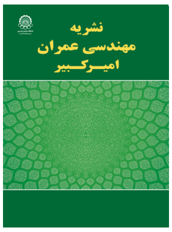

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Effect of Structural Parameters on Failure Probability of Piers in Seismic Isolated Concrete Bridges

M.R. Shiravand* , M. Vasef

Faculty of Civil, water and Environment Eng., Shahid Beheshti University, Tehran, Iran

ABSTRACT: Bridges are a critical part of the urban and suburban transportation network, so they are supposed to be designed to sustain earthquake-induced damages to be utilized after the earthquake. Various parameters can affect the behavior and probability of failure of a bridge and the present work aims to evaluate the effects of structural parameters on the probability of failure in isolated concrete bridges. OpenSees software is used for simulating and analyzing 16 different bridge models. Incremental dynamic analysis is conducted using this software and IDA and fragility curves of models are derived and presented. The results showed that the probability of failure decreases with the increase of the pier diameter, concrete compressive strength, yield strength of longitudinal rebar, and diameter of longitudinal bars. Also increasing the stiffness of the elastic isolator and decreasing the confined diameter of the pier resulted in increasing the probability of failure. Furthermore, results revealed that the probability of failure is more sensitive to the variation of pier confined diameter, yield strength of longitudinal rebar, the diameter of longitudinal bars, and the stiffness of elastic isolators in comparison with the variation of concrete compressive strength.

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1. INTRODUCTION

As often observed from destructive earthquakes, bridges are one of the most vulnerable components of a highway network system subjected to earthquake ground motion. The seismic behavior of isolated reinforced concrete bridges can be affected by changing geometrical or material properties. The object of this paper is to investigate the effect of structural parameters on the failure probability of piers in seismic isolated concrete bridges. For this reason, a group of structural parameters consisting of concrete compressive strength; yield strength of longitudinal rebar; pier confined diameter; pier diameter; stiffness of isolators, and diameter of longitudinal rebar are considered.

2. METHODOLOGY

The base model is a regular three-span isolated RC bridge with circular piers which is in a high seismic hazard zone, located on soil type III and has been designed based on AASHTO standard [1]. “Fig. 1” shows the main characteristics of the base model.

For bridges, a common idealized for dynamic analysis is using a stick model. OpenSees software is used for simulating and analyzing 16 different bridge models. Incremental dynamic analysis is conducted using this software and IDA and fragility curves of models are derived. Concrete and rebar materials were modeled by using Concrete02 and Steel02 materials, respectively. Isolators have been modeled using zero-length elements and assigning an elastic uniaxial material to them. Superstructure and columns have been modeled using a nonlinear element.

In this study, fragility curves which are developed by conducting incremental dynamic analysis, are used to evaluate the effects of structural parameters on seismic behavior and the probability of failure of isolated RC bridges. “Table 1” shows the assumed structural parameters and their amount.

A group of 7 near-field earthquakes has been chosen for incremental dynamic analysis and Dutta and Mander limit states which are based on piers’ drift are considered for developing fragility curves [2].

Table 1. Assumed structural parameters and their amounts

Assumed amounts	Unit	Parameter
20-25-28-30	MPa	Concrete compressive (*fc*) strength
300-400-500	MPa	(*fy*) Yield Strength
1.7-1.73-1.75-1.77	m	Confined diameter
100-200-400-800	Ton/m	(k) Stiffness of isolator
1.5-1.8-2.0	m	Pier diameter
20-26-32	mm	Rebar diameter

