ANALYSIS AND DESIGN OF TWISTED BUILDING BY USING STAAD.PRO V8i

[1]E.Srinivasulu,[2]K.S.Subrahmanyam,[3]L.Manikanta,[4]Ch.Satish,[5]Divya Anusha Naidu
[1]U.G Student, Department of Civil Engineering, Godavari Institute of Engineering & Technology (A), Rajahmundry, A.P, India
[2]U.G Student, Department of Civil Engineering, Godavari Institute of Engineering & Technology (A), Rajahmundry, A.P, India
[3]U.G Student, Department of Civil Engineering, Godavari Institute of Engineering & Technology (A), Rajahmundry, A.P, India
[4]U.G Student, Department of Civil Engineering, Godavari Institute of Engineering & Technology (A), Rajahmundry, A.P, India
[5]Assistant Professor, Department of Civil Engineering, Godavari Institute of Engineering & Technology (A), Rajahmundry, A.P, India

Abstract: Structural Analysis is a branch which involves in the determination of behaviour of structures in order to predict the responses of real structures such as buildings, bridges, trusses etc. Under the improvement of expected loading & external environment during the service life of structure. The results of analysis are used to verify the structure fitness for use. Computer software's are also being used for the calculation of forces, bending moment, stress, strain &deformation or deflection for a complex structural system. The principle objective of this project is the Design and Analysis of a High Rise Twisted building (G+10) by using STAAD.Pro V8i software. STAAD.Pro is one of the leading software's for the design of structures. In this project we had analysed the G+10 building for finding the shear forces, bending moments, deflections & reinforcement details for the structural components of building (such as Beams, columns & slabs) to develop the economic design. Finally we will make an attempt to define the economical section of G+10 twisted building using STAAD. Pro V8i Software tool.This project investigates challenges of designing buildings to accommodate challenging twisting architecture. The foremost challenge is to resist the torsion generated due to twisting geometry of the structure rising 10 stories, while rotating a total of 30°. The true twisting nature of the column posed a number of structural challenges that demanded innovative solutions. The horizontal component of the gravity load in the columns is resolved in the slabs then transferring it to core shear walls, which are the only consistently vertical structural elements in the building. The torsion caused by the remaining gravity load is resisted by a composite concrete shear wall and link beam system

Keywords–AnalysisandDesign,HighRise Twisted building,Residential Building, STAAD.Pro,StructuralEngineering..

I. INTRODUCTION

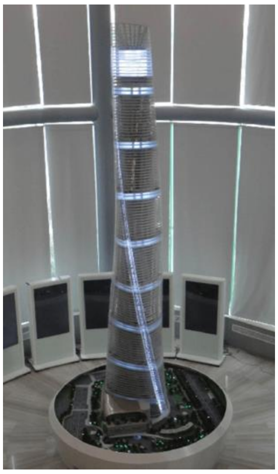
1.1 General:

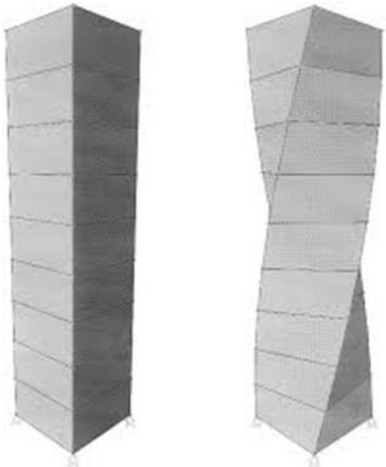
Nowadays the house building is major work of the social progress of the county. Daily new techniques are being developed for the construction of houses economically, quickly and fulfilling the requirements of the community engineers and architects do the design work, planning and layout, etc, of the buildings. Draughtsman are responsible for doing the drawing works of building as for the direction of engineers and architects. The draughtsman must know his job and should be able to follow the instruction of the engineer and should be able to draw the required drawing of the building, site plans and layout plans etc, as for the requirements.Due to rapid growth of population the area is decreasing, so for human needs it required build multi storied building. Complicated and High Rise Structures need very time taking and cumbersome calculations using conventional manual methods.A building frame consists of number of bays and storey. A multi-storey, multi-paneled frame is a complicated statically intermediate structure. A design of R.C building of G+10 storey frame work is taken up by STAAD Pro.

