IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 22, Issue 2 Ser. 2 (Mar. – Apr. 2025), PP 26-39
www.iosrjournals.org

Analysis And Design Of Multi Storey Building By Using "STAADPRO"

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Abstract:
A review of the analysis and design of a multi-storey building with STAAD Pro is carried out. Planning is done by using AutoCAD and load calculations were done manually and then the structure was analysed using STAAD Pro . The dead load , imposed load and wind load with load combination are calculated and applied to the structure. Overall , the concepts and Procedures of designing the essential components of a multi-storey building are described . STAAD Pro software also gives a detailed value of shear force , bending moment and torsion of each element of the structure which is with in IS code limits.
Keywords: *STAAD Pro, Multi-storey building, dead load, imposed load, wind load, Shear force, bending moment, torsion, IS code limits.*

Date of Submission: 25-03-2025 Date of Acceptance: 05-04-2025

I. Introduction

Now a days tall or multi-storey buildings has gain very much importance, because in metro Cities there is a rapid increase in population with limited land.

All people require good accommodations, aesthetic, comfort and safety.Thats the reason for increase in construction ofmulti-storey buildings.

Structural design of multi-storey buildings is basically worried with safety during ground mo-tion, serviceability what's more, potential for monetary mis fortune.

Design of structures using Limit State method Design the members are designed for the limiting bending moment and Service ability limits, hence the structures are left with minimum reserve energy. Earthquake Will cause more severe effect on tall buildings compare to small buildings. Due to earthquake .A symmetrical buildings will damage more than symmetrical buildings.In case of high rise structures horizontal loads produce develop high lateral displacements which is not desirable for the occupants and the structure it self. The enormous increase in population and scarcity of land makes the people to move from rural Areas to urban paces and construction of multi-storied buildings in small areas is being common now-a-days.

Functional designing of the building has become very important and the requireMents vary from one building to another .

Every Civil Engineer should know the usage of the Buildings by contacting the people and basic principles of designing of the R.C.C structures.

This is project is intended at Analyzing and designing the multi-storey structure using STAAD.PROV8i and STAAD.ETC. In this project, we adopted limitstate method of analysis and Design the structural members manually and using STAAD.PRO.V8i and STAAD.ETC .Manually design is done for particular beam, column and slab by using IS456:2000 and load sare dead load, imposed load and external load considered according to IS875:1987 (PARTIII).
It is the checked in STAAD.PRO.V8i and STAAD.

II. Objectives

The study aims to Analysis and design of the RCC frame structure apply Load Combination as Live load,dead load,wind load and other earthquake .These objectives are defined as follows:
Analysis of the Structure of G+5 Building Live load and Dead Load.
Analysis of the Structure of G+5 Building Wind load ,Earthquake Load and Secmic Load .
C) Generating structural framing plan .
D) Creating 3D Structural Model in STAAD PRO .
E) Analysis of the Structure with Apply All Load combination.
F) Design of G+5 RCC frame structure .

III. Literature Review

A) Ibrahim,et.al(April2019)1: Design and Analysis of Residential Building(G+ 4):
B) Dunnala Lakshmi Anuja,et.al (2019) 2: Planning, Analysis and Design of Res-Identical Building(G+ 5)By using STAAD Pro:
C) Mr K.Prabin Kumar,et.al(2018)3:
D) Deevi Krishna Chaitanya,et.al(January,2017)4:Analys is and Design of a (G+ 6)Multi-Storey Building Using STAAD Pro:
E) R. D. Deshpande, et. Al (June,2017)5: Analysis, Design and Estimation of Basement+ G+ 2 Residential Building:

IV. Methodology

About Staad Pro

Our project involves analysis and design of multi-storeyed[G+ 5]using a very popular designing Software STAADPro.We have chosen STAAD Pro because of its following.

Advantages

• easy to use interface,
• conformation witht 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,and powerful analy-sis 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 the professionals choice for steel,concrete,timber,aluminium 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 problem susing STAAD Pro and checked the accuracy of the results with manual calculations.The results were to satisfaction and were accurate.In the initial phase of our project we have done calculations regarding loadings on buildings and also considered seismic and wind loads.

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behaviour of structures.Structur alanalys is can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design with out a dependence on directly testing it.

To perform an accurate analysis a structural engineer must determine such in formation as structural loads,geometry,support conditions,and materials properties.The results of such ananalysis typically include support reactions,stresses and displacements.This informationis then compared to criteria that indicate the conditions of failure.Advanced structural analysismay examine dynamic response,stability and non-linear behavior.

Loads Considered

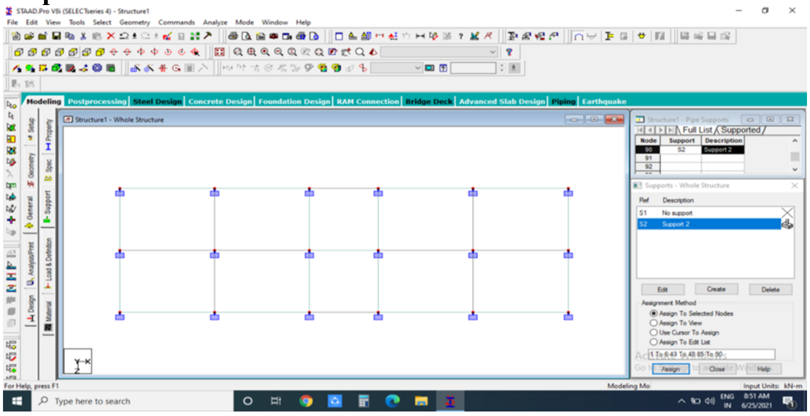
1.Dead load:-The unit weights of plain concrete and reinforced Concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/ $m^2$and 25 kN/ m^2respectively.