*Corresponding author’s email: mshiravand@sbu.ac.ir

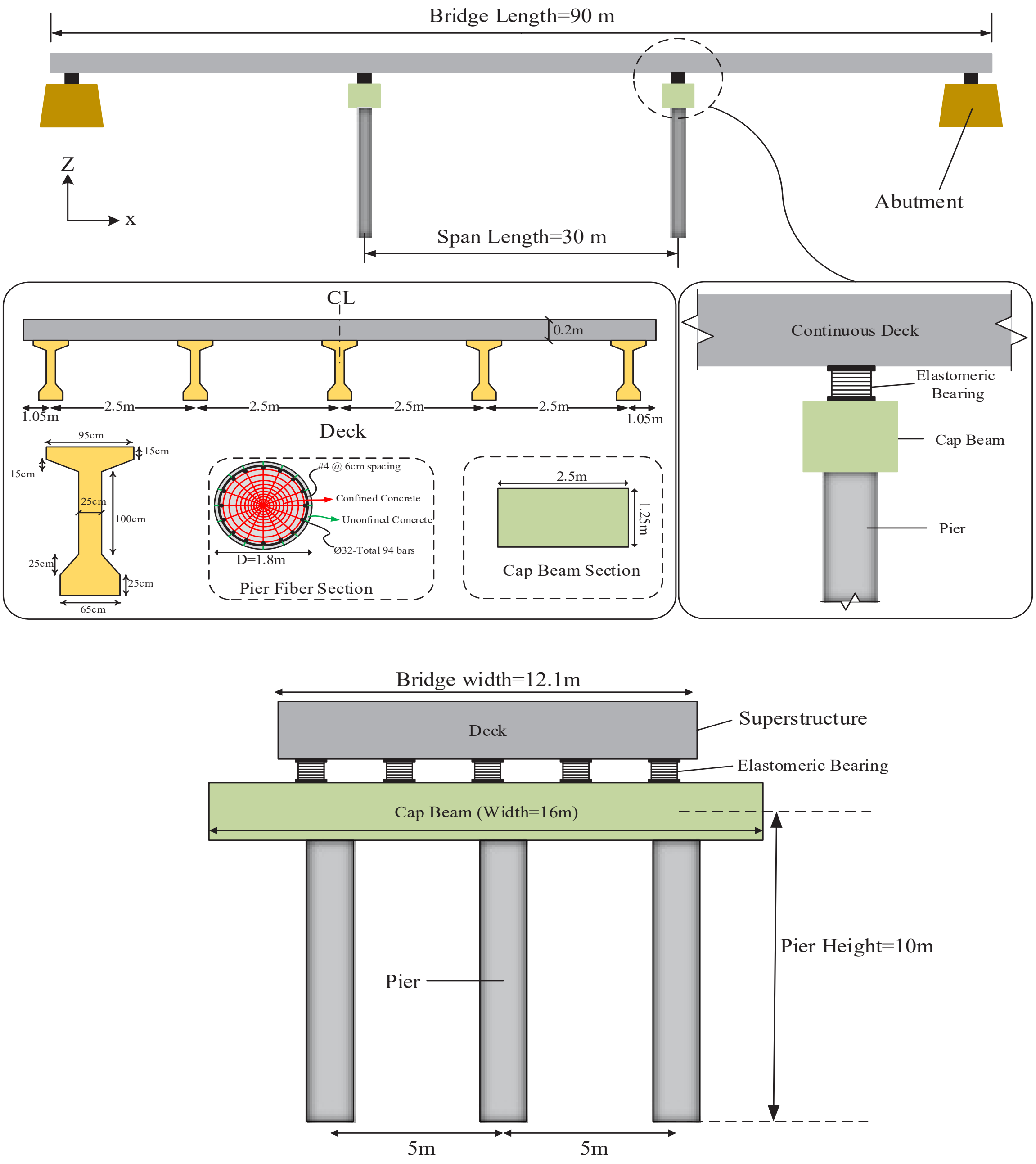

Fig. 1. Main characteristics of the base bridge model

3. RESULTS AND DISCUSSION

In Figs. 2 to 7, fragility curves of bridge piers based on considered limit states and structural parameters are available.

4. CONCLUSION

The focus of this study was to investigate the effect of structural parameters on the failure probability of piers in seismically isolated RC bridges. Based on developed fragility curves:

1. By decreasing the amount of piers' confined diameter, failure probability increased.

2. Increasing the amounts of pier diameter and rebar yield strength, resulted in decreasing the probability of failure.

3. Although the concrete compressive strength did not have a substantial effect on the seismic behavior of piers, increasing the amount of this parameter, decreased the probability of failure.

4. Stiffness of isolators is one of the major parameters in the seismic behavior of isolated RC bridges. Increasing the amount of this parameter increased piers' drift and displacement and as a result, the probability of failure increased.

