Effect of Configuration of building Subjected to Seismic load and Design of RCC Framed Structure by Staad.pro

Pawan Pandey[1] Dilip Kumar[2]
[1]Research Scholar [2]Assistant Professor
[1,2]Department of Civil Engineering
[1,2]Madan Mohan Malviya Technical University, Gorakhpur Uttar Pradesh, India

Abstract— The behavior of building during Earthquake depends critically on its overall shape, size and geometry. The Seismic performance of building is available and new design methods should account for the building ability to dissipate energy and the effect of the lateral deformation. These aspects involve both plan and structural configuration of building. This paper presents structural and seismic behavior of buildings. The purpose is to outline the criteria loading on structure of building during strong earthquake. Building are the complex system and multiple configuration have to be considered at the moment of designing them. That’s why at the planning stage of building, architects and structural Engineers must work together to ensure that the unfavorable features are avoided and good configuration is chosen. The principle objective of this project is to analysis and design a multistoried building [G + 21 (3 dimensional frame)] using STAAD Pro. The design involves load calculations manually and analyzing the whole structure by STAAD Pro. The design methods used in STAAD-Pro analysis are Limit State Design conforming to Indian Standard Code of Practice. We considered a 3-D RCC frame with the dimensions of 4 bays @5m in x-axis and 3 bays @5m in z-axis. The y-axis consisted of G + 21 floors.

Key words: seismic effect, structural configuration, susceptible, analysis & design by staadpro8vi

I. INTRODUCTION

Configuration plays an important role in the seismic performance of structure subjected the Earthquake actions. Concentrations of inelastic depend are likely to occur in zones of geometrical discontinuities and/or mass and stiffness irregularities if the available ductility is limited, failure is initiated, thus possibly leading to collapse. Seismic causes impulsive ground motions; which are complex and irregular in character, changing in period and amplitude each lasting for short time. Therefore, resonance of type as visualized under steady-state sinusoidal excitations; will not occur as it would need time to build up such amplitudes. Irregular buildings constitute a large portion of the modern urban infrastructure. The group of people involved in constructing the building facilities, including owner, architect, structural engineer, contractor and local authorities, contribute to the overall planning, selection of structural system, and to its configuration. This may lead to building structures with irregular distributions in their mass, stiffness and strength along the height of building. When such buildings are located in a high seismic zone, the structural engineer’s role becomes more challenging. Therefore, the structural engineer needs to have a thorough understanding of the seismic response of irregular structures. In recent past, several studies have been carried out to evaluate the response of irregular buildings. a structure is defined to be irregular if the ratio of one of the quantities (such as mass, stiffness or strength) between adjacent stories exceeds a minimum prescribed value. These values (such as 70-80% for soft story, 80% for weak story, 150% for set-back structures) and the criteria that define the irregularities have been assigned by judgment. Further, various building codes suggest dynamic analysis (which can be elastic time history analysis or elastic response spectrum analysis) to come up with design lateral force distribution for irregular structures rather than using equivalent lateral force (ELF) procedures. STAAD.Pro has a very interactive user interface which allows the users to draw the frame and input the load values and dimensions. Then according to the specified criteria assigned it analyses the structure and designs the members with reinforcement details for RCC frames. We continued with our work with some more multistoried 2-D and 3-D frames under various load combinations. This paper is to summarize building irregularities. Our final work was the proper analysis and design of a G + 21 3-D RCC frame under various load combinations.

II. IRREGULARITIES IN BUILDING CODES

In the earlier versions of IS 1893 (BIS, 1962, 1966, 1970, 1975, 1984), there was no mention of vertical irregularity in building frames. However, in the recent version of IS 1893 (Part 1)-2002 (BIS, 2002), irregular configuration of buildings has been defined explicitly. Five types of vertical irregularity have been listed as shown in Figure 1. They are: stiffness irregularity (soft story), mass irregularity, vertical geometric irregularity (set-back), in-plane discontinuity in lateral-force-resisting vertical elements, and discontinuity in capacity (weak story).

NEHRP code (BSSC, 2003) has classifications of vertical irregularities similar to those described in IS 1893 (Part 1)-2002 (BIS, 2002). As per this code, a structure is defined to be irregular if the ratio of one of the quantities (such as mass, stiffness or strength) between adjacent stories exceeds a minimum prescribed value. These values (such as 70-80% for soft story, 80% for weak story, 150% for set-back structures) and the criteria that define the irregularities have been assigned by judgment. Further, various building codes suggest dynamic analysis (which can be elastic time history analysis or elastic response spectrum analysis) to come up with design lateral force distribution for irregular structures rather than using equivalent lateral force (ELF) procedures.

For the soft and weak first story structures, increase in seismic demand has been observed as compared to the regular structures. For buildings with discontinuous distributions in mass, stiffness, and strength (independently or in combination), the effect of strength irregularity has been found to be larger than the effect of stiffness irregularity, and the effect of combined-stiffness-and-strength irregularity has been found to be the largest.

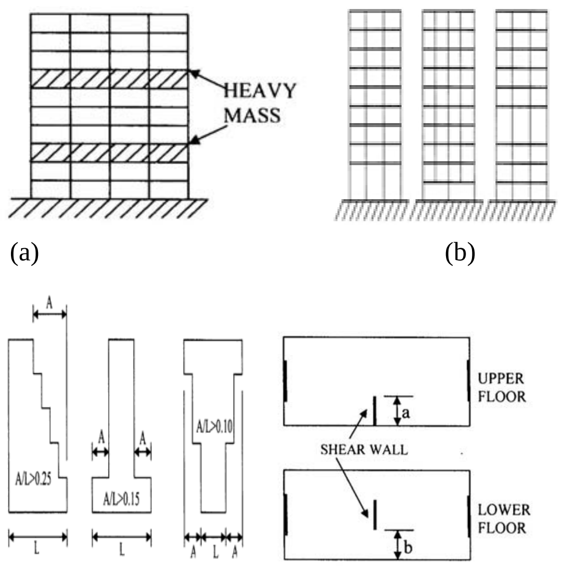


Fig. 1: (a) Stiffness/strength irregularity; (b) Mass irregularity; (c) Vertical geometric irregularity or set-back; (d) In-plane discontinuity in lateral-force-resisting vertical elements when b > a: plan view (after BIS, 2002).

