 & 0.17) % and (ρv) equals to (2.95 %).

No	Wall ID	Cross section	hw	lw	tw	Aspect %	ρv%	ρh%	ρd %	P%
1	SW21	Rectangular	1.3 (m)	0.65 (m)		2	2.95	0.8	0	0
2	SW23	Rectangular	1.3 (m)	0.65 (m)		2	2.95	0.8	0	0.169
3	SW24	Rectangular	1.3 (m)	0.65 (m)		2	2.95	0.8	0	0
4	SW25	Rectangular	1.3 (m)	0.65 (m)		2	2.95	0.8	0	0.17
5	SW26	Rectangular	1.3 (m)	0.65 (m)		2	2.95	0.4	0	0

Table 2.7- Lonnis D. Lefas, Michael D. Kotsovos, & Nicholas N. Ambraseys Walls.

2.6 Demand Parameters

These are some properties for the walls affecting their behavior under flexure testing and also affect their fragility curves such as:

- Vertical reinforcement ratio (ρv) %.
- Material of wall & strength of the used masonry blocks or compressive strength of reinforced concrete.
- Aspect ratio (length to width ratio) (As).
- Axial load ratio (P).
- Diagonal reinforcement ratio (ρd).

Chapter Three

Fragility Analysis

The general aim of this report is to create one curve describes the relation between drift and probability of occurring a specific damage state for groups of walls whichhave common engineering properties and have changes in one or more ofengineering property, then we have to compare between walls by fragility values and see the shear walls that have nearly fragility value (by specific limit for dispersion) although it`s difference in some engineering properties, also see the value of this difference and its effect on wall behavior and fragility value.
This comparison should setup by statistics analysis We used the statistical value of (variance) to govern each trail we do and govern the dispersion of each curve belong to each trail, if we had a variance value > 5% we will be in front of two probabilities; the first is that whichmaybe there were some errors in readings of fragility values of walls, may be during the test of this wall and the second, the behavior of the two walls was changed with respect to the change that was in the properties of the walls and simply fragility values had been affected by this change. So we hadamust to neglect some points which may cause this big dispersion, but with a reasonable limit we had taken it at maximum two points to never exceed 10% of the number of total points, if we had reached this limit of 10% and variance value is still >5% we had to refuse the whole trails and then we can say; that this group of walls we cannot make a union curve for itdescribes the fragility curves of it and the difference which hasbeen in some engineering properties can affect the behavior and fragility curves greatly, so that we cannot merge this walls in one group.

Also, in other trails we will not judge on two walls only we judge on more than two walls, and then we can neglect more than one wall to reach the permissible limit for dispersion (5%).
Also, we don’t care about the final variance only;we care about the variance of each damage state.It must never exceed 5%, curves of walls for each damage states and the range of its conformity or dispersion from each other.

So that we need the fragility values for each shear walls at each damage state from the four damage states we have (DS1, DS2, DS3, and DS4).

We can see the fragility values for all walls in **(Table 1 in Appendix A).**

We start statistical comparison by discovering the effect of changing of each engineering parameter in shear walls behavior and fragility values.

3.1 Studying the effect of differences in one engineering property on behavior of the wall and fragility curves

3.1.1 Studying varying of (P) on walls

3.1.1.a Studying the effect of varyingof (P)from (0 to 0.1) %, when (ρv) is equal to (0.16) %, (As) is equal to (1) %, thematerial of walls is reinforced masonry and the (ρh)is equal to (0.16) %.

This study can clearly be seen by walls: PBS-4 and PBS-12.
We can see the statistical analysis operation for this study in
(Table 2in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 1, Curve 2, Curve 3 and Curve 4

As we can see from curves there is big dispersion between the two walls at DS2, DS3 and DS4.
And, as we can see From**(Table 2 in Appendix A)**, we find that;
DS1 has 0.41% dispersion value < 5% and still within the accepted range (≤ 5%),
DS2 has 37.48% dispersion value >> 5%,
DS3 has 16.67% dispersion value >>5%,
DS4 has 6.25% dispersion value >5%,
Totalvariance is equal to 13.71 % >> 5 %, therefore we will try to neglect one reading and see the effect of neglecting it on variance. See **(Table 3in Appendix A).**
We chose to neglect the value of variance at DS2 at 0.5 % drift ratio, because DS2 has the biggest dispersion ratio and specifically0.5 % drift ratio has the biggest dispersion ratio at DS2 also.
From **(Table 3in Appendix A)** we can extract that total variance is equal to 11.43 % >> 5 %, we still have one trail to neglectone reading without exceeding the limit of 10% of the total readings, so we will try to neglect one value and see the effect of neglecting it on variance. See **(Table 4 in Appendix A).**
From **(Table 4in Appendix A)** we can extract that variance is equal to 9.6 % > 5 %, so that we can assure that there were no errors in the readings andthe variationof (P) from (0 to 0.1) % can affect greatly the behavior of the wall and fragility value when (ρv)is equal to (0.16) %,(As)is equal to (1) % and (ρh) equals to (0.16) %.

3.1.1.b Studying the effect of varying of (P) from (0 to 0.1) % when (ρv) is equal to (0.33) %, (As) is equal to (1) % and (ρh)is equal to (0.33) %.

This study can clearly be seen by walls: PBS-3 and PBS-11
We can see the statistical analysis table for this study in **(Table 5 in Appendix A).**

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 5, Curve 6, Curve 7 and Curve 8.

As we can see from curves there is no big dispersion between the two walls at DS1, DS2, DS3 and DS4.
And we can see from **(Table 5 inAppendix A);**
DS1 has dispersion value equals to (zero) and this is the ideal case,
DS2 has 1.64% dispersion value < 5% and still within the accepted range (≤ 5%),
DS3 has 1.97% dispersion value <5% and still within the accepted range (≤ 5%),
DS4 has 0% dispersion value,
Total dispersion is equal to 0.84% << 5% this is clearly seen in **(Table 5 in Appendix A).**Therefore we can extract that varying of (P) from (0 to 0.1) % does not affect the wall

behavior and fragility value when (ρv)is equal to (0.33) %, (As)is equal to (1) % and (ρh)is equal to (0.33) %.
We can see this curve in (Appendix B) in Curve 9.
Then we can draw the curvewhich expresses the fragility values for any wall engineering properties in the same limit of these two wall, the dispersion of this curve is equal to 0.84% << 5%.

3.1.1.c Studying the effect of varying of(P) from (0 to 0.75) %, when (ρv)is equal to (1.31) %,(As)is equal to (2) % and (ρh)is equal to (0.26) %.

This study can clearly be seen by walls: Wall4 and Wall5.
We can see the statistical analysis table for this study in
(Table 6 in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 10, Curve 11, Curve 12 and Curve 13.

As we can see from curves there is conformity for fragility curves at DS1, there is no big dispersion between the two walls at DS2, DS3 and DS4. And as we can see from
(Table 6 inAppendix A);
DS1 has dispersion value equals to (zero) and this is the ideal case which rarely appears to us, this demonstrated conformity between two curves at DS1.
DS2 has 2.39% dispersion value < 5% and still within the accepted range (≤ 5%),
DS3 has 0.71% dispersion value < 5% and still within the accepted range (≤ 5%),
DS4 has 0.01% dispersion value < 5% and still within the accepted range (≤ 5%),
Total dispersion is equal to 0.63% << 5% this is clearly seen in
(Table 6 in Appendix A),Therefore we can extract that varying of (P) from (0 to 0.75) % does not affect the wall`s behavior and fragility value when (ρv)is equal to (1.31) %,(As)is equal to (2)% and (ρh) equals to (0.26) %.

Then we can draw the curve which expresses the fragility values for any wall engineering properties in the same limit of these two wall, the dispersion of this curve is equal to 0.63% << 5%.
We can see this curve in (Appendix B) in Curve 14.

3.1.1.d Studying the effect of varying of(P)from (0.75 to 1.5) %, when (ρv)is equal to (1.31) %,(As)is equal to (2) % and (ρh) is equal to (0.26) %.

This study can clearly be seen by walls: Wall5 and Wall6.
We can see the statistical analysis table for this study in
(Table 7in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 15, Curve 16, Curve 17 and Curve 18.

As we can see from curves there is no big dispersion between the two walls at DS1, DS2, DS3 and DS4,
And as we can see from **(Table 7 inAppendix A);**
DS1 has 0.55% dispersion value < 5% and still within the accepted range (≤ 5%),
DS2 has 1.75% dispersion value < 5% and still within the accepted range (≤ 5%),
DS3 has 0.78% dispersion value < 5% and still within the accepted range (≤ 5%),
DS4 has 0.03% dispersion value < 5% and still within the accepted range (≤ 5%),

Total dispersion is equal to 0.64% << 5% this is clearly seen in **(Table 7 in Appendix A).** Therefore we can extract that varying of (P) from (0.75 to 1.5) % does not affect the behavior of wall greatly and fragility values also when the (ρv) is equal to (1.31) %,(As) is equal to (2) % and (ρh)is equal to (0.26) %.

Then we can draw the curve which expresses the fragility values for any wall has engineering properties in the same limit of these two wall, dispersion of this curves is equal to 0.64% << 5%.

We can see this curve in (Appendix B) in Curve 19.

3.1.1.e Studying the effect of varying of(P) from (0 to 1.5) %, when (ρv)is equal to (1.31) %, the (As)is equal to (2) % and (ρh)is equal to (0.26) %.

This study can clearly be seen by walls: Wall4, Wall5 and Wall6.
We can see the statistical analysis table for this study in
(Table 8 in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 20, Curve 21, Curve 22 and Curve 23.

As we can see from curves there is conformity between Wall4 and Wall5 in DS1 and there is no big dispersion between the two curves and curve of Wall6, there is no big dispersion between the three walls in DS2, DS3 and DS4,
And as we can see from **(Table 8 in Appendix A);**
DS1 has 0.37% dispersion value < 5% and still within the accepted range (≤ 5%),
DS2 has 4.05% dispersion value < 5% and still within the accepted range (≤ 5%),
DS3 has 0.55% dispersion value < 5% and still within the accepted range (≤ 5%),
DS4 has 0.01% dispersion value < 5% and still within the accepted range (≤ 5%),

Total dispersion is equal to 0.96% << 5% this is clearly seen in **(Table 8 in Appendix A).** Therefore we canassure that varying of (P) from (0 to 1.5) % does not affect the behavior of the wall and fragility value when (ρv)is equal to (1.31) %,(As)is equal to (2) % and (ρh)is equal to (0.26) %.

Then we can draw the curve which expresses the fragility values for any wall has engineering properties in the same limit of these two wall, dispersion of this curves is equal to 0.96% << 5%.

We can see this curve in (Appendix B) in Curve 24.

3.1.1.f Studying the effect of varying (P) from (0 to 0.17) % when (ρv)is equal to (2.95%),(As)is equal to (2) % and (ρh) varying from (0.40 to 0.80) %

This study can clearly be seen by walls: SW21, SW24, SW26, SW23 and SW25
We can see the statistical analysis table for this study in
(Table 9in Appendix A).

We can see curves of DS1, DS2 and DS3 for the walls in (Appendix B) in Curve 25, Curve 26 and Curve 27.

As we can see from curves there is conformity between SW21, SW24, SW26 and SW23, SW25 in DS1 and there is semi conformity between SW21, SW24, SW26 and SW23, SW25 in DS2 and there is no big dispersion between the curves in DS3.
And as we can see from **(Table 9 in Appendix A);**
DS1 has dispersion value equals to (zero) and this is the ideal case which rarely appears to us, this demonstrated conformity between two curves at DS1.
DS2 has 0.02% dispersion value < 5%, thisdemonstrated semi conformity between two curves at DS2.
DS3 has 4.66% dispersion value < 5% and still within the accepted range (≤ 5%),

Total dispersion is equal to 2% < 5% this is clearly seen in **(Table 9 in Appendix A).**
Therefore we can extract that varying of(P) from (0 to 0.17) % does not affect the behavior of the wall and fragility value when (ρv)is equal to (2.95) %, (As)is equal to (2) % and (ρh)varying from (0.40 to 0.80) %.

Then we can draw the curve which expresses the fragility values for any wall engineering properties in the same limit of these two wall, dispersion of this curves is equal to 2% < 5%.

We can see this curve in (Appendix B) in Curve 28.

3.1.2 Studying the effect of varying of (ρv) for walls

3.1.2.a Studying the effect of varying of (ρv)from (0.29 to 0.78) % when (P)is equal to (0) %,(As)is equal to (2) % and (ρh)varying from (0.08 to 0.13) %

This study can clearly be seen by walls: Wall 1 and Wall 2.
We can see the statistical analysis table for this study in
(Table 10in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 29, Curve 30, Curve 31 and Curve 32.

As we can see from curves there is no big dispersion between the two walls in DS1, DS2, DS3 and DS4, there is semi conformity between two curves in DS3.
And as we can see from **(Table 10 inAppendix A);**

DS1 has dispersion value equals to (zero) and this is the ideal case which rarely appears to us,
DS2 has 0.52% dispersion value < 5%.
DS3 has dispersion value equals to (zero); this is demonstrated semi conformity between two curves in DS3.
DS4 has 4.68% % dispersion value < 5%, and still within the accepted range (≤ 5%),
Total dispersion is equal to 1.8% < 5% this is clearly seen in **(Table 10 in Appendix A).**

Therefore we can extract that varying of (ρv) from (0.29 to 0.87) % does not affect the behavior of the wall and fragility value when (P)is equal to (zero) %,(As)is equal to (2) %and (ρh)varying from (0.08 to 0.13) %.

Then we can draw the curve which expresses the fragility values for any wall has engineering properties in the same limit of these two wall, dispersion of this curves is equal to 1.8% < 5%.

We can see this curve in (Appendix B) in Curve 33.

3.1.3 Studying the effect of varying of (As) for walls

3.1.3.a Studying the effect of varying (As) from (1.47 to 2.21) %, when (ρv)is equal to (1.17) %,(P)varying from (1.05 to 1.09) % and (ρh)varying from (0.30 to 0.60) %.

This study can clearly be seen by walls: Wall 1` and Wall 4`.
We can see the statistical analysis table for this study in
(Table 11 in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 34, Curve 35, Curve 36 and Curve 37.

As we can see from curves there is conformity between Wall1` and Wall4` in DS1 and there is no big dispersion between the two walls in DS2, DS3 and DS4,
And as we can see from **(Table 11 inAppendix A);**

DS1 has (zero) dispersion value, this demonstrated conformity between the two curves in DS1.
DS2 has (zero) dispersion value.
DS3 has 1.50% dispersion value < 5% and still within the accepted range (≤ 5%),
DS4 has 0.08% dispersion value < 5% and still within the accepted range (≤ 5%),
Total dispersion is equal to 0.44% << 5% this is clearly seen in **(Table 11 in Appendix A).**

Therefore we can extract that the variation of (As) from (1.47 to 2.21) % does not affect the behavior of wall and fragility values when (ρv)is equal to (1.17)%,(P) is between (1.05 & 1.09) % and (ρh)varying from (0.30 to 0.60) %.

We can see this curve in (Appendix B) in Curve 38.

3.1.4 Studying the effect of the presence of (ρd) and (Dd)

3.1.4.a Studying the effect of the varying of(ρd) from (0 to 0.42) % when (ρv)is equal to (0.68) %, (P)is equal to (zero) %,(As)is equal to (1) %and (ρh) is equal to (0.277) %.

This study can clearly be seen by walls: LWS2 and LWS4.
We can see the statistical analysis table for this study in
(Table 12 in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 39, Curve 40, Curve 41 and Curve 42.

As we can see from curves there is semi conformity between the curves of the two walls in DS2 and there is no big dispersion between curves of the two walls in DS1, DS3 and DS4.
And, as we can see from **(Table 12 inAppendix A);**
DS1 has (zero) dispersion value.
DS2 has 0.06% dispersion value, this demonstrated semi conformity between the two curves in DS2.
DS3 has 0.23% dispersion value < 5% and still within the accepted range (≤ 5%),
DS4 has 1.07% dispersion value < 5% and still within the accepted range (≤ 5%),
Total dispersion is equal to 0.46% << 5% this is clearly seen in **(Table 12 in Appendix A).**

Therefore we can extract thatthe presence or variation of (ρd) from (0 to 0.42)% does not affect the behavior of the wall and fragility value, when (ρv)is equal to (0.68)%, (P)is equal to (zero), (As)is equal to (1)% and (ρh)is equal to (0.277) %.

Then we can draw the curve, it`s dispersion is equal to 0.46% << 5%.

We can see this curve in (Appendix B) in Curve 43.

3.1.4.b Studying the effect of variation of(ρd) from (0 to 0.42) % when (ρv)is equal to (0.68) %, (P)is equal to (zero) %,(As)is equal to (1.5) % and (ρh)is equal to (0.277) %.

This study can clearly be seen by walls: MWS2 and MWS4.
We can see the statistical analysis table for this study in
(Table 13in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 44, Curve 45, Curve 46 and Curve 47.

As we can see from curves there is no big dispersion between the two walls in all damage states.
And, as we can see from **(Table 13 inAppendix A);**
DS1 has 7.94% dispersion value >5%.
DS2 has 1.67% dispersion value<5% and still within the accepted range (≤ 5%),
DS3 has 11.67% dispersion value> 5%.
DS4 has 0.02% dispersion value < 5% and still within the accepted range (≤ 5%),

Total dispersion is equal to 4.94% << 5% this is clearly seen in **(Table 13 inAppendix A),** Total dispersion by this final value for dispersion is accepted that mean that there is no big dispersion or difference in behavior of the two walls and increasing of (ρd) from (0 to 0.42) % in any wall has(0.68) % (ρv), (0) % (P)and (1.5) % (As) cannot affect the behavior of the wall greatly and its fragility curve.

But the value of dispersion of DS1 and DS3 should be in the accepted range (≤ 5%), so that we should neglect one or more than one point which may be the reason of this big dispersion and see the final dispersion`s value this is because there is a probability that this dispersion was because of error in this point`s reading during test, if the dispersion still >5% we should refuse all the statistical operation.

So that we startedby neglecting the point of 0.25% drift at DS1, this statistical operation can be seen in **(Table 14in Appendix A).** Final dispersion of DS1 became zero% , there is no points has dispersion bigger than zero except point of 0.25% drift, this means that the error maybewas because of error in reading during test, what support this judgment the small dispersion between the two curves in DS1.

For DS3 we chose to neglect the point of 0.75% drift, this statistical operation can be seen in **(Table 15in Appendix A).**

Final dispersion of DS2 became 5.34% and this is bigger than the accepted range (≤5%) by small margin, we can accept the statistical operation because of more than one reason:

1- DS3 has dispersion value bigger than (5)% by a small value.
2- There is another point has dispersion 26.72% >> 5 %, but has a very small effect on dispersion of DS3 and the total dispersion.
3- The total dispersion after all statistical operations has value equals to 1.68% << 5 % and this is accepted dispersion.
4- The total dispersion after the first statistical operation is equal to 4.94% doesn’t exceed the allowable limit.
5- The four curves of DS1, DS2, DS3 and DS4 clearly showing the small dispersion between the two walls.

Therefore we can extract that the variation of (ρd) from (0 to 0.42) % does not affect the behavior of the wall and fragility values when (ρv)is equal to (0.68) %, (P)is equal to (0) %,(As)is equal to (1.5) % and (ρh)is equal to (0.277) %.

Then we can draw the curve, it`s dispersion is equal to 4.94% << 5%.

We can see this curve in (Appendix B) in Curve 48.

3.1.4.c Studying the effect of varying of (Dd) from (0 to 0.96) m when (ρv)is equal to (0.68%), (P)is equal to (0) %, (As)is equal to (1) %,(ρd)is equal to (0.42) % and (ρh)is equal to (0.277) %.

This study can clearly be seen by walls: LSW4 and LSW5.
We can see the statistical analysis table for this study in
(Table 16in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in

(Appendix B) in Curve 49, Curve 50, Curve 51 and Curve 52.

As we can see from curves there is conformity between the two curves in DS1 and there is no big dispersion between the two curves in DS2, DS3 and DS4.
And as we can see from **(Table 16 in Appendix A);**
DS1 has zero% dispersion value and this is an ideal case demonstrated the conformity between the two curves in DS1.
DS2 has 3.62% dispersion value <5% and still within the accepted range (≤ 5%),
DS3 has 1.15% dispersion value > 5%.
DS4 has 2.80% dispersion value < 5% and still within the accepted range (≤ 5%),
Total dispersion is equal to 1.99% << 5% this is clearly seen in **(Table 16 in Appendix A).**

Therefore we can extract that the variation in (Dd) from (0 to 0.96) m does not affect the wall behavior and fragility value when (ρv)is equal to (0.68) %, (P)is equal to (0) %, (As)is equal to (1) %,(ρd)is equal to (0.42) % and (ρh)is equal to (0.277) %.

Then we can draw the curve, it`s dispersion is equal to 1.99% << 5%.

We can see this curve in (Appendix B) in Curve 53.

3.1.4.d Studying the effect of varying of (Dd) from (0 to 0.96) m when (ρv)is equal to (0.68) %, (P)is equal to (0) %, (As)is equal to (1.5) %,(ρd)is equal to (0.42) % and (ρh)is equal to (0.277) %.

This study can clearly be seen by walls: MSW4 and MSW5.
We can see the statistical analysis table for this study in
(Table 17in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 54, Curve 55, Curve 56 and Curve 57.

As we can see from curves there is no big dispersion between the two curves in DS1, DS2, DS3 and DS4.
And, as we can see from **(Table 17 inAppendix A);**
DS1 has zero% dispersion value and this is an ideal case.
DS2 has 0.44% dispersion value <5% and still within the accepted range (≤ 5%),
DS3 has 0.04% dispersion value > 5%.
DS4 has zerodispersion value and this is an ideal case.

Total dispersion is equal to 0.09% << 5% this is clearly seen in **(Table 17 in Appendix A).**
Therefore we can extract that varying of (Dd) from (0 to 0.96) m does not affect the behavior of the wall and fragility value when (ρv)is equal to (0.68) %, (P)is equal to (0) %, (As)is equal to (1.5) % and(ρd)is equal to (0.42) %.
Then we can draw the curve, it`s dispersion is equal to 0.09% << 5%.

We can see this curve in (Appendix B) in Curve 58.

3.2 Studying the effect of differences in more than one engineering property on behavior of the wall & fragility curves

As we had proved in **(3.1.1.b)** that the variation of(P) from (0 to 0.1) % does not affect the fragility curve and behavior of wall when (ρv)is equal to (0.33) % and(As)is equal to (1%),

Also we had proved in **(3.1.1.c)**that the variation of(P) from (0 to 0.75) % does not affect the fragility curve and behavior of the wall when (ρv)is equal to (1.31) % and(As)is equal to (2) %

And we had proved in **(3.1.2.a)**thatvarying of (ρv) from (0.29 to 0.78) % does not affect the fragility curve and behavior of the wall when (As)is equal to (2) % and(P)is equal to (0) %.

As the range of (0.29 to 0.78) % of (ρv)is in the range of (0.39 to 0.82) % and the range of (0 to 0.75) % of (P) is close to the range of (0.051 to 0.128) %, then

3.2.1 Studying the effect of varying of(ρv)from (0.39 to 0.82) % and varying of (P) from (0.051 to 0.128) % when (As)is equal to (2.2) % and (ρh)is equal to (0.25) %.

This study can clearly be seen by walls: WSH1, WSH2, WSH3, WSH4, WSH5 and WSH6
We can see the statistical analysis table for this study in **(Table 18 in Appendix A).**

We can see curves of DS1, DS2 and DS3 for the walls in (Appendix B) in Curve 59, Curve 60 and Curve 61.

As we can see from curves there is semi conformity between the curves of the six walls in DS1 and there is small dispersion between the curves in DS2 and DS3.
And as we can see from **(Table 18 in Appendix A);**
DS1 has 0.03% dispersion value <5% and still within the accepted range (≤ 5%),
DS2 has 5.47% dispersion value >5%,
DS3 has 6.77% dispersion value > 5%.
Total dispersion is equal to 4.47% << 5% this is clearly seen in
(Table 18 in Appendix A).

This value of total dispersion means that there is no big dispersion between the six walls in behavior and fragility values, but big dispersion in DS2 and DS3 cannot be neglected; we do not know the reason of this big variance because of theerror in some readings for specific walls or because of the difference of the engineering properties of walls.
So we have to neglect the wall which may be the reason of this big dispersion (we cannot neglect some points here, we have a statistical operation to six walls not two walls only).
Wall (WSH1) has the smallest ratio of (P) and clearly similar to wall (WSH2) in the other engineering properties, we started to neglect it and see the new dispersion value. This statistical operation can be seen in **(Table 19 in Appendix A).**

From **(Table 19 in Appendix A)** we find that:

DS1 has 0.03% dispersion value, that is mean wall (WSH1) has no effect on DS1 dispersion value.
DS2 has 5.26% dispersion value that is means neglecting of wall (WSH1) caused 0.21% effect in dispersion value of DS2.
DS3 has 4.96% dispersion value, that is mean neglecting of wall (WSH1) has 1.81% effect in dispersion value of DS3 and this is great effect, we reached the accepted limit in DS3 by one step only, that is mean our choose to neglect wall (WSH1) was true,
Especially the total dispersion equals to 3.64% and this is accepted value of dispersion.
Here we have just DS2 has dispersion bigger than the accepted limit (≤5%) by small margin with accepted total dispersion.
This combination means that the five walls we have now with its different properties have semi similar behavior enough to create one union curve describes the fragility curve for any wall has engineering properties in the same range of the five walls have, but there is DS2 only has dispersion > 5% by small value.

So we have to neglect another wall to reach the accepted limit for dispersion for DS2.
We have wall (WSH5) which has the smallest ratio for (ρv) and has the highest ratio for (P), so we neglect it and see the effect of neglecting it in dispersion of DS2 and total dispersion.
We can see this statistical operation in **(Table 20 in Appendix A).**

From **(Table 20 in Appendix A)** we find that:
DS1 has 0.04% dispersion value, that is mean neglecting of wall (WSH5) has a very small effect on DS1 (0.001%) which can be easily neglected.
DS2 has 2.2% dispersion value, that is mean neglecting of wall (WSH5) has 3.06% effect in dispersion of DS2 and this is a great effect we have dispersion now less than the accepted limit by 2.8% this is a very accepted dispersion,
DS3 has 3.91% dispersion value, that is means neglecting of wall (WSH5) has (1.05) % reduction effect in dispersion of DS3, and this is a great effect we have dispersion.
Also the total dispersion became 2.32%, this is a very accepted dispersion, which is means that our choice to neglect wall (WSH5) was true.
Therefore we can extract that varying in (ρv) from (0.54 % to 0.82 %) and varying in (P) from (0.057 % to 0.108 %) does not affect the behavior of the wall and fragility value when (As) varying between (2.26 to 2.28) % and (ρh) is equal to (0.25) %.

Then we can draw the curve, it`s dispersion is equal to 2.32% << 5%.

We can see this curve in (Appendix B) in Curve 62.

As we had extracted before in **(3.1.2.a)**that the variation of (ρv) from (0.29 to 0.78) % does not affect the behavior of the wall and fragility curves when (As)is equal to (2) %,(P)is equal to (zero) % and as we extracted also in **(3.1.4.a)**and **(3.1.4.c)** that varying of (ρd) from (0 to 0.42) % and varying of (Dd) from (0 to 0.96) m does not affect the behavior of the wall or fragility curves when (ρv) is equal to (0.68) %, (As)is equal to (1 or 1.5) % and(P)is equal to (zero).

So we can study the effect of varying of (P) from (0 to 0.07) % and varying of (As) from (1 to 1.5) % when (ρv) is equal to (0.68) % and (ρh) is equal to (0.277) %, as this ranges are in the same ranges in **(3.1.2.a), (3.1.4.a)** and **(3.1.4.c)**

3.2.2 Studying the effect of varying of (P) from (0 to 0.07) % and varying of (As) from (1 to 1.5) % when (ρv) is equal to (0.68) % and (ρh) is equal to (0.277) %.

This study can clearly be seen by walls: LSW2, LSW3, LSW4, LSW5, MSW2, MSW3, MSW4 and MSW5.
We can see the statistical analysis table for this study in
(Table 21 in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 63, Curve 64, Curve 65 and Curve 66.

As we can see from curves there is semi conformity in DS1 between the curves of all wall except wall MSW2, for DS2 there is dispersion between all curves but closer to each other in comparing with the curve of wall MSW2 also, the same judgment for DS3 about wall MSW2 and for DS4 we have dispersion clearly seen between all curves specially wall MSW2 and to govern if this dispersion is accepted or no we have to see the values of dispersion in the statistical operation in **(Table 21 in Appendix A).**

From **(Table21 in Appendix A),** we find that;
DS1 has 1.98% dispersion value<5% and still within the accepted range (≤ 5%),
DS2 has 5.67% dispersion value >5%,
DS3 has 6.82% dispersion value >5%,
DS4 has 3.75% < 5% and still within the accepted range (≤ 5%),
Total dispersion is equal to 4.61% < 5% this is clearly seen in
(Table 21 in Appendix A).

This value of total dispersion means that there is no big dispersion between the eight walls in behavior and fragility values, but big dispersion in DS2 and DS3 cannot be neglected; we do not know thereason of this big variance because of theerror in some readings for specific walls or because of the difference of the engineering properties of walls.
So we have to neglect the wall which may be the reason of this big dispersion (we cannot neglect some points here we have a statistical operation to eight walls not two walls only).
Wall (MSW2) it`s curve showed the dispersion from the other curves and this was clearly seen in DS1, DS2, DS3 and DS4, surely wall (MSW2) should be the first wall to neglect and see the effect of neglecting it on the dispersion value of DS2 and DS3 also on the total dispersion.
We can see the statistical operation of neglecting (MSW2) in
(Table 22 in Appendix A).

From **(Table 22 inAppendix A)** we find that:
DS1 has zero dispersion value, this is an ideal case, that is mean neglecting of (MSW2) has a great effect on DS1, and what enhance that is (MSW2) has the smallest value in drift ratio in DS1, also it`s curve has a clearly big dispersion from the other semi conforming curves in DS1.

DS2 has 5.2% dispersion value, that is mean neglecting of (MSW2) has a small effect on DS2`s dispersion clearly (0.47%), but clearly has an effect, what enhance that the dispersion of the curve of (MSW2) from the other curves in DS2, so we have a big possibility to be had neglected the wanted wall.

DS3 has 3.7% dispersion value, that is mean neglecting of (MSW2) has a great effect on DS3`s dispersion clearly (3.12%), that was also very clear in the curve`s dispersion of (MSW2) in DS3.

DS4 has 3.95% dispersion value <5%and still within the accepted range (≤ 5%), even though there is an increment in dispersion about (0.2%) from the last statistical operation, but dispersion is still under the accepted limit, the other damage states showed reduction in dispersion values,
Also the total dispersion became 3.39% with reduction equals to (1.22%).
So that wall (MSW2) was the wall which caused the big dispersion in DS2 and DS3.

DS2 still has 5.2% dispersion is bigger than the accepted limit (≤5%) by a small margin, that is mean there is another wall which causes this small dispersion. We should neglect this wall.
From the value of drift in DS2, we find that wall (MSW4) has the smallest value at 0.25% drift from the other walls.
So we should neglect wall (MSW4) and see its effect on DS2`s dispersion value.
The statistical operation of neglecting wall (MSW4) can be seen in
(Table 23 in Appendix A).

From **(Table 23 inAppendix A),** we find that;
DS1 has zero dispersion value and this is an ideal case,
DS2 has 4.74% dispersion value <5%, that is mean neglecting of wall (MSW4) has effect on DS2`s dispersion (0.46%), so that wall (MSW4) was the wall which caused the big dispersion in DS2.
DS3 has 3.49% dispersion value <5% with reduction equals to (0.21%) from the last statistical operation.
DS4 has 4.06% dispersion value <5%, even though there is an increment in dispersion value from the last statistical operation equals to (0.11%), but there is no damage states have dispersion bigger than the accepted limit (≤ 5%), all curves showed semi conformity in DS1, DS2, DS3 and there is an accepted dispersion between the curves in DS4.
Finally total dispersion is equal to 3.29% with reduction equals to (0.1%) from the last statistical operation, so there is no dispersion out from the accepted limit (≤5%).

Therefore we can extract that the variationof (P) from (0 to 0.07) % and varying (As) from (1 to 1.5) % does not affect greatly the behavior of the wall or fragility curves when (ρv)is equal to (0.68) % and (ρh)is equal to (0.277) %.

Then we can draw the curve, it`s dispersion is equal to 3.29% << 5%.

