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COMPUTER AIDED ANALYSIS AND DESIGN OF MULTI-STOREYED BUILDING USING STAAD Pro

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Abstract: *The main objective is to analyze and design a multi-storeyed building [G + 21 (3 dimensional frame)] using STAAD Pro. The design of G+21 building involves manual load calculations and the whole structure is analyzed by STAAD Pro. Limit State Design method is used in STAAD-Pro analysis conforming to IS Code of Practice. STAAD Pro is the professional's choice; from model generation, analysis and design to visualization and result verification, STAAD Pro gives accurate results and the software is user friendly too. To check the accuracy of our results with the software generated results, we analyzed a simple 2D frame manually. The results proved to be very accurate. A G+7 storey building was initially analyzed for all possible load and load combinations as per IS Code of Practice.*

Key Words: **STAAD Pro, Analysis, Multi-storeyed, Design, IS Code of Practice, Seismic.**

1.INTRODUCTION

The paper involves analysis and design of multi-storeyed [G + 21] using a very popular designing software STAAD Pro. We have chosen STAAD Pro because of its following advantages:

-Easy to use interface,
-Conformation with the Indian Standard Codes,
-Versatile nature of solving any type of problem,
-Accuracy of the solution.

STAAD Pro features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, STAAD Pro is preferred for steel, concrete, timber, aluminum and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

To start with we have solved some sample problems using STAAD Pro and checked the accuracy of the results with manual calculations. The results were to satisfaction and were accurate.

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behavior of structures. Structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.

2.ANALYSIS AND DESIGN OF G + 21 RCC FRAMED BUILDING USING STAAD Pro:

G+21 storey building.
All columns = 0.50 X 0.50 m (until ground floor)
Columns at the ground floor: 0.80 X 0.80 m
All beams = 0.30 X 0.50 m
All slabs = 0.20 m thick
Terracing = 0.20 m thick avg.
Parapet = 0.10 m thick RCC

2.1 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)
Grade of concrete and steel used: M30 concrete and Fe 415 steel.
Base support: Fixed.

2.2 Self Weight:

Self weight was auto generated by STAA Pro software with the self weight command in the load case column.

2.3 Dead Load:

Terrace - 14.482 KN/m^2
Typical Floor - 13.5 KN/m^2
First Floor - 14.37 KN/m^2

2.4 Live Load:

Live load on the floors is 2.5kN/m^2
Live load on the roof is 0.75kN/m^2

2.5 Wind load:

Height [h]	Design wind speed [Vz]	Design wind pressure [Pz]
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: Wind Speed and Pressure

2.6 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.

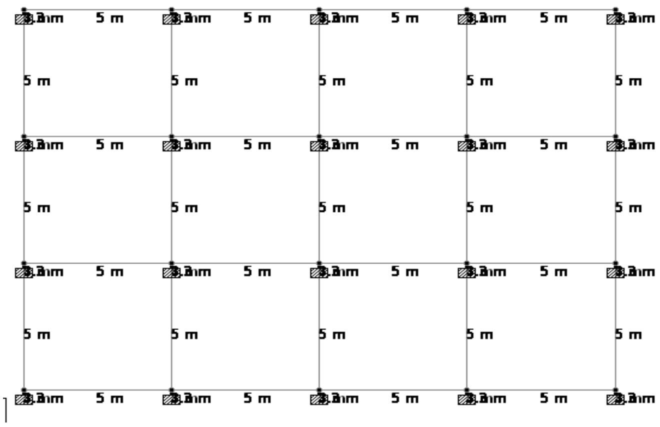

Figure 1: Plan View

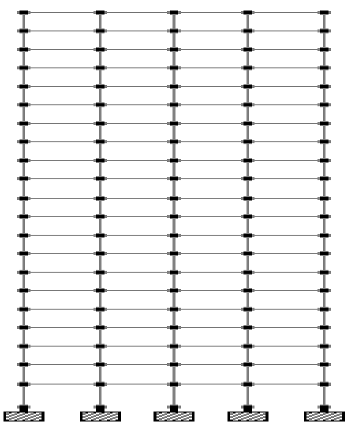

Figure 2: Elevation View

3. RESULT

Some of sample analysis and design results have been shown below for a beam.

