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DYNAMIC ANALYSIS OF REGULAR AND IRREGULAR RC FRAMES WITH STEEL BRACING AND MEGA BRACING USING ETABS

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Abstract - *During earthquake there is strong shaking of the surface of the earth due to seismic waves, leads to huge damage to human life and the giant structures and the damage may be partial or full. Seismic retrofitting is most important aspect for mitigating seismic hazards in earthquake prone areas. The present work deals with Dynamic analysis of RC frame with different types of steel bracings like X, V, K, Diagonal bracings and Mega bracings using ETABS software. Vertical Regular, irregular structure of G+12 building located in zone IV is analyzed. 14 models are studied with different type of bracings, mega bracing and unbraced. The result is formatted for lateral displacement, story drift and base shear and compared between RB, VIRB, VIRB MB. The performance of VIRB with different arrangement of steel bracings provided more stability. Mega bracings also have great influence on seismic performance of the building.*

Key Words: Dynamic Analysis, Steel Bracings, Mega Bracings, Seismic Retrofitting, ETABS.

1. INTRODUCTION

A trend of tall and slender buildings has taken the lime light in construction field and every structural engineer has a challenge to design very strong structures which stay intact even during very harsh climatic conditions with strength and stability. The damage caused may be partial or full, strengthening of structure is better option than totally replacing the structure.

Generally, the structure has to resist mainly three types of loads.

1.Vertical Loads 2. Horizontal Loads 3. Longitudinal Loads

Vertical Loads consists of Dead load, Live load and Impact load, Snow load. Horizontal Loads consists of Wind load, Earthquake load and Blasting loads. Longitudinal Loads consists of Tractive loads and Braking force. Various estimated loads are calculated precisely using Indian Standard Code IS 875-1987(Part I-V).

1.1 TECHNIQUES OF RETROFITTING

Retrofitting is an art of updating the strength and capacity of the existing structure and enable to with stand strong earthquake in future. Global retrofitting involves structure-level approach which involves modification in the whole structure. Conventional retrofitting involves increasing the seismic resistance of the existing building by reducing the adverse effect of design or construction. some of the methods are addition of shear wall which controls the lateral drift and protects the frame. Steel bracing for providing extra strength and stiffness. Infill walls to be used for building with 3-5 storeys to increase the strength.

Non-conventional retrofitting involves reduction in seismic demands given to existing building. Base isolation is a technique of including rubber bearing usually at foundation level, thus decreasing the effect of seismic waves reaching to the building. Rubber bearing consists of laminated layers of rubber and steel plates. Mass reduction can be accomplished by removing upper storeys, heavy cladding, partions, stored goods. The supplementary dampers such as addition of viscous damper, elastic damper, viscous-elastic damper, friction dampers in diagonal of bays of frame reduces earthquake effect by dissipation of energy.

Local retrofitting is direct treatment given to vulnerable load bearing member. Jacketing around the existing member's increases lateral load capacity of the structure in a uniformly distributed way with a minimal increase in loading on any single foundation and with no alternative in the basic geometry of the building.

Mega steel bracings are used as solution to both global lateral stiffness and strength. Mega refers to huge i.e. instead of providing bracings between every column and beams at the exterior of building the mega bracings are provided for two to three floor at once.

Viswanath K. G *et. al.* (2010) [1] RC frame of G+4 3D model is analyzed in the STADD Pro V8i software with concentric steel bracings. The result obtained for G+4 in X direction for lateral displacement in mm is reduced to the largest extent for X bracing then compared to unbraced structure. The maximum axial force is increased for buildings with bracing systems. Whereas, shear force and bending moment in column is decreased for bracing systems which increase the axial compression in columns connected. The bending moment is less for buildings with bracing then without bracing. Nauman Mohammed and Islam Nazrul (2013) [2] seismic analysis of G+14 storied structure is carried out in STAAD Pro V8i software with special moment resisting frame situated in zone IV according to IS 1893:2002. The building was analysed for X, Chevron, Diagonal and K bracing with unbraced in four faces. It was found that the lateral displacement at terrace level drastically reduced after applying bracings. The axial forces increased after applying bracings. The shear force increased after applying bracings.

