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Behavior of difference types of transfer floors under seismic loads

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ABSTRACT

In normal cases, the columns that transfer the loads from the different building floors to the ground are vertical, but due to the increase in high rise buildings, especially multi-purpose buildings, it became necessary to make a transfer floor(s) to change the column system since it is logic to have same column in both residential and underneath commercial floors. Here the importance of the transformational roles floors with its various systems. In this research, a comparison has been made between two major different systems of transfer floors roles, namely the slab system and the beams system, and then a 30 cms thickness slab was integrated with beams once on the crown of the beams another one was in the bottom of the beams. A commercial program has been used, which is the Etabs program version 19, (in order to approximate the reality because Etabs is one of the most programs, which are used to design in reality). A three-dimensional model of the building with a transfer floor was made using ETABS program, a comparison was made between the four systems in the transfer floor, using the flexible response spectrum method. The impact of the transfer floor on the building's drift, building's displacement and the various obtaining actions were studied. The results show that using slab system is waste for money and the location of the slab in relative to beams has no effect.

KEYWORDS: Transfer slab, High rise building, Girder transfer slab, ad transfer buildings.

1-Introduction

Anitha. K, R.J Rinu Isah studied span to depth ratio, transverse girders' spacing and ratio of thickness of web to flange's thickness. These results were compared with numerical method. The results of the study give range of various parameters to be considered to obtain optimum performance of grid floors [1]. In 2021 Sophia A. Pechorskaya, et. al. presnt a comparison between influence of the structural analysis results from ETABS and RSA software for high rise building especially which is subjected to gravitational loads and lateral loads due to wind loads. The results presented from RSA software were bigger the results which presented from ETABS software [2]. Aqueeb Rizwaan Shaikh, et. al. made a study in International Journal of Scientific Research in Science and Technology. This study was a revision to the behavior transfer slab structures under different seismic zones and effective factors [3]. Yasser M. Abdlebasset , et. al. at 2016 made a nonlinear numerical analysis for high rise buildings with transfer floor taking in consideration the effect of construction stages. the effect of construction stages analysis while time dependent material properties of various structural elements for a high-rise building with a transfer floor on the performance and design of these buildings was assessed [4]. At 2014 Yasser M. ABDELBASSET. et. al. made a numerical modeling of high-rise building depends on reducing the stiffness for the vertical elements for strength analysis and full stiffness for drift analysis and serviceability. The effect of transfer floors on the buildings' drift was investigated where judgment for adopting a full or reduced stiffness for the vertical elements was scrutinized [5]. A study was made to present a seismic analysis of high rise building with transfer floor. Using ETABS 2016 and using linear response spectrum analysis a number of proto type models of high rise building were analyzed. Five different models of 10 stories building had been studied by providing a transfer slab at different floor levels such as first floor, second floor, third floor, fourth floor and fifth floor of the building and the vertical position of transfer slab with respect to building height was investigated [6]. Muchate B. G., Shaikh A. N. presented a seismic analysis of multi-storey building with transfer floor. In this paper, four different models of 10 storey building had studied by providing a transfer girder at different floor levels. And the vertical position of transfer girder with respect to building height was investigated. The seismic response of high rise building such as storey shear, storey moment, storey displacement, inter-storey were numerically evaluated [7]. In China at 2008 a paper proposes an integrated seismic optimum design approach for the high-rise buildings with girder transfer floor, including topology optimum design of the transfer floor and size optimum design of girders and columns. The initial cost and life cycle cost were employed as the objective function in the seismic design, respectively. Finally, a numerical example of 19-storey high-rise building was calculated, and the results showed the optimum design of minimum life cycle cost was more cost-effective [8]. In this paper, an analytical seismic study for the response of high rise buildings with transfer floors is carried out via 3-D modeling of these buildings using the finite element technique. The numerical models are analyzed using elastic response spectrum. A comparison between four kinds of transfer slabs was done.