5. The last considered parameter is longitudinal rebar diameter that increasing the amount of this parameter resulted in decreasing the failure probability of seismically isolated RC bridges.

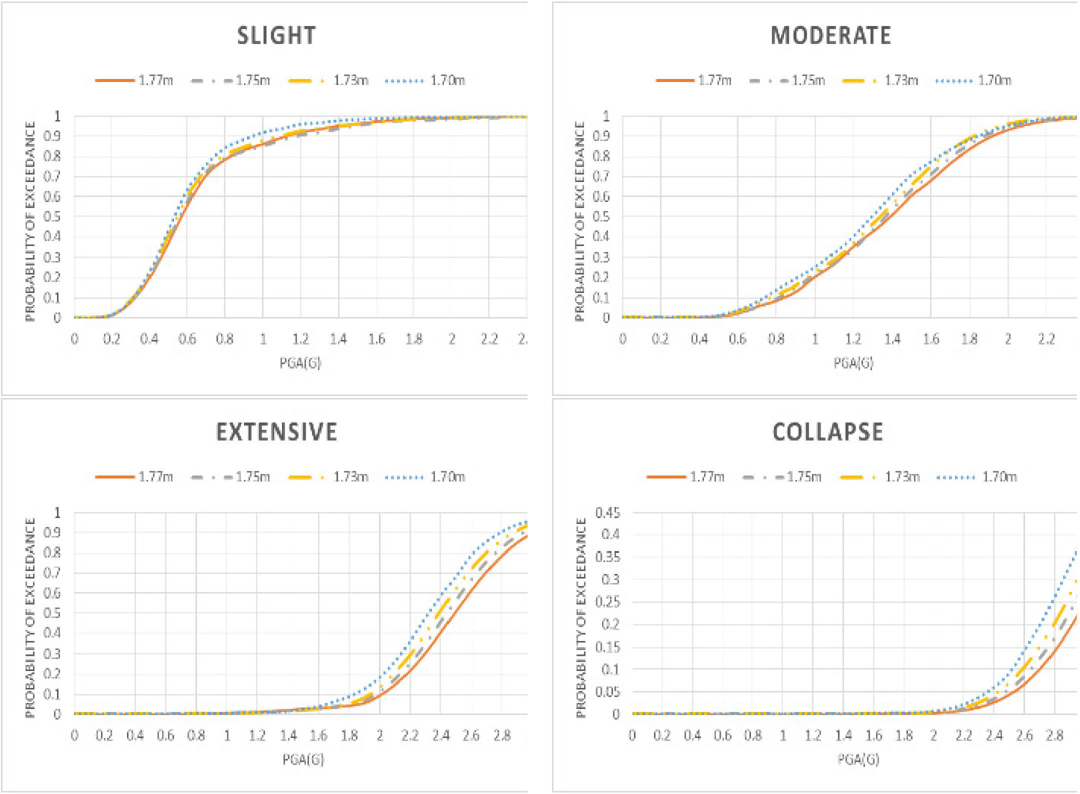

Fig. 2. Fragility curves for piers

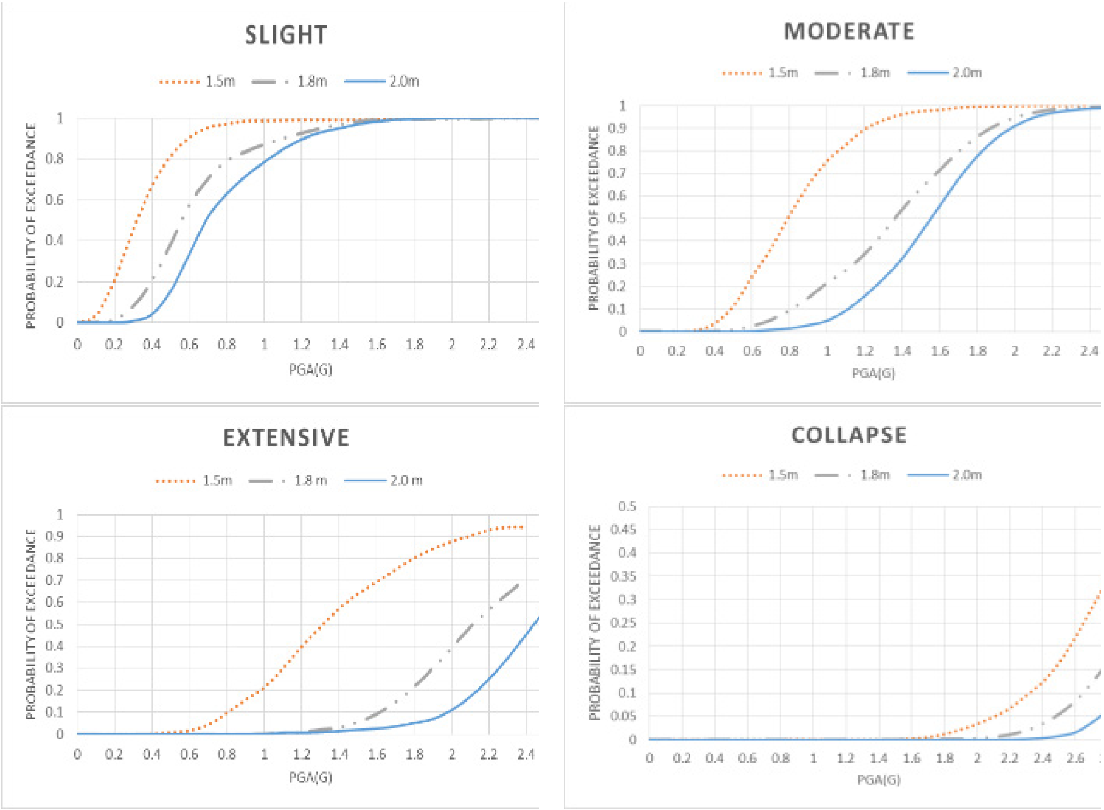

Fig. 3. Fragility curves of pier diameter

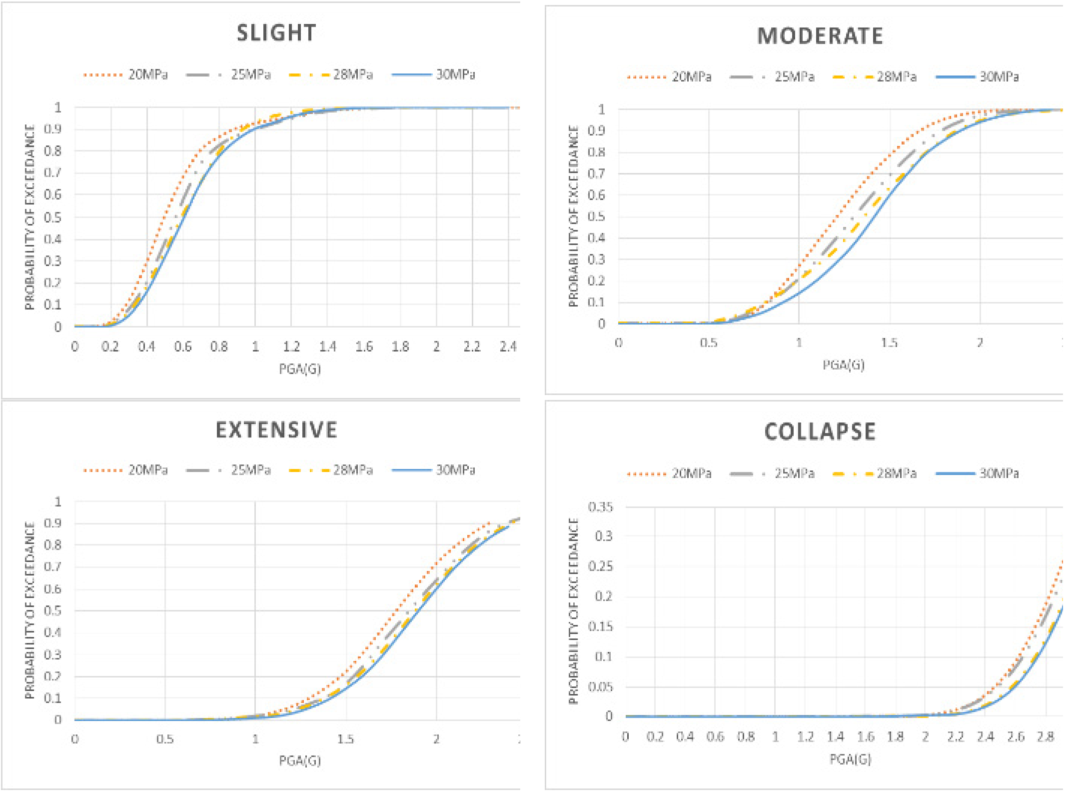

