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Comparison between slab and girders in transfer slab system on high buildings

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الملخص العربى :

في المنشات العادية فان الاعمدة التي تنقل الاحمال من ادوار المبنى المختلفه الى الارض تكون مستمرة راسيا و لا يتم تغييرها و لكن نظرا للازدياد في المباني المرتفعه و خاصة المتعددة الاغراض اصبح من الضروري عمل دور او ادوار تحويليه لتغيير نظام الاعمدة حيث انه من غير المنطقي ان يستمر النظام الانشائي الذي يستخدم لتغطية الادوار التجارية - التي تحتاج الى مساحات واسعه بدون اعمدة – لتغطية الادوار الادارية و السكنية حيث ان تكلفة هذه الانظمة تكون عالية جدا. هنا ظهرت اهمية نظام الادوار التحويلية بانظمتها المختلفة.

في هذا البحث تم المقارنة بين نظامين مختلفين من الادوار التحويلية و هما نظام البلاطة و نظام الكمرات المتقاطعه و قد تم استخدام برنامج تجاري و هو برنامج الايتابس اصدار 19 و ذلك للتقريب من الواقع حيث انه من اشهر البرامج التي يتم التصميم بها في الواقع. تم عمل نموذج ثلاثي الابعاد لمبنى به دور تحويلي باستخدام برنامج الاتابس السابق ذكره و تمت المقارنة بين نظامي البلاطه و الكمرات في الدور التحويلي و ذلك باستخدام طريقة طيف الاستجابة المرن و تاريخ الوقت غير الخطي. تمت دراسة تاثير الدور التحويلي على انحراف المبنى و ازاحة الادوار و القوى المختلفة على الادوار.

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, 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 different systems of transfer floors roles, namely the slab system and the cross-beam system, a commercial program has been used, which is the Etabs program version 19, (in order to approximate the reality because Etabs is the most program which is 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 slab and beam systems in the transfer floor, using the flexible response spectrum method and the non-linear time-date. The impact of the transfer floor on the building's drift, building's displacement and the various obtaining actions were studied.

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]. Sophia A. Pechorskaya, et al (2021) [2] made 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.

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 (2016) [4] 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. Yasser M. ABDELBASSET Ezzeldin et al (2014) [5] 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. "Analysis of High Rise Building with Transfer Floor", 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. , Prof. Shaikh A. N. made a paper "ANALYSIS OF MUILTYSTOREY BUILDING BY USING TRANSFER FLOOR" , at 2020. This study 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 23-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 and time history analysis techniques. A comparison between two kinds of transfer slabs was done.

2. Methodology

The research has a numerical nature; it is performed using numerical modeling of prototypes for high-rise buildings with transfer floors. These prototypes are modified from real high-rise buildings which have already been designed and constructed. A three-dimensional finite element models for prototype buildings with transfer floors are built-up. The seismic response of these buildings is investigated using elastic response spectrum and time history analysis techniques as a first step of a wider research. The shear distribution, bending moment distribution for the storey, inter-storey drift, floor displacements and accelerations are numerically evaluated and compared to their values deducted via codes of practice.

Using the three-dimensional models, investigation into considering a comparison between grid and slab transfer floor are carried out. Linear time history analysis model will present the benchmark for the drift calculations where recommendations on using the girder or slab as transfer system is given after comparing the time history model results to the outcomes of the common analysis strategies which are currently adopted in design offices.

3. Case Study

3.1 General

The linear elastic seismic behavior of structural wall buildings with transfer floors was investigated using the numerical investigation. The study considers two types of transfer: solid transfer plates (slabs) with thickness 1.5 m and girder girders system with 1.5*1.5m dimensions.

A parametric study was conducted on a prototype building with total number of 18 stories having transfer floor. Analytical results of this research present a comparison between the two types of transfer floor systems. These results cover the global behavior of the structures i.e., the value and distribution of shear and moment moreover the structure periodic time/frequency and mass participation ratio.

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].