2.Imposed load:- Imposed load is produced by the intended use or occupancy of a buildingin cluding the weight of movable partitions ,distributed and concentracted Loads due to the impact and vibration and dust loads.

3.Wind load:- The wind speeds are assessed with the aidofanemometers or Anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 meters above ground.

4.Secmic load:- According to the severity of earthquake intensity they are divided in to zones.
1.ZoneIandIIarecombinedaszoneII.
2.ZoneIII.
3.ZoneIV.
4.ZoneV.

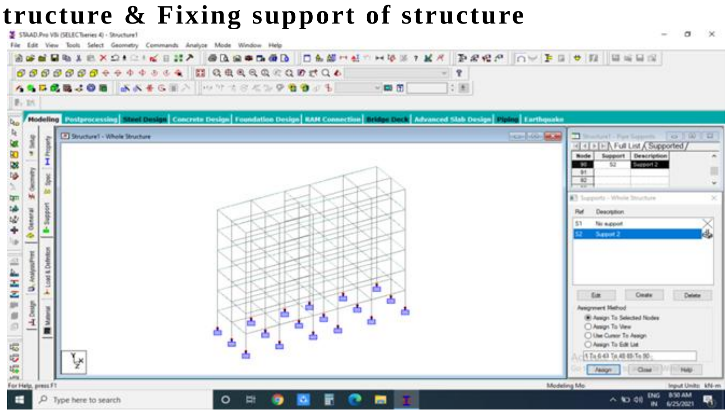
Working With Staadpro



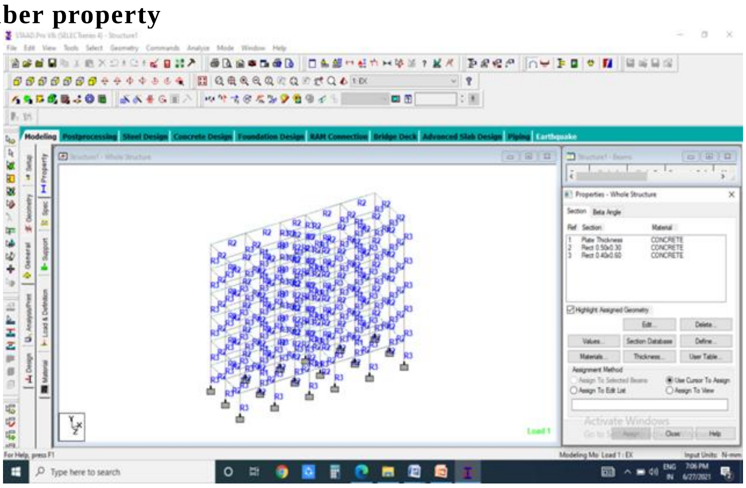
Plan of G+5 storey building
All columns= 0.40*0.60m
All beams= 0.3*0.5m
All slabs= 0.125mthick

Physical parameters of building
Length= 4 bays @5.5m+ 1 bay@4m= 26m
Width= 2 bays @4m= 8.0m
Height= 3m+ 5 storeys @3.5m= 20.5m
Live load on the floors is 2kN/ m2
Live load on the roof is 1.5kN/ m2
Grade of concrete and steel used
Used M 25 concrete and Fe 415 steel

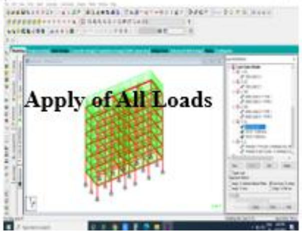
Generation of the structure & Fixing support of structure



