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Retrofitting Techniques on Earthquake Damaged Buildings

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Abstract

Earthquakes are one of nature's greatest hazards to life on this planet. The impact of this phenomenon is sudden with little or no warning to make preparations against damages and collapse of buildings/structures. The hazards to life in case of earthquake are almost entirely associated with manmade structures such as buildings, dams, bridges etc. Prevention of disasters caused by earthquake has become increasingly important in recent years. Disaster prevention includes the reduction of seismic risk through retrofitting existing buildings in order to meet seismic safety requirements. The planning of alterations to existing buildings differs from new planning through an important condition; the existing construction must be taken as the basis for all planning and building actions. The new structure can be built sufficiently earthquake resistant by adoption proper design methodology and construction quality control. But the existing old structures which have mostly been planned without considering this important aspect, pose enormous seismic risk, in particular to human life and historical monuments. India is one of the most earthquake prone countries in the world and has experienced several major/moderate earthquakes during the last 15 years. About 50-60% of the total area of the country is vulnerable to seismic activity intensities. In India, almost 85% of the total buildings are non engineered buildings made up of earthen walls, stone walls, brick masonry walls, etc. These buildings are more vulnerable and in the event of a major earthquake, there is likely to be substantial loss of lives and property. The recent earthquakes have posed a serious threat to many existing Indian RC buildings which are designed mainly for gravity loads. Hence focusing on the damage and collapse of RC buildings, it is important to estimate the response of existing buildings under earthquakes from the viewpoint of life reservation and risk management.

Keywords: *Retrofitting Techniques, Earthquake, Buildings.*

1. Introduction

Earthquakes are one of the nature's greatest hazards to life on this planet. The impact of this phenomenon is sudden with little or no warning to make preparations against damages and collapse of buildings structures. The hazard to life in case of earthquake is almost entirely connected with manmade structures such as buildings, dams, bridges etc. Prevention of disasters caused by earthquake has become increasingly important in recent years. Disaster prevention includes the reduction of seismic risk through retrofitting existing buildings in order to meet seismic safety requirements. The planning of alterations to existing buildings differ from new planning through an important condition, the existing construction must be taken as the basis for all planning and building actions. The new structure can be built sufficiently earthquake resistant by adoption proper design methodology and construction quality control. But the existing old structures which have mostly been planned without considering the important aspect create massive seismic risk, in particular to human life and historical moments.

India is one of the most earthquake prone countries in the world and has experienced several major/moderate earthquakes during the last 15 years. About 50-60% of the total area of the country is exposed to seismic activity of varying intensities. The earthquakes as, Latur (1993), Jabalpur (1997), Chamoli (1999) and Bhuj (2001) had exposed the vulnerability of buildings in India. The codes of practice on earthquake resistant design (IS 4326:1993), earthquake resistance of earthen buildings (IS 13827:1993), and earthquake resistance of low strength masonry buildings (IS 13828:1993), ductile detailing of reinforced concrete structures (IS 13920:1993) and seismic strengthening of buildings (IS 13935: 1993) were published almost simultaneously to meet the necessity of seismic design of buildings. IS 1893 code of practice for earthquake resistant design and construction of buildings was first prepared in 1962 and subsequently revised in 1996, 1970, 1975, 1984 and the fifth prepared recently in 2002. Part 1 and other parts of this code are under revision. Many existing buildings do not meet the seismic strength requirement. The need for seismic retrofitting in existing building can arise due to any of the following reasons: (1) building not designed to code (2) consequent updating of code and design practice (3) subsequent upgrading of seismic zone (4) weakening of strength and aging (5) adjustment of existing structure (6) change in use of the building, etc.

2. Research Work

Retrofitting material is used – fiber reinforced polymer.

Model with fiber reinforced polymer wrapped at the ground floor columns.

Material Constants: - For modeling in STAAD Pro v8i

A. Concrete:

Density= 25KN/m^3
Elasticity= 2.5×10^7 KN/m^2
Poisson's ratio= 0.15

B. Steel :

Density= 78.5 KN/m^3
Elasticity= 2.1×10^8 KN/m^2
Poisson's ratio= 0.15

C. FRP:

Design of FRP jacketing:

a. Calculate the FRP system design properties-

$$f_{fu} = C_E \; f_{fu}^*$$
$$\varepsilon_{fu} = C_E \varepsilon_{fu}^*$$

Where f_{fu}^*= ultimate tensile strength of FRP
ε_{fu}^* = rupture strain of FRP
C_E= environmental reduction factor

b. Find percentage of existing reinforcing steel $p_s = {A_s}/{bd}$ and externally bonded FRP $p_f = {A_f}/{bd}$
Where $A_f = nt_f \, w_f$

c. Determine the existing strain in the soffit-

$$\varepsilon b_i = {M_{DL}(h - kd)}/{I_{cr}E_c}$$

d. Determine the bond-dependent coefficient and check limits-

$$k_m = {\left(1 - \left({nt_f w_f}/{2000000}\right)\right)}/{60\varepsilon_{fu}} \le 0.6$$

3. Comparison of Average Displacement of Various Models

It is seen that the maximum displacement of model A is more than that of retrofitted model. It is also observed for all models the average displacement increases with height. There is minor difference in the average displacement in case of model C and model D. Retrofitting with steel braces decreases the average displacement of the structure.

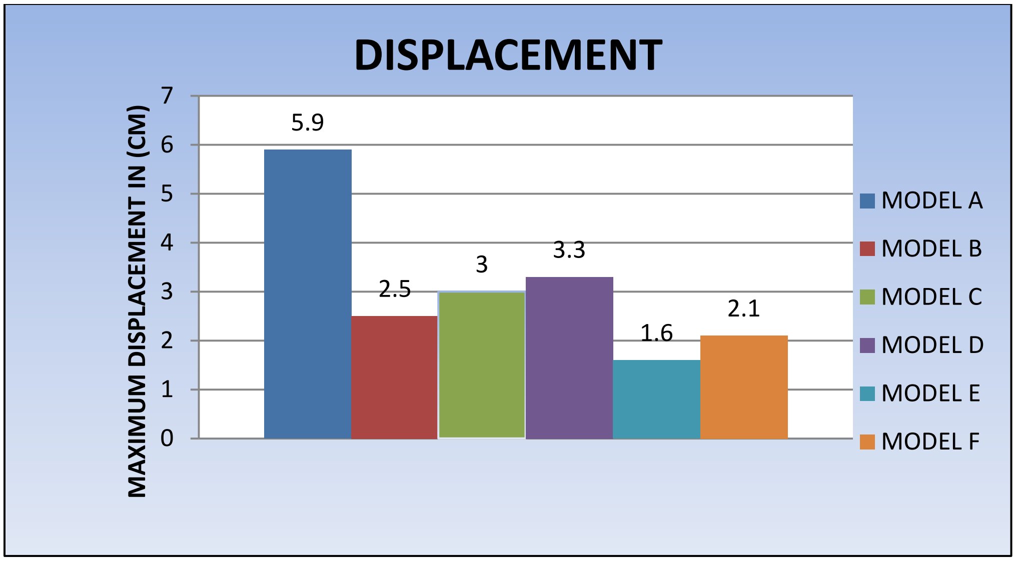

Figure 1: Average displacement of different models with height

4. Conclusion

Comparative study of results of different models on building with or without retrofitting materials has been made for original structure and retrofitted structure. The result of various parameters storey drift, lateral displacement in original model and earthquake damaged retrofitted model is shown in form of bar chart.

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