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Analysis and Design of Flat Slab with and without Shear Wall of Multi-Storied Building Frames

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***Abstract*:-** Conventional R.C.C structure i.e flat slab, shear wall , column for different heights are modelled and analyzed for the different combinations of static loading with varying thicknesses of shear wall with varying height of multistoried building .The comparison is made between the conventional R.C.C flat slab structure of 10,20and 30 stories without shear wall . The comparison made between the conventional R.C.C flat slab structure of 10,20 and 30 stories with varying thicknesses of shear wall in multi - storied buildings have been provided at some particular locations .The main objective of analysis is to study the structural behavior of shear wall – flat slab interaction.The main objective of the analysis is to study the behaviour against different forces acting on components of a multistoried building and to study the effect of part shear walls on the performance of these two types of buildings under seismic forces. The analysis is carried out using STAAD Pro2007 software Present work also provides a good source of information on various parameters like lateral displacement, plate stresses and storey drift.

Keywords *— Flat slab, Shear walls, Plate Stresses, Flexibility, Lateral displacement, Storey drift.*

I. INTRODUCTION

Generally the analysis of flat slab is more complex and also is important to study the behaviour against different forces acting on the components of a multistoried building. The analysis may be carried out using software like Stadd Pro, Sturdd, Etabs etc. In this dissertation work, modern R.C.C structure i.e flat slab, shear wall, column for different heights are modelled and analyzed for the different combinations of static loading with varying thicknesses of shear wall with varying height of multistoried building .The comparison is made between the conventional R.C.C flat slab structure of 10,20and 30 stories without shear wall. The comparison made between the conventional R.C.C flat slab structure of 10,20 and 30 stories with varying thicknesses of shear wall in multi - storied buildings have been provided at some particular locations .The main objective of analysis is to study the structural behavior of shear wall flat slab interaction. A reinforced concrete flat slab, also called as beamless slab, is a slab supported directly by columns without beams. A part of the slab bound on each of the four sides bycentrelinesofcolumnsiscalledapanel.

The flat slab is often thickened near to supporting columns to provide adequate strength in shear and to reduce the quantity of negative reinforcement in the support regions.

A shear wall is a structural system composed of parallel walls that counter the effects of lateral loads acting on a structure. Wind and seismic loads are the most common loads that shear walls are designed to carry.

Shear walls are not only designed to resist gravity/ vertical loads (due to self-weight and other living/ moving loads), but they are also designed for lateral loads of earthquakes / wind. The walls are structurally integrated with roofs / floors and other lateral walls running across at right angles, thereby giving the three dimensional stability for the building. Walls have to resist the uplift forces caused by the pull of the wind. Walls have to resist the shear forces that try to push the walls over. Shear walls are quick to construct, Shear walls don't need any extra plastering or finishing as the wall itself gives a high level of precision & it don't require plastering.

II. PROBLEM FORMULATION & ANALYSIS

Conventional R.C.C flat slab structure without shear wall and flat slab R.C.C structures with shear wall at particular locations are modelled and analyzed for the different combinations of static loading. Comparison is made between the conventional R.C.C flat slab structure and flat slab R.C.C. structure with shear walls situated in seismic zone IV. Different cases of building considered are as given below:

Case-1: Design and analysis of flat slab without shear wall for 10 storied multistoried building.

Case-2: Design and analysis of flat slab with shear wall for 10 storied multistoried building.

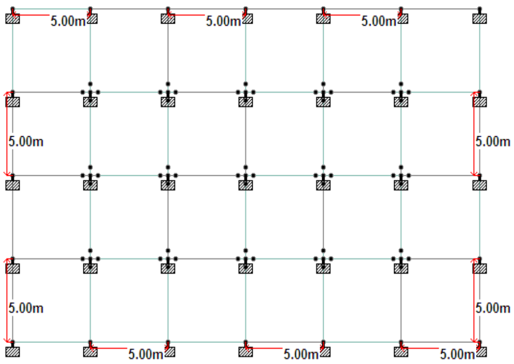
Case-3: Design and analysis of flat slab without shear

wall for 20 storied multistoried building
Case-4: Design and analysis of flat slab with shear
wall for 20 storied multistoried building.
Case-5: Design and analysis of flat slab without shear
wall for 30 storied multistoried building.
Case-6: Design and analysis of flat slab with shear
wall for 30 storied multistoried building.

