

ANALYSIS OF BUILDING

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Abstract – Structural configuration of reinforced concrete moment resisting frame (RCMRF) should be appropriate to ensure the proper energy dissipation capacity when subjected to seismic loading. Structural planning and design is an art and science of designing with economy and elegance, serviceable and durable structure. The entire process of structural planning and designing requires not only imagination and conceptual thinking but also sound knowledge of science of structural engineering besides knowledge of practical aspects, such as relevant design codes and byelaws backed up by example experience. The functional requirements and aspects of aesthetics are locked into normally be the architect while the aspect of the safety, serviceability, durability and economy of the structure are attended by structural designer. The purpose of this project is to make comparison between structure with and without shear wall. This purpose will be attained by the analysis using ETABS 2015. ETABS is the ultimate integrated software package for the structural analysis and design of buildings. It integrates every aspect of the engineering design process. Design of steel and concrete frames (with automated optimization), composite beams, composite columns, steel joists, and concrete and masonry shear walls is included, as is the capacity check for steel connections and base plates...

Keywords: Base Shear, Displacements, Story Drifts, Response Spectrum

1. INTRODUCTION

Extended Three Dimensional Analysis of Building System usually known as ETABS is a very powerful and practical tool for structural design. ETABS 2015 Version 15.2.0 follows in the same tradition featuring a very sophisticated, intuitive and versatile user interface powered by an unmatched analysis engine and design tools for engineers. ETABS2015 is a full-featured program that can be used for the simplest problems

and it can also be used for or most complex projects. ETABS has many features comprising of non-linear and pushover analysis, dynamic analysis, bridge modelling and design.

From its 3D object based graphical modelling environment to the wide variety of analysis and design options. ETABS2015 represents the most sophisticated and user friendly release all other computer programs. Creation and modification of the model, execution of the analysis, checking and optimization of the design and production of the output are all done under a single interface. A Single structural model can be used for a wide variety of different types of analysis and design. ETABS2015 can be used for all of our analysis and design tasks. In ETABS2015, Complex Models can be generated and meshed with powerful Templates built into the interface which is the major advantage of this package. Bridge Designers can use ETABS2015 Bridge Templates for generating Bridge Models, Automated Bridge Live Load Analysis and Design, Bridge Base Isolation, Bridge Construction Sequence Analysis, Large Deformation Cable Supported Bridge Analysis and Pushover Analysis. From a simple small 2D static frame analysis to a large complex 3D nonlinear dynamic analysis, ETABS2015 is the answer to all structural analysis and design needs.

2 DESIGN PARAMETERS

We are focusing on the behavior of RCC structure in two cases . One is without

shear wall and another one is with shear wall at the corners and these two models are modeled, one with shear walls at corners and the other with column as usual at the corners. As it is clear from previous literature that structure with shear wall are more stable for seismic forces, we are analytically investigating the behavior RCMRF during the earthquakes (Zone V) and checked for difference in maximum story displacement, story drift, rebar percentage. Response spectrum method is considered to analyze the structure by using ETABS software.

2.1 STORY DRIFT: Is defined as the difference in lateral deflection between two adjacent stories. During an earthquake, large lateral forces can be imposed on structures. Due to these Lateral loads the structure will undergo lateral deformation and these deformation or deflection can be measured in terms of story drift. It indicates three primary effects on a structure. Due to deformation the movement produced can affect the structural elements such as columns and beams. And also the movements can affect nonstructural elements, such as windows, cladding, etc. May sometimes the movements can affect adjacent structures also. Without proper monetization during the design process, it leads to excessive lateral deflections and drifts and it may produce adverse effects on structural elements, nonstructural elements, and adjacent structures too. In addition, if the lateral deformation of any structure becomes too large, P- Δ effect can lead to instability in the structure and progressively results in collapse. This effect also can be monitored by drift value. As per IS. 1893-2002 CL.7.11.1, the story drift in any story due to the minimum specified design lateral force with partial load factor 1.00 shall not exceed 0.004 times the story height.

