Behavior study of RCC Building with and without bracing Using STAAD.Pro

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Abstract: *In general the structure are analysis as RC structure. RCC high rise building of G + 11 Storey is used for bracing system to improve seismic resistance using various type of r.c.c. bracing system (diagonal type, V type, X type, inverted V type) and arrangement of bracing system. To build the seismically safe structure with adequate lateral resistance. Bracing system is installed between column member to resist the lateral load. Bracing system is easy to installed, economical and occupies less space. The structure is analyzed for seismic zone IV with different types of bracing system and compared with the bare frame with the using of Staad Pro software. The load condition is applied as per IS 1893 :2002. Bracing system improve the displacement capacity of the structure. The percentage reduction in storey displacement is found out. It is found that the X type of concrete bracing significantly contributes to the structural stiffness and reduces the maximum storey drift of the frames. The bracing system improves not only the stiffness and strength capacity but also the displacement capacity of the structure.*

Keywords*- Stiffness, Strength, Bracing System, Seismic zone III and IV, IS 1893:2002 and STAAD -PRO v 8i.*

I. Introduction

In tall RC [reinforced concrete] building bracing system is provide for stiffness, strength and energy dissipation to resist the lateral load. The study about the different bracing system (diagonal type, V type, inverted v type and X type) and arrangement of bracing system. To build the seismically safe structure with adequate lateral resistance. Bracing system is installed between column members to resist the lateral load. Bracing system is easy to installed, economical and occupies less space. The structure is analyzed for seismic zone III with different types of bracing system and compared with the bare frame with the using of STAAD-PRO v8i software. The load condition is applied as per IS 1893:2002. Bracing system improve the displacement capacity of the structure. Seismic analysis is calculating the response of structure to the earth quake.

Nowadays high rise building is constructed for the purpose of stiffness and lateral load resistance. Larger seismic waves strike the earth surface caused shaking the earth surface in all possible direction. Bracing are the most prominent method used by structural engineers. Increase the lateral load resistance by bracing. There are many braced system in RC structure (like v, Inverted v, K and X, diagonal type) Structures are connected with various activities like sport, healthcare, transport, residence and power generation. Colum and beam distribute the gravity load in to the structure but there are not significant for stability of structure. They provide the different bracing system to transfer the seismic wave in to the structure. With the different method we analyses the structure. Reinforced Concrete bracings are most used in RC structure. Reinforced Concrete bracings transfer the load to the frame. India is fast developing country which demand hybrid structure or building with high seismic resistance. The multistory building requires safety due to earthquake and wind forces. Damage to the RC building causes seismic waves of earthquake and low strength of material used. Bracing stable the multistory building. Reinforced Concrete bracings mostly used in that RC structure. Most of structure collapse due to seismic waves. In this project we are adopting X-type bracing system and V-type bracing system. The RC buildings used in this study are G+11 storied. All building models have same floor plan in X and Z both direction. Four Models were generated in STAAD-PRO Software.

1.1 Strengthening Of RCC Structures with Concrete Bracing Systems

Concrete bracing is a highly efficient and economical method of resisting horizontal forces in a frame structure. Bracing has been used to stabilize laterally the majority of the world's tallest building structures as well as one of the major retrofit measures. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing stiffness and strength against horizontal shear. A number of researchers

have investigated various techniques such as infilling walls, adding walls to existing columns, encasing columns, and adding concrete bracing or steel bracing to improve the strength and/or ductility of existing buildings. A bracing system improves the seismic performance of the frame by increasing its stiffness and capacity. Through the addition of the bracing system, load could be transferred out of the frame and into the braces, bypassing the weak columns while increasing strength. Steel braced frames are efficient structural systems for buildings subjected to seismic or wind lateral loadings.