The plan area for the proposed work is 20x30 m in which size of panels is 5x5 m. The properties of material adopted are. The Young's modulus of elasticity of concrete adopted was 25,000 MPa while the Poisson's ratio was 0.2. The preliminary sections of columns and beams were fixed on the basis of deflection criteria [i.e. span to depth ratio]. The sections were found to be satisfactory for the given loads for a ten storied model. These sections were maintained uniform throughout the height. Similarly, all other models of (twenty and thirty stories) were analyzed and designed to meet the current Codes (IS 456:2000 and IS 1893:2002) and their structural member sizes chosen for the study are given in table below:In the present work, the self weight of the members is calculated by considering the density as 25 kN/m^3 for concrete. According to IS 456 minimum grade of concrete is M20 and grade of steel adopted is Fe415. The self weight of slab =0.2 x 1 x 1 x 25 = 5 kN/m2Load considered due to floor finish= 1 kN/m2To study the behaviour the response parameters selected are lateral displacement and storey drift. All the cases are assumed to be located in zone III, zone IV and zone V. To reduce lateral displacement and storey drift shear walls have been provided at corners without affecting the parking in ground floors. Further, in practice multi-storey buildings are analysed by providing rigidity at various floors using master slave command in STAAD.Pro software. In reality slabs exist at various floor levels which provide additional rigidity to floors. Therefore, in present work a comparative study of above mentioned practice and reality is also made. Observations show that lateral displacement and storey drift are significantly reduced by providing part shear walls.

TABLE 1

Earthquake Load	Variables
Earthquake Parameters Zone (Z) Response Reduction factor RF	IV 1



PLAN AREA (20X30) m
PLAN OF FLAT SLAB WITHOUT SHEAR WALL FOR 10,20 and 30 STORIED BLDG.

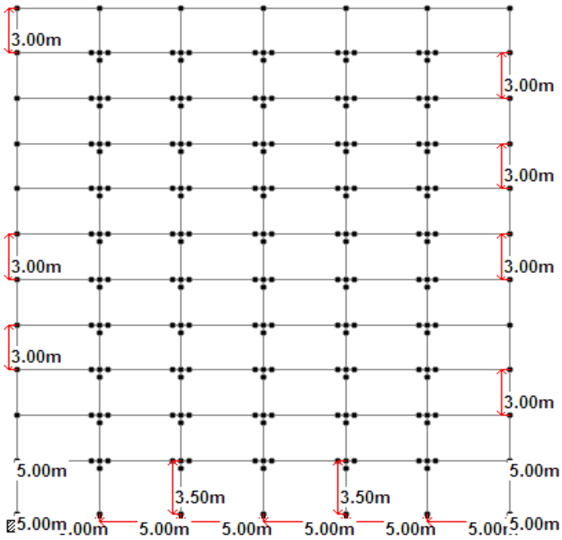


Plate No: 5

ELEVATION OF FLAT SLAB WITHOUT SHEAR WALL FOR 10 STORIED BLDG.

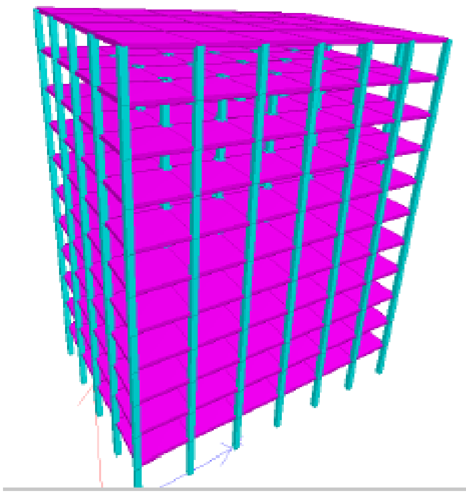


Plate no:6

3-D VIEW OF FLAT SLAB WITHOUT SHEAR FOR 10 STORIED BUILDING

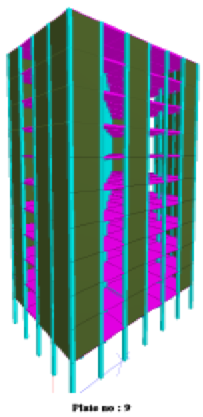


Plate no : 9

3-D VIEW OF FLAT SLAB WITH SHEAR FOR 10 STORIED BUILDING

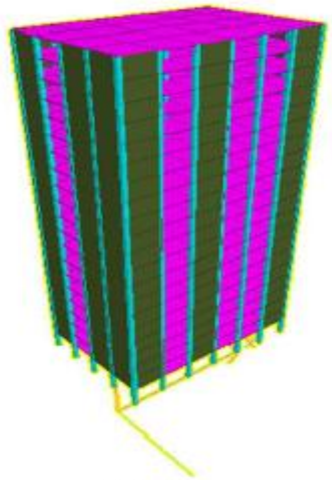


Plate no : 11

3-D VIEW OF FLAT SLAB WITH SHEAR WALL FOR 20 STORIED BUILDING

III. RESULT

Following results are tabulated:

FLAT PLATE CENTER STRESS SUMMARY FOR 10 STORIED FLAT SLAB MULTISTORIED BUILDING

			Shear		Membrane			Bending Moment		
	Plate	L/C	SQX (local	SQY (local	SX (local)	SY (local)	SXY (local	Mx kNm/r	My kNm/r	Mxy kNm/
Max Qx	2435	5 GENERA	362.278	-110.565	-481.333	-310.234	190.053	74.208	-18.171	7.324
Min Qx	2417	5 GENERA	-362.31	-113.817	-483.464	-312.566	-185.325	74.341	-18.166	-6.99
Max Qy	2425	5 GENERA	36.245	280.588	-375.438	-273.757	-58.234	-53.712	21.441	-41.337
Min Qy	501	5 GENERA	-27.253	-1244.38	-211.721	-1674.48	272.599	16.186	118.313	-18.133
Max Sx	2233	5 GENERA	-43.37	-174.991	556.406	296.517	155.132	21.132	4.035	12.773
Min Sx	2417	5 GENERA	-362.31	-113.817	-483.464	-312.566	-185.325	74.341	-18.166	-6.99
Max Sy	2242	5 GENERA	8.532	-71.103	166.838	452.94	27.125	8.704	43.726	2.622
Min Sy	501	5 GENERA	-27.253	-1244.38	-211.721	-1674.48	272.599	16.186	118.313	-18.133
Max Sxy	502	5 GENERA	44.021	-764.86	52.939	-1333.64	279.756	0.66	-20.167	-31.311
Min Sxy	2418	5 GENERA	-297.013	-164.244	-369.898	-251.216	-200.271	50.428	-31.683	-50.13
Max Mx	2417	5 GENERA	-362.31	-113.817	-483.464	-312.566	-185.325	74.341	-18.166	-6.99
Min Mx	2429	5 GENERA	109.059	34.852	-453.812	-226.533	75.007	-220.428	-113.187	16.983
Max My	495	5 GENERA	59.355	-993.085	144.875	-1129.4	148.418	25.172	125.518	-2.232
Min My	2429	5 GENERA	109.059	34.852	-453.812	-226.533	75.007	-220.428	-113.187	16.983
Max Mxy	2415	5 GENERA	-287.373	-22.253	-335.975	-274.977	-120.625	48.183	-13.785	70.212
Min Mxy	2433	5 GENERA	285.215	-22.531	-332.614	-282.424	125.603	49.124	-14.683	-70.057

FLAT PLATE CENTER STRESS SUMMARY FOR 30 STORIED FLAT SLAB MULTISTORIED BUILDING

			Shear		Membrane			Bending Moment		
	Plate	L/C	SQX (local	SQY (local	SX (local)	SY (local)	SXY (local	Mx kNm/r	My kNm/r	Mxy kNm/
Max Qx	8571	5 GENERA	69.919	-74.206	8.85	2.285	-0.92	-0.065	0.678	-0.28
Min Qx	8558	5 GENERA	-63.291	38.05	6.151	12.135	-8.504	-0.321	-2.235	0.005
Max Qy	8576	5 GENERA	47.317	48.096	6.948	12.088	9.026	-1.476	-1.374	-0.041
Min Qy	495	5 GENERA	14.128	-104.601	2.486	-24.816	18.615	0.219	1.713	-0.794
Max Sx	497	5 GENERA	-9.696	-17.701	37.897	22.737	4.127	-3.193	-0.957	0.036
Min Sx	8584	5 GENERA	-1.707	-26.455	-122.359	-159.407	28.573	-5.602	-3.75	-0.021
Max Sy	487	5 GENERA	-43.276	-32.935	18.781	35.346	-5.807	-2.504	-2.682	0.146
Min Sy	8592	5 GENERA	2.145	-15.676	-96.395	-236.191	15.711	-5.593	-4.453	-0.218
Max Sxy	8587	5 GENERA	-3.218	-7.346	-99.809	-220.293	49.208	-8.819	-9.379	0.144
Min Sxy	8600	5 GENERA	33.564	35.062	-41.422	-106.246	-29.249	-1.847	-1.641	-0.684
Max Mx	6902	5 GENERA	-16.368	-41.959	4.2	4.51	-4.126	1.228	0.429	0.378
Min Mx	8587	5 GENERA	-3.218	-7.346	-99.809	-220.293	49.208	-8.819	-9.379	0.144
Max My	8343	5 GENERA	4.227	-8.083	12.117	7.531	-0.208	-0.676	3.073	-0.559
Min My	8587	5 GENERA	-3.218	-7.346	-99.809	-220.293	49.208	-8.819	-9.379	0.144
Max Mxy	483	5 GENERA	-10.767	-54.055	20.867	7.735	-1.219	-3.282	-0.28	1.457
Min Mxy	501	5 GENERA	32.106	-89.495	-10.078	-30.746	13.799	1.074	2.781	-1.678