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2. Methodology

The research had a numerical nature; it is performed using numerical modeling of prototypes for high-rise buildings with transfer floor. A three-dimensional finite element models for prototype buildings with transfer floor is built-up. The seismic response of these buildings was investigated using elastic response spectrum techniques as a first step of wider researches in future. The shear distribution, bending moment distribution for the storey, storey drift and floor displacements are numerically evaluated. Using the three-dimensional models, investigation into considering a comparison between the four systems are carried out.

3. Case Study

3.1 General

The linear elastic seismic behavior of structural wall buildings with transfer floors was studied using numerical investigation. The study considers four types of transfer: solid transfer plates (slabs) with thickness 1.5 m, girder system with beams of 1.5*1.5m dimensions, the previous beams combined with upper slab which has thickness 30 cm and the previous system but with moving the slab to the bottom of the beams.

A parametric study was conducted on a building with total number of 19 stories having transfer floor. Analytical results of this research present a comparison between the four types of transfer floor systems. These results cover the global behavior of the structures i.e., the value and distribution of shear and moment.

3.2 Seismic Input

Response spectrum analysis was conducted on the models to evaluate the behavior of the building incorporating the first twelve vibrational modes using the CQC combining sequence [9].

Cairo (Egypt), the location chosen for this study, falls under seismic zone 2A according to UBC 97[10]. The building floors are loaded such that for all typical floors above and including transfer floor, dead load is 3.0 kN/m^2 and the live load (LL) is 2.0 kN/m^2. For all typical floors below transfer floor dead load is 4.5kN/m^2 and the live load is 5.0 kN/m^2.

Linear time history analysis was performed on the numerical models of the prototype building in order to evaluate the base shear, the overturning moments, the shear distribution along the building height, the displacement and the story drift for the first twelve modes using CQC combining sequence According to most codes of practice. The displacement and the story drift for the first twelve modes using CQC combining sequence. The complete quadratic combination (CQC) rule for modal combination is applicable to a wider class of structures as it overcomes the limitations of the SRSS rule. According to the CQC rule,

$$r_o \simeq \left(\sum_{i=1}^{N} \sum_{n=1}^{N} \rho_{in} r_{io} r_{no} \right)^{1/2} \tag{1}$$

For more information about CQC back to reference [9].

Fig. 1. Response Spectrum

3.3 Modeling

A 19 storey building (simulated) was selected for analysis of high rise building with transfer slab. Building has a shear wall structure below the transfer floor and long spacing columns above the transfer floor.

The vertical position of transfer slab in high rise building 19 storey building was in 6th floor according to architectural requirements. Fig. 2 shows the building model with transfer slab which has been analyzed using elastic response spectrum using ETABS 2019 software.

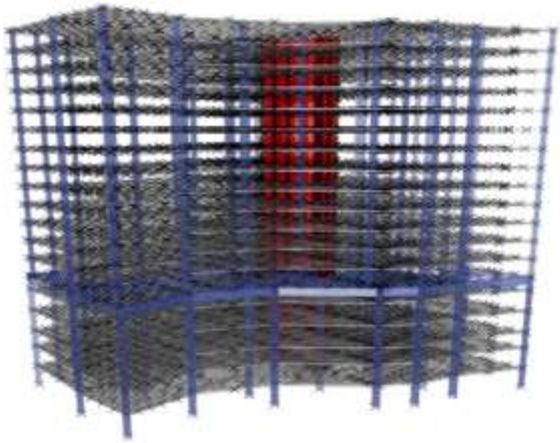

Fig. 2. Model shape

4. RESULTS

Structural model was created using ETABS 2019 to analyze the four systems of transfer floors. The study building has 19 stories. All interval faces and displacement were calculated and drawn as shown in the following figures.

