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# Interaction of Flat Slab and Shear Wall in a Multi-storey Building under Earthquake Forces

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**ABSTRACT:**In today's scenario the analysis of a multistorey building with provision of flat slab and shear wall is much more composite as the analysis involved various elements and the various load combinations. The analysis can be carried out manually (which takes a lot of time) or can be done using various software such as STADD PRO, ETABS, etc. In this research work we will compare the behaviour of conventional framed buildings with that of multistorey flat slab building with and without shear wall on seismic behaviour with different positions of shear wall. For this G+9 storeyed models with plan 20\*20 m are chosen. For calculating various parameters during analysis shear wall are provided at different positions. The analysis is carried out using STADD.PRO and to study effect of different location of shear wall on flat slab multi-storey building static analysis (Equivalent Static Analysis) is carried out for zone V and is checked using response spectrum method of analysis. The seismic parametric studies comprise of lateral displacement, storey drift, drift reduction factor and contribution factor.

**KEYWORDS:**Flat Slab, Conventional Slab, Seismic Analysis, Seismic Zones, STADD PRO.

## I. INTRODUCTION

In present scenario with the increase in population, one of the major problems we are facing is the availability of vacant land. This scarcity of vacant land has led to the construction of multi-storey building as the growth can be done in vertical side due to lack of land. These buildings can be low-rise, medium-rise, tall buildings and even sky-scraper (over 50 meters tall). These buildings are generally framed buildings and are mainly subjected to both vertical loads as well as vertical loads. The main concern while designing in that these types of buildings are subjected to strong lateral loads that are due to earthquake (seismic) loads and wind loads rather than vertical loads. These both factors may be inversely proportional to each other as the building which is designed for sustaining vertical loads may not have the capacity to sustain or resist the above-mentioned lateral loads. The lateral loads are the foremost ones as they are in contrast against one another as the vertical loads are supposed to increase linearly with height; on the other hand, lateral loads are fairly variable and increase rapidly with height. For buildings taller than 15 to 20 stories, pure rigid frame system is not adequate because it does not provide the required lateral stiffness and causes excessive deflection of the building. These requirements are satisfied by two ways:

- by increasing the members size above the requirements of strength but this approach has its limitation
- by changing the structural form into more stable and rigid to restrict deformation. This increases the structure's stability and rigidity and also restricts the deformation requirement.

So, the second way by changing the structural form into more stable and rigid to restrict deformation is used. From it the concept of shear wall come into action and it overall increases the structures stability and rigidity.

## II. MATERIALS & METHODS

The aim of this study is to see how flat slab and shear wall interacts under earthquake loads. This takes into account multi-story buildings. This study examines the structural behaviour of the structural composition proportionate to the interaction of flat slab and shear wall. Shear walls are provided at particular locations in a multi-story building to



mitigate storey-drift and column-shear. Under seismic loading, a systematic survey of the response and behaviour of flat slab and shear wall interaction is carried out. For this study, the method of analysis used are listed below:

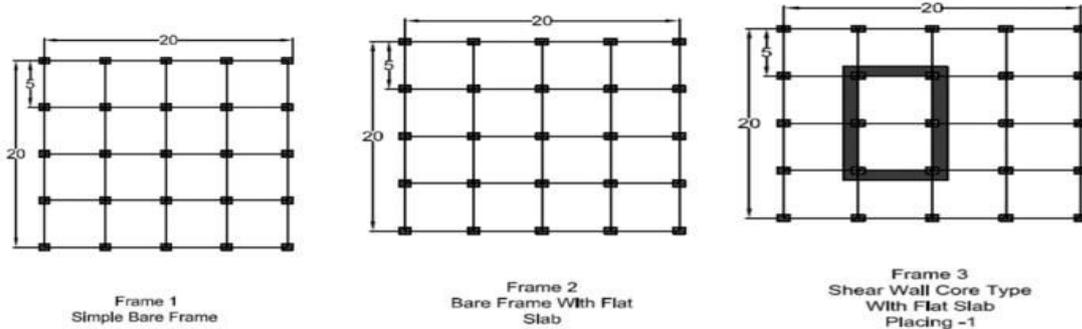
- Equivalent Lateral Force Method( Staticmethodof analysis)
- Response Spectrum method ( Dynamic method of analysis)