1.2 Importance of seismic analysis

Earthquake is one of the most unpredictable and massive damage causing phenomena of nature. With immense loss of life and property witnessed in last couple of decades alone in India due to failure of structure caused by earthquake, attention is now being given to detail study related to Earthquake. Although a great deal has been learned about earthquakes and their effects on buildings during the last 50 years, seismic design is still an inexact science. Because seismic design deals with dynamic forces rather than static forces, and because of the many variables involved, it is often difficult to precisely predict the performance of a building in an earthquake and provide the best possible design to resist the resulting lateral forces. Another difficulty with seismic design is that the forces produced by an earthquake are so great that no building can economically and reasonably be designed to completely resist all loads in a major earthquake without damage. Building codes and analytical methods of designer, therefore, a compromise between what could resist all earthquakes and what is reasonable. Because of this, the current approach in designing earthquake resistant structures is that they should first of all not collapse during major seismic activity. Additionally, the components of buildings should not cause other damage or personal injury even though they may be structurally damaged themselves.

1.3 Objective

- To understand various types of structures and bracing systems and their behavior.
- To identify the suitable bracing system for resisting the lateral loads efficiently in seismic zone III and IV.
- To explain the advantages of braced systems.
- To discuss the limitations of Braced frames.
- Establishing a comparison between the structures and analysing the result and establishing a needful similarity with effectiveness in tabular form

II. Literature Review

Kartik Prashar[1] In this paper, the structure is analyzed for seismic zone V with different types of bracing system and compared with the bare frame with the using of ETAB software. The load condition is applied as per IS 1893:2002. Bracing system improve the displacement capacity of the structure. In tall RC [reinforced concrete] building bracing system is provide for stiffness, strength and energy dissipation to resist the lateral load. The study is about the different bracing system (diagonal type, V type, inverted and k type) and arrangement of bracing system. To build the seismically safe structure with adequate lateral resistance. Bracing system is installed between column members to resist the lateral load. Bracing system is easy to installed, economical and occupies less space. Steel bracing system is an efficient and effective lateral load resisting system. Steel braced RC frame as the lateral load resistance system for reinforced concrete structure is a effective technique. Structure with different types of bracing system reduce the storey drift and displacement of the structure. Out of various arrangements of bracing, X- bracing system are more effective in increasing lateral load capacity of structure. Bracing system reduce bending moment and shear force in the column. Steel bracing transfer the lateral load through axial action. The performance of the steel cross bracing is better than other bracing system. Steel bracing can be used to retrofit the existing structure.

Mehul M. kanthariya[2] In general the structures are analysis as RC structure RCC high rise building of G + 10 Storey is used for bracing system to improve seismic resistance using various type of R.C.C. bracing system such as single diagonal bracing, Double diagonal bracing in seismic zone III using IS-1893:2002 for RC structure. Compare base shear, bending moment, deflection of a structure analysis by using STAAD PRO V8i. Bracing, which provides stability and resists lateral loads, may be from diagonal steel members or, from a concrete 'core'. In braced construction, beams and columns are designed under vertical load only, assuming the bracing system carries all lateral loads. Braced systems exhibit high lateral stiffness and strength under moderate-to-large magnitude earthquakes. When establishing a Comparison of bending moment of both bracing systems. From the table-1 and chart-1 is represented deflection in single and diagonal bracing systems. Deflection in single diagonal system deflection is more compare to double diagonal bracing system and produce jerk in single diagonal system. From the table-1 and chart-1 is represented shear force in single and diagonal bracing systems. In this chart shown very clearly base shear is high in top in single diagonal bracing system and average decrease to floor to floor.

Prof. Bhosle A. Tanaji[3] Concrete braced and steel braced reinforced concrete frame is one of the structural systems used to resist earthquake loads in multistoried buildings. Many existing reinforced concrete buildings need retrofit to overcome deficiencies to resist seismic loads. The use of concrete and steel bracing systems for strengthening seismically inadequate reinforced concrete frames is a viable solution for enhancing earthquake resistance. Concrete and steel bracing is economical, easy to erect, occupies less space and has flexibility to design for meeting the required strength and stiffness. In this study, the seismic analysis of reinforced concrete (RC) buildings with different types of bracing (Diagonal, V type, Inverted V type, Combine V type and X type) is studied. The bracing is provided for peripheral columns and any two parallel sides of building model. A thirteen-storey building is analyzed for seismic zone III as per IS 1893: 2002 using ETAB software. The percentage reduction in storey displacement is found out. It is found that the X type of concrete bracing significantly contributes to the structural stiffness and reduces the maximum storey drift of the frames.