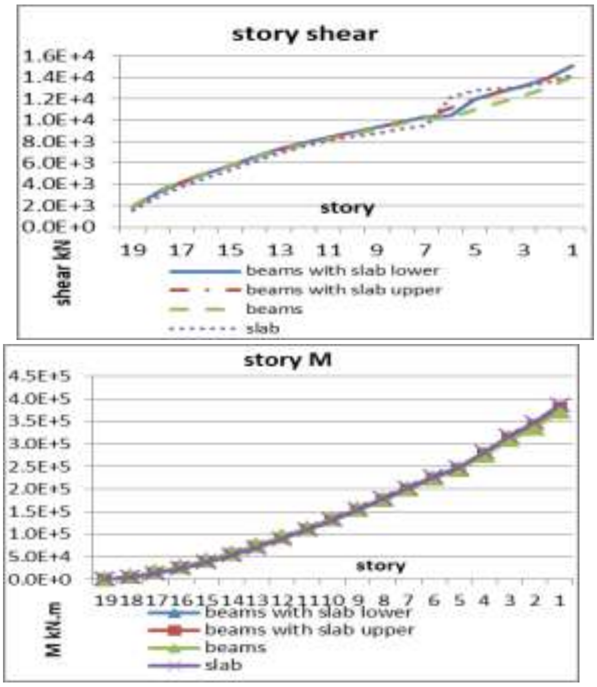

Fig. 3. story forces for the four cases

Fig. 3 shows the distributions of the story forces along the building height because it is not clear so the comparison was implemented first between the slab and beam systems only.

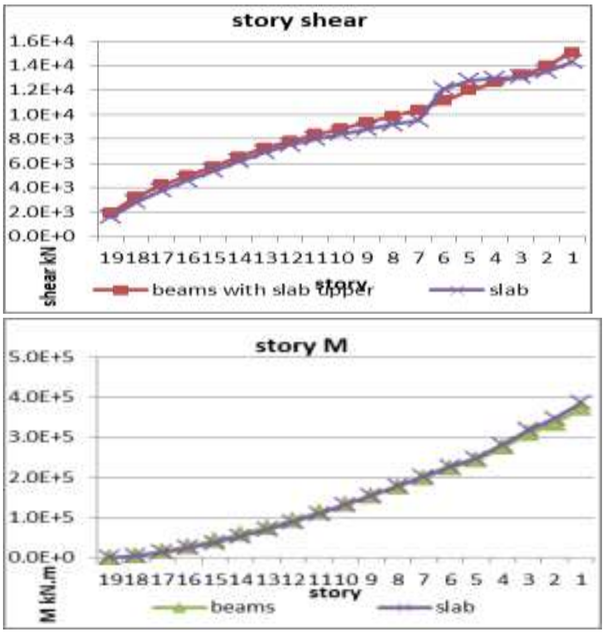

Fig. 4. story forces for slab and beams systems

Fig. 4 demonstrated that the shear and moments above the transfer floor have closer values but under the transfer floor the moments slab case is bigger than the beams case, for the shear case at the transfer floor the slab case has a grater values than the beams slab then the shear values decreases with decreases to become smaller than the beams case with a small values.