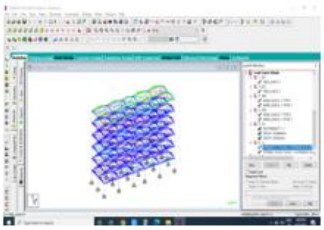
Generation of member property



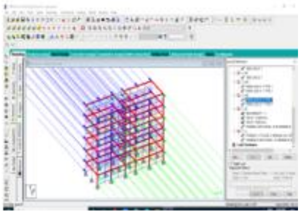
Apply of All Loads



Dead load

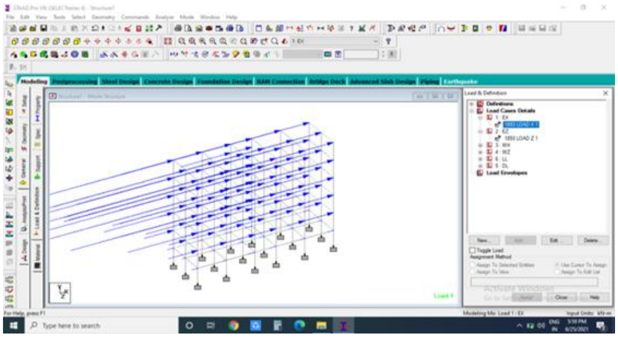


Live load

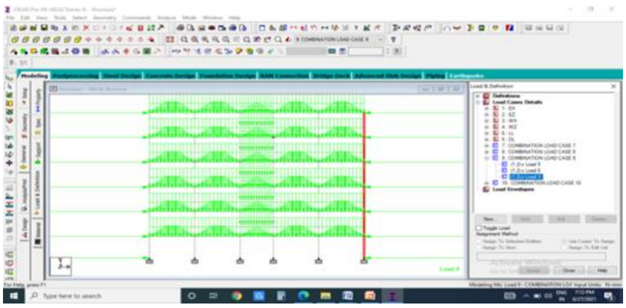


Wind load

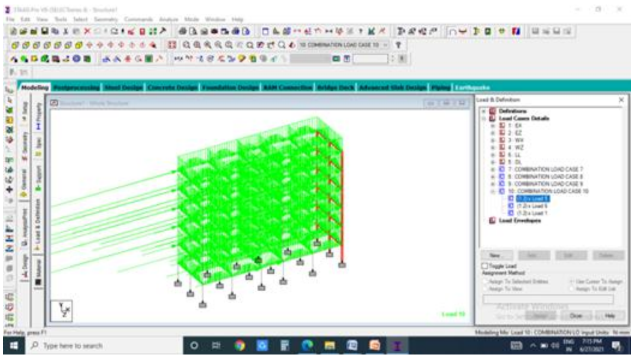
Sructure under sesmic load



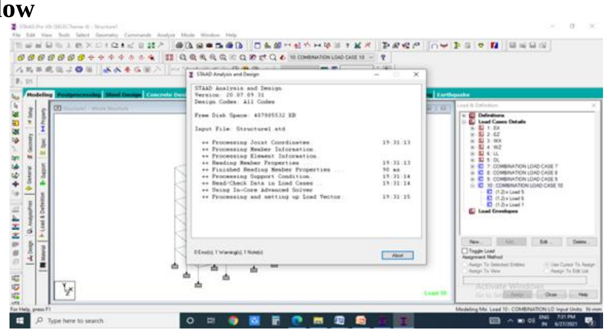
Combination under wind load



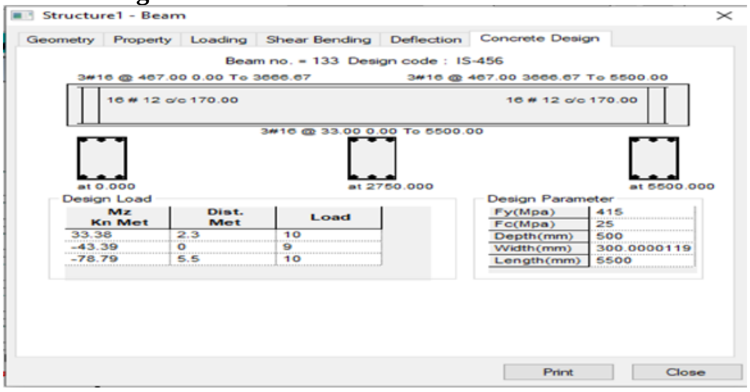
Combination under Secmic load



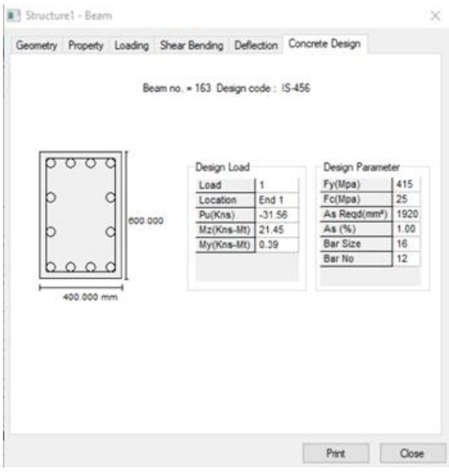
Showing the analyzing window



Design of G+ 5RCCBulding

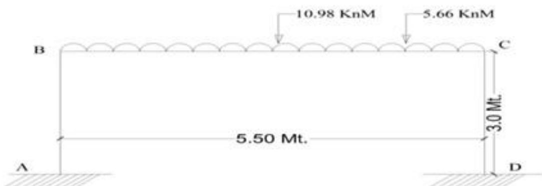


Beam Design



Column Design

Manual Analysis (Kanis Method)



Step1: Fixed End Moments

MFAB, MFBA, MFCD, MFDC= 0

MFBC= -wl2/ 12= -10.985.52/ 12-5.665.52/ 12= -41.946KNm

Step2: Rotation Factor

Joint	Member	Relativestiffness(k)	summK	RF= -0.5(k/ summK)
B	BA	(4EI/ l) = 1.33EI	2.057EI	-0.323
-	BC	(4EI/ l) = 0.727EI	-	-0.176
C	CB	(4EI/ l) = 0.727EI	2.057EI	-0.176
-	CD	(4EI/ l) = 1.33EI	-	-0.323

Step3: Kanis scheme and Rotation Contribution

Rotation Contribution= RF[FEM+ Near end contribution+ Far end contribution]

RCforBA1= -0.323[-41.946+ 0+ 0]= 13.54

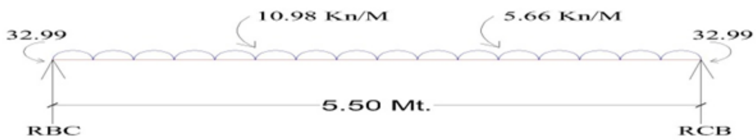
RCforBC1= -0.176[-41.946+ 0+ 0]= 7.38

RCforCB1= -0.176[41.946+ 7.38+ 0]= -8.68
RCforCD1= -0.323[41.946+ 7.38+ 0]= -15.93
RCforBA2=- 0.323[-41.9468.68+ 0]= 16.35
RCforBC2= -0.176[-41.9468.68+ 0]= 8.91
RCforCB2= -0.176[41.946+ 8.91+ 0]= -8.95
RCforCD2= -0.323[41.946+ 8.91+ 0]= -16.42
RCforBA3=- 0.323[-41.9468.95+ 0]= 16.43
RCforBC3= -0.176[-41.9468.95+ 0]= 8.95
RCforCB3= -0.176[41.946+ 8.95+ 0]= -8.95
RCforCD3= -0.323[41.946+ 8.95+ 0]= -16.43