Stadd.Pro v8i software is used to carry out the above two methods of analysis

### III. MODELLING

For the different combinations of loading conventional R.C.C flat slab structure with & without shear wall at particular locations are modelled & analysed using static method and response spectrum method respectively in Stadd.Pro. Now compare between conventional R.C.C flat slab structure and flat slab R.C.C. structure with shear walls situated in seismic zone V. Following cases of building are as follows:

- Structure 1. Conventional R.C.C. structure having no flat slab and no shear wall.
- Structure 2. Conventional R.C.C. structure having Flat slab.
- Structure 3. Core type shear wall having flat slab (location-1).
- Structure 4. Core type shear wall having flat slab (location-2).
- Structure 5. C type shear wall having flat slab (location-1).
- Structure 6. C type shear wall having flat slab (location-2).
- Structure 7. L type shear wall at the edges having flat slab.
- Structure 8. Parallel type shear wall along the outskirts having flat slab.
- Structure 9. Non-Parallel type shear wall along the outskirts having flat slab.
- Structure 10. + type shear wall at center having flat slab.
- Structure 11. E type shear wall having flat slab (location-1).
- Structure 12. E type shear wall having flat slab (location-2).



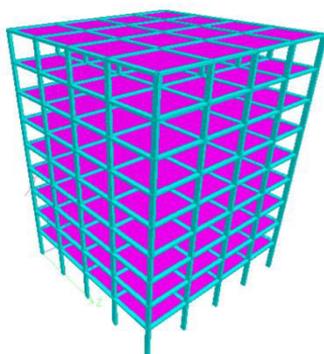
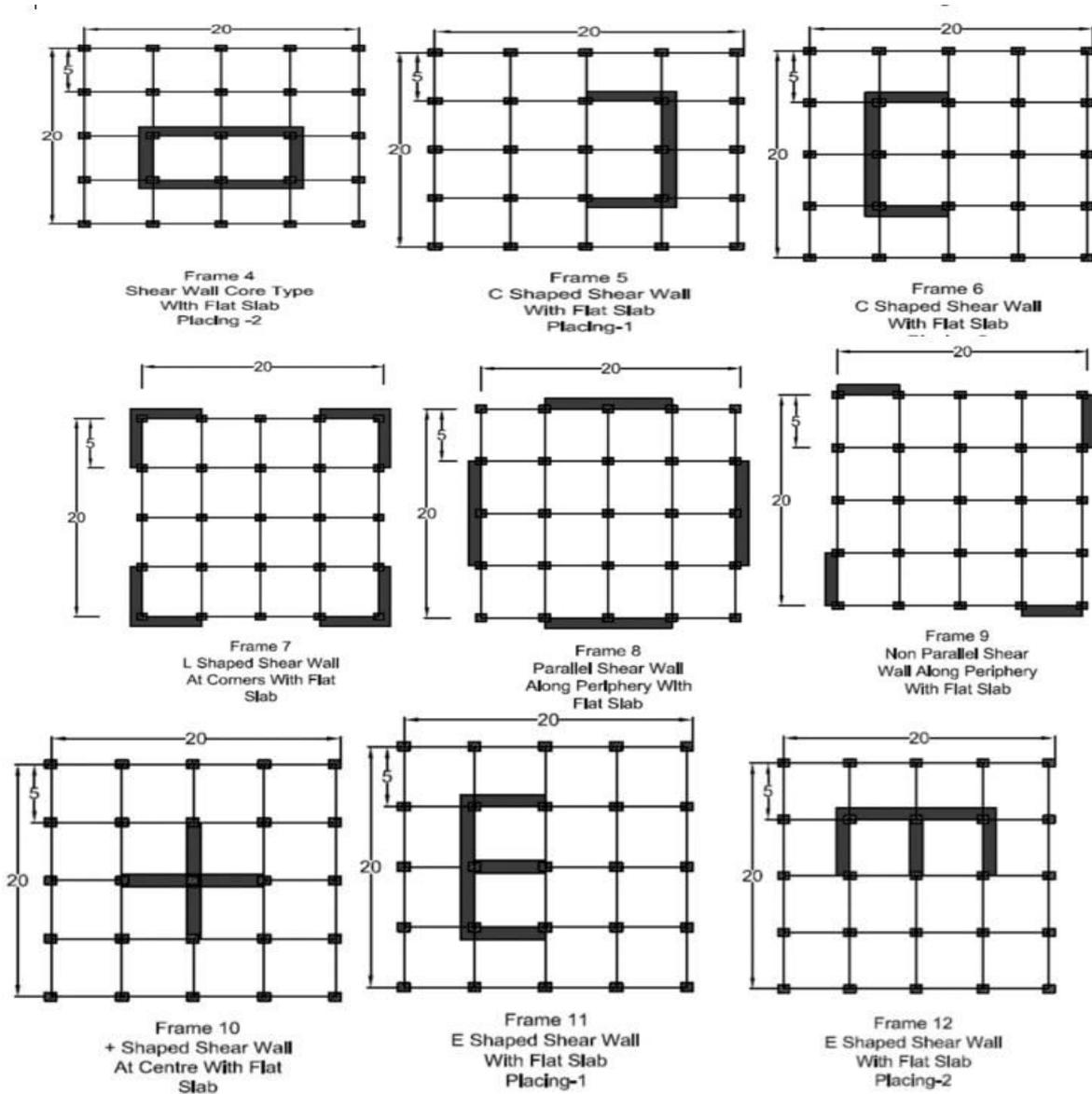


