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Comparative Study of Flat Slab Structure Based on IS-1893:2002 & IS-1893:2016

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ABSTRACT: In the fast growing construction industry, buildings with flat slab are becoming more popular as they have more advantages when compared with conventional slab beams type of construction from architectural point of view, effective utilization of space, volume of formwork lesser construction duration. With conventional beam slab construction method floor to floor height will get reduced. Thus in order to improvise the aesthetical & structural aspect of high raised buildings which require larger open spaces like function halls, offices, theatres etc. will be built in a way where the slab will be directly rested on columns. These types of slabs which are placed on the column are commonly considered as flat slab.

KEYWORDS: Flat Slab, Shear Wall, Conventional Slab, Story Displacement, Story drift

I. INTRODUCTION

Flat slab can be called as a reinforced slab that will not be provided with any beams/ girders & here a slab will be directly sitting on the column. Its load transferring mechanism will include transferring of any load coming on it directly from this slab to columns which are supporting this slab. Flat slab will helps in providing extra head room since we don't have beams system & thus helps in providing more area for the services. The mini thickness of any flat slabs will be 125 mm & 250 mm max. We have n number of entities that are altered to make the work quicker an example is adopting pre-cast technologies this will reduce the time of construction, utilization of alternate structural material & inception of different kinds of flat slab fabrication methods will also decrease the self weight and floor to floor height helps in making beams hidden and this will increase floor height.

Seismic performance of any building need to be checked thoroughly to protect that structure to withstand the earthquake. Horizontal loads are generally more at the higher storey in comparison with the lower storey. Because of this reason structure starts to behave cantilever. In most of the seismic affecting places we have lots of case of failure of structures that weren't designed for seismic cases. All these result in carrying out the research of the cause of horizontal forces critically more essential.

This study helps to compare a results as per the guidelines of both IS prescribed codes and will examine their behaviour against seismic resistance.

A reinforced cement concrete floor which is provided with beams will not be able to provide as flat and plane ceiling surface. This won't be able to provide better lighting; the services need to be run below the beams in order to avoid bends and turns. Because of providing services below the beam the headroom will be reduced. In order to take care of reduced head room floor to floor height has to be increased. Increase in each floor height will affect an overall structure height. This will have the effect on fire protection design and requirements. This in turn has the effect on the primary fetch of the project also the maintenance fetch of fire protection system. Providing beam and slab system will also affect the construction, economy needs more formwork. Abstracting beams will also don't be able to provide a better aesthetic interior view.

In order to address all these problems we can take help of one more system called as flat slab system. In flat slab system we can eliminate all the beams which are connecting the columns with each other. Due to elimination of beams

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and clear ceiling space one can run all the services just below the slab. Since the services are moved upwards towards the ceiling the headroom required for the material and man movement will be increased. This way we can maintained floor to floor height required to the minimum value. Hence the height of the building will be under control.

II. EXPERIMENTAL PROGRAM

For this project a G + 13 floors building used as a office shall be considered which is rectangular in shape. Lower most floor i.e. ground floor shall be treated as parking area. This floor is resting directly on the ground. Hence, no reinforced slab is provided only PCC flooring and plinth beams are considered. First floor to terrace floor flat slab is provided with capital. Floor to Floor height of 4 m is taken. Once the architecture plan is frozen, columns are located at appropriate positions.

As it's an office Building square columns of 600 mm X 600 mm are considered as a trial size. Solid concrete blocks of 200 mm thick are considered for the construction of exterior walls. As mentioned before as it's an office building with a flat slab concept we have considered span between two columns to be between 6.5 m to 7.0 m. Once the columns positions are finalized column capitals of suitable sizes are assumed and provided on thumb rule basis. However, at ground floor level as there will be no slabs we have connect the columns with the help of tie beams of size 300mm X 500mm and floors where there are toilets we have provided raised floor in order to take out all the toilet pipes.

