ANALYSIS OF VARIOUS EFFECTS ON MULTISTORY BUILDING (G+27) BY STAAD PRO. SOFTWERE

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Abstract - *The point of this research is to decide the arrangement whether the structure with or without shear wall is appropriate and area of the shear wall as per the suitability. For this reason three unique models 28 storied building each has been considered i.e. one model without shear wall and other with shear wall with various areas (i.e., inward and external part). Models were contemplated as the comparison between the load exchange and lateral dislodging to different basic components with various situating of shear wall. The structures were displayed utilizing programming STAAD Pro. Giving shear walls at satisfactory areas considerably decrease the removals because of tremor as well as wind load is taken into consideration.*

***Key Words*: With/Without Shear wall, lateral loads, Location of Shear wall, High Rise Building, Displacement**

1. INTRODUCTION

In many respects concrete is an ideal building material, combining economy, versatility of form and function, and noteworthy resistance to fire and the ravages of time. The raw materials are available in practically every country, and the manufacturing of cement is relatively simple. It is little wonder that in this century it has become a universal building material. Tall buildings are the most complex built structures since there are many conflicting requirements and complex building systems to integrate. Today's tall buildings are becoming more and more slender, leading to the possibility of more sway in comparison with earlier high-rise buildings. RC Buildings are adequate for resisting both the vertical and horizontal load. When such building is designed without shear wall, the beam and column sizes are quite heavy, steel quantity is also required in large amount thus there is lot of congestion at these joint and it is difficult to place and vibrate concrete at these places and displacement is quite heavy which induces heavy forces in member. Shear wall may become imperative from the point of view of economy and control of lateral deflection. In RC multi-storey building R.C.C. lift well or shear wall are usual requirement. Centre of mass and stiffness of the building must coincide. However, on many occasions the design has to be based on the off center position of lift and stair case wall with respect to center of mass which results into an excessive forces in most of the structural members, unwanted torsion moment and deflection.

Generally shear wall can be defined as structural vertical member that is able to resist combination of shear, moment and axial load induced by lateral load and gravity load transfer to the wall from other structural member. As per assumptions, it is considerably regarded that less self-weight causes less story shears. Previously, the findings of researches had almost identical outcomes to determine the effectiveness of strengthening systems. Discussions on comparison between with shear walls and without shear wall system based on performance levels were made. Reinforced concrete walls, which include shear walls, are the usual requirements of Multi Storey Buildings. Design by coinciding centroid and mass center of the building is the ideal for a Structure. An introduction of shear wall represents a structurally efficient solution to stiffen a building structural system because the main function of a shear wall is to increase the rigidity for lateral load resistance. In modern tall buildings, shear walls are commonly used as a vertical structural element for resisting the lateral loads that may be induced by the effect of wind and earthquakes which cause the failure of structure. Provision of walls helps to divide an enclose space, whereas of cores to contain and convey services such as elevator. Wall openings are inevitably required for windows in external walls and for doors or corridors in inner walls or in lift cores. The size and location of openings may vary from architectural and functional point of view. The use of shear wall structure has gained popularity in high rise building structure, especially in the construction of service apartment or office/ commercial tower.

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. RC shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan. Shear walls are more effective when located along exterior perimeter of the building such a layout increases resistance of the building to twisting. The most probable structure which is suitable for resist the building from all the classified causes like Wind, seismic transformation, torsional forces, displacement of the body and etc. is expectably RC Building with braced system (Shear wall).

1.1 APPLICATION OF SHEAR WALL

Following are the applications of Shear wall:-

1. Shear wall is a structural member used to resist lateral forces i.e. parallel to the plane of the wall. In other words, Shear walls are vertical elements of the horizontal force resisting system.
2. In building construction, a rigid vertical diaphragm applicable for transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes.
3. Shear walls are especially applicable in high-rise buildings subject to lateral wind and seismic forces. They provide adequate strength and stiffness to control lateral displacements.
4. Structurally, the best position for the shear walls is in the center of each half of the building. This is rarely practical, since it also utilizes the space a lot, so they are positioned at the ends.