Seismic causes impulsive ground motions; which are complex and irregular in character, changing in period and amplitude each lasting for short time. Therefore, resonance of type as visualized under steady-state sinusoidal excitations; will not occur as it would need time to build up such amplitudes. Some irregularity type in structural configuration It has been found that the seismic behavior is influenced by the type of model (i.e., beam hinge model or column hinge model) used in the study. Finally, buildings with a wide range of vertical irregularities that were designed

Ref.	Typeofbuildi-ng	ExtentofVerticalIrregula			Remarks
		Mass Ratio	StiffnessRatio	StrengthRatio	
RuizandDiederich(1989)	5-Story(withBrittleInfillWalls)	-	4.0	0.65-2.0	Massi rregularities have not been studied and infillwallshavebeenprovidedatallfloors
	12-Story(withBrittleInfillWalls)	-	0.9	1.0-2.0	
	5-Story(with DuctileInfill Walls)	-	4.0	1.0-2.0	
Valmudssonand Nau(1997)	5-Story	0.1,0.5,1.5,2.0,5	0.5,0.6,0.7,0.8,0.9	0.5,0.6,0.7,0.8,0.9	
	10-Story	0.1,0.5,1.5,2.0,5			
	20-Story	0.1,0.5,1.5,			
Al-AliandKrawinkler(1998)	10-Story	0.25,0.5,2.0,4.0	0.1,0.25,0.5,2.0,4.0,10.0	0.5	
Dasand Nau2003	5-Story	2.5-	0.09-1.6	0.27-	
	10-Story	2.5-	0.09-1.71	0.27-	
	20-Story	2.5-5.0	0.08-1.89	0.27-1.07	
ChintanapakdeeandChopra(2004)	12-Story	-	0.2,0.5,2.0,5.0	0.2,0.5,2.0,5.0	Mass irregularities have not been studied
Fragiadakisetal.(2006)	9-Story	-	0.5,2.0	0.5,2.0	Mass irregularities have not been studied

Table 1: Summary of Types and Extent of Vertical Irregularities Studied by Various Researchers

III. ANALYSIS & DESIGN OF RCC FRAMED BUILDING(G+21) BY STAAD.PRO

We considered a 3-D RCC frame with the dimensions of 4 bays @5m in x-axis and 3 bays @5m in z-axis. The y-axis specifically for code- based limits on drift, strength and ductility, have exhibited reasonable performances, even though the design forces were obtained from the ELF (seismic coefficient) procedures. Consisted of G + 21 floors. The total numbers of beams in each floor were 28 and the numbers of columns were 16. The ground floor height was 4m and rest of the 21 floors had a height of 3.3m.The structure was subjected to self-weight, dead load, live load, wind load and seismic loads under the load case details of STAAD.Pro. The wind load values were generated by STAAD.Pro considering the given wind intensities at different heights and strictly abiding by the specifications of IS 875. Seismic load calculations were done following IS 1893-2000. The materials were specified and cross-sections of the beam and column members were assigned. The supports at the base of the structure were also specified as fixed. The codes of practise to be followed were also specified for design purpose with other important details. Then STAAD.Pro was used to analyse the structure and design the members. In the post-processing mode, after completion of the design, we can work on the structure and study the bending moment and shear force values with thegenerated diagrams. We may also check the deflection of various members under the given loading combinations. The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes. The minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads, the structure would be required to bear. Strict conformity to loading standards recommended in this code, it is hoped, will ensure the structural safety of the buildings which are being designed. Structure and structural elements were normally designed by Limit State Method.

Complicated and high-rise structures need very time taking and cumbersome calculations using conventional manual methods. STAAD.Pro provides us a fast, efficient, easy to use and accurate platform for analysing and designing structures.

IV. PROBLEM STATEMENT

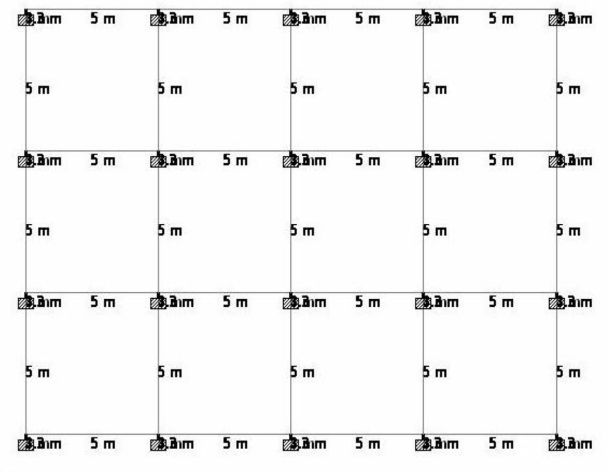


Fig. 3: plan of the G+21 storey building

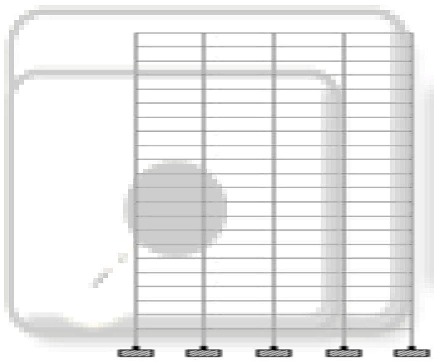


Fig. 2: elevation of the G+21 storey building

A. Physical parameters of building

Length = 4 bays @ 5.0m = 20.0m

Width = 3 bays @5 m =15.0m

Height = 4m + 21 storeys @ 3.3m = 73.3m

(1.0m parapet being non- structural for seismic purposes, is not considered of building frame height)

Live load on the floors is 2kN/m2

Live load on the roof is 0.75kN/m2\

B. Grade of concrete and steel used:

Used M30 concrete and Fe 415 steel

Number of bays inXdirection @5m	4
Number of bays in Y direction	G+21 Floor
Number of bays inZ direction@5m	3
Spanof each bay	5m
Length 4-bays@5.0m	20m
Width 3-bays@5.0m	15m
Height(4m until ground floor+21storeys@3.3)	73.3m
Parapet being non-structural for seismic purpose	1.0m

