

Analysis and Design of G+10 RCC and Steel Frame Structure in different Seismic Zone using STAAD.Pro

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Abstract - The objective of this project is to design a RCC frame structure in all seismic zone of India for the comparison in the amount of material along with study of dynamic complexities in each zone. Along with this another steel frame structure will also be designed for all seismic zone with the same objective as RCC structure. As we know that the ground shakings generate internal forces within the building called the inertial forces which in term causes most seismic damage and the internal inertial forces generated depends on the mass of the structure. Construction with less mass is typically an advantage in seismic design. Greater mass generates greater lateral forces thereby increasing the possibility of column being displaced out of plumb and buckling under vertical load. Thus, taking these conditions into account, the structure will be designed and analyzed following all other seismic design strategies and providing the appropriate facilities for possible options to reduce construction costs. The devices provided could be shear walls, braced frames, moment resistant frames, energy dissipating devices, isolation devices etc. as per the suitability. The design methods used in the STAAD.Pro analysis are limit state design confirming to Indian Standard code of practice. The thesis involves STAAD modeling with seismic load for a building height of 33m with 3m depth of foundation. The proposed structures are 10 storied building with 3m as height of each floor. The overall plan dimension of building will be 28.0 m x 20.0 m.

Key Words: STAAD.Pro, Seismic Zone, RCC structure, Steel frame structure, Seismic design, Inertial forces, etc.

1. INTRODUCTION

Nowadays, there is a great demand for many multi-storey buildings in cities due to population growth on the one hand and limited available space across the country and especially in cities on the other hand. Recent technological advances also encourage us to build multi-storey buildings. Particularly when selecting a multi-storey building project for construction, the condition of the ground and the loading condition will be a frequent problem on site. To eliminate the problem, a full design and analysis is performed in each earthquake zone so that the structure gets the most relatively economical structure. Theories, experiment and experience adopted and the need to design for durability should be taken into account.

1.1 Objectives

Through this study, we focus on understanding the behavior of a structure facing an earthquake of varying magnitude as well as its intensity, by comparing the magnitude of material variation in each earthquake zone in terms of structure and providing basic structural changes so that there will be no failures. The field of structural engineering deals with the principles and methods of designing building and engineering structures. The purpose of designing is to create a structure with appropriate safety and usability under the influence of appropriate loads and actions during the life of the structure. Because it covers the behavior, bearing capacity and design of structural elements and connections.

When designing a structure, self-load, active load, wind load, seismic load, etc. must be taken into account in order to balance all external forces acting on structures with the appropriate percentage of beam and column reinforcement. The ground under the structure should be hard enough to distribute the load to the foundation. As for precise calculations, we use STAAD.Pro for accuracy and design confirmation with IS456-2000. A seismic design is carried out with the anticipation that a strong earthquake will cause some damage, and a seismic design philosophy has been developed over the years. The goal of a seismic project is to reduce damage to a building to an acceptable level.

1.2 Details on Earthquake

The fault point at which skid begins is the focus or hypocenter, and the point vertically above that on the Earth's surface is the epicenter. The depth of field from the epicenter, called focal depth, is an important parameter in determining the damaging potential of an earthquake. Most devastating earthquakes are shallow sharpness with focal lengths less than about 70 km. The distance from the epicenter to any point of interest is called the epicenter distance. Several minor earthquakes occur before and after a major earthquake (ie, a major earthquake). Those that occur before the big shocks are called front shocks and those that come are called aftershocks.

1.3 Load Combination

We usually provide a load combination when more than one load is acting on the structure. As we use load safety factors to ensure that the designed structure can withstand any

sudden increase in the expected load, the calculated loads are likewise combined to ensure the safety of the structure under different maximum expected load scenarios. These combinations are specified in different code books according to the type of load and structure.

2. LITERATURE REVIEW

Dinesh Dhanji Patel, Deviji Kuverji Patel, Khimji Lalji Pindoria. The authors listed the causes of the damage that occurred during the 2001 earthquake in Bhuj, Gujrat, India. The clear cause among all others is old structures older than modern building practices. Photographs are presented showing the relevant details in the various failure categories and are therefore very good documentation of this type as well as provide detailed guidance for the general public, owners and engineers on how to repair various types of structures as well as for new structures.

Kevadkar M.D., Kodag P.B. (IJMER). Lateral Load Analysis of RCC Buildings. (IJMER). The authors emphasized the need for "lateral load analysis" as these loads can cause high stresses, swaying motion or vibration. Therefore, it is important that such structures, as well as new structures, can withstand vertical and transverse forces. In addition, they discuss strengthening methods such as providing a shear wall, steel bracing. They compared the steel bracing with the shear wall method and concluded that the steel bracing is better than the shear wall.

Bhaiswar N.N., Shelke K.S., Mehere M.D., Dhapekar N.K., Awatade S.M. (ANUL XIX, NR. 1,2012 ISSN 1452-7397). Principles of designing earthquake-resistant buildings and post-earthquake research, a structural engineering perspective. The authors emphasize the design principles of earthquake-resistant buildings and earthquake-proof effects from a structural point of view, which were compulsory during construction. They explained aspects of precautionary measures from structural aspects. Finally, summarize the need for the design engineer to follow the appropriate IS codes, which will reduce the death toll.

Tabish Izhar, Samreen Bano, Neha Mumtaz: Aimed at comparative studies, analysis and design of a reinforced concrete building under the influence of seismic forces for various code guidelines. The main purpose of the work is to conduct a detailed seismic analysis and structural design on the STAAD PRO simulation tool of a multi-storey building plan. This study focuses on exploring the advantages of multi-story building seismic design using different national standards with STAAD PRO on a global level with ease of use.