2.2 BASE SHEAR: It is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. The total design base shear or design lateral force along any principal direction shall be determined by

the following expression

$$V_B = A_h W$$

where

W = seismic weight of building

A_h = design horizontal seismic coefficient for a structure

A_h shall be determined by the following expression

$$A_h = (Z/2)(I/R)(S_a/g)$$

The value of A_h will not be less than $Z/2$ whatever the value of (I/R) .

Z = zone factor

I = Importance factor

R = Response reduction factor

3. METHODOLOGY

MODELING AND ANALYSIS OF G+12 STORY ADMINISTRATIVE BUILDING

Grade of concrete = M30

Grade of steel = Fe500

Number of Stories = G+12

Number of bays along X-direction = 3

Number of bays along Y-direction = 9

Story height = 3.3 meters

Bay width along X-direction = 34.05m

Bay width along Y-direction = 15.325m

Column = 0.4x0.6m

Beam = 0.3x0.525m

Slab Thickness = 0.125

Shear wall thickness = 0.3m

Loading specifications.

Dead Load Wall 230mm (30% deduction) = 8.84 kN/m

Dead Load Wall 110mm (30% deduction) = 4.228 kN/m

Dead Load Parapet Wall 110mm (1m) = 2.10 kN/m

Dead Load Floor Finish = 1.31 kN/m²

Staircase Dead load = 12.642 kN/m

Staircase Live Load = 12.9 kN/m

Live Load Floor office room/toilet = 2.5 kN/m²

Live Load Floor balcony/passage/meeting room = 4.0 kN/m²

Live Load Floor terrace = 1.5 kN/m²

Earthquake load for the building has been calculated as per IS-1893:2002

i. Zone (Z) = V

ii. Soil = Medium

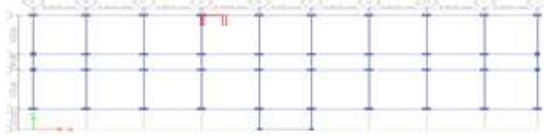
iii. Response Reduction Factor (R)

= 5

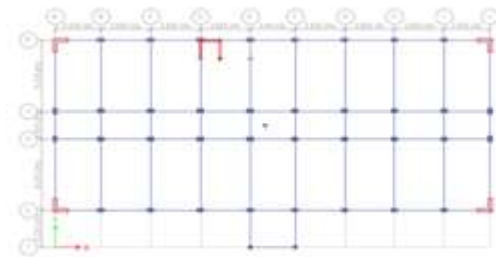
iv. Importance Factor = 1.5

v. Damping Ration = 0.05

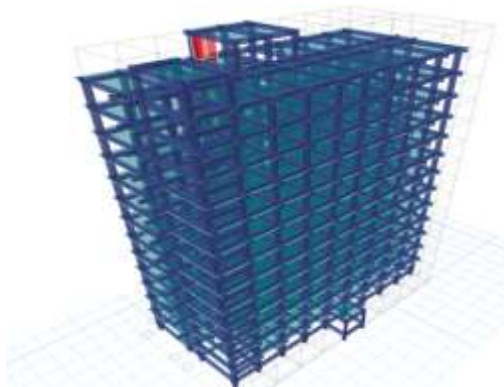
Percentage of imposed load to be considered for seismic weight calculations only 50% of the imposed load is considered, when imposed load is more than 3kN/m² only 25% of the imposed load is considered, when imposed load is less than or equal to 3kN/m²



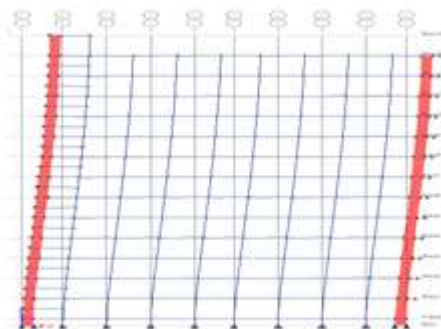
Plan of model 1(without shear wall at corners) in ETABS



Plan of model 2(with shear wall) in ETABS



3D view of model 1 in ETABS



Deformation due to Earthquake load for Model

4. DESIGN RESULTS

4.1 BEAM DESIGN

Beams are designed for flexure, shear and torsion. If required the effect of the axial force may be taken into consideration. For all these forces, all active beam loadings are rescanned to identify the critical load cases at different sections of the beams. For design to be performed as per IS: 13920 the width of the member shall not be less than 200mm. Also the member shall preferably have a width to depth ratio of more than 0.3.