Number of storey	21
All column (until ground floor)Size	0.5m x0.5 m
Column at ground floor	0.8 m x 0.8 m
All Sizeof beam	0.3 m x0.5 m
Total number of beam in each floor	28
Total number of columnsin each floor	16
Slabthickness	0.20m
Terracing avg thickness	0.20m
Parapet	0.10m
ConcreteGrade	M-30
SteelGrade	Fe-415
Densityof Concrete	25kN/m^3
Densityof Steel	78.5 kN/m^3
Densityof wall Masonry	20kN/m^3
Floor finishonslab	1kN/m^2
Imposedloadonslab	2kN/m^2
Seismic Zone	IV
Soil Condition	Medium

C. Generation of member property

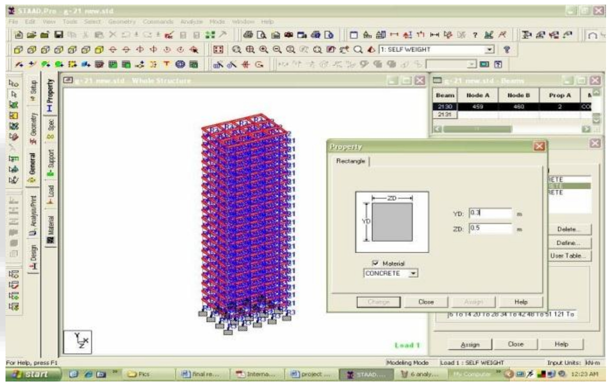


Fig 4: Generation of member property

Generation of member property can be done in STAAD.Pro by using the window as shown above. The member section is selected and the dimensions have been specified. The beams are having a dimension of 0.5 * 0.3 m and the columns are having a dimension of 0.8 * 0.8 m at the ground floor and at the other top floors they are having a dimension of 0.5 * 0.5 m.

D. Supports

The base supports of the structure were assigned as fixed. The supports were generated using the STAAD.Pro support generator.

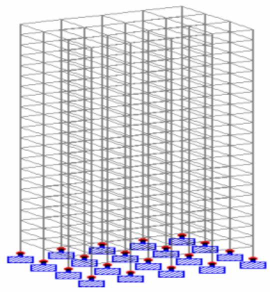


Fig 4: fixing supports of the structure

E. Materials for the structure

The materials for the structure were specified as concrete with their various constants as per standard IS code of practice.

F. Loading

The loadings were calculated partially manually and rest was generated using STAAD.Pro load generator. The loading cases were categorized as:

Self-weight

- Dead load from slab
- Live load
- Wind load
- Seismic load Load combinations

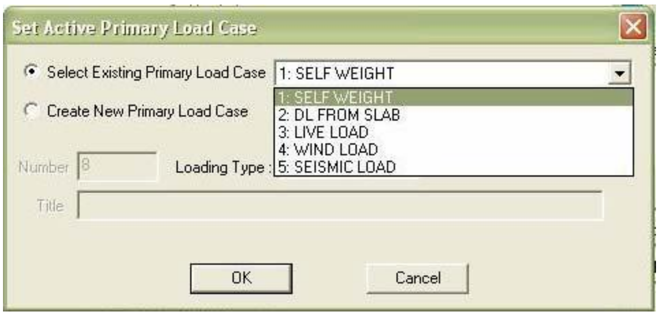


Fig. 5: primary load cases

1) Self-weight

The self-weight of the structure can be generated by STAAD.Pro itself with the self-weight command in the load case column.

2) Dead load from slab

Dead load from slab can also be generated by STAAD.Pro by specifying the floor thickness and the load on the floor per sq m. Calculation of the load per sq m was done considering the weight of beam, weight of column, weight of RCC slab, weight of terracing, external walls, internal walls and parapet over roof.

The load was found to be:

14.482 KN/sq m [terrace]

13.5 KN/sq m [typical floor]

14.37 KN/sq m [first floor]

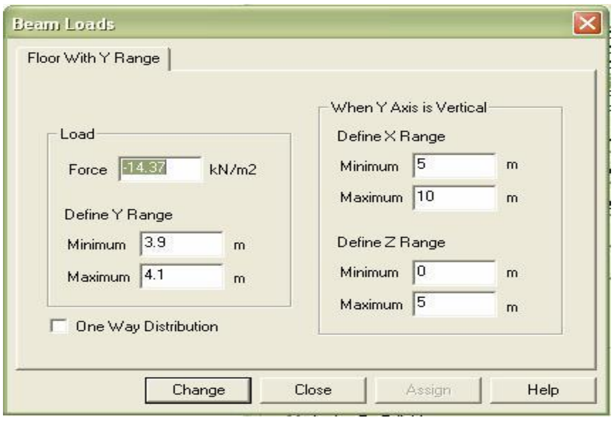
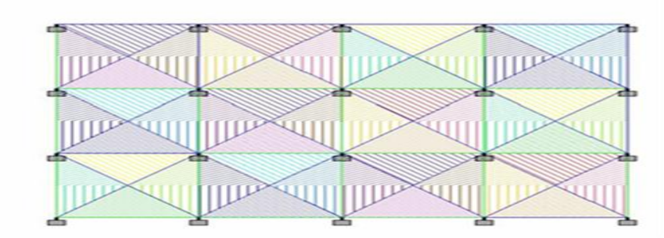


Fig. 6: input window of floor load generator



Fig, 4.7: load distribution by trapezoidal method

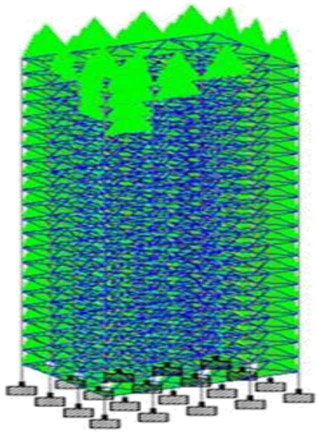


Fig. 7: the structure under DL from slab

3) Live load

The live load considered in each floor was 2.5 KN/sq m and for the terrace level it was considered to be 0.75 KN/sq m. The live loads were generated in a similar manner as done in the earlier case for dead load in each floor. This may be done from the member load button from the load case column

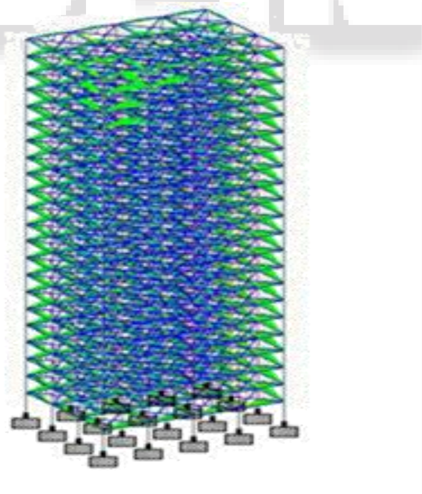


Fig. 8: the structure under live load

4) Wind load

The wind load values were generated by the software itself in accordance with IS 875. Under the define load command section, in the wind load category, the definition of wind load was supplied. The wind intensities at various heights were calculated manually and feed to the software. Based on those values it generates the wind load at different floors.