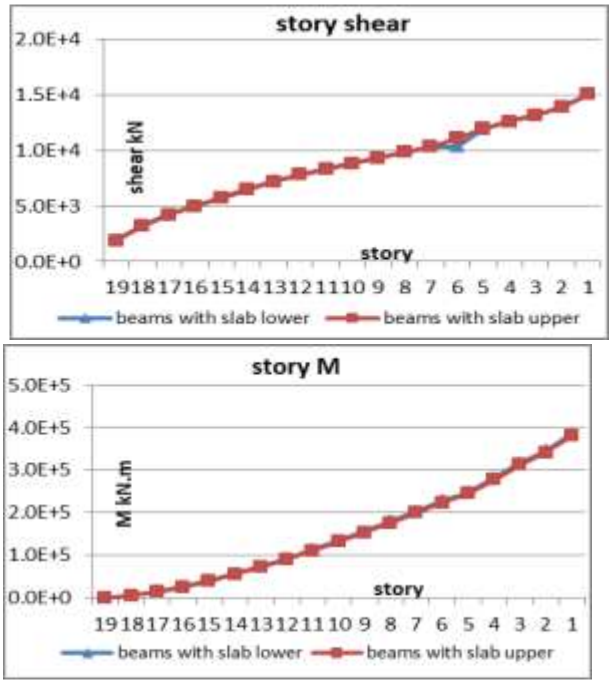

Fig. 5. story forces for slab lower and upper systems

Fig. 5 shows a comparison between the using the slab upper the beams and lower the beams. For moments the figure shows that the two systems have closer values, for the shear the figure shows that the two systems are similar in values in all stories except at the transfer story the lower slab has smaller values than the upper one.

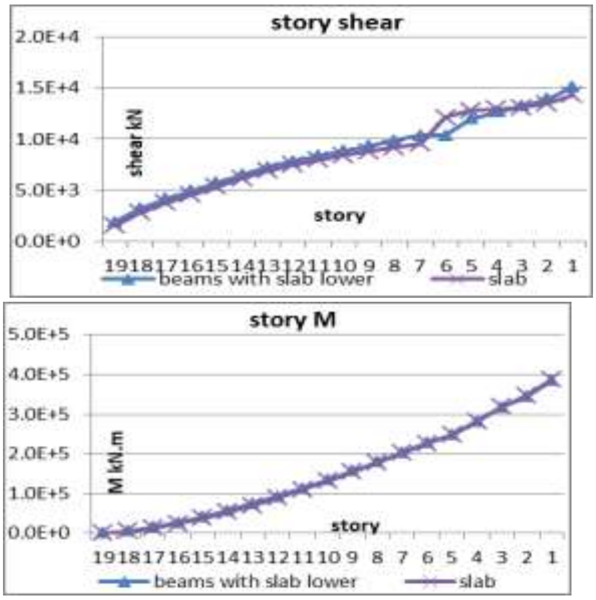

Fig. 6. story forces for slab lower and slab systems

From Fig. 6, it can be concluded that the slab only and beams lower slab have the same moment's values but in shear they are almost typical in all floors except in the transfer floor and lower floors the beams with slab lower has a smaller values than the slab system only.

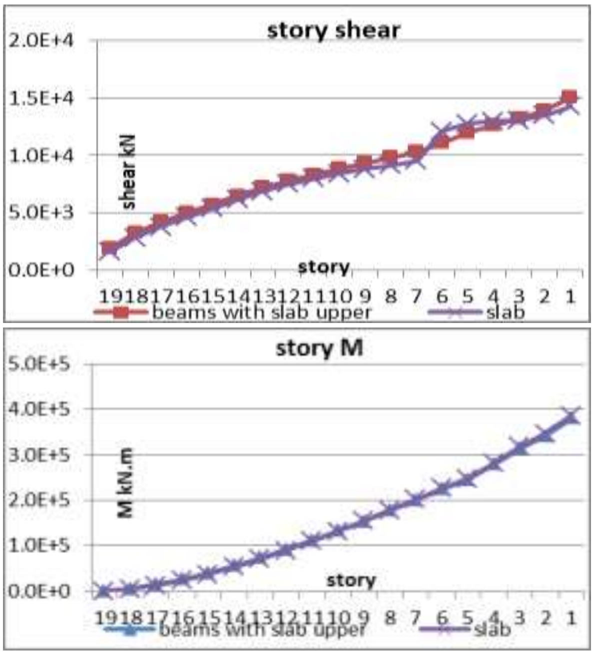

Fig. 7. story forces for slab upper and slab systems

From Fig. 7, it can be concluded that the slab only and beams upper slab have the same moment's values but in shear they are almost typical in all floors except in the transfer floor and lower floors the beams with slab upper has a smaller values than the slab system only.