3. PROPOSED BUILDING DETAIL

Proposed framed structure is a 33m high 10 storied made up of RCC and Steel with overall plan dimension 28.0 m x 20.0 m. The RCC structure will be analyzed and designed as per each of the seismic zone and later will be compared with the result of it. Similarly, the Steel structure will be analyzed and

designed as per each of the seismic zone and later will be compared with the result of it. For this the component of structure, type of material and required data is selected as per suitability.

Table -1: Details of Proposed Building frame

Description of Building Frame		
1	Plan Dimension	28m*20m
2	Building height	33m
3	Storey height	3m
4	Number of storey	10nos.
5	Depth of foundation	3m
6	Grade of Steel	Fe-415
7	Grade of concrete	M-30
8	I-Section	ISHB200
9	I-Section	ISHB400
10	I-Section	ISHB150
11	Tube(British)	TUB1501006.3
12	Seismic zone	All four seismic zones

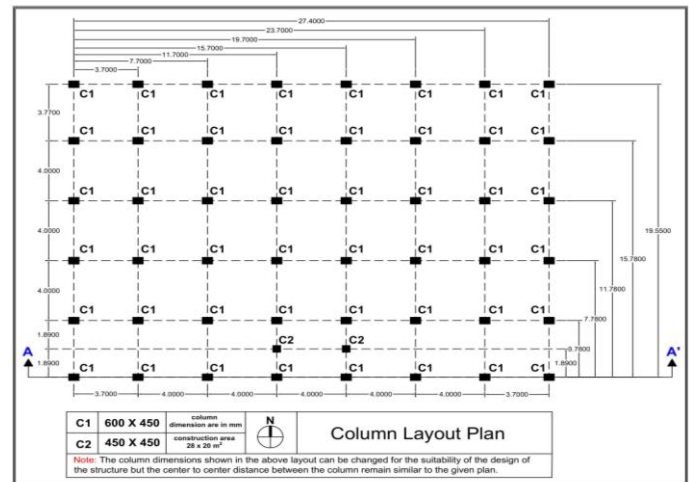


Fig -1: Plan and section of Proposed Building

4. METHODOLOGY

The selected model will be made of RCC and Steel as per proposed building material mentioned above for a 10 storied building with the building height of 33m. Through STAAD.Pro a 3-d model has been developed which is the frame of both RCC and Steel structure in which the dimension of beam, column and slab thickness is applied. All the members in the frame can be seen in the 3D model through which the visualization of frame is possible. Before the loads are applied the factors for seismic load and soil factor is decided, Also the foundation is designed but the foundation is not shown in the 3D model.

4.1 Analysis and Design Procedure

At first step of modelling the geometric design of the structure is defined and the frame of structure is obtained with no dimensions of the members. As the members have no dimension so the property of the members of frame is assigned. Slab or surface elements other than frame is also created and their properties are assigned. Then the support to frame is assigned as per requirement. After assigning of the supports the load is applied by selecting the member on which load is affecting. Then the analysis is done to find the errors. After which we can design the structure. Then the result is obtained for design. And then the report for different zones can be compared.

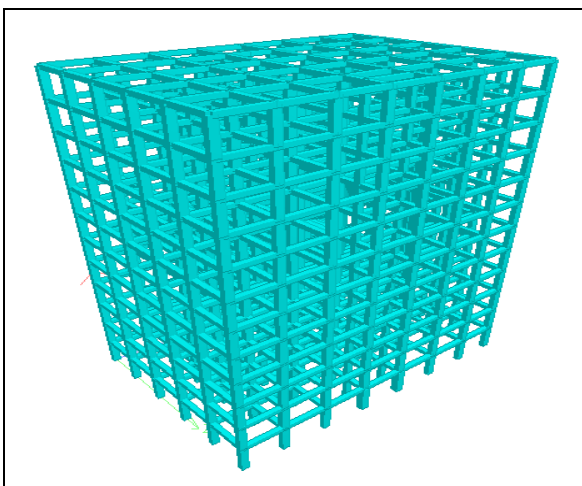


Fig -2: 3D Rendered RCC Frame Isometric View

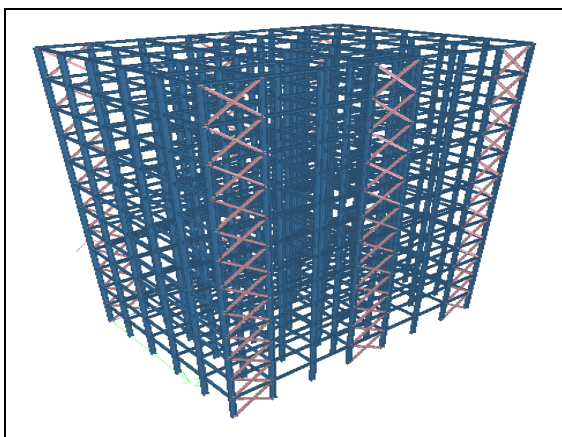


Fig -3: 3D Rendered STEEL Frame Isometric View

4.2 Design

STAAD is a software which has the capabilities of performing concrete design by limit state method of IS-456 (2000).

RCC Frame design: Beams are design for flexure, shear, and torsion. If required the effect of axial forces may be considered. For all these forces, all active beam loadings are

pre-scanned to identify the critical load cases at different sections of beams. Columns are design for axial forces and biaxial moments at the ends. All tests are executed to calculate reinforcement with active load cases.

Steel Frame design: For steel design the material selected will be steel and code selected will be IS 800. The design parameters include track and takeoff. Yield strength of steel selected is 550000 kN/m².

Foundation Design: The type of foundation selected for design is mat foundation with properties and design parameters of Slab design thickness as 600 mm, Subgrade modulus as 10000 KN/m²/m, Soil density as 22 KN/m³, Depth of foundation as 3m, Mesh region with 1m offset to the column boundary, Fc as 30 KN/m² and Fy as 415 KN/m².

