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Seismic Response of Vertically Irregular Structure with Composite Columns

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Abstract – *Behaviour of a multi-storey building depends on its structural configuration during strong earthquake motion. One of the major causes of failure during earthquake is recognized as the Irregular configuration of the building either in plan or elevation. Structures generally possess combination of irregularities, the choice of type, degree and location of irregularities in the design of structures is important as it helps in improving the utility as well as aesthetics of the structures. And the use of composite materials is of particular importance, due to its significant potential in improving overall performance of the structures. In composite column construction, steel and concrete are unites in such a manner that materials are efficiently employed. In this study, the seismic response of a regular structure with composite column is compared with that of a regular structure. Vertically irregular structures are modelled by changing the distribution of mass, stiffness and strength along the height. The analysis is carried out by ETABS software, which is commonly used for structural analysis and design of building. By this study, it is possible to quantify the effects of vertical irregularities on the seismic performance of structures.*

Key Words: **Seismic response, Configuration, Vertical irregularity, Displacement, storey drift, Time period, ETABS, Time history analysis**

1. INTRODUCTION

In India, majority structures fall under the category of low-rise buildings. So, for these structures reinforced concrete members are used extensively because the construction becomes relatively convenient and provident in nature. But since the population is growing exponentially and the land is limited, there is a need of vertical growth of buildings. So, for the fulfilment of this purpose a large number of medium to high rise structures are coming up these days. For these high-rise structures, it has been noted that use of composite members in construction is more effective and profitable than using reinforced concrete members. Reinforced concretes frames are used in low rise structures because loading is nominal. But in medium and high-rise structures, the conventional reinforced concrete construction cannot be adopted as there is increased dead load along which is relatively vulnerable to hazards. In India use of steel is very less in construction industry compared to other developing nations like China, Brazil etc.

In a Composite Structure when a steel component, like an I section beam, is attached to a concrete component such that there is a transfer of forces and moments between them, then a composite member is formed. In such a member, the high strength of the concrete in compression complements the high strength of the steel in tension. Here it is very important, that both the materials are used to fullest of their capabilities. This gives an efficient and economical construction.

In this investigation, a vertically irregular structure with composite column is compared with that of a regular structure.

2. SCOPE AND OBJECTIVES

- A seismic analysis of multi-storied composite structure is carried-out for different parameters of vertical irregularities.
- The installation of composite column in a construction increases strength, fire resistance and resistance towards lateral forces.
- To ensure safety while constructing buildings in future**.**
- To study the seismic performance of an irregular multistorey building with composite column.
- To understand the behavior of vertical irregular structure with composite column on the basis of shear force, storey drift and storey displacement.

3. METHODOLOGY

The methodology adopted in order to lay focus on achieving the objectives is as follows: Three-dimensional mathematical modelling of Composite column building in ETABS software. Validation of software using ETABS software. Modelling of additional models in ETABS. Comparison of displacement, storey drift and base shear obtained using equivalent static analysis and response spectrum analysis. Interpretation of results.

4. MODELLING

ETABS software is used to model and analyse the buildings. A publication titled "Time-History Analysis of Reinforced Concrete Frame Buildings with Soft Storeys" was used to fix the dimensions of beams, column and slabs.

The support and loading conditions are also chosen according to the journal. The number of stories, dimensions of beams and columns and loads applied are the same with same properties for all the three models.

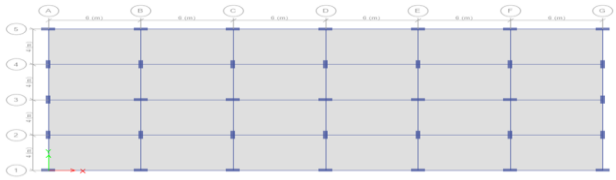

Fig-1: Plan view of the models

Table -1: Material Properties of the validated model

Properties	Values
Characteristic compressive strength of concrete, f_{ck}	30 MPa
Yield stress for steel, f_y	345 Mpa
Elastic modulus of steel, E_s	21,0000 Mpa
Elasticity modulus of concrete, E_c	27000 Mpa

Table -2: Geometry of the considered model

No. of storeys	X direction bay width	Y direction bay width	Height of bottom storey	Height of storey
13	6	4	3	3

As part of the research, three different types of models were examined. The three types are of vertical irregularities and they are examined with and without composite columns. These are vertical geometric irregular structures. The first model is symmetric on both axis (same on both plan view and elevation). The second model is symmetric on one axis (symmetry on plan view but asymmetric elevation). The third model is asymmetric (both in plan view and elevation). The composite column used is of same dimension (300*900) as that of the validated model with ISLB 600 Section.

In this investigation, the horizontal ground motion records of RSN:6, Imperial Valley02 El Centro (1940) from PEER ground motion data base have been selected for performing the nonlinear dynamic TH analysis.