Fig. 1 3-D View of Conventional RCC Structure

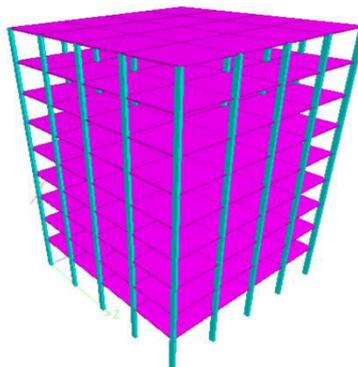


Fig. 2 3-D View of Flat slab structure

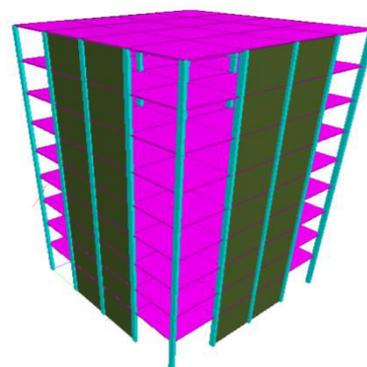


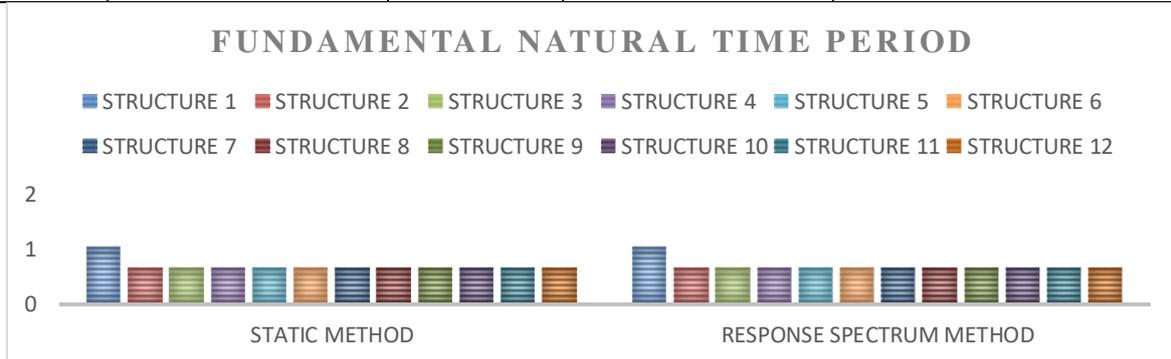
Fig. 1 3-D View of Flat slab structure with shear wall