2 OBJECTIVES

1. To evaluate the response of vertical regular and irregular buildings with different types of bracings and without bracing, and also the behaviour of the structure with different types of mega bracings subjected to earthquake and wind loads using response spectrum method of analysis in ETABS 2016.

2. To compare the variations of lateral displacement, story drift and base shear for regular and irregular structures with and without different types of bracing systems.

3. To identify the suitable type of bracing system for resisting the seismic load.

3. METHODOLOGY

In the present study, the Reinforced Concrete 13 storied building with vertical regular and irregular plans.

The Regular building has floor plan of 6 bays having 4.5 m distance along longitudinal direction and 6 bays having 3.5 m distance along transverse direction as shown in Fig 3.1.

The Irregular building with vertical irregularity of 6 bays having 4.5m distance along longitudinal direction and 6 bays having 3.5m distance along transverse direction is considered as shown in Fig 3.1. Analysis is done in ETABS 2016 16.0.3 software, using code IS 1893-2002 (part I) and IS 456.

Table 1 - Description of Model

Structural details of model	
Type of frame	Reinforced concrete frame
No of stories	13 (G+12)
Plan dimension	27x21m (L=27m, B= 21m)
Width of each bay	3.5m transversely and 4.5m longitudinally
Height of each floor	3.5m
Total height if building	46m
Type of building use	Residential
Material properties	
Grade of concrete	M25-slab M30 – beam and column
Grade of steel	Fe 500
Density of reinforced concrete	25 kN/m^3
Density of brick masonry	20 kN/m^3
Section properties	
Beam size	0.30 x 0.45 m
Column size	0.40 x 0.60 m
Thickness of wall	0.23 m
Thickness of the slab	0.15 m
Loads	
Floor finish	1 kN/m^2
Live load	3 kN/m^2
Wall load	19 kN/m^2
Earthquake live load on slab as per IS 1893-2002(part 1) cl. 7.3.1 and cl. 7.3.2	
Floor	0.25 x 3 = 0.75 kN/m^2
Roof	0 kN/m^2
Seismic zone	IV
Sub soil type	II (medium)
Response reduction factor	5
Importance factor	1
Method of analysis	Response Spectrum Method
Steel bracings used	ISMB 250
Software used	ETABS 2016 16.0.3

Different types of models considered for analysis.

