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Analysis and Design of Residential Building (G+1) using STAAD Pro

Ankur Chauhan[1], Sukrit Jain[1], Raghav Kumar Tiwary[2]

[1]M Tech Scholar, Department of Structural Engineering,
Deenbandhu Chhotu Ram University of Science & Technology, Sonipat, Haryana, India
[2]Director, Satya Infrastructure, Giridih (Jharkhand) & Founder Member,
Dynamic Lab and Consultant, Patna, Bihar, India

ABSTRACT

The development lately are far than the reach thanks to developing status that our country India holds. With development of country, development of residential buildings takes place. In this paper the planning of residential building is completed with limit state analysis. Limit state method may be a great way to achieve strength of structure with low cost when compare to other design synopsis. The modelling and analysis of the structure is done by using STAAD. Pro 2007, and the designing was done manually. Practical knowledge is an important and vital skill required by every engineer. Then the design follows with different types of loading conditions with different cases of rooms and position of rooms. The Plan is made by AUTOCAD 2018. After plotting the design, analysis is made with the help of STAAD Pro software and the results found out to be same.

KEYWORDS: *STAAD Pro, Residential Building, AUTOCAD*

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I. INTRODUCTION

The basic requirements of human presences are food, apparel's and shelter. From times immemorial man has been attempting endeavors in enhancing their way of life. The purpose of his endeavors has been to give a monetary and productive sanctuary. The ownership of safe house other than being a fundamental, utilized, gives a sentiment security, obligation and demonstrated the societal position of man.

Each individual has an inborn enjoying for a quiet domain required for his charming living, this item is accomplished by having a position of living arranged at the safe and advantageous area, such a spot for agreeable and wonderful living requires considered and kept in stand point.

- A Peaceful domain
- Security from all normal source and atmosphere conditions
- General facilities for group of his neighborhood

The basic requirement for a man is to reduce the cost of construction. The limit state method is use.

II. EXPERIMENTAL SETUP

The main aim of this project is to style a residential building with appropriate reinforcement as per Indian standards with limit state analysis. The design of residential building takes generation of plan which is completed with the assistance of AUTOCAD software. Before browsing this software the respective positions of rooms (like kitchen, dining hall, master bedrooms, utensils etc). The positioning of rooms is done with respect to aspects of building.

A. Arrangements of Rooms

1. Aspects

Aspect means particular arrangement of doors and windows in external walls of residential building while environment to undergo it. The important aspect in panning is not only providing the sunshine but also hygiene and eco-friendly environment. The room is based upon the allowance of air and light and referred to such particular aspect. As per the plan the different arrangements of room are shown below.

ROOM(IN BOTH FLOORS)	ASPECT
ENTRANCE	NORTH
KITCHEN	EAST
DINING HALL	SOUTH
LIVING ROOM	SOUTH WEST
PRAYER ROOM	EAST
MASTER BEDROOM	SOUTH EAST
STAIRCASE	NORTH
VERANDAH	WEST OR SOUTH WEST
UTENSILS	WEST NEAR TO BEDROOM
BEDROOM	WEST

TABLE: 1

2. Size

The total area of residential building is 198.00 sq m. The area is divided into number of rooms as per requirement. In keeping the view of health and ventilation, The sizes of room are provided keeping in view of National Building code, the different dimensions of rooms are provided as.

ROOM	DIMENSIONS
GROUND FLOOR	
KITCHEN	3x2.5
DINING HALL	3x2.5
MASTER BEDROOM	3.5x3
BEDROOM	4x3.5
LIVING ROOM	5x3
PRAYER ROOM	1x1.5
UTENSILS	2x1.5
FIRST FLOOR	
KITCHEN	3x2.5
DINING HALL	3x2.5
MASTER BEDROOM	3.5x3
BEDROOM	4x3.5
PRAYER ROOM	1.5x2
UTENSILS	1.8x2

TABLE: 2

The plan section and elevation of residential building which are drafted in AUTOCAD software in 2018 version and is shown below.

3. Plan

The residential building consists of two storeys. First storey is referred as ground floor and second is referred as first floor. The respective plan for ground floor, first floor upto top floor which are drafted in AUTOCAD software are shown as individually as below.