III. RESULT & DISCUSSION

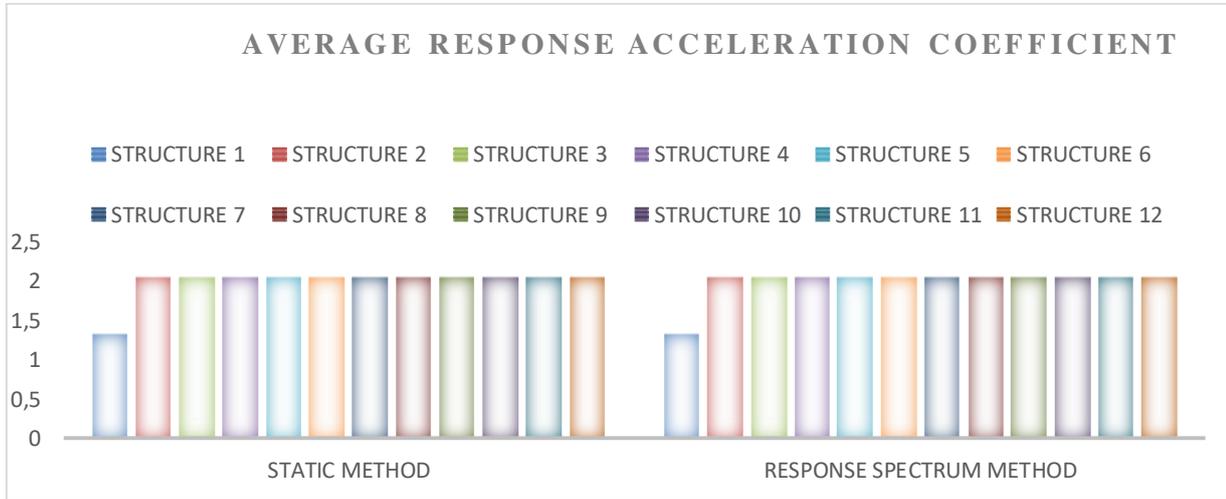
(A) Fundamental Natural Period( $T_n$ ): In comparison of buildings with different frames, the approximate fundamental natural time of vibration ( $T_n$ ) of a moment resisting frame structure can be measured to the highest values as:

S.NO.	TYPE OF STRUCTURE	HEIGHT OF BULDING (meters)	FUNDAMENTAL NATURAL TIME PERIOD (sec.) By static method	FUNDAMENTAL NATURAL TIME PERIOD (sec.) Response spectrum method
1	STRUCTURE 1	33	1.032	1.032
2	STRUCTURE 2	33	0.664	0.664
3	STRUCTURE 3	33	0.664	0.664
4	STRUCTURE 4	33	0.664	0.664
5	STRUCTURE 5	33	0.664	0.664
6	STRUCTURE 6	33	0.664	0.664
7	STRUCTURE 7	33	0.664	0.664
8	STRUCTURE 8	33	0.664	0.664
9	STRUCTURE 9	33	0.664	0.664
10	STRUCTURE 10	33	0.664	0.664
11	STRUCTURE 11	33	0.664	0.664
12	STRUCTURE 12	33	0.664	0.664