We can see this curve in (Appendix B) in Curve 67.

As we had extracted before in **(3.1.3.a)**that the variation of (P) from (1.05 to 1.09) % and varying of (As) from (1.47 to 2.21) % does not affect the behavior of the wall and fragility curve greatly when (ρv)is equal to (1.17) %,
And also we hadextracted before in **(3.1.1.e)** that varying of (P) from (0 to 1.5) % does not affect the behavior of the wall and fragility curve greatly when (As)is equal to (2) % and(ρv)is equal to (1.31) %.

3.2.3 Studying the effect of varying of (ρv) from (1.17 to 1.31) %, varying of (P) from (0 to 1.5) %, varying of (As) from (1.47 to 2.2) % and varying of (ρh) from (0.26 to 0.6) % on fragility curves

This study can clearly be seen by walls: WALL4, WALL5, WALL6, WALL`1 andWALL`4.
We can see the statistical analysis table for this study in
(Table 24in Appendix A).

We can see curves of DS1, DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 68, Curve 69, Curve 70 and Curve 71.

As we can see from curves there is no big dispersion between curves in all damage states.
And as we can see from **(Table 24 in Appendix A);**
DS1 has 5.72% dispersion value >5%,
DS2 has 3.29% dispersion value >5%, and still within the accepted range (≤ 5%),
DS3 has 4.91% dispersion value > 5%, and still within the accepted range (≤ 5%),
DS4 has 0.04% dispersion value > 5%, and still within the accepted range (≤ 5%),
Total dispersion is equal to 2.99% << 5% this is clearly seen in
(Table 24 in Appendix A).
This total dispersion means;that there is no big dispersion between the five walls in behavior and fragility values but, big dispersion in DS1 cannot be neglected. We do not know thereason of this big variance because of theerror in some readings for specific walls or because of the difference of the engineering properties of walls that cannot allow behaviors of the two walls to be semi similar.
By seeing the values in **(Table 24 in Appendix A),** there is only one point has value bigger than zero in all values in DS1. It was the value of variance at 0.25% drift.

Also, we had extracted before in **(3.1.3.a)** that varying of (P) from (1.05 to 1.09) % and varying of (As) from (1.47 to 2.21) % does not affect the behavior of the wall and fragility curve greatly when (ρv) is equal to (1.17) % and also we had extracted before in **(3.1.1.e)** that varying of (P) from (0 to 1.5) % does not affect the behavior of the wall and fragility curve greatly when (As) is equal to (2) % and (ρv) is equal to (1.31) %.
Also there is no damage states have dispersion more than the accepted limit (≤ 5%) except DS1.

Also final dispersion equals to 2.99% and this is a perfect value for dispersion. Curves also showed small dispersion about each other in all damage states in comparing with a various cases had been accepted previously.

So that we can neglect the value of dispersion in DS1 at 0.25% drift and see the effect of neglecting it on dispersion.
We can see this statistical operation in **(Table 25 in Appendix A).**
From **(Table 25 in Appendix A),** we find that;
DS1 has zero dispersion value,
Total dispersion became 2.05% with reduction equals to (0.94%).

Therefore we can extract that the variationof (ρv) from (1.17% to 1.31%), varying (P) from (0 to 1.5) % and varying (As) from (1.47 to 2.21) % does not affect the behavior of the wall or the fragility value greatly.

Then we can draw the curve, it`s dispersion is equal to 2.99% << 5%.

We can see this curve in (Appendix B) in Curve 72.

3.3 Future work

There is some similarity between reinforced concrete and reinforced masonry walls in fragility curves and variance values, this means that we can create curves shows fragility curves for any wall concrete or masonry with a respected dispersion value and with respected engineering properties range, and this is an example for that:

Shing reinforced masonry clay walls have the same (ρv) and equals to (0.40%), (As)equals to (1%), (P) equals to (0.07%) and (ρh)equals to (0.26%).
We had reached before in**(3.1.1.a)** that varying of (P) from (0 to 1) % doesn`t affect fragility values when (ρv)equals to (0.33) % and (As) equals to (1) %.
Actually Shing walls will not add any new curve or data to us but we can use it to know the behavior of masonry clay shear walls having these engineering properties which are close to the reinforced concrete walls properties.

This study can clearly be seen by walls: WALL 17, WALL 18, WALL 19 andWALL 20.
We can see the statistical analysis table for this study in
(Table 26in Appendix A).

We can see curves of DS2, DS3 and DS4 for the walls in (Appendix B) in Curve 73, Curve 74 and Curve 75.

As can be seen from curves there is very small dispersion between curves in DS2.
For DS3 and DS4 there is a variance we will check about if it is accepted or no.
And as can be seen from **(Table 26 inAppendix A);**
DS2 has 3.59% dispersion value <5%, and still within the accepted range (≤ 5%),
DS3 has 8.70% dispersion value > 5%,
DS4 has 1.61% dispersion value > 5%,
Total dispersion is equal to 4.41% << 5% this is clearly seen in
(Table 26 in Appendix A).
This total dispersion means that there is no big dispersion between the fourwalls in behavior and fragility values, but big dispersion in DS3 cannot be neglected.
Here, this big dispersion we can assure that it caused from some error in a specific wall, because there is no any difference in properties, so that we will neglect this wall to reach the accepted limit for DS3 (≤ 5) %.
From **(Table26 inAppendix A)**, we can see that, wall 18 has the highest value of fragility value in DS2 at 0.25% and has the highest value also in DS3 at 0.25%, 0.5% and 0.75%.
Also, from curves, the curve of wall 18 has a big dispersion from the other curves in DS3 and DS4, so that we will neglect wall 18 and see the effect of neglecting it in dispersion and fragility values.
We can see this statistical operation in **(Table 27in Appendix A).**
From **(Table 27 in Appendix A),**we find that;
DS2 has 3.07% dispersion value <5%, and still within the accepted range (≤ 5%),

DS3 has 1.62%dispersion value <5%, and still within the accepted range (≤ 5%), so that neglecting wall 18 has effect on DS3 estimated by (7.08 %).
DS4has 1.96%dispersion value <5%,neglecting of wall 18 effect on increasing DS4 dispersion estimated by (0.35 %), but still within the accepted range (≤ 5%).
Final dispersion equals 2.09% and this is perfect value for dispersion, so that wall 18 caused the last big dispersion.

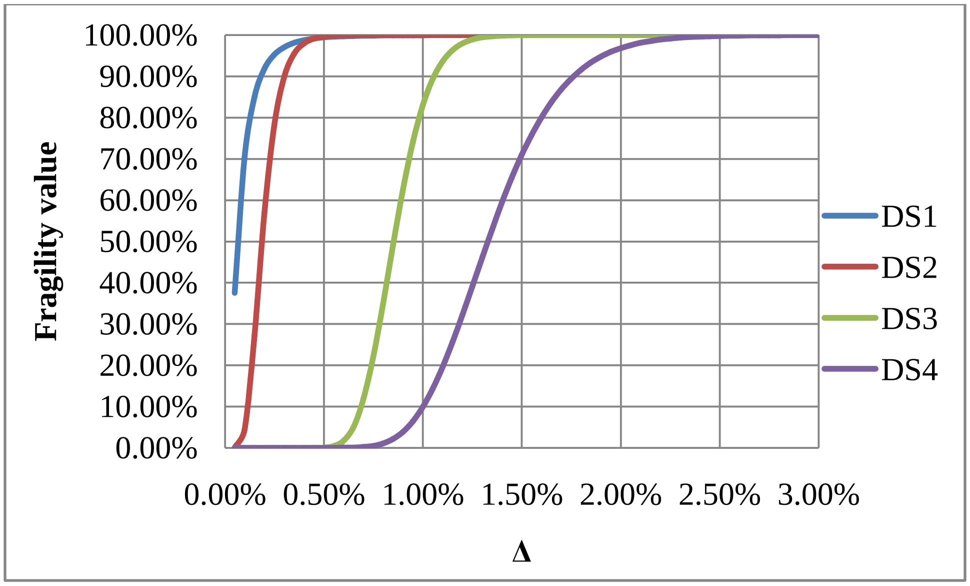
Therefore, we can extract that the behavior of this reinforced clay masonry walls doesn`t differ from the behavior of the reinforced concrete walls that having the same engineering properties.
And this is very clear from these curves, **See curves in list of curves in Curve 76, Curve 77 and Curve 78.**

From curves we can see semi conformity between the two curves; this is showing the similar behavior of the reinforced concrete and clay masonry walls during DS2.
There is also small dispersion between the two curves in DS3 and DS4, and this is very clear from **(Table 28in Appendix A).**
We see that DS2 has 3.08% dispersion value <5%, and still within the accepted range (≤ 5%),
DS3 has 3.34% dispersion value <5%, and still within the accepted range (≤ 5%),
Ds4 has 1.34% dispersion value <5%, and still within the accepted range (≤ 5%).
We can finally assure that when (ρv)equals to (0.40 %) or (0.33 %), (As) equals to (1 %) and (P) varying from (0 to 0.1) % or (0.03 to 0.09) % the reinforced concrete and masonry clay walls have the same behavior and fragility values.

3.4 Curves we had created

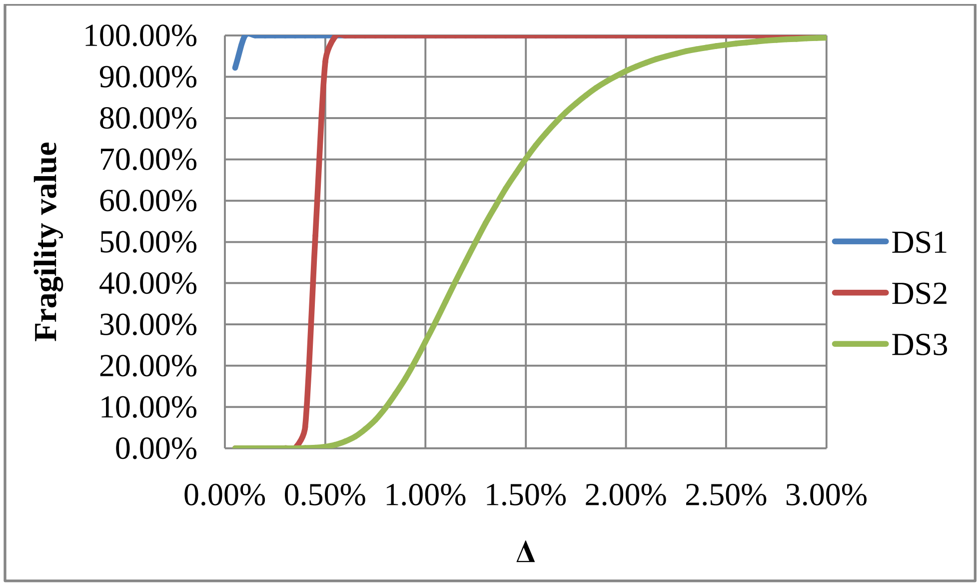
From all statistics operations we had created 14 curves, simply from the summarization processes we done in (3.2) we created 6 curves only describes all ranges of engineering properties we have and there are the six curves:

3.4.1 Curve shows fragility curves for any wall has (P) varying from (0 to 0.1), (ρv) is equal to (0.33) % and (As) is equal to (1) %.



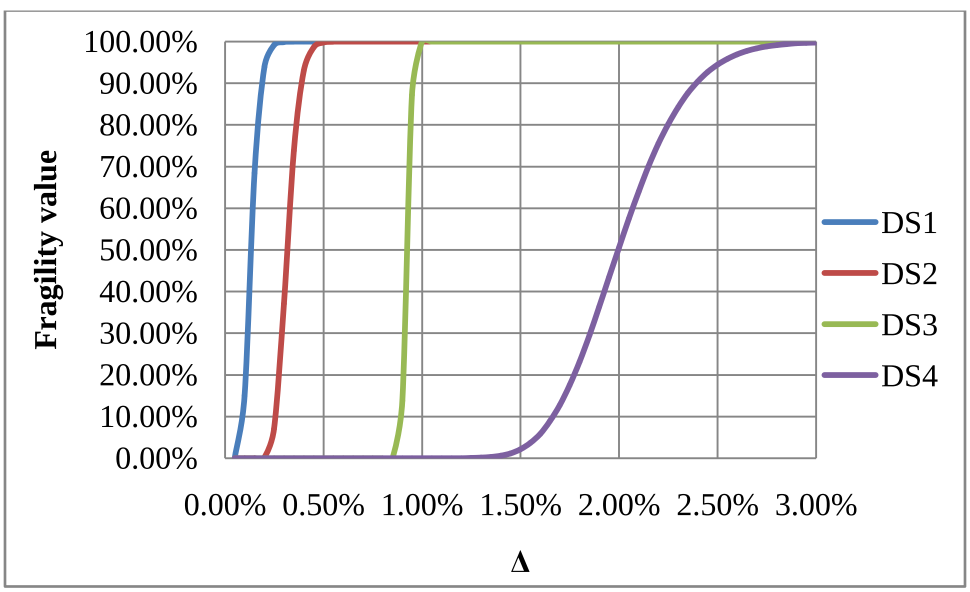
Curve 1
ρv =0.33%
P %: 0 → 0.1 %
As =1% &ρh = 0.33%

3.4.2 Curve shows fragility curves for any wall has (P) varying from (0 to .17) %, (ρv) is equal to 2.95% and (As) is equal to (2) %.



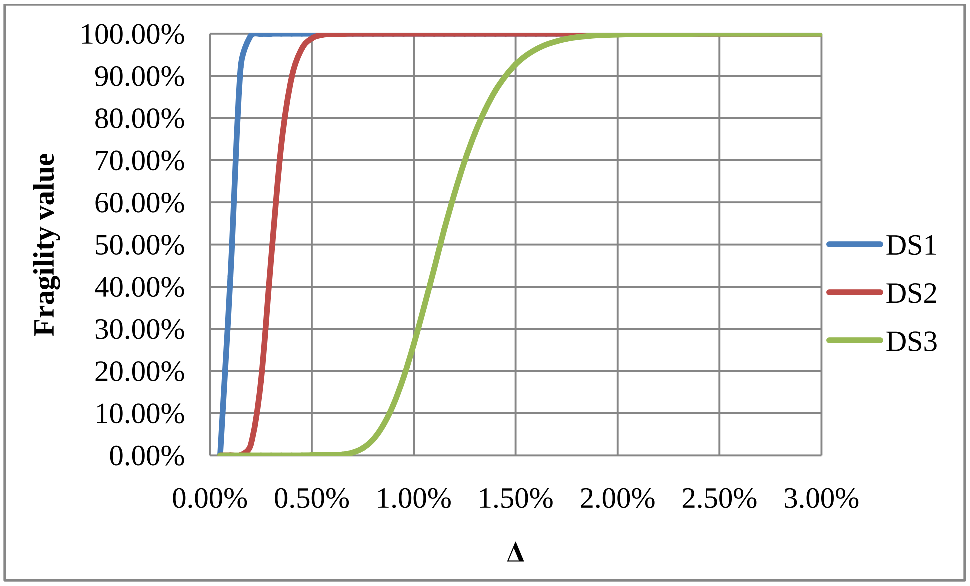
Curve 2
ρv = 2.95 %
, P %: 0 → 0.17 %
, As = 2 % & ρh: 0.40 → 0.80 %

3.4.3 Curve shows fragility curves for any wall has (P) is equal to (zero) %, (ρv) varying from (0.29 to 0.78) % and (As) is equal to (2) %



Curve 3
ρv: 0.29 → 0.78 %, P % = 0, As = 2% &ρh: 0.33 → 0.13 %

3.4.4 Curve shows fragility curves for any wall has (P) varying from (0.057 to 0.108) %, (ρv) varying from (0.54 to 0.82) % and (As) is equal to (2.2) %.

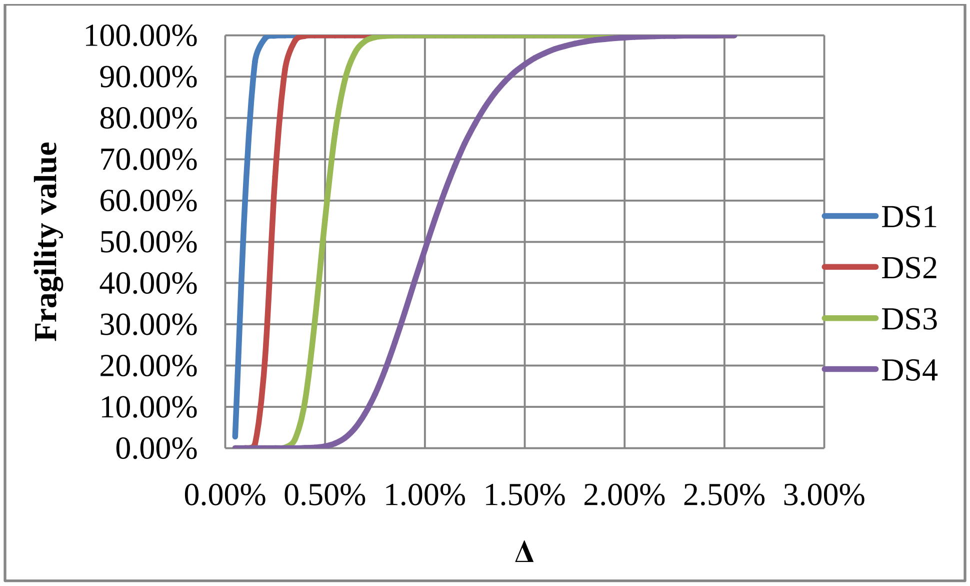


Curve 4
ρv: 0.54 → 0.82 %,

P %: 0.057 → 0.108 %,

As = 2.2 % &ρh =0.25%

3.4.5 Curve shows fragility curves for any wall has (P) varying from (0 to 0.07) %, (ρv) is equal to (0.68) %, (As) varying from (1 to 1.5) %, (ρd) is equal to (0.42) % and (Dd) varying from (0 to 0.96) m



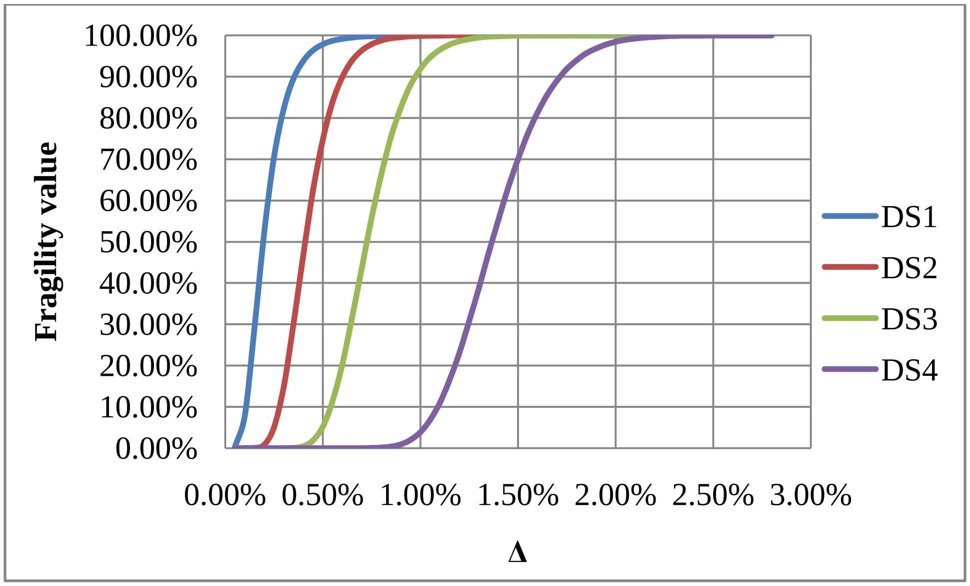
Curve 5
ρv = 0.68 %

P %: 0 → 0.07 %

As: 1 → 1.5 %

ρh = 0.277% &ρd: 0 → 0.42, Dd:0 → 0.96 m

3.4.6 Curve shows fragility curves for any wall has (P) varying from (0 to 1.5) %, (ρv) varying from (1.17 to 1.31) % and (As) varying from (1.47 to 2.21) %.



Curve 6

ρv:1.17 → 1.31%

P %: 0 →1.5 %

As: 1.47→2.21 %

ρh: 0.26 → 0.6 %

Chapter Four
Conclusion

This chapter will conclude and summarize the fragility curves and fragility analysis for reinforced concrete shear walls and reinforced masonry shear walls.

This report had been set up by using 34 shear walls, simply we had convert 34 curves to 6 curves only describes fragility curves and values for any wall has engineering properties located in the same range for a specific curve.

The summarization processes had been done by comparing between curves of all walls and specifying the curves which have conformity with each other or have a small dispersion between each other and supporting this comparison by using statistical method to ensure that there is no dispersion had been produced from the merging and summarizing process is out of the accepted range for this report (≤5%).

Each curve had been created from studying some changes in engineering properties differ from the engineering properties for the other curves.

We had studied the effects of various changes in engineering properties for walls such as:

1- Axial load ratio.
2- Vertical reinforcement ratio.
3- Aspect ratio.
4- Diagonal reinforcement ratio and distance between it.

We had also done summarizing for combined changes in the same time and in the little coming lines we will summarize the effect of these changes and its curve.

First we should mention the general notes we had discovered it:

For all six curves we had created;

- Damage state one (DS1):
  For all statistical operations we have, DS1 has the lowest dispersion ever, its dispersion value varying from (zero to 0.04) %.
  For all comparisons by curves also, there is conformity, semi conformity between curves or the smallest dispersion ever in DS1.

- Damage state two (DS2):
  For all comparisons by curves, there is semi conformity or small dispersion between the curves.

- Damage state three (DS3):

For all comparisons by curves, there is small dispersion between the curves in comparing with DS2.

- Damage state three (DS4):

For all comparisons by curves, there is the biggest dispersion between curves in comparison with the other damage states.
And for the engineering parameters we had tested its changes we found that:

A- Axial load ratio:

1- When aspect ratio equals to (1) % and vertical reinforcement has (0.33) %, the variation of axial load ratio from (0 to 0.1) % has no effect on fragility values. See (curve 1).
2- But when aspect ratio equals to (1) % and vertical reinforcement ratio equals to (0.16) % fragility values will change greatly because of the low reinforcement ratio.
3- When aspect ratio equals to (2) % and vertical reinforcement ratio equals to (2.95) %, the variation of axial load ratio from (0 to 0.17) % has no effect on fragility values. See (curve 2), that is because of the high vertical reinforcement ratio.

B- Vertical reinforcement ratio:

1- When aspect ratio equals to (2) % and axial load ratio equals to (zero) %, variation of vertical reinforcement ratio from (0.29 to 0.78) % has no effect on fragility values. See (curve 3), that is because of disappearing of the axial load action.

C- Aspect ratio:

1- Variation of aspect ratio from (1 to 1.5) % with variation in axial load from (0 to 0.07) % and (0.68) % vertical reinforcement ratio, has no effect on fragility values, that is because of the very low axial load ratio and moderate vertical reinforcement ratio. See (curve 5).
2- The same action on fragility values appeared when axial load ratio varied from (0.057 to 0.108) % and vertical reinforcement ratio varied from (0.54 to 0.82) %, aspect ratio which equals to (2.2) % has no effect on fragility values. See (curve 4).
3- Variation of aspect ratio from (1.47 to 2.21) % with variation in axial load from (1 to 1.5) % and variation in vertical reinforcement ratio from (1.17 to 1.31) % has no effect on fragility values, that is because the moderate vertical reinforcement and axial load ratios. See (curve 6).

D- Diagonal reinforcement ratio:

1- We had only one range for the variation of diagonal reinforcement ratio is from (0 to 0.42) %, and had no effect on the fragility values when vertical reinforcement ratio equals to (0.68) %, aspect ratio varying from (1 to1.5) % and axial load ratio varying from (0 to 0.07) %.

E- Horizontal reinforcement ratio:

1- We had used and statistically tested 34 walls having a various values for horizontal reinforcing ratio (0.08, 0.13, 0.26, 0.277, 0.30, 0.40, 0.60 and 0.80) % we didn`t find any effect of varying the ratio of horizontal reinforcing ratio through this values on fragility values.

List of Symbols

The following symbols are used in this report:

hw → Height of the wall

lw → Length of the wall

tw → Thickness of the wall

ρv → Vertical reinforcement ratio

ρh → Horizontal reinforcement ratio

ρd → Diagonal reinforcement ratio

As → Aspect ratio

P → Axial load ratio (vertical stress)

Dd → Horizontal distances between axes of diagonal reinforcement at base of wall

fm`→ The specified compressive strength of masonry

fy → The specified yield strength of reinforcement

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Appendix A

No	Wall ID	Ds1				Ds2				Ds3						Ds4							
		0.25%	0.50%	0.75%	1.00%	0.25%	0.50%	0.75%	1.00%	0.25%	0.50%	0.75%	1.00%	2.00%	3.00%	0.25%	0.50%	0.75%	1.00%	2.00%	3.00%	4.00%	5.00%
1	PBS-3	99.90%	99.90%	100.00%	100.00%	60.35%	95.14%	99.80%	99.90%	0.00%	0.00%	6.90%	59.80%	99.90%	100.00%	0.00%	0.00%	0.00%	0.00%	99.20%	100.00%	100.00%	100.00%
2	PBS-4	82.00%	97.40%	99.40%	99.80%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%
3	PBS-11	99.90%	100.00%	100.00%	100.00%	96.30%	99.90%	100.00%	100.00%	0.00%	0.00%	34.20%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	2.60%	100.00%	100.00%	100.00%	100.00%
4	PBS-12	99.90%	100.00%	100.00%	100.00%	99.90%	100.00%	100.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%
5	WALL 1	100.00%	100.00%	100.00%	100.00%	0.57%	99.90%	100.00%	100.00%	0.00%	0.00%	0.00%	99.90%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%
6	WALL 2	98.90%	99.90%	100.00%	100.00%	21.00%	99.50%	99.90%	99.90%	0.00%	0.00%	0.00%	99.90%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	86.50%	99.90%	100.00%	100.00%

7	WALL 4	21.00%	100.00%	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	97.10%	99.90%	100.00%	100.00%
8	WALL 5	21.00%	100.00%	100.00%	100.00%	0.00%	56.30%	100.00%	100.00%	0.00%	0.00%	29.20%	98.70%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%
9	WALL 6	0.00%	100.00%	100.00%	100.00%	0.00%	20.90%	87.90%	99.50%	0.00%	0.00%	1.70%	85.50%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	93.20%	99.90%	99.90%	100.00%
10	WALL 1`	99.9%	100%	100%	100%	0%	100%	100%	100%	0%	0%	100%	100%	100%	100%	0%	0%	0%	0%	100%	100%	100%	100.00%
11	WALL 4`	100.00%	100%	100%	100%	0.25%	100%	100%	100%	0%	42.4%	99.9%	100%	100%	100%	0%	0%	0%	11.5%	100%	100%	100%	100.00%
12	WSH1	100.00%	100.00%	100.00%	100.00%	86.90%	100.00%	100.00%	100.00%	0.00%	0.00%	87.40%	99.90%	100.00%	100.00%	0%	0%	0%	0%	0%	0%	0%	0.00%
13	WSH2	100.00%	100.00%	100.00%	100.00%	59.30%	99.70%	99.90%	99.90%	0.00%	0.00%	0.00%	99.60%	100.00%	100.00%	0%	0%	0%	0%	0%	0%	0%	0.00%
14	WSH3	99.60%	100.00%	100.00%	100.00%	0.48%	95.10%	99.90%	100.00%	0.00%	0.00%	0.00%	0.25%	95.40%	99.90%	0%	0%	0%	0%	0%	0%	0%	0.00%
15	WSH4	100.00%	100.00%	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	5.30%	100.00%	100.00%	0%	0%	0%	0%	0%	0%	0%	0.00%

16	WSH5	100.00%	100.00%	100.00%	100.00%	99.90%	100.00%	100.00%	100.00%	0.00%	0.00%	27.50%	99.90%	100.00%	100.00%	0%	0%	0%	0%	0%	0%	0%	0.00%
17	WSH6	91.70%	99.90%	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%	0%	0%	0%	3.10%	99.90%	100.00%	0%	0%	0%	0%	0%	0%	0%	0.00%
18	LSW2	99.70%	99.90%	100.00%	100.00%	93.20%	99.90%	100.00%	100.00%	0.12%	83.30%	99.90%	99.90%	100.00%	100.00%	0.00%	0.00%	25.60%	99.30%	100.00%	100.00%	100.00%	100.00%
19	LSW3	99.90%	100.00%	100.00%	100.00%	96.20%	100.00%	100.00%	100.00%	0.00%	96.20%	99.90%	100.00%	100.00%	100.00%	0.00%	0.00%	1.70%	27.00%	99.80%	99.90%	100.00%	100.00%
20	LSW4	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	0.00%	99.80%	100.00%	100.00%	100.00%	100.00%	0.00%	1.05%	66.90%	99.10%	100.00%	100.00%	100.00%	100.00%
21	LSW5	100.00%	100.00%	100.00%	100.00%	46.18%	100.00%	100.00%	100.00%	0.00%	62.70%	99.90%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	98.00%	100.00%	100.00%	100.00%	100.00%
22	MSW2	20.30%	99.90%	100.00%	100.00%	0.00%	63.50%	99.90%	99.90%	0.00%	0.00%	0.00%	26.90%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	94.40%	100.00%	100.00%	100.00%
23	MSW3	99.70%	99.90%	100.00%	100.00%	0.17%	100.00%	100.00%	100.00%	0.00%	1.10%	99.70%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%
24	MSW4	100.00%	100.00%	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%	0.00%	0.00%	93.08%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%

25	MSW5	100.00%	100.00%	100.00%	100.00%	18.80%	99.90%	100.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%
26	WALL 17	0.00%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	1.4%	99.9%	100.0%	0.00%	0.00%	0.00%	0.44%	86.00%	99.90%	99.90%	99.90%
27	WALL 18	0.00%	0.0%	0.0%	0.0%	89.1%	99.9%	99.9%	99.9%	0.0%	51.8%	97.8%	99.9%	100.0%	100.0%	0.00%	0.00%	0.00%	0.00%	99.90%	100.00%	100.00%	100.00%
28	WALL 19	0.0%	0.0%	0.0%	0.0%	51.8%	99.9%	99.9%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.00%	0.00%	0.00%	0.00%	23.50%	99.90%	100.00%	100.00%
29	WALL 20	0.0%	0.0%	0.0%	0.0%	66.7%	96.7%	99.6%	99.9%	0.0%	0.1%	9.5%	53.9%	99.9%	99.9%	0.00%	0.00%	0.00%	0.03%	96.80%	99.90%	100.00%	100.00%
30	SW21, SW24, SW26	100.0%	100.0%	100.0%	100.0%	0.0%	90.6%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	99.7%	100.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
31	SW23, SW25	100.0%	100.0%	100.0%	100.0%	0.0%	94.4%	100.0%	100.0%	0.0%	0.8%	24.8%	70.6%	99.9%	99.9%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 1 Fragility values for all walls

Damage States	Percentage of Drift	PBS-4	PBS-12	Standard deviation	Variance	Variance
DS1	**0.25%**	82.00%	99.90%	12.66%	1.60%	0.41%
	0.5%	97.40%	100.00%	1.84%	0.03%	
	0.75%	99.40%	100.00%	0.42%	0.00%	
	1.0%	99.80%	100.00%	0.14%	0.00%	
DS2	**0.25%**	0.00%	99.90%	70.64%	49.90%	37.48%
	0.5%	0.00%	100.00%	70.71%	50.00%	
	0.75%	0.00%	100.00%	70.71%	50.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	16.67%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	100.00%	70.71%	50.00%	
	1.0%	0.00%	100.00%	70.71%	50.00%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	6.25%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	
	2.0%	0.00%	100.00%	70.71%	50.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement		**0.16%**	**0.16%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.1**	**19.97%**	**13.71%**	
Aspect ratio %		**1**	**1**			
Material of Wall		**Reinforced Concrete**				
Cross Section Shape		**rec.**	**rec.**			

Table 2 (1st statistical analysis for PBS-4 and PBS-12)

Damage States	Percentage of Drift	PBS-4	PBS-12	Standard deviation	Variance	Variance
DS1	**0.25%**	82.00%	99.90%	12.66%	1.60%	0.41%
	0.5%	97.40%	100.00%	1.84%	0.03%	
	0.75%	99.40%	100.00%	0.42%	0.00%	
	1.0%	99.80%	100.00%	0.14%	0.00%	
DS2	**0.25%**	0.00%	99.90%	70.64%	49.90%	24.98%
	0.5%	--------	--------	--------	--------	
	0.75%	0.00%	100.00%	70.71%	50.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	

DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	16.67%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	100.00%	70.71%	50.00%	
	1.0%	0.00%	100.00%	70.71%	50.00%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	6.25%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	
	2.0%	0.00%	100.00%	70.71%	50.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement		**0.16%**	**0.16%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.1**	**17.55%**	**11.43%**	
Aspect ratio %		**1**	**1**			
Material of Wall		**Reinforced concrete**				
Cross Section Shape		**rec.**	**rec.**			

Table 3 (2nd statistical analysis for PBS-4 and PBS-12)

Damage States	Percentage of Drift	PBS-4	PBS-12	Standard deviation	Variance	Variance
DS1	**0.25%**	82.00%	99.90%	12.66%	1.60%	0.41%
	0.5%	97.40%	100.00%	1.84%	0.03%	
	0.75%	99.40%	100.00%	0.42%	0.00%	
	1.0%	99.80%	100.00%	0.14%	0.00%	
DS2	**0.25%**	0.00%	99.90%	70.64%	49.90%	24.98%
	0.5%	--------	--------	--------	--------	
	0.75%	0.00%	100.00%	70.71%	50.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	10.00%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	--------	--------	--------	--------	
	1.0%	0.00%	100.00%	70.71%	50.00%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	6.25%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	

	2.0%	0.00%	100.00%	70.71%	50.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement %		**0.16%**	**0.16%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.1**	**14.89%**	**9.60%**	
Aspect ratio %		**1**	**1**			
Material of Wall		**Reinforced concrete**				
Cross Section Shape		**rec.**	**rec.**			

Table 4 (3rd statistical analysis for PBS-4 and PBS-12)

Damage States	Percentage of Drift	PBS-3	PBS-11	Standard deviation	Variance	Variance
DS1	**0.25%**	99.90%	99.90%	0.00%	0.00%	0.00%
	0.5%	99.90%	100.00%	0.07%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	60.35%	96.30%	25.42%	6.46%	1.64%
	0.5%	95.14%	99.90%	3.37%	0.11%	
	0.75%	99.80%	100.00%	0.14%	0.00%	
	1.0%	99.90%	100.00%	0.07%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	1.97%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	6.90%	34.20%	19.30%	3.73%	
	1.0%	59.80%	100.00%	28.43%	8.08%	
	2.0%	99.90%	100.00%	0.07%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	2.60%	1.84%	0.03%	
	2.0%	99.20%	100.00%	0.57%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement %		**0.33%**	**0.33%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.1**	**3.60%**	**0.84%**	
Aspect ratio %		**1**	**1**			
Material of Wall		**Reinforced concrete**				

Cross Section Shape	rec.	rec.			