For regular building

Model 1 - Unbraced building

Model 2 - Building with X bracing

Model 3 - Building with V bracing

Model 4 - Building with K bracing

Model 5 - Building with Diagonal bracing

For irregular building

Model 6 - Unbraced building

Model 7 - Building with X bracing

Model 8 - Building with V bracing

Model 9 - Building with K bracing

Model 10 - Building with Diagonal bracing

For irregular building with Mega Bracing

Model 11 - Building with Mega X bracing

Model 12 - Building with Mega V bracing

Model 13 - Building with Mega K bracing

Model 14 - Building with Mega Diagonal bracing

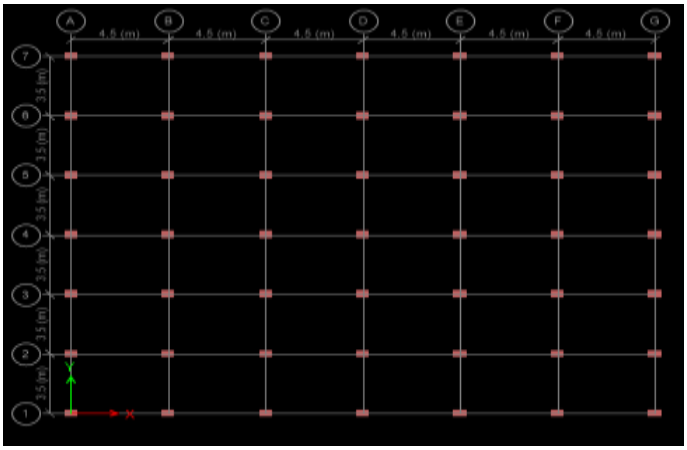

Fig 1 - Plan of the building

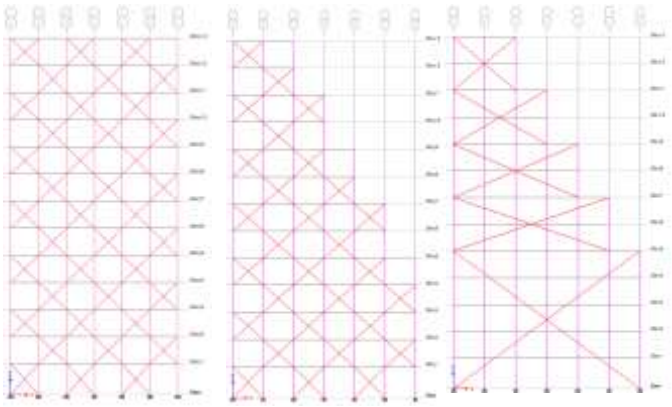

Fig 2 – Elevation of regular, irregular building with X bracing and Mega X bracing

3. RESULTS AND DISCUSSION

The structural response of all the 14 models for dynamic analysis are studied along long and short direction i.e X and Y direction due to seismic loading. The structural response studied are Lateral displacement, Story drift and Base shear. Comparative studies have been made between X, V, K, Diagonal braced and unbraced structures.