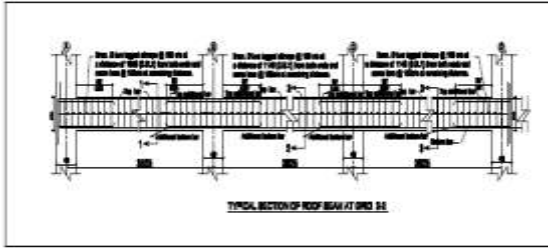
4.2 Design for Flexure

Design procedure is same as that for IS 456. However while designing following criteria are satisfied as per IS-13920:

1. The minimum grade of concrete shall preferably be M20
2. Steel reinforcements of grade Fe500 or less only shall be used.
3. The minimum tension steel ratio on any face, at any section, is given by: $p_{min} = 0.24 \sqrt{f_{ck}/f_y}$
4. The positive steel ratio at a joint face must be at least equal to half the negative steel at that face.
5. The steel provided at each of the top and bottom face, at any section, shall at least be equal to one-fourth of the maximum negative moment steel provided at the face of either joint.

4.3 Design for Shear:

The shear force to be resisted by vertical hoops is guided by the IS 13920:1993 revision. Elastic sagging and hogging moments of resistance of the beam section at ends are considered while calculating shear force. Plastic sagging and hogging moments of resistance can also be considered for shear design if PLASTIC parameter is mentioned in the input file. Shear reinforcement is calculated to resist both shear forces and torsional moments

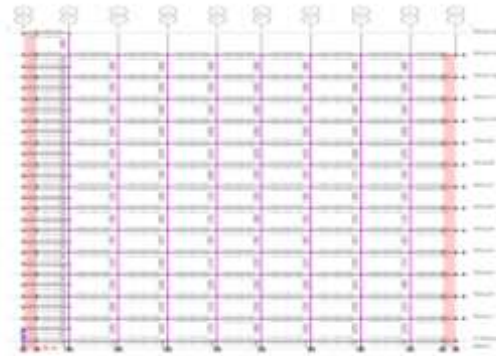


4.1 Beam reinforcement details







4.4 COLUMN DESIGN

Columns are designed for axial forces and biaxial moments per IS 456:2000. Columns are also designed for shear forces. All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS: 456 have been taken care of in the column design of ETABS. However following clauses have been satisfied to incorporate provisions of IS 13920.

- 1 The minimum grade of concrete shall preferably be M20
- 2 Steel reinforcements of grade Fe500 or less only shall be used.
- 3 The minimum dimension of column member shall not be less than 200 mm, For columns having unsupported length exceeding 4m, the shortest dimension of column shall not be less than 300 mm.
4. The spacing of hoops shall not exceed half the least lateral dimension of the column, except where special confining reinforcement is provided.
6. Special confining reinforcement shall be provided over a length l_o from each joint face, towards mid span, and on either side of any section, where flexural yielding may occur. The length l_o shall not be less than a) larger lateral dimension of the member at the section where yielding occurs, b) 1/6 of clear span of the member, and c) 450 mm.
7. The spacing of hoops used as special confining reinforcement shall not exceed of minimum member dimension but need not be less than 75 mm more than 100 mm