Structural Configuration

A. EXPLANATION OF ETABS MODELS

- Model 1 = Stilt +13+ Terrace with no shear wall
- Model 2 = Stilt +13+ Terrace with s shear wall around staircase and lift

B. BUILDING DETAILS

- Type of Frame = Ordinary Moment Resistance RCC Frame
- Building shape = Rectangular (26.8m X 28.0M) shape Structure
- Building Dimension = Shown as above
- Total Height of Building from Plinth
- (Stilt + 13 + Terrace + Head Room) = 64.0 m
- Stilt floor height = 4.00 m
- Height of typical Storey : 4.00m
- Along X-dir = 4 spans of 6.7m each
- Along Y-dir = 4 spans of 7.0m each

C. MATERIAL PROPERTIES

- Concrete = M40 for columns & M30 other structural elements
- Rebar = Fe550
- Concrete Density = 25KN/m³

D. SECTION SIZES

- RCC Beam size = 300mmx500mm, & 600mmX600mm
- RCC Column = 600mmx600mm
- RCC Slab Thickness = 200mm
- Wall Thickness = 200mm, 100mm (Solid Concrete Block wall)

E. LOAD CONSIDERATION

Imposed Floor Loads

- Floor Finish- 1.0 kN/sqm, Partition wall load on slab 1.0 kN/sqm,
- Terrace Water Proofing 1.0 kN/sqm

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- Live Load
 - 4.0 kN/sqm inside the flats,
 - 3.0 kN/sqm in common area like corridors, staircase
 - 1.5 kN/sqm at terrace

1. Main Wall Load

Density of SCB (0.20m thk) = 17.65*0.20	= 3.53 kN/sqm	
Density of Mortar $(0.012+0.02 = 0.032 \text{ m thk}) = 20.40*0.032 = 0.65 \text{ kN/sqm}$		
Total	= 4.18 kN/sqm	
Floor to Floor height	= 4.0m	
Beam depth	= 0.6m	
Concrete Block Wall height = $4.0 - 0.6$	= 3.40m	
Main Wall Load = 4.18*3.40 = 14.21 kN/m = 14.25 kN/m (say)		

2. Partition Wall Load

Density of brick (0.10m thk) = 17.65*0.10	= 1.77 kN/sqm	
Density of Mortar $(0.012+0.012 = 0.024 \text{ m thk}) = 20.40*0.024 = 0.49 \text{ kN/sqm}$		
Total	= 2.26 kN/sqm	
Floor to Floor height	= 4.0m	
Beam depth	= 0.6m	
Concrete Block Wall height = $4.0 - 0.6$	= 3.40m	
Main Wall Load = 2.26*3.40 = 7.68 kN/m =7.70 kN/m (say)		

3. Seismic Factors for Lateral Load Analysis

- Soil Profile = Medium
- Zone Factor = Zone 3
- Reduction Factor = 5.0
- Importance Factor = 1.0
- Damping = 5.0 %



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Load Combinations and Analysis of the Model

SLNo.	Factored Load Combinations
1.	1.5 DL
2.	1.5(DL + LL)
3.	1.5(DL +WLY)
4.	1.2(DL + LL - WLX)
5.	1.2(DL + LL + WLY)
6.	1.2(DL + LL + WLX)
7.	1.5(DL + WLX)
8.	1.5(DL -WLY)
9.	0.9DL +1.5WLX
10.	0.9DL -1.5WLX
11.	0.9DL +1.5WLY
12.	0.9DL - 1.5WLY
13.	1.2(DL + LL + THX)
14.	1.2(DL + LL + THY)
15.	1.5(DL - THX)
16.	1.5(DL + THY)
17.	0.9DL + 1.5THX
18.	1.2(DL + LL - THX)
19.	1.2(DL + LL - THY)
20.	1.5(DL + THX)
21.	1.5(DL - THY)
22.	0.9DL - 1.5THX
23.	0.9DL + 1.5THY
24.	0.9DL - 1.5THY
25.	1.2(DL + LL - WLY)
26.	1.5(DL - WLX)
27.	1.2 (DL + LL + EQX)