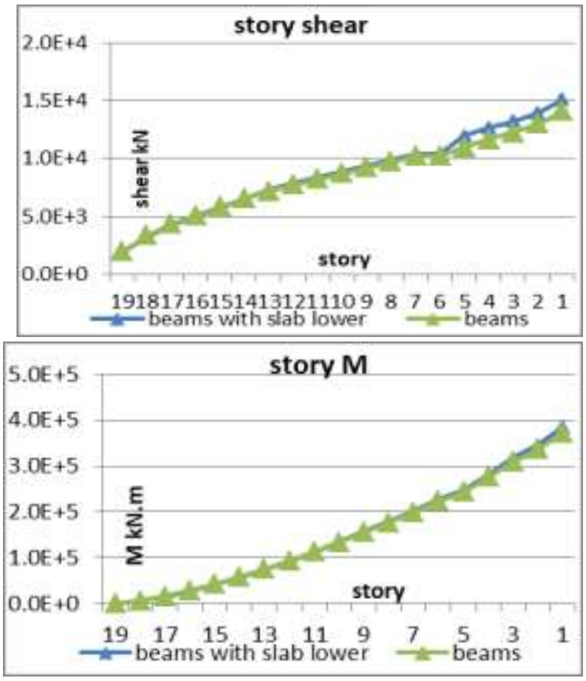

Fig. 8. story forces for beams with slab lower and beams systems

From Fig. 8, it can be concluded that the beams only and beams with lower slab have the same moment's values but in shear they are almost typical in all floors except in the transfer floor and lower floors the beams with slab lower has a bigger values than the beams system only.

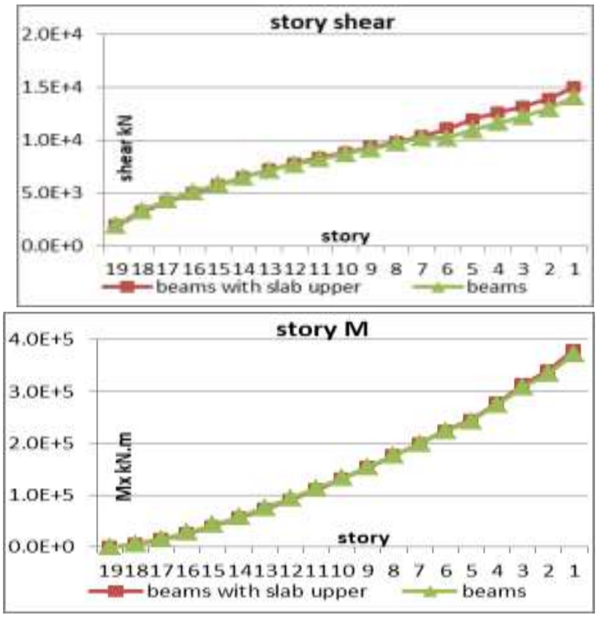

Fig. 9. story forces for beams with slab upper and beams systems

From Fig.9, it can be concluded that the beams only and beams with upper slab have the same moment's values but in shear they are almost typical in all floors except in the transfer floor and upper floors the beams with slab upper has a bigger values than the beams system only.

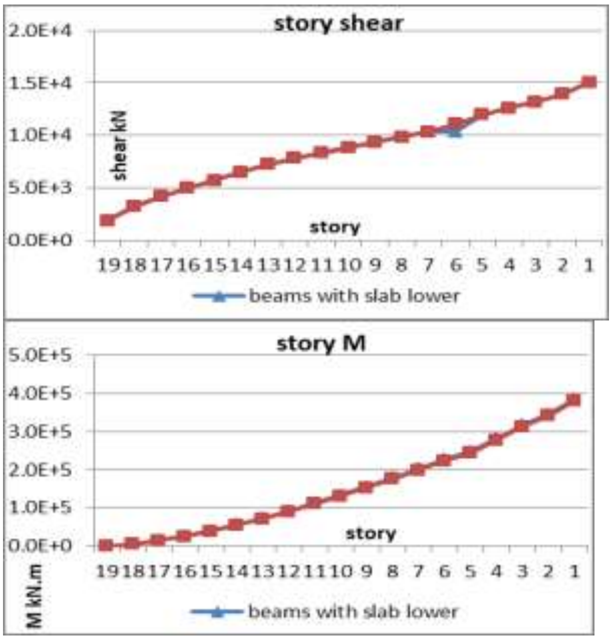

Fig. 10. story forces for beams with slab upper and beams with slab lower systems