Table 5 (1st statistical analysis for PBS-3 and PBS-11)

Damage States	Percentage of Drift	WALL4	WALL5	Standard deviation	Variance	Variance
DS1	**0.25%**	21.00%	21.00%	0.00%	0.00%	0.00%
	0.5%	100.00%	100.00%	0.00%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	0.00%	0.00%	0.00%	0.00%	2.39%
	0.5%	100.00%	56.30%	30.90%	9.55%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.71%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	29.20%	20.65%	4.26%	
	1.0%	100.00%	98.70%	0.92%	0.01%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.01%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	
	2.0%	97.10%	100.00%	2.05%	0.04%	
	3.0%	99.90%	100.00%	0.07%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement %		**1.31%**	**1.31%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.75**	**2.48%**	**0.63%**	
Aspect ratio %		**2**	**2**			
Material of Wall		**Reinforced masonry units**				
Cross Section Shape		**rec.**	**rec.**			

Table 6 (1st statistical analysis for Wall 4 and Wall 5)

Damage States	Percentage of Drift	WALL5	WALL6	Standard deviation	Variance	Variance
DS1	**0.25%**	21.00%	0.00%	14.85%	2.21%	0.55%
	0.5%	100.00%	100.00%	0.00%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	

DS2	**0.25%**	0.00%	0.00%	0.00%	0.00%	1.75%
	0.5%	56.30%	20.90%	25.03%	6.27%	
	0.75%	100.00%	87.90%	8.56%	0.73%	
	1.0%	100.00%	99.50%	0.35%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.78%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	29.20%	1.70%	19.45%	3.78%	
	1.0%	98.70%	85.50%	9.33%	0.87%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.03%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	
	2.0%	100.00%	93.20%	4.81%	0.23%	
	3.0%	100.00%	99.90%	0.07%	0.00%	
	4.0%	100.00%	99.90%	0.07%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement %		**1.31%**	**1.31%**	**Average**	**Average**	
Axial load ratio %		**0.75**	**1.5**	**3.75%**	**0.64%**	
Aspect ratio %		**2**	**2**			
Material of Wall		**Reinforced masonry units**				
Cross Section Shape		**rec.**	**rec.**			

Table 7 (1st statistical analysis for Wall 5 and Wall 6)

Damage States	Percentage of Drift	WALL4	WALL5	WALL6	Standard deviation	Variance	Variance
DS1	**0.25%**	21.00%	21.00%	0.00%	12.12%	1.47%	0.37%
	0.5%	100.00%	100.00%	100.00%	0.00%	0.00%	
	0.75%	100.00%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%	4.05%
	0.5%	100.00%	56.30%	20.90%	39.62%	15.70%	
	0.75%	100.00%	100.00%	87.90%	6.99%	0.49%	
	1.0%	100.00%	100.00%	99.50%	0.29%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.55%
	0.5%	0.00%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	29.20%	1.70%	16.39%	2.69%	
	1.0%	100.00%	98.70%	85.50%	8.02%	0.64%	
	2.0%	100.00%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	100.00%	0.00%	0.00%	

DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
	0.5%	0.00%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	0.00%	
	2.0%	97.10%	100.00%	93.20%	3.41%	0.12%	
	3.0%	99.90%	100.00%	99.90%	0.06%	0.00%	
	4.0%	100.00%	100.00%	99.90%	0.06%	0.00%	
	5.0%	100.00%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement		**1.31%**	**1.31%**	**1.31%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.75**	**1.5**	**3.95%**	**0.96%**	
Aspect ratio %		**2**	**2**	**2**			
Material of Wall		**Reinforced masonry units**					
Cross Section Shape		**rec.**	**rec.**				

Table 8 (1st statistical analysis for Wall 4, Wall 5 and Wall 6)

Damage States	**Percentage of Drift**	**SW21 ,SW24 ,SW26**	**SW23 ,SW25**	**Standard deviation**	**Variance**	**Variance**
DS1	**0.25%**	100.0%	100.0%	0.00%	0.00%	0.00%
	0.5%	100.0%	100.0%	0.00%	0.00%	
	0.75%	100.0%	100.0%	0.00%	0.00%	
	1.0%	100.0%	100.0%	0.00%	0.00%	
DS2	**0.25%**	0.0%	0.0%	0.00%	0.00%	0.02%
	0.5%	90.6%	94.44%	2.72%	0.07%	
	0.75%	100.0%	100.0%	0.00%	0.00%	
	1.0%	100.0%	100.0%	0.00%	0.00%	
DS3	**0.25%**	0.0%	0.00%	0.00%	0.00%	4.66%
	0.5%	0.0%	0.82%	0.58%	0.00%	
	0.75%	0.0%	24.84%	17.56%	3.09%	
	1.0%	0.0%	70.57%	49.90%	24.90%	
	2.0%	99.7%	99.90%	0.14%	0.00%	
	3.0%	100.0%	99.90%	0.07%	0.00%	
Vertical reinforcement %		**2.95%**	**2.95%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.17**	**5.07%**	**2.00%**	
Aspect ratio %		**2**	**2**			
Material of Wall		**Reinforced concrete**				
Cross Section Shape		**rec.**	**rec.**			

Table 9 (1st statistical analysis for SW21, SW24, SW26 and SW23, SW25)

Damage States	Percentage of Drift	WALL1	WALL2	Standard deviation	Variance	Variance
DS1	**0.25%**	100.00%	98.90%	0.78%	0.01%	0.00%
	0.5%	100.00%	99.90%	0.07%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	0.57%	21.00%	14.45%	2.09%	0.52%
	0.5%	99.90%	99.50%	0.28%	0.00%	
	0.75%	100.00%	99.90%	0.07%	0.00%	
	1.0%	100.00%	99.90%	0.07%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	99.90%	99.90%	0.00%	0.00%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	4.68%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	
	2.0%	0.00%	86.50%	61.16%	37.41%	
	3.0%	100.00%	99.90%	0.07%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement %		**0.29%**	**0.78%**	**Average**	**Average**	
Axial load ratio %		**0**	**0**	**3.50%**	**1.80%**	
Aspect ratio %		**2**	**2**			
Material of Wall		**Reinforced masonry units**				
Cross Section Shape		**rec.**	**rec.**			

Table 10 (1st statistical analysis for Wall 1 and Wall2)

Damage States	Percentage of Drift	WALL`1	WALL`4	Standard deviation	Variance	Variance
DS1	**0.25%**	99.9%	100%	0.07%	0.00%	0.00%
	0.5%	100%	100%	0.00%	0.00%	
	0.75%	100%	100%	0.00%	0.00%	
	1.0%	100%	100%	0.00%	0.00%	
DS2	**0.25%**	0%	0.25%	0.18%	0.00%	0.00%

	0.5%	100%	100%	0.00%	0.00%	
	0.75%	100%	100%	0.00%	0.00%	
	1.0%	100%	100%	0.00%	0.00%	
DS3	**0.25%**	0%	0%	0.00%	0.00%	1.50%
	0.5%	0%	42.4%	29.98%	8.99%	
	0.75%	100%	99.9%	0.07%	0.00%	
	1.0%	100%	100%	0.00%	0.00%	
	2.0%	100%	100%	0.00%	0.00%	
	3.0%	100%	100%	0.00%	0.00%	
DS4	**0.25%**	0%	0%	0.00%	0.00%	0.08%
	0.5%	0%	0%	0.00%	0.00%	
	0.75%	0%	0%	0.00%	0.00%	
	1.0%	0%	11.5%	8.13%	0.66%	
	2.0%	100%	100%	0.00%	0.00%	
	3.0%	100%	100%	0.00%	0.00%	
	4.0%	100%	100%	0.00%	0.00%	
	5.0%	100%	100%	0.00%	0.00%	
Vertical reinforcement %		**1.17%**	**1.17%**	**Average**	**Average**	
Axial load ratio %		**1.09**	**1.05**	**1.75%**	**0.44%**	
Aspect ratio %		**2.21**	**1.47**			
Material of Wall		**Reinforced masonry units**				
Cross Section Shape		**rec.**	**rec.**			

Table 11 (1st statistical analysis for Wall 1` and Wall 4`)

Damage States	Percentage of Drift	LSW4	LSW2	Standard deviation	Variance	Variance
DS1	**0.25%**	100.00%	99.70%	0.21%	0.00%	0.00%
	0.5%	100.00%	99.90%	0.07%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	100.00%	93.20%	4.81%	0.23%	0.06%
	0.5%	100.00%	99.90%	0.07%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS3	**0.25%**	0.00%	0.12%	0.08%	0.00%	0.23%
	0.5%	99.80%	83.30%	11.67%	1.36%	
	0.75%	100.00%	99.90%	0.07%	0.00%	
	1.0%	100.00%	99.90%	0.07%	0.00%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	1.07%

	0.5%	1.05%	0.00%	0.74%	0.01%	
	0.75%	66.90%	25.60%	29.20%	8.53%	
	1.0%	99.10%	99.30%	0.14%	0.00%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement %		**0.68%**	**0.68%**	**Average**	**Average**	
Axial load ratio %		**0**	**0**	**2.14%**	**0.46%**	
Aspect ratio %		**1**	**1**			
Material of Wall		**Reinforced Concrete**				
Cross Section Shape		**rec.**	**rec.**			
Diagonal reinforcement %		**0.42%**	**0**			
Distance between diagonal		**0**	**0**			

Table 12 (1st statistical analysis for LSW2 and LSW4)

Damage States	Percentage of Drift	MSW2	MSW4	Standard deviation	Variance	Variance
DS1	**0.25%**	20.30%	100.00%	56.36%	31.76%	7.94%
	0.5%	99.90%	100.00%	0.07%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	0.00%	0.00%	0.00%	0.00%	1.67%
	0.5%	63.50%	100.00%	25.81%	6.66%	
	0.75%	99.90%	100.00%	0.07%	0.00%	
	1.0%	99.90%	100.00%	0.07%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	11.67%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	93.08%	65.82%	43.32%	
	1.0%	26.90%	100.00%	51.69%	26.72%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.02%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	
	2.0%	94.40%	100.00%	3.96%	0.16%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	

Vertical reinforcement %	**0.68%**	**0.68%**	**Average**	**Average**	
Axial load ratio %	**0**	**0**	**9.27%**	**4.94%**	
Aspect ratio %	**1.5**	**1.5**			
Material of Wall	**Reinforced Concrete**				
Cross Section Shape	**rec.**	**rec.**			
Diagonal reinforcement %	**0**	**0.42%**			
Distance between diagonal	**0**	**0**			

Table 13 (1st statistical analysis for MSW2 and MSW4)

Damage States	**Percentage of Drift**	**MSW2**	**MSW4**	**Standard deviation**	**Variance**	**Variance**
DS1	**0.25%**	--------	--------	--------	--------	0.00%
	0.5%	99.90%	100.00%	0.07%	0.00%	
	0.75%	100%	100.00%	0.00%	0.00%	
	1.0%	100%	100.00%	0.00%	0.00%	
DS2	**0.25%**	0.00%	0.00%	0.00%	0.00%	1.67%
	0.5%	63.50%	100.00%	25.81%	6.66%	
	0.75%	99.90%	100.00%	0.07%	0.00%	
	1.0%	99.90%	100.00%	0.07%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	11.67%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	93.08%	65.82%	43.32%	
	1.0%	26.90%	100.00%	51.69%	26.72%	
	2.0%	100%	100.00%	0.00%	0.00%	
	3.0%	100%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.02%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	
	2.0%	94.40%	100.00%	3.96%	0.16%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement %		**0.68%**	**0.68%**	**Average**	**Average**	
Axial load ratio %		**0**	**0**	**7.02%**	**3.66%**	
Aspect ratio %		**1.5**	**1.5**			
Material of Wall		**Reinforced Concrete**				
Cross Section Shape		**rec.**	**rec.**			

Diagonal reinforcement %	**0**	**0.42%**			
Distance between diagonal reinforcement	**0**	**0**			

Table 14 (2nd statistical analysis for MSW2 and MSW4)

Damage States	Percentage of Drift	MSW2	MSW4	Standard deviation	Variance	Variance
DS1	**0.25%**	--------	--------	--------	--------	0.00%
	0.5%	99.90%	100.00%	0.07%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	0.00%	0.00%	0.00%	0.00%	1.67%
	0.5%	63.50%	100.00%	25.81%	6.66%	
	0.75%	99.90%	100.00%	0.07%	0.00%	
	1.0%	99.90%	100.00%	0.07%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	5.34%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	--------	--------	--------	--------	
	1.0%	26.90%	100.00%	51.69%	26.72%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.02%
	0.5%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0.00%	
	2.0%	94.40%	100.00%	3.96%	0.16%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement		**0.68%**	**0.68%**	**Average**	**Average**	
Axial load ratio %		**0**	**0**	**4.08%**	**1.68%**	
Aspect ratio %		**1.5**	**1.5**			
Material of Wall		**Reinforced Concrete**				
Cross Section Shape		**rec.**	**rec.**			
Diagonal reinforcement %		**0**	**0.42%**			
Distance between diagonal reinforcement		**0**	**0**			

Table 15 (3rd statistical analysis for MSW2 and MSW4)

Damage States	Percentage of Drift	LSW4	LSW5	Standard deviation	Variance	Variance
DS1	**0.25%**	100.00%	100.00%	0.00%	0.00%	0.00%
	0.5%	100.00%	100.00%	0.00%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	100.00%	46.18%	38.06%	14.48%	3.62%
	0.5%	100.00%	100.00%	0.00%	0.00%	
	0.75%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	1.15%
	0.5%	99.80%	62.70%	26.23%	6.88%	
	0.75%	100.00%	99.90%	0.07%	0.00%	
	1.0%	100.00%	100.00%	0.00%	0.00%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	2.80%
	0.5%	1.05%	0.00%	0.74%	0.01%	
	0.75%	66.90%	0.00%	47.31%	22.38%	
	1.0%	99.10%	98.00%	0.78%	0.01%	
	2.0%	100.00%	100.00%	0.00%	0.00%	
	3.0%	100.00%	100.00%	0.00%	0.00%	
	4.0%	100.00%	100.00%	0.00%	0.00%	
	5.0%	100.00%	100.00%	0.00%	0.00%	
Vertical reinforcement %		**0.68%**	**0.68%**	**Average**	**Average**	
Axial load ratio %		**0**	**0**	**5.14%**	**1.99%**	
Aspect ratio %		**1**	**1**			
Material of Wall		**Reinforced Concrete**				
Cross Section Shape		**rec.**	**rec.**			
Diagonal reinforcement %		**0.42%**	**0.42%**			
Distance between diagonal reinforcement		**0**	**0.96**			

Table 16 (1st statistical analysis for LSW4 and LSW5)

<table>
<tr><th>Damage States</th><th>Percentage of Drift</th><th>MSW4</th><th>MSW5</th><th>Standard deviation</th><th>Variance</th><th>Variance</th></tr>
<tr><td rowspan="4">DS1</td><td>0.25%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td><td rowspan="4">0.00%</td></tr>
<tr><td>0.5%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>0.75%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>1.0%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td rowspan="4">DS2</td><td>0.25%</td><td>0.00%</td><td>18.80%</td><td>13.29%</td><td>1.77%</td><td rowspan="4">0.44%</td></tr>
<tr><td>0.5%</td><td>100.00%</td><td>99.90%</td><td>0.07%</td><td>0.00%</td></tr>
<tr><td>0.75%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>1.0%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td rowspan="6">DS3</td><td>0.25%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td rowspan="6">0.04%</td></tr>
<tr><td>0.5%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>0.75%</td><td>93.08%</td><td>100.00%</td><td>4.89%</td><td>0.24%</td></tr>
<tr><td>1.0%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>2.0%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>3.0%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td rowspan="8">DS4</td><td>0.25%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td rowspan="8">0.00%</td></tr>
<tr><td>0.5%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>0.75%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>1.0%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>2.0%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>3.0%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>4.0%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>5.0%</td><td>100.00%</td><td>100.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td colspan="2">Vertical reinforcement %</td><td>0.68%</td><td>0.68%</td><td>Average</td><td>Average</td><td></td></tr>
<tr><td colspan="2">Axial load ratio %</td><td>0</td><td>0</td><td>0.83%</td><td>0.09%</td><td></td></tr>
<tr><td colspan="2">Aspect ratio %</td><td>1.5</td><td>1.5</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Material of Wall</td><td colspan="2">Reinforced Concrete</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Cross Section Shape</td><td>rec.</td><td>rec.</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Diagonal reinforcement %</td><td>0.42%</td><td>0.42%</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Distance between diagonal reinforcement</td><td>0</td><td>0.96</td><td></td><td></td><td></td></tr>
</table>

Table 17 (1st statistical analysis for MSW4 and MSW5)

Damage States	Percentage of Drift	WSH1	WSH2	WSH3	WSH4	WSH5	WSH6	Standard deviation	Variance	Variance
DS1	**0.25%**	100.00%	100.00%	99.60%	100.00%	100.00%	91.70%	3.36%	0.11%	0.03%
	0.5%	100.00%	100.00%	100.00%	100.00%	100.00%	99.90%	0.04%	0.00%	
	0.75%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	86.90%	59.30%	0.48%	0.00%	99.90%	0.00%	46.72%	21.83%	5.47%
	0.5%	100.00%	99.70%	95.10%	100.00%	100.00%	100.00%	1.98%	0.04%	
	0.75%	100.00%	99.90%	99.90%	100.00%	100.00%	100.00%	0.05%	0.00%	
	1.0%	100.00%	99.90%	100.00%	100.00%	100.00%	100.00%	0.04%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.77%
	0.5%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
	0.75%	87.40%	0.00%	0.00%	0.00%	27.50%	0.00%	35.20%	12.39%	
	1.0%	99.90%	99.60%	0.25%	5.30%	99.90%	3.10%	53.11%	28.20%	
	2.0%	100.00%	100.00%	95.40%	100.00%	100.00%	99.90%	1.87%	0.03%	
	3.0%	100.00%	100.00%	99.90%	100.00%	100.00%	100.00%	0.04%	0.00%	
Vertical reinforcement %		**0.54%**	**0.54%**	**0.82%**	**0.82%**	**0.39%**	**0.82%**	**Average**	**Average**	
Axial load ratio %		**0.051**	**0.057**	**0.058**	**0.057**	**0.128**	**0.108**	**10.17%**	**4.47%**	
Aspect ratio %		**2.28**	**2.28**	**2.28**	**2.28**	**2.28**	**2.26**			
Material of Wall		**Reinforced concrete**								
Cross Section Shape		**rec.**	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**			

Table 18 (1st statistical analysis for WSH1, WSH2, WSH3, WSH4, WSH5 and WSH6)

Damage States	Percentage of Drift	WSH2	WSH3	WSH4	WSH5	WSH6	Standard deviation	Variance	Variance
DS1	**0.25%**	100.00%	99.60%	100.00%	100.00%	91.70%	3.67%	0.13%	0.03%
	0.5%	100.00%	100.00%	100.00%	100.00%	99.90%	0.04%	0.00%	
	0.75%	100.00%	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	

	1.0%	100.00%	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	59.30%	0.48%	0.00%	99.90%	0.00%	45.82%	20.99%	5.26%
	0.5%	99.70%	95.10%	100.00%	100.00%	100.00%	2.16%	0.05%	
	0.75%	99.90%	99.90%	100.00%	100.00%	100.00%	0.05%	0.00%	
	1.0%	99.90%	100.00%	100.00%	100.00%	100.00%	0.04%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.96%
	0.5%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	27.50%	0.00%	12.30%	1.51%	
	1.0%	99.60%	0.25%	5.30%	99.90%	3.10%	53.09%	28.18%	
	2.0%	100.00%	95.40%	100.00%	100.00%	99.90%	2.05%	0.04%	
	3.0%	100.00%	99.90%	100.00%	100.00%	100.00%	0.04%	0.00%	
Vertical reinforcement %		**0.54%**	**0.82%**	**0.82%**	**0.39%**	**0.82%**	**Average**	**Average**	
Axial load ratio %		**0.057**	**0.058**	**0.057**	**0.128**	**0.108**	**8.52%**	**3.64%**	
Aspect ratio %		**2.28**	**2.28**	**2.28**	**2.28**	**2.26**			
Material of Wall		**Reinforced concrete**							
Cross Section Shape		**rec.**	**rec.**	**rec.**	**rec.**	**rec.**			

Table 19 (1st statistical analysis for WSH2, WSH3, WSH4, WSH5 and WSH6)

Damage States	Percentage of Drift	WSH2	WSH3	WSH4	WSH6	Standard deviation	Variance	Variance
DS1	**0.25%**	100.00%	99.60%	100.00%	91.70%	4.09%	0.17%	0.04%
	0.5%	100.00%	100.00%	100.00%	99.90%	0.05%	0.00%	
	0.75%	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	
	1.0%	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	
DS2	**0.25%**	59.30%	0.48%	0.00%	0.00%	29.57%	8.74%	2.20%
	0.5%	99.70%	95.10%	100.00%	100.00%	2.40%	0.06%	
	0.75%	99.90%	99.90%	100.00%	100.00%	0.06%	0.00%	
	1.0%	99.90%	100.00%	100.00%	100.00%	0.05%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.91%
	0.5%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
	1.0%	99.60%	0.25%	5.30%	3.10%	48.40%	23.43%	
	2.0%	100.00%	95.40%	100.00%	99.90%	2.28%	0.05%	
	3.0%	100.00%	99.90%	100.00%	100.00%	0.05%	0.00%	
Vertical reinforcement %		**0.54%**	**0.82%**	**0.82%**	**0.82%**	**Average**	**Average**	
Axial load ratio %		**0.057**	**0.058**	**0.057**	**0.108**	**6.21%**	**2.32%**	
Aspect ratio %		**2.28**	**2.28**	**2.28**	**2.26**			
Material of Wall		**Reinforced concrete**						
Cross Section Shape		**rec.**	**rec.**	**rec.**	**rec.**			

Table 20 (1st statistical analysis for WSH2, WSH3, WSH4 and WSH6)

Damage States	Percentage of Drift	LSW2	LSW3	LSW4	LSW5	MSW2	MSW3	MSW4	MSW5	Standard deviation	Variance	Variance
DS1	**0.25%**	99.70	99.90	100.00	100.00	20.30	99.70	100.00	100.00	28.14%	7.92%	1.98%
	0.5%	99.90	100.00	100.00	100.00	99.90	99.90	100.00	100.00	0.05%	0.00%	
	0.75%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
	1.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
DS2	**0.25%**	93.20	96.20	100.00	46.18	0.00%	0.17%	0.00%	18.80	45.85%	21.02%	5.67%
	0.5%	99.90	100.00	100.00	100.00	63.50	100.00	100.00	99.90	12.89%	1.66%	
	0.75%	100.00	100.00	100.00	100.00	99.90	100.00	100.00	100.00	0.04%	0.00%	
	1.0%	100.00	100.00	100.00	100.00	99.90	100.00	100.00	100.00	0.04%	0.00%	
DS3	**0.25%**	0.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.00%	6.82%
	0.5%	83.30	96.20	99.80	62.70	0.00%	1.10%	0.00%	0.00%	46.86%	21.96%	
	0.75%	99.90	99.90	100.00	99.90	0.00%	99.70	93.08	100.00	35.06%	12.29%	
	1.0%	99.90	100.00	100.00	100.00	26.90	100.00	100.00	100.00	25.84%	6.68%	
	2.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
	3.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.75%
	0.5%	0.00%	0.00%	1.05%	0.00%	0.00%	0.00%	0.00%	0.00%	0.37%	0.00%	
	0.75%	25.60	1.70%	66.90	0.00%	0.00%	0.00%	0.00%	0.00%	23.98%	5.75%	
	1.0%	99.30	27.00	99.10	98.00	0.00%	0.00%	0.00%	0.00%	49.19%	24.20%	
	2.0%	100.00	99.80	100.00	100.00	94.40	100.00	100.00	100.00	1.97%	0.04%	
	3.0%	100.00	99.90	100.00	100.00	100.00	100.00	100.00	100.00	0.04%	0.00%	
	4.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
	5.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
Vertical reinforcement %		**0.68%**	**0.68%**	**0.68%**	**0.68%**	**0.68%**	**0.68%**	**0.68%**	**0.68%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.07**	**0**	**0**	**0**	**0.07**	**0**	**0**	**12.29%**	**4.61%**	
Aspect ratio %		**1**	**1**	**1**	**1**	**1.5**	**1.5**	**1.5**	**1.5**			
Material of Wall		**Reinforced Concrete**										

Cross Section Shape	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**			
Diagonal reinforcement %			**0.42%**	**0.42%**			**0.42%**	**0.42%**			
Distance between diagonal reinforcement			**0**	**0.96**			**0**	**0.96**			

Table 21 (1st statistical analysis for LSW2, LSW3, LSW4, LSW5, MSW2, MSW3, MSW4 and MSW5)

Damage States	**Percentage of Drift**	**LSW2**	**LSW3**	**LSW4**	**LSW5**	**MSW3**	**MSW4**	**MSW5**	**Standard deviation**	**Variance**	**Variance**
DS1	**0.25%**	99.70%	99.90%	100.00	100.00	99.70%	100.00	100.00	0.14%	0.00%	0.00%
	0.5%	99.90%	100.00	100.00	100.00	99.90%	100.00	100.00	0.05%	0.00%	
	0.75%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
	1.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
DS2	**0.25%**	93.20%	96.20%	100.00	46.18%	0.17%	0.00%	18.80%	45.59%	20.78%	5.20%
	0.5%	99.90%	100.00	100.00	100.00	100.00	100.00	99.90%	0.05%	0.00%	
	0.75%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
	1.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
DS3	**0.25%**	0.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.00%	3.70%
	0.5%	83.30%	96.20%	99.80%	62.70%	1.10%	0.00%	0.00%	47.03%	22.12%	
	0.75%	99.90%	99.90%	100.00	99.90%	99.70%	93.08%	100.00	2.58%	0.07%	
	1.0%	99.90%	100.00	100.00	100.00	100.00	100.00	100.00	0.04%	0.00%	
	2.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
	3.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.95%
	0.5%	0.00%	0.00%	1.05%	0.00%	0.00%	0.00%	0.00%	0.40%	0.00%	
	0.75%	25.60%	1.70%	66.90%	0.00%	0.00%	0.00%	0.00%	25.38%	6.44%	
	1.0%	99.30%	27.00%	99.10%	98.00%	0.00%	0.00%	0.00%	50.12%	25.12%	
	2.0%	100.00	99.80%	100.00	100.00	100.00	100.00	100.00	0.08%	0.00%	

	3.0%	100.00	99.90%	100.00	100.00	100.00	100.00	100.00	0.04%	0.00%	
	4.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
	5.0%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00%	0.00%	
Vertical reinforcement %		**0.68%**	**0.68%**	**0.68%**	**0.68%**	**0.68%**	**0.68%**	**0.68%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.07**	**0**	**0**	**0.07**	**0**	**0**	**7.80%**	**3.39%**	
Aspect ratio %		**1**	**1**	**1**	**1**	**1.5**	**1.5**	**1.5**			
Material of Wall		**Reinforced Concrete**									
Cross Section Shape		**rec.**	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**		
Diagonal reinforcement %				**0.42%**	**0.42%**			**0.42%**	**0.42%**		
Distance between diagonal reinforcement				**0**	**0.96**			**0**	**0.96**		

Table 22 (1st statistical analysis for LSW2, LSW3, LSW4, LSW5, MSW3, MSW4 and MSW5)

DAMAGE STATE	**PERCENTAGE OF DRIFT**	**LSW2**	**LSW3**	**LSW4**	**LSW5**	**MSW3**	**MSW5**	**Standard deviation**	**Variance**	**Variance**
DS1	**0.25%**	99.70%	99.90%	100.00	100.00	99.70%	100.00	0.15%	0.00%	0.00%
	0.5%	99.90%	100.00%	100.00	100.00	99.90%	100.00	0.05%	0.00%	
	0.75%	100.00%	100.00%	100.00	100.00	100.00	100.00	0.00%	0.00%	
	1.0%	100.00%	100.00%	100.00	100.00	100.00	100.00	0.00%	0.00%	
DS2	**0.25%**	93.20%	96.20%	100.00	46.18%	0.17%	18.80%	43.53%	18.95%	4.74%
	0.5%	99.90%	100.00%	100.00	100.00	100.00	99.90%	0.05%	0.00%	
	0.75%	100.00%	100.00%	100.00	100.00	100.00	100.00	0.00%	0.00%	
	1.0%	100.00%	100.00%	100.00	100.00	100.00	100.00	0.00%	0.00%	
DS3	**0.25%**	0.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.00%	3.49%

	0.5%	83.30%	96.20%	99.80%	62.70%	1.10%	0.00%	45.75%	20.93%	
	0.75%	99.90%	99.90%	100.00	99.90%	99.70%	100.00	0.11%	0.00%	
	1.0%	99.90%	100.00%	100.00	100.00	100.00	100.00	0.04%	0.00%	
	2.0%	100.00%	100.00%	100.00	100.00	100.00	100.00	0.00%	0.00%	
	3.0%	100.00%	100.00%	100.00	100.00	100.00	100.00	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.06%
	0.5%	0.00%	0.00%	1.05%	0.00%	0.00%	0.00%	0.43%	0.00%	
	0.75%	25.60%	1.70%	66.90%	0.00%	0.00%	0.00%	27.04%	7.31%	
	1.0%	99.30%	27.00%	99.10%	98.00%	0.00%	0.00%	50.17%	25.17%	
	2.0%	100.00%	99.80%	100.00	100.00	100.00	100.00	0.08%	0.00%	
	3.0%	100.00%	99.90%	100.00	100.00	100.00	100.00	0.04%	0.00%	
	4.0%	100.00%	100.00%	100.00	100.00	100.00	100.00	0.00%	0.00%	
	5.0%	100.00%	100.00%	100.00	100.00	100.00	100.00	0.00%	0.00%	
Vertical reinforcement %		**0.68%**	**0.68%**	**0.68%**	**0.68%**	**0.68%**	**0.68%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.07**	**0**	**0**	**0.07**	**0**	**7.61%**	**3.29%**	
Aspect ratio %		**1**	**1**	**1**	**1**	**1.5**	**1.5**			
Material of Wall		**Reinforced Concrete**								
Cross Section Shape		**rec.**	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**			
Diagonal reinforcement %				**0.42%**	**0.42%**		**0.42%**			
Distance between diagonal reinforcement				**0**	**0.96**		**0.96**			