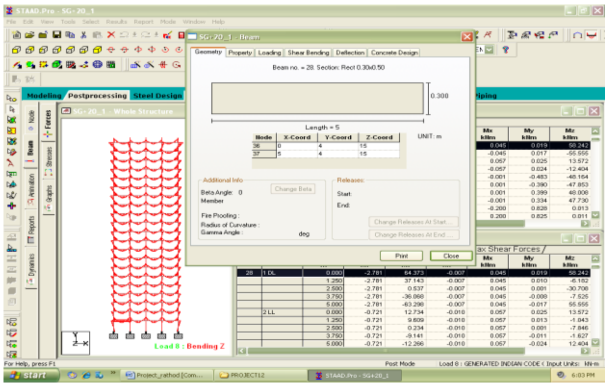

Figure 3: Geometry of beam no. 28

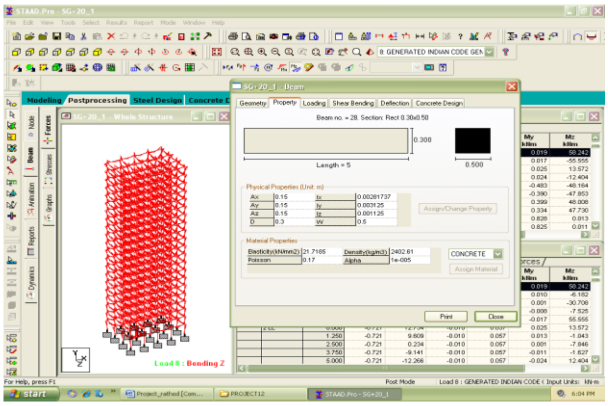

Figure 4: Property of beam no. 28

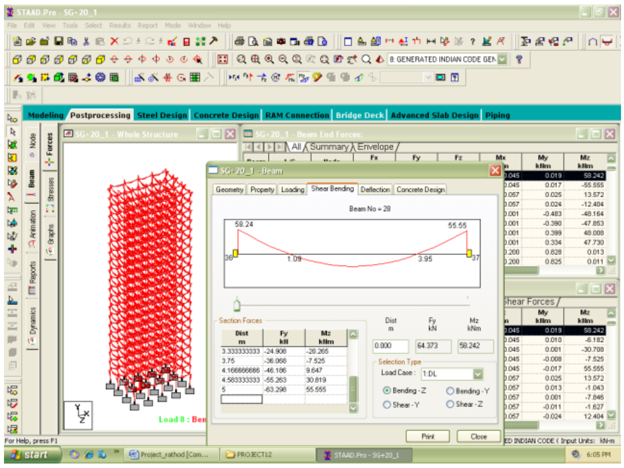

Figure 5: Shear bending of beam no. 28

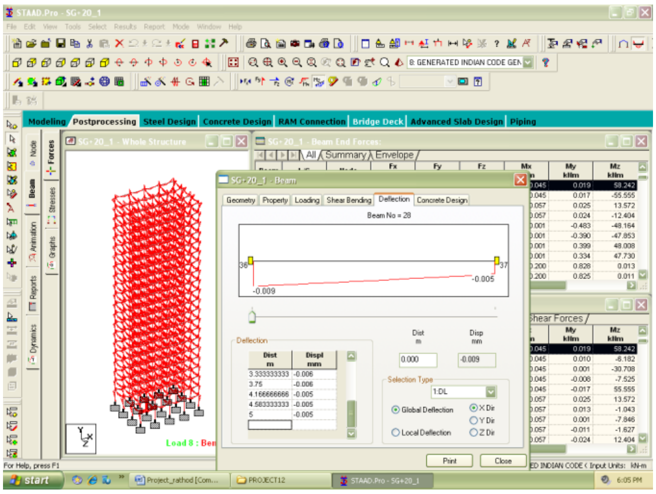

Figure 6: Shear bending of beam no. 28

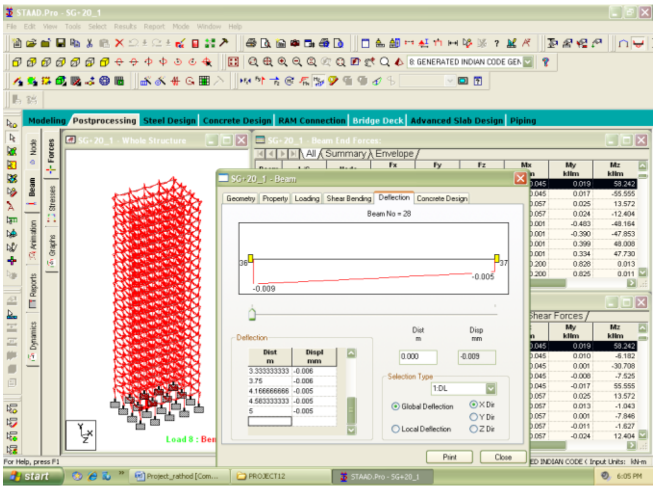

Figure 7: Deflection of beam no. 28

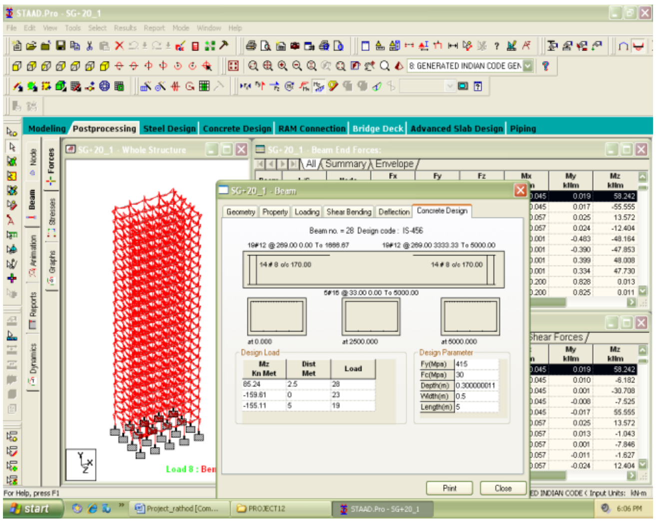