4.3 Points to be Compared

Through this analysis we'll compare the Load behavior of members, Stress distribution, Moment on members, Area of reinforcement in beam and column, change in dimension of column and beam, providing shear wall if required in any zone, quantity takeoff, type of material and grade of material chosen, design parameters and Displacement of structure.

5. DESIGN RESULTS AND REPORTS

Beam numbers and the column number in the frame for each storey has to be provided so that the changes in dimension and reinforcement of members in structure for each zone can be recognised by their number.

1	2	3	4	5	6	7	
91	92	93	94	95	96	97	98
16	17	18	19	20	21	22	
99	100	101	102	103	104	105	106
31	32	33	34	35	36	37	
107	108	109	110	111	112	113	114
46	47	48	49	50	51	52	
115	116	117	118	119	120	121	122
61	62	63	64	65	66	67	
123	124	125	126	127	128	129	130
			131	132			
76	77	78	79	80	81	82	

Fig -4: Plan and section of Proposed Building

5.1 Zone 2 RCC Design Results

The design of RCC frame results in changing values of column dimension chosen earlier. Also on application of loads the value of maximum loads is to be analyzed for both nodes and beams. As it is difficult to show the design and changes in each and every beam and column so a few of the beams and columns experiencing maximum changes are shown through figures.

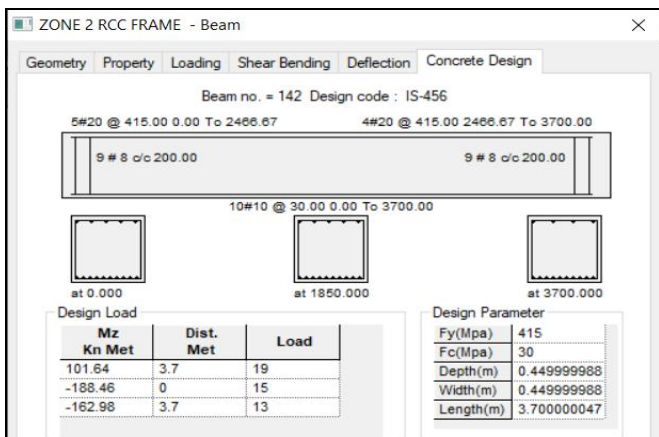


Fig -5: Beam design result in Zone 2

5.2 RCC Frame Material Quantity for Zone 2

Concrete quantity represents volume of concrete in beams, columns, and plates designed above. Steel quantity represents reinforcing steel in beams and columns designed above. In the reported quantity reinforcing steel in plates is not included.

Total volume of concrete = 1293.6 cu.meter

Total volume of steel = 851730 Newton

5.3 Zone 2 Foundation Design Results

As for the RCC frame the loading variation is also supposed to be analysed for the foundation. And it can be seen in the reaction load curve for the x direction the max load intensity is gradually increasing and the minimum load intensity is gradually decreasing as similar to the RCC frame.

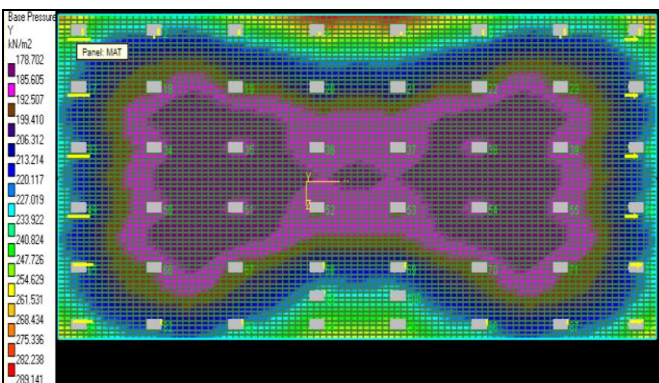


Fig -6: Base pressure in Zone 2

5.4 Zone 2 Steel Frame Design Results

As for the design of the steel frame the selected members will be as per the selected assigned section but after the complete design and analysis the software changes the section with a suitable section to carry load without failure. So the dimension of the section is not specified in this and only the design report of selected members and takeoff will be shown. As it is difficult to show the design and changes in

each and every beam and column so a few of the beams and columns experiencing maximum changes are shown.

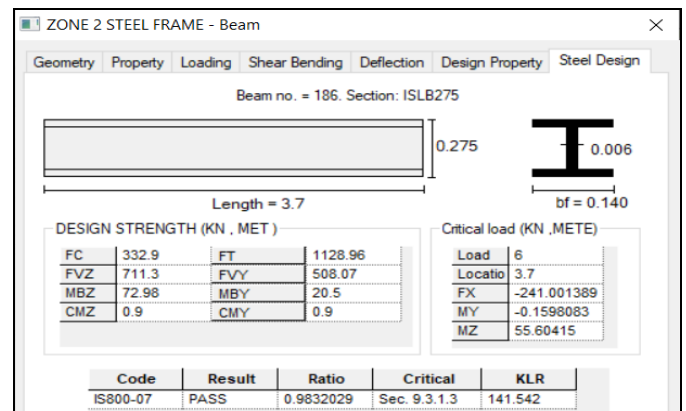


Fig -7: Steel section design result in Zone 2

5.5 Steel Frame Material Quantity for Zone 2

On analyzing the Steel Structure we'll get the most suitable and most economical design in which the section provided or selected by the software itself will be the lightest but safest to carry the load without failure.

Total volume of steel = 2250744.331 KN

6. COMPARISON OF RESULT

One of the Objective of this study is also to compare the quantity of structure so it became important to analyse both the steel and RCC structure through it. The loads at each node and beam are analysed and compared with the data of each frame structure to obtain most feasible design factors.

