Effect of solid slabs on Loads and moments induced in columns of multistoried frames

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***Abstract*— This paper compares the analysis of a multi-storied structure with and without considering the effect of flexural stiffness of the slab on the distribution of loads and moments in the columns. The study focuses the effect of flexural stiffness of slab in corner columns, penultimate columns and interior columns in the upper most storeys and on the ground storey. STAAD software has been used to model the frame without considering the effect of flexural stiffness and ETABS software has been used to incorporate the effect of flexural stiffness of slab. The results shows that there is a significant impact in the loads and moments induced in the columns and influences the design of structural elements especially in the design of corner columns, penultimate columns of topmost storey.**

***Index Terms*— Solid slab, corner column, penultimate column, interior column, load and moment transfer.**

I. INTRODUCTION

When a building structure is subjected to gravity and lateral forces the induced forces, axial loads and moments are transmitted through floor slabs to the vertical structural components. The floor slab functions as diaphragm placed between the vertical components of various floors.

In analysis and design of three dimensional structures under seismic loadings, the diaphragms Frequently are assumed to be perfectly rigid discussed by Masayoshi Nakashima et al. [1] D.K.Bull [2] discuss that Diaphragms exhibit two types of behaviour at the same time. The first type occurs in every floor, where the floor acts like a horizontal deep beam and transmits forces generated by wind and earthquakes to the various vertical lateral force-resisting components such as frames and structural walls. The second type of behaviour is required where large in plane forces need to be transferred from one vertical lateral force resisting component to another. Danso Humphrey [3] discuss the model with elastic base foundation has high bending stress as compared to the model with firm base foundation by 30% for first floors and 28% for the subsequent floors. It could therefore be concluded that bending moment effect on the floors was greater in the model with elastic base than the model with firm base. To investigate realistic values of bending moment and normal forces, a full three dimensional (3D) analysis are needed in order to obtain correct values. Design and calculations of multi-storey residential and public buildings is complex. There are numerous difficulties associated with the design of multi-storey buildings, some of which are the choice of appropriate computational models, performance mode analyses and nature of the soil bases.

Mohanad Y. Abdulwahid et al. [4] discuss the importance of slabs. Such as that the most reinforced concrete structures are subdivided into beams and slabs, which are subjected primarily to flexure (bending), and columns, which are subjected to axial compression and bending. A good design requires accurate calculation of loads on structure to get the requirements of any design which are safety and economy. A slab is a structural element and has little thickness comparing to its cross section. Slabs are widely used in floor and roof construction.

Laporan akhir [5] generally, flexural stiffness of slabs is ignored in the conventional analysis of bare frame structures. However, in reality, the floor slabs may have some influence on the lateral response of the structures. Consequently, if the flexural stiffness of slabs in a frame system structure is totally ignored, the lateral stiffness of the global frames may be underestimated. The results show that the slabs can slightly increase the lateral stability of bare frames by about 10% to18%. Furthermore, it can be seen from the study that the main important role of the slab is to be known.

The model may be built up and analysis can be carried out either by considering the effect of rigidity of the slab as in the case of ETABS or ignoring it as in the case of STAAD. In the present study a 5 storied, 10 storied and 15 storied building are considered to study the effect of rigidity of slab in the corner columns, penultimate columns and interior columns of the top most storeys and in the lower most storey. The results considering the effect of rigidity of slab represents closely the realistic value and they study is useful in identifying the column where the effect of rigidity influences the loads and moments transferred to the columns and the design of members. The distributing lateral forces to vertical structural elements, through the solid slab play a key role in transferring forces. The functions of the Structural elements are to resist forces, and transfer these forces to other members and to the ground. Since the columns are important for the role of structural stability it is necessary to know the influences on structural elements. This paper focus on the effect of flexural stiffness of slab in columns with respect to the moments induced in the top and ground storey.

II. OBJECTIVE OF STUDY:

The aim of this research is to understand the behavior of moments induced in the columns when the stiffness of slab is considered. The present paper mainly focused on the behavior of the effects of floor slabs in the frame due to Vertical loading and the moments induced in columns.

The main objectives are:

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(i) To study the moments induced in the columns at different height of the buildings.

(ii)To investigate realistic values of bending moments induced in column.