Table 23 (1st statistical analysis for LSW2, LSW3, LSW4, LSW5, MSW3 and MSW5)

Damage States	Percentage of Drift	WALL4	WALL5	WALL6	WALL`1	WALL`4	Standard deviation	Variance	Variance
DS1	0.25%	21.00%	21.00%	0.00%	99.9%	100%	47.85%	22.90%	5.72%
	0.5%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
	0.75%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
	1.0%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
DS2	0.25%	0.00%	0.00%	0.00%	0%	0.25%	0.11%	0.00%	3.29%
	0.5%	100.00%	56.30%	20.90%	100%	100%	35.88%	12.88%	
	0.75%	100.00%	100.00%	87.90%	100%	100%	5.41%	0.29%	
	1.0%	100.00%	100.00%	99.50%	100%	100%	0.22%	0.00%	
DS3	0.25%	0.00%	0.00%	0.00%	0%	0%	0.00%	0.00%	4.91%
	0.5%	0.00%	0.00%	0.00%	0%	42.4%	18.96%	3.60%	
	0.75%	0.00%	29.20%	1.70%	100%	99.9%	50.45%	25.45%	
	1.0%	100.00%	98.70%	85.50%	100%	100%	6.36%	0.41%	
	2.0%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
	3.0%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
DS4	0.25%	0.00%	0.00%	0.00%	0%	0%	0.00%	0.00%	0.04%
	0.5%	0.00%	0.00%	0.00%	0%	0%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0%	0%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0%	11.5%	5.14%	0.26%	
	2.0%	97.10%	100.00%	93.20%	100%	100%	2.99%	0.09%	
	3.0%	99.90%	100.00%	99.90%	100%	100%	0.05%	0.00%	
	4.0%	100.00%	100.00%	99.90%	100%	100%	0.04%	0.00%	
	5.0%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
Vertical reinforcement %		**1.31%**	**1.31%**	**1.31%**	**1.17%**	**1.17%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.75**	**1.5**	**1.09**	**1.05**	**7.89%**	**2.99%**	
Aspect ratio %		**2**	**2**	**2**	**2.21**	**1.47**			
Material of Wall		**Reinforced masonry units**							
Cross Section Shape		**rec.**	**rec.**	**rec.**	**rec.**	**rec.**			

Table 24 (1st statistical analysis for WALL4, WALL5, WALL6, WALL`1 and WALL`4)

Damage States	Percentage of Drift	WALL4	WALL5	WALL6	WALL`1	WALL`4	Standard deviation	Variance	Variance
DS1	0.25%	--------	--------	--------	--------	--------	--------	--------	0.00%
	0.5%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
	0.75%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
	1.0%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
DS2	0.25%	0.00%	0.00%	0.00%	0%	0.25%	0.11%	0.00%	3.29%
	0.5%	100.00%	56.30%	20.90%	100%	100%	35.88%	12.88%	

	0.75%	100.00%	100.00%	87.90%	100%	100%	5.41%	0.29%	
	1.0%	100.00%	100.00%	99.50%	100%	100%	0.22%	0.00%	
DS3	**0.25%**	0.00%	0.00%	0.00%	0%	0%	0.00%	0.00%	4.91%
	0.5%	0.00%	0.00%	0.00%	0%	42.4%	18.96%	3.60%	
	0.75%	0.00%	29.20%	1.70%	100%	99.9%	50.45%	25.45%	
	1.0%	100.00%	98.70%	85.50%	100%	100%	6.36%	0.41%	
	2.0%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
	3.0%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
DS4	**0.25%**	0.00%	0.00%	0.00%	0%	0%	0.00%	0.00%	0.04%
	0.5%	0.00%	0.00%	0.00%	0%	0%	0.00%	0.00%	
	0.75%	0.00%	0.00%	0.00%	0%	0%	0.00%	0.00%	
	1.0%	0.00%	0.00%	0.00%	0%	11.5%	5.14%	0.26%	
	2.0%	97.10%	100.00%	93.20%	100%	100%	2.99%	0.09%	
	3.0%	99.90%	100.00%	99.90%	100%	100%	0.05%	0.00%	
	4.0%	100.00%	100.00%	99.90%	100%	100%	0.04%	0.00%	
	5.0%	100.00%	100.00%	100.00%	100%	100%	0.00%	0.00%	
Vertical reinforcement %		**1.31%**	**1.31%**	**1.31%**	**1.17%**	**1.17%**	**Average**	**Average**	
Axial load ratio %		**0**	**0.75**	**1.5**	**1.09**	**1.05**	**5.98%**	**2.05%**	
Aspect ratio %		**2**	**2**	**2**	**2.21**	**1.47**			
Material of Wall		**Reinforced masonry units**							
Cross Section Shape		**rec.**	**rec.**	**rec.**	**rec.**	**rec.**			

Table 25 (2nd statistical analysis for WALL4, WALL5, WALL6, WALL`1 and WALL`4)

DAMAGE STATE	PERCENTAGE OF DRIFT	WALL17	WALL18	WALL19	WALL20	Standard deviation	Variance	Variance
DS1	**0.25%**	-	-	-	-			-----
	0.5%	-	-	-	-			
	0.75%	-	-	-	-			
	1.0%	-	-	-	-			
DS2	**0.25%**	0.0%	89.1%	51.8%	66.7%	37.84%	14.32%	3.59%
	0.5%	100.0%	99.9%	99.9%	96.7%	1.62%	0.03%	
	0.75%	100.0%	99.9%	99.9%	99.6%	0.17%	0.00%	
	1.0%	100.0%	99.9%	100.0%	99.9%	0.06%	0.00%	
DS3	**0.25%**	0.0%	0.04%	0.0%	0.0%	0.02%	0.00%	8.70%
	0.5%	0.0%	51.8%	0.0%	0.05%	25.89%	6.70%	
	0.75%	0.0%	97.8%	0.0%	9.5%	47.53%	22.59%	

	1.0%	1.4%	99.9%	0.03%	53.9%	47.83%	22.88%	
	2.0%	99.9%	100.0%	100.0%	99.9%	0.06%	0.00%	
	3.0%	100.0%	100.0%	100.0%	99.9%	0.05%	0.00%	
DS4	**0.25%**	0.0%	0.0%	0.0%	0.0%	0.00%	0.00%	1.61%
	0.5%	0.0%	0.0%	0.0%	0.0%	0.00%	0.00%	
	0.75%	0.0%	0.0%	0.0%	0.0%	0.00%	0.00%	
	1.0%	0.4%	0.0%	0.0%	0.03%	0.22%	0.00%	
	2.0%	86.0%	99.9%	23.5%	96.8%	35.86%	12.86%	
	3.0%	99.9%	100.0%	99.9%	99.9%	0.05%	0.00%	
	4.0%	99.9%	100.0%	100.0%	100.0%	0.05%	0.00%	
	5.0%	99.9%	100.0%	100.0%	100.0%	0.05%	0.00%	
Vertical reinforcement %		**0.40%**	**0.40%**	**0.40%**	**0.40%**	**Average**	**Average**	
Axial load ratio %		**0.07**	**0.07**	**0.07**	**0.07**	**10.96%**	**4.41%**	
Aspect ratio %		**1**	**1**	**1**	**1**			
Material of Wall		**Reinforced clay masonry units**						
Cross Section Shape		**rec.**	**rec.**	**rec.**	**rec.**			

Table 26 (1st statistical analysis for WALL 17, WALL 18, WALL 19 and WALL 20)

DAMAGE STATE	PERCENTAGE OF DRIFT	WALL17	WALL19	WALL20	Standard deviation	Variance	Variance
DS1	**0.25%**	-	-	-			
	0.5%	-	-	-			
	0.75%	-	-	-			
	1.0%	-	-	-			
DS2	**0.25%**	0.0%	51.8%	66.7%	35.01%	12.26%	3.07%
	0.5%	100.0%	99.9%	96.7%	1.88%	0.04%	
	0.75%	100.0%	99.9%	99.6%	0.21%	0.00%	
	1.0%	100.0%	100.0%	99.9%	0.06%	0.00%	
DS3	**0.25%**	0.0%	0.0%	0.0%	0.00%	0.00%	1.62%
	0.5%	0.0%	0.0%	0.05%	0.03%	0.00%	
	0.75%	0.0%	0.0%	9.5%	5.48%	0.30%	
	1.0%	1.4%	0.03%	53.9%	30.71%	9.43%	
	2.0%	99.9%	100.0%	99.9%	0.06%	0.00%	
	3.0%	100.0%	100.0%	99.9%	0.06%	0.00%	
DS4	**0.25%**	0.0%	0.0%	0.0%	0.00%	0.00%	1.96%
	0.5%	0.0%	0.0%	0.0%	0.00%	0.00%	

	0.75%	0.0%	0.0%	0.0%	0.00%	0.00%	
	1.0%	0.4%	0.0%	0.03%	0.25%	0.00%	
	2.0%	86.0%	23.5%	96.8%	39.57%	15.66%	
	3.0%	99.9%	99.9%	99.9%	0.00%	0.00%	
	4.0%	99.9%	100.0%	100.0%	0.06%	0.00%	
	5.0%	99.9%	100.0%	100.0%	0.06%	0.00%	
Vertical reinforcement %		**0.40%**	**0.40%**	**0.40%**	**Average**	**Average**	
Axial load ratio %		**0.07**	**0.07**	**0.07**	**6.30%**	**2.09%**	
Aspect ratio %		**1**	**1**	**1**			
Material of Wall		**Reinforced clay masonry units**					
Cross Section Shape		**rec.**	**rec.**	**rec.**			

Table 27 (1st statistical analysis for WALL 17, WALL 19 and WALL 20)

DAMAGE STATE	PERCENTAGE OF DRIFT	WALL17	WALL19	WALL20	PBS-3	PBS-11	Standard deviation	Variance	Variance
DS1	**0.25%**	-	-	-	-	-	-	-	
	0.5%	-	-	-	-	-	-	-	
	0.75%	-	-	-	-	-	-	-	
	1.0%	-	-	-	-	-	-	-	
DS2	**0.25%**	0.0%	51.8%	66.7%	60.35%	96.30%	35.02%	12.27%	3.08%
	0.5%	100.0%	99.9%	96.7%	95.14%	99.90%	2.27%	0.05%	
	0.75%	100.0%	99.9%	99.6%	99.80%	100.00%	0.17%	0.00%	
	1.0%	100.0%	100.0%	99.9%	99.90%	100.00%	0.05%	0.00%	
DS3	**0.25%**	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	3.34%
	0.5%	0.0%	0.0%	0.05%	0.00%	0.00%	0.02%	0.00%	
	0.75%	0.0%	0.0%	9.5%	6.90%	34.20%	14.10%	1.99%	
	1.0%	1.4%	0.03%	53.9%	59.80%	100.00%	42.51%	18.07%	
	2.0%	99.9%	100.0%	99.9%	99.90%	100.00%	0.05%	0.00%	
	3.0%	100.0%	100.0%	99.9%	100.00%	100.00%	0.04%	0.00%	
DS4	**0.25%**	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	1.34%
	0.5%	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	
	0.75%	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	
	1.0%	0.4%	0.0%	0.03%	0.00%	2.60%	1.13%	0.01%	
	2.0%	86.0%	23.5%	96.8%	99.20%	100.00%	32.68%	10.68%	
	3.0%	99.9%	99.9%	99.9%	100.00%	100.00%	0.05%	0.00%	
	4.0%	99.9%	100.0%	100.0%	100.00%	100.00%	0.04%	0.00%	
	5.0%	99.9%	100.0%	100.0%	100.00%	100.00%	0.04%	0.00%	
Vertical reinforcement %		**0.40%**	**0.40%**	**0.40%**	**0.33%**	**0.33%**	**Average**	**Average**	

Axial load ratio %	**0.07**	**0.07**	**0.07**	**0**	**0.1**	**7.12%**	**2.39%**	
Aspect ratio %	**1**	**1**	**1**	**1**	**1**			
Material of Wall	**Reinforced clay masonry units**			**Reinforced concrete**				
Cross Section Shape	**rec.**	**rec.**	**rec.**	**rec.**	**rec.**			

Table 28 (1st statistical analysis for WALL 17, WALL 19, WALL 20 and PBS-3, PBS-11)

Appendix B

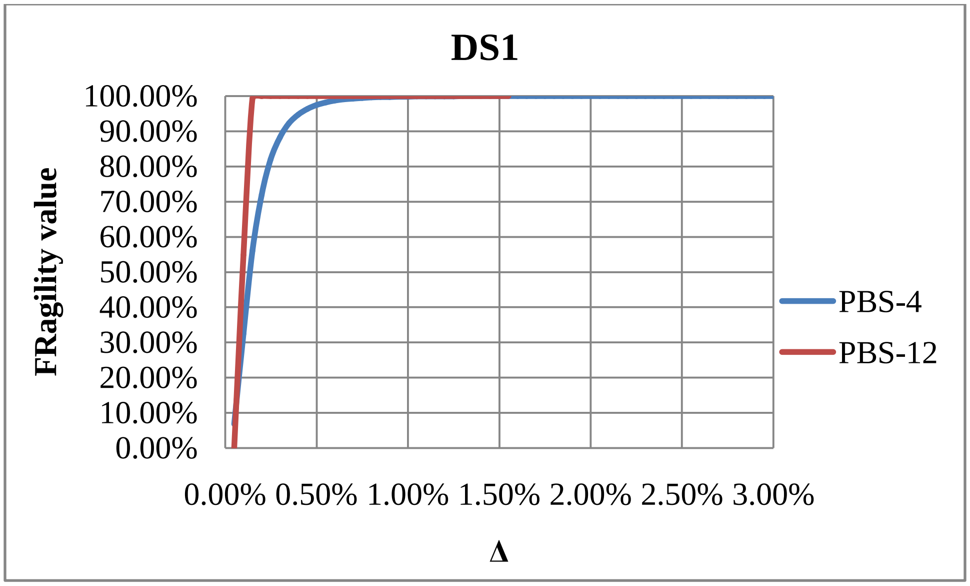

Figure 1- Damage state 1 fragility curve for PBS-4 and PBS-12

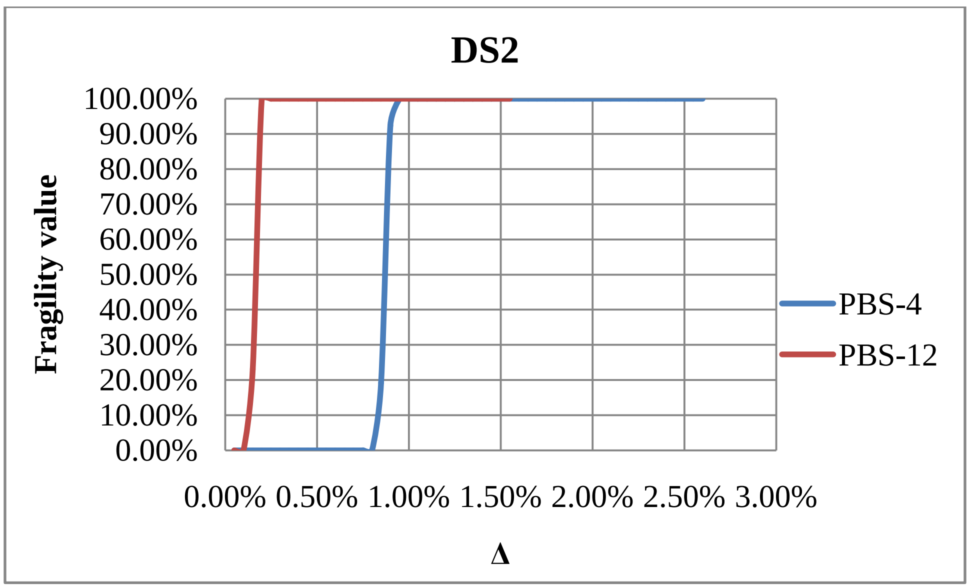

Figure 2- Damage state 2 fragility curve for PBS-4 and PBS-12

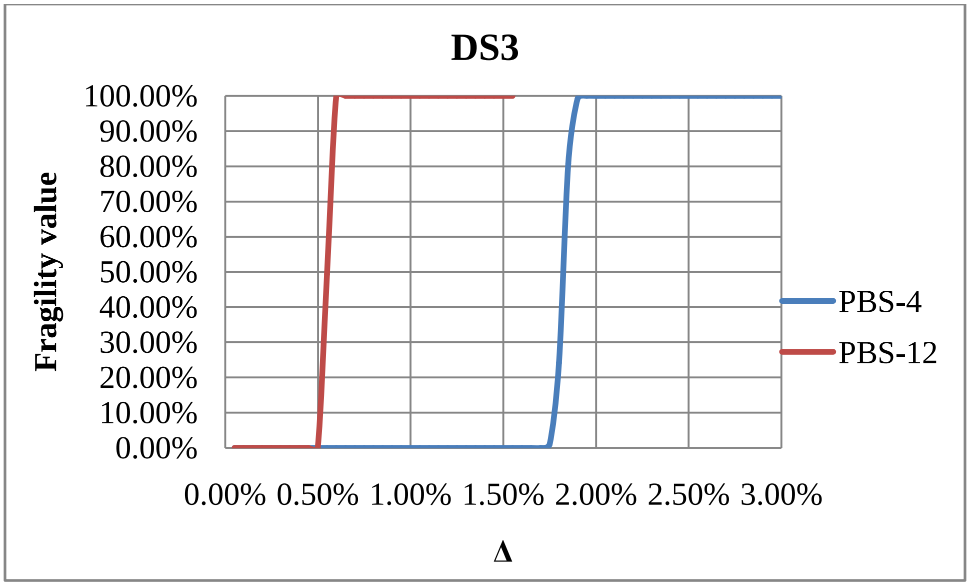

Figure 3- Damage state 3 fragility curve for PBS-4 and PBS-12

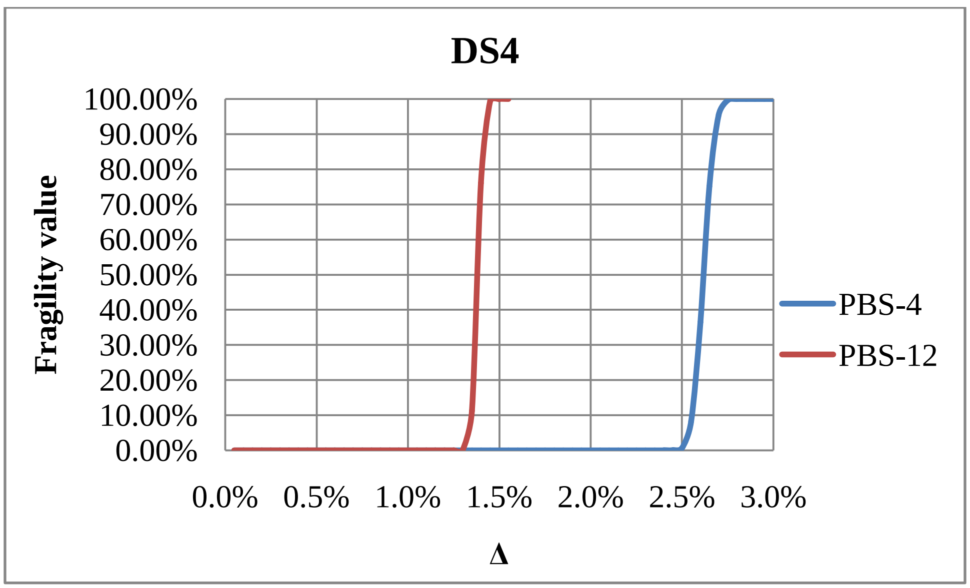

Figure 4- Damage state 4 fragility curve for PBS-4 and PBS-12

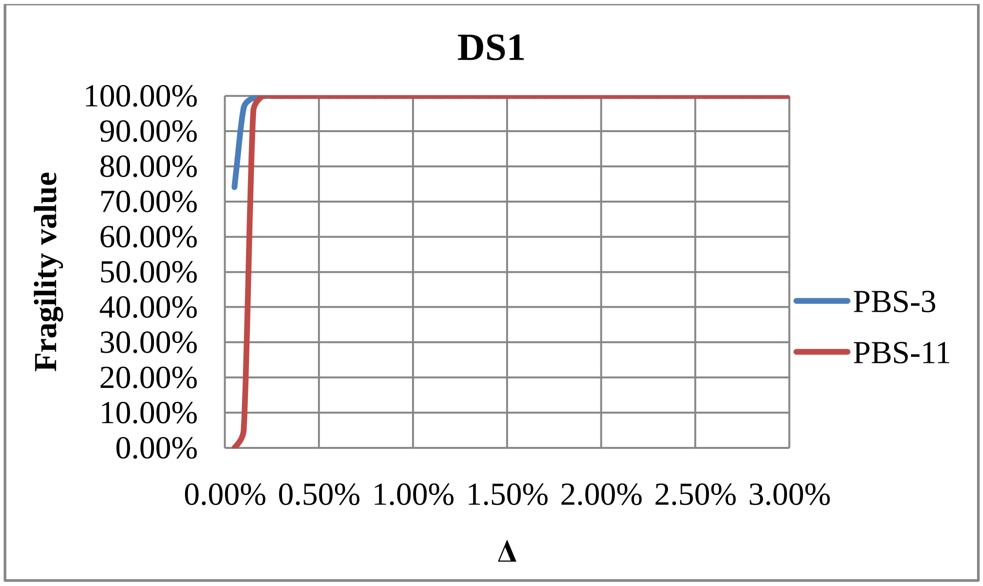

Figure 5- Damage state 1 fragility curves for PBS-3 and PBS-11

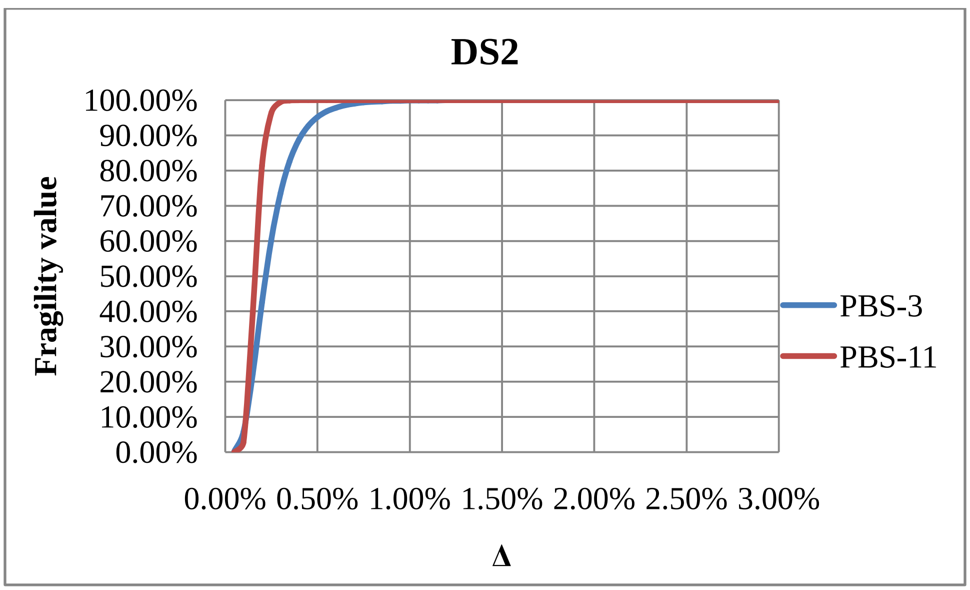

Figure 6- Damage state 2 fragility curves for PBS-3 and PBS-11

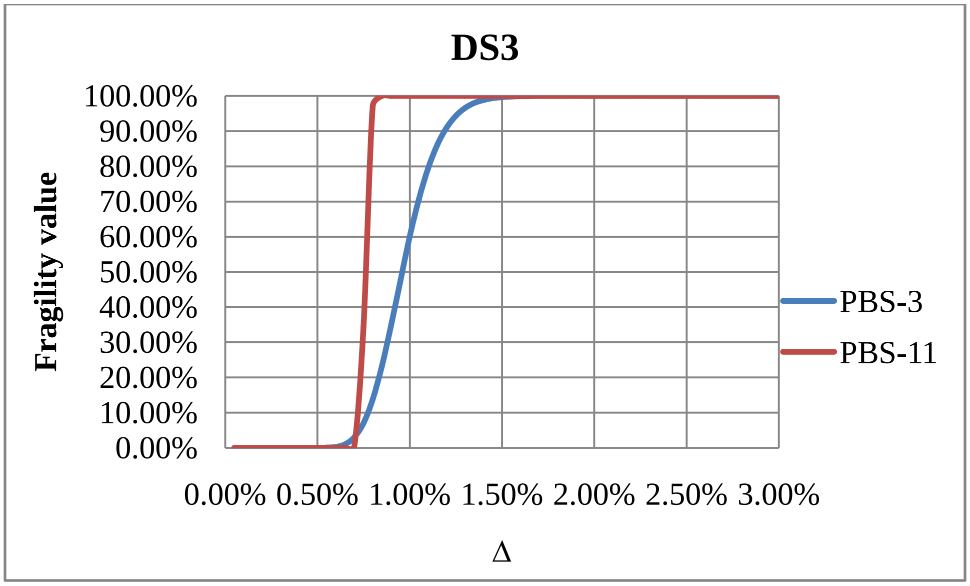

Figure 7- Damage state 3 fragility curves for PBS-3 and PBS-11

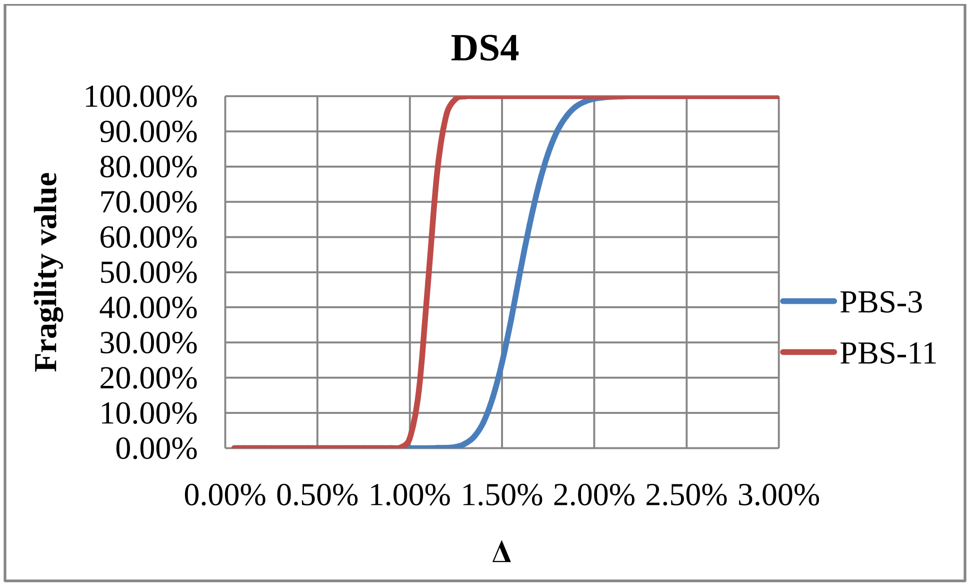

Figure 8- Damage state 4 fragility curves for PBS-3 and PBS-11

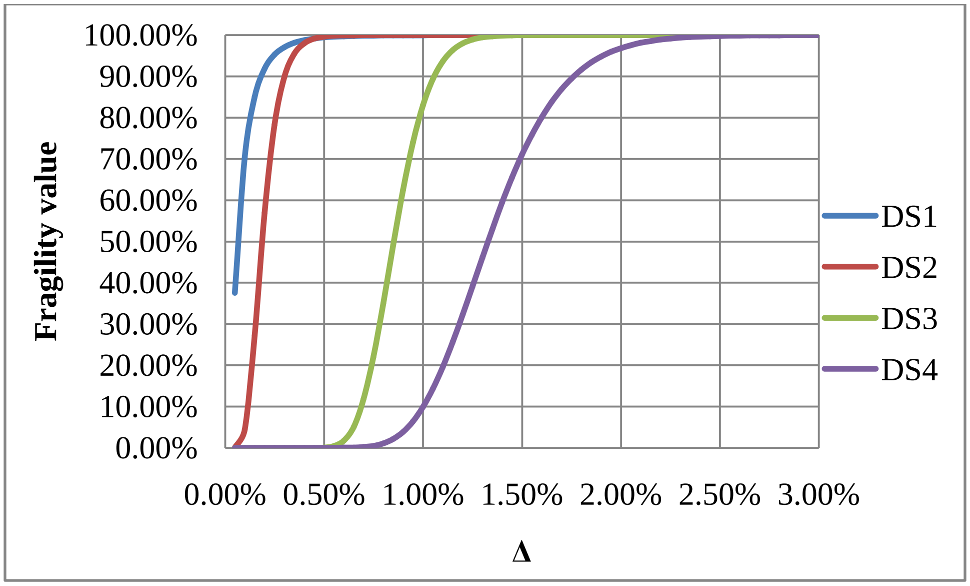

Figure 9- fragility curve for any wall has (0.33) % (ρv), (1) % (As), (P) varying from (0 to 0.1) % and (0.33) % (ρh)

