

Seismic Analysis of Irregular Shear Wall in Reinforced Concrete Structures

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Abstract— Structural Dynamics study has been steadily increasing over the years. The modern trend is towards tall and slender structures which have been designed as irregular due to innovative and architectural aspect. These buildings are affected by environmental factors like wind, earthquake and waterways. Millions of people world-wide annually die due to earthquakes which are responsible for billions of rupees of property damage. This has necessitated the study of Earthquake Engineering. However, study and research in the field of Irregular Buildings under seismic conditions is gaining momentum. The provision of shear wall in building has been found effective and economical. Shear walls are structural members used for providing strength of RCC (Reinforced Cement Concrete) structures against seismic load. Their very high in-plane stiffness and strength makes them ideally best for using in tall structure. They act as vertical cantilevers in the form of separate planer wall. In this study, a building in Zone IV is presented to reduce the effect of earthquake using reinforced concrete shear wall-framed structures in the building. The results were tabulated by performing Response spectrum analysis using SAP2000 in the form of maximum storey displacements, base shear reactions, mode shapes and storey drifts. This paper also gives an idea about the behavior of irregular shear wall i.e. by varying the thickness of Shear wall, on a RCC frame structure under the action of Seismic loading with irregularity in vertical direction. The Shear wall performance is assessed by means of flexural stiffness. The analysis of Shear wall RCC frame structure shows the more accurate results against the seismic loading based on IS code depends on linear performance of material.

Key words: Base Shear, Multi-storey Buildings, Response Spectrum Analysis, Seismic loading, Shear wall-framed structures, Vertical Irregularity Stiffness, SAP2000

I. INTRODUCTION

Stability of earth is always disturbed due to internal forces which causes vibrations or jerks in the earth's crust known as an earthquake. Earthquakes which are unpredictable and a devastating natural disaster produces low - high waves which vibrate the base of the structure in various manners and directions, so that lateral force is developed on the structure (Oscillation / Vibration (motion which repeats itself after an interval of time) in structural systems results due to wind, earthquake, height etc. Dynamics is concerned with the study of forces and motions which are time dependent. When a structure is subjected to dynamic load, it starts vibrating resulting in the displacement of the structure. Seismic zones IV & V are high intensity earthquake zones. After the recent Bhuj earthquakes, tsunami in Indonesia, there is a growing interest in the process of designing civil engineering structures capable of withstanding dynamic (earthquake

induced) loads. Shear walls are Concrete/masonry vertical walls serving both architecturally as partitions and structurally to carry gravity & lateral loading. Their very high in-plane stiffness and strength makes them ideally suited for bracing tall buildings. They are usually continuous down to the base to which they are rigidly attached to form vertical cantilevers.

II. REGULAR & IRREGULAR CONFIGURATION AS PER IS 1893:2002

Buildings having simple & regular geometry and uniformly distributed mass and stiffness in plan as well as elevation, suffer much less damage than buildings with irregular configurations. Irregular buildings are of two types.

A. Plan Irregularities

a) Torsion Irregularity, b) Re-entrant Corners, (c) Diaphragm Discontinuity, (d) Non- parallel Systems

B. Vertical Irregularities

a) Stiffness Irregularity, b) Mass Irregularity, (c) Vertical Geometric Irregularity, (d) Discontinuity in Capacity – Weak Storey

Buildings are designed as per Design based earthquake (DBE), but the actual forces acting on the structure is far more than that of DBE. So, in higher seismic zones Ductility based design approach is preferred as it narrows the gap. The primary objective in designing an earthquake resistant structure is to ensure ductility to withstand the earthquake forces.

III. SHEAR WALL

A shear wall is a structural system composed of braced panels known as shear panels. Shear panels are used to counter the effects of lateral load acting on a structure. In the centre of a large building a structure of shear walls often encasing an elevator shaft or stairwell form a shear core. Shear wall resist in plane loads that are applied along its height. The applied load is generally transferred to the wall by a diaphragm or collector or drag member. They are built in wood, concrete and (masonry). Plywood is the conventional material used in wood (timber) shear walls, but with advances in technology and modern building methods, other prefabricated options have made it possible to inject shear assemblies into narrow walls that fall at either side of an opening. Sheet steel and steel-backed shear panels in the place of structural plywood in shear walls has proved to provide stronger seismic resistance. A typical timber shearwall is to create braced panels in the wall line using structural plywood sheathing with specific nailing at the edges and supporting framing of the panel.