2. REVIEW OF LITERATURE

First part of this Chapter focuses on the literature review on behavior of structural buildings, analytical and experimental studies on shear walls and modeling of reinforced concrete elements. The last part of this Chapter presents the summary of the models and analysis approach with a published literature.

2.1 ANALYTICAL & EXPERIMENTAL STUDIES ON SHEAR WALL

Lopes (2001) described a comprehensive test in order to study the seismic performance of reinforced concrete walls subjected to extreme conditions and a shear failure was observed. To conduct this experiment, a test setup was designed to impose beam behavior and low shear ratio was maintained during the test had been described in this work. Finally, observations were made and some special features described that were failure mode dependent.

Rana et al. (2004) performed a nonlinear static analysis of a 19-storey reinforced concrete building with total area of 430,000 Sq. ft. located in San Francisco. The building was typically designed as per 1997 Uniform Building Code with shear walls as a lateral resisting system to check the provisions and guidelines of the Life Safety performance level when subjected to design earthquake and results were presented in this work.

Lee et al. (2007) studied the response of seismic parameters of three different models of 17-storey reinforced concrete wall building with various types of irregularity at the bottom storey when subjected to the same series of scaled earthquake motions. The first model consists of moment resisting frame symmetrical in nature and next model had an infill shear wall in the middle frame and last one, third had an infill shear wall provided only in exterior frames. On the basis of test observations, following conclusions were out forward and presented that the calculated fundamental time periods for other models than moment resisting

Frames and shear wall were found to be reasonable in UBC 97 and AIK 2000. The total absorption of energy by damage was similar irrespective of the location and existence of the infill shear wall. The huge amount of energy absorption was due to overturning and finally followed due to shear deformation. The rigid system of upper storey rendered rocking behavior of the lower frame. Therefore, the self-weight of the structure contributed about 23% of resistance against the total turning moment.

Esmaili et al. (2008) studied the structural aspects of a 56-storey reinforced concrete tall building located in highest seismic active area. For this structure, shear wall and irregular opening system was provided for lateral loads and gravity loads which might result some important issues in the behavior of shear wall, coupling beams etc. For seismic assessment, numerous nonlinear analyses were used to evaluate its structural behavior with prevailing retrofitting provisions as per FEMA 356. A study of assessment of the load bearing system with some special features had been considered and presented. At the end, a general assessment of ductility levels of shear wall was described in this work.

Fahjan et al. (2010) thoroughly studied the various types of modeling approaches for modeling the linear and nonlinear behavior of shear wall of buildings for structural analyses. Based on overall structural behavior of the system, results of analyses using various modeling approaches were obtained and compared.

Chandiwala (2012): In the present paper the researcher, had tried to get moment occur at a particular column including the seismic load, by taking different lateral load resisting structural systems, different number of floors, with various positions of shear wall for earthquake zone III in India has been found. Moment Resistant Frames, Braced Frames, Shear Wall Structures, Tube Structures, Multi-Tube Structures are the system used to resist lateral load in economy.

The shear wall can be either planar, open sections, or closed sections around elevators and stair cores. Dynamic analysis of structure involves free vibration analysis to determining the mode shapes and frequencies of the structure .The structure can be analyzed for seismic loading in form of response Spectrum or acceleration/force time history. After the analysis of the different position of shear wall in the building configuration following is the comparison in maximum base shear in X & Y-direction. Among different location of shear wall (F- shear wall at end of ―L‖ section) gives best result. Here shear wall directly obstruct this end oscillation, hence reduce overall bending moment of building.

Gonzales and Almansa (2012) conducted a research work aiming to provide well-grounded seismic provisions and guidelines for the design of thin wall structures especially buildings. The starting goals are to study the seismic behavior of these structures and proposing initial criteria for design and spread the research to a great extent for future needs. This exploration concentrates on buildings situated in Peru, being illustrative of the circumstances in other nations. The vulnerability of these buildings was tested by nonlinear static and nonlinear dynamic analyses with structural characteristics were acquired from accessible testing data. The extracted results showed that seismic capacity was quite low of these buildings. However, minor corrections in the structural configuration may upgrade the seismic performance of such buildings. Inexpensive and effective design suggestions were issued.