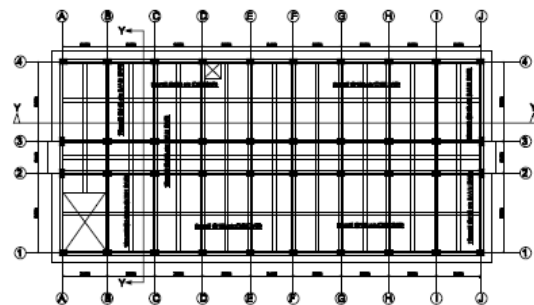
Column rebar percentage in model

REINFORCEMENT DETAILS FOR COLUMN						
S.NO.	COLUMN NAME	SIZE OF COLUMN (IN MM)	REINFORCEMENT			
			GROUND FLOOR	FIRST FLOOR	SECOND FLOOR	EMERGENCY FLOOR AT HEIGHT 10.000m
1	C1 MODEL	400x500				
			14nos # 32mmØ @ 100x100 & 100x100	18nos # 25mmØ @ 100x100 & 100x100	14nos # 25mmØ @ 100x100 & 100x100	
2	C2 MODEL	400x500				
			18nos # 25mmØ @ 100x100 & 100x100	14nos # 25mmØ @ 100x100 & 100x100	10nos # 25mmØ @ 100x100 & 100x100	

Column reinforcement details in model 1 & 2

4.5 DESIGN OF SLAB

L_x = Length of shorter span = 3.525m
 L_y = Length of longer span = 6.225m
 $L_y/L_x = 6.225/3.525 = 1.76 < 2$



Reinforcement detail of bottom continuous bars

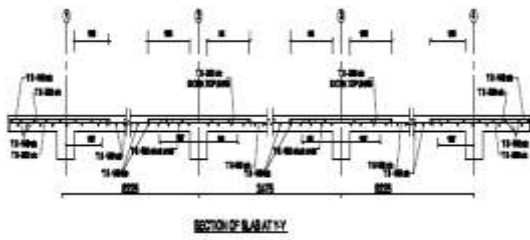


Figure No 4.5: Section at Y-Y

4.6 POST PROCESSING FACILITIES

All output from the ETABS run may be utilized for further processing by the ETABS 2015.2.0

4.6.1 Stability Requirements: Slenderness ratios are calculated for all members and checked against the appropriate maximum values. IS: 800 summarize the maximum slenderness ratios for different types of members. In ETABS implementation of IS: S00, appropriate maximum slenderness ratio can be provided for each member. If no maximum slenderness ratio is provided, compression members will be checked against a maximum value of 180 and tension members will be checked against a maximum value of 400.

4.6.2 Deflection Check: This facility

allows the user to consider deflection as criteria in the CODE CHECK and MEMBER SELECTION processes. The deflection check may be controlled using three parameters. Deflection is used in addition to other strength and stability related criteria. The local deflection calculation is based on the latest analysis results.

4.6.3 Code Checking: The purpose of code checking is to verify whether the specified section is capable of satisfying applicable design code requirements. The code checking is based on the IS 800(1984) requirements. Forces and moments at specified sections of the members are utilized for the code checking calculations Sections may be specified using the BEAM parameter or the SECTION command. If no sections are specified, the code checking is based on forces and moments at the member ends.

5. Results

5.1 RESPONSE SPECTRUM PARAMETERS

Table no 5.1 Modal participating mass ratios for Model 1

Case	Mode	Period sec	UX	UY	Sum UX	Sum UY
Modal	1	2.914	0.0011	0.7508	0.0011	0.7508
Modal	2	2.634	0.068	0.0089	0.0691	0.7597
Modal	3	2.169	0.706	5.081E-07	0.7751	0.7597
Modal	4	0.909	0.0012	0.0969	0.7762	0.8566
Modal	5	0.843	0.0099	0.0112	0.7861	0.8678
Modal	6	0.679	0.0913	0.0000108	0.8774	0.8678
Modal	7	0.501	0.0022	0.0206	0.8796	0.8885
Modal	8	0.462	0.0027	0.0203	0.8823	0.9087
Modal	9	0.367	0.0352	0.000004491	0.9174	0.9087
Modal	10	0.339	0.0014	0.0065	0.9188	0.9152
Modal	11	0.297	0.0009	0.0164	0.9198	0.9316
Modal	12	0.25	0.0024	0.0029	0.9222	0.9345

5.2 COMPARISON OF MODAL FREQUENCIES AND PERIODS IN TWO MODELS

Table.No5.2 Modal Periods and Frequencies for Model 1.