Shear walls are especially important in high rise building subject to lateral wind and seismic forces. Generally, shear walls are either plane or flanged in section, while core walls consist of channel sections. They also provide adequate strength and stiffness to control lateral displacement.

IV. MODELING & ANALYSIS

The study in thesis is based on response spectrum analysis of structural frame models using SAP 2000 vs. 19. Accurate modeling of all models consist various elements is very important in earthquake analysis. In present study, frame element is modeled with elastic flexural hinge using elastic model and shear wall is design as area element providing concrete property.

G+10 building with bare frame and Shear wall frame structure were taken for the study. Four different building models with bay width of 6m in X-direction and story height equal to 4m were considered for this study. The structures are modeled by using computer software SAP 2000vs19. The column section defined for the frame satisfies both the requirement for strength and stiffness. All the selected models were designed with M-25, M-30 grade of concrete are used and Fe-415 grade of reinforcing steel as per Indian standards. Detail of structure and Finite element modeling, the basic geometries of shear wall structure with four different models with same plans are as following

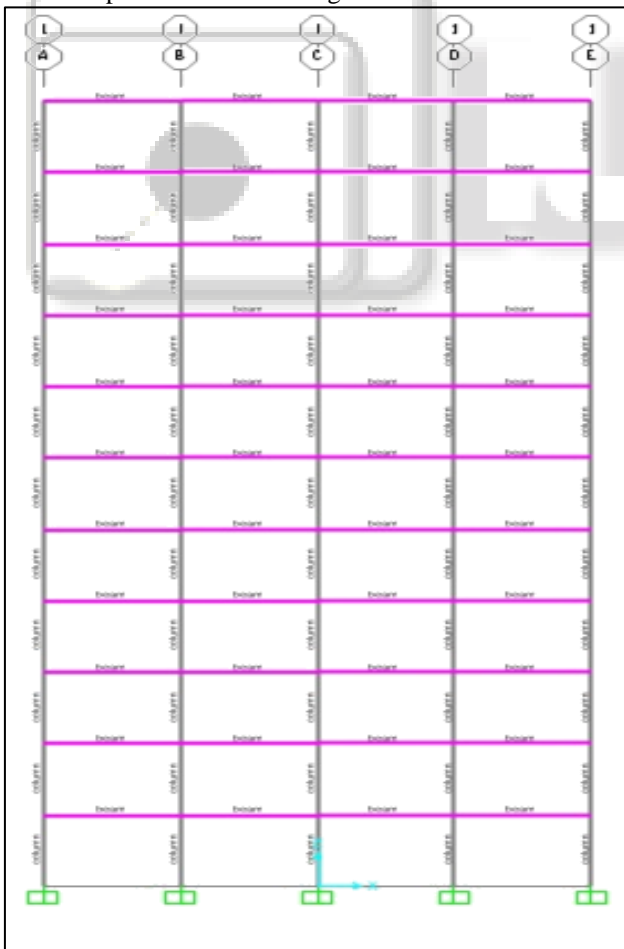


Fig. 1: bare frame model

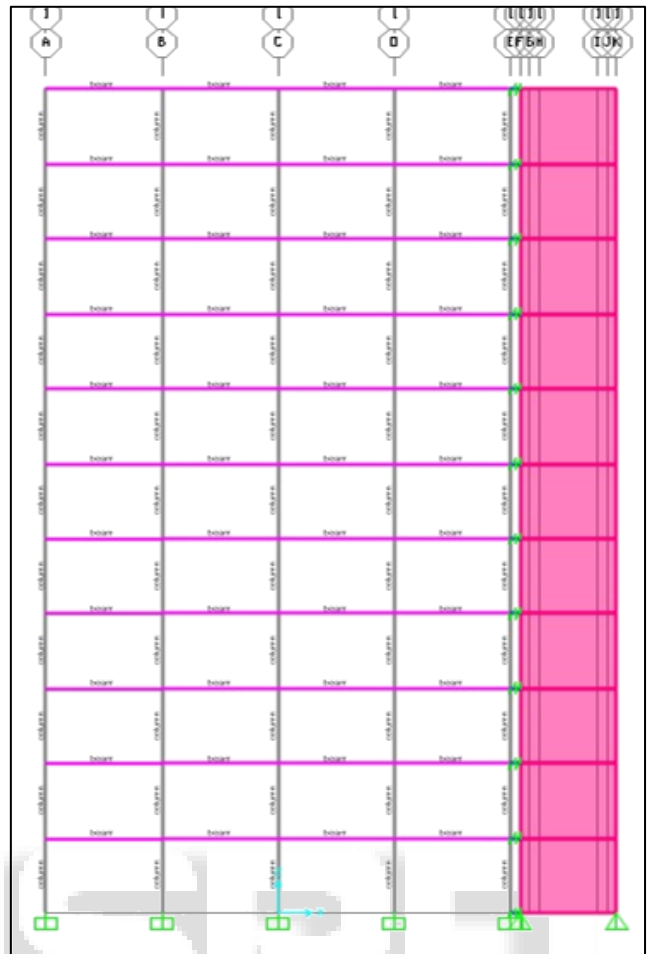


Fig. 2: Regular Shear Wall structure

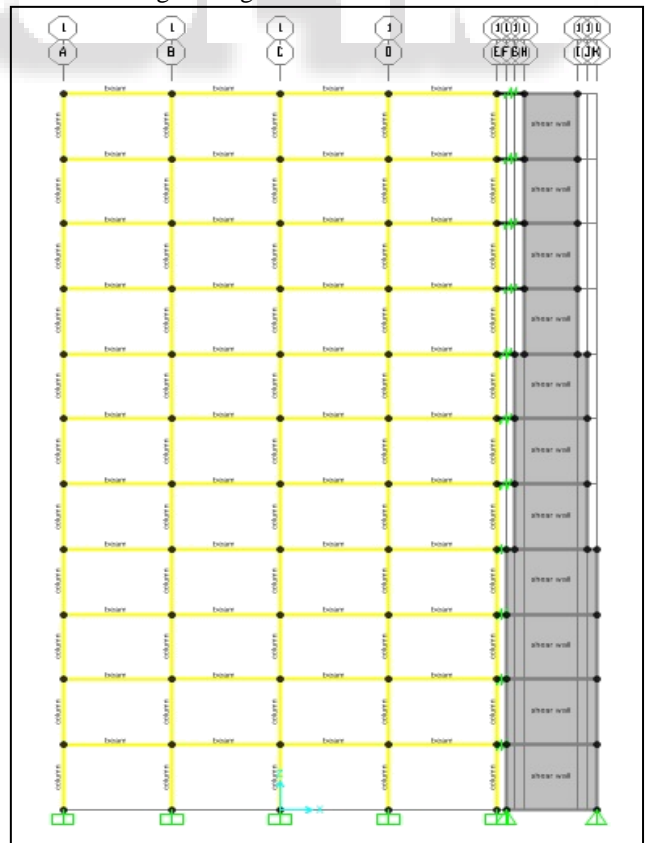


Fig. 3: Irregular Shear Wall Structure

Unsymmetrical shear wall is used in two different manners for the purpose of analysis. 2-dimensional model is prepared to find out interaction between shear wall and rigid frame structure.

Model 3 is prepared with unsymmetrical shear wall with variation in length having constant depth shown in figure.