III. Problem Statement And Methodology

Analysis of any structure for resisting earthquake is the basic need of this study. In this project analysis of a seismic resistant structure is a need of concern, and thereby establishing a comparison between structures with normal bracing with flanged concrete column. In high rise structures most adoptable type to resist earthquake is to provide bracing. Basically, many analysis and design software's can be adopted to analyse and design any earthquake resistant structure. The structure selected for this project is a Residential building (Hotel, apartment type) with the following description as stated below.

Table 1: Problem Statement For The Project Models

Sr. No.	Description of structure	Values
1	Grade of concrete	M30
2	Grade of steel	Fe415
3	Number of bays in X direction and its width	6 bays of 4 m each
4	Number of bays in Z direction and its width	5 bays of 3 m each
5	Story height	3 m each
6	Number of storey (Excluding the plinth and substructure and including the Ground floor)	12
7	Depth of foundation from ground level	2.5 m
8	Plinth height	600 mm
9	Column size	300 mm x 600 mm

10	Beam size	300 mm x 450 mm
11	Thickness of Slab	150 mm
12	Density of concrete	25 kN/m^3
13	Live load on roof	1.5 kN/m^2
14	Live load on floors	3 kN/m^2
15	Floor finish	1 kN/m^2
16	Brick wall on peripheral beams	230 mm
17	Brick wall on internal beams	115 mm
18	Density of brick wall	20 kN/m^3
19	Internal Plaster	12mm
20	External Plaster	15mm
21	Density of Plaster	18 kN/m^3

For the present study following values for seismic analysis are assumed. The values are assumed on the basis of reference steps given in IS 1893-2002, 13920-1993 and IS 456:2000. For this present study assigning zone III & IV for moderate seismic intensity as stated in table 2 of IS 1893 – 2002.

Table 2: Seismic Parameters

1	Zone factor for zone III & IV	0.16 & 0.24 (Table 2, Clause 6.4.2)
2	Importance factor	1 (Table 6, Clause 6.4.2)
3	Special Reinforced Concrete Moment resisting Frame	
4	SMRF is a moment resisting frame detailed to provide ductile behavior and comply with the requirements of 13920-1993	
5	Response reduction factor	5 (Table 7, Clause 6.4.2)
6	Type of soil	Medium (Type II)
8	Damping percent	5 % (0.05)
9	Thickness of Shear wall	230 mm

1. Plan and Model Generated for Problem Statement

From the values mentioned in the problem definition five models are generated to study the behavior of earthquake resistant structure. Figure 2 shows plan of the structure generated in STAAD Pro V8i SS5.

Following are the models generated.

i. Model I: Simple structure without any bracing. Figure 2 (Model I) illustrates this model. In this model all the parameters are considered for designing the structure as earthquake proof as per IS1893:2002. ii. Model II: Double diagonal Bracing. Figure 2 (Model II) illustrates the model. In this model all the parameters are same as model I. iii. Model III: Inverted V Bracing iv. Model IV: Single Diagonal Bracing v. Model V: V-type Bracing.