Figure 8: Concrete design of beam no. 28

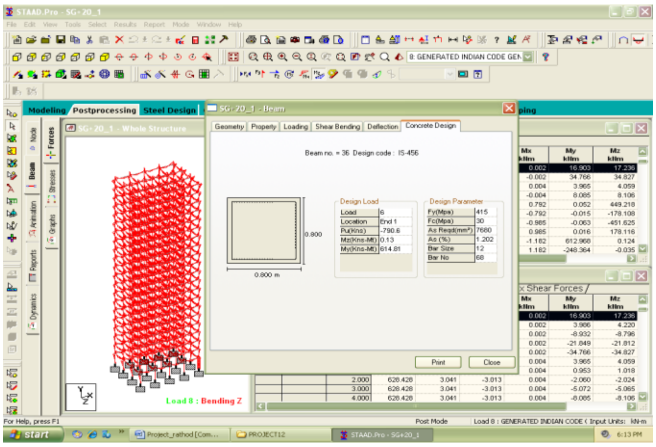

Figure 9: Concrete design of beam no. 28

BEAM NO. 28 DESIGN RESULTS

M30 Fe415 (Main) Fe415 (Sec.)
Length = 5000mm, Size = 500mm X 300mm, Cover = 25mm

Table 2: Summary of Reinforcement Area (Sq.mm)

Section	0 mm	2500 mm	5000 mm
Top Reinforcement	2109.40 Sq. mm	277.00 Sq. mm	2047.78 Sq. mm
Bottom Reinforcement	529.05 Sq. mm	986.77 Sq. mm	523.98 Sq. mm