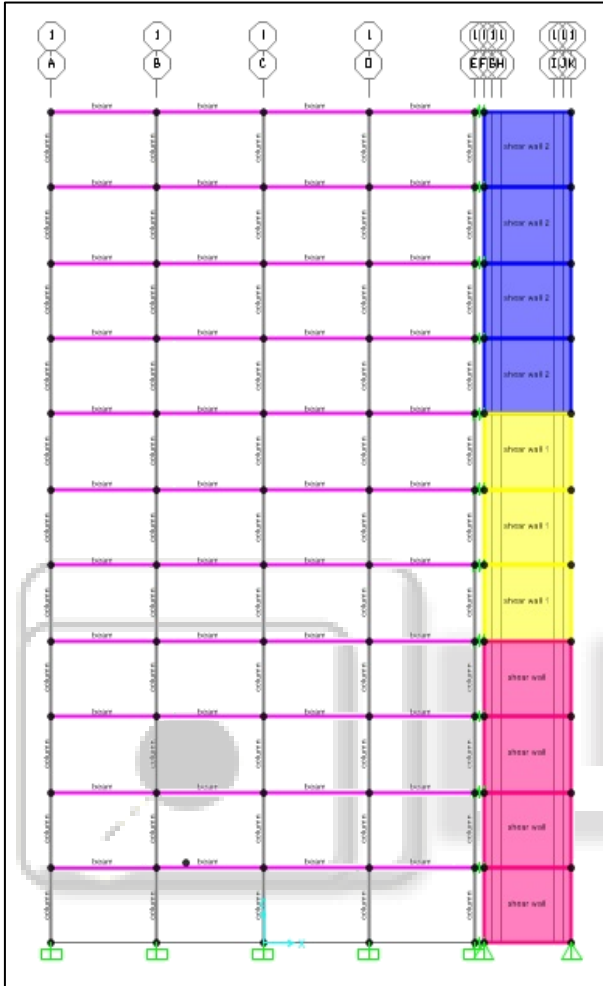


Fig. 4: Regular Shear wall with Varying Thickness.

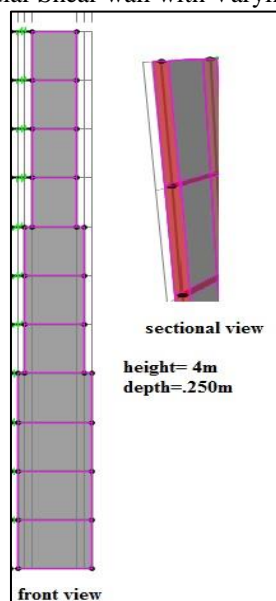


Fig. 5: shear wall description of model3

Model 4 is prepared with unsymmetrical shear wall with variation in depth having constant length shown in figure.

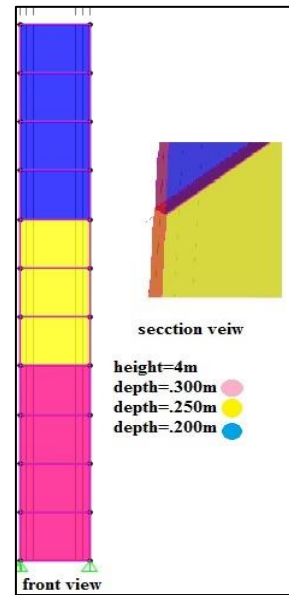


Fig. 6: shear wall description of model 4

The analysis has been carried out for various models using SAP2000 and the results has been tabulated in the form of base shear, displacement, drift & stress distribution along the storey.

V. RESULTS

In this chapter the results obtained from SAP2000 19 software package are used for the numerical results given below, the procedure to obtained the results on SAP given above. The SAP program must be first verified in order to ensure the subsequent analyses are free of error. Therefore the result obtained from the analysis is compared with available results of references.

A. Base Reaction and Displacement

According to IS 1893 seismic analysis is done and following results are obtained.