III. MODEL DESCRIPTION:

In this present paper the six models of a structural system are generated with the help of ETAB and STAAD. The six models include the 5Storey, 10storey and 15 storey building with and without considering flexural stiffness. The height of each storey is taken as 3.0 m.
Column Size=450mmx450mm.
Beam size=300mmx300mm.
Thickness of slab=127mm
Live load=2 KN / m^2 (IS 875 (part-II):1987)
Material Properties: concrete
Grade of concrete: M25
Unit weight of concrete-25 KN/m^3 (IS 875 (part-I):1987)
The Framed structure considered is 6x4 bays with span of 3metres at x-direction and 4metres at y-direction.

(i)In this case we are interested to analyze different heights of the building model under vertical load.

(ii)After analyzing the structure, determine the forces and moments in a structural element.

(iii)The present study is done on both the software STAAD and ETAB.

(iv)Where With slab is on ETAB and without slab is on STAAD.

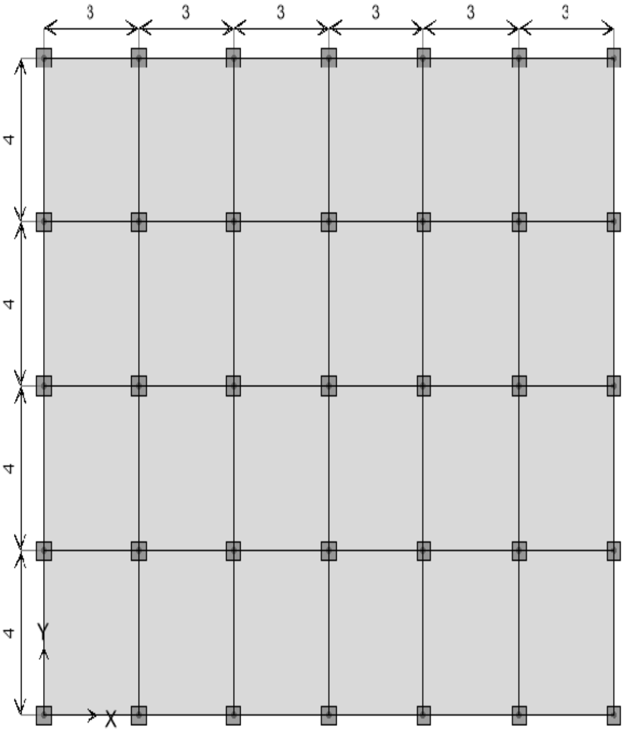

Fig: 1. Plan for considered building with slab (ETAB)

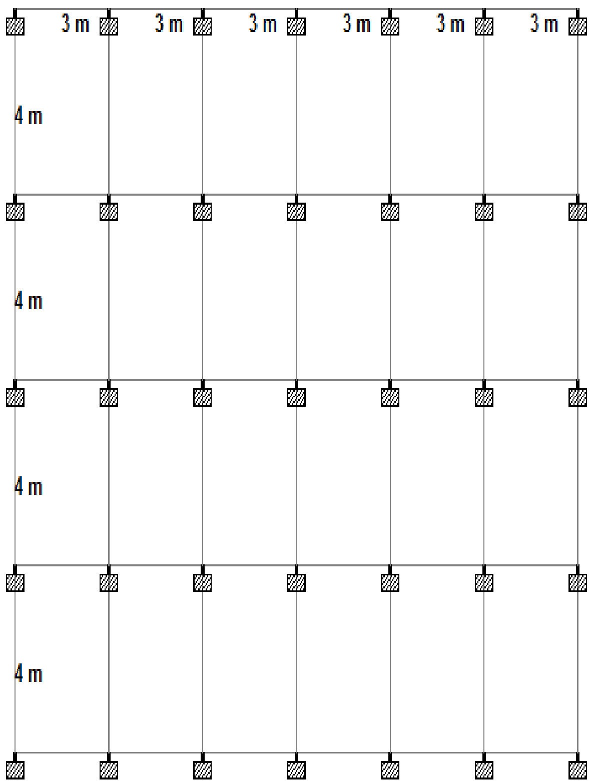

Fig: 2. Plan for considered building without slab (STAAD PRO)

IV. MODELLING AND ANALYSIS:

A Building is modeled using software STAAD and ETAB. Beams and columns are modeled as per the sections mentioned above. Analysis is performed on vertical loading. The following models have been considered.
The models are:

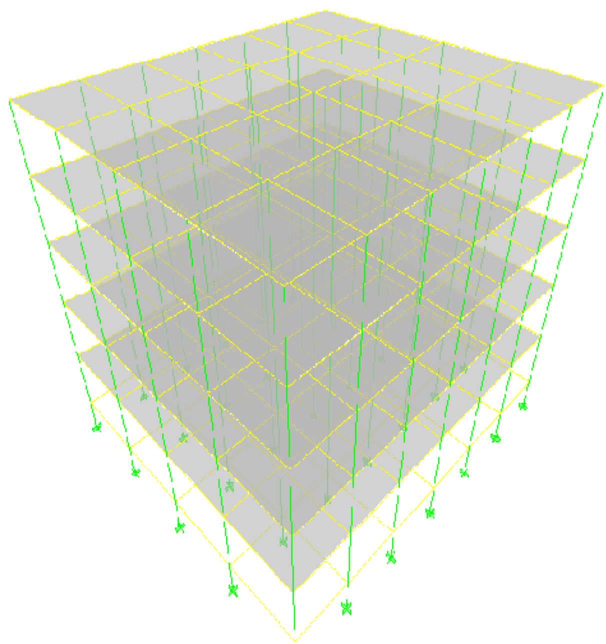

Fig: 3: 3D modeled five storey building with slab

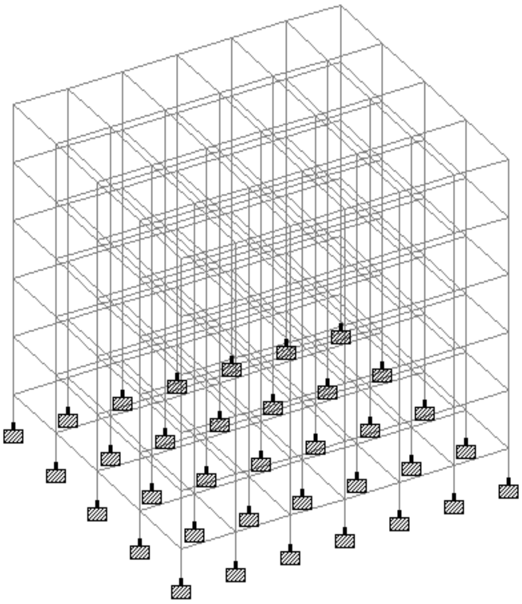

Fig: 4:3D modeled five storey building without slab

Fig: 5 Elevation of a ten storey building

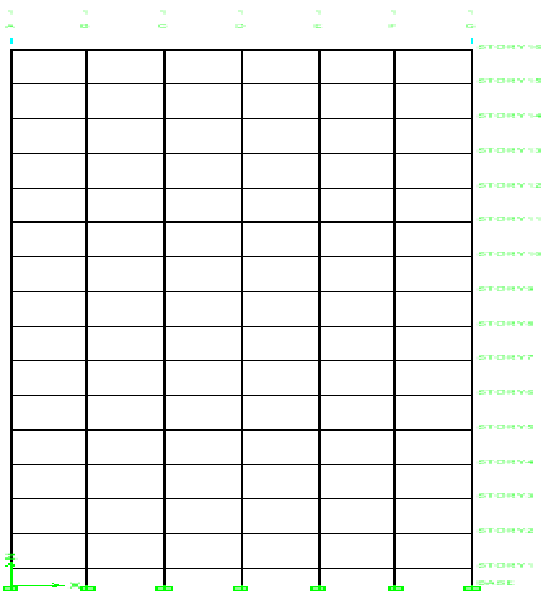

Fig: 6 Elevation of a fifteen storey building

V. RESULTS

In vertical loading the combination of 1.5(DL+LL) moments obtained are:

TABLE-I: Moments induced in columns with slab for a five storey building at shorter span and longer span.

	WITH SLAB(KN-M)			
Column position	**5 storey**		**1 storey**	
	Mz (Shorter span)	**My (Longer span)**	**Mz (Shorter span)**	**My (Longer span)**
1.Corner	7.33	12.85	3.05	5.84
2.penultimate	1.44	21.26	0.23	9.69
8.penultimate	12.17	0.74	5	0.08
9.Interior	2.58	1.23	0.41	0.19

TABLE-II: Moments induced in columns without slab for a five storey building at shorter span and longer span

	WITHOUT SLAB(KN-M)			
Column position	**5 storey**		**1 storey**	
	Mz (Shorter span)	**My (Longer span)**	**Mz (Shorter span)**	**My (Longer span)**
1.Corner	8.61	15.21	3.78	7.19
2.penultimate	1.42	25.14	0.4	11.88
8.penultimate	14.27	0.47	6.18	0.17
9.Interior	2.59	0.8	0.71	0.27

TABLE-III: Moments induced in columns with slab for a ten storey building at shorter span and longer span