FLAT PLATE CENTER STRESS SUMMARY FOR 30 STORIED FLAT SLAB WITH SHEAR WALL

MULTI STORIED BUILDING

			Shear		Membrane			Bending Moment		
	Plate	L/C	SQX (local	SQY (local	SX (local)	SY (local)	SXY (local	Mx kNm/r	My kNm/r	Mxy kNm/
Max Qx	8572	5 GENERA	141.16	-111.586	1.497	-40.161	73.817	-0.584	-4.576	-2.21
Min Qx	8555	5 GENERA	-151.575	-5.796	28.133	-11.262	-38.567	0.767	-1.973	1.195
Max Qy	8564	5 GENERA	-36.755	150.359	-4.439	1.312	7.122	-4.669	2.374	-1.442
Min Qy	8565	5 GENERA	4.035	-183.536	47.154	5.819	37.683	-4.727	3.619	-2.196
Max Sx	501	13 GENER	41.219	-9.308	1436.346	1271.013	-669.498	0.708	-2.607	-2.045
Min Sx	489	9 GENERA	24.364	-52.314	-893.619	-825.948	105.039	4.201	5.663	0.414
Max Sy	488	5 GENERA	23.859	-35.313	1322.665	1430.384	-32.376	-3.556	-6.362	0.173
Min Sy	484	15 GENER	-30.762	-2.255	-836.17	-982.868	134.568	4.254	4.656	0.075
Max Sxy	499	13 GENER	35.733	17.784	-113.124	60.89	372.431	0.45	2.043	0.795
Min Sxy	501	8 GENERA	36.968	-22.19	1391.746	1212.616	-672.613	0.213	-0.836	-2.032
Max Mx	494	12 GENER	-2.487	34.768	-892.84	-893.25	-56.116	4.44	4.552	-0.284
Min Mx	8586	5 GENERA	-24.85	-4.023	-273.793	-495.195	42.459	-13.807	-8.868	0.402
Max My	8600	12 GENER	39.635	14.404	-62.342	-9.627	1.601	-1.672	7.858	5.502
Min My	8587	5 GENERA	-16.38	17.386	-233.227	-441.092	23.912	-13.783	-16.039	-1.204
Max Mxy	8577	5 GENERA	-52.932	-33.18	-80.917	-84.237	13.23	-4.255	2.253	6.419
Min Mxy	8582	5 GENERA	-44.064	33.53	-55.646	-116.784	46.365	0.55	4.022	-6.131