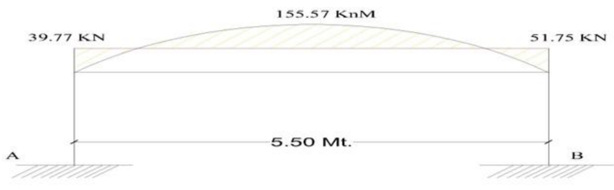
Step4: FinalMoments

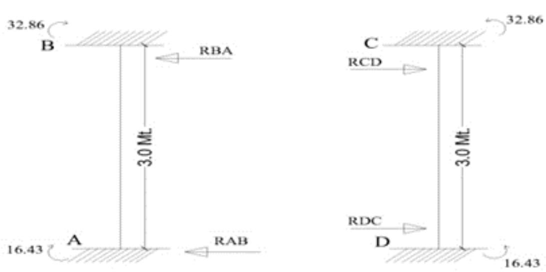
Joint	A	B	B	C	C	D
Members	AB	BA	BC	CB	CD	DC
FEM	0	0	-41.946	-41.946	0	0
2NEM	0	32.86	17.9	-17.9	-32.86	0
2FEM	16.43	0	-8.95	8.95	0	-16.43
FinalMoments	16.43	32.86	-32.99	32.99	-32.86	-16.43

Summ Mbc= 0

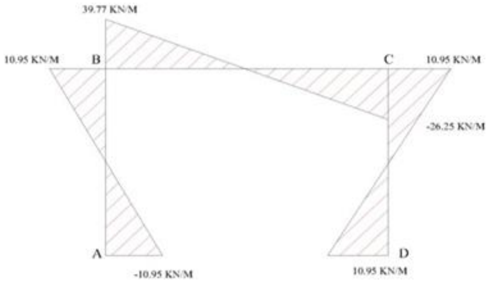


-Rcb*5.5+ 32.99+ 5.66*5.5*2.75+ 10.98*5.5*2.75= 0
Rcb= 51.75KN/ m
SummV= 0
Rbc+ Rcb= 10.98*5.5+ 5.66*5.5
Rbc= 91.52-51.75= 39.77KN/ m
BM at center,91.52*2.75-32.99-10.98*2.75*1.375-5.66*2.75*1.375= 155.77KNm





-Rba*3+ 32.86= 0
Rba= 10.95KN/ m,Rab= -10.95KN/ m
Rcd*3-32.86= 0
Rcd= 10.95KN/ m,Rdc= -10.95KN/ m
ForBc,at0m,Rbc= 39.77KN/ m
At5.5m,Rbc-10.95*5.5-5.66*5.5= -26.28KN/ m



Beam Design (IS456:2000)
Width of support= 400mm
Clearspan= 5.5m
Load= 21.16KN/ m^2
$b = 300mm, D = 500mm$
$fck = 25N/mm^2, fy = 415N/mm^2$

Step1: Effective Length
d= Dd= 500-25= 475mm
1.clear span+ Effective depth= 5.5+ 0.475= 5.975m
2.clear span+ c/ c distance between supports= 5.5+ 0.2+ 0.2= 5.9m

Step2: UltimateMoment
Self Weight of Beam(Wb) = b*D*25= 0.3*0.5*25= 3.75KN/ m
Totalload(W)= Wb+ w= 3.75+ 21.16= 24.98KN/ m
Now,Ultimate Load(wu) = 1.5*24.98= 37.337KN/ m
Now,Ultimate Moment(Mu)= Wul2/ 8= 37.337*5.92/ 8= 162.63KNm
Now,From page 96 IS456
Mulim= 0138*fckbd2= 0138*25*300*4752= 233.52KNm
Mu less than Mu lim,Hence it is Under reinforced beam

Step3: Calculation of area of steel
Mu= 0.87fyAstd[1-(fyAst/ fckbd)162.63*10^6= 0.87∗415∗Ast∗475∗[1−(415∗Ast/25∗300∗475)
Ast= 1085.56 mm2
Using 20 mm dia bars,ast= (pi/ 4)*202= 314.45 mm^2
No of bars= (Ast/ ast)= (1085.56/ 314.45)= 3.45= 3
Provide 3no 20mm dia bars
Actual Ast= 3*(pi/ 4)*202= 942.47mm^2
Min Ast= 0.85bd/ fy= (0.85*300*475) / 415= 291.86mm^2
Max Ast= 0.04bd= 0.04*300*475= 6000 mm^2

Step4: Shear Reinforcement
Factored Shear force= Wul/ 2= 37.377*5.9/ 2= 110.26KN/ m
From page 72, IS 456,
Nominal shear stress(Tv)= (Vu/ bd)= (110.26*10^3 / 300∗475)= 0.77N/mm
Now,% of tension Reinforcement
P = (Ast/ bd)*100= (942.47/ 300*475)*100= 0.66%