2. Calculation of Load and Earthquake related Parameters: -

i. Dead load of slab = (0.15 x 1 x 25)
= 3.75 kN/m2

ii. Dead load of Outer Brick wall can
be calculated as = (0.23) x (3-0.45) x 20
= 11.73 kN/m

iii. Dead load of Inner Brick wall can
be calculated as = (0.115) x (3-0.45) x 20
= 5.87 kN/m

iv. Dead load of Parapet wall can
be calculated as = (0.23) x (1) x (20)
= 4.6 kN/m

v. Dead load of Plaster for outer walls can

be calculated as = (0.015+0.012) x (3-0.45) x 18
= 1.24 kN/m

vi. Dead load of Plaster for inner walls
and parapet wall can be calculated as
= (0.012+0.012) x (3-0.45) x 18
= 1.10 kN/m

vii. Total Dead Load for outer walls
= 11.73 +1.24 = 12.97 (considering 85% of weight due to openings) i.e. 11.02 kN/m

viii. Total Dead Load for inner walls
= 5.87+1.04 = 6.56 kN/m (Least openings are there in Partitions)

ix. Total Dead Load for Parapet walls
= 4.6 +1.10 = 5.70 kN/m

3. Seismic Weight Calculation: As per Table 8 in Clause 7.3.1 of IS 1893 (Part 1):2002 "Percentage of Imposed Load to be considered in Seismic Weight calculation" (As per the norms given in the IS 1893 (Part 1):2002 for live load greater than 3, 50% of the live load is added for seismic weight. And for live load up to and less than 3, 25% live load is added for seismic weight).

i. Total Seismic weight floors = 3.75 + (0.25 x 3)
= 4.5 kN/m2

ii. Total Seismic weight roof floors = 3.75 kN/m2

iii. STAAD Pro V8i SS5 calculates the design base shear by adding some useful parameters during analysis. The fundamental natural period of vibration (Ta) is calculated by

Ta = 0.09h/√d , Where, "h" = height of building and "d" = width of building at plinth height in a particular direction

a) Hence along X- Direction, Ta = 0.09h/√d =0.09x36/√20= 0.724

b) Along Z- Direction, Ta = = 0.09h/√d =0.09x36/√20= 0.724

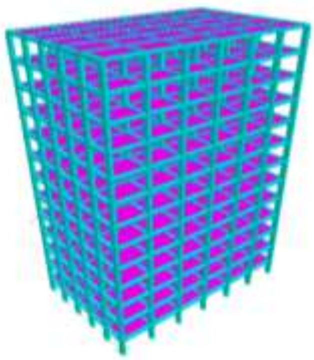

Figure 1: - Models generated in STAAD Pro V8i SS5 for the Problem Statement.

4. Loadings and Analysis Loads as mentioned above are added and generated in STAAD Pro V8i SS5 for earthquake analysis and applied to the prepared models as shown in figure 2.

Dead Load
Live Load
Roof Live Load
Earthquake Load in +ve X- Direction

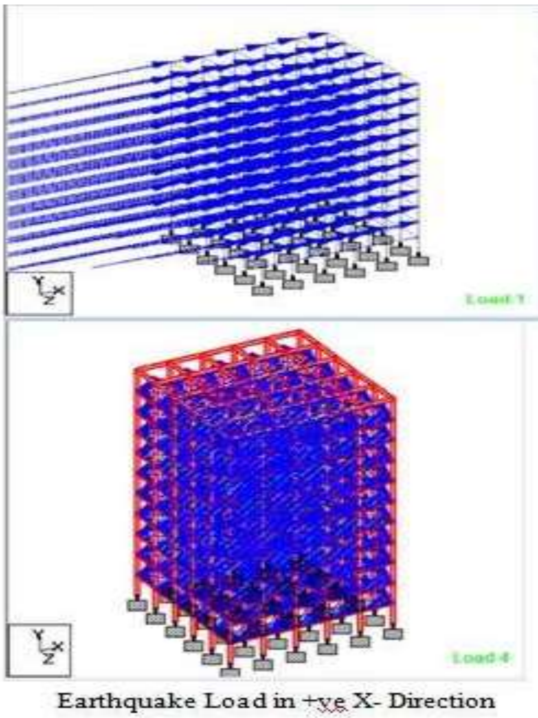

Figure 2: - Load distribution for Model I (STAAD Pro V8i SS5 model)

Loads as mentioned above are added and generated in STAAD Pro V8i SS5 for earthquake analysis and applied to the prepared models as shown in figure 1. The wall loads (Member loads) are same for all the floors except roof floor.

