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Behaviour of RCC Building with Transfer Floor System under Earthquake Loading

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Abstract— ***Now a days building is constructed for mixed use like residential, commercial, parking etc. Transfer girder system is one of the way to provide large space at bottom stories and fulfil this requirement. In transfer floor system heavy load from top storey is transferred by transfer plate, transfer girder and largely spaced columns. Transfer floor system can be used for framed building as well as building with shear wall. As transfer floor system develops mass irregularity at transfer level, its behaviour under seismic load must be investigated. In this paper two case studies are conducted and seismic parameters are calculated. 3D finite element model is used for analysis. In one case study, analysis of moment resisting framed building is done with and without transfer floor system. In second case study building with shear wall is considered for analysis with and without transfer floor system. Equivalent static method is considered for analysis as per codal provision. Comparative study of seismic parameters like base shear, storey drift and storey displacement are done for different finite element models.***

Keywords— Transfer floor, base shear, storey drift, seismic, mass irregularity

I. INTRODUCTION

Conventional moment resisting framing consists of beam column which is generally used for medium height building. For high rise buildings shear wall, coupled shear wall is used which will restrict open space in the ground floor. In some cases, architectural requirement also needs open space at ground floor. Large opening space can be achieved by providing transfer beam at ground floor level which will collect vertical and horizontal load and distribute it to the widely spaced column or shear wall.

These transfer structure can be in the form of transfer girder and transfer plate supported by shear walls or columns. The analysis of these type of structure is complex and approximate formulation is not possible. Hence modeling with finite element analysis is required to understand actual structural behavior. One of the major challenges in transfer girder system is that it creates mass irregularity at transfer floor level which results in the formation of the soft storey below transfer floor level. At the exterior wall, shear concentration also developed significantly at transfer level.

II. LITERATURE REVIEW

In India, there are few buildings designed on the transfer floor mechanism. But in countries like China, Shri Lanka, and Australia there are a no. of examples. One of the researchers R.K.L.Su (2008) has investigated the inelastic behavior of transfer structures and suggested design principles for controlling the soft story. He has also reviewed the positioning of transfer floor on the seismic response. He has also reviewed the transfer structure by numerical analysis and shake table test. In another research Elawady, Abdelrahman and Sayed-Ahmed (2014) have analyzed a number of prototype model with transfer floor systems using finite element models. Methods like Elastic linear response spectrum and inelastic nonlinear time history analysis are used for analysis. The analysis concluded that the transfer girders system can be a better alternative with the comparison to transfer slab system as it reduces the seismic weights and material cost. Cheang, Xiaolei, Jian Qiu, Xuewei (2008) had introduced capacity design into the design of transfer storey structure. He has evaluated various parameters, overstrength of the shear wall, shear overstrength of coupling beam, that influence structure behavior under seismic loading.

III. METHODOLOGY

In the present work seismic analysis of RCC moment resisting frame building and RCC building with shear wall was analyzed with and without transfer girder system. Total height of building was 42m with G+ 14 storeys. The height of each storey was 3m. 3D modeling was done using ETABS software. Design of structural components was done in software. The seismic behavior of model was investigated by equivalent static method as per IS1893:2002. Seismic zone IV was considered with soil type medium.

CASE STUDY 1

A rectangular model with dimension 40m X 30m was chosen. Two models were analyzed for RCC moment resisting framed building, one with transfer floor system and another model was analyzed without transfer floor. For model without transfer floor system, typical beam size was 200mmX500mm and column size was 300mmX500mm for columns till 3rd story and 300x700 for the 3rd story to base. For the model with transfer floor system, the 3rd storey was considered as transfer floor above building configuration is same as that of the building without transfer floor. At 3rd storey, 600mm transfer slab was used. Size of transfer girder was 800mmX1000mm and 1000mmX1200mm depending upon the span of girder. Size of column below 3rd storey was 800mmX1400mm and 1200mmX1200mm. Design of all the members was done in ETABS.