4. GROUND FLOOR

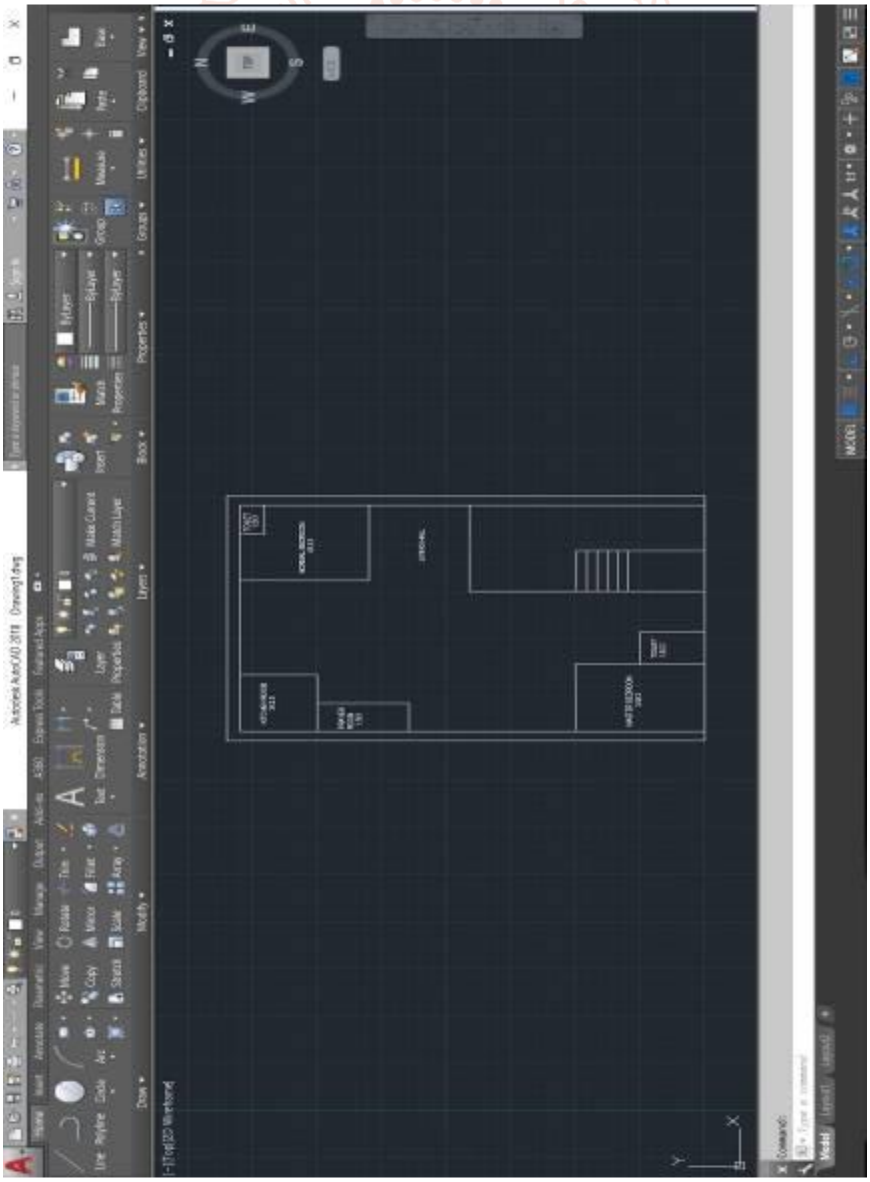

FIG.1

5. FIRST FLOOR

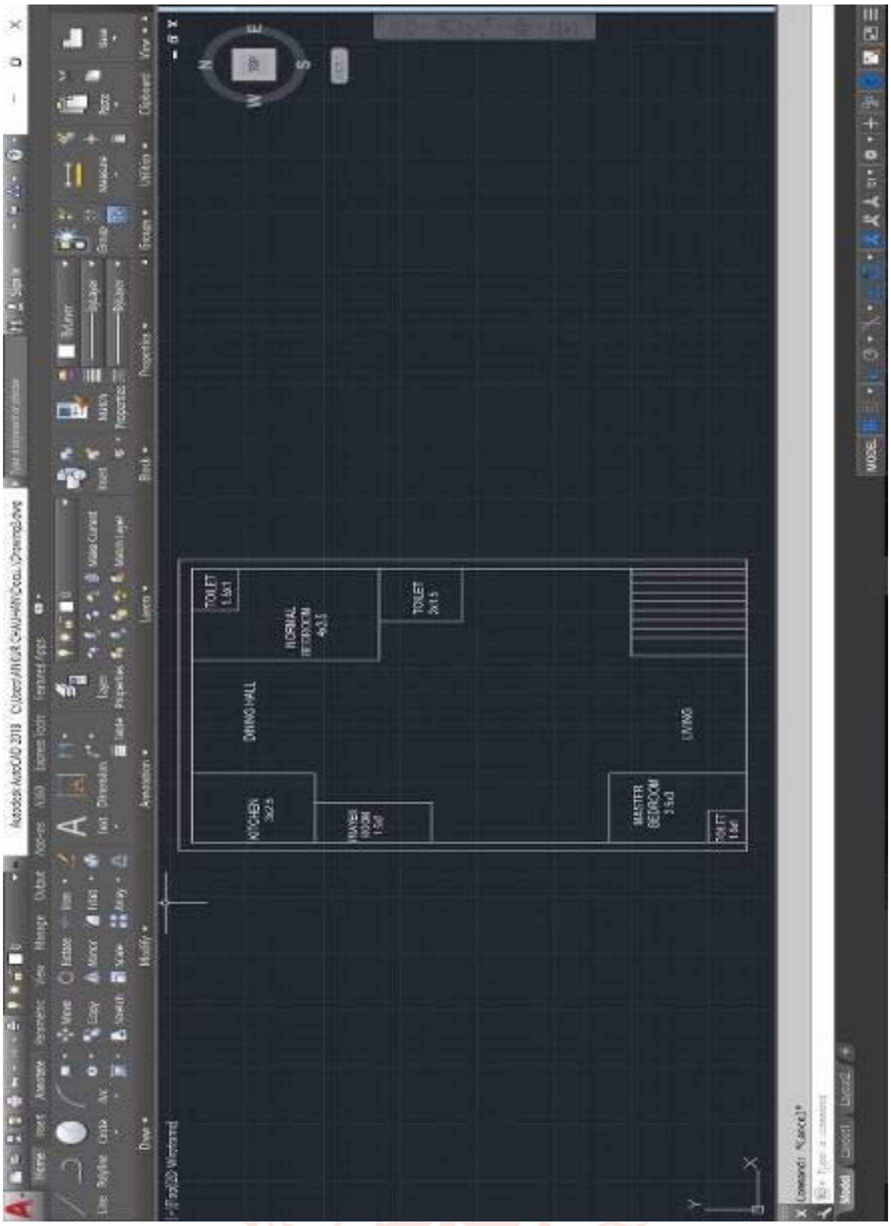

FIG.2

III. DESIGN OF RESIDENTIAL BUILDING

The design of residential building is carried out as per Limit state analysis or Limit state method. The IS codes used in the design are IS:456 2000 and IS:875 1980

IV. DESIGN OF SLAB

The foremost important point in design of slab is analysis of loads. The loads are directly provided in Indian Standard IS: 875 1980 (Part 1 for dead load; Part 2 for live load; Part 3 for wind load)

As per IS: 875 1980 part II, the live loads for different types of rooms rested on ground floor is sort out as.

ROOM	LOADS AS PER IS:875 1980
KITCHEN	3KN/m^2
DINING HALL	4 KN/m^2
MASTER BEDROOM	3 KN/m^2
BEDROOM	2 KN/m^2
LIVING ROOM	2 KN/m^2
PRAYER ROOM	2 KN/m^2
UTENSILS	2 KN/m^2

TABLE: 3

A. Kitchen
The dimensions of kitchen room are 3x2.5 m (as we discussed earlier)

1. Type of Slab
The type of slabis decided based upon ratio of longer span to shorter span
Longer span/ shorter span=3/2.5 = 1.2
If this ratio is less than 2 then two way slab (If more than 2 one way slab)
As per our dimensions of kitchen the design goes with two way slab
The super imposed load for kitchen is taken as 3 KN/m2.

