Comparison of seismic performance of reinforced concrete frame structure and composite frame structure using response spectrum analysis

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Abstract. This research is mainly focused on the behaviour of the concrete and composite framed structures when such structural buildings are subjected to special loadings such as seismic loading. To evaluate the forces and failures in such building subjected to seismic forces linear dynamic statistical analysis method - Response spectrum analysis is carried out. This method results us with a complete response of time history at each and every particular joint by showing its displacements and member forces. In this an RC framed structure of M25 grade of concrete with G+7 storey and also a Composite structure of G+6 storey is modelled in ETABS as per Indian Standard Code 1893: 2002 Part(I). The building is situated in Himachal Pradesh with a seismic intensity of zone factor V. The concept of strong column weak beam is adopted here throughout the paper. Response spectrum analysis technique was used with the help of ETABS for both the composite and reinforced concrete structure. The results were explained in detail having the parameters in consideration with the base shear, storey deflection and storey drift are compared for each model.

1. Introduction

Low raise buildings are the types of building which prevail very common in India at the current situation, such buildings are constructed with the help of conventional reinforced concrete members that are found to be easier for finishing the structural work and is also found economical. But in the cities which are densely populated the only choice for construction is high-raise construction. High-raise buildings have the same conventional method of concrete construction that will be having many restrictions such as the span, depth of the member, stiffness etc., For such reasons Steel concrete composite structures can be adopted. Steel concrete composite structures are highly efficient than the conventional concrete structures from cost and performance factors such as increased stiffness, lesser deflection, longer span, less overall weight, reduction in the slenderness of column etc.

Since earthquakes are generally unpredictable natural disaster, in order to find the response of the building for such seismic loadings, we should confirm the serviceability of the structure to give proper warning before failure of the structure for the large scale of earthquakes and the structure must withstand for small scale of loadings. The performance based design of reinforced concrete and steel concrete composite buildings under seismic loading for various parameters are compared in this study and the results are given as follows.
2. Literature Survey

Vishwanatha S N and D S Sandeep Kumar investigated the seismic performance of concrete and composite buildings for different constraints of vertical irregularities in buildings and composite columns are installed in the structure to increase the strength and fire resistance of the column and also to resist lateral forces. Finally, they concluded from their study is that the maximum storey drift and displacement will increases as the vertical irregularities increases. Jingbo and Yangbing studied the behaviour of composite framed structure system under seismic loads are studied in detail. In this study four types of columns such as composite beam concrete filled square tubular column, Equivalent stiffness RC column and other two types are analyzed under response spectrum analysis. And from the analysis of those columns and frame they come to a conclusion that, in composite frames the maximum storey drift angle is reduced by 18% and in composite we can achieve greater span and height but in RC the columns must be enlarged to meet the desired bearing capacity.

3. Elastic Analysis of Systems

The analysis can be carried out in two methods one is by using the equivalent lateral force that is the static method and the other one is dynamic method which is response spectrum method. Both the methods will lead to the analysis procedures of the horizontal forces in the direction of the ground motion component. The main differences between both the methods are the distribution of the lateral forces throughout the height of the building and the magnitude. In this study we have analyzed the structure by using the dynamic method that is by using Response spectrum method.

3.1 Response Spectrum Analysis

It is the Linear Dynamic statistical method and this is also called as mode super position method or modal method. This is one of the type of linear analysis of structures. This method is based on the criteria that for definite forms of damping the response of each and every individual natural mode of vibration is calculated independently of the others and the results of the response are combined together to find the complete response of the structure. Each mode we analysed would reflect its own mode shape, natural frequency with its own modal damping. A complete modal analysis of the structure gives us the full history of the response in various parameters such as forces, deformations and displacements with a ground acceleration history. This method is mainly applicable for the analysis of the dynamic response of the structures, and for asymmetrical buildings and buildings with some irregularities such as vertical irregularity or discontinuity. Square root of the sum of squares method.

![Figure 1. Plan of the structure.](image-url)
Figure 2. Frame model of structure in ETABS.

- Complete quadratic Combination method
- Absolute peak values are summed up

3.2. Description of the framed model

The building which is modelled in ETABS software are of the following dimensions.

| Parameter                  | Value          |
|----------------------------|----------------|
| No of storey               | = G+6          |
| Structure                  | = OMRF         |
| $f_{ck}$                   | = 25N/mm$^2$   |
| $f_y$                      | = 415N/mm$^2$  |
| Spacing of frame           | = 3.5m         |
| Spacing of storey          | = 3m           |
| Type of Seismic analysis   | = Response Spectrum analysis |
| Seismic zone               | = V            |
| Important factor           | = 1.5          |
| Reduction factor           | = 2 (medium)   |
Figure 3. Deformed shape of RC structure.

Figure 4. Deformed shape of composite structure.

Figure 5. Deflection of RC structure.

Figure 6. Deflection of composite structure.
On performing the seismic analysis of the RCC and composite G+6 Storey building under response spectrum method the following conclusions were obtained.

- The deflection of the composite structure is more when compared with the RC structure, since the stiffness of the RC building is very high.
The storey drift of the composite structure is found maximum when it is compared with the RC building. This is mainly because of the stiffness criteria. The RC structure has more stiffness so that it has minimum storey drift.

When comparing the base shear parameter for both the composite and RC structure RC building has the maximum base shear. This is because of the self weight of the RC building.

References

[1] Vishwanatha S N, D S Sandeep Kumar, “Seismic Analysis Of Multistoreyed RCC And Composite Building Subjected To Vertical Irregularity”, International Research Journal of Engineering and Technology, Vol.5(5), pp.3628-3633, 2018.

[2] LIU Jingbo, LIU Yangbing, “Seismic Behavior Analysis Of Steel-Concrete Composite Frame Structure Systems”, The 14th World Conference on Earthquake Engineering, October 12-17, 2008, Beijing, China

[3] IS 11384:1985, “Code of Practice for Design of Composite Structure, Bureau of Indian Standards”, New Delhi.

[4] IS 800: 2007, “Indian Standard Code of practice for General Construction of Steel in India, Bureau of Indian Standards”, New Delhi.

[5] Earthquake resistant design of structures by S.K. Duggal.

[6] IS 456: 2000, “Code for practice of plain and reinforced concrete code of practice, Bureau of Indian Standards”, New Delhi.

[7] IS 1893: 2002, “Code for earthquake resistant design of structures- general provisions for buildings, Part I, Bureau of Indian Standards”, New Delhi.