Load Combination along -ve X- direction for Model I

Load Combination along +ve X- direction for Model I

Earthquake load on Model II along +ve X- direction

Earthquake load on Model II along +ve X- direction

Figure 2.1: - Dead load, live load and seismic load (STAAD Pro V8i SS5 model).

A plan generated in STAAD Pro V8i SS5 and the floor loads distributed on the respective beams on each floor as per the guidelines of IS 456: 2000. All the models are same in size and height except the introduction of bracing and without Bracing in model II and model III respectively.

IV. Result And Discussion

The equivalent static method or seismic coefficient method had been used to find the design lateral forces along the storey in X and Z direction of the building since the building is unsymmetrical. A 12 storied RCC building in zone III and IV is modelled using STAAD Pro V8i SS5 software and the results are computed. The configurations of all the models are discussed in previous chapter. Each zone for five models were prepared based on different configuration, Model I for without bracing of multistoried building, Model II for double Model III diagonal bracing, Model IV inverted v bracing, Model V single diagonal bracing. These models are analyzed and designed as per the specifications of Indian Standard codes IS1893, IS 13920, IS 875 and IS 456: 2000.

Figure 3: - Maximum Nodal Displacements

Sr. No.	Height Of Building	Bracing Patterns	Max Displacement MM (zone no III)	Max Displacement MM (zone no IV)
1)	G + 11	Without Bracing	53.84	79.97
2)	G + 11	X Bracing	17.12	19.58
3)	G + 11	Inverted V Bracing	19.20	25.04
4)	G + 11	Diagonal Bracing	29.80	33.50
5)	G + 11	V Bracing	20.04	23.204

Figure 4: - Maximum base Shear Force

Sr. No.	Height Of Building	Bracing Patterns	Max Base Shear KN (zone no III)	Max Base Shear KN (zone no IV)
1)	G + 11	Without Bracing	44.49	66.63
2)	G + 11	X Bracing	47.97	67.31
3)	G + 11	Inverted V Bracing	47.32	66.32
4)	G + 11	Diagonal Bracing	48.62	68.65
5)	G + 11	V Bracing	54.85	74.70

Figure 5: - Maximum Base Moment

Sr. No.	Height Of Building	Bracing Patterns	Max Base Moment KN-M (zone no III)	Max Base Moment KN-M (zone no IV)
1)	G + 11	Without Bracing	75.67	112.90
2)	G + 11	X Bracing	84.74	120.81
3)	G + 11	Inverted V Bracing	79.76	114.97
4)	G + 11	Diagonal Bracing	88.40	122.32
5)	G + 11	V Bracing	93.12	129.72

V. Conclusions

In present study ten models are designed and analyzed by the help of civil engineering structural software STAAD PRO. First five models M1, M2, M3, M4 and M5 are in seismic zone III respectively without bracing, X bracing, Inverted V Bracing, Diagonal Bracing and V bracing. Another five models M6, M7, M8, M9 and M10 are in seismic zone IV. All models having same plan aspect ratio and same slenderness ratios. The structural members such as Coolum, beam, slab and foundation have same dimension in all models. As per previous chapter data some important point can be made in term of conclusion given below.

1. Higher seismic zone having higher nodal displacement. In seismic zone IV, value of displacement is 79.971 mm and 53.838 mm in seismic Zone III.
2. The bracing system effectively reduces the lateral displacement (up to 75%) of the structure compared to Bare frame.
3. In both zones X type bracing have minimum value of displacement. So X type of bracing is more effective to resist deformation or X type bracing make stiff of any building compare then other type of bracing.
4. The base shear of bracing frame building increased as compare to building without bracing which indicates that the stiffness oh building increases.

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