Height [h]	Design wind speed [V_z]	Design wind pressure [P_z]
Up to 10 m	36.379 m/s	0.793 KN/sq m
15 m	38.85 m/s	0.905 KN/sq m
20 m	40.51 m/s	0.984 KN/sq m
30 m	42.58 m/s	1.087 KN/sq m

Table 1: design wind pressure at various heights

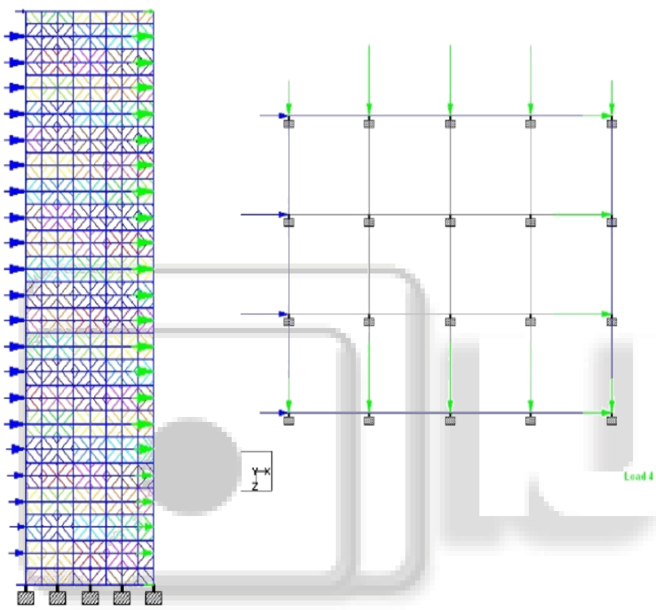


Fig. 9: wind load effect on structure elevation and plan

5) Seismic load

The seismic load values were calculated as per IS 1893-2002. STAAD.Pro has a seismic load generator in accordance with the IS code mentioned.

Description:The seismic load generator can be used to generate lateral loads in the X and Z directions only. Y is the direction of gravity loads. This facility has not been developed for cases where the Z axis is set to be the vertical direction using the "SET Z UP" command.

Methodology:The design base shear is computed by STAAD in accordance with the IS: 1893(Part 1)-2002.

V = Ah*W

Where, Ah = (Z*I*Sa)/ (2*R*g)

STAAD utilizes the following procedure to generate the lateral seismic loads.

- User provides seismic zone co-efficient and desired "1893(Part 1)-2002 specs" through the DEFINE 1893 LOAD command.
- Program calculates the structure period (T).
- Program calculates Sa/g utilizing T.
- Program calculates V from the above equation.
- W is obtained from the weight data provided by the user through the DEFINE 1893 LOAD command.

The total lateral seismic load (base shear) is then distributed by the program among different levels of the structure per the IS: 1893(Part 1)-2002 procedures.

6) General format:

DEFINE 1893 LOAD

ZONE f1 1893- spec SELFWEIGHT JOINT WEIGHT Joint-list WEIGHT w

1893-Spec= {RF f2, I f3, SS f4, (ST f5), DM f6, (PX f7), (PZ f8), (DT f9)}

Where,

- Zone f1 = Seismic zone coefficient.
- RF f2 = Response reduction factor.
- I f3 = Importance factor depending upon the functional use. of the structures, characterized by hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance.
- SS f4 = Rock or soil sites factor (=1 for hard soil, 2 for medium soil, 3 for soft soil). Depending on type of soil, average response acceleration coefficient Sa/g is calculated corresponding to 5% damping
- ST f5 = Optional value for type of structure (=1 for RC frame building, 2 for Steel frame building, 3 for all other buildings).
- DM f6 = Damping ratio to obtain multiplying factor for calculating Sa/g for different damping. If no damping is specified 5% damping (default value 0.05) will be considered corresponding to which multiplying factor is 1.0.
- PX f7 = Optional period of structure (in sec) in X direction. If this is defined this value will be used to calculate Sa/g for generation of seismic load along X direction.
- PZ f8 = Optional period of structure (in sec) in Z direction. If this is defined this value will be used to calculate Sa/g for generation of seismic load along Z direction.
- DT f9 = Depth of foundation below ground level. It should be defined in current unit. If the depth of foundation is 30 m or below, the value of Ah is taken as half the value obtained. If the foundation is placed between then ground level and 30 m depth, this value is linearly interpolated between Ah and 0.5Ah

f. l.	Wi (KN)	Hi (m)	Hi^2	Wi hi^2 $*10^3$	(Wi hi^2)/∑(Wi hi^2)	Along x direction		Along Y direction	
						Qix	Storey shear	Qiy	Storey shea
22	4129	73.3	5372.89	22184662.81	.123	426.309		372.1	