	Model1	Model2	Model3	Model4
Base shear (kN)	300.637	248.616	238.117	266.13

Table 1: Base Shear of all models

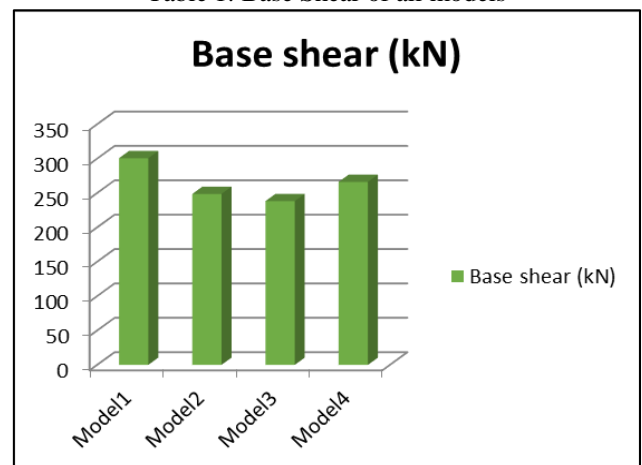


Fig. 5.1: Base reaction of all models

Story No.	Story displacement (mm)			
	Model1	Model2	Model3	Model4
Story1	14.36	0.83	0.77	0.766
Story2	43.173	3.04	2.804	2.78
Story3	76.648	6.39	5.88	5.8
Story4	111.12	10.70	9.81	9.8
Story5	144.93	15.75	14.69	14.5
Story6	177.02	21.36	20.52	19.8
Story7	206.467	27.36	26.97	25.6
Story8	232.298	33.60	34	31
Story9	253.56	39.97	41.43	38
Story10	269.47	46.37	48.92	44
Story11	280.07	52.74	56.30	50.61

Table 2: Story displacement

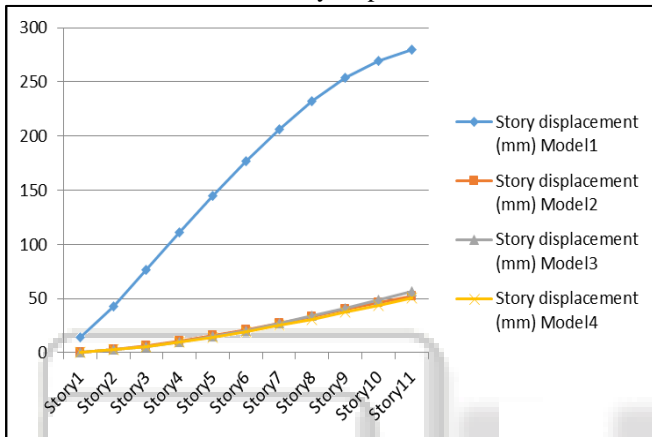


Fig. 5.2: Story displacement

Story No.	Story drift (mm/m)			
	Model1	Model2	Model3	Model4
Story1	6.6	0.21	0.19	0.19
Story2	6.9	0.55	0.51	0.5
Story3	7.3	0.84	0.77	0.75
Story4	7.6	1.1	1	1
Story5	7.9	1.3	1.22	1.17
Story6	8.3	1.4	1.46	1.32
Story7	8.6	1.5	1.61	1.45
Story8	9.05	1.56	1.75	1.35
Story9	9.4	1.6	1.85	1.75
Story10	9.84	1.6	1.87	1.5
Story11	9.95	1.59	1.84	1.65

Table 3: Story drift

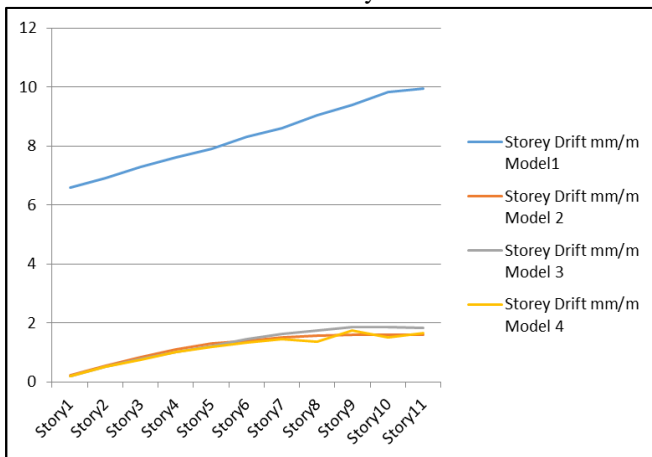


Fig. 5.3: Story drift

Story No.	Story force distribution (kN)			
	Model1	Model2	Model3	Model4
Story1	0.604	0.433	0.509	0.472
Story2	2.417	1.73	2.037	1.887
Story3	5.439	3.893	4.584	4.246
Story4	9.669	6.92	8.029	8.989
Story5	15.108	10.813	12.357	11.794
Story6	21.755	15.57	17.793	16.983
Story7	29.611	21.193	23.85	23.116
Story8	38.675	27.68	30.668	30.192
Story9	48.949	35.033	38.815	38.212
Story10	60.43	43.25	47.919	47.175
Story11	67.98	48.654	51.556	53.068