Case	Mode	Period	Frequency	Circular Frequency	Eigen value
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		sec	cyc/sec	rad/sec	rad ² /sec ²
Modal	1	2.914	0.343	2.156	4.6483
Modal	2	2.634	0.38	2.3857	5.6915
Modal	3	2.169	0.461	2.8962	8.3882
Modal	4	0.909	1.1	6.9109	47.7609
Modal	5	0.843	1.186	7.4529	55.5462
Modal	6	0.679	1.473	9.2571	85.6939
Modal	7	0.501	1.997	12.5471	157.4292
Modal	8	0.462	2.165	13.6023	185.0234
Modal	9	0.367	2.725	17.1227	293.1856
Modal	10	0.339	2.954	18.5591	344.4399
Modal	11	0.297	3.372	21.1883	448.9435
Modal	12	0.25	3.997	25.115	630.7645

Table.No5.2 Modal Periods and Frequencies for Model 2.

TABLE: Modal Periods and Frequencies					
Case	Mode	Period	Frequency	Circular Frequency	Eigenvalue
		sec	cyc/sec	rad/sec	rad ² /sec ²
Modal	1	2.74	0.365	2.2932	5.2586
Modal	2	2.239	0.447	2.8062	7.8747
Modal	3	2.034	0.492	3.0895	9.545
Modal	4	0.835	1.198	7.5282	56.6744
Modal	5	0.687	1.457	9.1524	83.7667
Modal	6	0.623	1.604	10.0783	101.5712
Modal	7	0.435	2.297	14.4344	208.3512
Modal	8	0.364	2.746	17.2533	297.6755
Modal	9	0.325	3.081	19.3605	374.8281
Modal	10	0.272	3.683	23.1408	535.4986
Modal	11	0.233	4.295	26.9889	728.3994
Modal	12	0.201	4.97	31.2253	975.0205

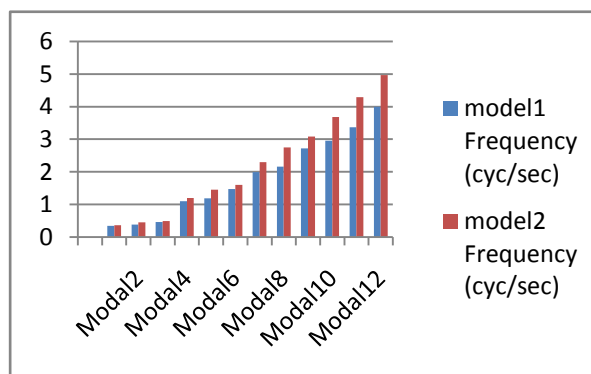


Fig.No:5.1 Comparison of modal frequencies in 2models

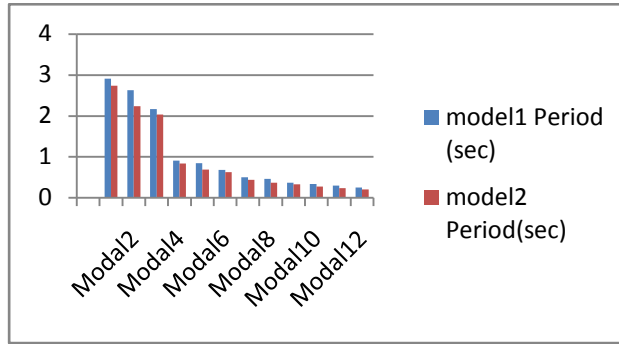


Fig.No:5.2 Comparison of modal periods in 2models

Table.No5.3 Comparison of design story shear (for x-direction) in 2 Models.

