THE DEVELOPMENT OF FRAGILITY CURVES FOR MASONRY BUILDING- STATE OF ART REVIEW

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Abstract- A significant portion of buildings worldwide are made of masonry, that is the reason that buildings are more vulnerable to earthquake damage. Fragility curves are crucial tools for evaluating seismic risk as they provide a quantitative measure of the probability of a building exceeding a particular damage condition in response to a given ground motion intensity. This review study provides a thorough analysis of the current knowledge in the development of fragility curves specifically for masonry buildings. The review starts by explaining the significance of fragility curves in earthquake mitigation techniques. The review article then investigates numerous methods for developing fragility curves for masonry buildings, such as the empirical method, analytical method, expert judgment, and hybrid approach. Following that, various findings of the researchers, the methodology they employed, and the crucial aspects they studied in order to construct the fragility curves are discussed.

Keywords- fragility curves, fragility analysis, risk assessment of buildings, non-linear analysis.

1 Introduction

Seismic fragility curves illustrate the vulnerability of buildings to earthquakes. Figure 1 represent the general representation of fragility curves by showing the probability of structural failure as a function of an earthquake intensity measure [1].

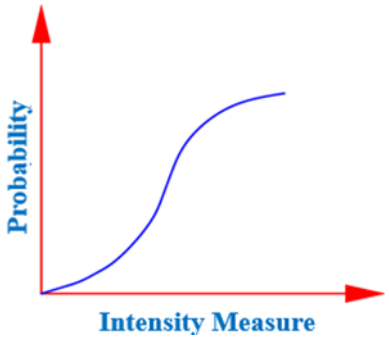

Figure 1: General representation of fragility curves [1]

Fragility curves tell us what's likely happen to our buildings when the ground starts shaking.

Fragility curve are necessary to evaluate the vulnerability of structures to unforeseen events and for setting retrofit and/or repair priorities [2]. The fragility curve provides the possibility of exceedance of a specific damage level based on a chosen ground motion parameter [3].

According to D'Ayala [3] , there are various types of fragility curves,

1. Empirical method
2. Analytical method
3. Expert judgement
4. Hybrid method

Table 1 pros and cons of each method [4]

Approaches	Advantages	Disadvantages
Empirical method	It shows the actual vulnerability It represents a realistic picture of the structure	Lack of data Inconsistency in damage observation
Analytical method	It is less biased It covers all types of uncertainties	It is quite costly Its computation takes a lot of time
Expert Judgement	This approach quite Simple It may include all the factors	It is very subjective It is totally dependent on the panel expertise It is not that much accurate
Hybrid method	It considers the post-earthquake data It can reduce the computational effort	It generally requires multiple data because of combination of experimental and analytical approaches

According to Table 1 each method has its strengths and weaknesses. An empirical approach is based on actual data, but can be hampered by data limitations. The analytical approach provides a rigorous and unbiased assessment, but with a large cost and time investment. Expert judgment offers simplicity and the ability to take different factors into account, although it is subjective and relies on expert knowledge. Finally, the hybrid approach aims to balance these factors by using post-event data and reducing computational requirements, although it requires extensive and diverse data sources. The choice of method depends on the specific context, the available resources and the required accuracy of the vulnerability assessment.

2 Methodology

In Pakistan, significant research work has been carried out in the past on masonry buildings including different building typologies such as unreinforced masonry building (URM), reinforced concrete frame structure, confined masonry building, and adobe buildings. Here we will shed light on some of the significant work on developing fragility for buildings carried out in the past.

[5] Provides an analytical procedure for developing the fragility curves for masonry buildings. Figure 2 shows the fragility curves for masonry buildings having PGA on x axis and probability on the y axis which is developed by identifying all mechanical properties of masonry buildings that can vary (e.g. strength and stiffness), and using Monte Carlo simulations to generate random values for these properties. Then by performing nonlinear static and dynamic analysis of the building the fragility curves are obtained.

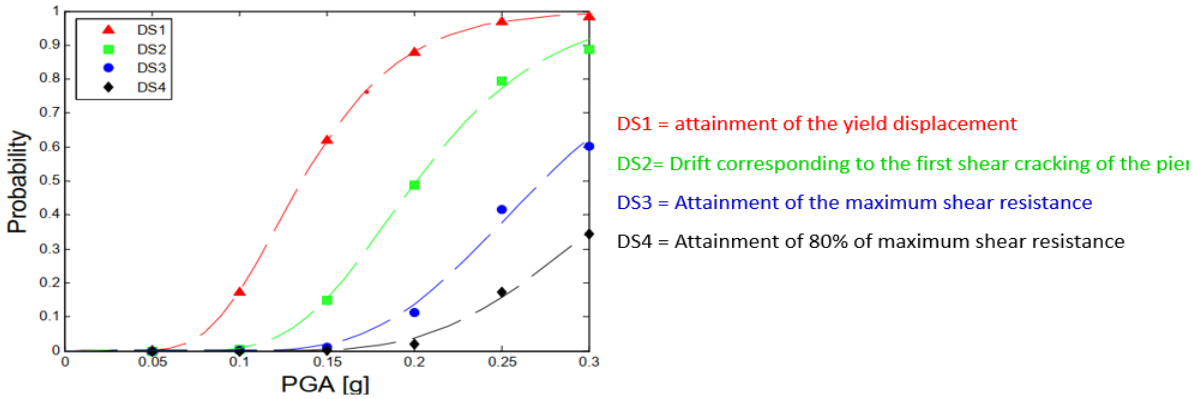

Figure 2: Masonry building fragility curves [5]

[6] developed empirical fragility curves for adobe buildings using methodology proposed by Giovinazzi (2005). Figure 3 shows the fragility curves for adobe buildings having intensity measures on x axis and probability of damage on y axis. They Compared damage potential of adobe buildings in Pakistan and Europe and found Pakistani buildings are more vulnerable to collapse.