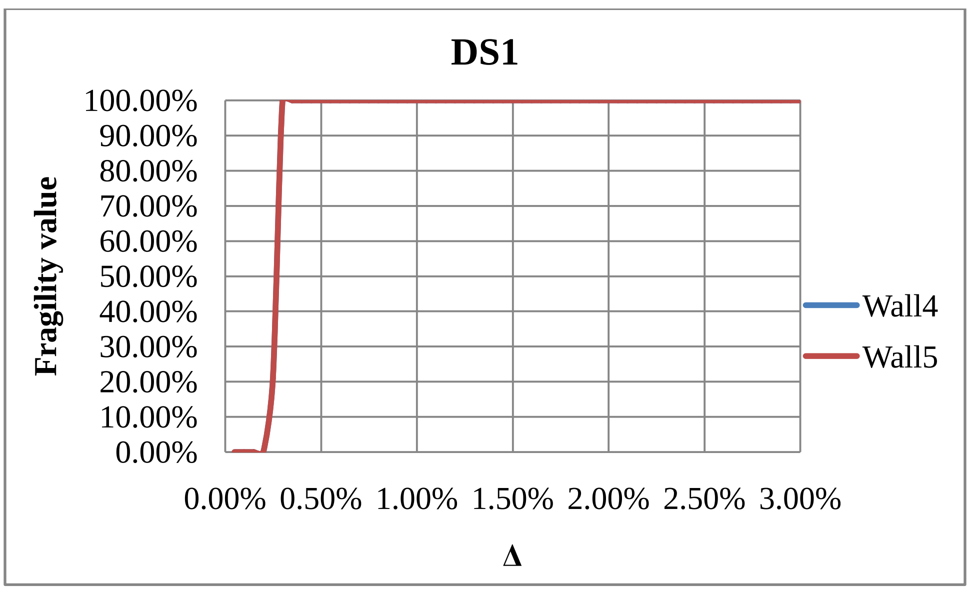

Figure 10- Damage state 1 fragility curves for Wall 4 and Wall 5

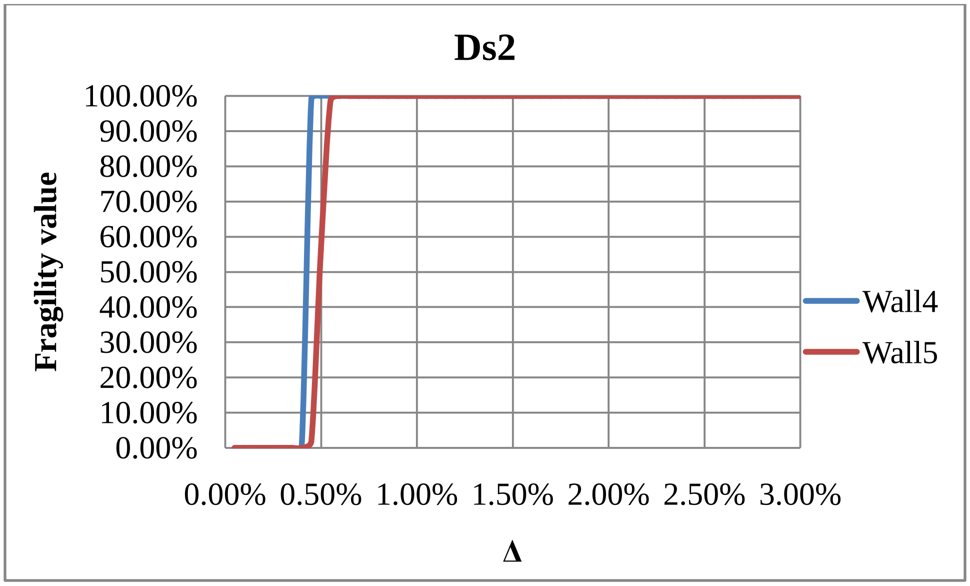

Figure 11- Damage state 2 fragility curves for Wall 4 and Wall 5

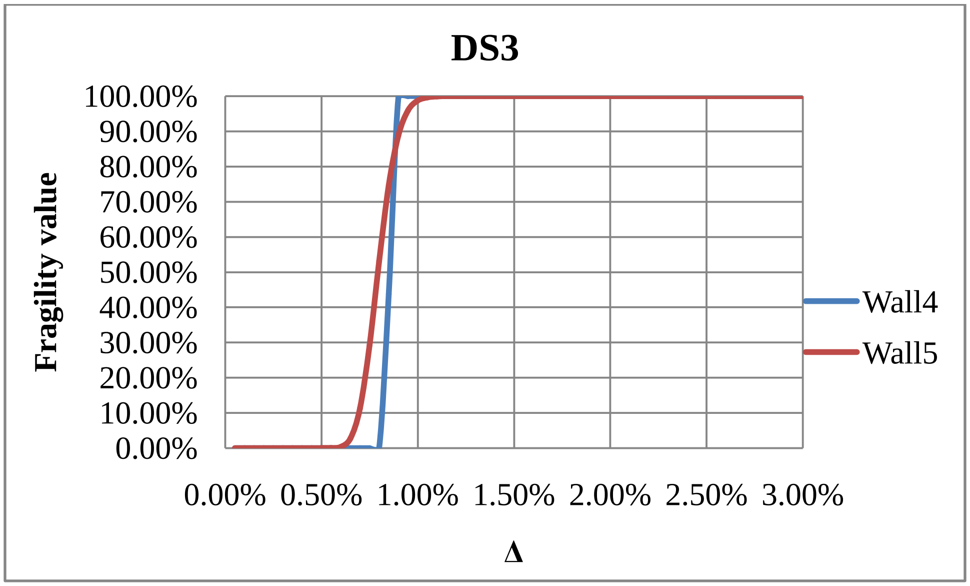

Figure 12- Damage state 3 fragility curves for Wall 4 and Wall 5

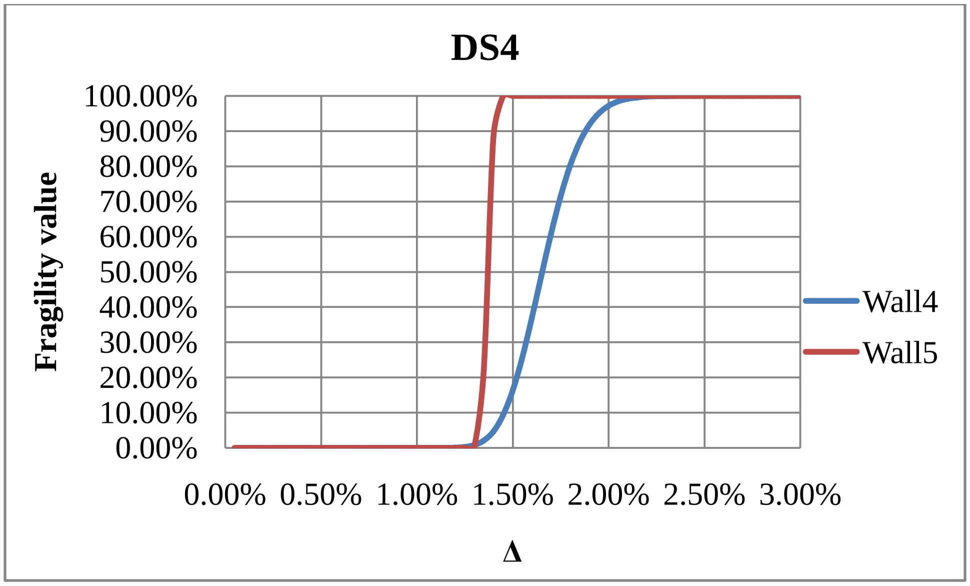

Figure 13- Damage state 4 fragility curves for Wall 4 and Wall 5

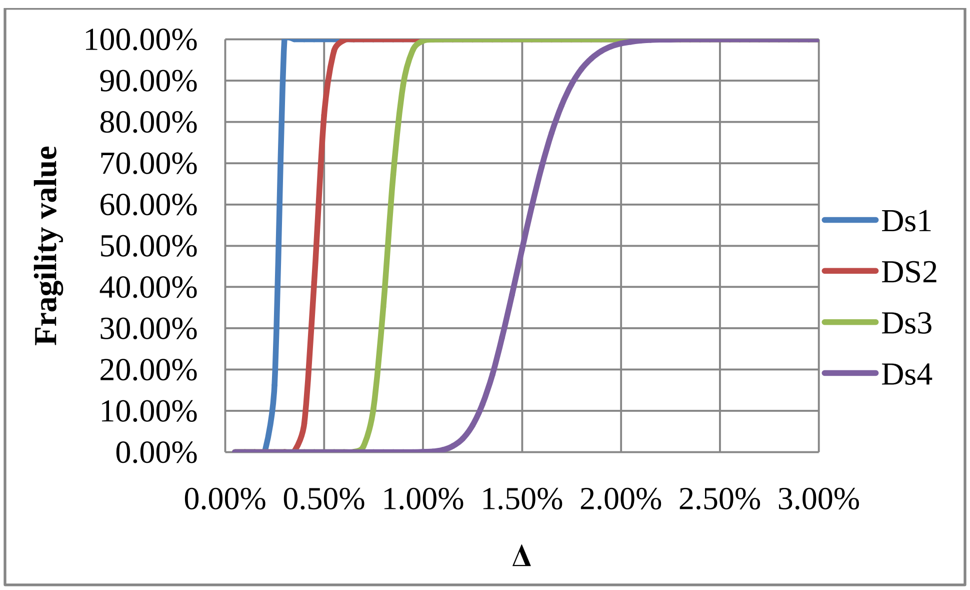

Figure 14- fragility curve for any wall has (1.31) % (ρv), (2) % (As), (P) varying from (0 to 0.75) % and (ρh) is equal to (0.26) %

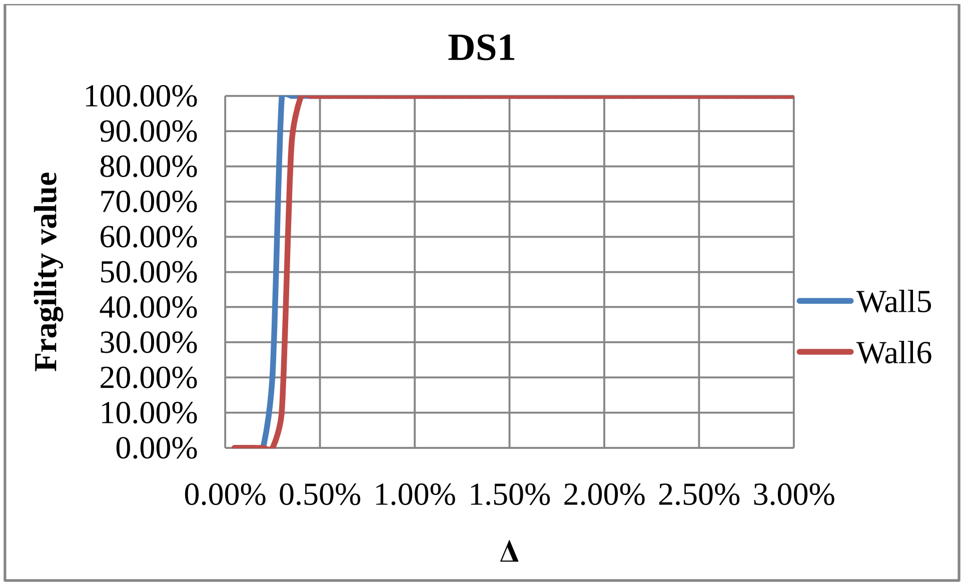

Figure 15- Damage state 1 fragility curves for Wall 5 and Wall 6

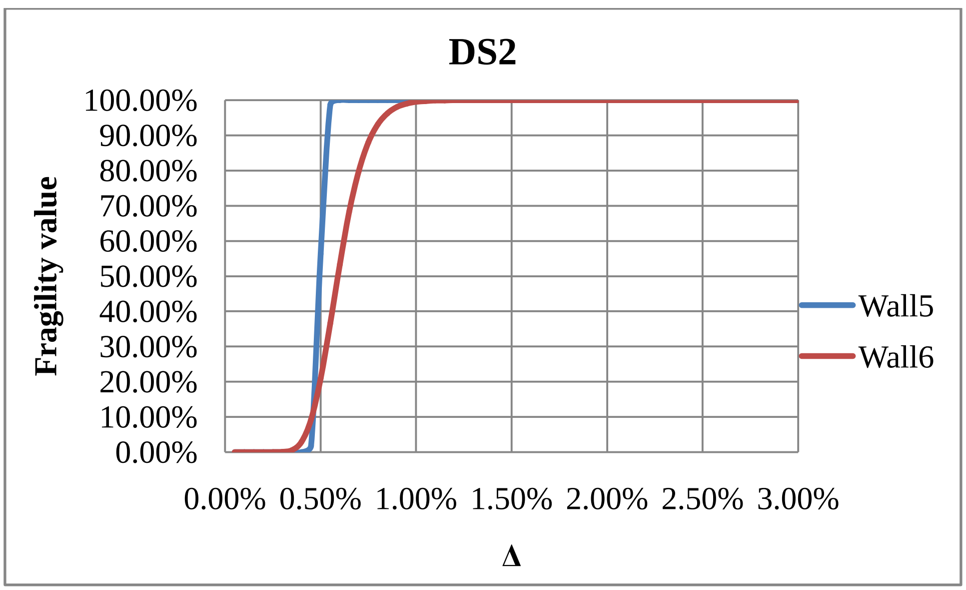

Figure 16- Damage state 2 fragility curves for Wall 5 and Wall 6

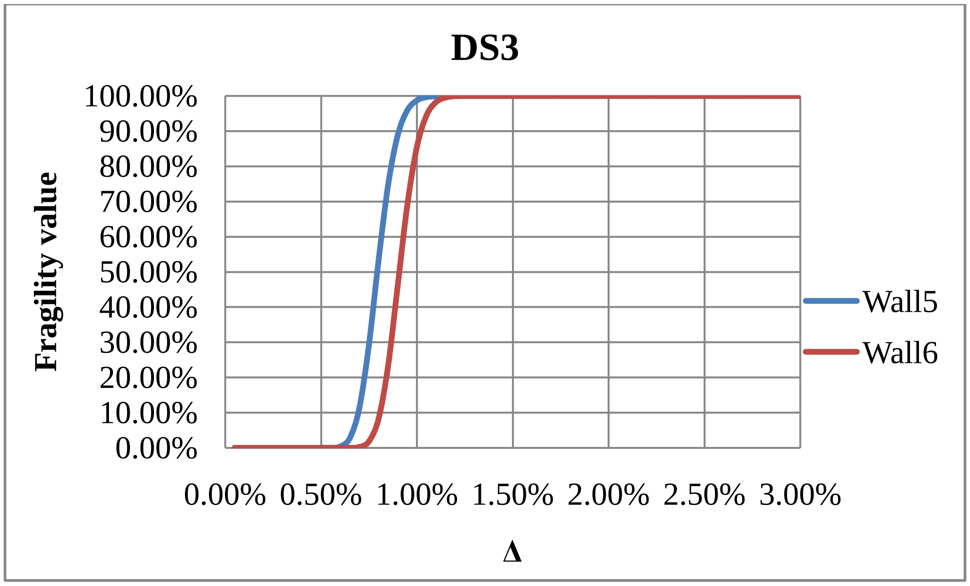

Figure 17- Damage state 3 fragility curves for Wall 5 and Wall 6

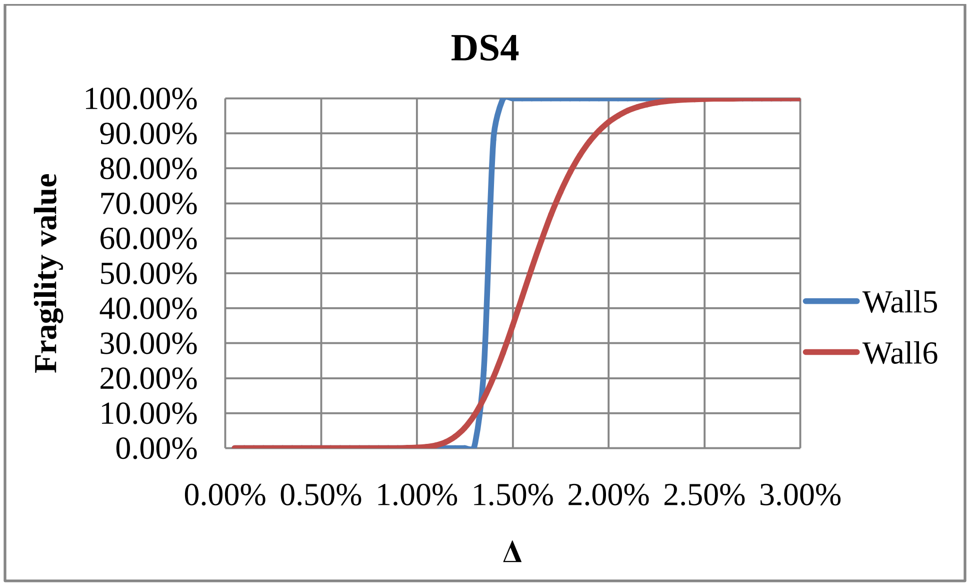

Figure 18- Damage state 4 fragility curves for Wall 5 and Wall 6

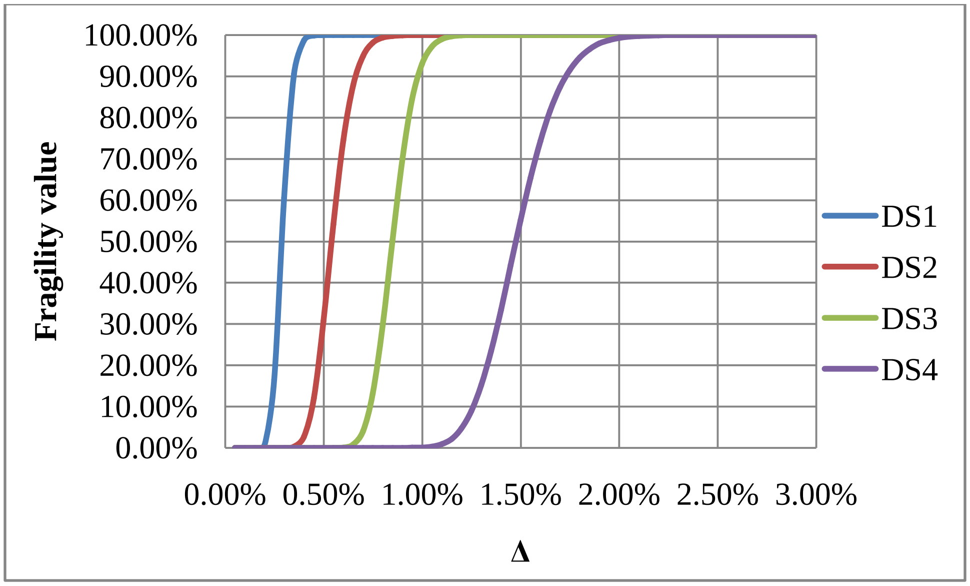

Figure 19- fragility curve for any wall has (ρv) is equal to (1.31) %, (As) is equal to (2) %, (P) varying from (0.75 to1.5) % and (ρh) is equal to (0.26) %

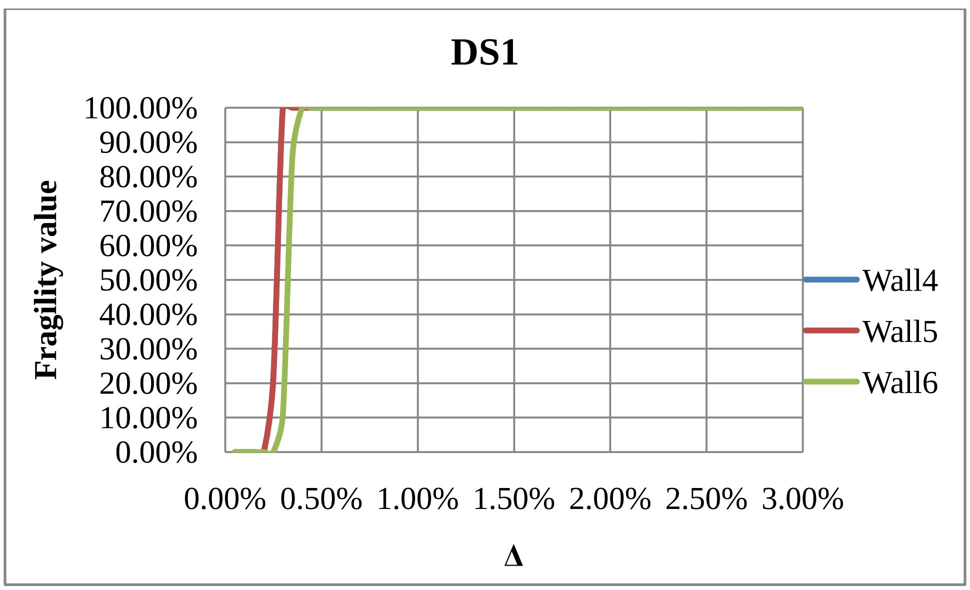

Figure 20- Damage state 1 fragility curves for Wall4, Wall 5 and Wall 6

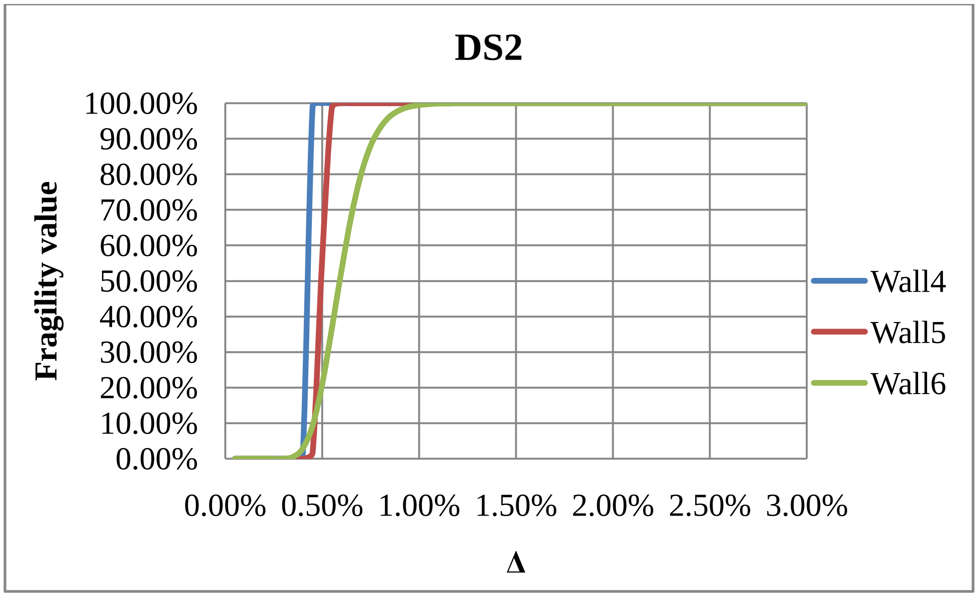

Figure 21- Damage state 2 fragility curves for Wall4, Wall 5 and Wall 6

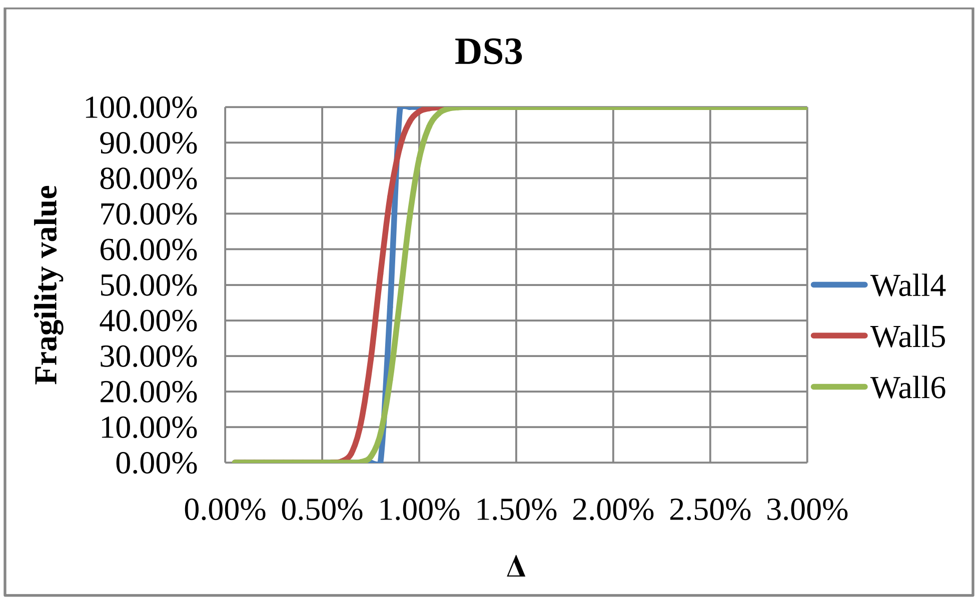

Figure 22- Damage state 3 fragility curves for Wall4, Wall 5 and Wall 6

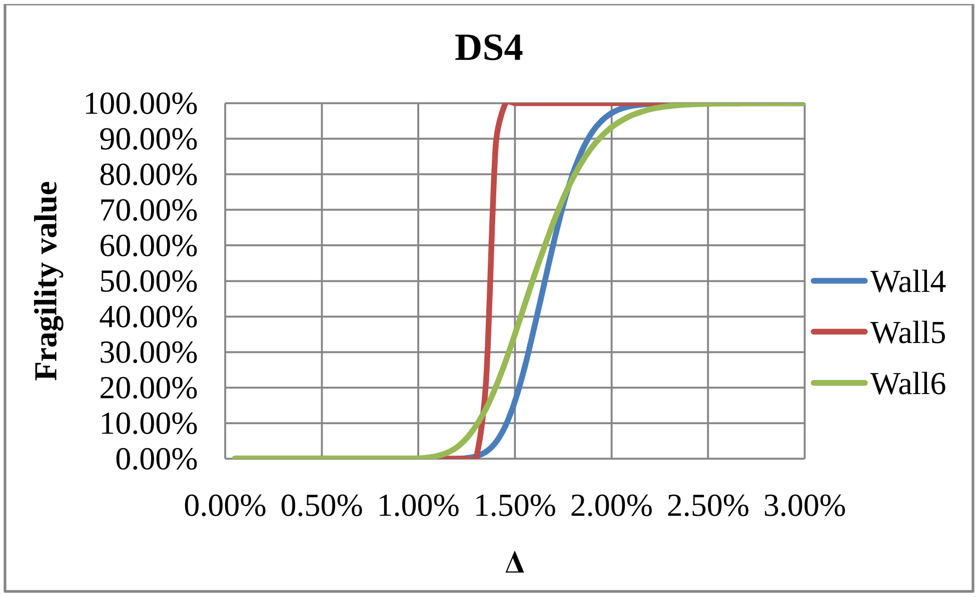

Figure 23- Damage state 4 fragility curves for Wall4, Wall 5 and Wall 6

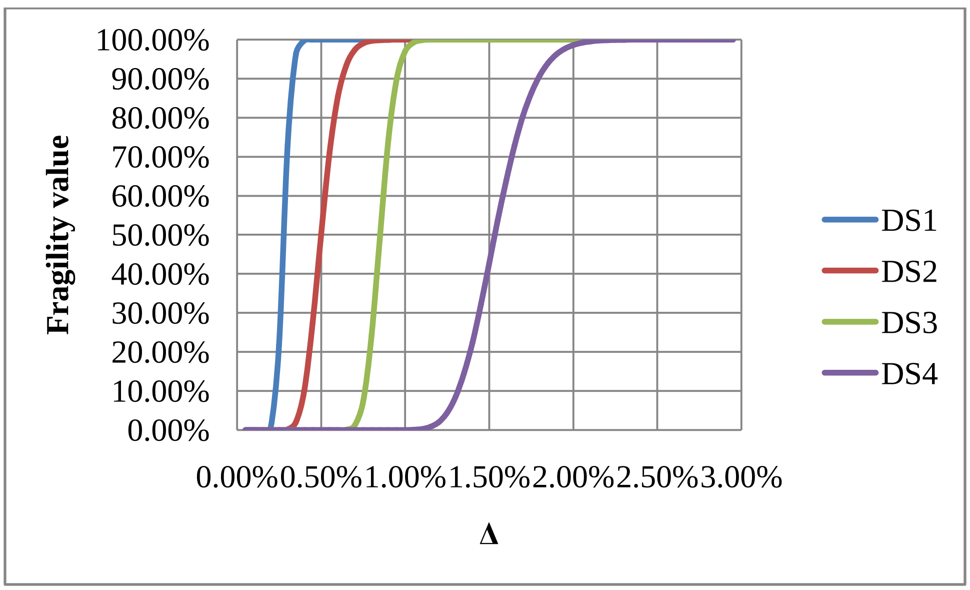

Figure 24- fragility curve for any wall has (1.31) % (ρv), (2) % (As), (P) varying from (0 to 1.5) % and (ρh) is equal to (0.26) %

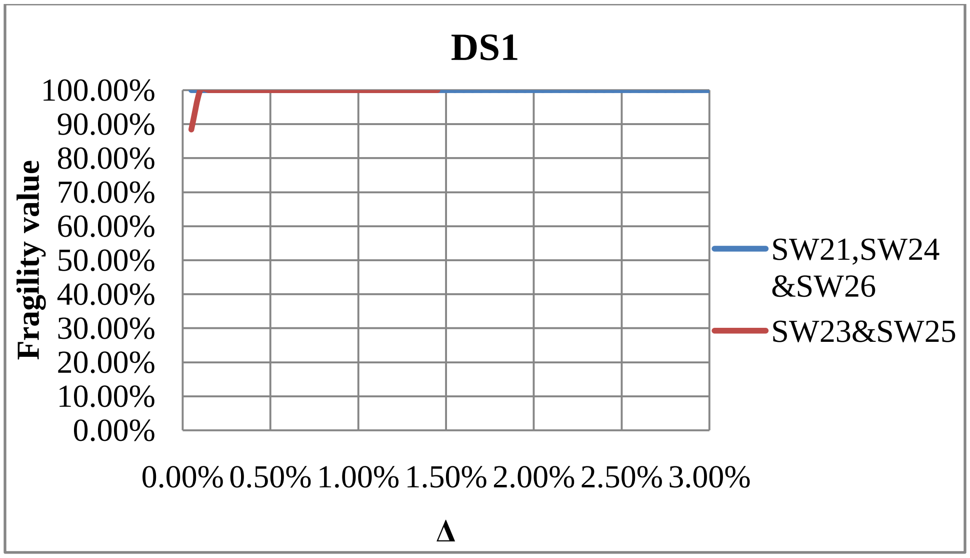

Figure 25- Damage state 1 fragility curves for Walls: SW21, SW24, SW26, SW23 and SW25

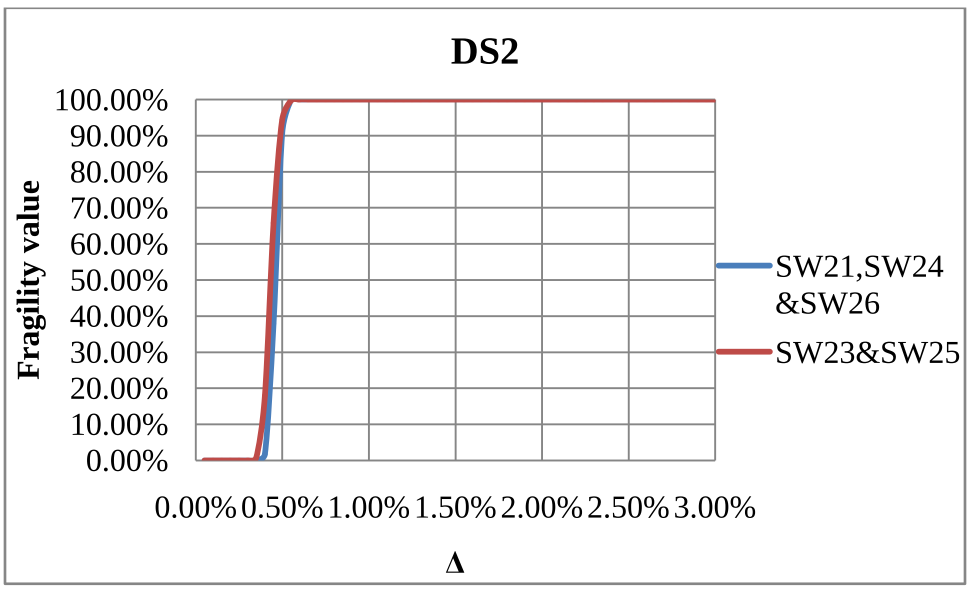

Figure 26- Damage state 2 fragility curves for Walls: SW21, SW24, SW26, SW23 and SW25

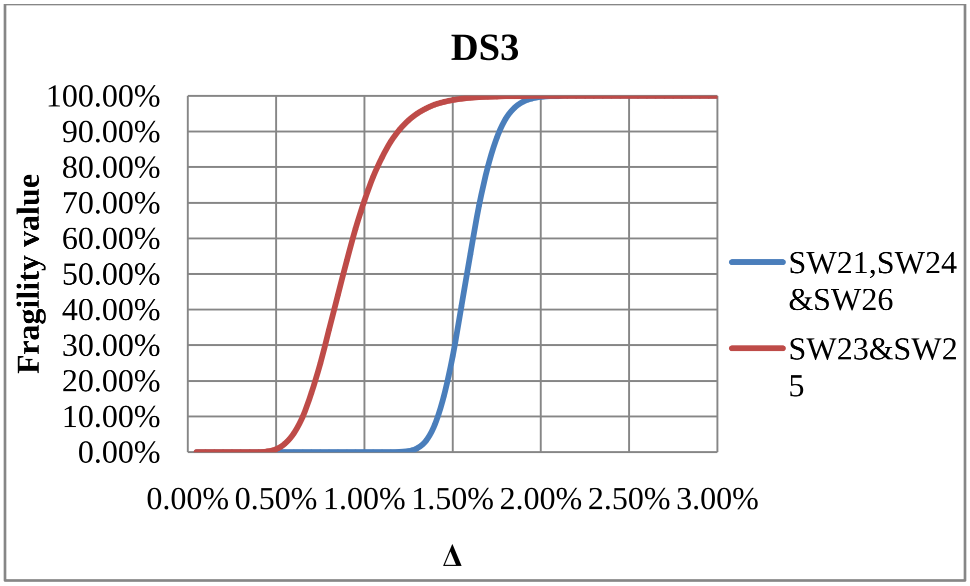

Figure 27- Damage state 3 fragility curves for Walls: SW21, SW24, SW26, SW23 and SW25