Table 3: Summary of Provided Reinforcement Area

Section	0 mm	2500 mm	5000 mm
Top R/f	19-12i 2 layers	4-12i 1 layer	19-12i 2 layers
Bottom R/f	4-16i 1 layer	5-16i 1 layer	4-16i 1 layer
Shear R/f	2 legged 8i @ 170mm c/c	2 legged 8i @ 170mm c/c	2 legged 8i @ 170mm c/c

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

Shear Design result at 665.0 mm AWAY from start support

VY = 104.84 MX = 0.07 LD = 23
Provide 2 legged 8i @ 170mm c/c

Shear Design result at 665.0 mm AWAY from end support

VY = -103.05 MX = 0.06 LD = 19
Provide 2 legged 8i @ 170mm c/c

BEAM NO. 48 DESIGN RESULTS

M30 Fe415 (Main) Fe415 (Sec.)
Length = 5000mm, Size = 500mm X 300mm, Cover = 25mm

Section	0 mm	2500 mm	5000 mm
Top Reinforcement	2617.73 Sq. mm	275.48 Sq. mm	2684.60 Sq. mm
Bottom Reinforcement	814.18 Sq. mm	928.82 Sq. mm	883.74 Sq. mm

Table 4: Summary of Reinforcement Area (Sq.mm)

Section	0 mm	2500 mm	5000 mm
Top R/f	14-16i 2 layers	4-16i 1 layer	14-16i 2 layers
Bottom R/f	4-20i 1 layer	4-20i 1 layer	4-20i 1 layer
Shear R/f	2 legged 8i @ 170mm c/c	2 legged 8i @ 170mm c/c	2 legged 8i @ 170mm c/c

Table 5: Summary of Provided Reinforcement Area

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

Shear Design result at 665.0 mm away from start support

VY = 128.96 MX = 0.00 LD = 12
Provide 2 legged 8i @ 170mm c/c

Shear Design result at 665.0 mm away from end support

VY = -130.93 MX = 0.00 LD = 16
Provide 2 legged 8i @ 170mm c/c

COLUMN NO. 34 DESIGN RESULTS

M30 Fe415 (Main) Fe415 (Sec.)
Length = 4000mm, Size = 800mm X 800mm, Cover = 40mm
Guiding Load Case: 26 END JOINT: 33 SHORT COLUMN

Required steel area = 10682.54 sq. mm
Required concrete area = 629317.44 sq. mm
Main r/f = Provide 56 - 16 dia. (1.76% - 11259.47 sq. mm) (equally distributed)
Tie r/f = Provide 8mm dia. Rectangular ties @ 225mm c/c
Section capacity based on r/f required (KNS-MET)
Puz = 11820.73 Muz1 = 1037.19 Muy1 = 1037.19
Interaction ratio = 0.99 (as per Cl. 39.6 IS 456:2000)
Section capacity based on r/f provided (KNS-MET)
Worst load case = 26
End joint = 33 Puz = 11992.51 Muz = 1090.84
Muy = 1090.84 IR = 0.91

COLUMN NO. 332 DESIGN RESULTS

M30 Fe415 (Main) Fe415 (Sec.)
Length = 3300mm, Size = 600mm X 600mm, Cover = 40mm
Guiding Load Case: 7 END JOINT: 156 SHORT COLUMN

Required steel area = 2880.00 sq. mm
Required concrete area = 357120.00 sq. mm
Main r/f = Provide 28 - 12 dia. (0.88% - 3166.73 sq. mm) (equally distributed)
Tie r/f = Provide 8mm dia. Rectangular ties @ 190mm c/c
Section capacity based on r/f required (KNS-MET)
Puz = 5717.52 Muz1 = 180.32 Muy1 = 180.32
Interaction ratio = 0.48 (as per Cl. 39.6 IS 456:2000)
Section capacity based on r/f provided (KNS-MET)
Worst load case = 8
End joint = 136 Puz = 5162.51 Muz = 0.00
Muy = 0.00 IR = 0.88