6.1 Observations in RCC Frame

The maximum and minimum load and moment are both seen in the nodes at support (at the lowest nodes of the structure), So these loads are further countered in foundation design. All those nodes with maximum and minimum intensity are present in the central portion of the structure along X- axis or say center of the longer side. It is observed that there is a gradual increase in maximum loads and moment along each axis from zone 2 to zone 5 respectively. It seems that the minimum loads and moment keeps on gradually decreasing along each axis from zone 2 to zone 5 respectively. As the seismic loads are periodic it seems to be both positive and negative with almost similar type of curve shown in graph for maximum and minimum values. Through this it is clear that with the increasing loads and moment at the nodes the reinforcement or the cross-sectional area of the member will be increased to avoid failure while moving from zone 2 to 3 and so to 4 and so to zone 5 respectively.

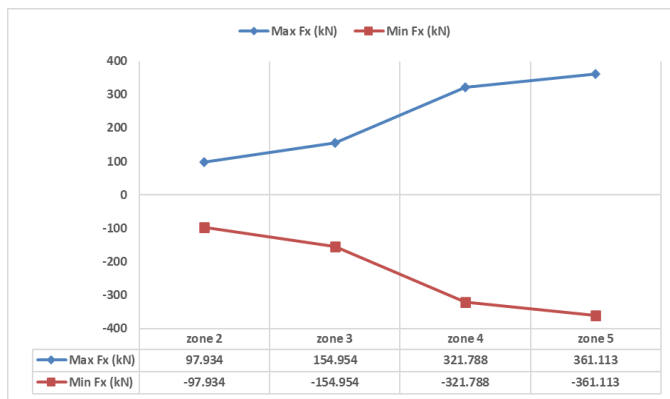


Chart -1: Load along X direction at node in RCC frame

The maximum and minimum loads and moments are experienced by the beam (both beams and columns) at the center of the structure along the x direction or to say at the center of the length. These members are either at stair case portion or at the lift portion opposite to staircases at front. The maximum and minimum load along X and Z direction and moments are only affecting the column of the structure upto zone 2 to zone 4. But at zone five due to high load both beams and columns cross section is redesigned to sustain failure. The maximum and minimum load along Y direction highly affecting the beams at zone 5. All these loads and moments at each zone increases gradually. It can be seen in the graph as the values go increasing with zone 2 to zone 5 in case of maximum and goes decreasing with zone 2 to zone 5 in case of minimum loads and moments.

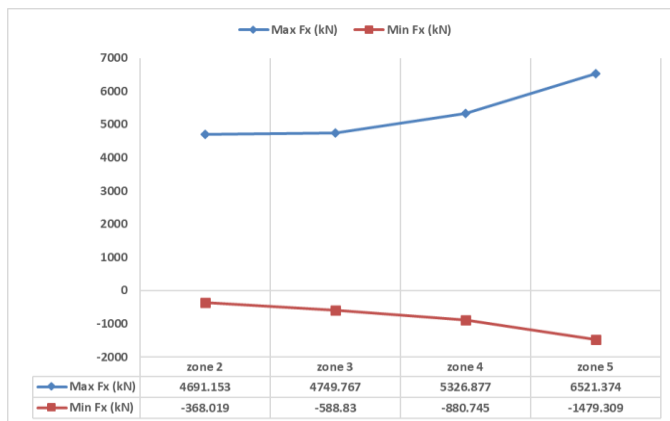


Chart -2: Load along X direction at beam in RCC frame

The gradual increase in displacement on moving from zone 2 to zone 4 can be clearly seen in this graph. It is observed that the node displacement in zone is quite lower than the displacement in zone 3. And there is a sudden rise in displacement at zone 3 and zone 4 from the previous zone. But at zone 5 the displacement graph shows no such high increment in displacement compared to the previous zone. It is quite similar to the graph of load and moment at both beam and node. It is also observed that the nodes or joints experiencing maximum displacement are all present at the top floor level in the frame.

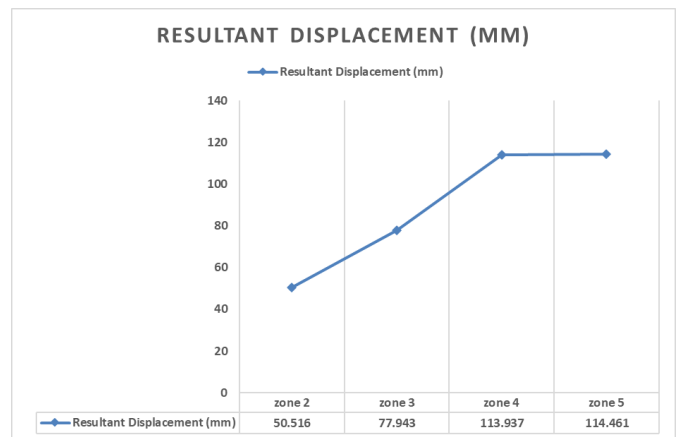


Chart -3: Resultant displacement at node in RCC frame

Through the graph it is observed that there is no such difference in quantity of concrete in zone 2, 3 and 4. But the increase of quantity of concrete in zone 5 is comparatively very high as compared to another zones. As in zone 5 the beam dimension is also changed as the beam fails in large numbers. And to match the flexure, column dimension is also changed. As the reinforcement provided in other zone except zone 5 is not crossing the limit of reinforcement ratio or affecting the proper reinforcement arrangement. Due to increase in concrete the dead load of structure also increases which result in failure of foundation with previous zone dimensions.