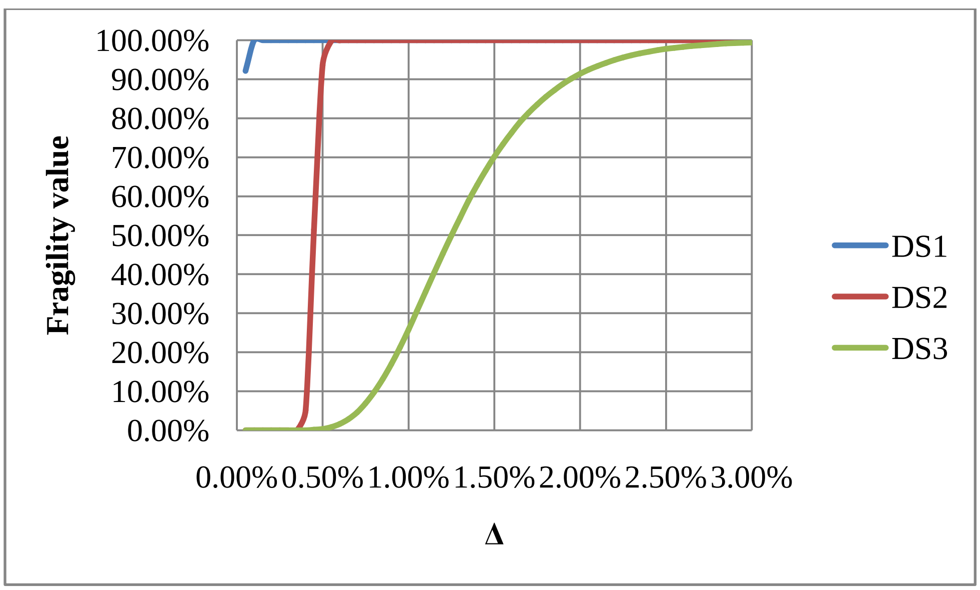

Figure 28- fragility curve for any wall has (2.95) % (ρv), (2) % (As), (P) varying from (0 to 0.17) % and (ρh) varying from (0.40 to 0.80) %

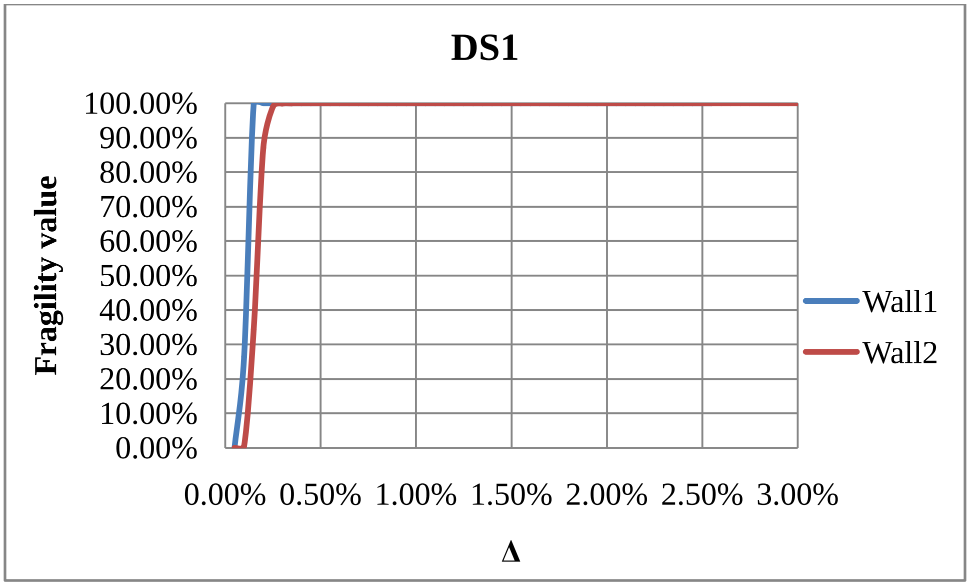

Figure 29- Damage state 1 fragility curves for Wall1 and Wall2

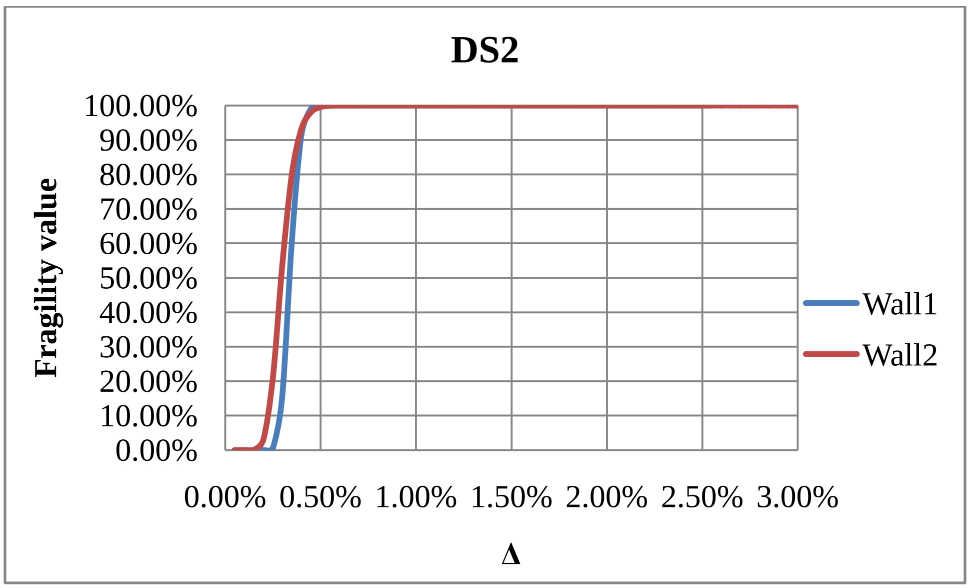

Figure 30- Damage state 2 fragility curves for Wall1 and Wall2

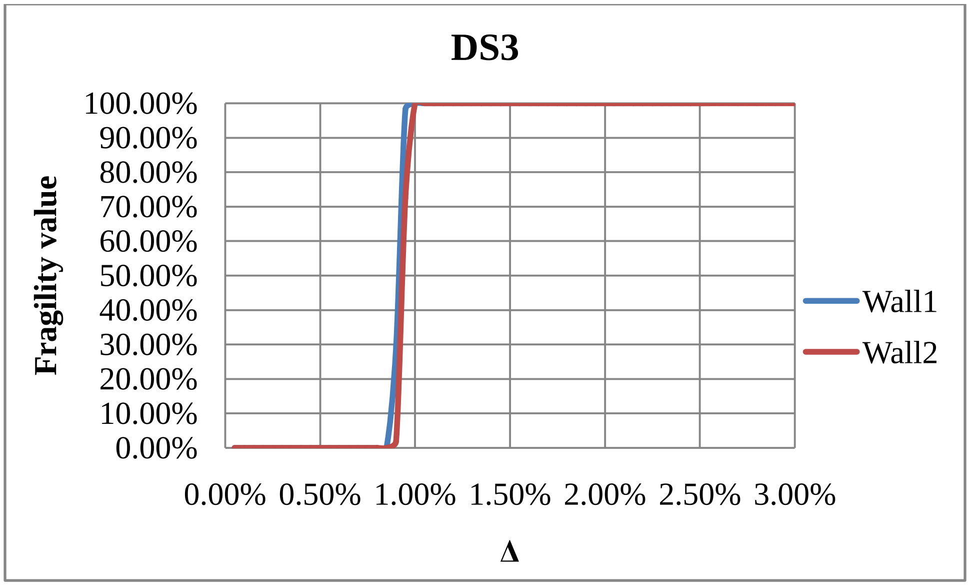

Figure 31- Damage state 3 fragility curves for Wall1 and Wall2

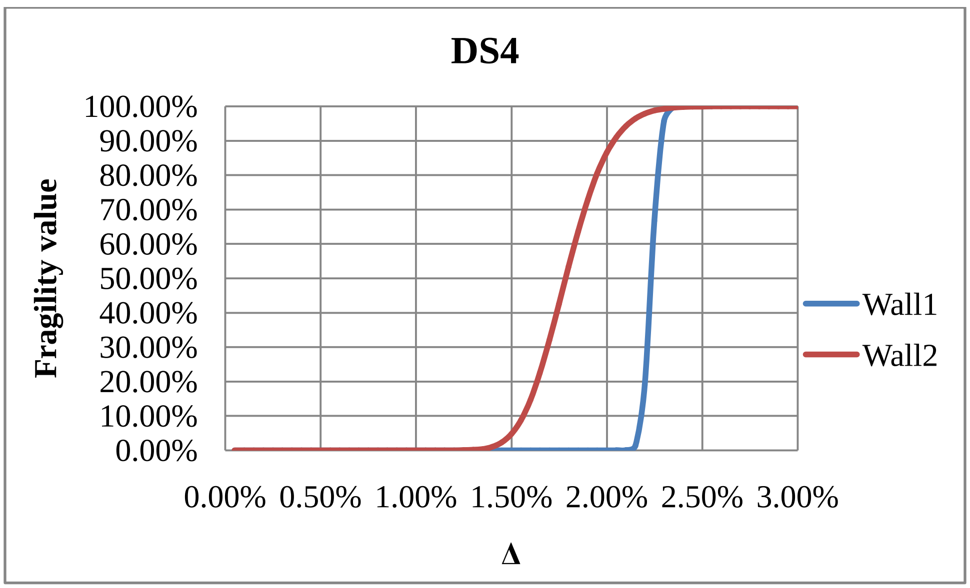

Figure 32- Damage state 4 fragility curves for Wall1 and Wall2

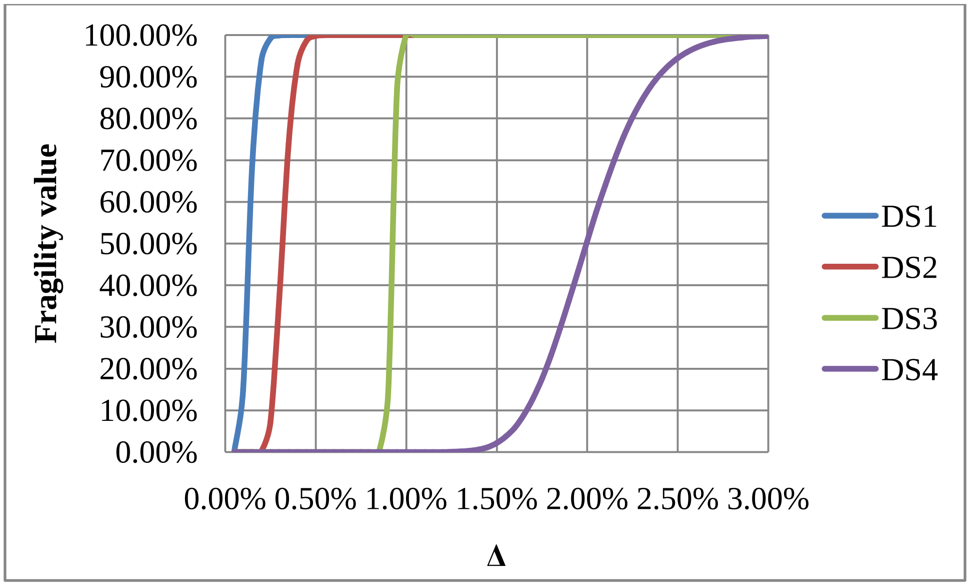

Figure 33- fragility curve for any wall has (ρv) varying from (0.29 to 0.78) %, (2) % (As), (P) is equal to (zero) % and (ρh) varying from (0.08 to 0.13) %

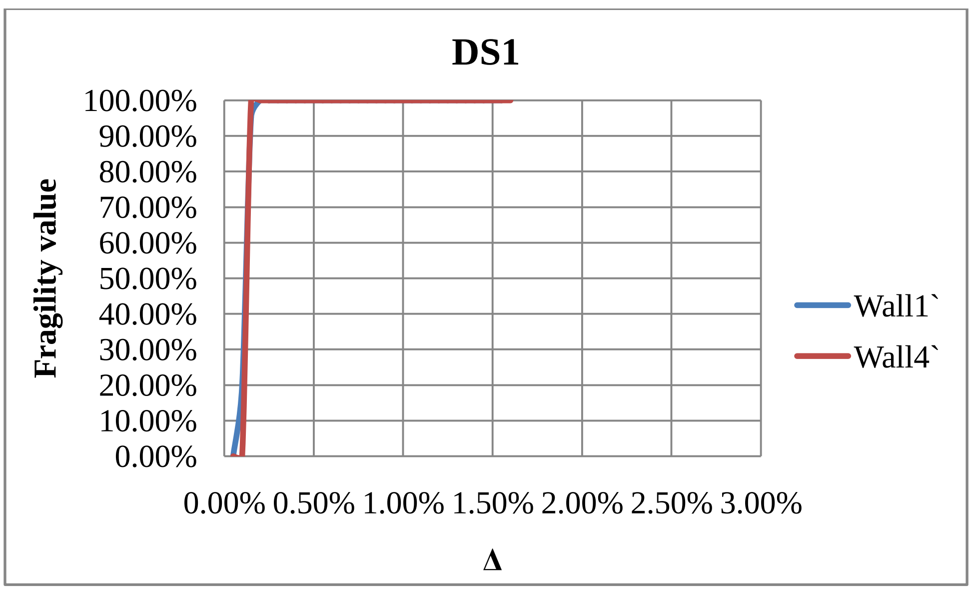

Figure 34- Damage state 1 fragility curves for Wall1` and Wall4`

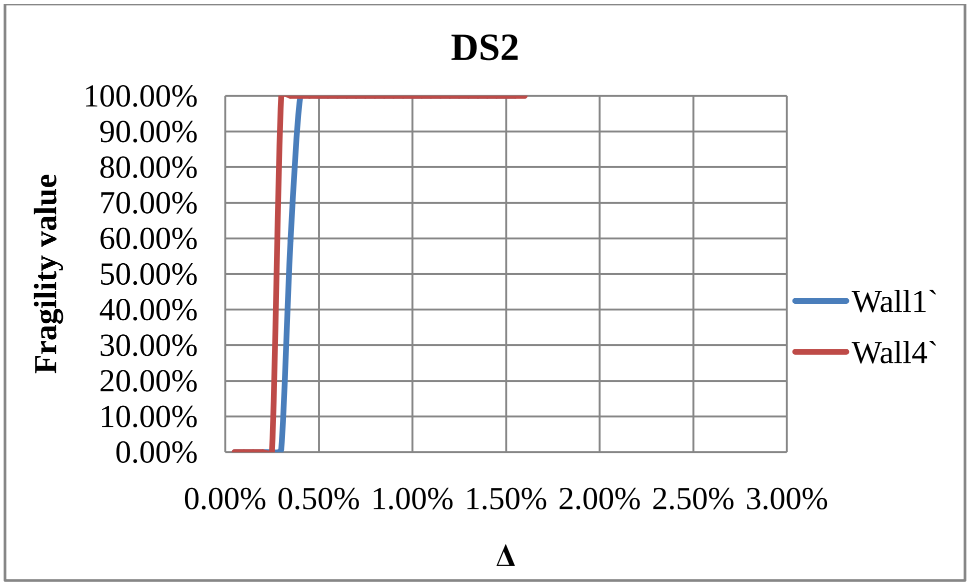

Figure 35- Damage state 2 fragility curves for Wall1` and Wall4`

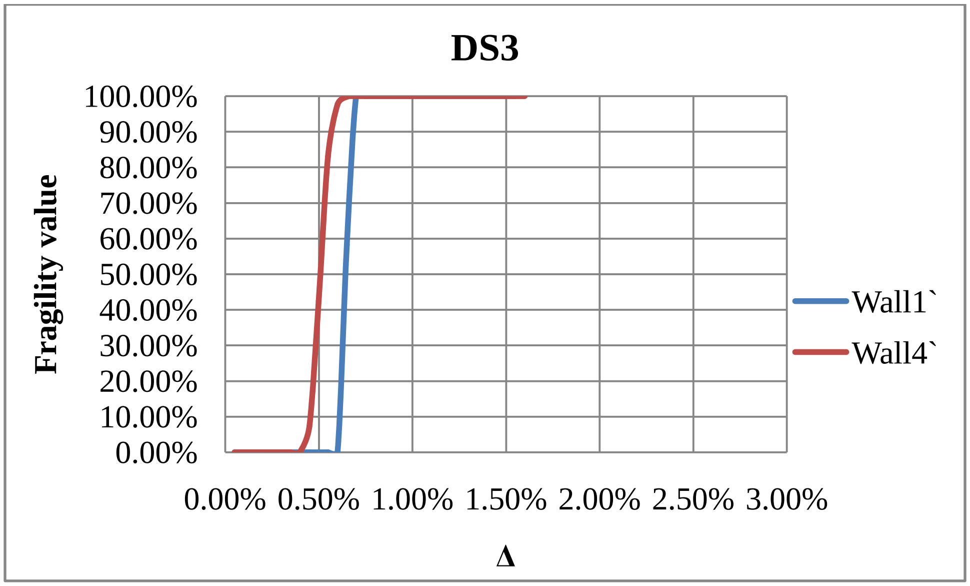

Figure 36- Damage state 3 fragility curves for Wall1` and Wall4`

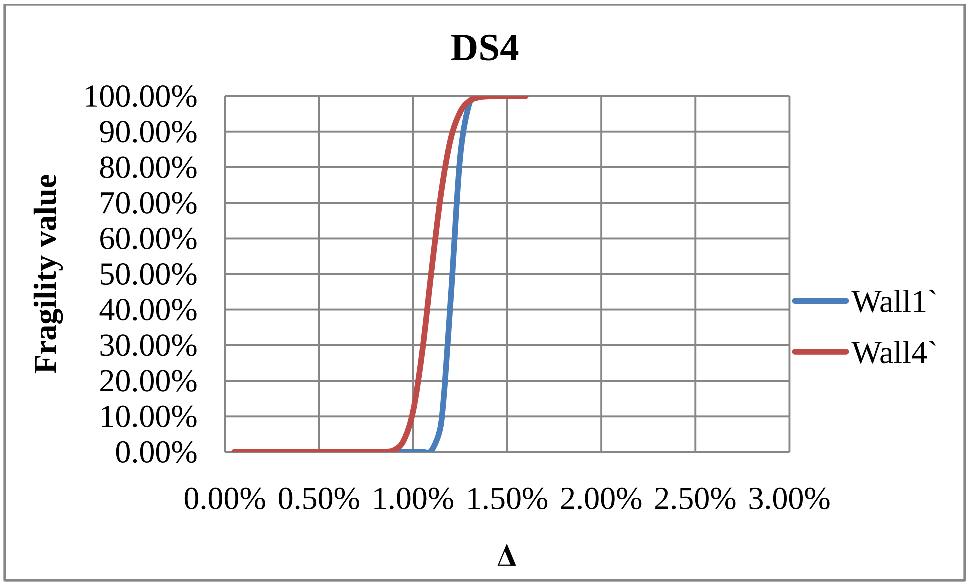

Figure 37- Damage state 4 fragility curves for Wall1` and Wall4`

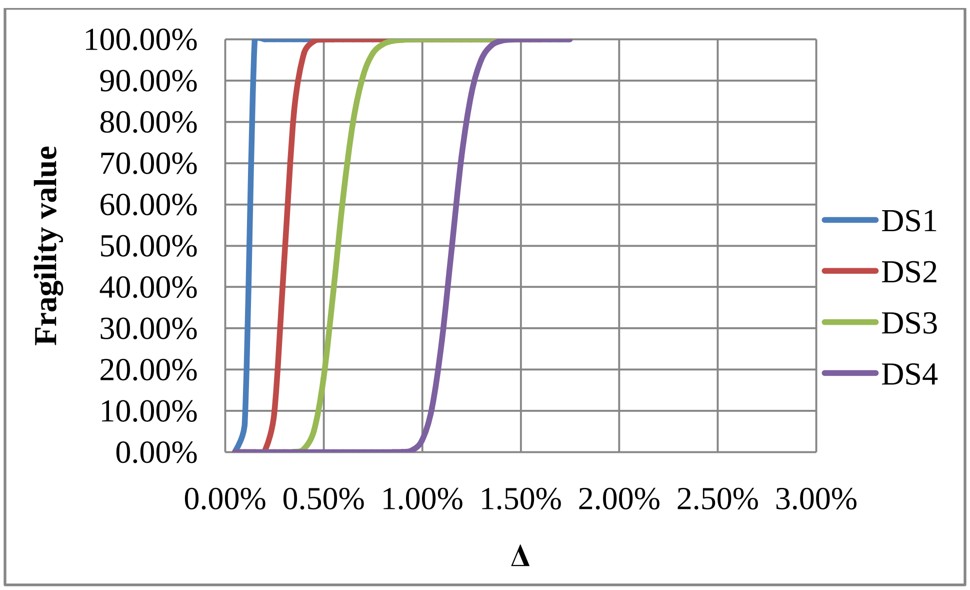

Figure 38- fragility curve for any wall has (1.17) % (ρv), (As) varying from (1.47 to 2.21) %, (P) varying from (1.05 to 1.09) % and (ρh) varying from (0.30 to 0.60) %

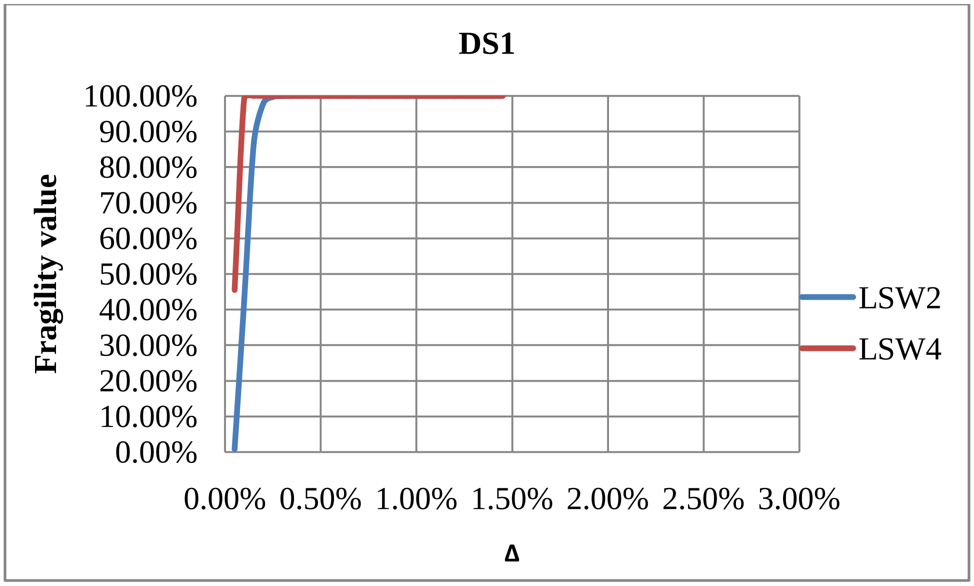

Figure 39- Damage state 1 fragility curves for LSW2 and LSW4

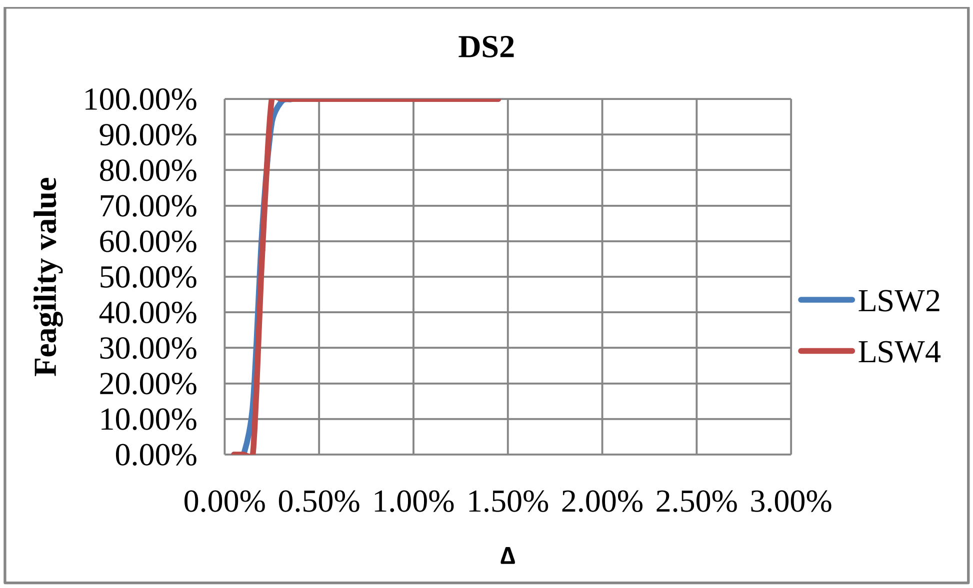

Figure 40- Damage state 2 fragility curves for LSW2 and LSW4

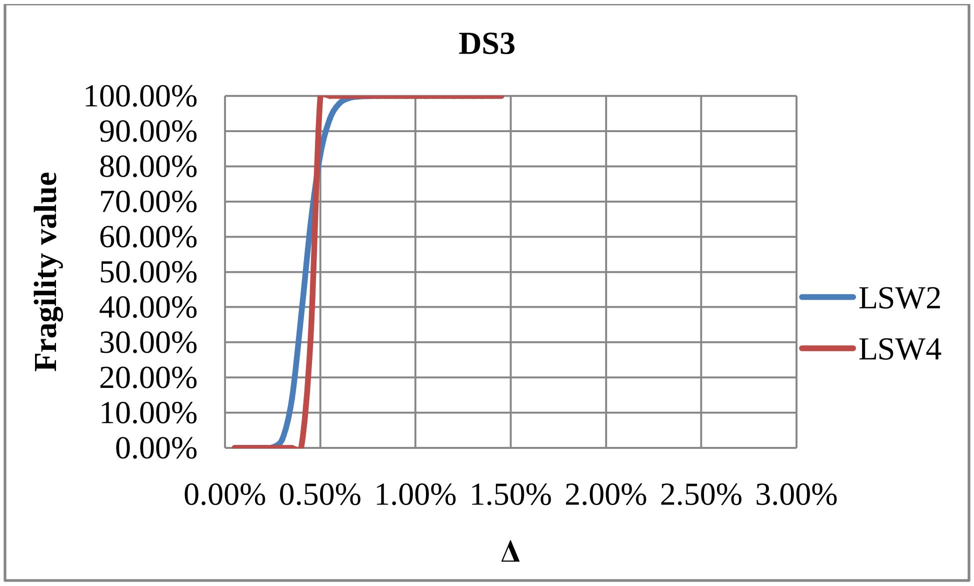

Figure 41- Damage state 3 fragility curves for LSW2 and LSW4

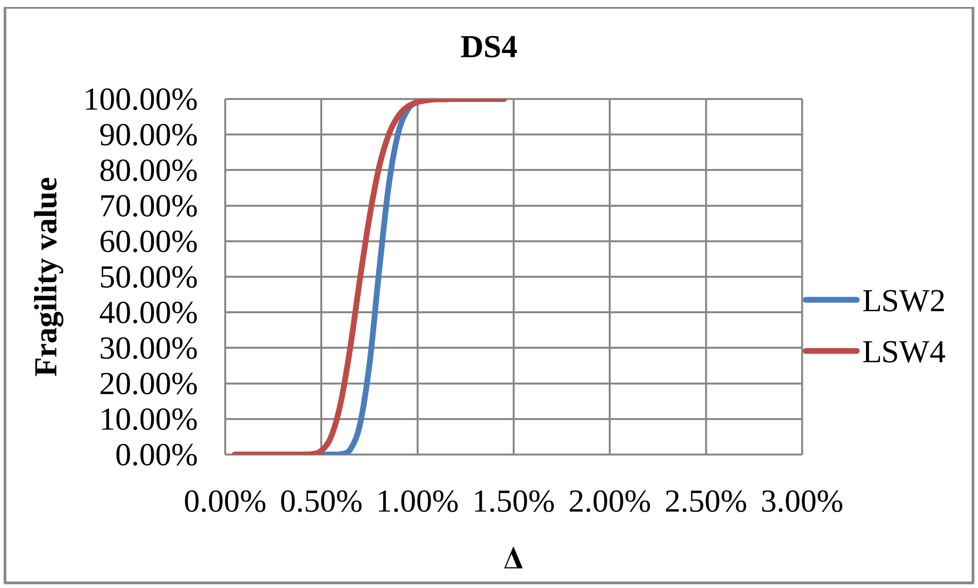

Figure 42- Damage state 4 fragility curves for LSW2 and LSW4

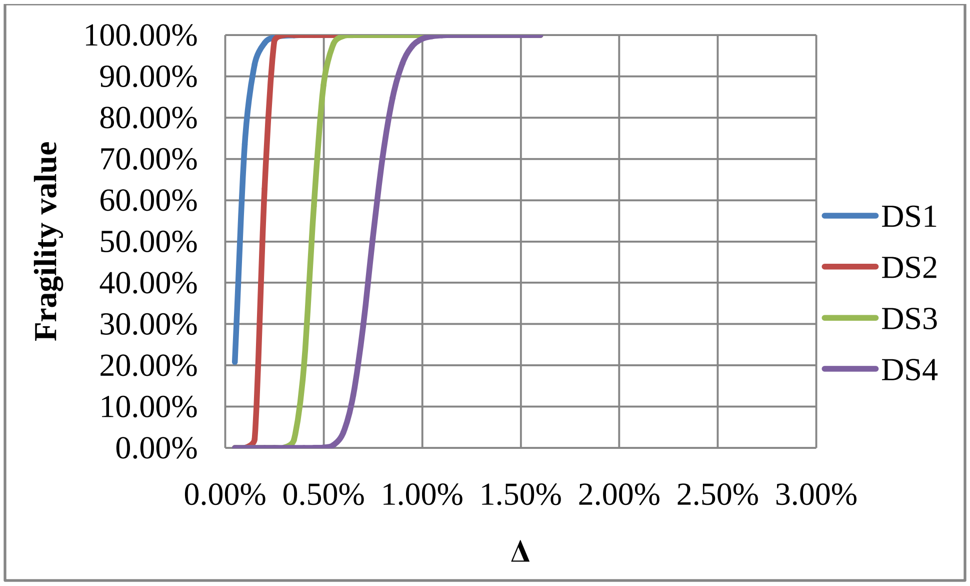

Figure 43- fragility curve for any wall has (0.68) % (ρv), (As) is equal to (1) %, (P) is equal to (0) %, (ρd) varying from (0 to 0.42) %, (Dd) is equal to (zero) m and (ρh) is equals to (0.277) %