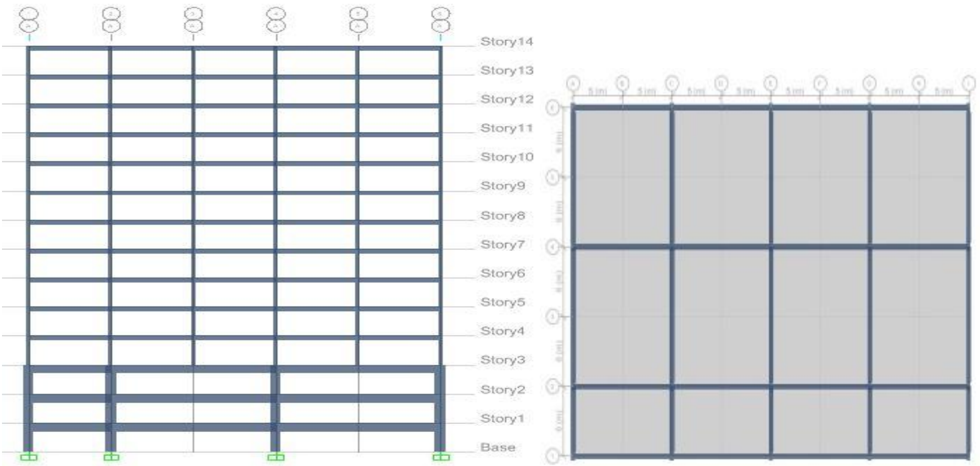


Fig -1: Elevation and Plan with Transfer Floor System

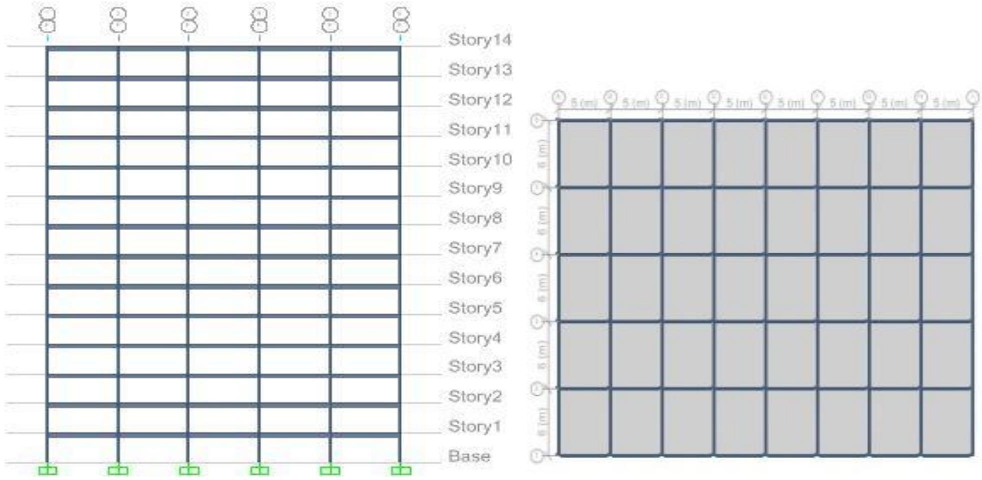


Fig -2: Elevation and Plan without Transfer Floor System

CASE STUDY 2

Another two models of RCC building with the shear wall was analyzed. Plan of the building was 40mX30m. One with transfer floor system and another model was analyzed without transfer floor. For model without transfer floor uniform shear wall and column was taken from base to roof level. The size of the shear wall was 150mm. size of beam and column were 200mmX500mm and 300mmX500mm respectively. For another model with transfer floor, the 3rd storey was considered as transfer floor and size of transfer girder was 800mmX1200mm. The thickness of transfer plate is 600mm. Column size below transfer floor is 1200mmX1200mm and 800mmX1000mm. Column size above transfer floor is 300mmX500mm. All the models were analyzed with the equivalent static method.