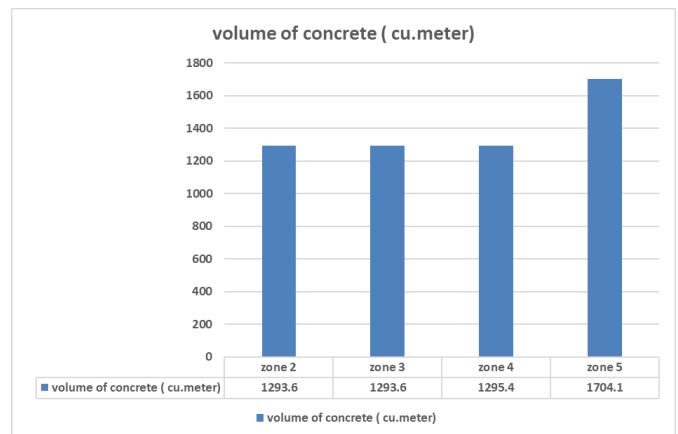


Chart -4: Volume of concrete in RCC frame

It is observed that apart from quantity of concrete the quantity of steel in structure increases gradually in each zone. Through the percentage increase graph the difference of steel quantity of zone 5 and zone 4 is still the maximum as compared to the differences in other zones. As it is clear now that due to the maximum load experienced by the structure in zone 5 it is necessary to keep a safe margin in reinforcement provided to the structure. As the reinforcement provided is observed maximum in the columns at edges and corners of the frame of structure. It should be kept mandatory to provide more reinforcement and increase the area of concrete by increasing the dimension of the column positioned at the corner and edges of the frame of the structure.

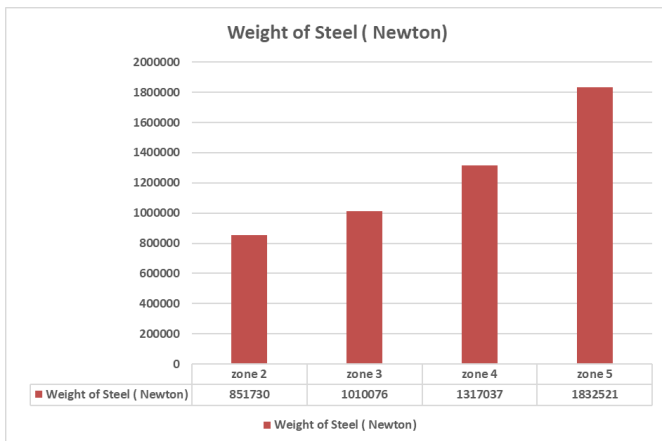


Chart -5: Weight of Steel in RCC frame

6.2 Observations in Foundation

As for the RCC frame the loading variation is also supposed to be analyzed for the foundation. As it can be seen in the reaction load curve for the x direction the max load intensity is gradually increasing and the minimum load intensity is gradually decreasing as similar to the RCC frame. At no certain zone the graph shows any uncertain change and the reaction is as per the increasing seismic loads. As observed for RCC frame the load at the vertical members is higher in the member positioned at the edge and outer faces of the whole frame. Similar kind of loading is seen in the foundation (mat footing type foundation) which is shown in the bearing capacity images in foundation design chapter. The data shown in the ultimate load intensity image represent the load distribution in the foundation exactly as per the observations in RCC frame for which certain changes seems mandatory in the foundation to avoid punching shear failure. As to make frame bearable to seismic loads the cross-sectional area of the members is increased and so for the foundation (particularly for the mat foundation) the offset of the mat from footing along with its thickness is to be increased. The reaction load along Y direction graph seems increasing at a normal rate for loads up to zone 4 but the change in it for zone 5 is higher than normal rate due to change in self weight that is increased by increasing the member dimension to sustain loads.

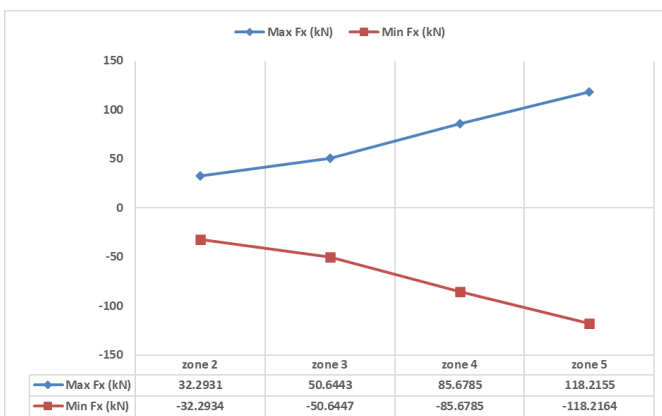


Chart -6: Load along X direction in Foundation

6.3 Observations in STEEL Frame

The graph for load and moment at node for steel structure is almost similar to the graph for RCC structure. The curve goes on increasing for maximum from zone 2 to 4 and decreasing in minimum for zone 2 to zone 4 along the three directions. The curve for load in steel frame shows no such extreme change and make it easy to understand the behavior of load in each zone. Just like the RCC frame the load at the vertical members located at the edge or corner of the frame and that too at the bottom experiences more load and their failure chances is high. And to avoid chances of failure of member the selected section is replaced with the suitable section that can easily bear the load with failure. The load at the connection of members seems maximum along Y direction. It is observed that the loads mainly affecting the structure and causing the failure are actually vertical loads as the loads along other two directions are very less on comparing it to the load along Y direction. But it is also observed that the loads along vertical direction are lesser than the minimum (negative) seismic loads along both the direction as here the minimum or negative loads means loads or force opposite to the direction it is applied. This signifies the design of connection as per both vertical and seismic loads together. On moving to the curve for moment at nodes it is seen that the both the maximum and minimum (negative and positive) moments are experienced by the structure along Z direction which is followed by the moment along X direction.

