Seismic Analysis of Multi-Storey Steel-Concrete Composite Frame By Using Various Bracing Systems

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Abstract-*This study aimed to compare the seismic behavior of different bracing systems in steel concrete composite buildings. This paper presents the comprehensive analysis of G+9 building Which is situated in earthquake zone III, The provisions of IS: 1893 (Part 1) is considered. A three dimensional modelling and analysis of the structure are carried out with the help of STAAD PRO software. Equivalent static analyses are carried out on all structures. The results show that the different braced frames performed well in terms of storey displacement, inter-storey drift ratio, base shear and performance point when compared with the moment resisting frame in high rise steel buildings.*

Keywords-Composite building, Seismic Analysis, Bracings, Moment resisting frame.

I. INTRODUCTION

In India most of the building structures fall under the category of low rise buildings. So, for these structures reinforced concrete members are used widely because the construction becomes quite convenient and economical in nature. But since the population in cities is growing exponentially and the land is limited, there is a need of vertical growth of buildings in these cities. So, for the fulfilment of this purpose a large number of medium to high rise buildings are coming up these days But in medium and high rise buildings, the conventional reinforced concrete construction cannot be adopted as there is increased dead load along with span restrictions, less stiffness and framework and complementary to each other they have an ideal combination of strengths with the concrete efficient in compression and the steel in tension; concrete also gives corrosion protection and thermal insulation to the steel at elevated temperatures and additionally can restrain slender steel sections from local or lateral-tensional buckling. This paper includes comparative study of RCC with Composite Story building Comparative study includes Storey Stiffness, Displacement, Drifts, Axial Force in column, Shear force in column, Twisting Moment in composite with respect to RCC Sections .Steel-concrete composite frame system can provide an effective and economic solution to most of these problems in medium to high-rise buildings.

Generally, global modifications to the structural system are conceived such that the design demands, often denoted by target displacement, on the existing structural and non-structural components, are less than their capacities. Lower demands may reduce the risk of brittle failures in the structure and/or avoid the interruption of its functionality. The attainment of global structural ductility is achieved within the design capacity by forcing inelasticity to

Several configurations of braced frames may be used for seismic rehabilitation. The most common are concentric braced frames (CBFs), eccentric braced frames (EBFs) and the novel knee-brace frames (KBFs), recently proposed for earthquake loads. Common configurations for CBFs include V and inverted-V bracings, K, X and diagonal bracings. However, V bracings are not advised for retrofitting because of the likelihood of damage in the beam mid-span. Under horizontal forces the compressed braces may buckle, thus reducing their load bearing capacity abruptly. Conversely, the force in the tension braces increases monotonically reaching yield strength and eventually strain-hardening. The net result is an unbalanced force concentrated at the brace-to-beam connection.

Alternatively, the unbalanced force in the beams may be eliminated through ad hoc bracing configurations such as macro-bracings, e.g., two, three storey X-bracings or V-bracings with a zipper column.

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This study aimed to compare the seismic behaviour of different bracing systems in high rise 2-D steel buildings. Nonlinear static pushover analyses were carried out to assess the structural performance on different bracing systems in high rise steel buildings of 15, 20, 25, 30 and 35 storeys. including type of the bracing system, the height of the building and lateral load patterns, were investigated. The results show that the different braced frames performed well in terms of storey displacement, inter-storey drift ratio, base shear and performance point when compared with the moment resisting frame in high rise steel buildings. It can be concluded, on a comparative account of the obtained results that use of CBF, VBF and ZBF enhances structural performances.

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Steel-concrete composite construction system is an efficient, economical and innovative method for seismic resistance of multi storied buildings. Equivalent static method of seismic analysis used in the analysis of geometric models and the results are compared with STRAP software. This study makes an attempt, to develop efficient geometric models for new constructions, and to provide necessary structural configuration against retrofitting of the existing structures, constructed in earthquake prone regions.

1.1. Steel bracings

On a global basis of resisting earthquake loads, shear walls are commonly used in RC framed buildings, whereas, steel bracing is most often used in steel structures. In the last two decades, a number of reports have also indicated the effective use of steel bracing in RC frames. The bracing methods adopted fall into two main categories, namely:

- External bracing
- Internal bracing

In the external bracing system, existing buildings are retrofitted by attaching a local or global steel bracing system to the exterior frames. Architectural concerns and difficulties in providing appropriate connections between the steel bracing and RC frames are two of the shortcomings of this method. In the internal bracing method, the buildings are retrofitted by incorporating a bracing system inside the individual units or panels of the RC frames. The bracing may be attached to the RC frame either indirectly or directly.