								5	
21	4252	70	4900	20834800	.115	398.58	824	347.95	372.1
20	4252	66.7	4448.89	18916680.28	.105	363.9	1188	317.69	720.1
19	4252	63.4	4019.56	17091169.12	.0949	328.91	1517	272.3	1037
18	4252	60.1	3612.01	15358266.52	.085	294.60	1812	257.18	1310
17	4252	56.8	3226.24	13717972.48	.076	263.41	2075	229.95	1567
16	4252	53.5	2862.25	12170287	.067	232.2	2307	202.7	1797
15	4252	50.2	2520.04	10717972.18	.059	204.48	2512	178.5	1999
14	4252	46.9	2199.61	9352741.72	.0519	179.88	2692	157.03	2178
13	4252	43.6	1900.26	8082881.92	.044	152.50	2844	133.12	2335
12	4252	40.3	1624.09	6905630.68	.0383	132.74	2977	115.88	2468
11	4252	37	1369	5820988	.032	110.90	3110	96.82	2584
10	4252	33.7	1135.69	4828953.88	.0268	92.80	3221	81.08	2665
9	4252	30.4	924.16	3929528.32	.021	72.78	3314	63.53	2729
8	4252	27.1	734.41	3122711.32	.017	58.92	3386	51.43	2780
7	4252	23.8	566.41	2408502.88	.013	45.05	3445	39.33	2831
6	4252	20.5	420.25	1786903	.0099	34.31	3490	29.95	2871
5	4252	17.2	295.84	1257911.68	.0069	23.91	3525	20.87	2901
4	4252	13.9	193.21	821528.92	.0045	15.59	3549	13.61	2922
3	4252	10.6	112.36	477754.72	.0026	9.01	3564	7.866	2935
2	4252	7.3	53.29	226589.08	.00125	4.33	3573	3.782	2943
1	4505	4	16	72080	.0004	1.38	3577	1.210	2947
l							3579		2948

Table 2: vertical distribution of earthquake forces to different floor levels

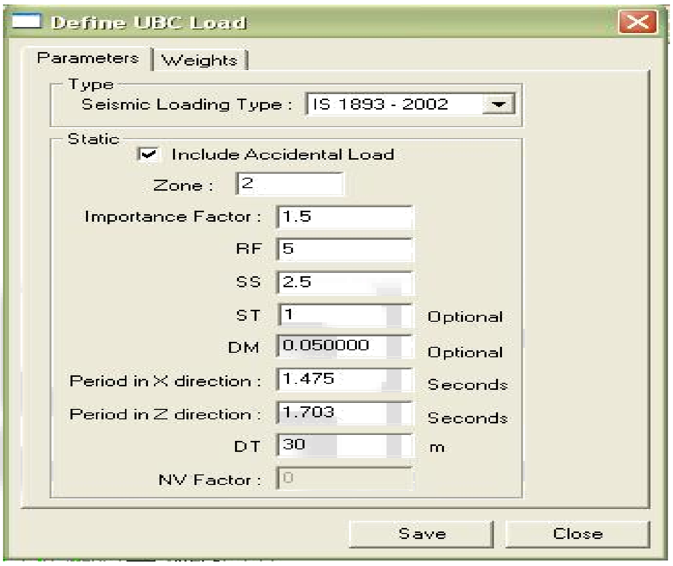


Fig. 10: seismic load definition

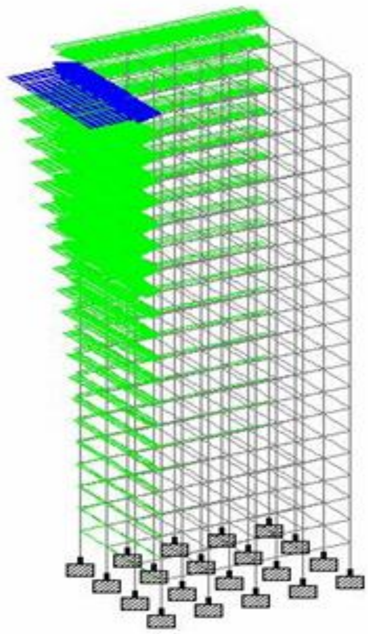
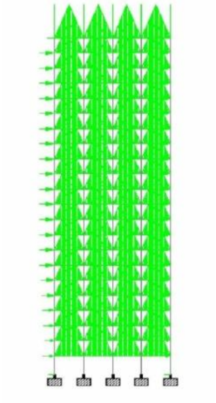


Fig. 11: structure under seismic load

7) Load combination

The structure has been analyzed for load combinations considering all the previous loads in proper ratio. In the first case a combination of self-weight, dead load, live load and wind load was taken in to consideration. In the second combination case instead of wind load seismic load was taken into consideration.



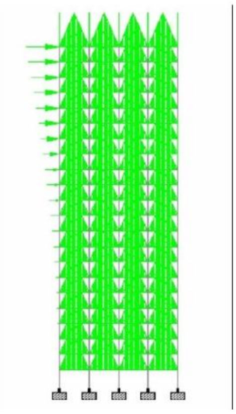


Fig. 12: under combination with wind load   Fig 13: under combination with seismic load.

V. DESIGN OF G + 21 RCC FRAMED BUILDING USING STAAD.PRO

The structure was designed for concrete in accordance with IS code. The parameters such as clear cover,Fy, Fc, etc were specified. The window shown below is the input window for the design purpose. Then it has to be specified which members are to be designed as beams and which member are to be designed as columns.

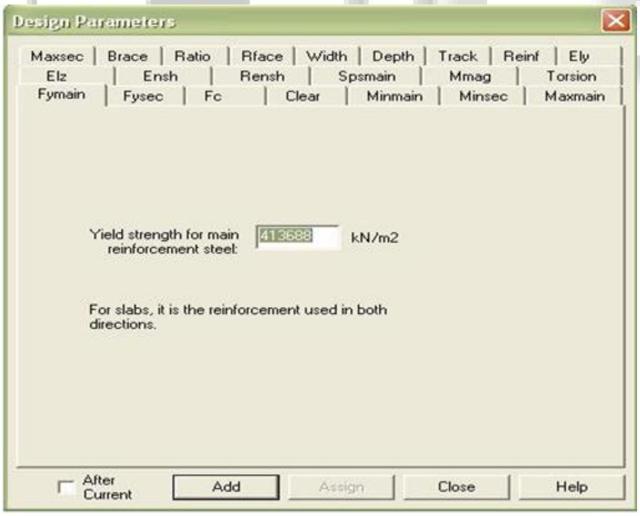


Fig 14: input window for design purpose.