Fig. 10 shows that the place of slab relative to beams has no effect and for shear it also has no effect in all the floors except in the transfer floor where the beams with lower slab have smaller value while in they have almost the same moment's value in all stories.

Fig. 11. story displacements for slab and beams systems and beams with slab upper and beams with slab lower systems

As shown in Fig. 11, the comparison between the slab and beams systems shows that the displacements under the transfer story is smaller in the beam system but above it the displacements is bigger than the slab system, and the beams with slab lower has displacements smaller than the beams with slab upper with small values.

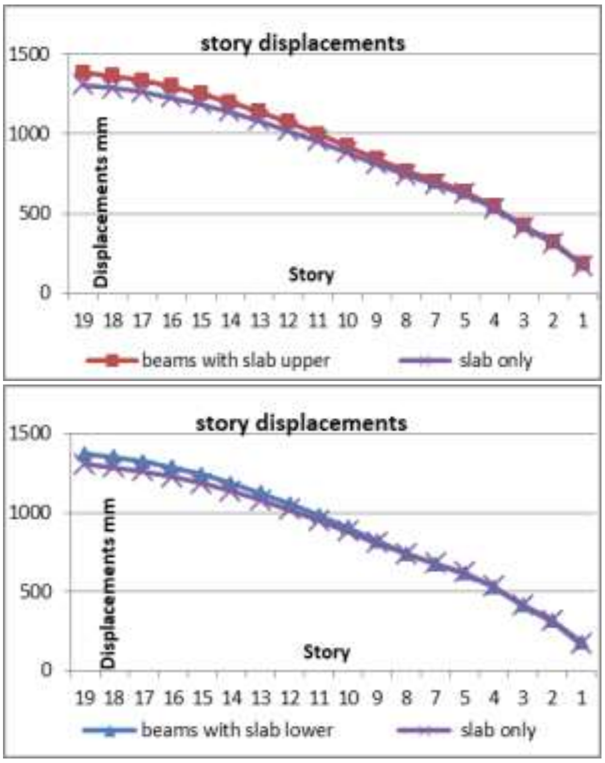

Fig. 12. story displacements for slab and beams with slab lower systems And slab and beams with slab upper

Fig. 12 shows that the story displacements in slab system are smaller than it in beams with slab in all locations.

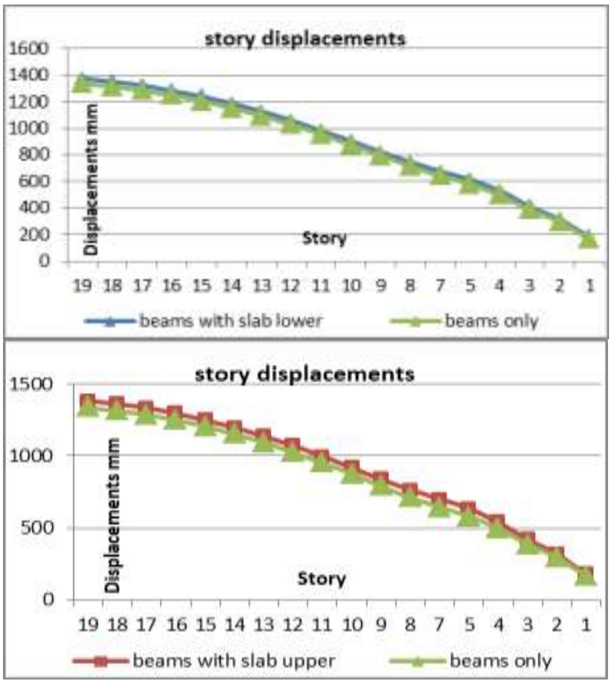

Fig. 13 story displacements for slab and beams with slab lower systems, slab and beams with slab upper

Fig. 13 shows that the story displacements in beams system are smaller than it in beams with slab in all locations.