There are two types of bracing systems

- Concentric Bracing System
- Eccentric Bracing System

The concentric bracings increase the lateral stiffness of the frame, thus increasing the natural frequency and also usually decreasing the lateral drift. However, increase in the stiffness may attract a larger inertia force due to earthquake. Eccentric Bracings reduce the lateral stiffness of the system and improve the energy dissipation capacity. Due to eccentric connection of the braces to beams, the lateral stiffness of the system depends upon the flexural stiffness of the beams and columns, thus reducing the lateral stiffness of the frame.

Concentric Bracings

Eccentric Bracings

Fig. 1: Different configuration of bracing system

1.2. Structural configurations

Constitute five different types of braced frame models (a, b, c, d, and e) considered in the analysis.

- Model (a) is a Moment resisting frame structure without bracings.
- Model (b) is a chevron braced frames (CBFs) bracing.
- Model (c) is a V braced frames (VBFs) bracing.
- Model (d) is an X type bracing pattern respectively, arranged in the end span of external frame.
- Model (e) is a zipper braced frames (ZBFs) bracing pattern arranged in the end span of external frame.

The explained five types of building models analysed by using Equivalent static method and the results are verified by software. Design parameters such as support reactions, bending moment, shear force, overall deflection, and story drift are verified by manually.

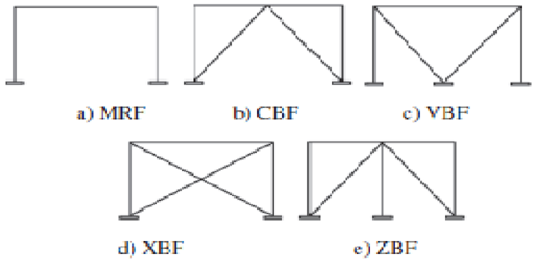


Fig. 2: Structural configuration of different bracing system

II. OBJECTIVES

1. The analysis and design of composite structure with different bracing under seismic loading by using STAAD PRO software.
2. To compare response of braced and unbraced building subjected to lateral loads and identify the suitable bracing systems for resisting the seismic loads efficiently.
3. To study the parameter such as story drift, base shear, time period, lateral displacement are compared along with the parameter obtained from seismic analysis.
4. Results are compared with moment resisting frame for the base shear, storey displacement and storey drift.

III. METHODOLOGY

3.1. Equivalent static analysis

This method is based on the assumption that whole of the seismic mass of the structure vibrates with a single time period. The structure is assumed to be in its fundamental mode of vibration. As per the IS 1893: 2002, total design seismic base shear is found by the multiplication of seismic weight of the building and the design horizontal acceleration spectrum value. This force is distributed horizontally in the proportion of mass and it should act at the vertical center of mass of the structure.

- The weight of all the floors and the roof is calculated and total seismic weight of the building is found out.

$$W = \sum_{i=1}^{n} W i$$

- The approximate fundamental natural period of vibration (Ta), in seconds, of all buildings, including moment-resisting frame buildings with brick infill panels, is estimated by the empirical expression

$$Ta = \frac{0.09h}{\sqrt{d}}$$

- The design horizontal seismic coefficient $h\ A$ for a structure is determined by the following expression

$$Ah = \frac{Z}{2} \times \frac{I}{R} \times \frac{Sa}{g}$$

- The total design lateral force or design seismic base shear is determined by the following expression.