2. Depth of slab
Based upon the stiffness, selected l/d ratio as 28
i.e., 25000/d=28
d=89.28 mm (approx. 90 ,,)
Provide 30 mm effective cover
Over all depth of slab = 120 mm

3. Loads per meter
Dead load = 25x1x0.12 = 3 KN/m
Super imposed load = 3 KN/m
Total load = 6 KN/m
Factored load = 1.5x6=9 KN/m

4. Effective span
As per IS: 456 2000 clause 22.2
The effective span is given as leff=90+2500=2590 mm

5. Moments
As per IS: 456 2000 table 27
Mx=αx Wleff2
αx=0.084
Mx=0.084x9x2.59x2.59=5.07 KNm
My=αy Wleff2
αy=0.059
My=0.059x9x2.59x2.59=3.56 KNm

6. Check for depth
M=0.138fckbd2
5.07x106=0.138x20x1000xd2
D=42.85 mm (HENCE SAFE)

7. Reinforcement

8. Longer span
Mx=0.87fyAstd(1-fyAst/fckbd)
The area of reinforcement for shorter span is obtained as Ast=112.47 mm2

9. Spacing
Provide 12 mmØdiameter bars
Spacing, S= ast/Ast x1000
ast=Πx122/4
We get spacing as S=1005.57 mm
As per IS: 456 2000, Clause 26.3.3
Spacing,
=3d=270 mm
=300 mm
Whichever is less
Provide 12 mm Ø bars @270 mm c/c

10. Shorter span
My=0.87fyAstd(1-fyAst/fckbd)
The area of reinforcement for shorter span is obtained as Ast=162.08 mm2

11. Spacing
Provide 12 mm Ødiameter bars
Spacing, S= ast/Ast x1000
ast=Πx122/4
We get spacing as S=697.78 mm
As per IS: 456 2000, Clause 26.3.3
Spacing,
=3d=270 mm
=300 mm
Provide 12 mm Ø bars @270 mm c/c

12. Edge Strip
As per IS: 456, Clause 26.5.1.2.1
Ast= 0.12 % of gross area = 0.12 x1000x120 /100=144 mm2

13. Spacing
Provide 8 mm Ødiameter bars
Spacing, S= ast/Ast x1000
ast=Πx82/4
We get spacing as S=349.06.78 mm
As per IS: 456 2000, Clause 26.3.3
Spacing,
=5d=450 mm
=450 mm
Provide 8 mm Ø bars @350 mm c/c

14. Check for deflection
Ll/d=20
Fs=0.58 fyAst(req)/Ast (pro)
As per IS: 456 2000, Clause 23.2.1
Modification factor = 2
l/d(req)=40
l/d(get)=2590/90 = 28.78 (HENCE SAFE)

B. Design of Beam
D=300mm
d=250mm
d'=50mm
b=125mm
fck=20N/mm2
fy=415N/mm2

1. Loads per meter
Dead load=25x0.25x0.125=0.781KN/M
Super imposed load=2KN/M
Live load=10.78KN/M
Total load=13.56KN/M
Factor load=1.5x13.56
Wu=20.34KN/M
Bending moment=wul2/8
=20.34x3.52/8
Mu=30.145KNM
Check for depth:-
Mu=0.138fckbd2
=0.138x20x125xd2
d=295.59mm
Depth is failed (So provide double reinforcement)

2. Reinforcement

3. Ast in compression
0.87fyAst1=0.36fckbxumax
Ast1=0.36x20x125x120/0.87x415
Ast1=299.12mm2
(From sp 16 charts) Fsc=342.4N/mm2
Mu limit=0.138fckbd2
Mu limit=21.56KNM
Mu2=8.585KNM
Mu2=fsc Asc(d-d')
8.58x106=342.4xAscx (250-50)
Asc=125.36mm2

4. Additional tensile steel (Ast2)
0.87fyAst2=fscAsc
Ats2=fscAsc/0.87fy
Ast2=118.88mm2

5. Total tensile steel
Ast=Ast1+Ast2
Ast=418mm2

6. No. of bars (in tension)
Ast=418,ϕ=18mm
=418/π/4x182
=2bars

7. In compression
Φ=12mm
=125.36/π/4x122
=2bars
Provide 2-18mm bars in tension
Provide2-12mm bars in compression

8. Column (Axial)
Height=2.75m
Factor load=1100KN
Let Assume the Gross area % of steel
Asc=1%Ag=0.01Ag
Area of concrete, Ac=Ag-Asc
Ag-0.01Ag=0.99Ag
Axially load column:-
Pu=0.4fck As+0.67fyAsc
1100x103=0.4x20x0.99Ag+0.67x415x0.01Ag
Ag=102798.93mm2
S2=102798.9
S=320x320mm
Asc=0.01x102798.9
Asc=1027.989mm2
Provide 4bars of 18mm diameter