The STAAD.Pro input command file for our particular G+21 storey building has beenshown below:

STAAD SPACE

START JOB INFORMATION

Analysis of G+21 storey building

Project work 2013-2014

ENGINEER DATE 04-Mar-14

END JOB INFORMATION INPUT WIDTH 79

UNIT METER KN JOINT COORDINATES

MEMBER INCIDENCES

DEFINE MATERIAL START

ISOTROPIC CONCRETE

E 2.17185e+007

POISSON 0.17

DENSITY 23.5616

ALPHA 1e-005 DAMP 0.05

END DEFINE MATERIAL CONSTANTS

MATERIAL CONCRETE MEMBER

MEMBER PROPERTY INDIAN

SUPPORTS

FIXED DEFINE WIND LOAD

TYPE 1

INT 0.793 0.905 0.984 1.087 HEIG 10 15 20 30 EXP 1 JOINT 1 TO 460

DEFINE 1893 ACCIDENTAL LOAD

ZONE 2 RF 5 I 1.5 SS 2.5 ST 1 DM 0.05 PX 1.475 PZ 1.703 DT 30 SELFWEIGHT

FLOOR WEIGHT

LOAD 1 SELF WEIGHT

SELFWEIGHT Y -1.4 LOAD 2 DL FROM

SLAB FLOOR LOAD

*Dead load [slab load + wall load + floor finishes] at ground floor level .

*dead load [slab load + wall load + floor finishes] at 21th floor level (roof):

YRANGE 73.2- 73.4 FLOAD -14.48 XRANGE 05ZRANGE 05

YRANGE73.2-73.4FLOAD-14.48 XRANGE 0 5 ZRANGE 5 10

YRANGE 73.2- 73.4 FLOAD -14.48 XRANGE 0 5 ZRANGE 10 15 YRANGE 73.2- 73.4 FLOAD -14.48 XRANGE 5 10 ZRANGE 0 5

YRANGE 73.2- 73.4 FLOAD -14.48 XRANGE 5 10 ZRANGE 5 10 YRANGE 73.2- 73.4 FLOAD -14.48 XRANGE 5 10 ZRANGE 10 15 YRANGE 73.2- 73.4 FLOAD -14.48 XRANGE 10 15 ZRANGE 0 5

YRANGE 73.2- 73.4 FLOAD -14.48 XRANGE 10 15 ZRANGE 5 10 YRANGE 73.2- 73.4 FLOAD -14.48 XRANGE 10 15 ZRANGE 10 15 YRANGE 73.2- 73.4 FLOAD -14.48 XRANGE 15 20 ZRANGE 0 5 YRANGE 73.2 73.4 FLOAD -14.48 XRANGE 15 20 ZRANGE 5 10 YRANGE 73.2 73.4 FLOAD -14.48 XRANGE 15 20 ZRANGE 10 15 LOAD 3 LIVE LOAD

*live load @ ground floor:

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 0 5 ZRANGE 0 5

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 0 5 ZRANGE 5 10

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 0 5 ZRANGE 10 15

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 5 10 ZRANGE 0 5

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 5 10 ZRANGE 5 10

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 5 10 ZRANGE 10 15

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 10 15 ZRANGE 0 5

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 10 15 ZRANGE 5 10

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 10 15 ZRANGE 10 15

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 15 20 ZRANGE 0 5

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 15 20 ZRANGE 5 10

YRANGE 3.9 4.1 FLOAD -2.5 XRANGE 15 20 ZRANGE 10 15

live load @ 21st floor [roof]:

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 0 5 ZRANGE 0 5

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 0 5 ZRANGE 5 10

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 0 5 ZRANGE 10 15

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 5 10 ZRANGE 0 5

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 5 10 ZRANGE 5 10

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 5 10 ZRANGE 10 15

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 10 15 ZRANGE 0 5

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 10 15 ZRANGE 5 10

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 10 15 ZRANGE 10 15 YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 15 20 ZRANGE 0 5

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 15 20 ZRANGE 5 10

YRANGE 73.2 73.4 FLOAD -0.75 XRANGE 15 20 ZRANGE 10 15

LOAD 4 WIND LOAD

WIND LOAD X 1 TYPE 1

WIND LOAD -X 1 TYPE 1

WIND LOAD Z 1 TYPE 1

WIND LOAD -Z 1 TYPE 1

LOAD 5 SEISMIC LOAD MEMBER LOAD

2104 2113 2122 UNI GX 28.42

2004 2013 2022 UNI GX 26.57

1904 1913 1922 UNI GX 24.26

……………………

121 TO 124 UNI GY 0.18

200 TO 203 UNI GZ 0.39

6 TO 9 UNI GZ 0.06 LOAD COMB 6 combine 1 1 0.75 2

0.75 3 0.75 4 0.75 LOAD COMB 7 combine 2 1 0.75 2 0.75 3 0.75 5 0.75

PERFORM ANALYSIS PRINT ALL START CONCRETE DESIGN CODE INDIAN

DESIGN BEAM 6 TO 14 20 TO 28 34 TO 42 48 TO 51 121 TO 151 200 TO 230 - 300 TO 330 400 TO 430 500 TO 530 600 TO 630 700 TO 730 800 TO 830 -

900 TO 930 1000 TO 1030 1100 TO 1130 1200 TO 1230 1300 TO 1330 1400 TO 1430 - 1500 TO 1530 1600 TO 1630 1700 TO 1730 1800 TO 1830 1900 TO 1930 -

2000 TO 2030 2100 TO 2130

DESIGN COLUMN 1 TO 5 15 TO 19 29 TO 33 43 TO 47 101 TO 120 152 TO 171 231 - 232 TO 250 331 TO 350 431 TO 450 531 TO 550 631 TO 650 731 TO 750 831 TO 850 - 931 TO 950 1031 TO 1050 1131 TO 1150 1231 TO 1250 1331 TO 1350 1431 TO 1450 - 1531 TO 1550 1631 TO 1650 1731 TO 1750 1831 TO 1850 1931 TO 1950 -2031 TO 2050

CLEAR 0.025 MEMB 1 TO 51 101 TO 171 200 TO 250 300 TO 350 400 TO 450 - 500 TO 550 600 TO 650 700 TO 750 800 TO 850 900 TO 950 1000 TO 1050 1100 -1101 TO 1150

1200 TO 1250 1300 TO 1350 1400 TO 1450 1500 TO 1550 1600 TO 1650 - 1700 TO 1750 1800 TO 1850 1900 TO 1950 2000 TO 2050 2100 TO 2130

END CONCRETE DESIGN FINISH

VI. Analysis And Design Results

Some of the sample analysis and design results have been shown below for beam number 52 which is at the roof level of 1st floor.