Martinelli et al. (2013) studied the capability of two distinctive of fiber beam-column finite elements to simulate the dynamic behavior of a shear wall using shake table test.

Todut et al. (2014) presented the results of an experimental program developed to study the seismic performance of precast reinforced concrete wall panels with and without openings. The specimen characteristics and reinforcement configuration were taken from a typical Romanian project used widely since 1981 and scaled

1:1.2 due to the constraints imposed by the laboratory facilities. This type of precast wall panels was used mostly for residential buildings with multiple flats built from 1981 to 1989. The performance and failure mode of all of the panels tested revealed a shear type of failure that is influenced by the opening type, and critical areas and lack of reinforcement were observed in certain regions. A numerical analysis was performed to create a model that could predict the behavior of the precast reinforced concrete shear walls of different parameters.

Lu et al. (2015) developed a new shear wall element model and associated material constitutive models based on the open source finite element (FE) code Open Sees, in order to perform nonlinear seismic analyses of high-rise RC frame-core tube structures. A series of shear walls, a 141.8 m frame-core tube building and a super-tall building (the Shanghai Tower, with a height of 632 m) are simulated. The rationality and reliability of the proposed element model and analysis method are validated through comparison with the available experimental data as well as the analytical results of a well validated commercial FE code. The research outcome will assist in providing a useful reference and an effective tool for further numerical analysis of the seismic behavior of tall and super-tall buildings.

3. METHODOLOGY

In this study comparison of conventional building under seismic forces is done with and without shear wall and also consideration of location to be determined. Here G+ 9 storey is taken and same live load is applied in the structure for its behavior and comparison.

The framed structure was subjected to be in regulatory motion because of quake and therefore analysis of earthquake is very essential for these structural frames. The system was analyzed by employing in structural frames in zone III by means of STAAD Pro. Software. The structural frame response with and without shear wall and the structure with shear wall in various location as in inner and outer direction of the building was studied for useful results. Selection of appropriate damage parameters is very important for performance evaluation.

Overall lateral deflection and inter-Storey drift are most commonly used damage parameters. Overall deflection is not always a good indicator of damage, but inter-Storey drift is quite useful because it is representative of the damage to the lateral load resisting system.

Maximum values of member or joint rotations, curvature and ductility factors are also good indicators of damage because they can be directly related to the element deformation capacities. However, the maximum value alone of any of these parameters may not be salient to quantify the overall damage caused by cyclic reversal of deformation.

Damage indices which take into account both the maximum deformation and cyclic effects have been developed for such cases. Both indices can be used to measure the overall damage date of a structure. For materials other than reinforced concrete (eg. steel), a damage index is similar.

It is recommended by most building codes including NBCC that the seismic design of ductile moment resisting frames be based on the capacity design (weak beam and strong column) concept. This is ensured by strict strength and detail requirements designed to avoid premature brittle failure modes.

When subjected to severe ground motion, such structures show a great deal of ductility and the damage is generally distributed over the structure. Global darn age index is a very useful measure of the darn age in such structures. For practical application, a relation must be established between the damage indices and the damage as specified in qualitative terms (or in terms of performance level).

3.1 STRUCTURAL DISPLACEMENT

The sidelong displacements for 10 story working with and without shear wall for zone III were resolved from the examination on STAAD Pro. Software. The horizontal displacement of 10 Story working with shear walls was then contrasted with the horizontal displacement of 10 story working without shear wall in Zone III and relating charts were plotted. According to IS 1893 (Part 1):2002, proviso 7.11.1, the removal should not surpass 0.004 times the story stature.

The most extreme cutoff points for 10 story building are as take after, For 10 Story Building, 0.004 x 45 = 0.180m.

3.2 STOREY DRIFTING

Drift of a working in straightforward terms can be characterized as the flat relocation experienced by the working regarding its base when subjected to level powers, for example, wind and seismic tremor loads. In this way story float can be characterized as the dislodging of one story level of the working as for its adjoining level above or beneath the considered floor level.

3.3 MODELING

For this investigation, G+ 27 stories working with 4-meters tallness for every story, consistent in design is demonstrated. These structures were planned in consistence to the Indian Code of Practice for Seismic Resistant Design of Buildings.