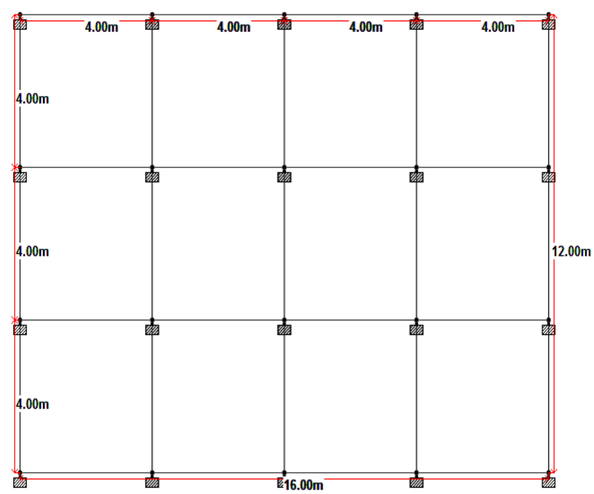
$$VB = Ah \times W$$

- The design base shear computed as above is distributed along the height of building as per the following expression.

$$Qi = VB \frac{Wihi^k}{\sum_{j=1}^{n} Wjhj^k}$$

IV. MODELING OF COMPOSITE STRUCTURE

The objective of this study is to develop efficient building models by using combination of braced frames. Five types of multi storied braced frame models are developed in seismic zone and evaluated its structural performance with respect to member strength, ductility and inter storey drift. Equivalent static method used for seismic analysis and the results are verified by software. The results of all five models are analysed and selected an efficient structural model for design of ten storied commercial building. The steel concrete composite building used in this study is ten storied (G+9). building have same floor plan with 4 bays having 4m distance along longitudinal direction and 3 bays having 4m distance along transverse direction as shown in figure.



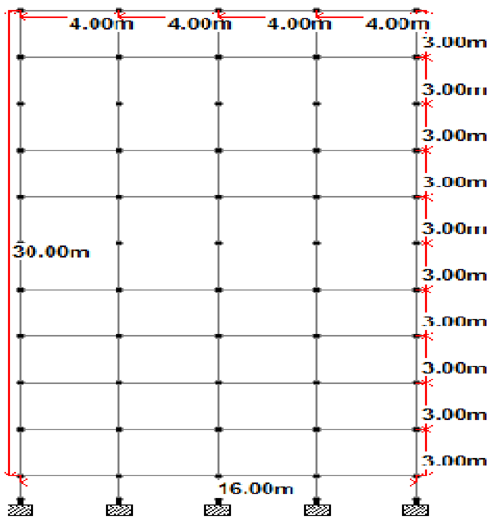


Fig.3 Plan and Elevation of RCC Frame

V. DESIGN DATA

Composite floors are designed based on limit state design philosophy. Since IS 456:2000 is also based on limit state methods, the same has been followed wherever it is applicable. The design should ensure an adequate degree of safety and serviceability of structure. The structure should therefore be checked for ultimate and serviceability limit states.

Model: G+9
Seismic zone: III
Zone factor: 0.16
Importance factor: 1
Height of building: 31.5 m
Floor height: 3.00m
Depth of foundation: 1.5 m
Plan size: 20 m X 15 m
Type of soil: Medium
Slab depth: 120 mm thick for R.C.C.
Wall thickness: 230 mm.

Material Properties

Unit weight of masonry: 20kN/m^3
Unit weight of R.C.C.: 25kN/m^3
Unit weight of steel: 79kN/m^3
Grade of concrete: M20 for R.C.C and Steel.
Grade of steel: HYSD bars for reinforcement Fe 415
Modulus of Elasticity for R.C.C.: 5000 X N/mm^2
Modulus of Elasticity for Steel: 2.1 x 105N/mm^2
The steel bracing used is ISA 110X110X10.
Codes for analysis
RCC design: IS 456:2000
Composite design: IS 11384
Seismic analysis is carried out on building models using the software Staad pro V8i. The load cases considered in the seismic analysis are as per IS 1893 – 2002 and IS 456.

VI. RESULT AND DISCUSSION

6.1 DYNAMIC LOAD

For dynamic load El-centro data is applied to the current structural systems and following results were obtained