POST PROCESSING MODE

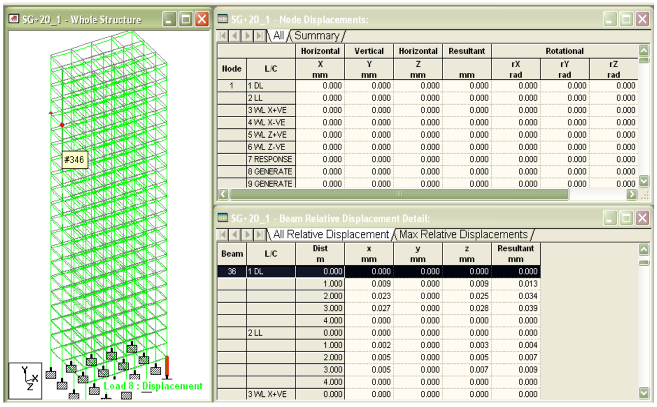

Figure 10: Post processing mode in STAAD Pro

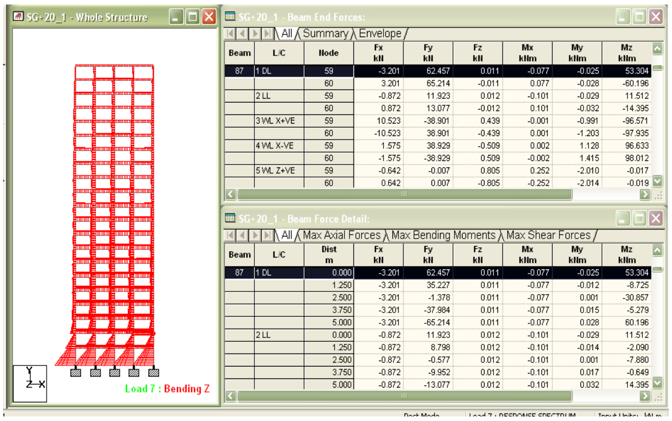

Figure 11: Bending in Z

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

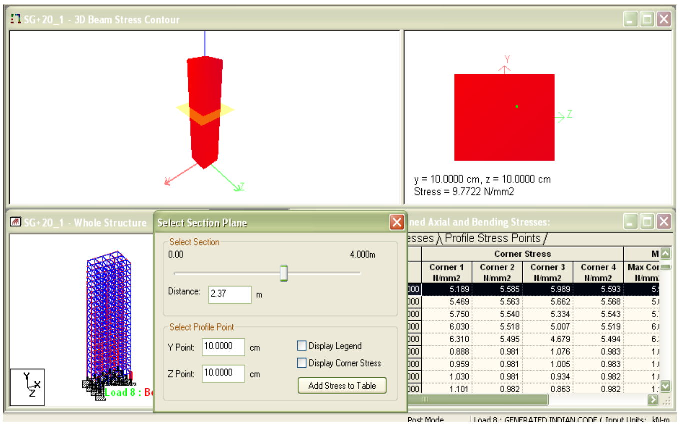

Figure 12: Shear stress at any section

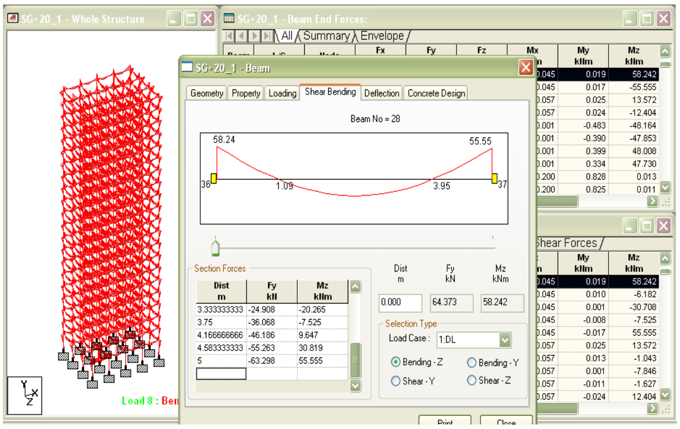

Figure 13: Graph for shear force and bending moment for a beam

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.