The structures are thought to be settled at the base. The areas of basic components are square and rectangular. Story statures of structures are thought to be consistent including the ground story. The structures are displayed utilizing programming STAAD. Four unique models were examined in which Structure with and without Shear divider, structure with various situating of shear divider in building i.e., Inward and Outer Portion of the Structure. Models are examined in zone-3 contrasting sidelong uprooting for all models.

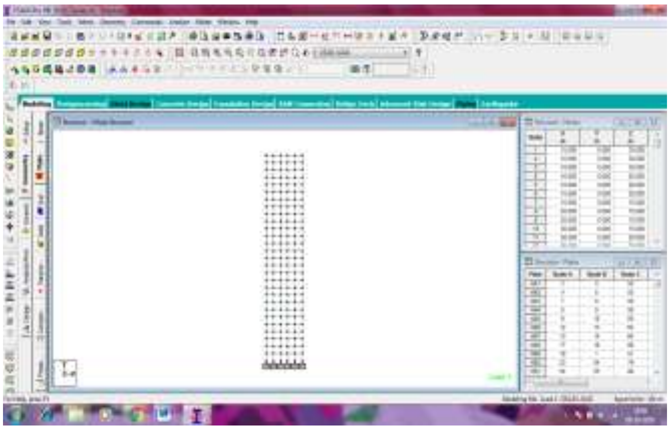

Fig -1: Modeling in StaadPro

3.4 MATERIALS

The modulus of elasticity of strengthened concrete according to IS 456:2000 is given by

$Ec=5000\sqrt{fck}$

For the steel rebar, the important data is yield stretch, modulus of flexibility and extreme quality. High return quality disfigured bars (HYSD) having yield quality 415 N/mm2is generally utilized as a part of configuration hone and is embraced for the present investigation.

- Type of frame: Special RC moment resisting frame fixed at the base
- Seismic zone: IV
- Number of storey: 27
- Floor height: 4.5 m
- Depth of Slab: 130 mm
- Size of beam: (450 × 600) mm
- Size of column (exterior): (400 × 800) mm
- Size of column (interior): (600× 600) mm
- Live load on floor: 2 KN/m2
- Floor finish: 1.0 KN/m2
- Wall load: 9.936 KN/m
- Materials: M 25 concrete, Fe 500 steel Material
- Thickness of wall: 230 mm
- Thickness of shear wall: 230mm
- Density of concrete: 25 KN/m3
- Type of soil: Hard
- Damping of structure: 5 percent

3.5 STRUCTURAL ELEMENTS

In this segment, the points of interest of the demonstrating embraced for different components of the edge are given beneath.

Beams and Columns

Beams and segments were displayed as edge components. The components speak to the quality, firmness and distortion limit of the individuals. While displaying the bars and segments, the properties to be doled out are cross sectional measurements, fortification subtle elements and the kind of material utilized.

LOADS

All heaps following up on the working aside from wind stack were considered. These are

1. Dead Load
2. Live Load

LOAD COMBINATIONS

The heap mixes considered in the examination as per IS 1893:2002 are given beneath.

COMB1 = 1.5(DL+LL)

4. RESULT AND DISCUSSION

The following are results from the analysis:-

- Comparison of Inner and Outer Shear wall using STAAD Software
- Over all displacement of the structure with respect to inner and outer shear wall.
- The behavior and resistance of shear wall against different locations and displacement, storey shear.
- Displacement
- Story Drift
- Cost analysis

4.1 DESIGN LOADS FOR RESIDENTIAL BUILDINGS

Loads were an essential thought in any building outline since they characterize the nature and magnitude of risks is outer forces that a building must oppose to give a performance all through the structure's helpful life. The expected loads are impacted by a building's planned utilize, setup and area. At last, the sort and greatness of configuration loads influence basic choices, for example, material utilization, development points of interest and building arrangement. Residential structures strategies for deciding plan loads are finished yet customized to common private conditions as with any outline work, the designer should at last understand and affirm the loads for a given task and in addition the general outline system, including all its characteristic qualities and weakness.