===
=

A. B E A M N O. 52 D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 5000.0 mm SIZE: 500.0 mm X 300.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION 0.0 mm 1250.0 mm 2500.0 mm 3750.0 mm 5000.0 mm

TOP 782.52 0.00 0.00 622.76 2545.68

REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

BOTTOM 1379.67 735.82 529.60 273.43 730.70

REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION 0.0 mm 1250.0 mm 2500.0 mm 3750.0 mm 5000.0 mm

TOP 7-12í 3-12í 3-12í 6-12í 23-12í

REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 2 layer(s)

BOTTOM 7-16í 4-16í 4-16í4-16í4-16í

REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

SHEAR 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í

REINF. @ 170 mm c/c @ 170 mm c/c @ 170 mm c/c @ 170 mm c/c @ 170 mm c/c

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 669.0 mm AWAY FROM START SUPPORt

VY = 59.82 MX = -0.25 LD= 2

Provide 2 Legged 8í @ 170 mm c/c

SHEAR DESIGN RESULTS AT 656.1 mm AWAY FROM END SUPPORT

VY = -120.46 MX = -0.56 LD= 6

Provide 2 Legged 8í @ 170 mm c/c

B E A M N O. 984 D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 5000.0 mm SIZE: 500.0 mm X 300.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION 0.0 mm 1250.0 mm 2500.0 mm 3750.0 mm 5000.0 mm

TOP 2642.22 364.49 0.00 391.62 1106.52

REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

BOTTOM 886.63 428.55 923.25 662.70 0.00

REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

STAAD SPACE -- PAGE NO. 1198

SUMMARY OF PROVIDED REINF. AREA

SECTION 0.0 mm 1250.0 mm 2500.0 mm 3750.0 mm 5000.0 mm

TOP 24-12í 4-12í 3-12í 4-12í 10-12í

REINF. 2 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

BOTTOM 4-20í 4-20í4-20í4-20í 2-20í

REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

SHEAR 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í

REINF. @ 170 mm c/c @ 160 mm c/c @ 170 mm c/c @ 170 mm c/c @ 170 mm c/c

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 505.5 mm AWAY FROM START SUPPORT

VY = 136.30 MX = 0.41 LD= 2

Provide 2 Legged 10í @ 170 mm c/c

SHEAR DESIGN RESULTS AT 519.0 mm AWAY FROM END SUPPORT

VY = -110.89 MX = 0.53 LD= 6

Provide 2 Legged 10í @ 170 mm c/c

B. COLUMN NO.189 DESIGN RESULTS

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3300.0 mm CROSS SECTION: 500.0 mm X 500.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 4 END JOINT: 65 TENSION COLUMN

REQD. STEEL AREA : 9612.29 Sq.mm.

REQD. CONCRETE AREA: 240387.72 Sq.mm

MAIN REINFORCEMENT : Provide 12 - 32 dia. (3.86%, 9650.97 Sq.mm.)

(Equally distributed

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 6237.06 Muz1 : 527.07 Muy1 : 527.07

INTERACTION RATIO: 0.99 (as per Cl. 39.6, IS456:2000)

STAAD SPACE -- PAGE NO. 1325

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 6

END JOINT: 65 Puz : 6248.58 Muz : 461.86 Muy : 461.86 IR: 0.78

===

C. COLUMN NO.2050 DESIGN RESULTS

M30Fe415 (Main) Fe415 (Sec.)

LENGTH: 3300.0 mm CROSS SECTION: 500.0 mm X 500.0 mm

COVER: 40.0 mm

** GUIDING LOAD CASE: 7 END JOINT: 460 SHORT COLUMN

REQD. STEEL AREA : 2510.85 Sq.mm.

MAIN REINFORCEMENT: Provide 8 - 20 dia. (1.01%, 2513.27 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT: Provide 8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY (KNS-MET)

Puz : 4122.60 Muz1 : 213.09 Muy1 : 213.09

INTERACTION RATIO: 1.00 (as per Cl. 39.6, IS456:2000)

VII. POST PROCESSING MODE

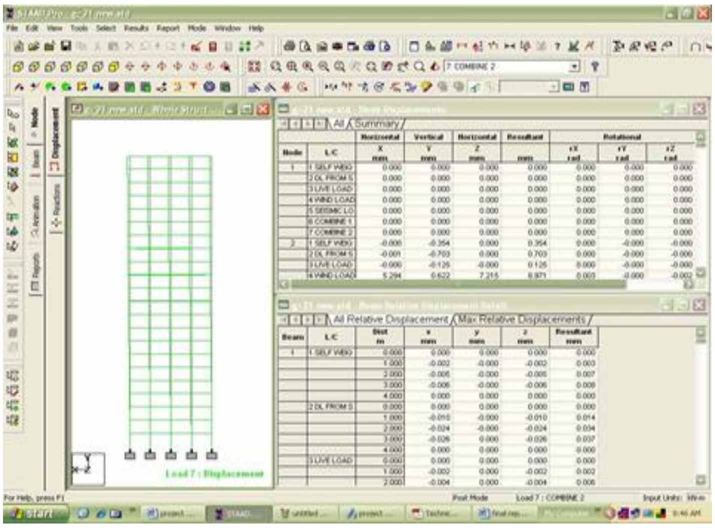


Fig 15: post processing mode in STAAD.Pro

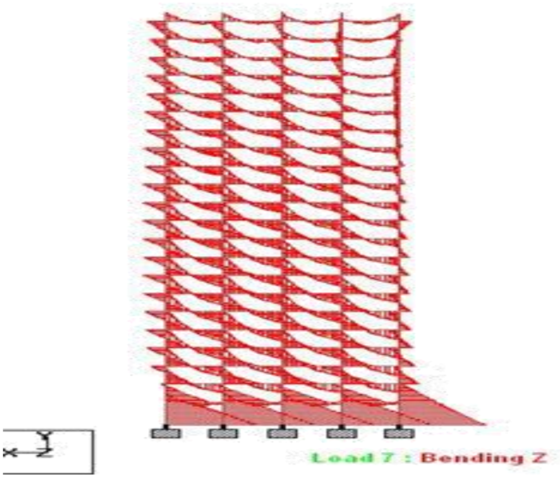


Fig 16: bending in Z

The stress at any point of any member can be found out in this mode. The figure below depicts a particular case.