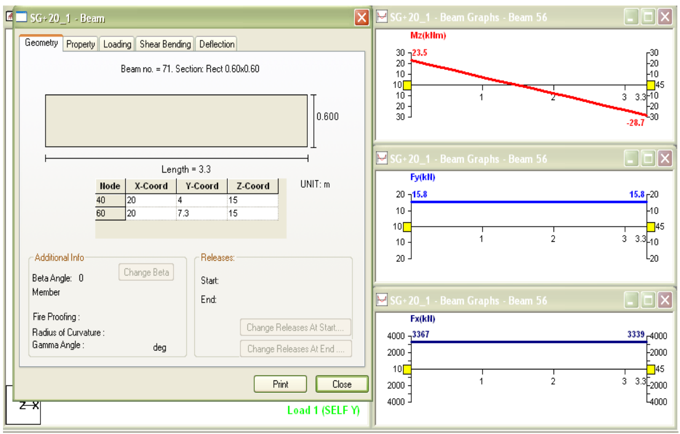

Figure 14: Graph for shear force and bending moment for a column

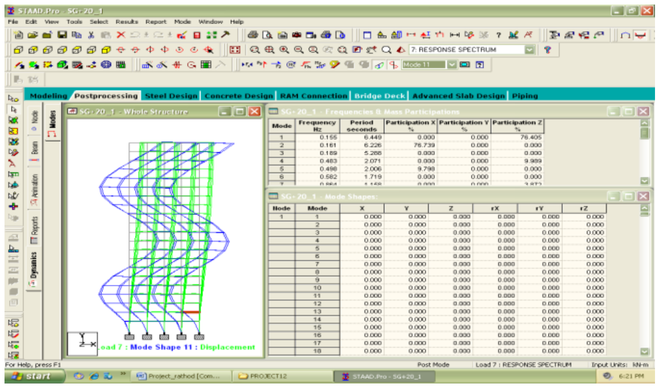

Figure 15: Deflection mode post processing

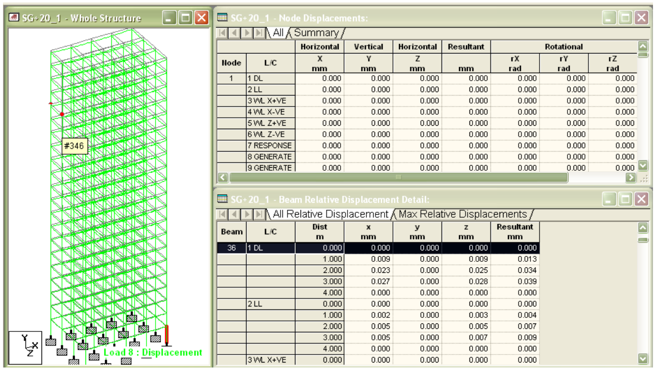

Figure 16: Nodes displacement summary

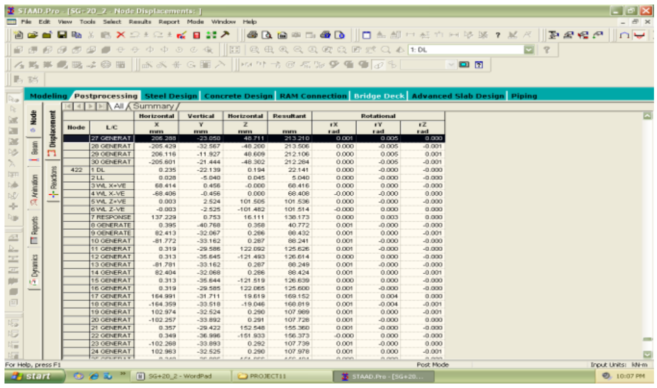

Figure 16: Node displacement table 01

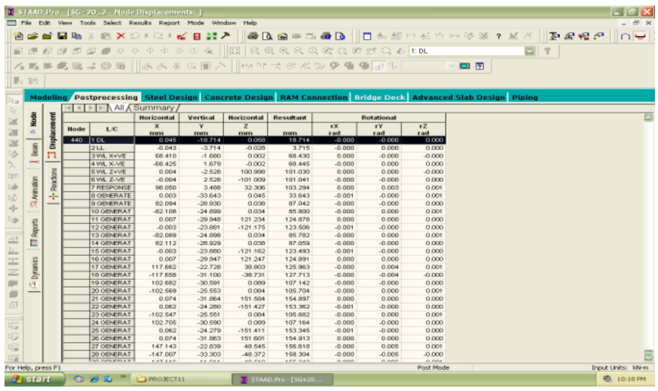

Figure 17: Node displacement table 02

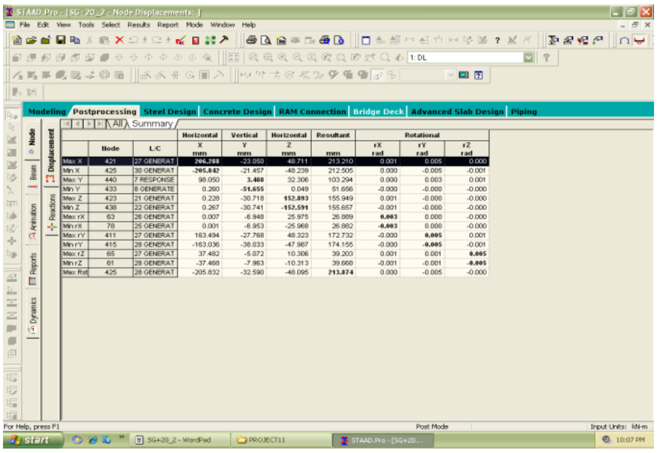

Figure 18: Node displacement table 03

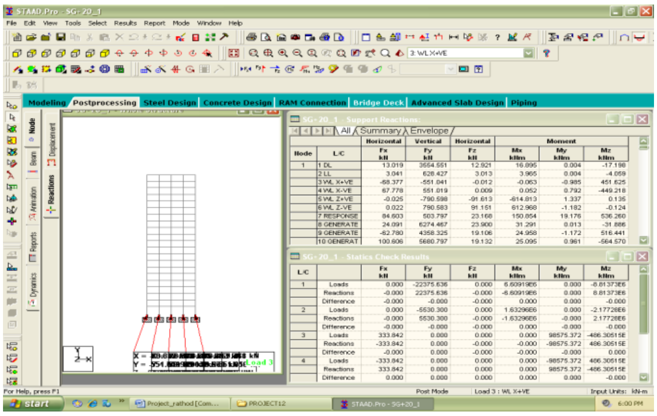

Figure 19: Node reactions

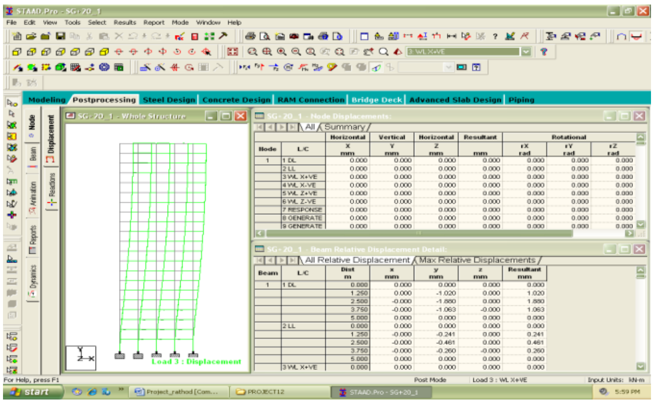

Figure 20: Node displacement

4.CONCLUSION

The program contains a number of parameters which are designed as per IS: 456(2000). Members 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.

Design for Shear:

Shear reinforcement is calculated to resist both shear forces and torsional moments. Two-legged stirrups are provided to take care of the balance shear forces acting on these sections.

Beam Design Output:

The default design output of the beam contains flexural and shear reinforcement provided along the length of the beam.

Column Design:

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.

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