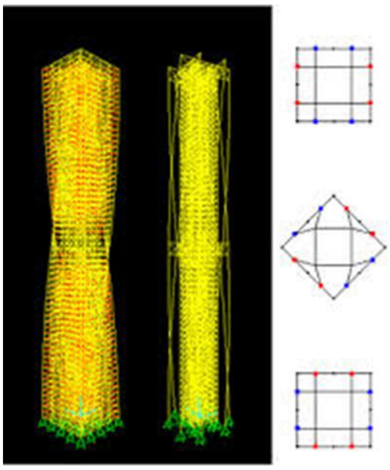
1.2 Tall Buildings As Twisted:

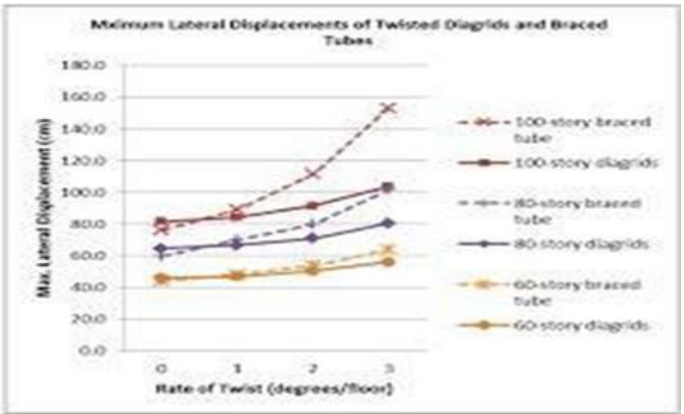
Tall buildings emerged in the late 19th century in Chicago and New York. After decades of eclectic design in the early 20th century, the International Style prevailed during the mid-20th century and produced numerous prismatic Miesian style towers all over the world. Today's architecture, including tall buildings, can be understood only through recognition of the dominance of pluralism. This contemporary architectural design trend has produced various complex-shaped tall buildings, such as twisted, tilted, tapered and freeform towers, as are the cases with the twisted Cayan Tower in Dubai, tilted Gate of Europe Towers in Madrid and tapered freeform Phare Tower in Paris. This paper studies performance-based structural system design options for various complex-shaped tall buildings.

Twisted forms employed for today's tall buildings can be understood as a reaction to rectangular box forms of modern architecture. In fact, this contemporary architectural phenomenon is not new in architecture. It is comparable to twisted forms of Mannerism architecture at the end of Renaissance architecture. For example, In Cortile Della Cavallerizza at Palazzo Ducale in Mantua, Giulio Romano designed twisted columns.


i Shanghai tower model


ii Prismatic Vs. Twisted tower


Iv 60-Story Twisted Outrigger Structures With A Rate Of Twist Of 1.5 Degrees/Floor.



Iii Maximum Lateral Displacements Of Twisted Diagrids

1.3 Details of the Project:

Salient features:

Utility of Building	:	TWISTED BILDING
No of Stories	:	G+10
No of Staircases	:	10
No of Lifts	:	9
Type of Construction	:	R.C.C Framed Structure
Types of Walls	:	Brick Wall
Total Rotation	:	30°
Each Floor Rotation	:	3°

Geometric details:

Ground Floor	:	3m
Floor To Floor Height	:	3m.
Height of Plinth	:	0.6m

Materials:

Concrete grade	:	M30
All steel grades	:	Fe415 grade
Bearing capacity of soil	:	300KN/M2

2.LITERATUREREVIEW

SANTIAGO CALATRAVA (2005) He designed Turning Torso was built in Malmo, Sweden, which is the first rotating building in the world. The total height of building is 190m including 54 storeys, Eachstorey staggered at 5.2 degrees. So, that the exterior columns are not in the same vertical line.

Damper-top floor.

Structural SC Cylindrical Cantilever

Since then they have gotten taller and ever more complex.

Based on the sculpture, twisting torso exploring the human body in motion twisting as far as it can naturally being pushed while staying directly upright. Form is made up of 9 cubes each individual cube containing 5 stories. Twists 90° from the ground level to the top floor. The average floor rotation is about 1.5°.

MOON K.S ET.AL (2007) Examined the influence of the diagonal angle on the behaviour of diagrid type structures. It was found that, for 60-storey diagrid structures having an aspect ratio of about 7, the optimal range of diagrids angle is about 65-75 degrees. For 42-storey buildings having an aspect ratio of about 5, the range is lowered by around 10 degrees because the importance of bending to the total lateral displacement is reduced as the building height decreases.

MURPHY JAHN(2010)approached the veer towers design with the intention of exhibiting urban responsibility, paying particular attention to the buildings performance in terms of function and systems. The idea was to establish a functional basis that defines a uique shape, which derives from a rational leasing span. The towers' cores and lobbies are planned into the retail base while the residential uses float above it. Considering the fact that the vortex-shedding-induced lock-in phenomenon often produces the most critical structural design condition for tall buildings.

3.DESCRIPTION OF TWISTED BULIDING

The structural systems like diagrids and braced tubes are employed for twisted buildings, the systems lateral stiffness decreases as the rate of twist increases. This paper describes about the twisting portion of the building, so that we can reduce sway forces, wind forces and etc,. The twisting angle of the present structure is about 30^0. Each floor or plate rotation is about 3^0.