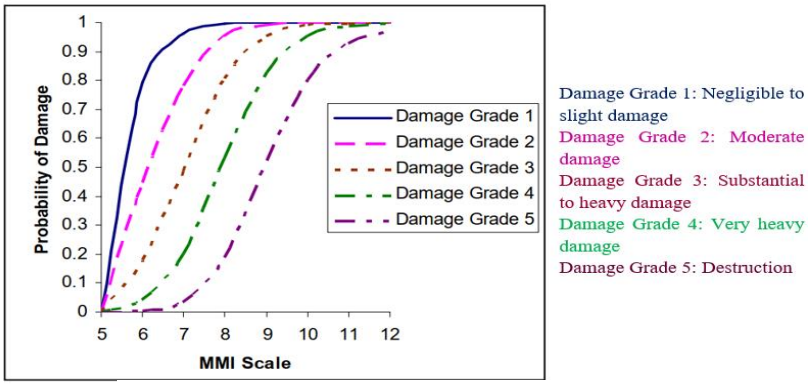

Figure 3 Adobe buildings fragility curves [6]

[7] developed the analytical fragility curves for masonry buildings based on Applied Element Method (AEM). Figure 4 depicts the fragility curves for masonry buildings having spectral acceleration on x axis and probability on y axis. AEM combines strengths of finite element method and discrete element methods for better simulation of complex structural behavior. Over 50 ground motion records were used to Studied the models. They concluded that AEM is a reliable tool for assessing earthquake risk in URM buildings.

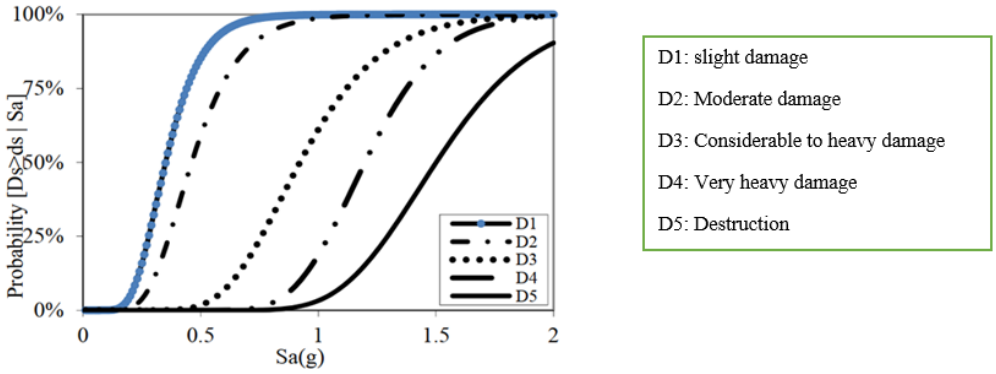

Figure 4: Brick Masonry Buildings fragility curves [7]

[8] developed the hybrid fragility curve for a confined masonry buildings in Lima, Peru. Figure 5 shows the fragility curves for confined masonry buildings having PGA on x axis and probability of exceedance on y axis They used a combination of field surveys, experimental tests, and computer simulations to create a database of information about these buildings. The results showed that confined masonry buildings in Lima are at moderate risk of damage from earthquakes. However, the risk of damage varies depending on the size and location of the building.

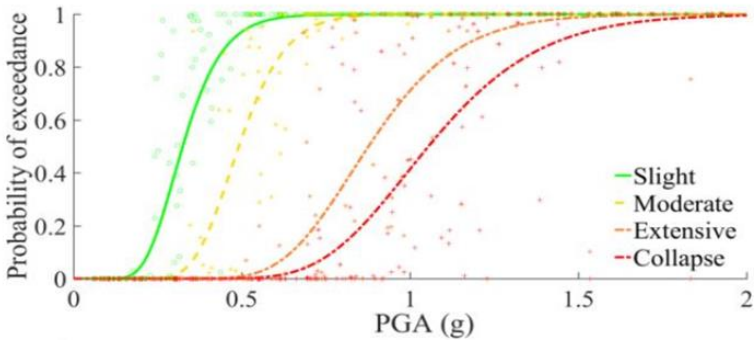

Figure 5: Confined Masonry Buildings fragility curves [8]

3 Practical Implementation

Engineers can use the seismic fragility curves to estimate the building's damage probability under different earthquakes. The information provided by the fragility curves can be directly used in prioritizing retrofitting efforts, establishing building codes, and implementing preventative measures, ultimately improving the seismic resilience of our masonry structures.

4 Conclusion

1. This review article thoroughly examines the fragility curves development for masonry buildings, which are an essential tool for assessing seismic risk.
2. The review showcased the effectiveness of these methodologies in evaluating the seismic vulnerability of various masonry structures through reviewing previous research.
3. Future research directions could focus on refining existing methodologies, incorporating regional construction practices, and developing fragility curves for a wider range of masonry building typologies.
4. By continuously improving fragility curve development, engineers can make informed decisions regarding earthquake risk mitigation strategies and ensure the safety and resilience of our built environment.

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