Therefore Design load considered for the Structure as follows:-

1. Dead Load
2. Live Load
3. Floor Load
4. Parapet Load
5. Generated Indian Code Combination

Dead Loads

Dead loads comprise of the permanent development material loads compacting the rooftop, floor, wall, and establishment frameworks, including claddings, complete and fixed gear. Dead load is the aggregate load of the majority of the parts of the segments of the building that for the most part don't change after some time, for example, the steel columns, concrete floors, blocks, roofing material and so on. In STAAD software professional task of dead load is naturally done by giving the property of the part. In loading case we have alternative called self-weight which consequently figures weights utilizing the properties of material.

Dead load calculation: - Weight=Volume x Density
Dead load is calculated as per IS 875 part 1

Live Load

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and Maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. The Uniform and concentrated live loads should not be applied simultaneously n a structural Evaluation. Concentrated loads should be applied to a small area or surface consistent with the application and should be located or directed to give the maximum load effect possible in endues conditions.

In STAAD we assign live load in terms of U.D.L .we has to create a load case for live load and select all the beams to carry such load. After the assignment of the live load the structure appears as shown below.

For our structure live load is taken as 3kN/m2for design.
Live loads are calculated as per IS 875 part 2

Floor Load

Floor load is calculated based on the load on the slabs. Assignment of floor load is done by creating a load case for floor load. After the assignment of floor load our structure looks as shown in the below figure.

The intensity of the floor load taken is: 3.5 kN/m2
Negative sign indicates that floor load is acting downwards.

Load combinations:

All the load cases are tried by taking loading factors and analyze the working in various load combination according to IS 456 and examined the working for all the load combination.

Load factors as per IS456-2000.
Lateral loads, minimum, average and maximum story displacements (δmin, δavg and δmax) are shown in Table 1. It must be noted that maximum torsional irregularity coefficient occurs at 1st story.

Table -1: Story displacements and torsional irregularity coefficients for 28-story Type A structure

Story no.	Lateral load (kN)	δ_{min}(cm)	δ_{avg}(cm)	δ_{max}(cm)	η_t ($\delta_{max}/\delta_{avg}$)
28	472	3.555	5.490	5.592	1.565
27	452	3.331	5.131	5.029	1.581
26	440	3.297	4.89	4.354	1.597
25	422	3.161	4.761	3.633	1.617
24	401	3.029	4.529	2.850	1.638
23	380	2.914	4.324	2.089	1.669
22	362	2.827	4.027	1.312	1.705
221	340	2.785	3.985	0.608	1.756
20	324	2.671	3.721	6.382	1.528
19	306	2.469	3.690	6.060	1.548
18	294	2.355	3.455	5.592	1.565
17	278	2.131	3.331	5.029	1.581
16	260	1.997	3.197	4.354	1.597
15	240	1.861	3.061	3.633	1.617
14	228	1.829	2.89	2.850	1.638
13	208	1.714	2.614	2.089	1.669
12	192	1.627	2.327	1.312	1.705
11	188	1.585	2.285	0.608	1.756
10	172	1.471	2.071	6.382	1.528
9	152	1.369	1.969	6.060	1.548
8	138	1.255	1.855	5.592	1.565
7	118	1.031	1.631	5.029	1.581
6	99	0.897	1.497	4.354	1.597
5	88	0.661	1.261	3.633	1.617
4	68	0.429	1.029	2.850	1.638
3	49	0.214	0.814	2.089	1.669
2	30	0.127	0.627	1.312	1.705
1	21	0.085	0.385	0.608	1.756

4.2 STORY DRIFT

Table 2: Story displacements and torsional irregularity coefficients for 28-storey Type B structure

Number of Storeys	Structure type			
	A	B	C	D
1	0.219	.340	.338	.18
2	0.395	.59	.634	.398
3	0.578	.85	.776	.543
4	0.625	.955	.864	.648
5	0.848	1.019	.922	.728
6	1.163	1.106	.959	.788
7	1.172	1.287	.984	.863
8	1.237	1.586	1.087	.924