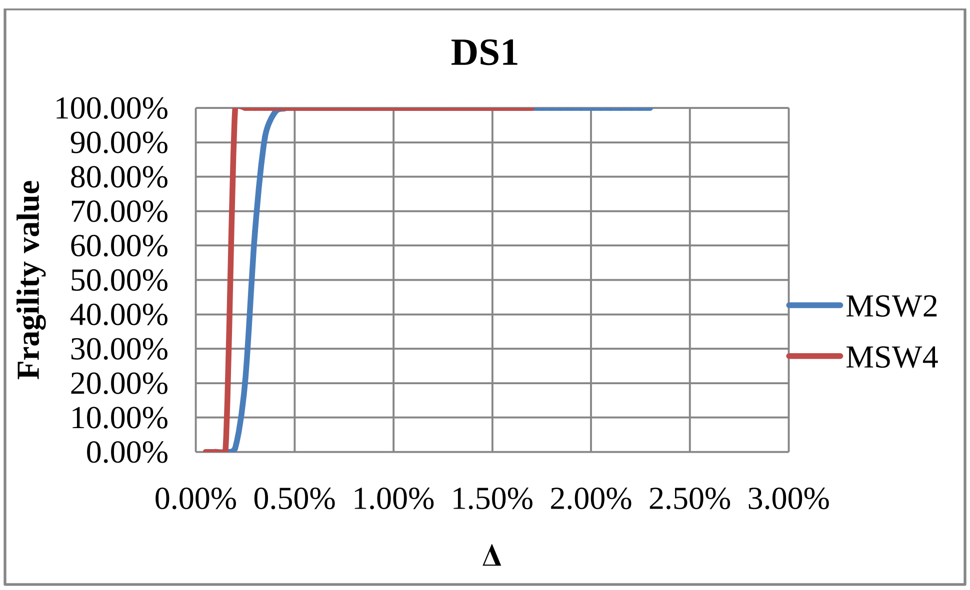

Figure 44- Damage state 1 fragility curves for MSW2 and MSW4

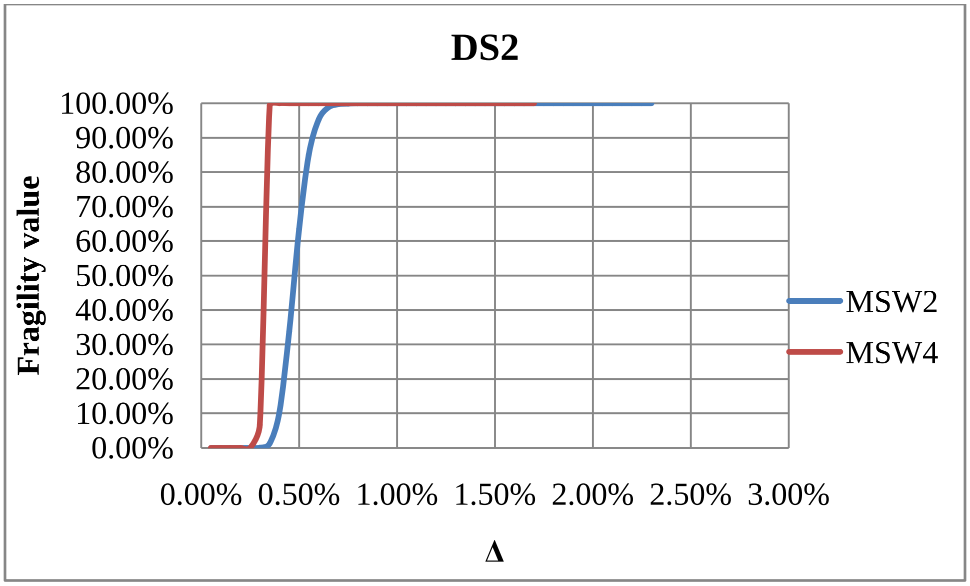

Figure 45- Damage state 2 fragility curves for MSW2 and MSW4

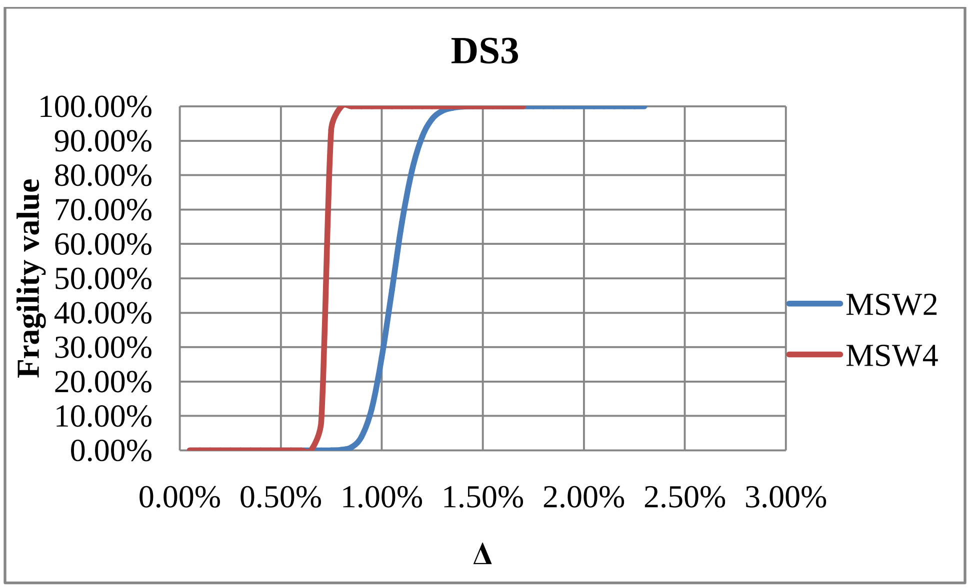

Figure 46- Damage state 3 fragility curves for MSW2 and MSW4

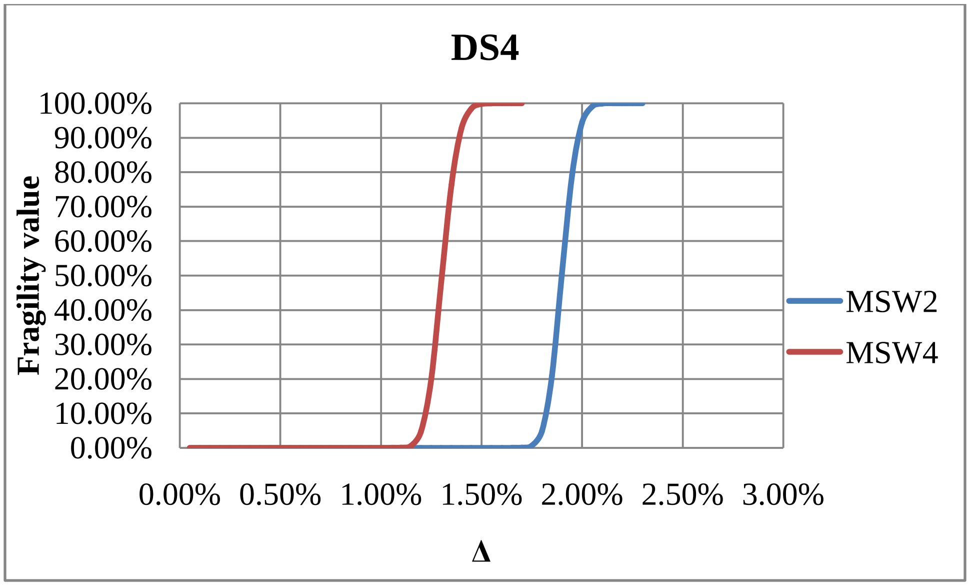

Figure 47- Damage state 4 fragility curves for MSW2 and MSW4

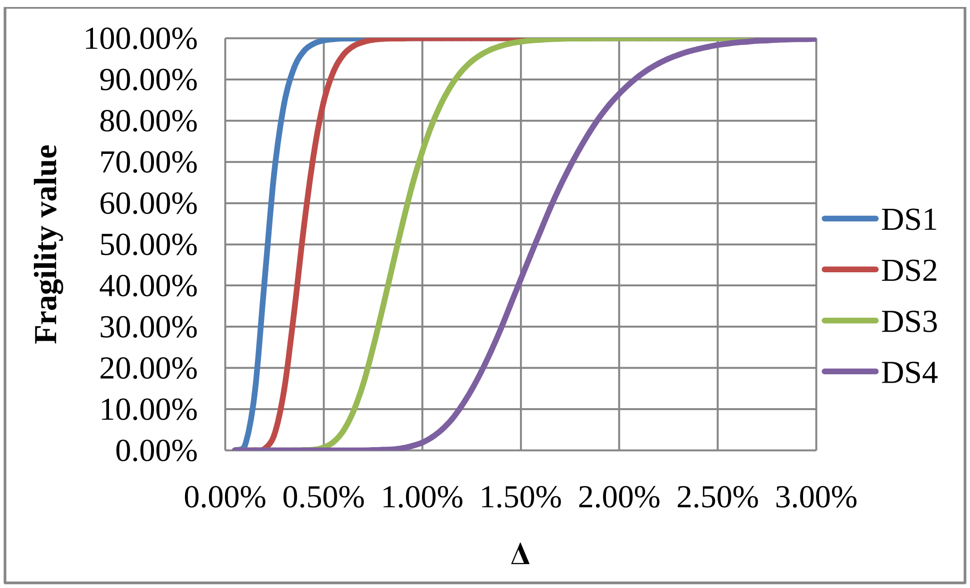

Figure 48- fragility curve for any wall has (0.68) % (ρv), (As) is equal to (1.5) %, (P) is equal to (0) %, (ρd) is equal to (0.42) %, (Dd) is equal to (zero) m and (ρh) is equal to (0.277) %

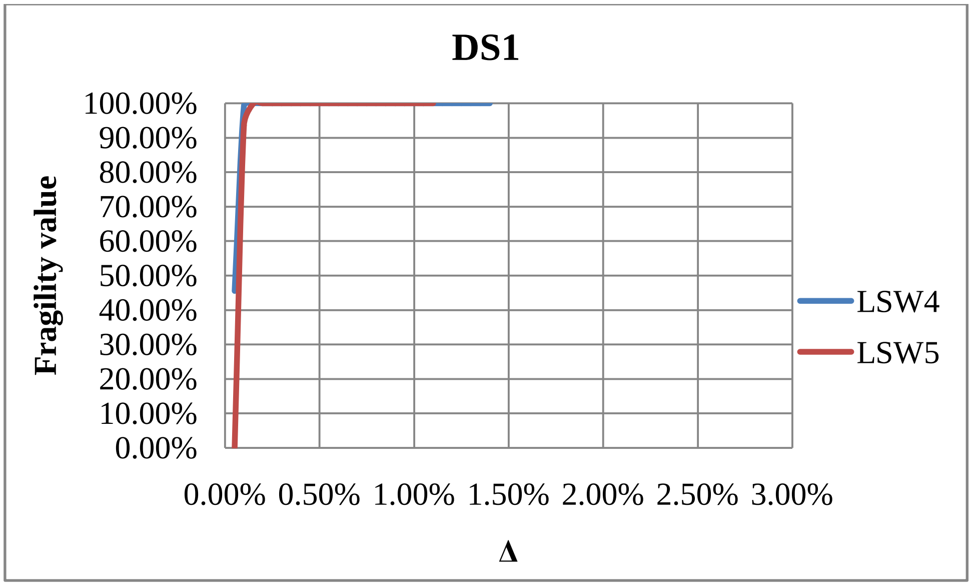

Figure 49- Damage state 1 fragility curves for LSW4 and LSW5

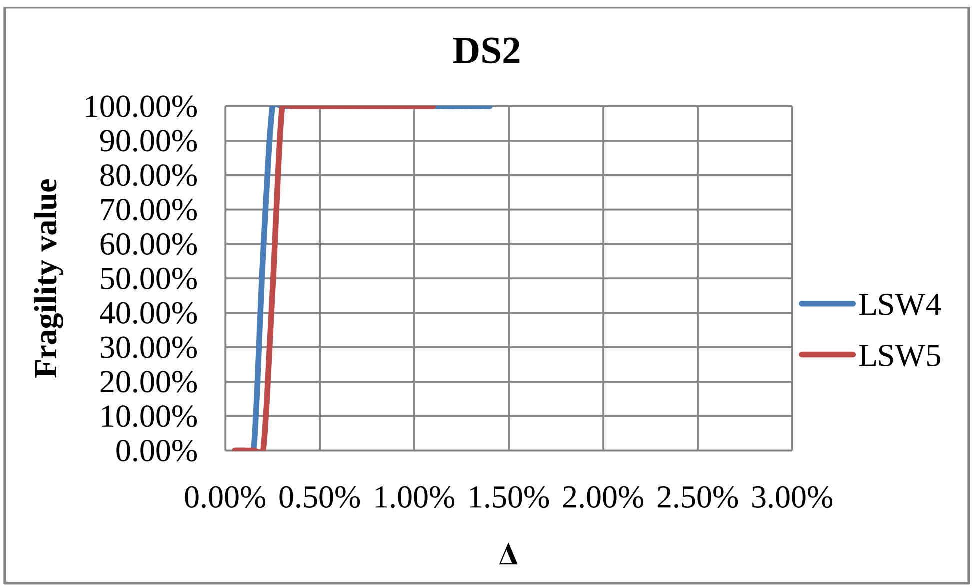

Figure 50- Damage state 2 fragility curves for LSW4 and LSW5

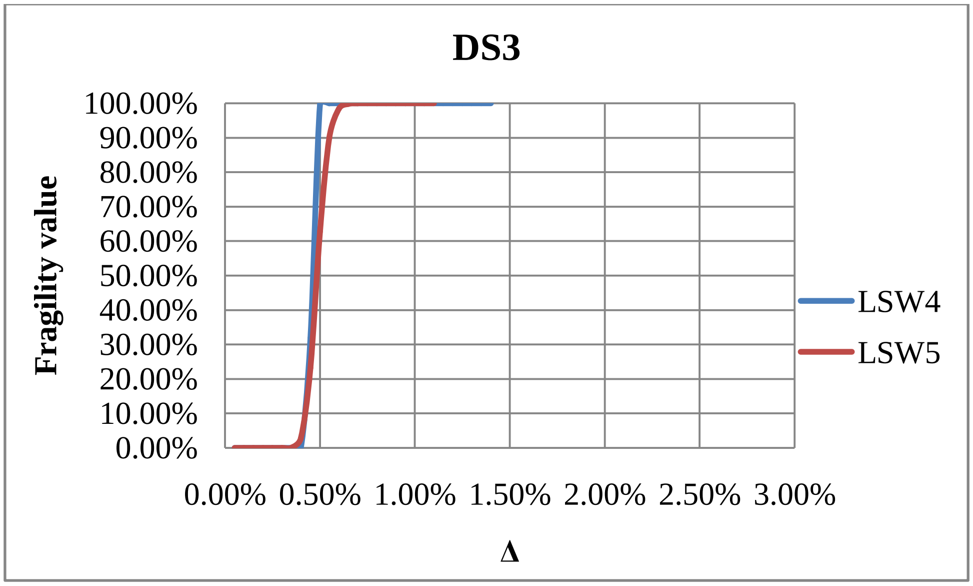

Figure 51- Damage state 3 fragility curves for LSW4 and LSW5

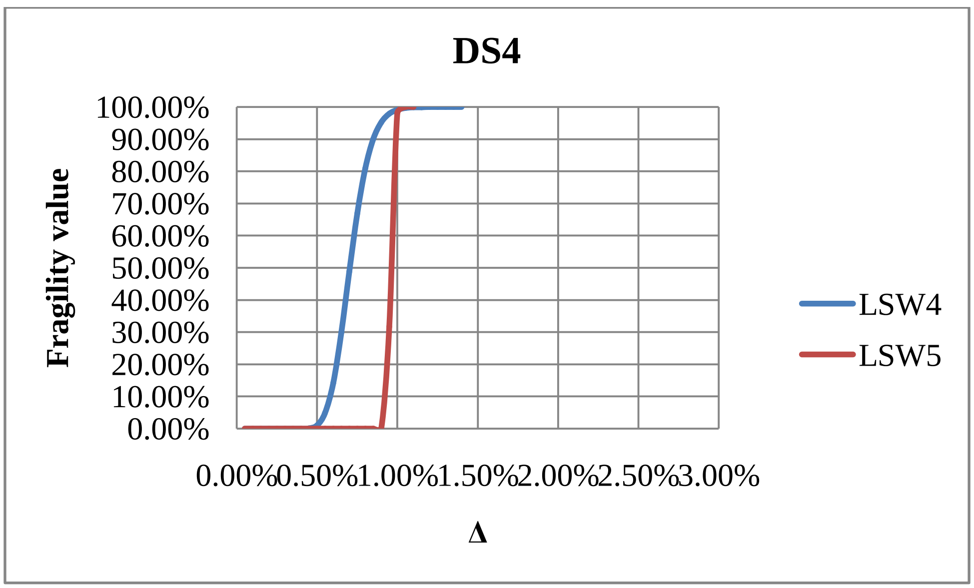

Figure 52- Damage state 4 fragility curves for LSW4 and LSW5

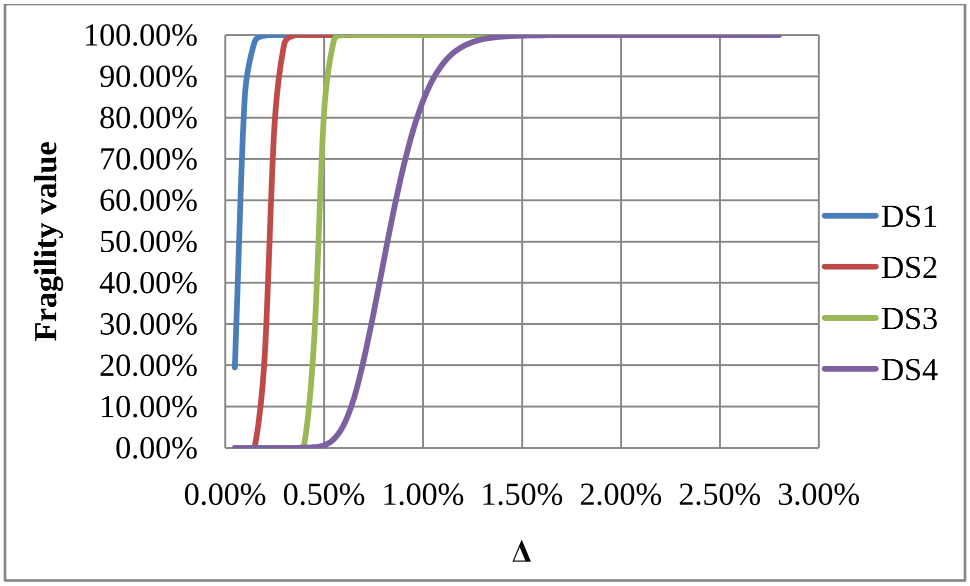

Figure 53- fragility curve for any wall has (0.68) % (ρv), (As) is equal to (1) %, (P) is equal to (0) %, (ρd) is equal to (0.42) %, (Dd) varying from (0 to 0.96) m and (ρh) is equal to (0.277) %

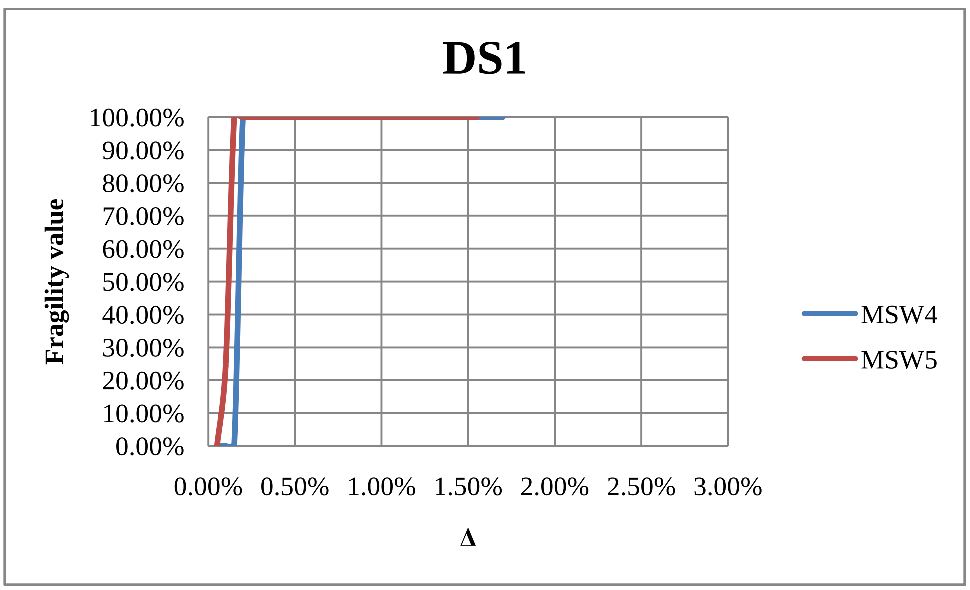

Figure 54- Damage state 1 fragility curves for MSW4 and MSW5

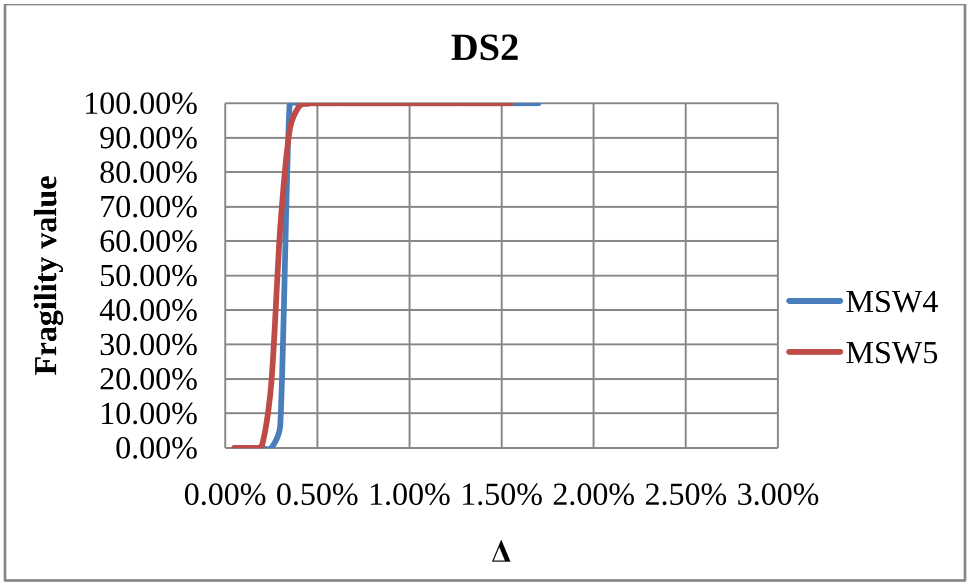

Figure 55- Damage state 2 fragility curves for MSW4 and MSW5.

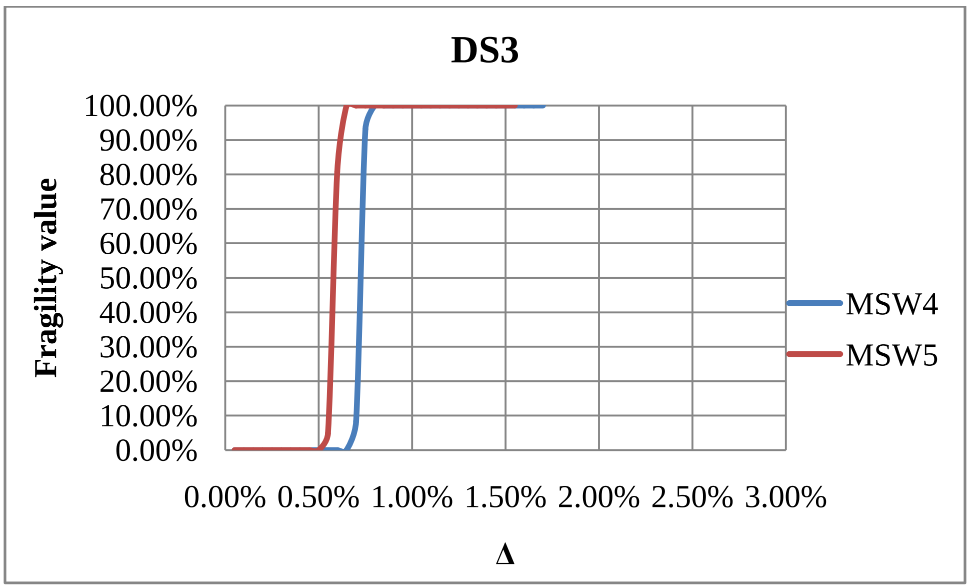

Figure 56- Damage state 3 fragility curves for MSW4 and MSW5

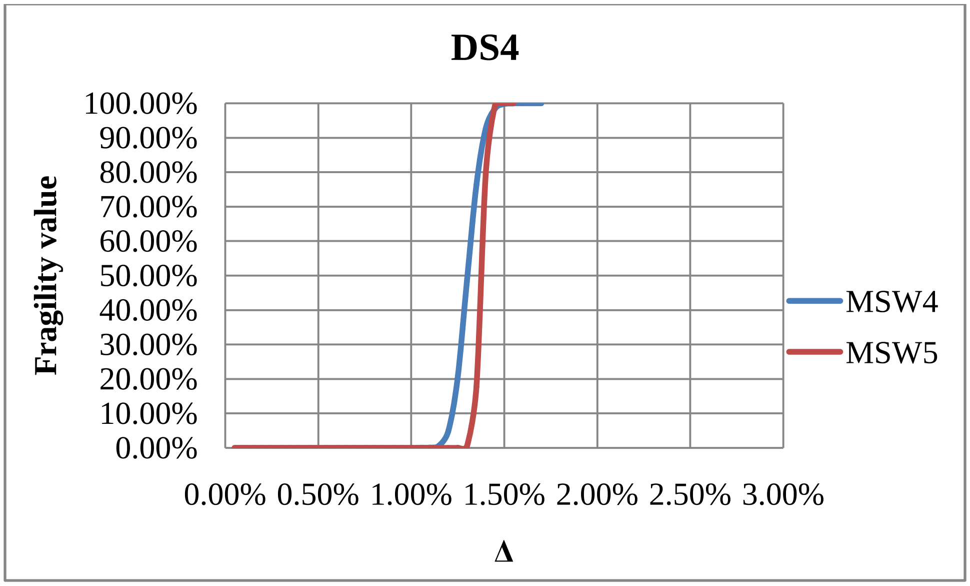

Figure 57- Damage state 4 fragility curves for MSW4 and MSW5

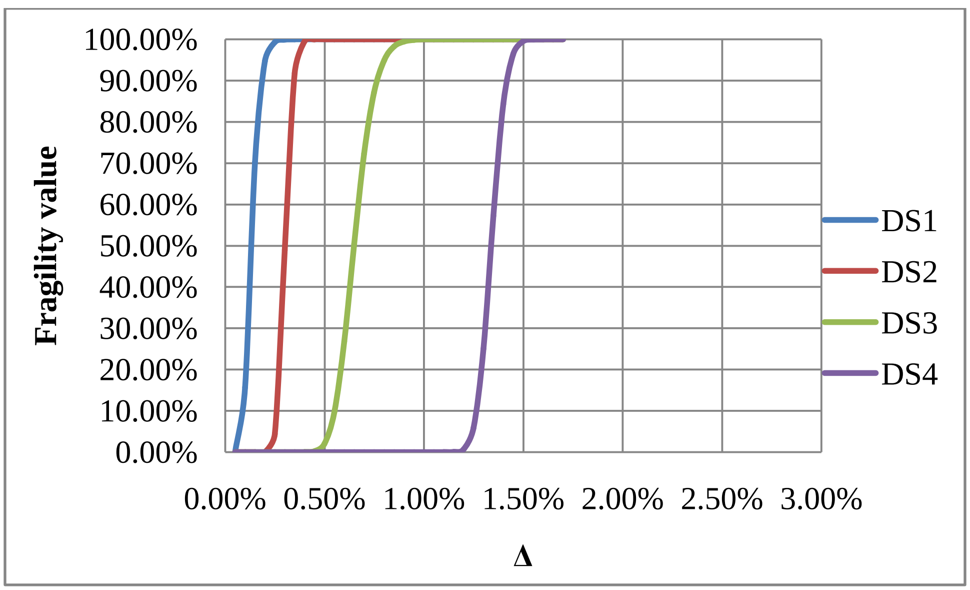

Figure 58- fragility curve for any wall has (0.68) % (ρv), (As) is equal to (1.5) %, (P) is equal to (0) %, (ρd) is equal to (0.42) %, (Dd) varying from (0 to 0.96) m and (ρh) is equal to (0.277) %

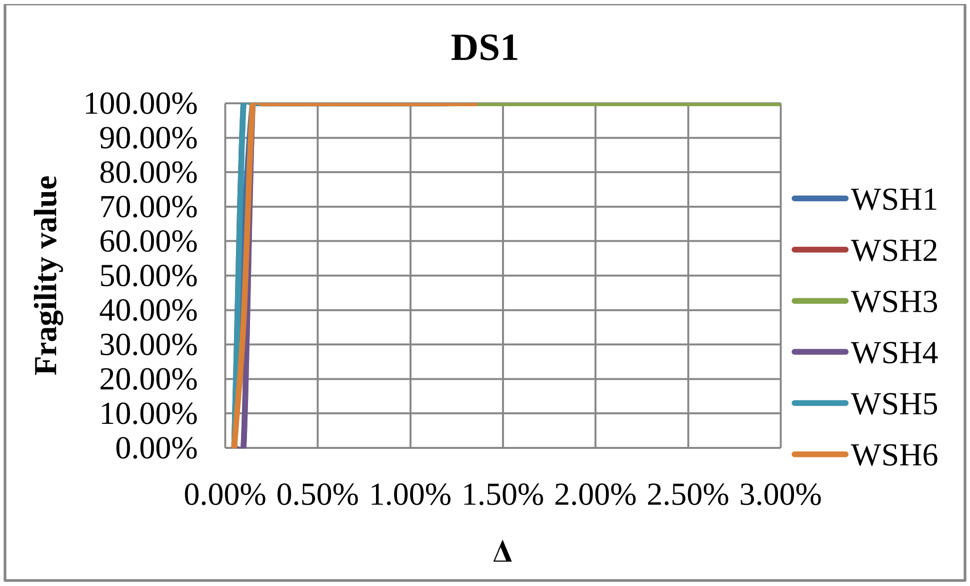

Figure 59- Damage state 1 fragility curves for WSH1, WSH2, WSH3, WSH4, WSH5 and WSH6

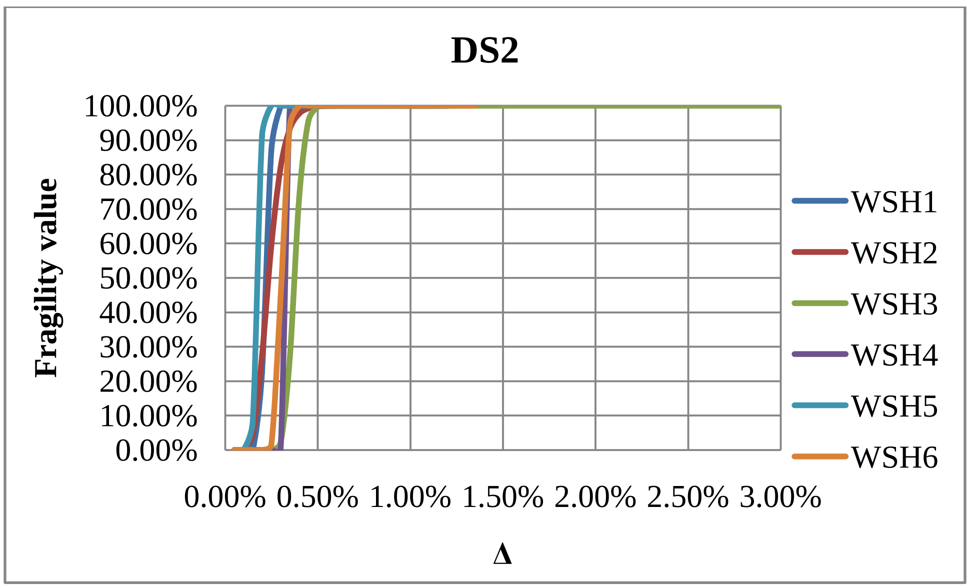

Figure 60- Damage state 2 fragility curves for WSH1, WSH2, WSH3, WSH4, WSH5 and WSH6

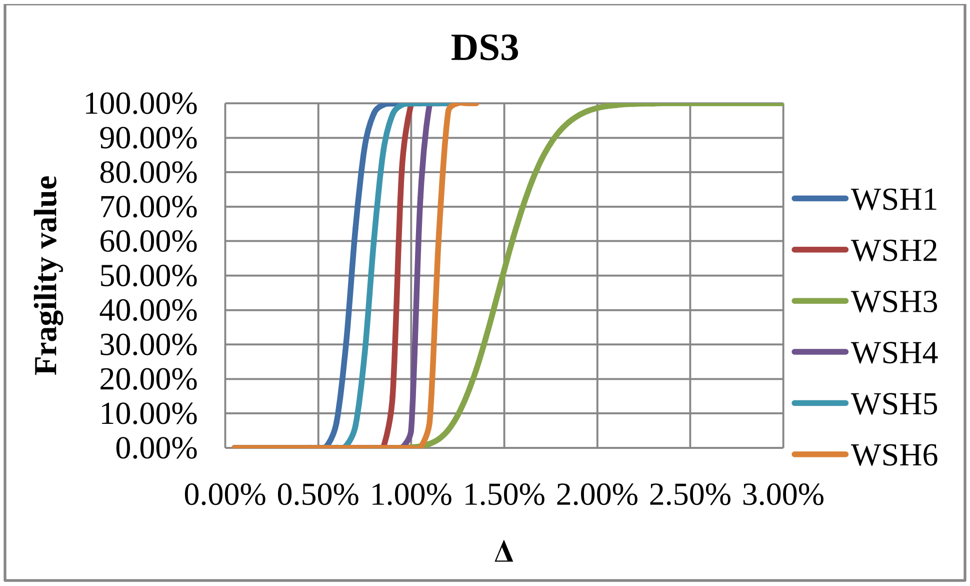

Figure 61- Damage state 3 fragility curves for WSH1, WSH2, WSH3, WSH4, WSH5 and WSH6