4.PLAN DETAILS OF THE STRUCTURE:

Length	=	12m
Height	=	3m
Width	=	12m
Number of bays along length	=	4
Number of bays along height	=	1
Number of bays along width	=	4
Angle of turning	=	3^0

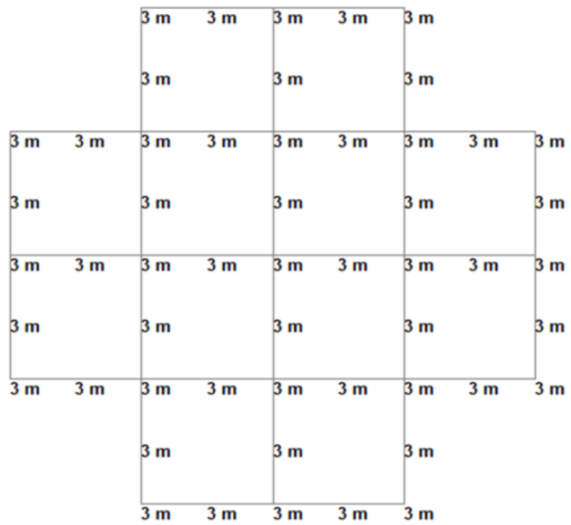


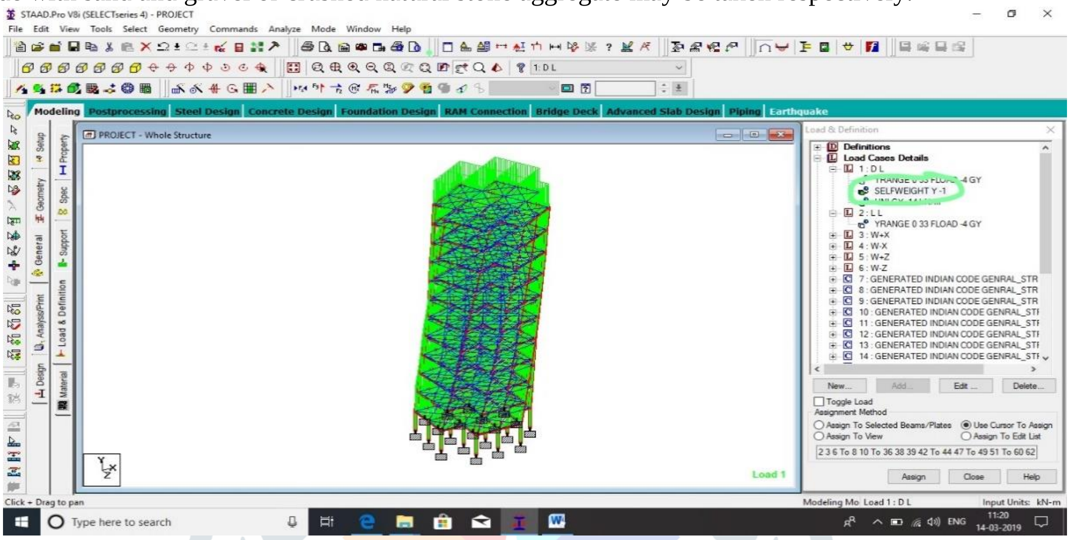
Fig 4.1 Line Daigram

5. DESIGN AND ANALYSIS OF THE STRUCTURE