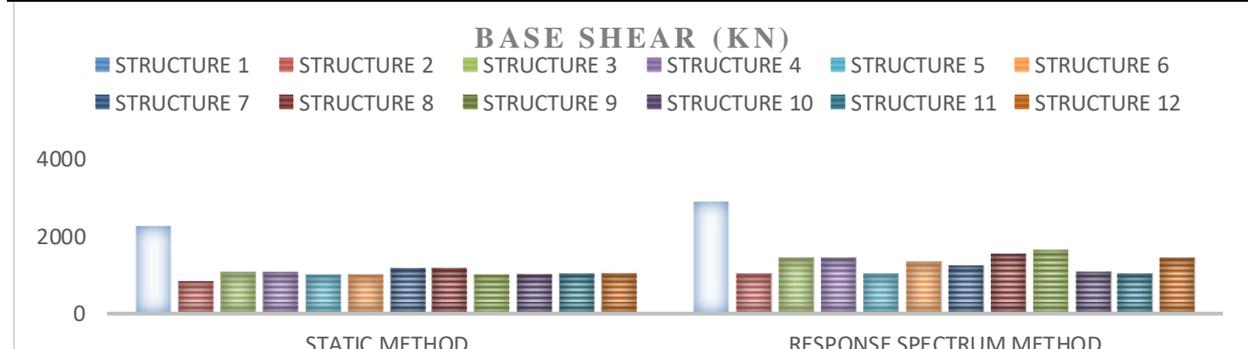
(B) Average Response Acceleration Coefficient ( $S_a/g$ ): In comparison of buildings with different frames, the average response acceleration coefficient is a factor represents acceleration response continuum of the structure exposed to seismic ground shaking(vibrations), and it relies on normal time of vibration and structure’s damping to highest values.

S.NO.	TYPE OF STRUCTURE	HEIGHT OF BULDING (meters)	AVERAGE RESPONSE ACCELERATION COEFFICIENT By Static method	AVERAGE RESPONSE ACCELERATION COEFFICIENT By Response spectrum method
1	STRUCTURE 1	33	1.317	1.317
2	STRUCTURE 2	33	2.048	2.048
3	STRUCTURE 3	33	2.048	2.048
4	STRUCTURE 4	33	2.048	2.048
5	STRUCTURE 5	33	2.048	2.048
6	STRUCTURE 6	33	2.048	2.048
7	STRUCTURE 7	33	2.048	2.048
8	STRUCTURE 8	33	2.048	2.048
9	STRUCTURE 9	33	2.048	2.048
10	STRUCTURE 10	33	2.048	2.048
11	STRUCTURE 11	33	2.048	2.048
12	STRUCTURE 12	33	2.048	2.048



(C) Base Shear:- When comparing buildings with different frames, the average response acceleration coefficient is a parameter that denotes the acceleration response range of the structure exposed to earthquake - induced motions. It is depending on normal duration of vibration and damping of the structure to optimum values.

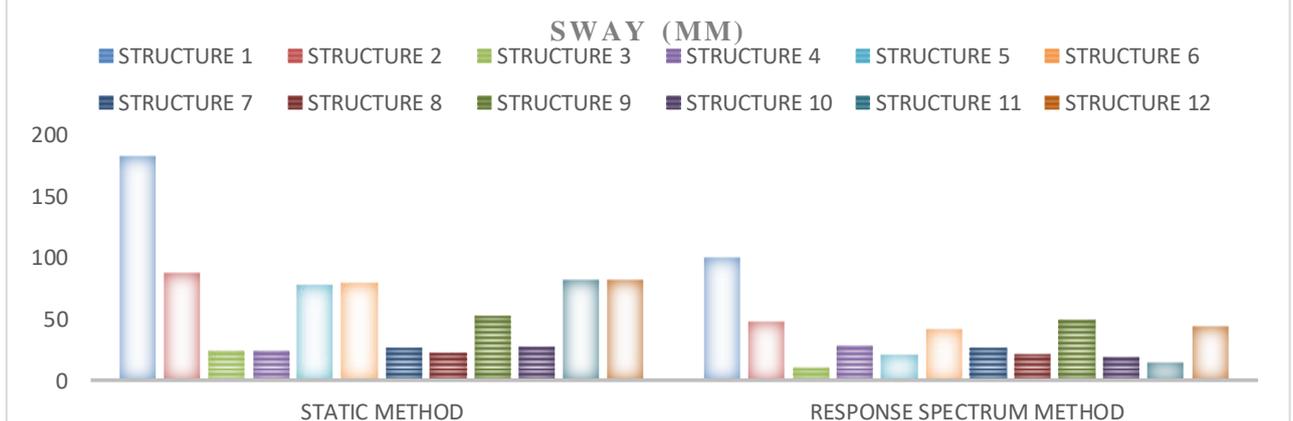
S.NO.	TYPE OF STRUCTURE	HEIGHT OF BULDING (meters)	BASE SHEAR (kN) by Static method	BASE SHEAR (kN) by Response spectrum method
1	STRUCTURE 1	33	2231.73	2879.08
2	STRUCTURE 2	33	817.73	1040.33
3	STRUCTURE 3	33	1072.10	1415.43
4	STRUCTURE 4	33	1072.10	1415.43
5	STRUCTURE 5	33	987.31	1017.81
6	STRUCTURE 6	33	987.31	1319.20
7	STRUCTURE 7	33	1156.89	1214.27
8	STRUCTURE 8	33	1156.89	1526.75
9	STRUCTURE 9	33	987.31	1607.90
10	STRUCTURE 10	33	987.31	1057.53
11	STRUCTURE 11	33	1029.70	1030.05
12	STRUCTURE 12	33	1029.70	1408.01