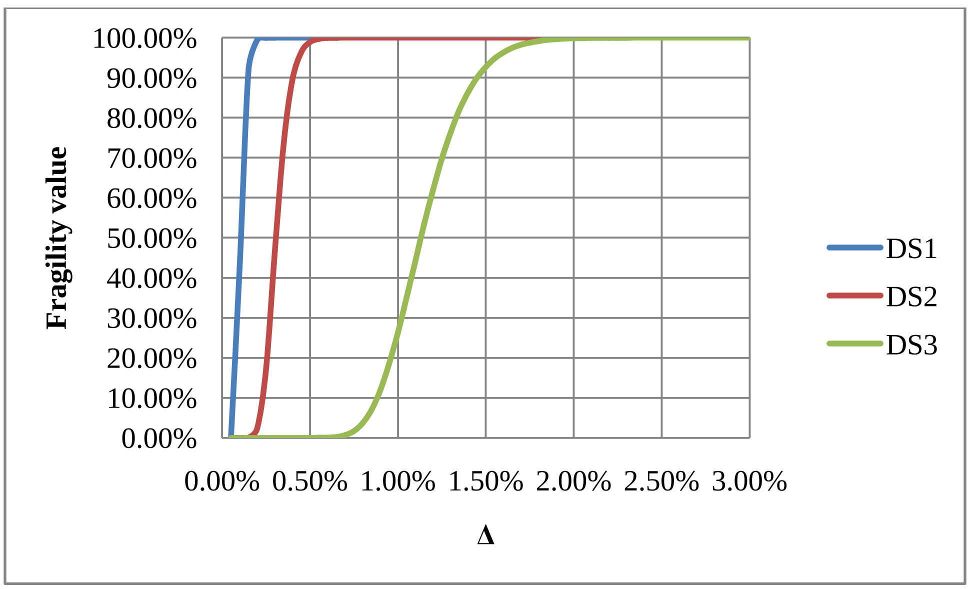

Figure 62- fragility curve for any wall has (ρv) varying from (0.54 to 0.82) %, (As) varyingg between (2.26 to 2.28) %, (P) varying from (0.057 to 0.108) % and (ρh) is equal to (0.25) %

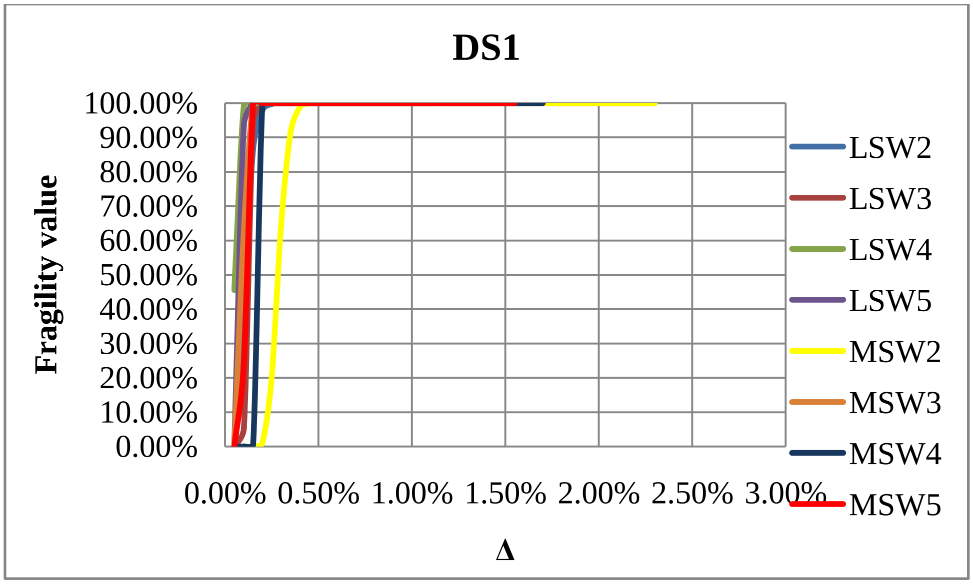

Figure 63- Damage state 1 fragility curves for LSW2, LSW3, LSW4, LSW5, MSW2, MSW3, MSW4 and MSW5

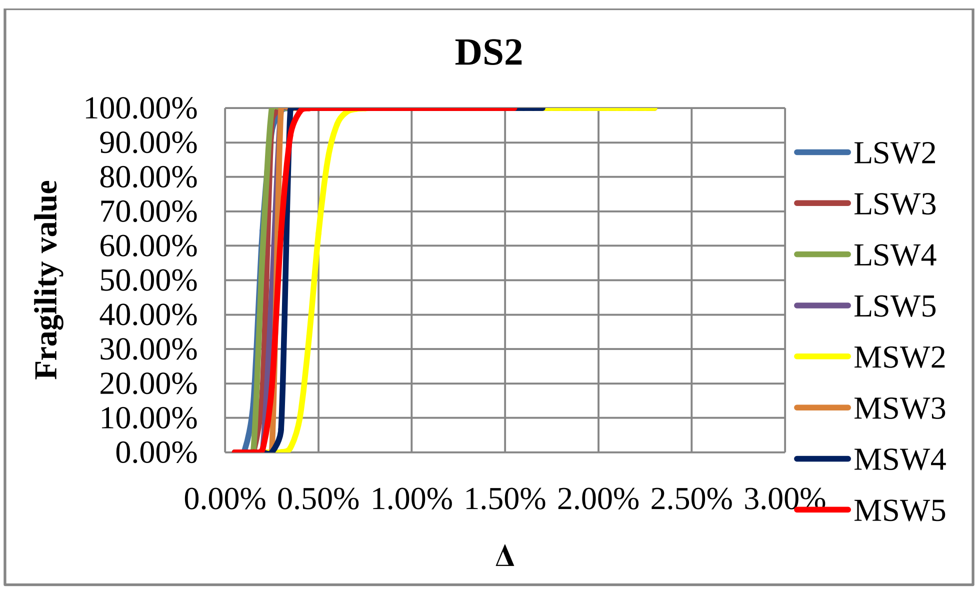

Figure 64- Damage state 2 fragility curves for LSW2, LSW3, LSW4, LSW5, MSW2, MSW3, MSW4 and MSW5

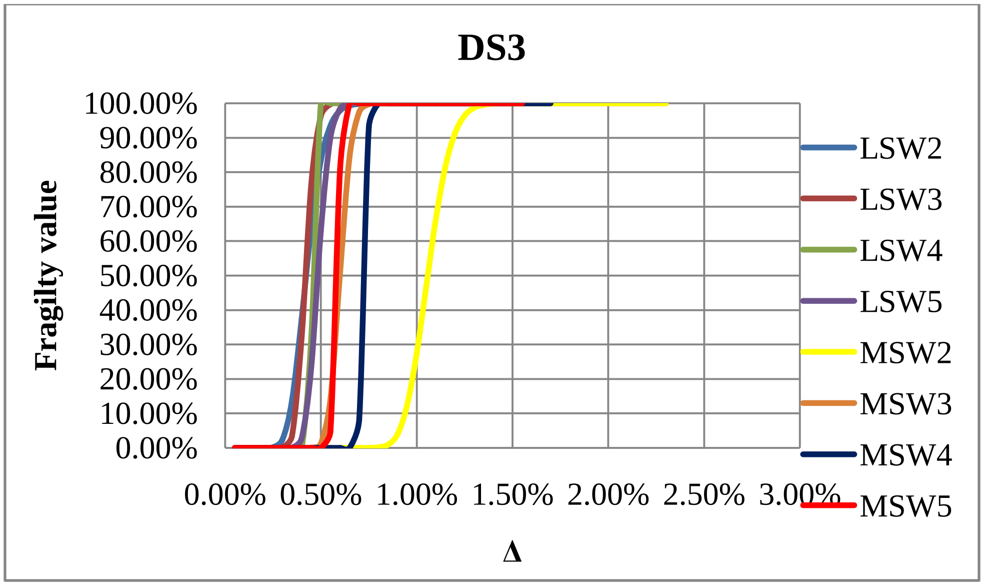

Figure 65- Damage state 3 fragility curves for LSW2, LSW3, LSW4, LSW5, MSW2, MSW3, MSW4 and MSW5

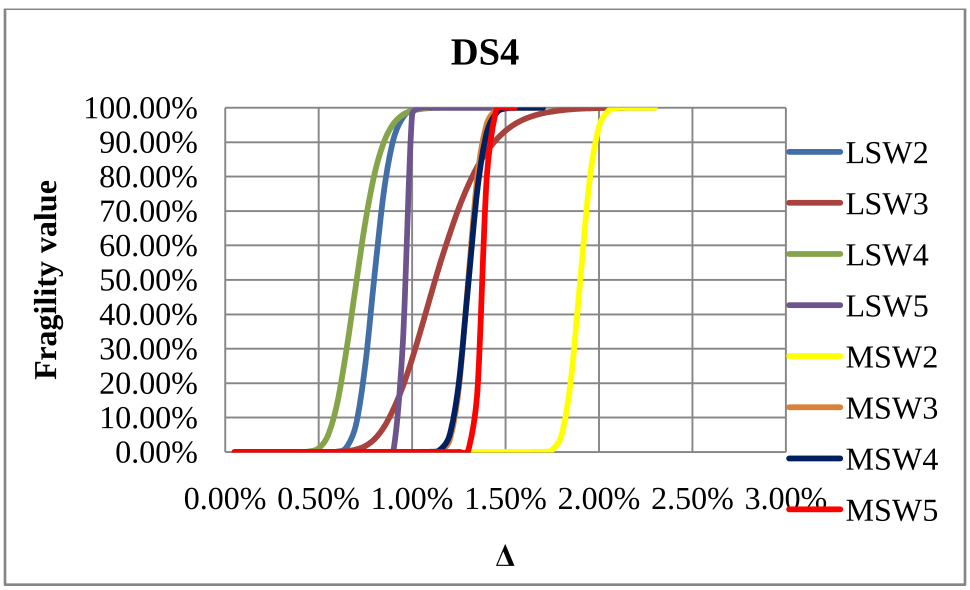

Figure 66- Damage state 4 fragility curves for LSW2, LSW3, LSW4, LSW5, MSW2, MSW3, MSW4 and MSW5

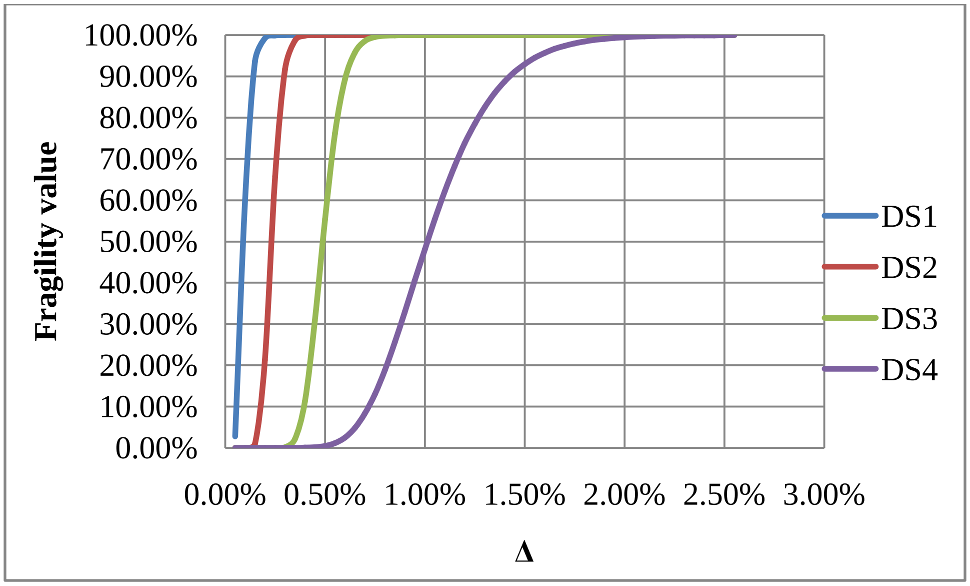

Figure 67- fragility curve for any wall has (0.68) % (ρv), (As) varying from (1 to 1.5) %, (P) varying from (0 to 0.07) %, (ρd) varying from (0 to 0.42) %, (Dd) varying from (0 to 0.96) m and (ρh) is equal to (0.277) %.

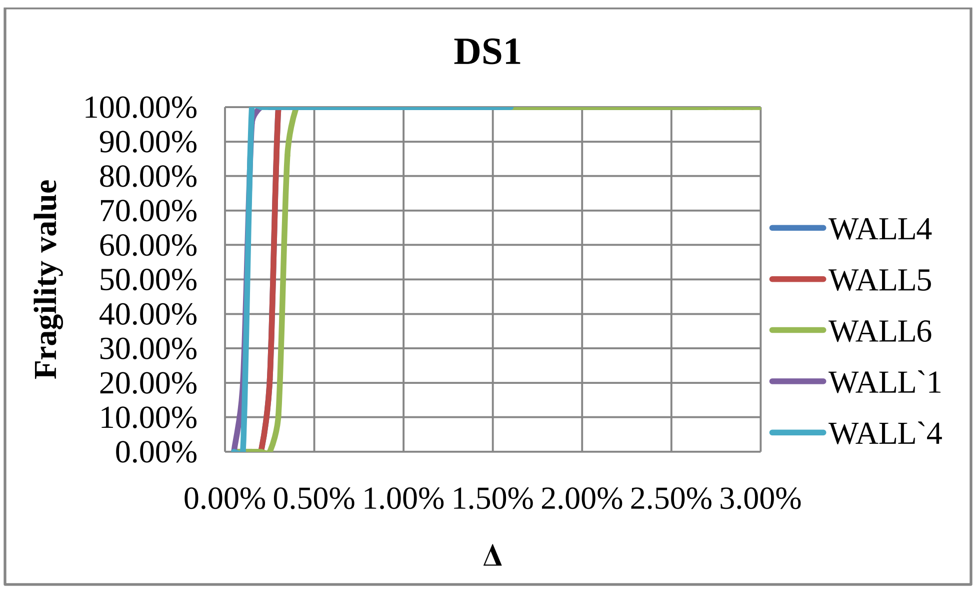

Figure 68-Damage state 1 fragility curves for WALL4, WALL5, WALL6, WALL`1 and WALL`4

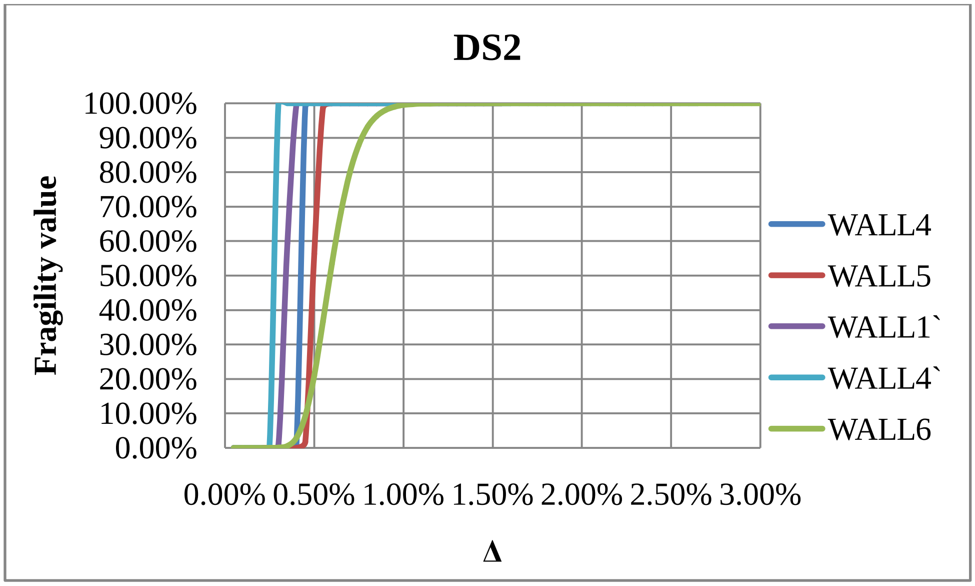

Figure 69- Damage state 2 fragility curves for WALL4, WALL5, WALL6, WALL`1 and WALL`4

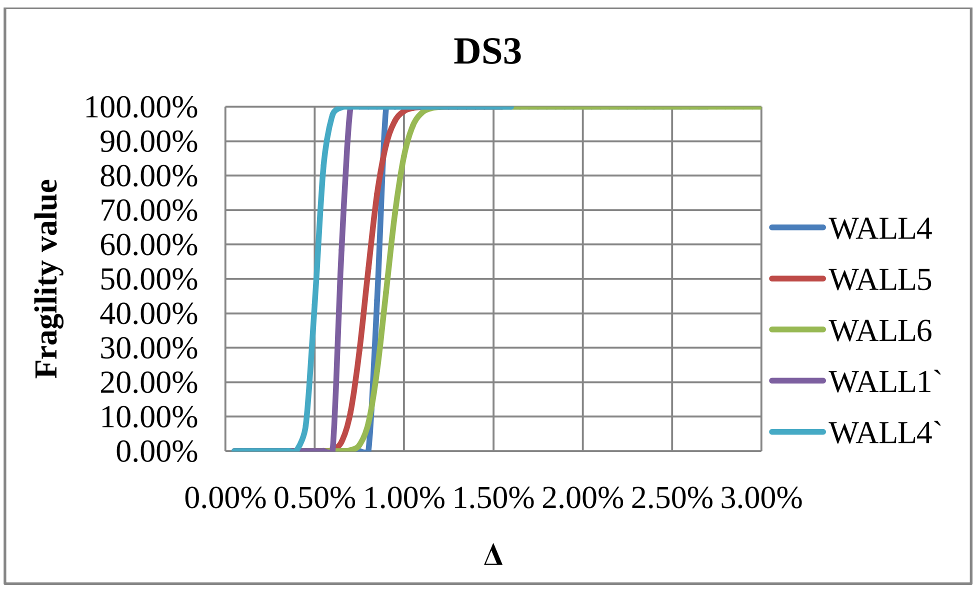

Figure 70- Damage state 3 fragility curves for WALL4, WALL5, WALL6, WALL`1 and WALL`4

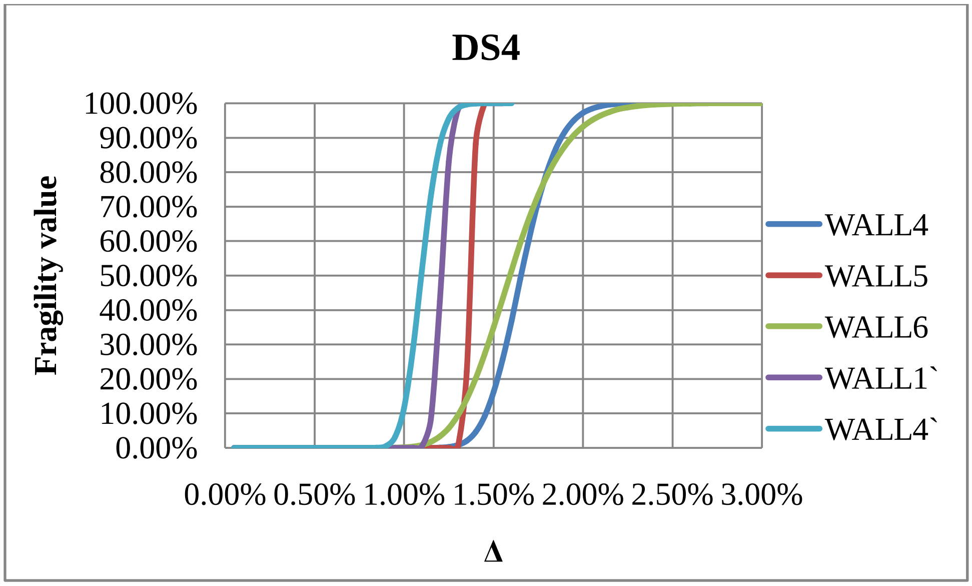

Figure 71- Damage state 4 fragility curves for WALL4, WALL5, WALL6, WALL`1 and WALL`4

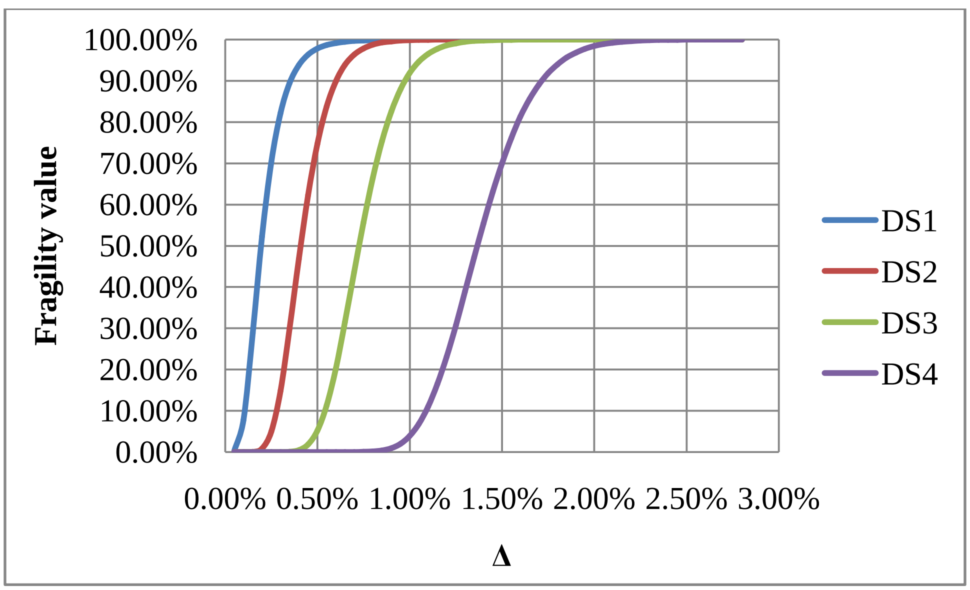

Figure 72- fragility curve for any wall has (ρv) varying from (1.17 to 1.31) %, (As) varying from (1.47 to 2.21) %, (P) varying from (0 to 1.5) % and (ρh) varying from (0.26 to 0.60) %

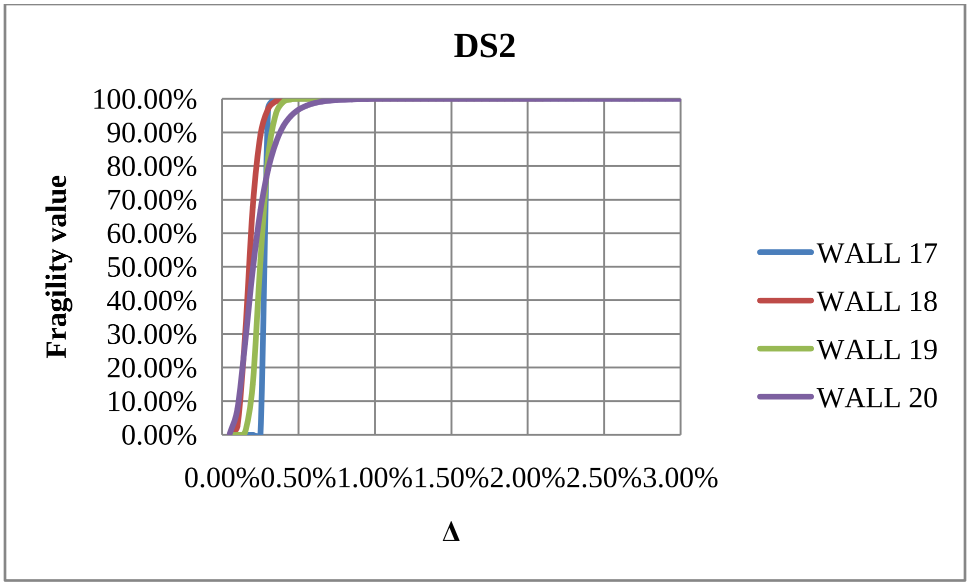

Figure 73- Damage state 2 fragility curves for WALL 17, WALL 18, WALL 19 and WALL 20

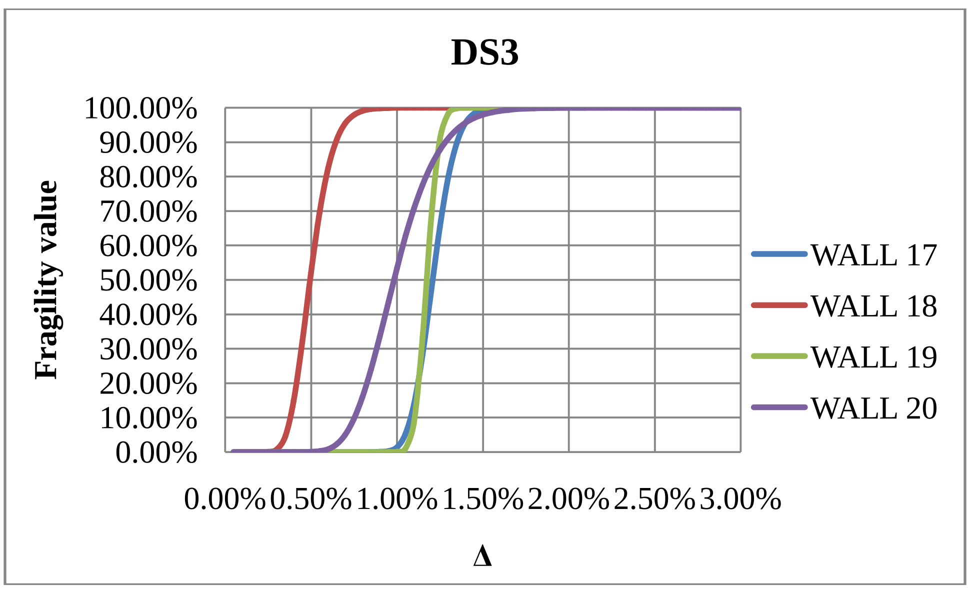

Figure 74- Damage state 3 fragility curves for WALL 17, WALL 18, WALL 19 and WALL 20

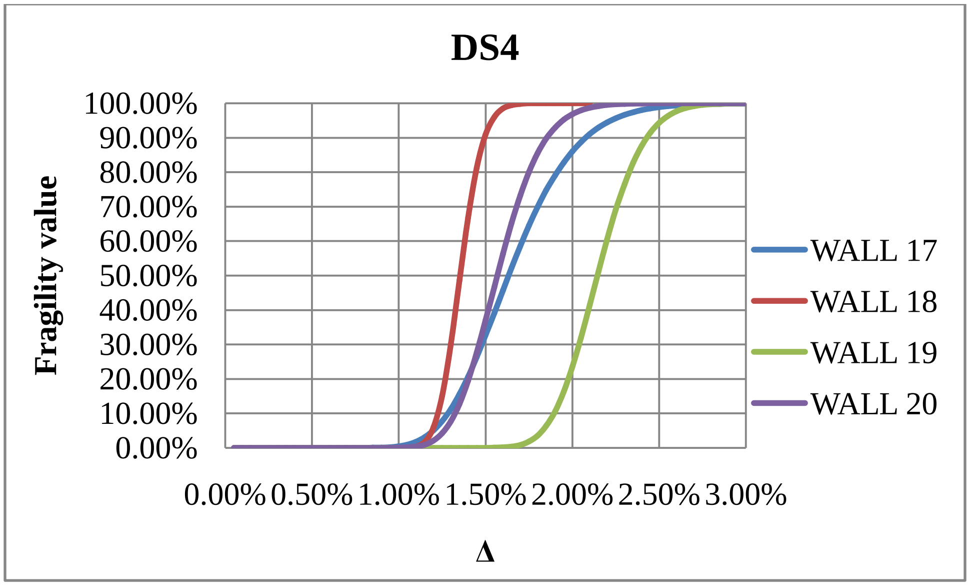

Figure 75- Damage state 4 fragility curves for WALL 17, WALL 18, WALL 19 and WALL 20

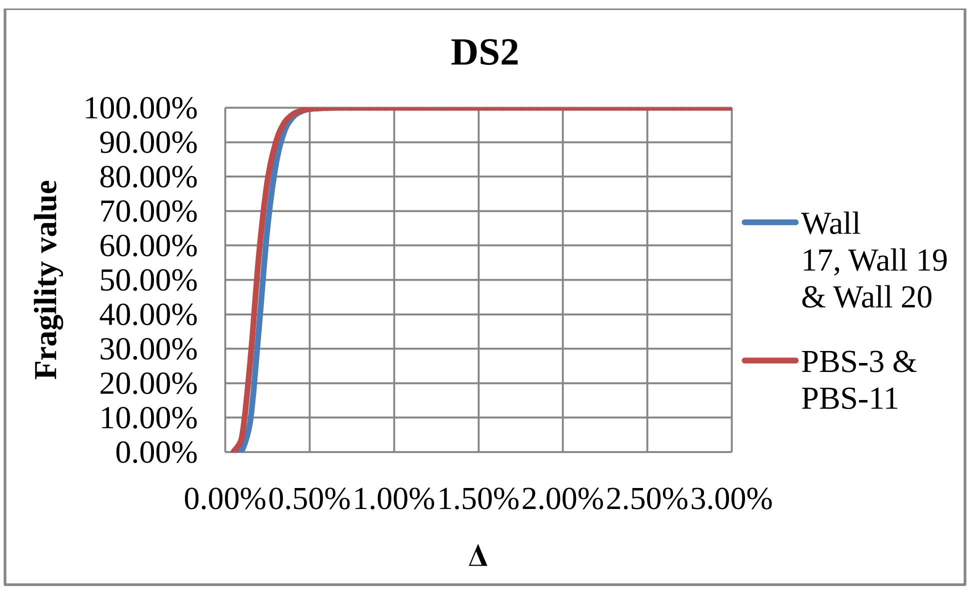

Figure 76- Damage state 2 fragility curves for Shing walls and PBS-3, PBS-11

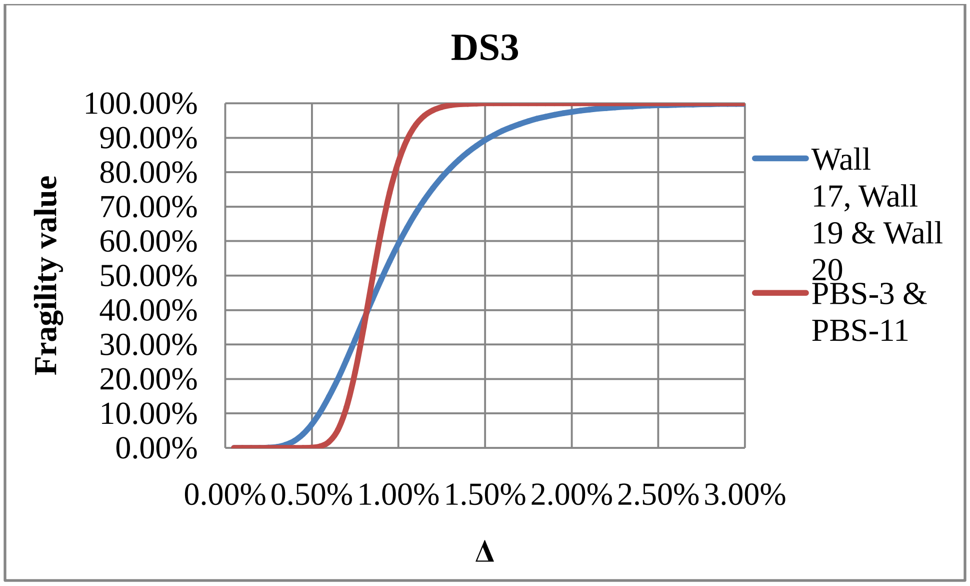

Figure 77- Damage state 3 fragility curves for Shing walls and PBS-3, PBS-11

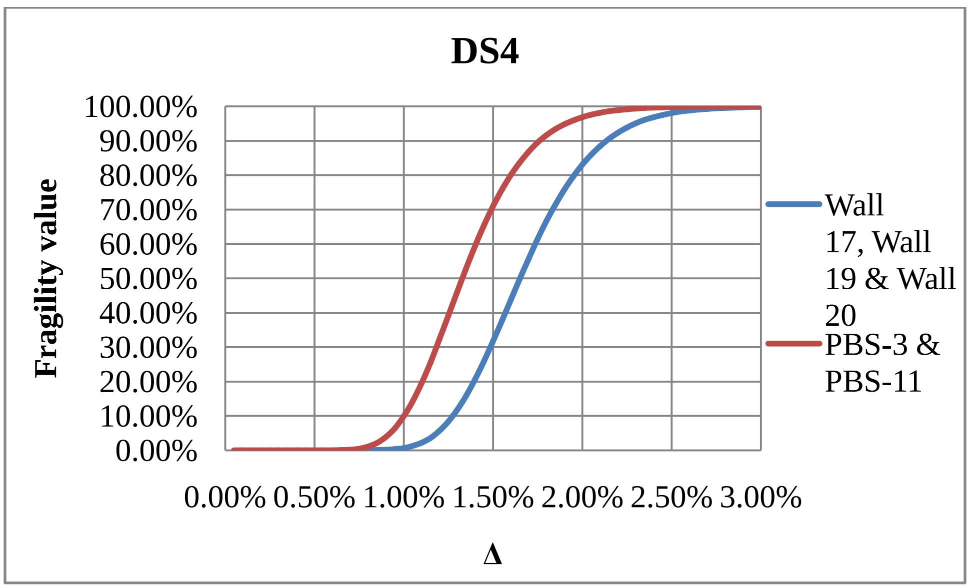

Figure 78- Damage state 4 fragility curves for Shing walls and PBS-3, PBS-11

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