Table 4.4: Story force distribution

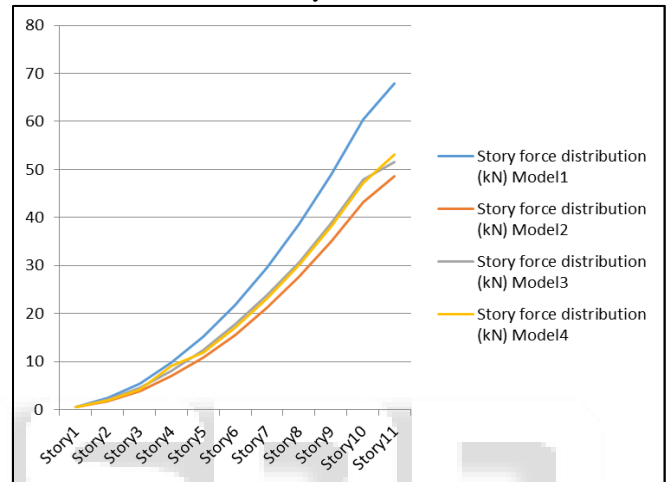


Fig. 5.4: Story force distribution

Story No.	Story shear distribution (kN)			
	Model1	Model2	Model3	Model4
Story1	300.637	248.616	238.117	266.13
Story2	300.033	248.183	237.608	265.658
Story3	297.616	246.453	235.571	263.771
Story4	292.177	242.56	230.987	259.525
Story5	282.508	235.64	222.958	250.536
Story6	267.4	224.827	210.601	238.742
Story7	245.645	209.257	192.808	221.759
Story8	216.034	188.064	168.958	168.451
Story9	177.38	125.351	138.29	130.239
Story10	128.431	82.101	99.475	83.064
Story11	67.98	48.654	51.556	53.068