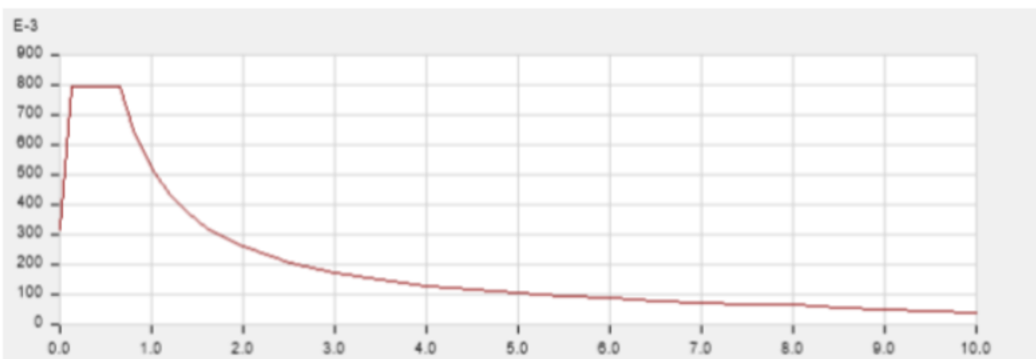
Cairo (Egypt), the location chosen for this study, falls under seismic zone 2A according to UBC 97[10]. The ductility reduction factor (R) of the lateral force resisting system, is taken as 5.50 and the live load seismic mass reduction factor is considered to be 0.80. The building floors are loaded such 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 4.5 kN/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 natural frequency/periodic time, the mass participation ratios, 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,

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

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

According to most codes of practice, As such, selected earthquake records are based on PGA, frequency content, and peak velocity. The chosen earthquakes are (Korean 2009) and (Korean 2016). As an example to the earthquakes which included in ETABS software.



Response spectrum

3.3 Modeling

A 18 storey building 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 18 storey building was in 6th floor. Figure 1 shows the building model with transfer slab which has been analyzed using elastic response spectrum using ETABS 2019 software.

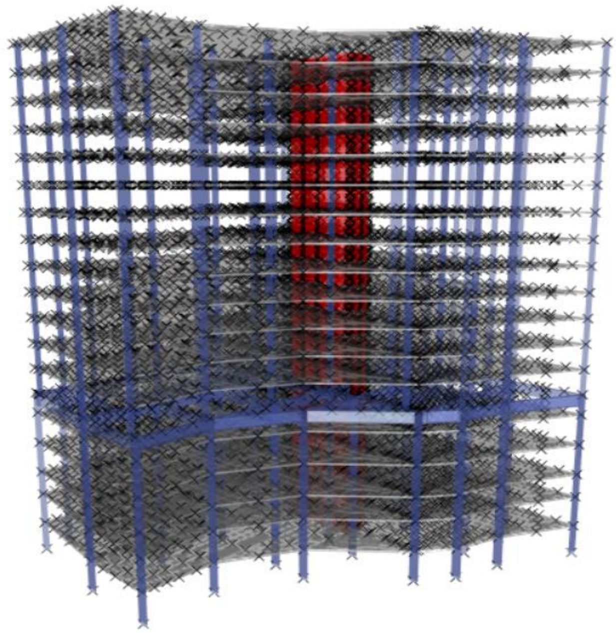
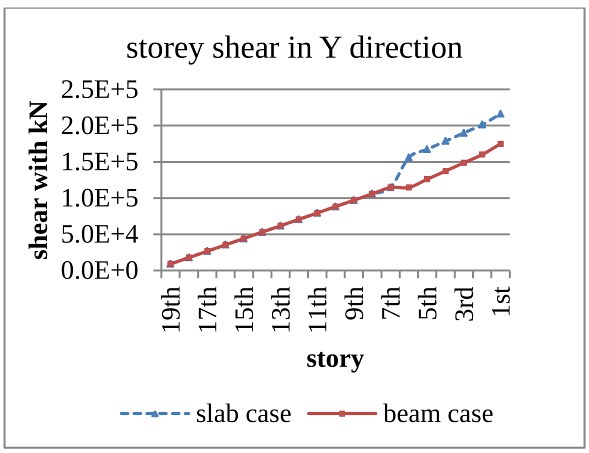


Figure 1

4. RESULTS

Structural model was created using ETABS 2019 to analyze the two systems of transfer floors. The study building has 18 stories. All interval faces and displacement were calculated and drawn as shown in the following figures.