Step5: Design Shear strength of concrete
Page 73, table19 IS 456 0.50,0.49,0.75,0.57
By inter polation,Tc= 0.49+ ((0.57-0.49)/(0.75-0.50))*(0.66-0.5)
Tc= 0.54N/ mm, Tv grater thanTc,Shear reinforcement required

Step 6 Shear Reinforcement
Vuc= Tcbd= 0.54*300*475= 76.95KN
Now,Shear to be carried by stirupps
Vus= VuVuc= 110.2676.95= 33.31KN
Provide 8mm diameter 2legged vertical stirrups
Asv=(pi/4)*82∗ 2=100.53mm2
SpacingSv=(0.87*415*100.53*475/ 33.31*1000)= 517.5mm
Frompage 48,IS 456,
1.Minimum Spacing= (ASv/ bSv)?(0.4/ 0.87fy) Sv= (ASv0.87fy/ 0.4b)= (100.53*0.87*415/ 0.4*300)
2.Spacing= 0.75d= 0.75*475= 356.25mm
3.300mm Provide 8 mm dia 2 legged vertical stirrups@300mmc/ cspacing.

Step7:Check for Deflection
From page38,IS456
% of steel= 0.66%
Fs= 0.58fy*(Astreq/ Astprov)= 0.58*415*(1058.6/ 942.47)= 277.24N/ mm^2
From fig 4,IS456
Modification factor(k)= 1.05
Step7:Development Length
(l/ d)max= 20k= 20*1.05= 22
(l/ d)prov= (5000/ 475)= 12.42
(l/ d)max greater than(l/ d)prov,Safein Deflection.

Column Design (IS456:2000)
Axial load= 2392KN
Size of column,L= 300mm,b= 400mm

Step1: %of Steel
Pt greater then 08%, Pt less than 6%
Assuming%= 1.0
Asc= 0.01Ag
Ac= Ag-Asc= Ag-0.01Ag= 0.99Ag

Step2: Depth Required
Pu= 0.4fckAc+ 0.67fyAsc
$2392*10^3$= 0.4∗25∗0.99Ag+067∗415∗0.01Ag
Ag= 188636.09mm
D= (188636.09/ 400)= 471.59
ProvideD= 480mm
ProvideAg= 192000mm^2

Step3: Check for eccentricity and Slenderness ratio
Emin= (L/ 500)+ (D/ 30)= (3000/ 500)+ (6000/ 30)= 26mm
Emin greater than 20
Emax= 0.05D= 0.05*480= 24mm
Emin less than Emax,ok
Effective length/ least lateral dimension= 3000/ 400= 7.5 less than12
Hence,it is a short column

Step4: Area of steel
$2392*10^3$= 0.4∗25∗0.99∗192000+0.6∗415∗Asc
Asc= 1972.69mm^2
Use 16 mm dia bars,No of bars= (1972.69/(pi/ 4)*162= 9.81= 12bars

Step5: Design of Lateral Ties
Dia of lateral ties not less than(1/ 4)*dia of reinforcement= (1/ 4)*16= 4mm
But not less then 6mm
Then provide 6mm dia of lateral ties
Spacing not greater than b= 400mm
16*16= 256mm
300mm
Provide 6mm dia,256 mm spacing of lateral ties
SlabDesign(IS456)

Step1.
Lx= 4mLy= 5.5m.
Ly/ Lx= 1.37lessthan2.
Hence,itistwo-wayslab.
Liveload= 2KN/ M^2
fck= 25N/ mm^2,$fy = 415N/mm^2$,$b(width) = 1000mm$

Step2.Estimations of slab thickness
Aslx grater than3.5,Hence(l/ d)is assumed as same for one way slab.
(l/ d)= 25
Effective depth(d)= 4000/ 25= 160mm
Over all depth(D)= 160+ 25= 185mm

Step3: Effective length
Leff= 4+ 016= 4.16m

Step4: Selfweight
Self weight of the slab= D25= 18525= 4.625KN/ m^2
Live load= 2KN/ m^2
Floor finish= 1KN/ m^2
Total load= 7.625KN/ m^2
Wu= 1.57.625= 11.43KN/ m^2

Step5: Calculation of ultimate moment
From table 26,IS 456 alphax= 0.083,alphay= 0056
Mx=alphax Wuleffx^2=0.083*11.43*4.162=16.41KNm
My= alphayWuleffx^2= 0.056*11.43*4.162= 11.07KNm
Vu=(Wuleff)/2=(11.4∗ 4.16)/2=23.77KN

Step6: Check for depth
Mulim=0.138fckbd^2
Mulim is maximum of Mx and My=16.41KN/ m^2
16.41 * 10^6=0.138 ∗25∗103∗d^2
d=68.96 mm less than d prov

Step7: Calculation of reinforcement
Mu=0.87*fy*Ast*d*(1-(fyAst)/(fckbd))
16.41*10^6=0.87*415*Ast*160(1−(415Ast)/(25*1000*60))
Ast=292.97mm^2
Adopt 10mmdia,Spacing=(ast1000/ Ast)=((pi/ 4)*10^2∗1000/ 292.97)=268mm
Provide10 mm diameter@268 mm c/ c spacing as main reinforcement