Fig. 4. Fragility curves for concrete compressive strength

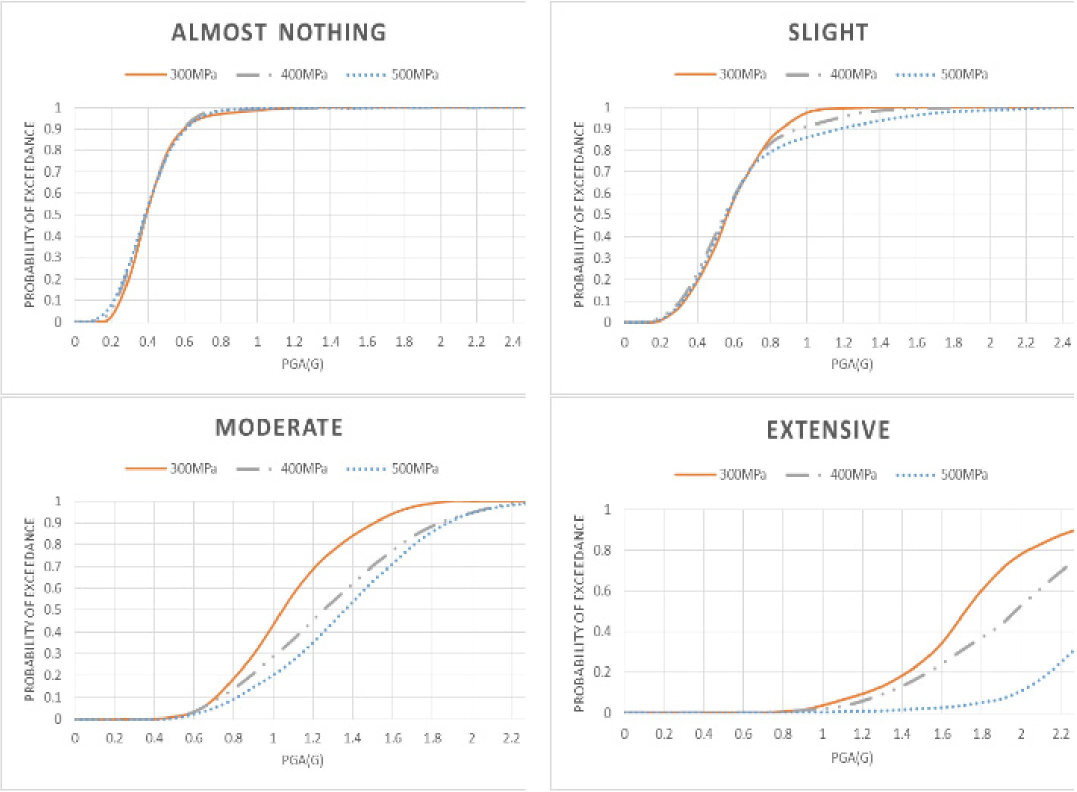

Fig. 5. Fragility curves for different rebar yield strengths

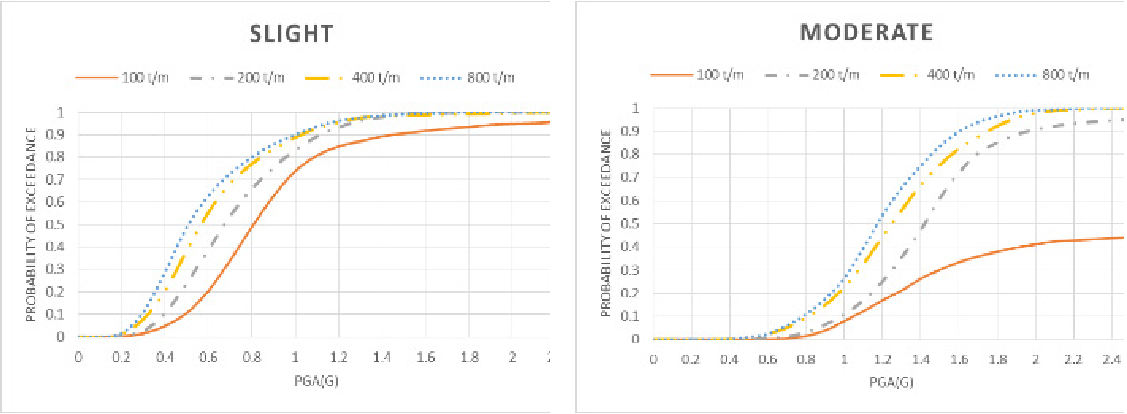

Fig. 6. Fragility curves for different isolator stiffness