Sl.No	Un-factored Load Combinations
1.	1.0(DL + LL)
2.	1.0(DL + THX)
3.	1.0(DL - THX)
4.	1.0(DL + THY)
5.	1.0(DL - THY)
б.	1.0DL + 0.8LL + 0.8THX
7.	1.0DL + 0.8LL - 0.8THX
8.	1.0DL + 0.8LL + 0.8THY
9.	1.0DL + 0.8LL - 0.8THY
10.	1.0(DL + WLX)
11.	1.0(DL - WLX)
12.	1.0(DL + WLY)
13.	1.0(DL - WLY)
14.	1.0DL + 0.8LL + 0.8WLX
15.	1.0DL + 0.8LL - WLX
16.	1.0DL + 0.8LL - WLX
17.	1.0DL + 0.8LL + 0.8WLY

Table1: Factored Load Combination in Etabs

Table 2: Un Factored Load Combination in Etabs

III. RESULT

A. Deflection Shape for 1.2(DL + LL + RSX)

With IS 1893-2002



Max = 3.307 at [-0.15, -0.15, 59.5]: Min = -33.246 at [10.05, 17.5, 55.5]

Fig 1: Deformed Shape as per IS 1893-2002



Fig 2: Deformed Shape as per IS 1893-2016

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B. BM & SF Diagram for 1.2DL + LL + RSX) With IS 1893-2002



Fig 3: Bending Moment as per IS 1893-2002



Fig 4: shear Force Diagram as per IS 1893-2002

With IS 1893-2016



Fig 5: Bending Moment Diagram as per IS 1893-2016



Fig 6: Shear Force Diagram as per IS 1893-2016



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C. Maximum Storey Drift

In x direction			
Story Drifts 1.2(DL + LL + RSX)			
Story	IS1893-2002	IS1893-2016	
Staircase	0.002098	0.000141	
Terrace	0.002262	0.000125	
13th	0.003771	0.000236	
12th	0.005111	0.00034	
11th	0.006104	0.000418	
10th	0.006881	0.00048	
9th	0.007558	0.000535	
8th	0.008164	0.000585	
7th	0.008707	0.00063	
6th	0.009202	0.000672	
5th	0.009644	0.000711	
4th	0.010035	0.000747	
3rd	0.010424	0.000783	
2nd	0.010834	0.000825	
1st	0.010889	0.000849	
Parking	0.006405	0.000506	

Table 3: Story Drift in X Direction



Fig 7: Chart Showing Story Drift in X Direction



Fig 8: Chart of IS 1893-2002 Vs IS 1893-2016 Story Drift in X Direction



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In Y Direction

Story Drifts 1.2(DL + LL + RSY)			
Story	IS 1893-2002	IS 1893-2016	
Staircase	0.002543	0.000615	
Terrace	0.002177	0.000227	
13th	0.003601	0.000353	
12th	0.004844	0.000455	
11th	0.005755	0.000529	
10th	0.006469	0.000586	
9th	0.007096	0.000637	
8th	0.007659	0.000681	
7th	0.008164	0.000721	
6th	0.008625	0.000756	
5th	0.009036	0.000788	
4th	0.009393	0.000814	
3rd	0.009722	0.000838	
2nd	0.009852	0.000847	
1 st	0.009751	0.00083	
Parking	0.005712	0.000489	

Table 4: Story Drift in Y Direction



Fig 9: Chart Showing Story Drift in Y Direction



Fig 10: Chart of IS 1893-2002 Vs IS 1893-2016 Story Drift in Y Direction

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D. Maximum Storey Displacement

In X Direction

Story Displacement 1.2(DL + LL + RSX)			
Story	IS 1893-2002	IS 1893-2016	
Staircase	358.371	20.898	
Terrace	421.114	30.334	
13th	414.064	29.988	
12th	402.879	29.348	
11th	387.479	28.382	
10th	368.266	27.116	
9th	345.583	25.574	
8th	319.709	23.775	
7th	290.888	21.736	
6th	259.338	19.473	
5th	225.25	16.997	
4th	188.788	14.318	
3rd	150.026	11.441	
2nd	108.985	8.362	
1st	65.849	5.081	