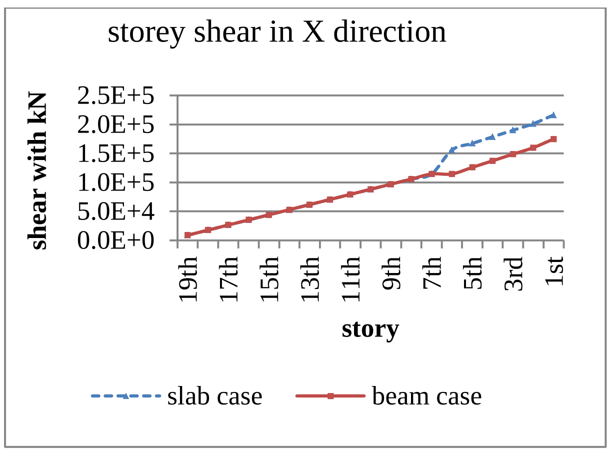


Figure 2

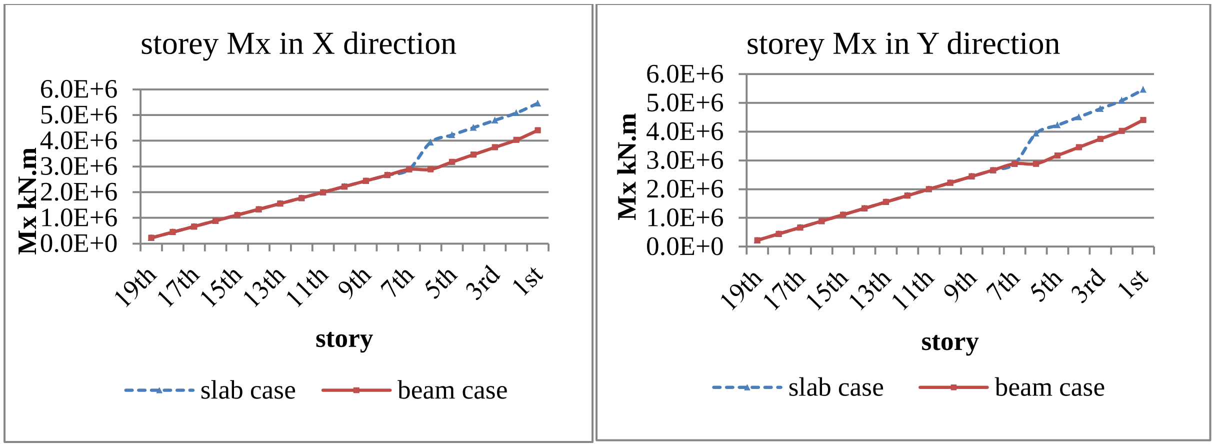


Figure 3

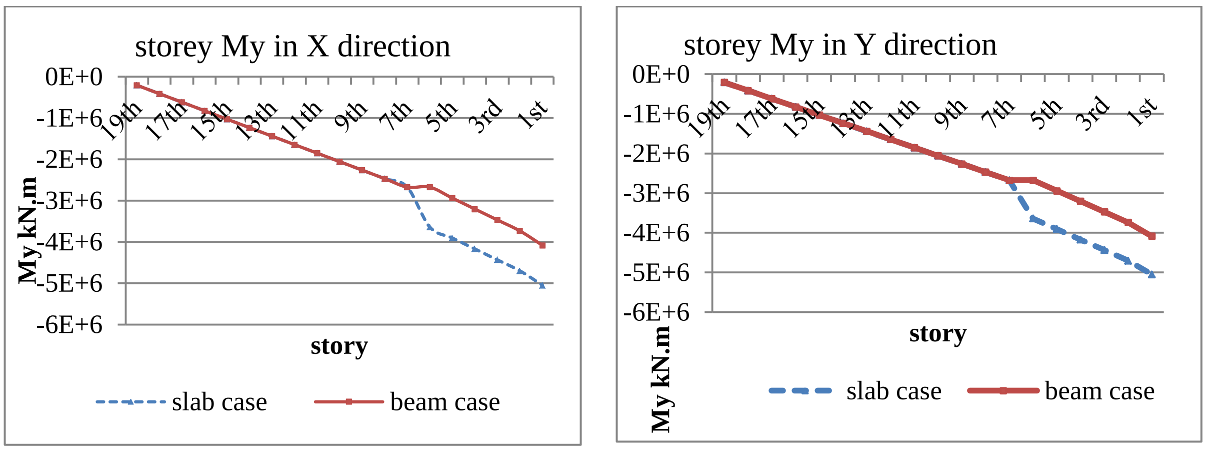


Figure 4

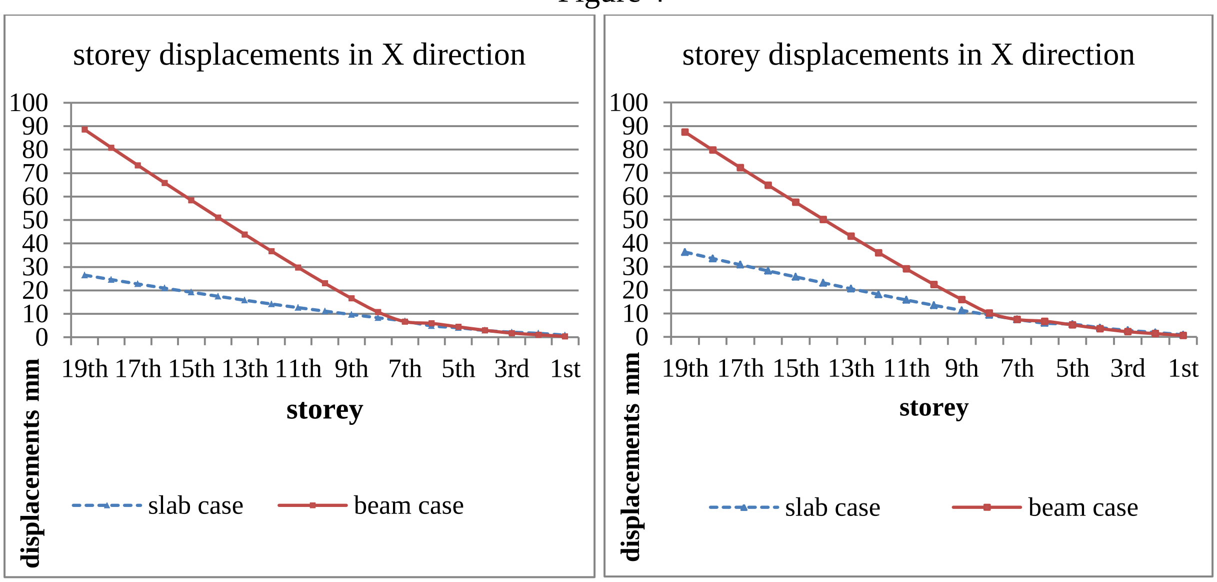


Figure 5

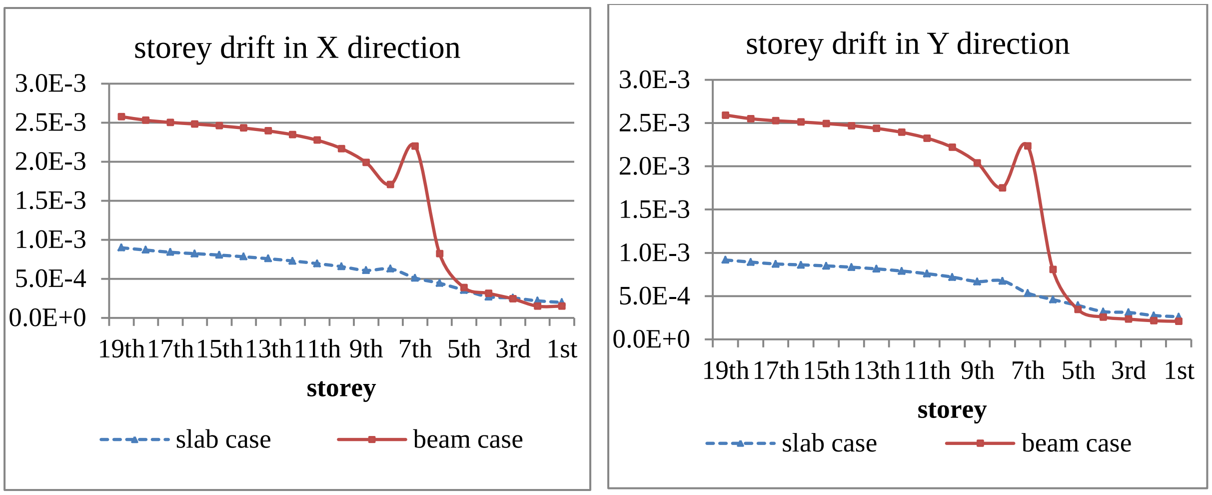


Figure 6

Figures 2 show that above the transfer floor the storey shears in both cases (slab and girders) are equal but below the transfer floor the storey shears in case of transfer slab is bigger than other. The same things can be notified in figures 3 and 4 which represent the storey moments. It can be noticed that transfer slab generate a massive moments on the floors under it and these moments are bigger than that generated from transfer girders.

A plot of the lateral displacement distribution over the building height is shown in Figure 5. It is evident that the lateral building displacement matches a flexural behavior mode till the transfer floor level for both cases. After the transfers slab the storey displacements in case of transfer girders become greater than it in case of transfer slab case with remarkable values. The same thing can be noticed in figures 6 which show that the storey drifts for the building getting bigger in the case of transfer girders than the transfer slab case.

5. CONCLUSION

According to above analysis it may be concluded that:

1- transfer floor slab system is better used in places of higher seismic zones (3 and 4) since the displacements and drifts are lower.

2- On other hand the system of girders are better used in places of lower seismic zones. However it is strongly recommended to take care of the higher straining actions in the design of structure elements in transfer slab system.

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