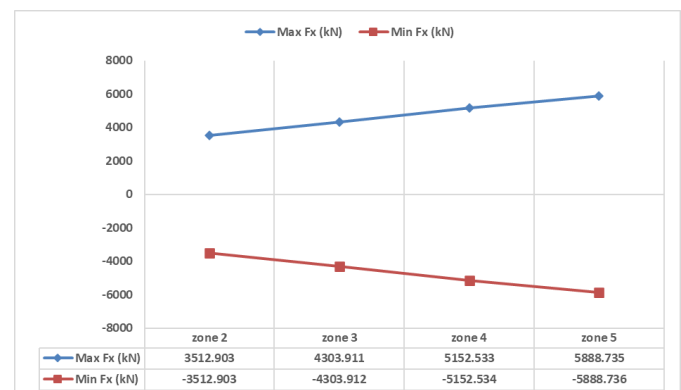


Chart -7: Load along X direction at node in STEEL frame

Through the graph obtained it is observed that the loads are maximum along X direction and minimum along Z direction in each zone. So the members designed will be as per the seismic loading. The mainly affected members are at the outer side or the edges and corners of the frame and with increase in the seismic loads all these members are redesigned resulting change in steel sections. It is also observed that the moment in members are maximum along Z direction and minimum along the x direction in each zone. There is no such sudden raise in the graph curve and the proportion of change in loading with changing zone can be easily determined. Rest other observations are quite similar to the RCC frame.

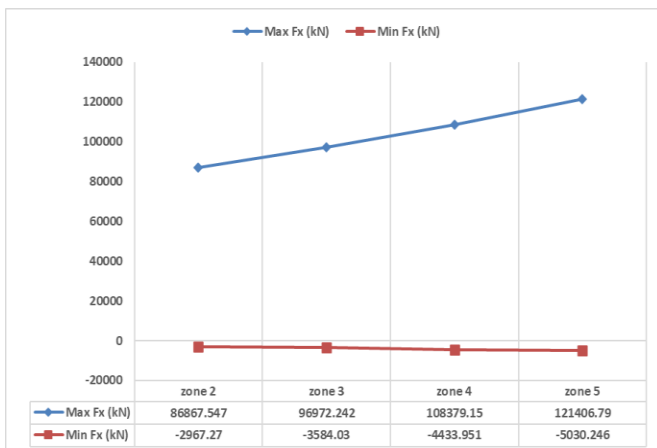


Chart -8: Load along X direction at beam in STEEL frame

It is observed that the resultant displacement in the steel frame is way too lower than the displacement in the RCC frame. Also the displacement observed in each zone is slightly changing and the factor of change can be easily denoted. The result displacement also increases with increase in seismic loads and it is similarly shown in the graph as well. The objective of this comparison is to find the rate of change and to verify it by comparing changes for both the RCC and Steel frames.

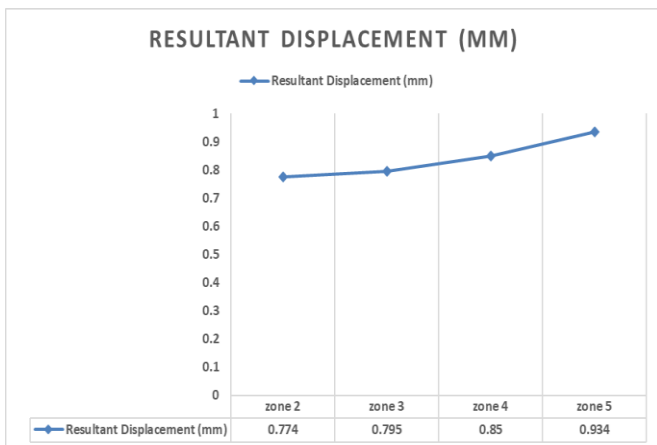


Chart -9: Resultant displacement at node in STEEL frame

The quantity of material is compared to check the rate of increase in the weight of steel in which the steel quantity required is denoted in the graph. And the percentage of change of the quantity of steel with respect to zone 2 is also shown in the graph next to the quantity graph. Through the graph of percentage increase of steel quantity, it is observed that the quantity of material increases with increase in the seismic loads. The rate of change is quite normal in each zone cause the sections are defined by the software itself. The data of change in rate is more suitable economically for the steel frame.

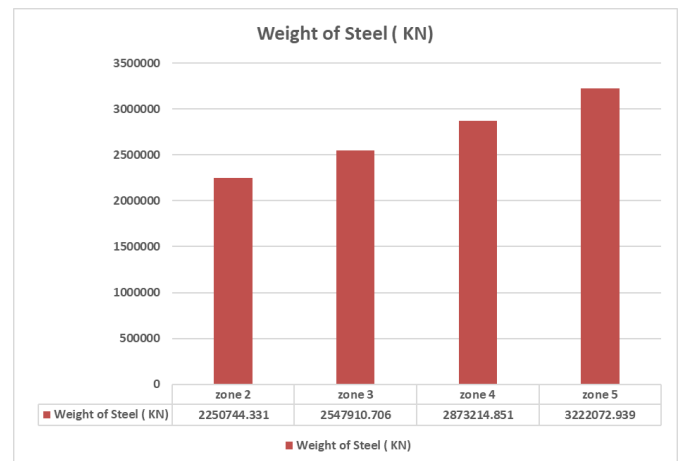


Chart -10: Weight of Steel in STEEL frame

7. CONCLUSIONS

The center of Torsion of the structure plays an important role for designing the frame of the structure especially for the vertical members. The distance of columns from the center of torsion is proportional to the torsional moment that creates shear in the column. So if the columns are placed at varied distances their behavior to the load will also be different. This can result in discontinuity of the periodic moment causing damage to the structure. It is important to maintain the symmetry in arrangement of structural and nonstructural elements in a building.