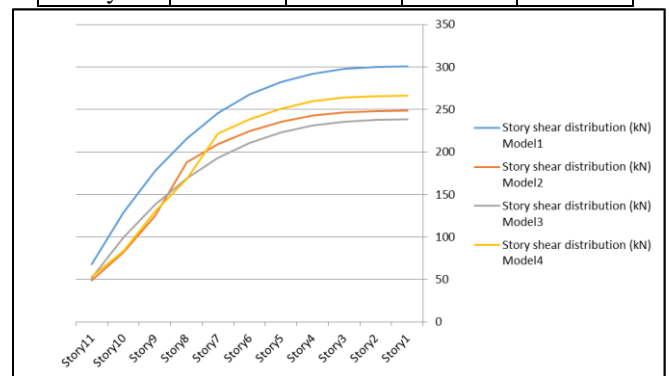


Fig. 5.5: Story shear

B. Stress Distribution in Shear Wall

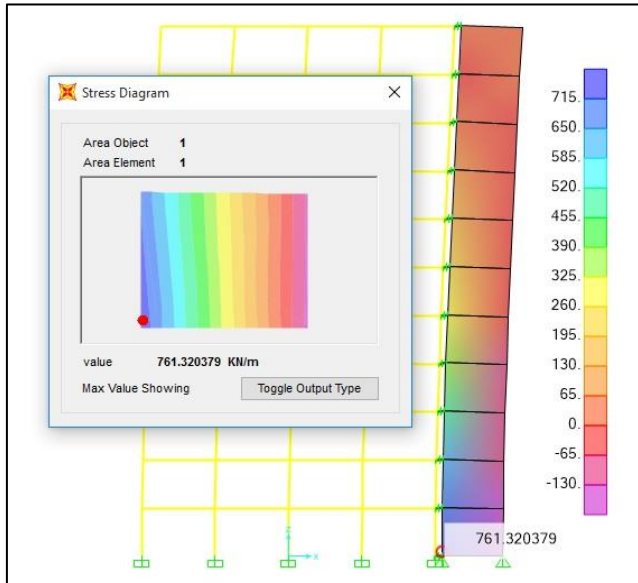


Fig. 5.6: Stress distribution in shear wall of model2

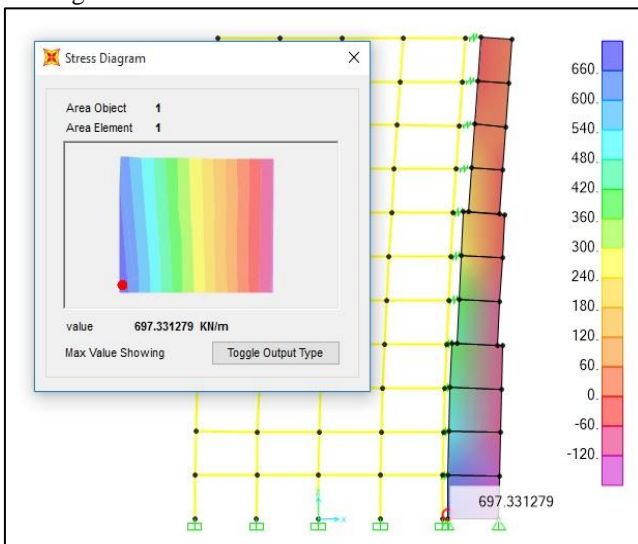


Fig. 5.7: Stress distribution in shear wall of model3

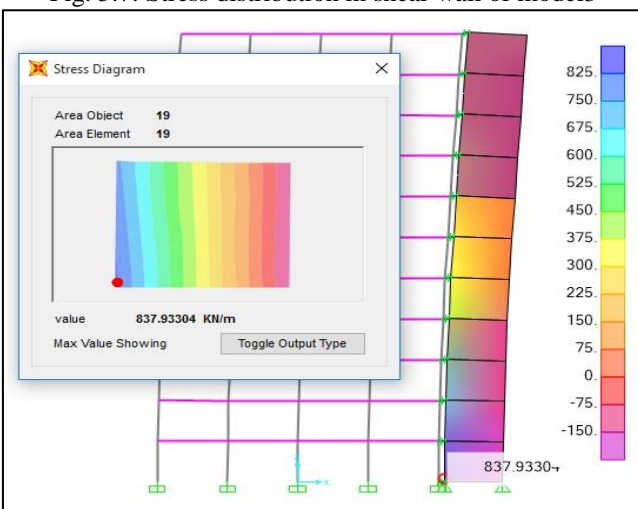


Fig. 5.8: Stress distribution in shear wall of model4

VI. CONCLUSIONS

The results of 2-dimensional modelling of Unsymmetrical shear wall frame structure from SAP 2000Vs. 19 software with the help of IS 1893. Four different models having constant Beam-column Cross-sectional area and different plan section are prepared by software with the help of IS code and comparative analysis studied between them. This project has introduced Unsymmetrical Shear wall Reinforced concrete frame structure which analysing to determine its structural performance.

From Seismic analysis on all Four models, (a) target displacement in model 4 is 17.07% of model1, (b) target displacement in model 3 is 20% of model1, (c) target displacement in model 2 is 18.5% of model1 due to the larger moment of inertia in perpendicular direction of laterally applied distributed force as compare to other models.

From earthquake analysis on all models according to IS-1893 the Base Shear in model 4 are 89.20% of model1, Base shear in model 2 is 95.77% of model1 and Base shear in model 3 is 79.47% of model1 due to the larger relative stiffness of unsymmetrical shear wall frame structure. The base shear in model3 is also found less as compare to other models due to vertical irregularity of the shear wall.

The storey drift of model2 is comparatively lesser than other model due to its regularity.

The storey force distribution of model 2 is comparatively lesser than model1, model3 and model4 because of symmetrical cross-section plan of shear wall in model 2.

Stress distribution of model 3 is comparatively lesser than model 2 and model 4 because of unsymmetrical shear section in X direction parallel to the direction of lateral force which reduced seismic weight of frame structure.

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