3D Rendered view

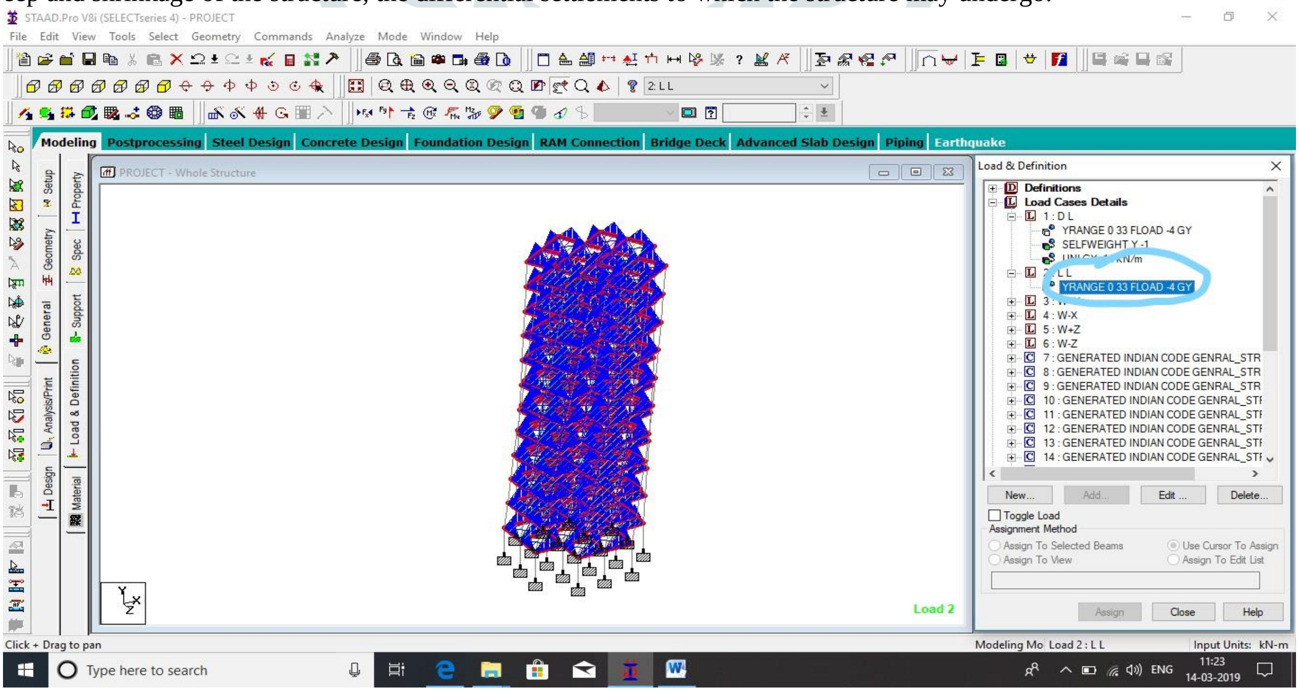
Dead loads

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads is calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken respectively.



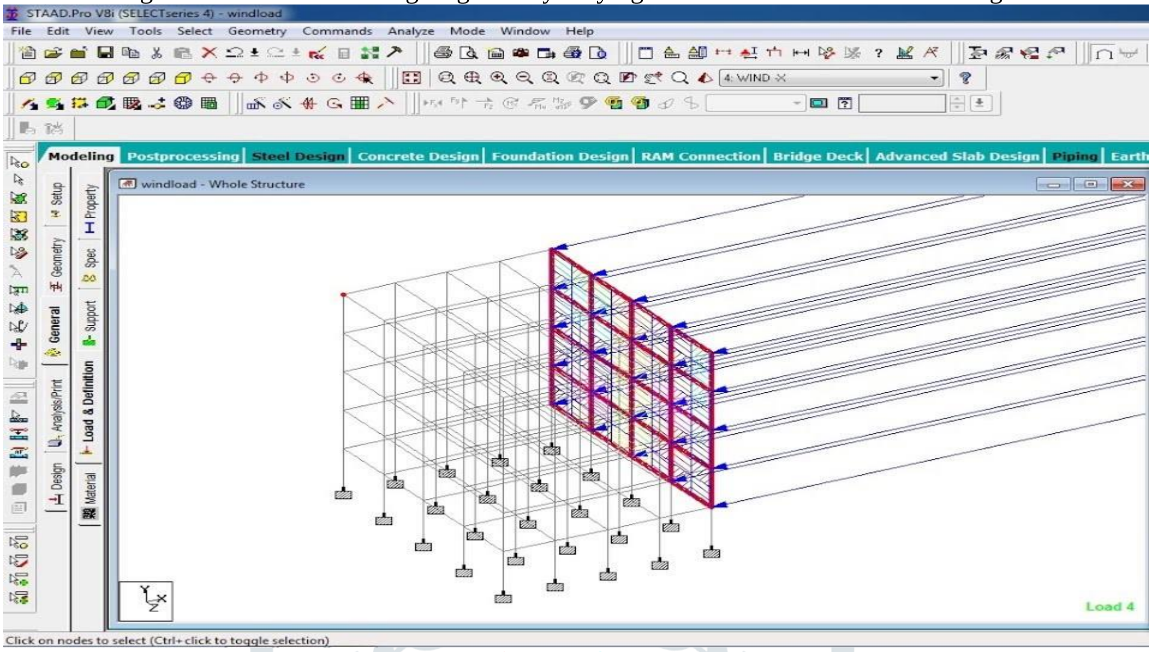
Live loads

Live load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.