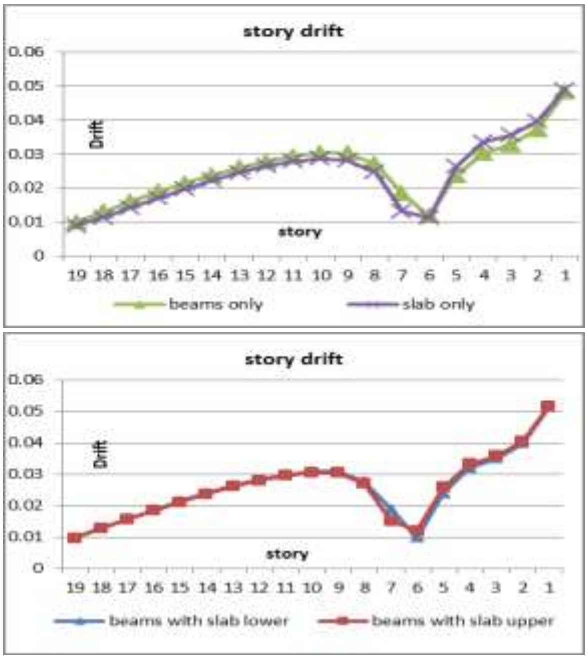

Fig. 14 story drift for slab and beams systems, beams with slab upper and beams with slab lower systems

The comparison between the slab and beams systems shows that the drift under the transfer story is smaller in the beam system but above it the drift is bigger than the slab system, and the beams with slab lower has drift smaller than the beams with slab upper with small values.

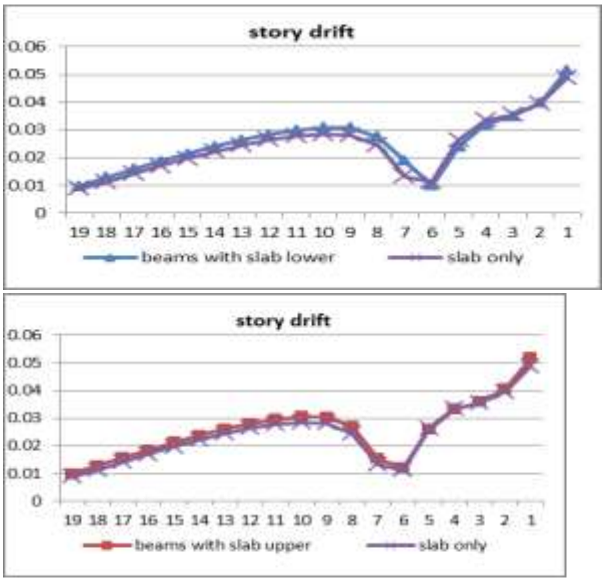

Fig. 15 story Drift for slab and beams with slab lower systems, slab and beams with slab upper

Fig. 15 show that the story drift in slab system is smaller than it in beams with slab in all locations.