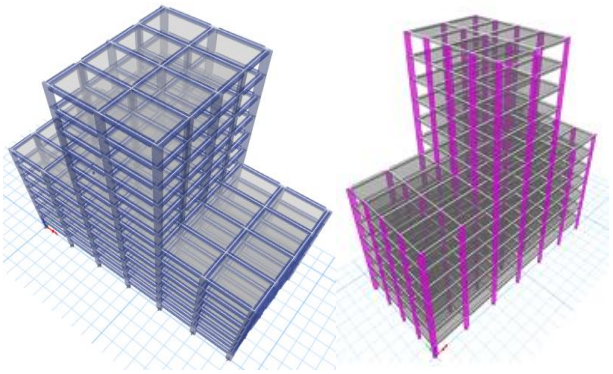

Fig-2: (a) IR1(b) IR1 with composite column

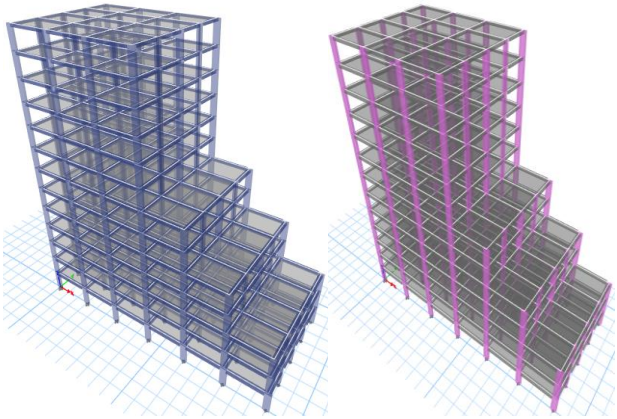

Fig-3: (a) IR2(b) IR2 with composite column

5. RESULTS

5.1 Seismic Analysis

Time History analysis is carried out in ETABS software. Storey displacement, storey drift and base shear are studied.

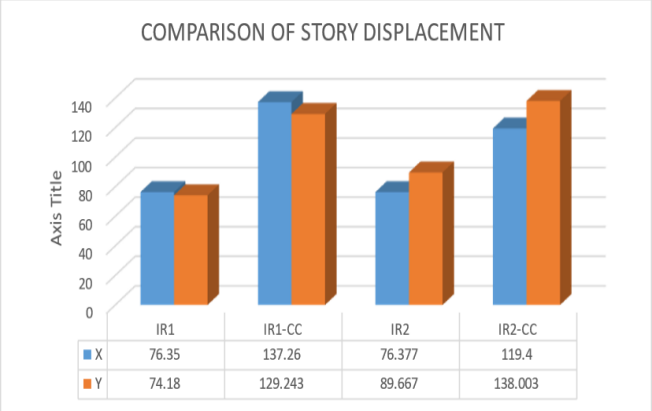

Chart 1 Comparison of storey displacements of models

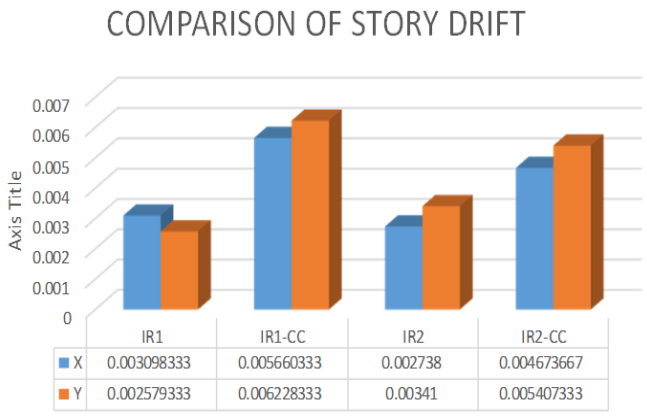

Chart 2 Comparison of story drift of models

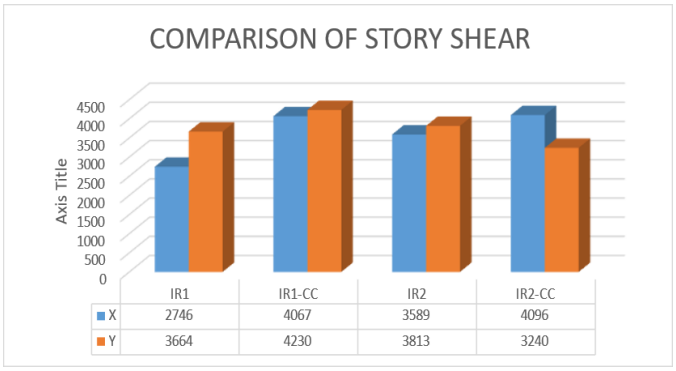

Chart 3 Comparison of story shear of models

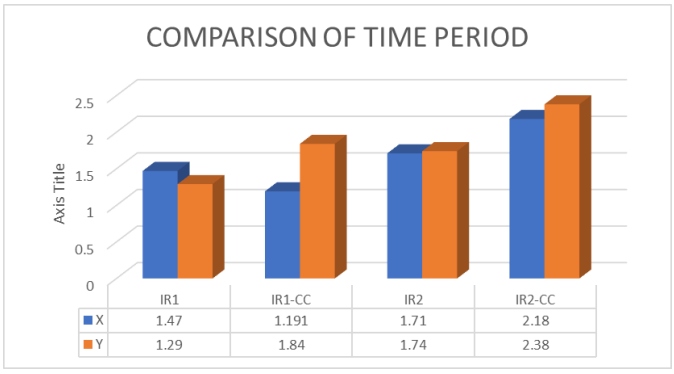

Chart 4 Comparison of time period of models

6. RESULTS AND DISCUSSION

The models with and without composite columns shows a higher displacement value than the validated model. Model IR2-CC shows highest value of displacement. The base shear of the models is comparatively lower than the validated model. Time period is comparatively higher which shows the models are flexible during earthquake which in turn reduce failure of the model. The percentage weight of the models decreased with composite column which helps in easy construction.

7. CONCLUSIONS

A G+12 multi storey rcc building is modelled and analysed as per reference journal [1]. Percentage error for time period, displacement and base shear is found to be 2.2, 7.42 and 6.22% respectively which is within the limit (15%). Hence the software is validated. Two types of models were modelled and analysed using etabs and the results were compared.

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