(D) Sway (mm): -In relation of buildings with different frames, the gap between the two consecutive floors is called storey, and the displacement of one floor compared to other floor below or above is called sway, in accordance to optimum values.

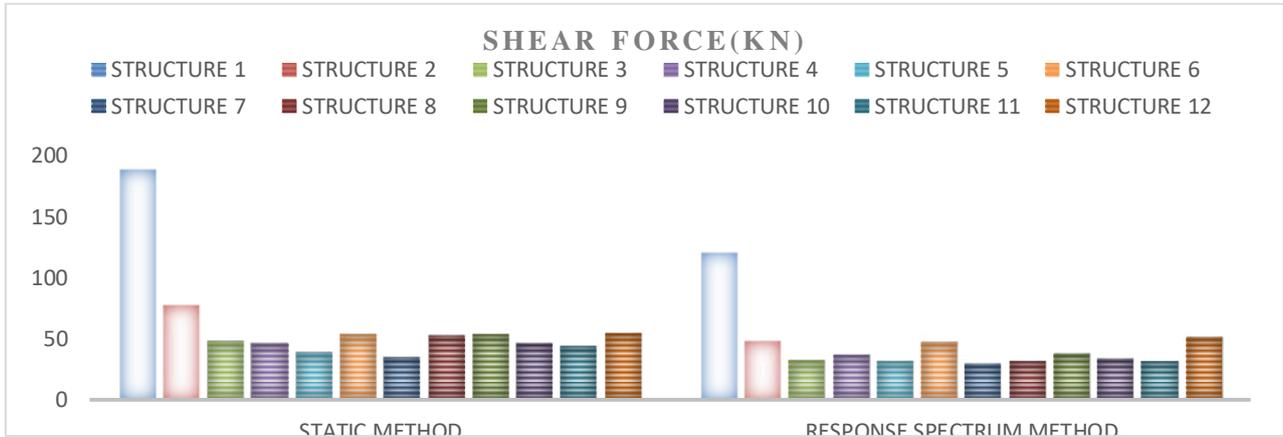


S.NO.	TYPE OF STRUCTURE	HEIGHT OF BULDING (meters)	SWAY (mm) by Static Method	SWAY (mm) by Response spectrum Method
1	STRUCTURE 1	33	182.238	100.189
2	STRUCTURE 2	33	87.980	48.145
3	STRUCTURE 3	33	24.661	10.429
4	STRUCTURE 4	33	24.661	28.793
5	STRUCTURE 5	33	77.517	21.306
6	STRUCTURE 6	33	78.943	41.750
7	STRUCTURE 7	33	26.960	26.098
8	STRUCTURE 8	33	22.393	21.582
9	STRUCTURE 9	33	51.964	48.811
10	STRUCTURE 10	33	27.624	19.288
11	STRUCTURE 11	33	81.135	14.790
12	STRUCTURE 12	33	81.135	43.668