	WITH SLAB(KN-M)			
Column position	**10 storey**		**1 storey**	
	Mz (Shorter span)	**My (Longer span)**	**Mz (Shorter span)**	**My (Longer span)**
1.Corner	11	15.93	3.31	6.02
2.penultimate	5.31	25.73	0.55	9.75
8.penultimate	18.16	3.64	5.41	0.25
9.Interior	8.9	5.41	0.91	0.55

TABLE-IV: Moments induced in columns without slab for a ten storey building at shorter span and longer span

	WITHOUT SLAB(KN-M)			
Column position	**10 storey**		**1 storey**	
	Mz (Shorter span)	**My (Longer span)**	**Mz (Shorter span)**	**My (Longer span)**
1.Corner	12.93	18.91	4.18	7.5
2.penultimate	5.95	30.49	0.86	12.33
8.penultimate	21.33	4.08	6.82	0.51
9.Interior	9.97	6.01	1.46	0.76

TABLE-V: Moments induced in columns with slab for a fifteen storey building at shorter span and longer span

	WITH SLAB(KN-M)			
Column position	**15 storey**		**1 storey**	
	Mz	**My**	**Mz**	**My**
	(Shorter span)	**(Longer span)**	**(Shorter span)**	**(Longer span)**
1.Corner	14.84	19.96	3.52	6.35
2.penultimate	10.13	31	0.82	10.34
8.penultimate	24.06	7.98	5.7	0.53
9.Interior	16.2	11.04	1.29	0.66

TABLE-VI: Moments induced in columns without slab for a fifteen storey building at shorter span and longer span.

	WITHOUT SLAB(KN-M)			
Column position	**15 storey**		**1 storey**	
	Mz	**My**	**Mz**	**My**
	(Shorter span)	**(Longer span)**	**(Shorte r span)**	**(Longer span)**
1.Corner	19.7	28.19	4.43	7.77
2.penultimate	11.97	45.04	1.21	12.67
8.penultimate	32.42	9.38	7.2	0.82
9.Interior	19.03	12.72	1.97	1.16

VI. SAILENT FEATURES OF THE PRESENT STUDY:

1. The structural parameters are considered as same to the 5storey, 10storey and 15 storey buildings.
2. In the figure1, the plan of considering slab in ETAB and figure2 shows the plan of without slab in STAAD PRO.Having the 6 bays at x-direction of span 3m and 4bays at y-direction of span 4m respectively.
3. The three dimensional view at figure3 shows the modeling with considering slab in ETAB and at figure 4 shows the modeling without slab in STAAD PRO.
4. The figure 5 and figure 6 shows the elevation of 10 storey and 15 storeys of a building. Figure 7 shows the representation of column labels.
5. Vertical loading to the combination of 1.5(DL+LL) the moments obtained are shown in table-I, II,III,IV,V and VI as 5 storey and 10storey and 15 storey buildings by considering with and without slab.
6. As from the above three tables it is clearly shown that the maximum moments are induced at top storey of a 5 storey, 10 storey and 15 storey buildings.
7. As from the above tables-I, II, III, IV, V and VI the maximum moments are obtained when the flexural stiffness of slab is not considered for a building.
8. The moments of a fifteen storey building are more compared with 5 storey and 10storey building as from table-I, II, III, IV.
9. The variation suggests the conventional method of analysis shows the more difference compared with realistic analysis of frames.

VII. CONCLUSIONS:

By considering the flexural stiffness of the slab, the realistic behavior of building can be predicted in a more realistic way. The analysis conducted for the buildings with 5 stories, 10 stories and 15 stories chosen for study for the gravity loading. The results obtained for the columns in the topmost storey, with and without considering the stiffness of the slab the following conclusions can be drawn.

1. The corner column shows a significant reduction in moment of magnitude 15.51% when the flexural stiffness of slab is considered in 5, 10 storeys and 27% in 15 storied building in longer direction of 4m span.
2. The penultimate column shows a significant reduction in moment of magnitude 15.4% when the flexural stiffness of slab is considered in 5, 10 stories and 31.2% in 15 storied building in longer span of 4 m direction.
3. The interior column shows a significant reduction in moment of magnitude 10.73% when the flexural stiffness of slab is considered in 10 storeys and 24.8% in 15 storied building in shorter span of 3 m-direction.
4. The effect of solid slab significantly reduces the reinforcement requirement in the penultimate column (column 8) in the longer direction.
5. From the results it can be concluded that the flexural stiffness (rigidity) of slab plays a significant role in the moments induced in the columns of the top most storey and need to be considered for representing a more realistic behavior of the structure and in the design of column.

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