The slab in each floor is to be designed similar and there should be no excessively large separation between the columns to maintain the stiffness of whole frame. The whole frame is supposed to be homogeneous and symmetrical to maintain stiffness-flexibility. The periodic moment of the structure could be maintained cyclic and controlled during the application of the seismic loads by using shear reinforced walls or thick high resistance masonry walls. The seismic coefficient increases with increase in the building height. So it becomes more important to place the heavy portion or heavy equipment and movable machineries at the lower levels in a building for better seismic resistance.

The light weight structure up to certain limit shows better resistance to the seismic loads as compared to the heavy structure. The length of both vertical and horizontal load carrying members of the structure also plays an important role. The stiffness of shorter length members increases the case of shear failure on application of the seismic forces, so it should be avoided to provide such short length members.

The area of reinforcement of the beam at the lower level increases with increasing seismic forces from zone II to zone V. For the design perspective the analyzed proportion can be used for safe design of beam in RCC frame structure-

Table -2: Analyzed Proportion of Beam in RCC Frame

MEMBER	ZONE	DIMENSION (L X B) mm ²	MAXIMUM TOP REINFORCEMENT (mm ²)	MAXIMUM BOTTOM REINFORCEMENT (mm ²)
BEAM-142	II	0.45 x 0.45	1407.64	708.47
	III	0.45 x 0.46	2228.14	1326.57
	IV	0.45 X 0.45	3259.35	2429.77
	V	0.60 X 0.60	3676.25	2892.04

The volume of concrete and area of steel reinforcement is majorly observed in the column at the edges and corners with increase in the seismic loads. So by the analysis, following proportions are obtained that be used for safe design in RCC frame structure -

Table -3: Analyzed Proportion of Column in RCC Frame

MEMBER	ZONE	DIMENSION (L X B) mm ²	Area of STEEL required (mm ²)	PROVIDED STEEL AS PER CROSS SECTION (%)
COLUMN- 164	II	0.60 X 0.45	1913	0.83
	III	0.60 X 0.45	2296	0.89
	IV	0.60 X 0.45	4536	1.78
	V	0.65 X 0.65	3380	0.85
COLUMN- 228	II	0.60 X 0.45	1888	0.83
	III	0.60 X 0.45	3004	1.17
	IV	0.60 X 0.45	6812	2.79
	V	0.65 X 0.65	6422	1.52
COLUMN- 230	II	0.60 X 0.45	1864	0.83
	III	0.60 X 0.45	2217	0.83
	IV	0.60 X 0.45	4320	1.78
	V	0.65 X 0.65	3380	0.85

The ratio of load and moment at node and beam of each zone with respect to zone 2 explains the variation of forces and the proportion of the severe load case for which the members and joints are to be designed in RCC frame structure-

Table -4: Ratio of Load and Moment in RCC Frame

RATIO OF LOADS AT NODE OF DIFFERENT ZONES WITH ZONE 2	ALONG X DIRECTION		ZONE- III	ZONE-IV	ZONE-V
		MAX	1.58	3.28	3.68
	MIN	1.58	3.28	3.68	
	ALONG Y DIRECTION	MAX	1.012	1.135	1.39
MIN		1.599	2.39	4.01	
ALONG Z DIRECTION	MAX	1.61	3.91	4.25	
	MIN	1.54	3.61	3.72	
RATIO OF LOADS AT BEAM OF DIFFERENT ZONES WITH ZONE 2	ALONG X DIRECTION		ZONE- III	ZONE-IV	ZONE-V
		MAX	1.0124	1.135	1.39
	MIN	1.59	2.39	4.01	
	ALONG Y DIRECTION	MAX	1.48	2.15	3.78
		MIN	1.45	2.199	3.58
	ALONG Z DIRECTION	MAX	1.53	3.45	5.91
MIN		1.48	3.03	4.701	
RATIO OF MOMENT AT BEAM OF DIFFERENT ZONES WITH ZONE 2	ALONG Y DIRECTION		ZONE- III	ZONE-IV	ZONE-V
		MAX	1.55	4.81	5
MIN	1.47	4.63	4.77		

The ratio of maximum displacement of each zone with respect to zone II shows the increase in displacement with increasing seismic forces. The proportion can be used for designing a RCC frame structure-

Table -5: Ratio of Maximum Displacement in RCC Frame

RATIO OF RESULTANT DISPLACEMENT OF DIFFERENT ZONES WITH ZONE 2	ZONE- III	ZONE-IV	ZONE-V
	1.54	2.255	2.26

The ratio of quantity of concrete and steel of each zones with respect to Zone II also shows that there is an increase in the quantity of material with increasing seismic loads. The obtained proportions can be used for estimating the cost of construction at different zones of a RCC frame structure-

Table -6: Ratio of Quantity of Material in RCC Frame

PERCENTAGE INCREASE IN QUANTITY OF CONCRETE AT DIFFERENT ZONES W.R.T ZONE 2	ZONE- III	ZONE-IV	ZONE-V
	100	100.13	131.73
PERCENTAGE INCREASE IN QUANTITY OF STEEL AT DIFFERENT ZONES W.R.T ZONE 2	ZONE- III	ZONE-IV	ZONE-V
	118.59	154.63	215.152

The ratio of reaction load at different zones with zone II explains that the reaction load at foundation also increases with increase in seismic forces in given proportion in RCC MAT Foundation -

Table -7: Ratio of Reaction Load in Foundation

RATIO OF REACTION LOADS OF DIFFERENT ZONES WITH ZONE 2	ALONG X DIRECTION		ZONE- III	ZONE-IV	ZONE-V
		MAX	1.56	2.65	3.66
	MIN	1.56	2.65	3.66	
	ALONG Y DIRECTION	MAX	1.102	1.169	1.45
		MIN	0.8	0.57	0.28
	ALONG Z DIRECTION	MAX	1.485	3.06	3.31
MIN		1.49	3.49	3.4	