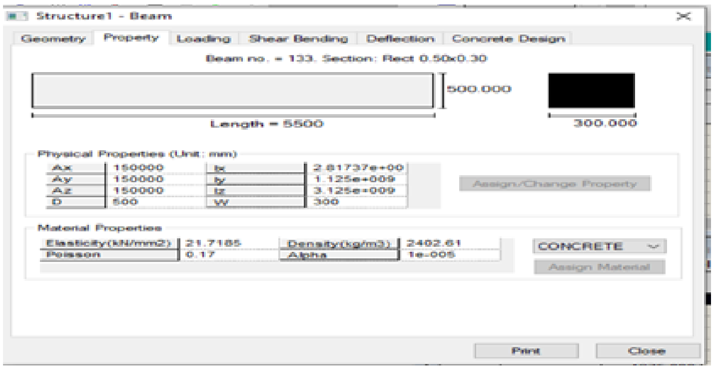
Step8: Calculation of distribution Reinforcement
Mu=11.04KNm,d=150mm(160-10)
11.04*106=0.87∗415∗Ast∗150∗(1−(415Ast)/(25∗1000∗150))
Ast=208.66mm^2
Assume 8mm dia,spacing=((pi/ 4)*8^2∗100/ 208.66)=240mm
Provide 8mm dia meter@240mmc/ c spacing as distribution reinforcement.

Step9: Check for Shear
Tv= (Vu/ bd)= (23.77*103/ 1000*160)= 0.14N/ mm^2
Tc,Pt= 100Ast/ bd= (100*292.97) / 1000*160= 0.18 and M25 grade
Tc= 0.31N/ mm^2
Tv less thanTc,Hence satisfied the criteria.
Step10:Check for Deflection
(l/ d)prov= (4160/ 160)= 26
(l/ d)permitted= (l/ d)basic*k*t= 20kt
Kt= fs= 0.58fy(Astreq/ Astprov)= 0.58*415*(292.97/ 314.15)= 224.47N/ mm^2
Kt= 2.0
(l/ d)permitted= 20*2.0= 40
(l/ d)permitted greater than(l/ d)prov

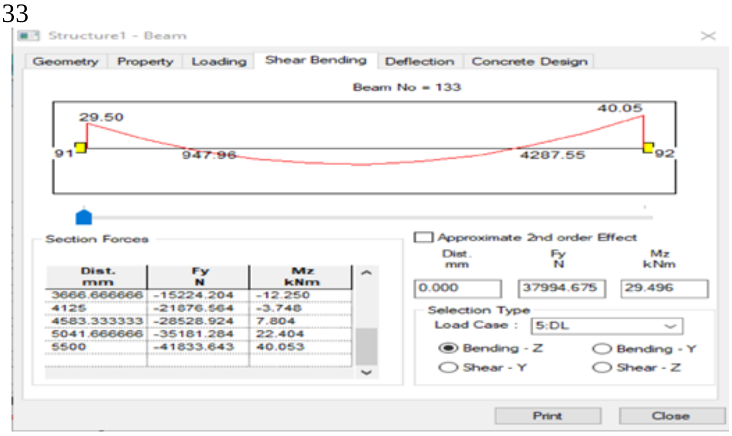
Step11: Calculation of reinforcement in edge strip
Ast prov= (0.12/ 100)*1000*185= 222mm^2
Assume 6mm dia meter,spacing= (ast1000) / Ast= (pi*62*1000/ 4) / 222= 230mm
Provide 6mm dia@230mmc/ c in edge strip.

Step12: Torsion steel at the corner
Area of reinforcement to be provided= (3/ 4)*Ast= (3/ 4)*292.97= 219.20mm^2
Distance up to which torsion reinforcement is to be provided
(lx/ 5)= (4000/ 5)= 800mm
Assume 6mm dia bars,
Spacing= ((ast*1000) / Ast)= ((pi/ 4)*6^2 *1000)/ 292.27)= 96.7= 100*mm*
Provide 6mm dia @100 mm c/c in both the direction at a distance of 800 mm@4 Corners.

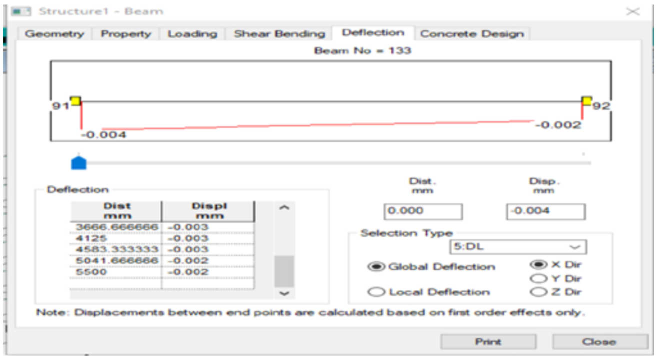
Analysis Results
Some of thesample analysis results have been shown below forbeam
Number 64 which is at the roof level of 1st floor