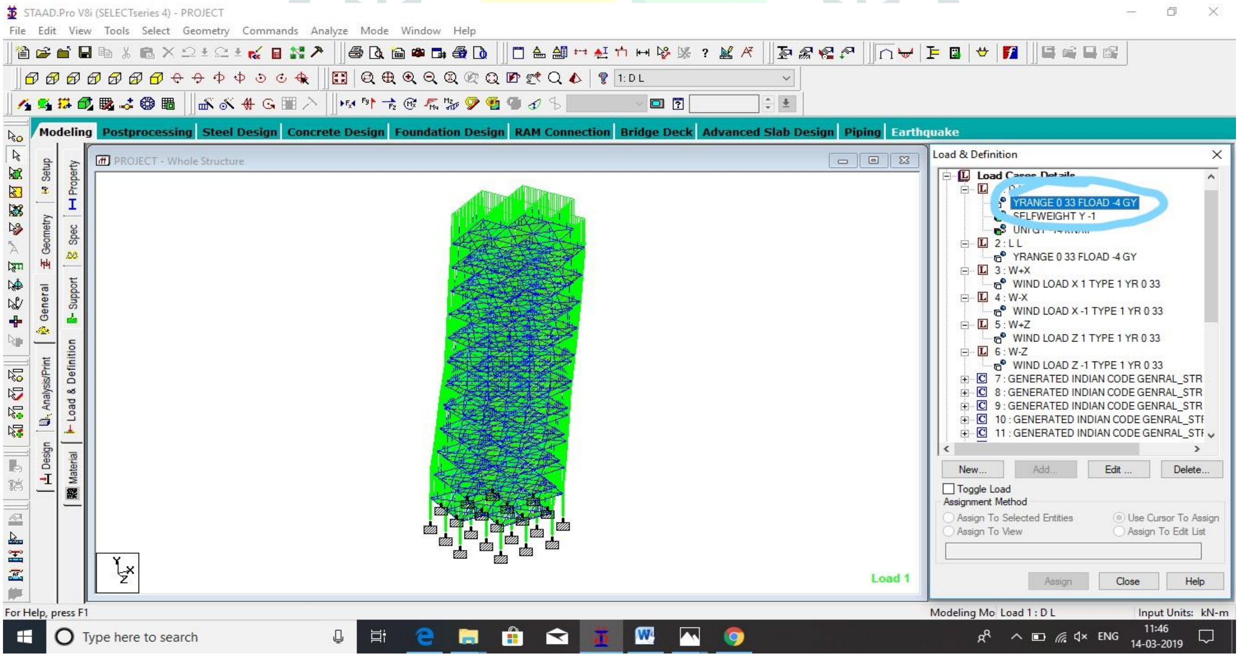
Wind loads

Wind is air in the motion relative to the surface of the earth. The primary cause of wind is traced to earth's rotation and differences in the terrestrial radiation. The radiation effects are primarily responsible for the convection either upwards or downwards. The wind generally blows from the horizontal to the ground at high wind speeds. Since vertical components of the atmospheric motion are relatively small, the term 'wind' denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speeds are to be assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 meters above the ground.



Floor load:

Floor load is calculated based on the load on the slabs. Assignment of floor load is done by creating a load case for floor load. After the assignment of floor load our structure looks as shown in the below figure. The intensity of the floor load taken is: 4 kN/m^2 -ve sign indicates that floor load is acting downwards.