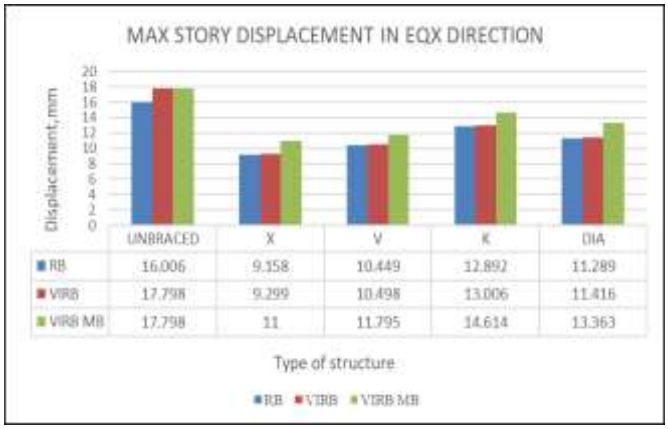

Fig no 3 - Lateral displacement in EQX direction

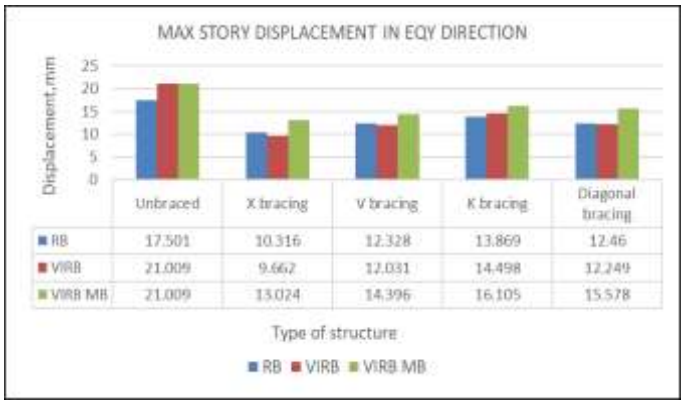

Fig no 4 - Lateral displacement in EQX direction

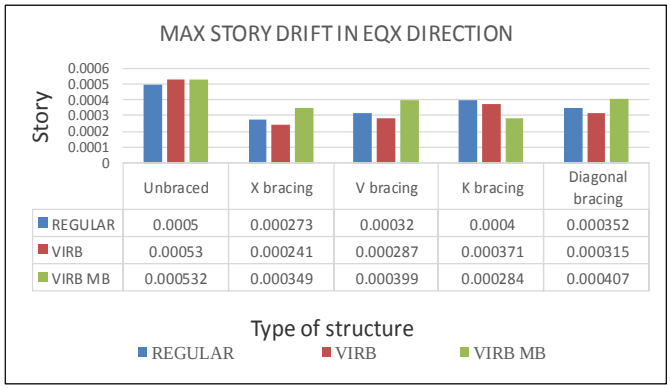

Fig no 5 – Max Story drift in EQX direction

VIRB shows less displacement when compared to RB and VIRB MB. Among bracings X bracing reduces max lateral displacement to 43% and 42% for RB, 47% and 54% for VIRB, 38.1% and 38% for VIRB MB in X and Y direction respectively compared to unbraced structure. X bracing, V bracing, diagonal bracing and K bracing is sequence of performance of bracing system.

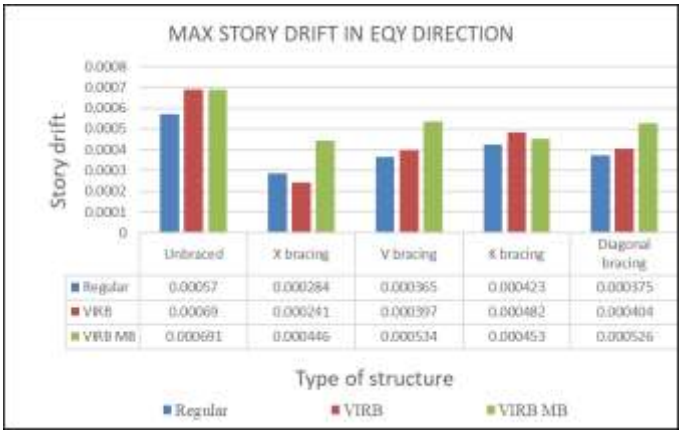

Fig no 6 – Max Story drift in EQX direction

VIRB shows less displacement when compared to RB and VIRB MB. Among bracings X bracing reduces max story drift to 45% and 50% for RB, 54% and 65% for VIRB, 34.3% and 35% for VIRB MB in X and Y direction respectively compared to unbraced structure. Followed by X bracing, V bracing, diagonal bracing and K bracing is sequence of performance of bracing system.

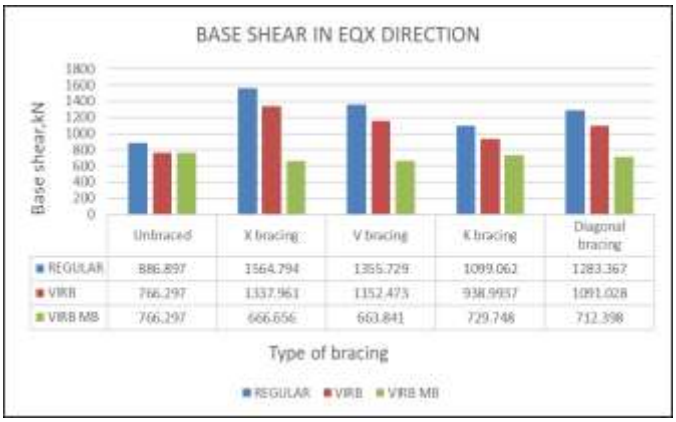

Fig no 7 – Base Shear in EQX direction

RB, VIRB, and VIRB MB for unbraced, X, V, K, Diagonal bracings, it was observed that VIRB MB shows less Base Shear when compared to RB and VIRB. Among bracings X bracing reduces Base Shear to 13% compared to unbraced structure**.**

4. CONCLUSION

- Structural parameters like lateral displacement, story drift tend to decrease after applying bracing system.
- Maximum reduction is observed for X bracing, followed by V bracing, diagonal bracing and K bracing system.
- VIRB MB shows less base shear compared to VIRB, RB. Hence mega bracings can be used effectively.
- Mega bracing frames are also effective to resist earthquake.

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