Height of building (m)	Story	MODEL1	MODEL2
		KN	KN
0	BASE	-3094	-3363
1.2	P-STORY	-3094	-3363
4.5	STORY1	-3087	-3356
7.8	STORY2	-3066	-3334
11.1	STORY3	-3025	-3289
14.4	STORY4	-2955	-3213
17.7	STORY5	-2850	-3099
21	STORY6	-2702	-2938
24.3	STORY7	-2504	-2723
27.6	STORY8	-2249	-2445
30.9	STORY9	-1928	-2096
34.2	STORY10	-1536	-1670
37.5	STORY11	-1064	-1157
40.8	STORY12	-505.31	-549.78
44.1	STORY13	-63.26	-69.55
47.4	STORY14	-63.26	-69.55

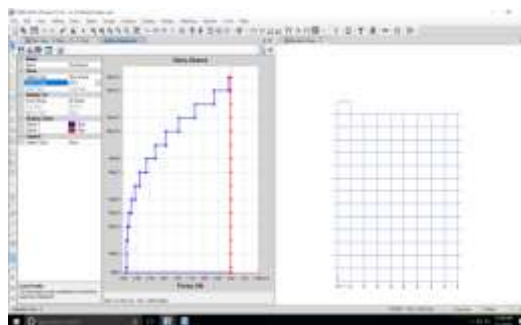


Fig.No:5.3 Graph shown for story shear(x-direction) in Model 1

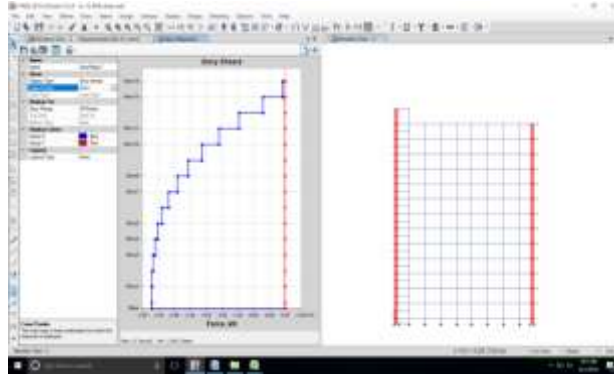


Fig.No:5.4 Graph shown for story shear(x-direction) in Model 2

Table.No5.4 COMPARISON OF COLUMN FORCES FOR 2MODELS

TABLE: Column Forces			MODEL1	MODEL2
Column	Unique Name	Load Case/Combo	P	P
			kN	kN
C6	1023	DCon11	46.3335	37.7506
C44	1585	DCon11	67.6624	48.1465
C31	1587	DCon11	71.0715	67.4949
C32	1586	DCon11	77.2198	50.902

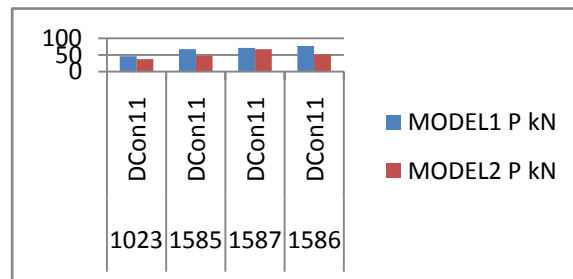


Fig.No:5.5 Graph shown for the comparison of axial load in 2mode

Table.No5.5 Comparison of shear force in 2models

TABLE: Column Forces			MODEL1	MODEL2
Column	Unique Name	Load Case/Combo	V2	V2
			kN	kN
C6	1023	DCon11	2.7548	7.3104
C44	1585	DCon11	26.465	9.8374
C31	1587	DCon11	42.375	13.0676
C32	1586	DCon11	30.835	4.8586