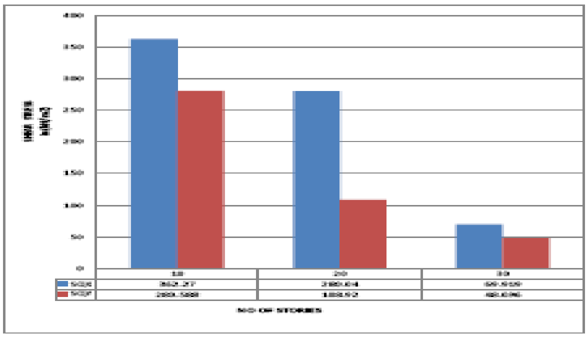


Fig no : 1
FLAT PLATE CENTER SHEAR STRESS FOR 10,20and 30 STORIED FLAT SLAB MULTISTORIED BUILDING

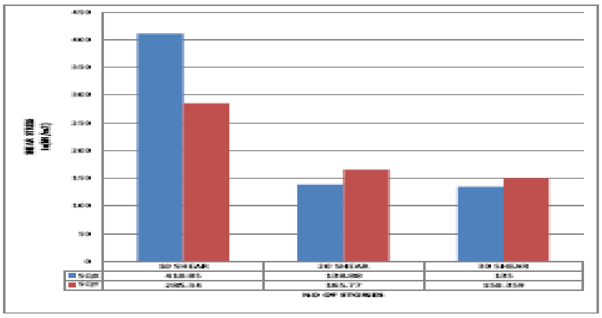


Fig no : 2
FLAT PLATE CENTER SHEAR STRESS FOR 10 ,20and30 STORIED FLAT SLAB WITH SHEAR WALL MULTISTORIED BUILDING

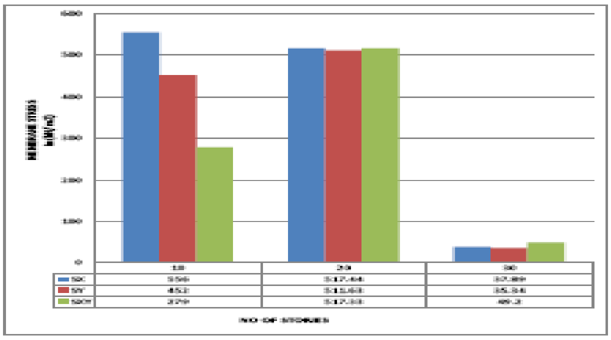


Fig no : 3
FLAT PLATE CENTER MEMBRANE STRESS FOR 10,20 and 30 STORIED FLAT SLAB MULTISTORIED BUILDING

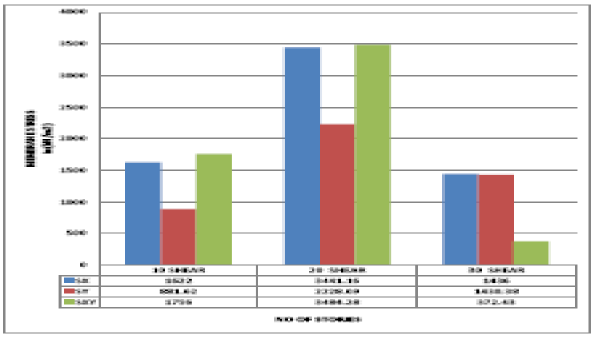


Fig no : 4

FLAT PLATE CENTER MEMBRANE STRESS FOR 10,20 and30 STORIED FLAT SLAB WITH SHEAR WALLMULTISTORIED BUILDING

FLATE STRESS FLAT PLATE OF 10 STORIED VON MIS TRESCA CONTOUR DIAGRAM:

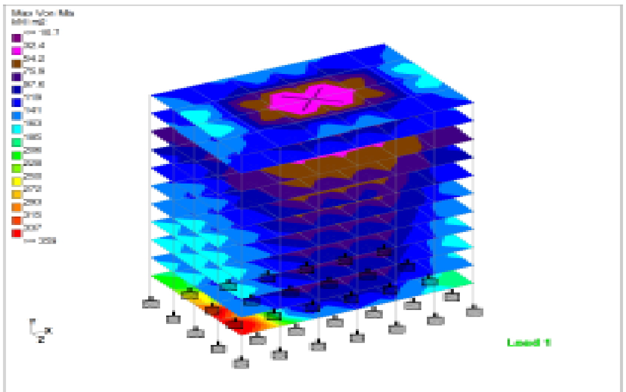


Plate no : 14

FLATE STRESS CONTOUR OF FLAT SLAB OF 10 STORIED BUILDING DUE TO LOAD EQx

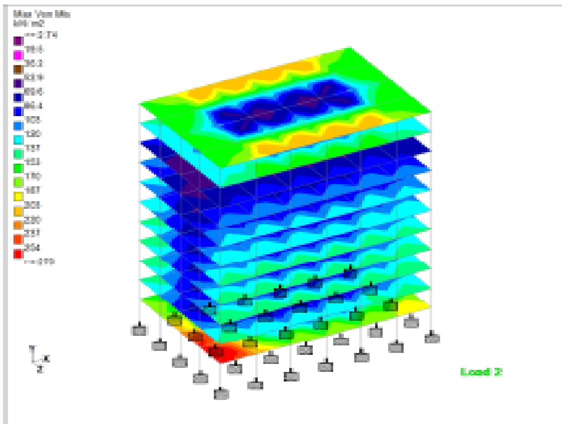


Plate no : 15

FLATE STRESS CONTOUR OF FLAT SLAB OF 10 STORIED BUILDING DUE TO LOAD EQz

Discussions: The study examines the performance of flat slab with shear walls in multi-storey buildings. The different cases were studied for buildings without shear wall and with shear wall. As it is discussed earlier, shear wall gives better performance under seismic loading because it resists the lateral loads in its own plane. It is more stiff in its own plane. In present study , Flat Slab system of 10,20and30 stories without shear wall and the Flat Slab system with shear wall of 10,20and30 stories having varying thicknesses of shear wall are compared. To study the effectiveness of all these models, the plate center stresses, plate corner stresses , flat plate principal Von Mis . stresses ,shear wall surface forces , storey drift are worked out and are presented in figures. The results presented in various figures are discussed briefly.Reinforcement calculated to resist Mx is called longitudinal reinforcement, and is denoted in the output by the expression "LONG. REINF. The reinforcement calculated to resist My is called transverse reinforcement, and is denoted in the output by the expression

"TRANS. REINF. The signs of Mx and My determine which face of the element the steel has to be provided on. Every element has a "top" face, and a "bottom" face, as defined by the direction of the local Z axis of the elements. Mx causes tension on one of those faces, and compression on the other. A similar effect is caused by My. The output report of reinforcement provided on those faces contains the terms "TOP" for top face, and"BOTT" for the bottom face. In the above output, the word TOP and BOTTOM refer to the 'local' top and bottom surfaces of the individual elements, and not in the global axis sense. The local top and bottom surfaces depend on the way an element is defined in its incidence statement. TOP is defined as the surface which coincides with the positive side of the local Z axis. BOTTOM is defined as the surface which coincides with the negative side of the local Z axis. The 2 nonzero Principal stresses at the surface (SMAX & SMIN), the maximum 2D shear stress (TMAX), the 2D orientation of the principal plane (ANGLE), the 3D Von Mises stress (VONT & VONB),3D Tresca stress (TRESCAT & TRESCAB) are also printed for the top and bottom surfaces of these elements. The top and the bottom surfaces are determined on the basis of the direction of the local z-axis. The third principal stress is assumed to be zero at the surfaces for use in Von Mises and Tresca stress calculations. However, the TMAX and ANGLE are based only on the 2D inplane stresses (SMAX &SMIN) at the surface. The 3D maximum shear stress at the surface is not calculated but would be equal to the 3D Tresca stress divided by 2.0.

IV. CONCLUSIONS

Analysis of 10,20 and 30 storied buildings with flat slab system without shear and the buildings with flat slab system with shear wall is carried out and the following conclusions are drawn from the study:

1 The values of storey drift are found to be within permissible limit i.e not more than 0.004 times the storey height as per norms according to IS 1893 :2002 Part-1.

2 Structure with shear wall along periphery is suitable for the effect of wind and earthquake load on the performance of building.

3 In flat slab with shear wall system as the thickness of shear wall is varying with the storey height , the surface shear stresses SQx and SQy increase in 10 & 20 storied building and then decrease in 20& 30 storied building.

4 In flat slab with shear wall system as the thickness of shear wall is varying with the storey height , the surface bending stresses Mx, My ,Mz increase in 10 & 20 storied building and then decrease in 20& 30 storied building.

5 In flat slab with shear wall system as the thickness of shear wall is varying with the storey height , the surface membrane stresses Fx, Fy,Fxy increase in 10 & 20 storied building and then decrease in 20& 30 storied building.

6 The flat slab Von Mis. top and bottom stresses increases for 10,20and30, storied flat slab building without and with shear wall.

7 The Von Mis. bottom stresses is more than the top stresses for 10,20and30 storied flat slab building without and with shear wall.

8 The flat slab Tresca top and bottom stresses increases for 10,20and30 storied flat slab building without and with shear wall.

9 The Tresca bottom stresses is more than top stresses for 10,20and30 storied flat slab building without and with shear wall.

10 The principal top stresses is more than bottom stresses for 10,20and30 storied flat slab building without and with shear wall.

11 The plate corner membrane stresses Sx,Sy,Sxy, increase for the 10,2and30 storied flat slab building within and without shear wall.

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