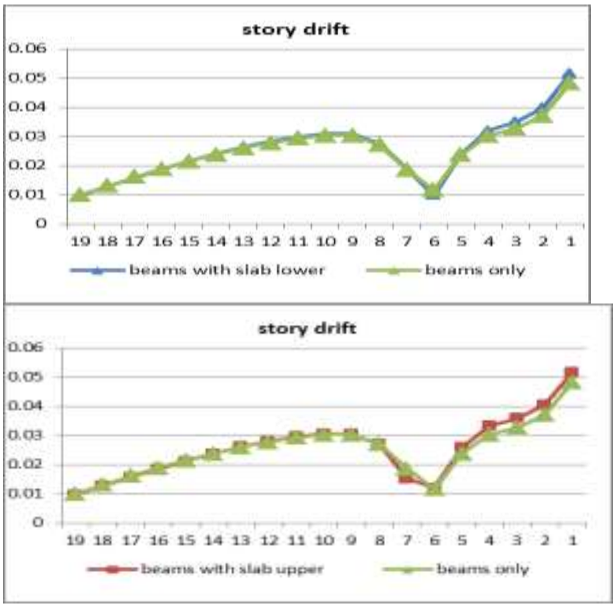

Figure 14 story drift for slab and beams with slab lower systems, slab and beams with slab upper

These figures show that the story displacements in beams system are smaller than it in beams with slab in all locations.

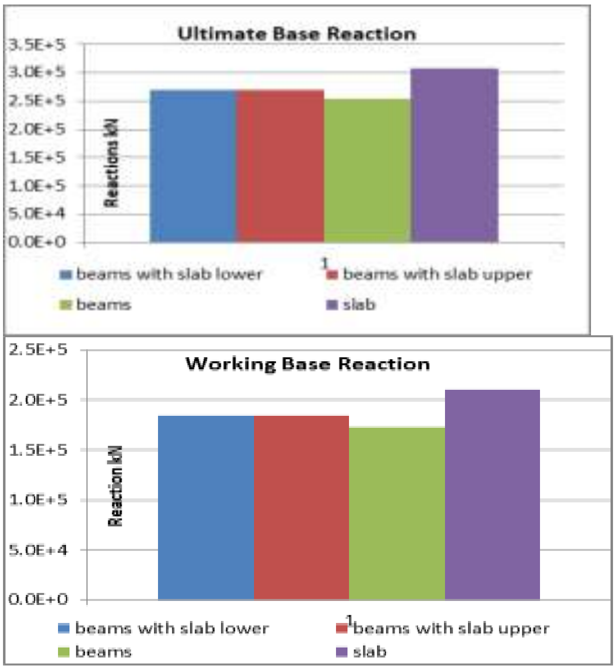

Fig. 16 ultimate and work base reactions for the four cases

Fig. 16 shows that using transfer slab increases the weight of the building with 21% comparing with the building using beams slab and increases it with 13% comparing with the building using beams with slab. Building using beams with slab is heavier than that one using beams only with 6.5%. No doubt that the building using beams with upper slab has the same weight of the one using beams with lower slab.

5. CONCLUSION

The above analyses show that for shear, the slab system is smaller than the beam system with average 3% and it smaller than the beams with slabs -wherever it was- with average 5% and the beams is smaller than the beams with slab with average 2.1%. For moments, the slab system is smaller than the beam system with average 3% and it smaller than the beams with lower slabs with average 3.6% and smaller than the beams with upper slab with 2.9% and the beams is smaller than the beams with slab -wherever it was- with average 1%. For displacements, the slab system is bigger than the beam system with average 1.33% and it smaller than the beams with lower slabs with average 2.7% and smaller than the beams with upper slab with 4.5% and the beams is smaller than the beams with slab -wherever it was- with average 4%. For drift, the slab system is smaller than the beam system with average 6% and it smaller than the beams with lower slabs with average 7% and smaller than the beams with upper slab with 6.7% and the beams is smaller than the beams with slab -wherever it was- with average 1%. For weight of the building the slab system is heavier than the beams system with 20% and heavier than the beams and slab systems with 14% and the beams system is lighter than the beams with slabs with 6%.

These results shows that the slab system gives smaller values in story forces comparison with other systems but with small values and in building displacements it has a displacements bigger than the beams system but it smaller than the beams with slab systems and in building drift it gives smaller values than the other system but in weight it gives very big values comparison with the other systems. So it is recommended to neglect the small benefits of the slab system and use the beams system because the very big difference in weight will not make this system economy. Also it is recommended to do more studies on the beams with slab using different thickness to know what optimum thickness.

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