Table 5: Maximum Story Displacement X Direction



Fig 11: Chart Showing Storey Displacement in X Direction



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Fig 12: Chart of IS 1893-2002 Vs IS 1893-2016 Storey Displacement in X Direction

Story Displacement 1.2(DL + LL + RSY)			
Story	IS 1893-2002	IS 1893-2016	
Staircase	330.384	28.3	
Terrace	391.127	34.809	
13th	384.399	34.064	
12th	373.778	32.96	
11th	359.23	31.535	
10th	341.134	29.822	
9th	319.803	27.847	
8th	295.493	25.634	
7th	268.433	23.201	
6th	238.826	20.568	
5th	206.853	17.749	
4th	172.672	14.761	
3rd	136.38	11.611	
2nd	98.102	8.311	
1st	58.885	4.939	

In Y Direction

Table 6: Maximum Story Displacement in Y Direction



Fig 13: Chart Showing Storey Displacement in Y Direction

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Fig 14: Chart of IS 1893-2002 Vs IS 1893-2016 Storey Displacement in Y Direction

E. Story Forces

Story Forces 1.2(DL + LL + RSX)		
Story	IS1893-2002	IS1893-2016
Staircase	810.5409	810.5409
Terrace	9922.2693	9922.2693
13th	23634.4269	23634.4269
12th	37346.5845	37346.5845
11th	51058.7421	51058.7421
10th	64770.8996	64770.8996
9th	78483.0572	78483.0572
8th	92195.2148	92195.2148
7th	105907.3724	105907.3724
6th	119619.53	119619.53
5th	133331.6875	133331.6875
4th	147043.8451	147043.8451
3rd	160756.0027	160756.0027
2nd	174468.1603	174468.1603
1st	188134.8474	188134.8474
Parking	191339.2108	191339.2108

Table 7: Story Forces



Fig 15: Chart of IS 1893-2002 Vs IS 1893-2016 Story Forces



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Story Stiffness 1.2(DL + LL + RSX)		
Story	IS1893-2002	IS1893-2016
Staircase	810.5409	810.5409
Terrace	9922.2693	9922.2693
13th	23634.4269	23634.4269
12th	37346.5845	37346.5845
11th	51058.7421	51058.7421
10th	64770.8996	64770.8996
9th	78483.0572	78483.0572
8th	92195.2148	92195.2148
7th	105907.3724	105907.3724
6th	119619.53	119619.53
5th	133331.6875	133331.6875
4th	147043.8451	147043.8451
3rd	160756.0027	160756.0027
2nd	174468.1603	174468.1603
1st	188134.8474	188134.8474
Parking	191339.2108	191339.2108

F. Story Stiffness

Table 8: Story Stiffness



Fig 16: Chart of IS1893-2002 Vs IS 1893-2016 Story Stiffness

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E. Response Spectrum Curves







Fig 16: RS Curve for Maximum Story Displacement as per IS1893-2016

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IV. CONCLUSION

- There is a difference in story displacement. Story displacement has reduced in IS 1893-2016 when compared to IS 1893-2002
- Similar to story displacement story drift has also reduced in IS 1893-2016 when compared to IS 1893-2002
- The above two points are evident both in the form of table with values as well as RS curve.
- Story forces are similar in X & Y directions as per both codes.
- Similar to story forces there is no difference in story stiffness between both the codes.
- We can conclude that flat slab structure is more flexible than conventional frame structure and because of that it does not perform well in higher seismic zones but with the application of flat slab structures showcase properties same or even better than conventional structure.
- The value of storey drift is within permissible limits and also less in flat slab structure then other structures.
- Overturning moment capacity value being higher in flat slab structure thus possessing higher resistance to lateral and wind loads.
- Through flat slab being vulnerable to lateral loads could be provided in higher zones when provided with manifest properties same as conventional structure with slab plan density less than what is suggested by I.S. code although it may vary from structure to structure.

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