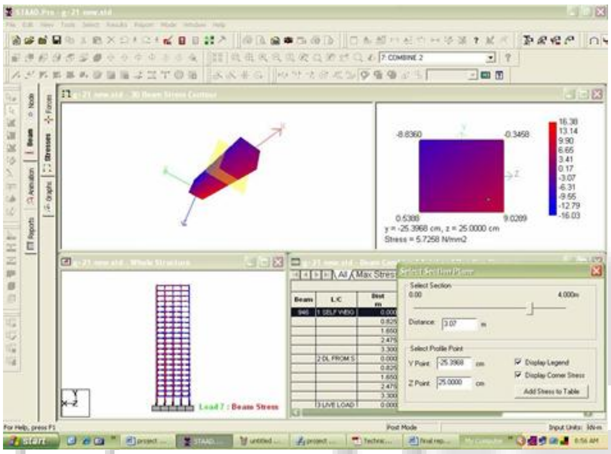


Fig. 17: shear stress at any section

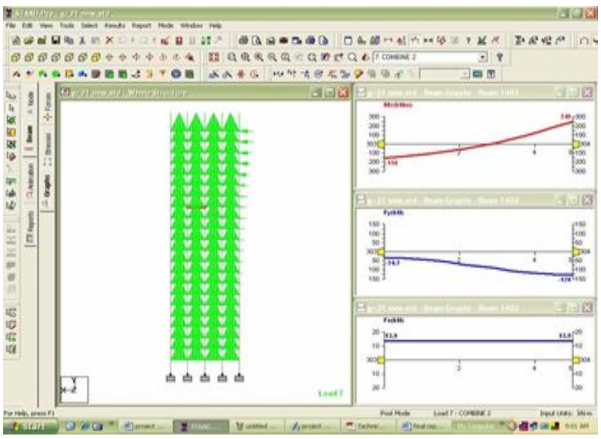


Fig. 18: graph for shear force & bending moment for a beam

The above figure shows that the bending moment and the shear force can be studied from the graphs generated by STAAD.Pro. The whole structure is shown in the screen and we may select any member and at the right side we will get the BMD and SFD for that member. The above figure shows the diagrams for member beam 1402.

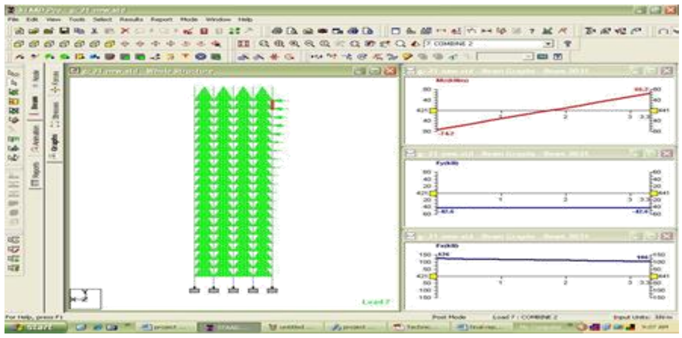


Fig. 19: graph for shear force and bending moment for a column

VIII. CONCLUSION

STAAD PRO has the capability to calculate the reinforcement needed for any concrete section. The program contains a number of parameters which are designed as per IS: 456(2000). Beams are designed for flexure, shear and torsion.

Design for Flexure maximum sagging (creating tensile stress at the bottom face of the beam) and hogging (creating tensile stress at the top face) moments are calculated for all active load cases at each of the above mentioned sections. Where ever the rectangular section is inadequate as singly reinforced section, doubly reinforced section is tried.

Shear reinforcement is calculated to resist both shear forces and torsional moments. Shear capacity calculation at different sections without the shear reinforcement is based on the actual tensile reinforcement provided by STAAD program. Two-legged stirrups are provided to take care of the balance shear forces acting on these sections.Beam Design Output of the beam contains flexural and shear reinforcement provided along the length of the beam.Columns are designed for axial forces and biaxial moments at the ends. All active load cases are tested to calculate reinforcement. The loading which yield maximum reinforcement is called the critical load. Column design is done for square section. Square columns are designed with reinforcement distributed on each side equally for the sections under biaxial moments and with reinforcement distributed equally in two faces for sections under uni-axial moment. All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS: 456 have been taken care of in the column design of STAAD.

REFERENCES

[1] Ghoubhir , M.L. (1984),” Earthquake resistance of structural systems for tall buildings”,Proceedings of the 8th World Conference on Earthquake Engineering , Vol. V, San Francisco, CA,USA,pp.491–498.
[2] Paz, Mario.(2004),”Structural Dynamics Theory & Computation “,5th Edition, CBS publication & Distribution.
[3] Charleason ,A.W, “ Seismic design within architectural education”, Victoria University of Wellington.
[4] Anil Chopra,(2001),”Dynamics of structures”, 2nd Ed., Prentice Hall,pp.271-350.

[5] Soni ,D.P. and Mistry, B.B," Qualitative Review of Seismic Response of vertically irregular building frames," ISET journal,Technical note,Vol.43,no.4; December2006,pp.121-132.
[6] Saatcioglu,M. and Humar,J.Donald L.Anderson."Dyanamic analysis of building for Earthquake resistant design," Can j.Civ.Eng;2003,pp.338-359.
[7] Adiyanto, M.I, Majid T.A. and Zaini S.S, "Analysis and design of 3 storey hospital structure Subjected to Seismic load using Staad pro," ICCBT,2008,pp.377-388.
[8] Prashawth. P, Anshuman.S, Pandey . R.K. and ArpanHernent," Comparision of design results of a structure designed using STAAD and ETAB Software," IJCSE, Vol2,No 3, 2012, pp. 869-875.
[9] I.S. !893-1 2002," Criteria for Earthquake Resistant design of Structures Part 1 : General Provisions and buildings, BIS, New Delhi.