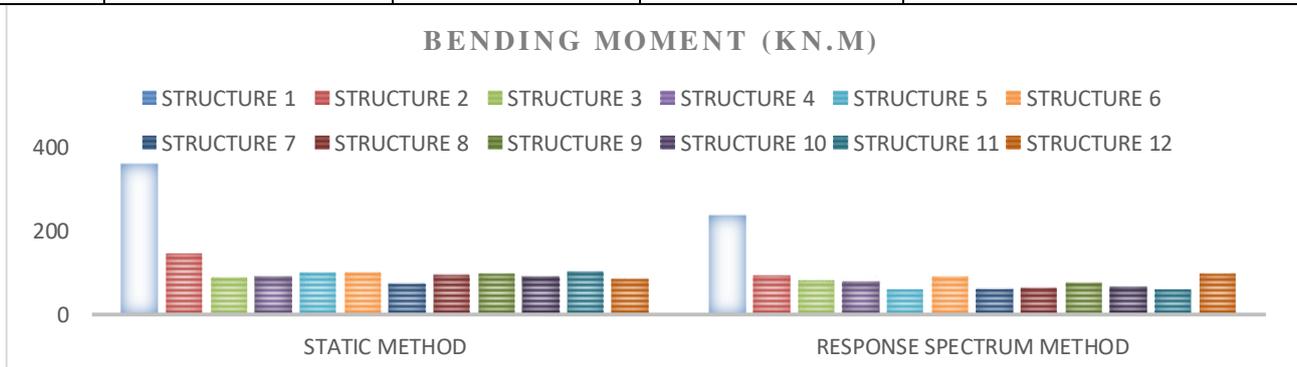
(E) Shear Force (kN): - The algebraic summation of each and every force acting along one phase of a beam section is known as shear force. The calculated value of shearing forces for various frames is as follows: -

S.NO.	TYPE OF STRUCTURE	HEIGHT OF BULDING (meters)	MAXIMUM SHEAR FORCE (kN) By static method	MAXIMUM SHEAR FORCE (kN) By Response spectrum method
1	STRUCTURE 1	33	188.602	120.421
2	STRUCTURE 2	33	78.089	48.766
3	STRUCTURE 3	33	48.734	32.283
4	STRUCTURE 4	33	46.531	37.154
5	STRUCTURE 5	33	39.339	31.484
6	STRUCTURE 6	33	53.631	47.137
7	STRUCTURE 7	33	34.566	29.661
8	STRUCTURE 8	33	52.372	31.656
9	STRUCTURE 9	33	53.955	38.373
10	STRUCTURE 10	33	46.730	33.680
11	STRUCTURE 11	33	43.863	32.035
12	STRUCTURE 12	33	54.083	50.979



(F) Moment (kN-m): - At any beam section, the bending moment is known as the algebraic summation of each and every force acting on one phase of that section. The calculated value of Bending Moment for various frames is as follows: -