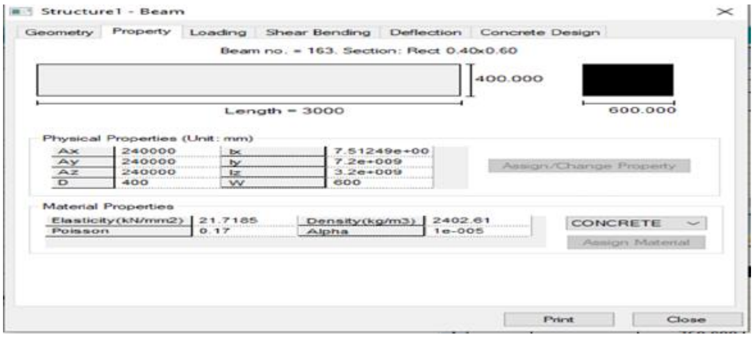
Property of baem no-133



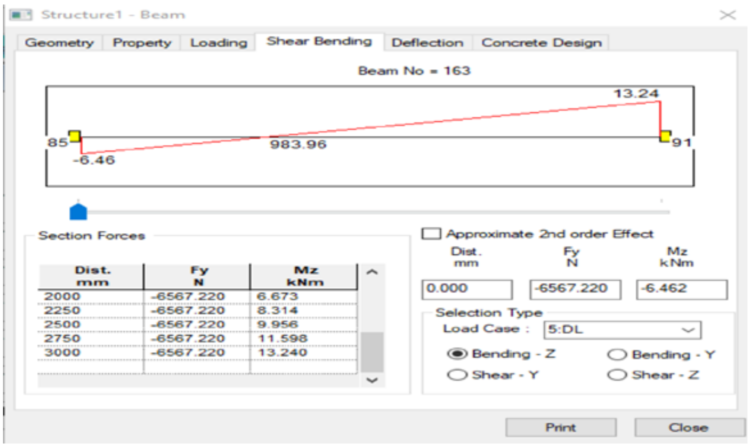
Shear bending of beam no-133



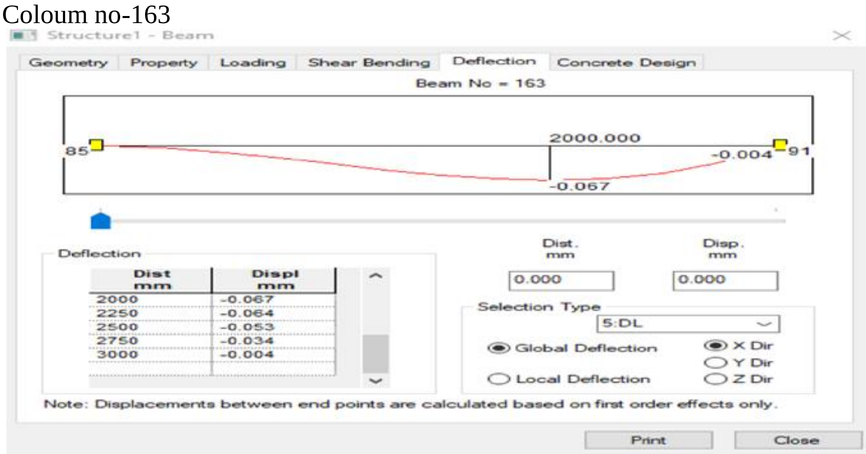
Deflection of beam no-133



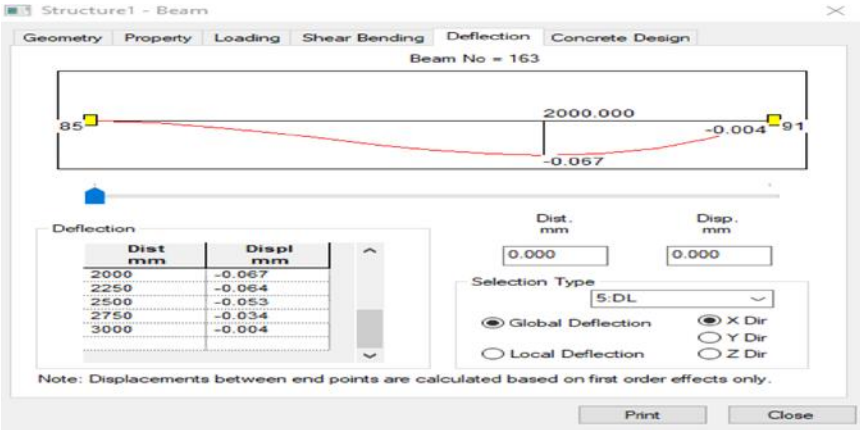
Property of Coloum no-163



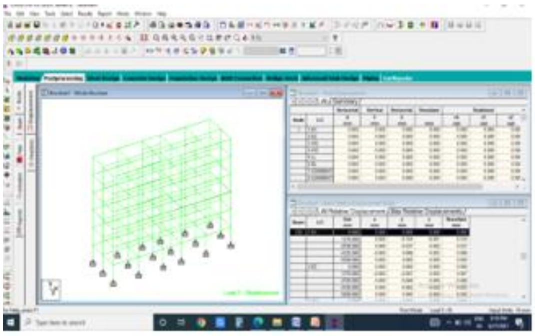
Shear bending of Coloum no-163

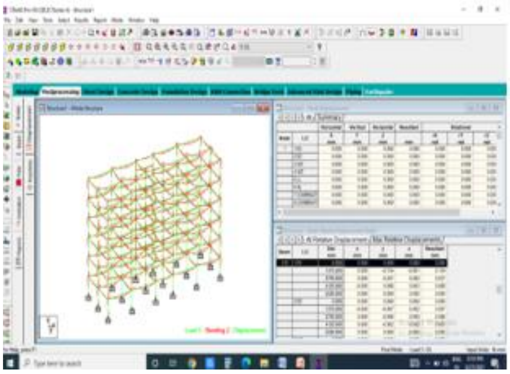


Deflection of Coloum no-163

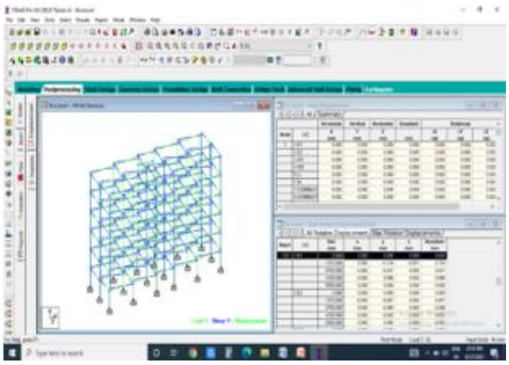


POST PROCESSING MODE



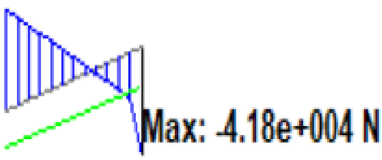


Bending in Z



Bending in Y

Bending moment diagram



Shear force digagram

V. Results & Discussion

BEAMNO.133 DESIGN RESULTS
M25 Fe415 (Main)Fe415(Sec.)
LENGTH:5500.0mm SIZE:500.0mmX300.0mm COVER:25.0mm

Summary of Reinforcement Area (Sq.mm)

Table5.1: Summary of Reinforcement beamno.133

Section	0.0mm	1375.0mm	2750.0mm	4125.0mm	5500.0mm
TOPREINF.	286.95(sqmm)	286.95(sqmm)	286.95(sqmm)	286.95(sqmm)	535.43(sqmm)
BOTREINF	286.95(sqmm)	286.95(sqmm)	286.95(sqmm)	286.95(sqmm)	286.95(sqmm)

Summary of Provided Reinforcement Area (Sq.mm)

Table5.2: Summary of Provided Reinforcement beamno.133

Section	0.0mm	1375.0mm	2750.0mm	4125.0mm	5500.0mm
Toprein.	3-16i2layers(s)	3-16i1layers(s)	3-16i1layers(s)	3-16i1layers(s)	3-16i2layers(s))
Botrein	3-16i2layers(s)	3-16i1layers(s)	3-16i2layers(s)	3-16i1layers(s)	3-16i2layers(s))
Shear rein	2leg12i@170mmc/ c	2leg12i@170mmc/ c	2leg12i@170mmc/ c	2leg12i@170mmc/ c	2leg12i@170mmc / c

Shear Design Results at Distance D (Effective Depth) from Face of the Support

Shear Design Results at 665.0 mm away from STRAT SUPPOTS
VY= 41.27MX= 0.30LD= 9
Provide 2 legged 12i@170mmc/ c
Shear Design Results at 665.0 mm away from END SUPPOTS
VY= -56.55MX= 0.35LD= 10
Provide 2 legged 12i@170mmc/ c

Column No.163 Design Results

M20Fe415(Main) Fe415(Sec.)
LENGTH:3000mm CROSS SECTION:600.0mmX400.0mmCOVER:40.0mm
**GUIDING LOAD CASE:1 END JOINT:85 SHORT COLUMN
REQD.STEEL AREA:1920Sq.mm.
REQD.CONCRETE AREA:238080Sq.mm.