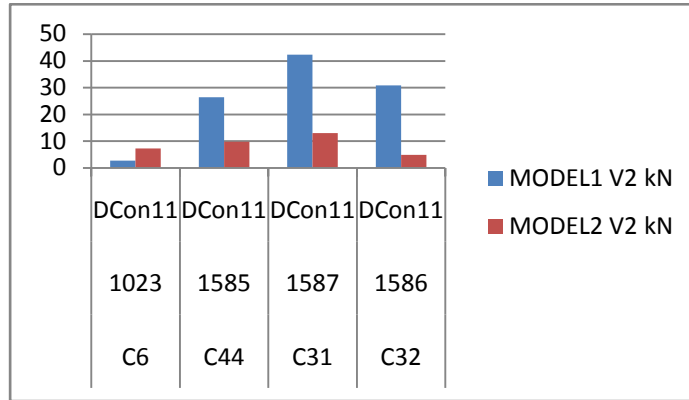


Fig.No:5.6 Graph shown for the comparison of shear force in 2models

Table.No5.6 Comparison of torsion in 2models

TABLE: Column Forces			MODEL1	MODEL2
Column	Unique Name	Load Case/Combo	T	T
			kN-m	kN-m
C6	1023	DCon11	0.0127	0.0003
C44	1585	DCon11	0.0127	0.0003
C31	1587	DCon11	0.0127	0.0003
C32	1586	DCon11	0.0127	0.0003

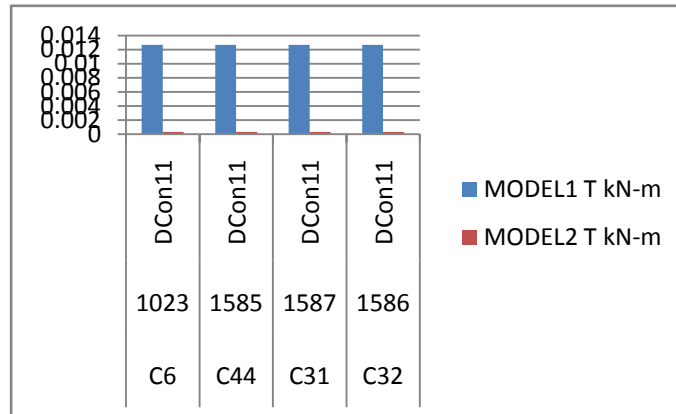


Fig.No:5.7 Graph shown for the comparison of torsion in 2models

Table.No5.7 Comparison of moment in 2models

TABLE: Column Forces			MODEL1	MODEL2
Column	Unique Name	Load Case/Combo	M3	M3
			kN-m	kN-m
C6	1023	DCon11	11.7019	12.4198
C44	1585	DCon11	47.2777	1.976
C31	1587	DCon11	59.1019	5.507
C32	1586	DCon11	51.5795	7.2

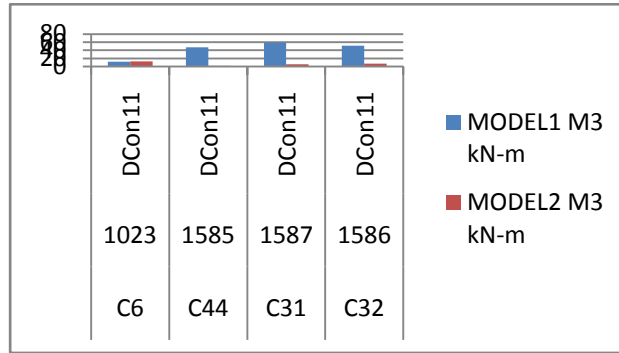


Fig.No:5.8 Graph shown for the comparison of moment in 2 models

6.CONCLUSIONS

Within the scope of present work, following conclusions are drafted

- Fundamental frequencies of model2 structure increase 20% i.e. with the implementation of shear wall at the corners compared to that in model1, so its about increasing of stiffness by providing shear walls.
- Parameters like displacement , story drift are found to be gradually decreasing in model2 as compared to model1.
- The rebar percentage is found to be more in the model without shear wall, therefore comes with the concept of economy and stability adjacently.
- Providing shear wall to the structure, story displacements reduces slightly, as stiffness increases slightly. Thus when RCMRF combine with shear walls, these displacements reduces tremendously as stiffness of shear walls increases overall lateral stiffness of structure.
- We can come to the most important point that the building with dual system is the most effective type of building in terms of earthquake effects.
- Provision of shear walls may not effective in reducing punching shear on intermediate story's but effective in top and bottom story's as shear wall attracts lateral moments from columns.

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