The base pressure in the foundation increases with increase in seismic forces. The given proportion used for the analysis or design in RCC MAT Foundation -

Table -8: Ratio of Base Pressure in Foundation

ZONE	BASE PRESSURE	
	Min	Max
II	178.702	289.141
III	178.702	289.141
IV	179.961	281.603
V	191.691	299.592

The beam in zone II requires section with lesser strength than the section required in zone III and similarly seen in other two zones as well. The change in sectional properties can be understood by the table below formed by the analysis data and can be used for designing as a factor or reference for other STEEL Structure -

Table -9: Analyzed Proportion of Beam in STEEL Frame

MEMBER	ZONE	STEEL SECTION	RATIO OF AST RE Q. PER AST PROVIDED	REMARK
BEAM -186	II	ISLB 275	0.98	
	III	ISSC 140	0.73	
	IV	ISSC 140	0.88	
	V	ISSC 150H	0.78	

The column at the edges and corner of the frame experiences higher loads as compared to the columns located at the center of the frame in steel structure as well. The data collected shows the proportion of area required in each zone for STEEL Structures -

Table -10: Analyzed Proportion of Column in STEEL Frame

MEMBER	ZONE	STEEL SECTION	RATIO OF AST REQ PER AST PROVIDED	REMARK
COLUMN- 136	II	ISWB 600	0.74	
	III	ISWB 600	0.941	
	IV	ISWB 600H	1.07	COMPOSITE
	V	ISWB 600H	1.44	COMPOSITE
COLUMN- 715	II	ISWB 550	0.84	
	III	ISWB 600	0.66	
	IV	ISWB 600	0.86	
	V	ISWB 600 H	1.015	COMPOSITE
COLUMN- 180	II	0.60 X 0.45	0.8	
	III	0.60 X 0.45	0.98	
	IV	0.60 X 0.45	1.36	COMPOSITE
	V	0.65 X 0.65	1.3	COMPOSITE

The data from the analysis of STEEL Structure shows almost similar variation of load and moment at joints. The proportion of loads with respect to zone II is given below that can be used for other calculations-

Table -11: Ratio of Load and Moment at STEEL Frame Node

RATIO OF LOADS AT NODE OF DIFFERENT ZONES WITH ZONE 2	DIRECTION	TYPE	ZONE- III	ZONE-IV	ZONE-V
			MAX	1.22	1.466
RATIO OF MOMENT AT NODE OF DIFFERENT ZONES WITH ZONE 2	ALONG X DIRECTION	MIN	1.22	1.466	1.67
		MAX	1.11	1.26	1.42
	ALONG Y DIRECTION	MIN	1.68	2.64	4
		MAX	1.36	1.89	2.54
RATIO OF MOMENT AT NODE OF DIFFERENT ZONES WITH ZONE 2	ALONG Z DIRECTION	MIN	1.3	1.8	2.46
		MAX	1.184	1.48	1.92
	ALONG X DIRECTION	MIN	1.35	1.82	2.54
		MAX	1.89	2.67	3.34
RATIO OF MOMENT AT BEAM OF DIFFERENT ZONES WITH ZONE 2	ALONG Y DIRECTION	MIN	1.89	2.67	3.34
		MAX	1.31	1.63	1.95
	ALONG Z DIRECTION	MIN	1.31	1.63	1.95
		MAX	1.31	1.63	1.95

The analysis of the beam explains the variation of load at different portion of the frame and the ratio of load variation seismic designing and understand the severe case of load combination under such conditions. Data provided below-

Table -12: Ratio of Load and Moment at STEEL Frame Beam

RATIO OF LOADS AT BEAM OF DIFFERENT ZONES WITH ZONE 2	DIRECTION	TYPE	ZONE- III	ZONE-IV	ZONE-V
			MAX	1.11	1.24
RATIO OF MOMENT AT BEAM OF DIFFERENT ZONES WITH ZONE 2	ALONG X DIRECTION	MIN	1.2	1.49	1.69
		MAX	1.08	1.23	1.386
	ALONG Y DIRECTION	MIN	1.08	1.23	1.386
		MAX	1.36	1.72	2.041
RATIO OF MOMENT AT BEAM OF DIFFERENT ZONES WITH ZONE 2	ALONG Z DIRECTION	MIN	1.36	1.72	2.041
		MAX	1.33	1.71	2.03
	ALONG X DIRECTION	MIN	1.33	1.71	2.03
		MAX	1.34	1.75	2.41
RATIO OF MOMENT AT BEAM OF DIFFERENT ZONES WITH ZONE 2	ALONG Y DIRECTION	MIN	1.11	1.33	1.703
		MAX	1.32	1.66	2
	ALONG Z DIRECTION	MIN	1.32	1.66	2
		MAX	1.32	1.66	2

The data of displacement varies in STEEL structure from the RCC frame structure cause the displacement in steel structure is very low as compared to RCC structure. So in case of calculating or assuming the displacement for steel frame structure the analyzed ratio of displacement in each zone with respect to zone II could be referred-

Table -13: Ratio of Maximum Displacement in STEEL Frame

RATIO OF RESULTANT DISPLACEMENT OF DIFFERENT ZONES WITH ZONE 2	ZONE- III	ZONE-IV	ZONE-V
	1.027	1.098	1.206

Through the analysis of STEEL structure, it is cleared that the quantity of material increases with increasing seismic load to avoid the condition of failure. Along with that the amount of change in quantity is also quite clear so that it can be used in cost estimation in different seismic zones.

Table -14: Ratio of Quantity of Material in STEEL Frame

PERCENTAGE INCREASE IN QUANTITY OF STEEL AT DIFFERENT ZONES W.R.T ZONE 2	ZONE- III	ZONE-IV	ZONE-V
	113.203	127.656	143.155

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