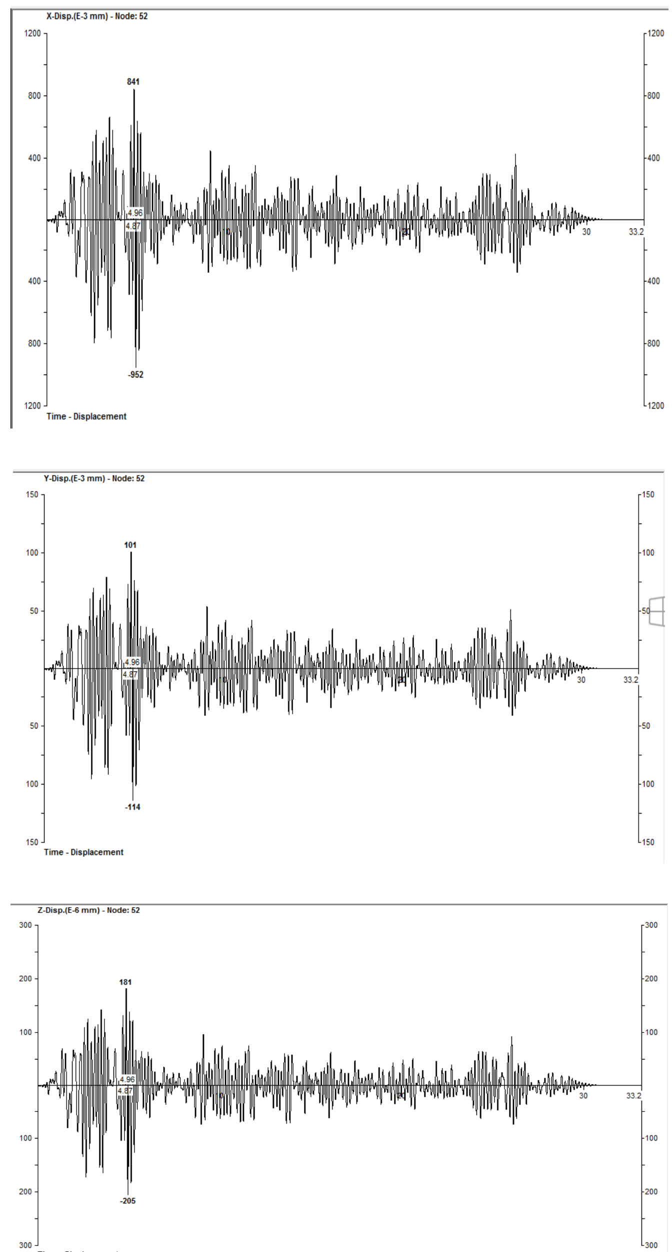


Fig. 4: Top node displacement, velocity, and acceleration of 30m for k-bracing tower due to 1940 Imperial Valley (El Centro) ground motion in x-direction

6.2 STORY DRIFT

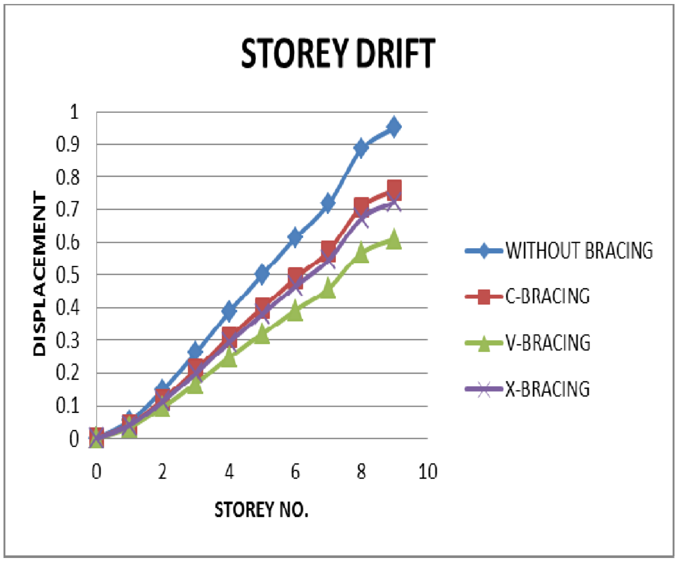


Fig. 5: Comparison of story drift of all models

VII. CONCLUSIONS

In the research paper high rise composite structure is analysed as per IS 11384 requirement, earthquake loadings are applied as per IS 1893:2002.In later part X-bracings, C bracing, V bracings and moment resisting frame is analysed using Staad-Pro

- For earthquake along EQ+X,EQ-X.EQ+Z,EQ-Z is applied and storey drift observed maximum in moment resisting frame is more as compared to bracing systems
- For dynamic loading i.e. El-centro peak value observed was 8.41 mm for moment resisting frame,in bracing system it is 20-30% less as compared to moment resisting frame

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