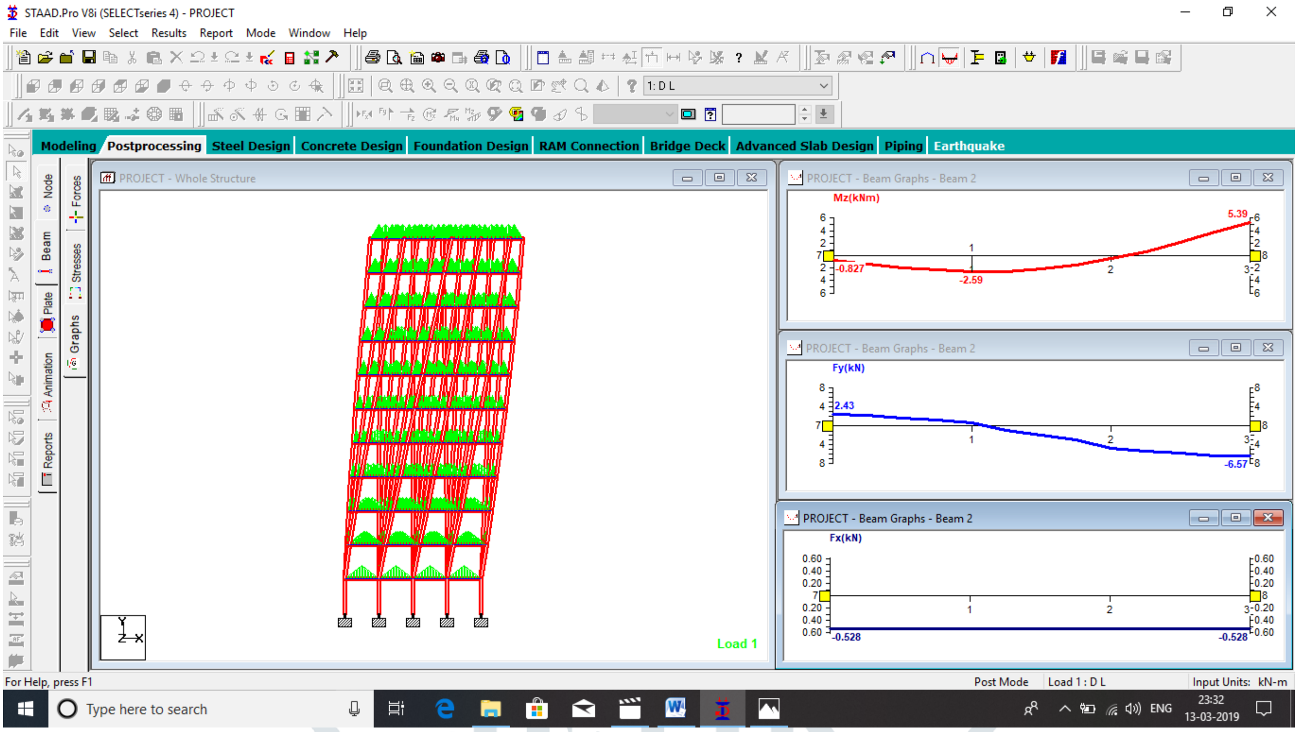


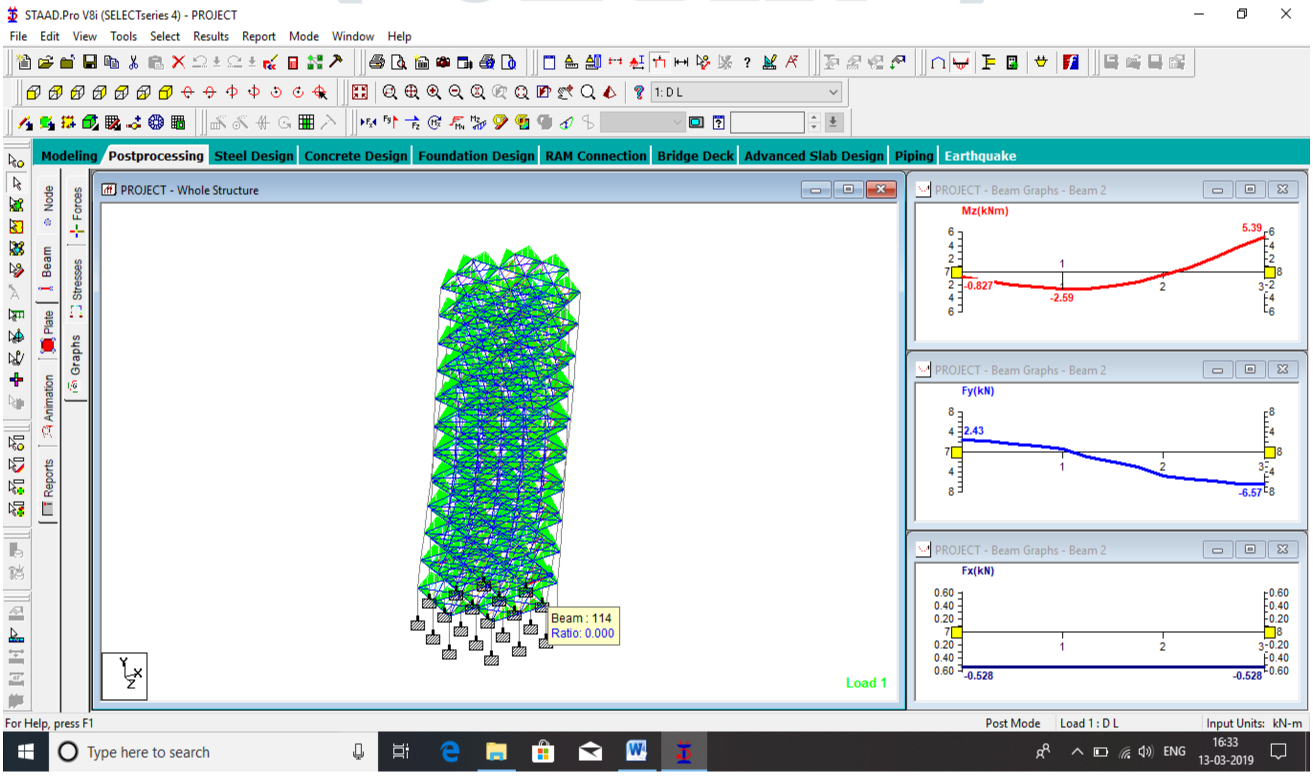
Combination loads (dead load + live load+ wind load)

In these projects we add the two types of the combination loads are added.