MAIN REINFORCEMENT:Provide12-16dia.(1.01%,2412.74Sq.mm.)
(Equally distributed)
TIE REIN FORCEMENT:Provide 12mm dia.rectangular ties @225mmc/ c
SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED(KNS-MET)
Puz:3276.00Muz1:107.30Muy1:169.13 INTERACTION RATIO:0.20(asperCl.39.6,
IS456:2000)
SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED(KNS-MET)
WORST LOADCASE:1
END JOINT:85Puz:3423.82Muz:133.16Muy:212.46IR:0.16

Element Design Summary

ELEMENT LONG.REINF MOM-X/ LOAD TRANS.REINF MOM-Y/ LOAD
(SQ.MM/ ME)(KN-M/ M)(SQ.MM/ ME)(KN-M/ M)
286TOP:126.0.17/ 10126.0.11/ 10
BOTT:126.0.00/ 2126.0.00/ 3
287TOP:126.0.14/ 9126.0.10/ 9
BOTT:126.-0.03/ 1126.0.00/ 1
288TOP:126.0.00/ 3126..07/ 10
BOTT:126.-0.26/ 10126.-0.04/ 2
289TOP:126.0.16/ 10126.0.10/ 10
BOTT:126.0.00/ 2126.0.00/ 4
290TOP:126.0.13/ 9126.0.09/ 9
BOTT:126.-0.03/ 1126.0.00/ 1
291TOP:126.0.00/ 0126.0.07/ 9
BOTT:126.-0.23/ 10126.-0.05/ 2
292TOP:126.0.16/ 10126.0.10/ 10
BOTT:126.0.00/ 2126.0.00/ 3

VI. Conclusions

1.By Using STADDPro.,analysis and design of multi-storey building is easier and quick process than manual process.
2.Proposed size of the beam and coloumn can be safelyused in the structure.

3.The structure is safe in shear bending and deflection.
4.There is no hazardous effect on the structure due to wind load and seismic load on the structure.
5.The structure we taken is stable and structurally defined using various loads and combination.
6.The deflection value is more in WL(WindLoad)combination than the SL (Seismic Load) combination.
7.To know the behaviour of the structure bya applying various loads like dead load, live load, wind load and seismic load byusing staad.pro.And also find out the Shear forces, displacement, bending and reactions of structure.
8.By using staadpro,we performed dynamic analysis.So that,the results obtained in Staad pro is more effective as compared to analysis and design performed by theoretical method.

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