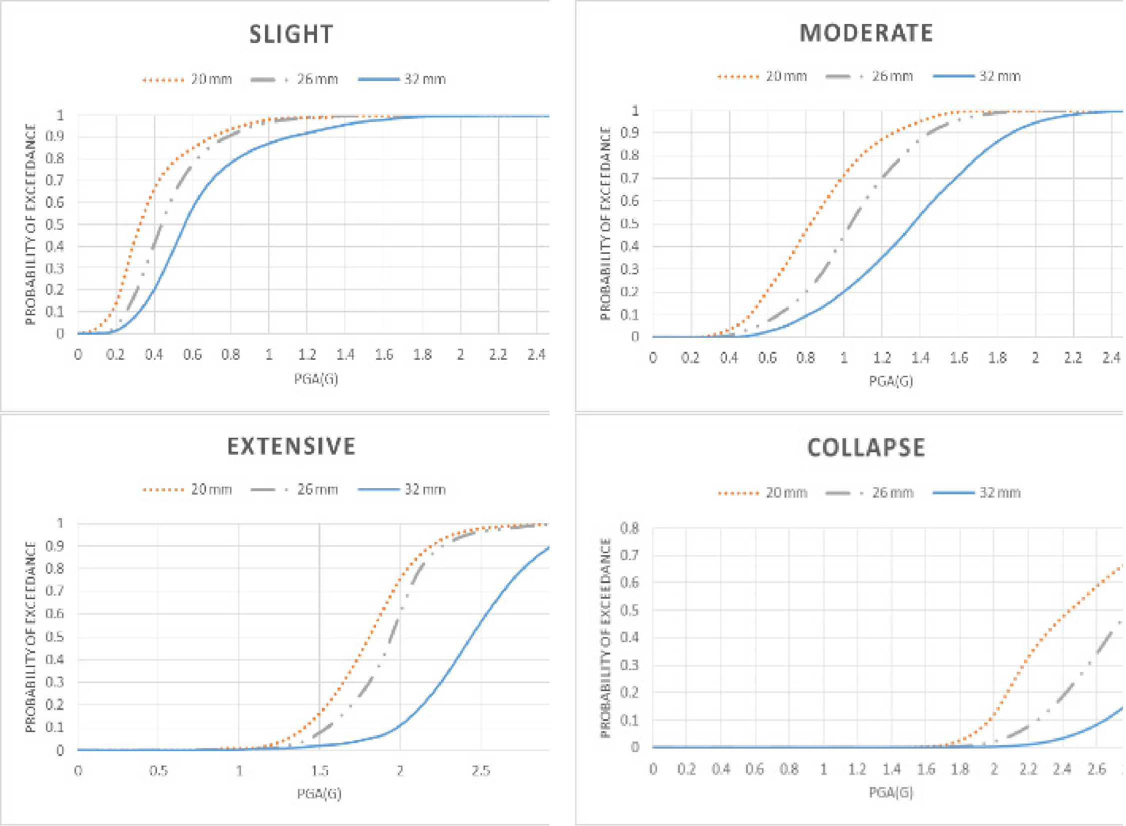

Fig. 7. Fragility curves of different longitudinal rebar diameters in all damage states

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