- 1.5 (D.L+L.L).
- 1.2(D.L+L.L+W.L)

BENDING AND SHEAR MOMENT DEFLECTIONS

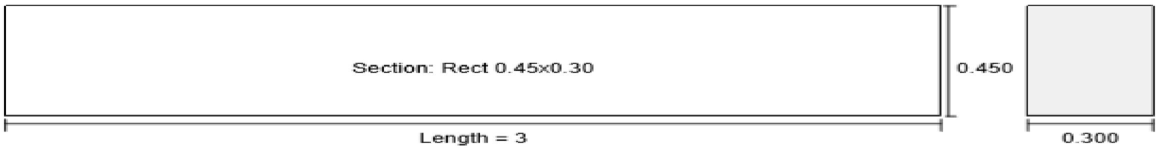




BEAM PROPERTIES

STAAD.Pro Query Property

Beam no. 28



Unit : kN - m

Physical Properties

Ax	0.135	Ix	0.002
Ay	0.135	Iy	0.001
Az	0.135	Iz	0.002
Depth	0.450	Width	0.300

Material Properties

Elasticity(kN/mm2)	21.718	Density(kg/m3)	23.562
Poisson	0.170	Alpha	10 E-6

BEAM BENDING AND SHEAR

STAAD.Pro Query Bending and Shear Results

Bending about Z for Beam 28

Load Case: 1:D L

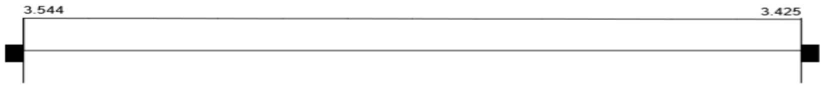
Dist.m	Fy(kN)	Mz(kNm)
0.000000	-94.9491	-185.7610
0.250000	-99.3693	-161.4764
0.500000	-104.0395	-136.0555
0.750000	-108.9597	-109.4358
1.000000	-114.1299	-81.5548
1.250000	-119.5501	-52.3500
1.500000	-125.2204	-21.7589
1.750000	-130.8906	10.2601
2.000000	-136.3108	43.6655
2.250000	-141.4810	78.3947
2.500000	-146.4012	114.3852
2.750000	-151.0714	151.5744
3.000000	-155.4916	189.9000

BEAM DEFLECTION

STAAD.Pro Query Deflection Result

Beam no. 28

Deflection in Global X axis. Load case 1.



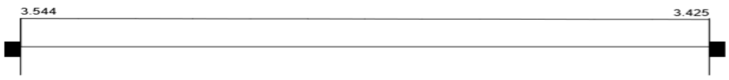
Dist.m	X(mm)	Y(mm)	Z(mm)
0.000000	3.5437	-0.1899	1.4139
0.250000	3.5338	-0.7508	1.2684
0.500000	3.5239	-1.1078	1.1467
0.750000	3.5139	-1.2931	1.0447
1.000000	3.5040	-1.3403	0.9581
1.250000	3.4941	-1.2846	0.8828
1.500000	3.4842	-1.1629	0.8146
1.750000	3.4743	-1.0139	0.7493
2.000000	3.4644	-0.8780	0.6828
2.250000	3.4545	-0.7974	0.6109
2.500000	3.4446	-0.8159	0.5294
2.750000	3.4347	-0.9791	0.4341
3.000000	3.4248	-1.3338	0.3209

BEAM DESIGN

STAAD.Pro Query Deflection Result

Beam no. 28

Deflection in Global X axis. Load case 1.



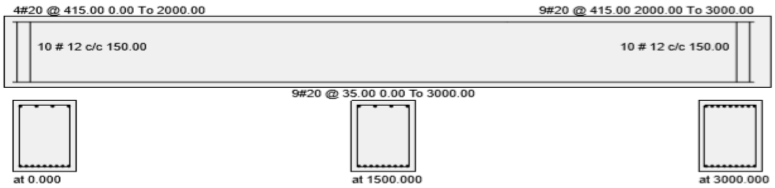
Dist.m	X(mm)	Y(mm)	Z(mm)
0.000000	3.5437	-0.1899	1.4139
0.250000	3.5338	-0.7508	1.2684
0.500000	3.5239	-1.1078	1.1467
0.750000	3.5139	-1.2931	1.0447
1.000000	3.5040	-1.3403	0.9581
1.250000	3.4941	-1.2846	0.8828
1.500000	3.4842	-1.1629	0.8146
1.750000	3.4743	-1.0139	0.7493
2.000000	3.4644	-0.8780	0.6828
2.250000	3.4545	-0.7974	0.6109
2.500000	3.4446	-0.8159	0.5294
2.750000	3.4347	-0.9791	0.4341
3.000000	3.4248	-1.3338	0.3209

BEAM DESIGN

STAAD.Pro Query Concrete Design

Beam no. 28

Design Code: IS-456



Design Load

Mz(Kn Met)	Dist.et	Load
309.420013	0.000000	7
-0.680000	0.000000	3
-319.589996	3.000000	7