9	1.376	1.683	1.534	1.281
10	1.508	1.867	1.776	1.536
11	1.619	1.940	1.838	1.78
12	1.795	2.069	1.934	1.998
13	1.878	2.285	2.176	2.243
14	1.925	2.455	2.364	2.648
15	2.048	2.519	2.522	2.728
16	2.163	2.706	2.759	2.788
17	2.272	2.887	2.984	2.963
18	2.437	3.086	3.087	3.124
19	2.676	3.183	3.234	3.281
20	2.808	3.367	3.476	3.636
21	2.919	3.340	3.338	3.38
22	3.095	2.969	2.934	2.698
23	2.078	2.85	2.776	2.543
24	1.125	2.55	1.864	1.648
25	1.148	2.019	1.220	1.428
26	1.163	1.506	.959	.788
27	1.172	1.087	.884	.763
28	.937	.886	.787	.724

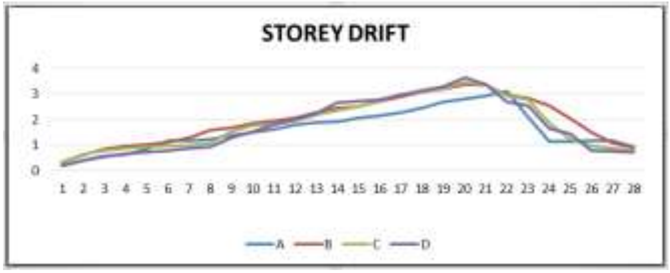

Chart -1: Storey Drift

4.3 LATERAL DISPLACEMENT

Table -3: Lateral Displacement for 28-storey Type B structure

Number of Storeys	Structure Type			
	A	B	C	D
1	1.56	0.99	0.99	0.55
2	7.64	5.43	5.5	3.30
3	14.46	11.24	10.41	7.35
4	21.47	17.61	16.14	12.13
5	28.53	24.21	22.05	17.30
6	35.55	30.83	27.96	22.63
7	42.40	37.30	33.72	27.93
8	48.94	43.47	39.21	33.07
9	55.02	49.20	44.27	37.90
10	57.83	54.33	48.79	42.31
11	61.56	60.99	50.99	50.55
12	77.64	75.43	55.5	53.30
13	84.46	91.24	60.41	57.35
14	91.47	117.61	66.14	62.13
15	128.53	124.21	72.05	67.30
16	135.55	130.83	77.96	72.63
17	142.40	137.30	83.72	87.93
18	148.94	143.47	89.21	93.07
19	155.02	149.20	94.27	97.90
20	157.83	154.33	98.79	102.31
21	161.56	160.99	105.99	109.55
22	171.64	175.43	115.5	113.30
23	184.46	181.24	120.41	117.35
24	191.47	197.61	126.14	122.13
25	208.53	204.21	132.05	137.30
26	215.55	215.83	137.96	142.63
27	222.40	237.30	143.72	152.93
28	248.94	243.47	169.21	158.07

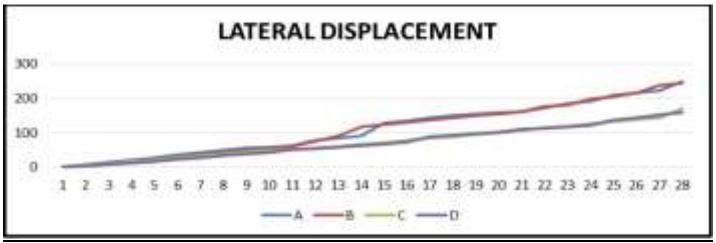

Chart -2: Lateral Displacement

5. CONCLUSIONS

- For all the investigations structural frames, torsional irregularity coefficients increment as the story numbers decreases, i.e., most extreme inconsistency coefficients happen for single-story structures.
- Floor revolutions increment in extent to the story numbers, i.e., most extreme floor rotation happen for most elevated story numbers.
- Floor turns accomplish their most extreme values for the structures where the walls are in most remote positions from the center of mass. It is seen that the outcomes got for torsional abnormality coefficients and floor turns are very opposing.
- Since the floor turns might be considered as the genuine representative of the torsional conduct, torsional irregularity coefficients as characterized in the controls to be totally amended.
- It has been discovered that model-D indicates lesser displacement when contrasted with different models longitudinal way.

• It has been discovered that model-D demonstrates lesser inter story drift when contrasted with different models longitudinal way.

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