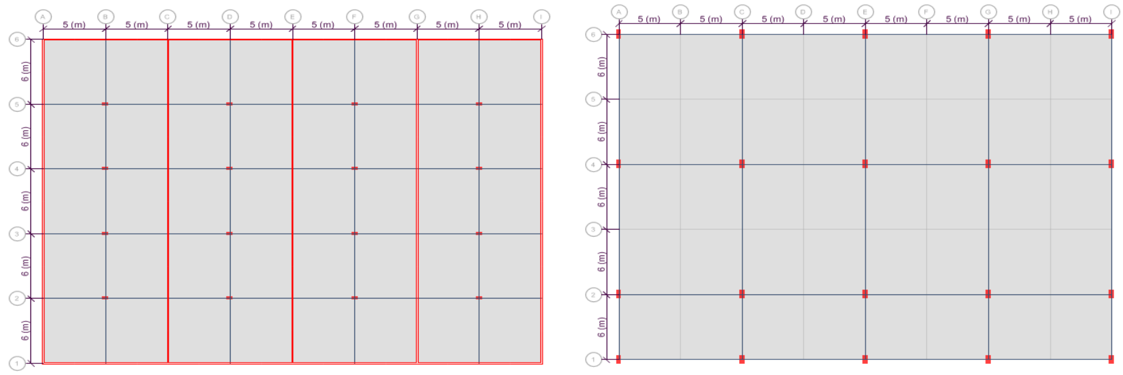


Fig -3: Plan at Typical floor and at Transfer floor

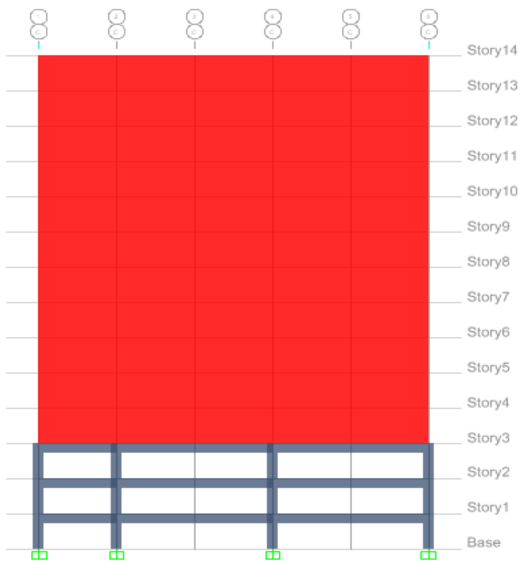


Fig -4: Elevation of Transfer Floor System

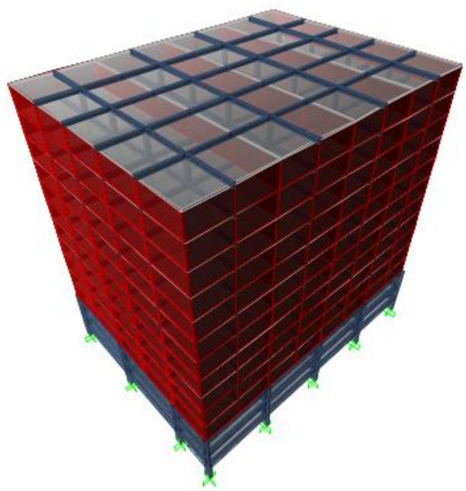


Fig -5: 3D model with transfer floor

IV. ANALYSIS AND RESULTS

Linear static was done according to IS1893:2002. Following results were obtained and represented in graphical form.