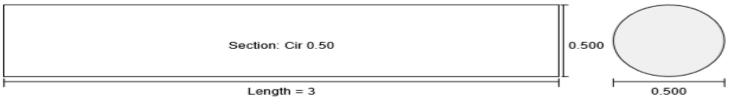
Design Parameter

Fy(Mpa)	415.000000
Fc(Mpa)	30.000000
Depth(m)	0.450000
Width(m)	0.300000
Length(m)	3.000000

COLUMN PROPERTIES

STAAD.Pro Query Property

Beam no. 32



Unit : kN - m

Physical Properties

Ax	0.196	Ix	0.006
Ay	0.175	Iy	0.003
Az	0.175	Iz	0.003
Dia	0.500	Width	N/A

Material Properties

Elasticity(kN/mm2)	21.718	Density(kg/m3)	23.562
Poisson	0.170	Alpha	10 E-6

COLUMN BENDING AND SHEAR

STAAD.Pro Query Bending and Shear Results

Bending about Z for Beam 32

Load Case: 1:D L

Dist.m	Fy(kN)	Mz(kNm)
0.000000	-18.8644	34.1234
0.250000	-18.8644	38.8395
0.500000	-18.8644	43.5555
0.750000	-18.8644	48.2716
1.000000	-18.8644	52.9877
1.250000	-18.8644	57.7038
1.500000	-18.8644	62.4199
1.750000	-18.8644	67.1360
2.000000	-18.8644	71.8521
2.250000	-18.8644	76.5682
2.500000	-18.8644	81.2843
2.750000	-18.8644	86.0004
3.000000	-18.8644	90.7164

COLUMN DEFLECTION

STAAD.Pro Query Deflection Result

Beam no. 32

Deflection in Global X axis. Load case 1.

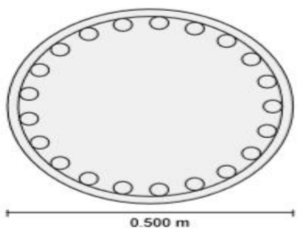
Dist.m	X(mm)	Y(mm)	Z(mm)
0.000000	0.0000	0.0000	0.0000
0.250000	0.0138	-0.0158	0.0092
0.500000	0.0641	-0.0317	0.0374
0.750000	0.1552	-0.0475	0.0848
1.000000	0.2916	-0.0633	0.1516
1.250000	0.4777	-0.0791	0.2380
1.500000	0.7179	-0.0950	0.3444
1.750000	1.0167	-0.1108	0.4709
2.000000	1.3785	-0.1266	0.6178
2.250000	1.8076	-0.1424	0.7853
2.500000	2.3086	-0.1583	0.9736
2.750000	2.8858	-0.1741	1.1831
3.000000	3.5437	-0.1899	1.4139

COLUMN DESIGN

STAAD.Pro Query Concrete Design

Beam no. 32

Design Code: IS-456



Design Load

Load	7
Location	End 2
Pu(Kns)	356.730011
Mz(Kns-Mt)	152.770004
My(Kns-Mt)	37.040001

Design Results

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	2342.000000
As (%)	1.210000
Bar Size	12
Bar No	21

6.RESULTS AND DISCUSSIONS

s.no	Beam no	F_x&F_y	Node no	F_x(KN)	F_y(KN)	F_z (KN)	M_x(KNM)	M_y (KNM)	M_z (KNM)
1	25	Max F_x	23	1198.885	3.79	1.961	-3.226	-5.744	16.400
2	42	Min F_x	42	-145.10	-7.02	-3.506	-4.4	5.1	16.293
3	114	Min F_x	114	-5.40	-122.19	-1.013	3.26	-1.52	182.042
4	116	Max Fy	116	434.207	121.197	3.974	-9.822	-9.206	201.382

7.CONCLUSION

1. Designing using Software's like STAAD reduces lot of time in design work.
2. Details of each and every member can be obtained using STAAD.Pro V8i.
3. All the List of failed beams can be Obtained and also Better Section is given by the software.
4. Accuracy is Improved by using software.
5. All details of each and every members are obtained by using STAAD pro software.
6. The wind loads combinations are more than Earthquake load combinations in Bending moment and Shear force.

REFERENCE

i. Mr. A. P. Patil, Mr. A. A. Choudhari 2017, Design & Analysis of Multi Storeyed Building (G+10) By Using Stadd Pro, International Journal of Advanced Engineering, Management and Science (IJAEMS) [Vol-3, Issue-3].

ii. Deevikrishnachaitanya, & Santhosh kumar 2017, Analysis and design of a (g + 6) multi storey residential building using STAAD pro, AIJREAS vol 2, (ISSN-2455-6300).

iii. Aman, Manjunath Nalwadgi 2016, Analysis and design of multistorey building by using STAAD Pro, (IRJET) Volume: 03