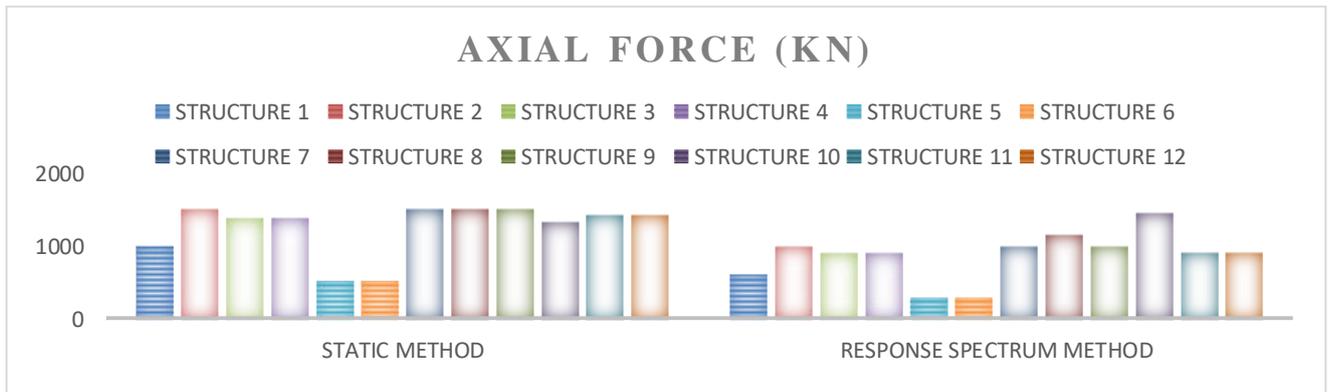
S.NO.	TYPE OF STRUCTURE	HEIGHT OF BULDING (meters)	MAXIMUM BENDING MOMENT (kN.m) by static method	MAXIMUM BENDING MOMENT (kN.m) by response spectrum method
1	STRUCTURE 1	33	359.185	238.136
2	STRUCTURE 2	33	144.626	95.265
3	STRUCTURE 3	33	88.572	81.812
4	STRUCTURE 4	33	90.967	79.946
5	STRUCTURE 5	33	99.914	61.672
6	STRUCTURE 6	33	100.238	89.602
7	STRUCTURE 7	33	73.242	59.446
8	STRUCTURE 8	33	94.513	63.898
9	STRUCTURE 9	33	97.764	76.889
10	STRUCTURE 10	33	90.010	65.165
11	STRUCTURE 11	33	102.096	61.689
12	STRUCTURE 12	33	84.803	96.090



(H)Axial Force (KN): -The stresses and strains in an axial-force member are evenly distributed around the cross section.As a result, when calculating axial forces in members in the upward global direction, we must consider forces in the x-z axis. The value of axial-force in accordance to various variations in storey’s elevation with various frames is calculated as: -



S.NO.	TYPE OF STRUCTURE	HEIGHT OF BUILDING(meters)	AXIAL FORCE (kN) by static method	AXIAL FORCE (kN) by response spectrum method
1	STRUCTURE 1	33	1001.299	606.645
2	STRUCTURE 2	33	1509.908	1006.605
3	STRUCTURE 3	33	1388.399	906.010
4	STRUCTURE 4	33	1388.399	906.010
5	STRUCTURE 5	33	526.052	287.535
6	STRUCTURE 6	33	526.052	287.535
7	STRUCTURE 7	33	1510.740	1007.16
8	STRUCTURE 8	33	1505.981	1154.98
9	STRUCTURE 9	33	1510.544	1007.029
10	STRUCTURE 10	33	1333.929	1459.571
11	STRUCTURE 11	33	1427.385	917.381
12	STRUCTURE 12	33	1427.385	917.381



IV. CONCLUSION

Based on the result following conclusion are drawn:

- (A) Since the values are expressed in form of tables graphs, the normal time interval changes as the structure's elevation changes, implying that all the frames have had the same values for various storey simulations. It rises in tandem with the building's height, but the most notable improvement is the improved value of Frame 1.
- (B) The Average Response Acceleration Coefficient ( $S_a/g$ ) reduces as the structure's elevation rises, meaning that almost all frames have had the exact values for various storey simulations; it decreases as the building's height increases, but the main difference is the decreased value of Frame 1; it decreases as the building's height increases, but the biggest shift is the lowered value of Frame 1.
- (C) Although the values of the various storeys vary slightly, design seismic base shear ( $V_b$ ) is large in 1st Frame while small in 2nd Frame. There are nine storeys in the high base shear case and nine storeys in the medium base shear case.
- (D) Sway values are expressly claimed that there is still sway when entering high-rise structures, but this report indicates that there is a lot of sway if we have a system that follows frame 1. Frame 8 has a lower limit from all the outcomes in a single storey, in comparison to this value.
- (E) The shear force increases as the structure's height increases. As a result, 9 storey frame 1 has the highest value and 9 storey frame 2 has the lowest value. Frame number seven.
- (F) The Bending Moment appears to be greatest in buildings of nine stories. Frame 1 has the highest values, while frame 7 has the lowest
- (G) By comparing the storeys of different heights, the axial force increases as well. Frame 7 appears to have the highest average value, while frames 5 AND 6 appear to have the lowest.



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