CASE STUDY 1

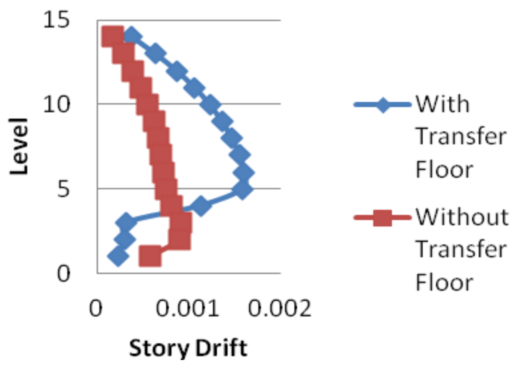


Fig-6: Storey Drift at different Storey Level

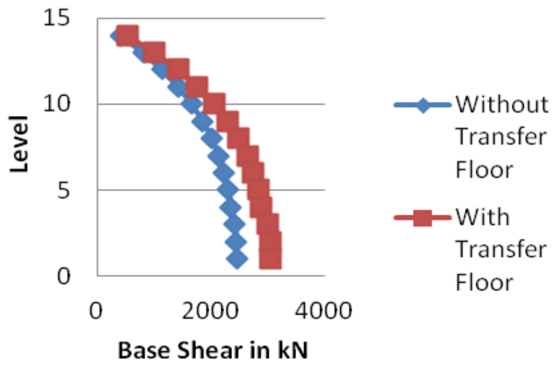


Fig 7 Vertical distribution of Total Base Shear

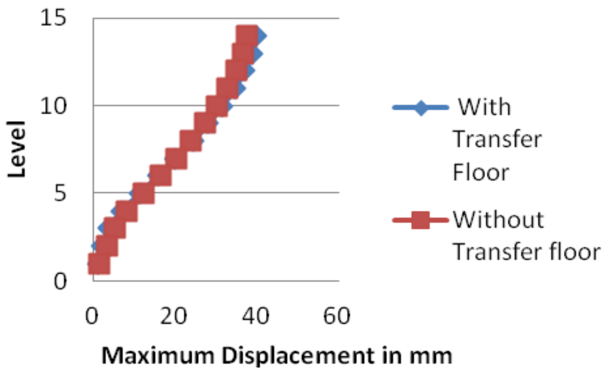
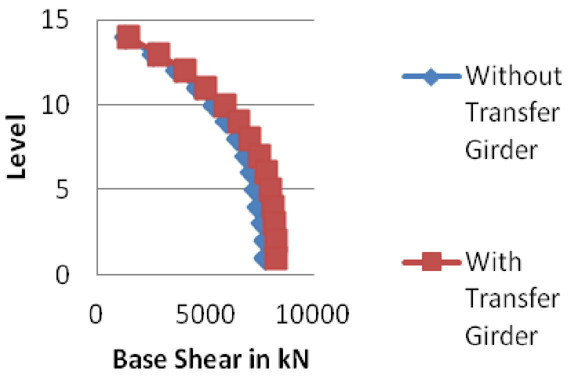


Fig 8 Maximum displacement at different level

Figure 6 shows the variation of storey drift with different storey level. From this graph, it can be seen that maximum drift was observed in structure with transfer floor system at levels between 6th to 4th storey. In figure 7, vertical distribution of total base shear in the x direction at the different storey was drawn. It can be seen that due to the large mass concentration at transfer floor, base shear was more in building with transfer floor system. Figure 8 shows the maximum displacement at various floor levels. It was observed that max. displacement was slightly more at bottom stories and less at top stories for the frame without transfer floor system.

CASE STUDY 2



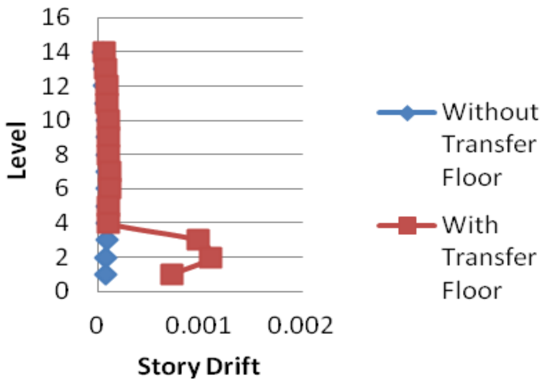


Fig. 9 Vertical distribution of Total Base Shear

Fig.10 Distribution of Storey Drift at different storey level

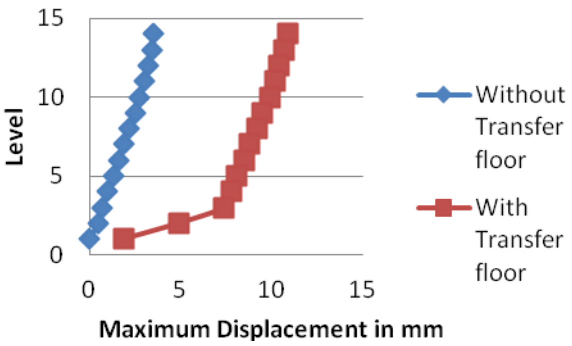


Fig. 11 Maximum displacement at different level

Figure 9 shows the variation of total static base shear in X direction at different storey levels. Similar result is obtained as of case 1 but the difference between the base shear for two cases of building with and without transfer floor, is less. Fig. 10 the shows variation of storey drift along different levels of building. Maximum storey drift was observed at level 2. The storey drift obtained for building with and without transfer floor system from 5th to 14th storey level was moderately same. Figure 11 represents the maximum displacement at different stories. It was observed that, for transfer floor system, max. displacement is more and it goes on increasing.

V. CONCLUSIONS

From above study of transfer floor system, following conclusions are drawn:

1) As the building with transfer floor system has mass irregularity at transfer level, storey drift was more near transfer level in both the cases.
2) Total base shear was more in case of transfer floor system in both the cases. The variation may be because of increase in dead weight at transfer floor level thereby increasing the seismic weight of the building.
3) Maximum displacement was observed at top floor in both the cases. The variation of maximum deflection was less in Case Study 1. On the other hand the variation of max displacement was significant for Case Study 2.
4) Transfer floor system should be only used where seismic force is not significant. If this system is used in seismic vulnerable zones, codal provision should be strictly followed.

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