9. Lateral reinforcement
From IS:456-2000,clause-26.5.3.2

10. Ties
Adopt 6mm ϕ bars

11. Pitch
320mm (or)
16xϕ=16x18=288mm (or)
300mm
Provide 6mm lateral ties @288mmc/c

C. Design of Footing
Axial load=1100KN
Size of column=320x320mm
Soil bearing capacity=200KN/M2
Fck=20N/MM2,Fy=415N/MM2

1. Size of footings
Assume dead load 10%
Dead load=1.1x733.33/200
Area=4m2
S2=4
S=2x2m

2. Upward soil pressure
Pu=733.33x1.5
Pu=1100KN
qu=1100/2x2=275
qu=0.275N/mm2

3. Moment
Mu=quxB/8(B-b)2
0.275x2000/8x(2000-320)2
Mu=194.04KNM

4. Depth
Mu=0.138fckbd2
d=400mm

5. Reinforcement
Mu=0.87fyAstd(1-fyAst/fckbd)
Ast=1393.98mm2

6. Spacing
From IS:456-2000,Clause-26.3.3
Φ=12mm
S=ast/AstxB
S=162.26mm
Provide 12mmϕ @ 160mmc/c
One-way shear:-
Vu1=quB[(B-b)/2-d]
Vu1=242000KN

7. Nominal shear stress
τv1=Vu1/bd
τv1=0.3025N/MM2
From IS:456-2000,Table-19
%P=100Ast/bd
%P=0.17
By linear interpolation:
τc1=0.296N/mm2
τv1>τc1(Provide shear reinforcement)

8. Needed reinforcement

9. Design stirrups
2legged-6mm
Asv=56.54mm2
Vus=Vu1-τc1bd
Vus=5200KN
Vertical stirrups:-
Vus=0.87fyAsvd/Sv
Sv=1570.28mm

10. Check
From IS:456-2000,Clause 26.5.1.5
0.75d=300mm(or)
300mm
Provide 2legged-6mmϕ @300mmc/c

Two-way shear:-
Vu2=qu(B2-(b+d)2)
Vus=957440KN
Area=4(b+d)d
A=1152X103
τv2=957440/1152x103
τv2=0.83N/mm2
τc2=0.25fck
τc2=1.11N/mm2
τv2<τc2 (Hence Safe)

D. Design of Stair Case

1. Proportioning of Stairs
Dimension of stair hall=2.5x4.5m
Height of floor=3.3m
Rise R=225mm
Tread T=150mm

2. Effective span
From IS:456-2000,Clause-22.2
le=4.73m
Thickness of waist slab:
Assume depth=2730/25=189.2mm
d=190mm,D=220mm

3. Loads
Weight of waist slab=D√(1+_(R/T))2X25 =6.61KN/m
Weight of steps = (1/2RT)/TX25=1.875KN/m2
Live load=3KN/m2
Floor finish=0.6KN/m2
Total load=12.1KN/m2
Factor load (wu)=1.5x12.1=18.15KN/m2
Bending moment Mu=wul2/8
Mu=50.76KNM

4. Depth
Mu=0.138fckbd2
d=190mm

5. Tension reinforcement
Mu=0.87fyAstd (1-fyAst/fckbd)
Ast=812mm2

6. Spacing
S=ast/Ast x B
S=139.3mm
Hence provide 12mm bars @130mmc/c

7. Distribution steel
Ast=0.12% of gross area
=0.12x1000x220/100=264mm2
Using 8mm bars, spacing
S=π/4x82=190.4mm
Hence provide 8mm bars @190mm c/c

8. Reinforcement details

a. Beams
Provide 2-18mm bars in tension
Provide 2-12mm bars in compression

b. Column
Provide 4 bars of 18mm diameter
Provide 6mm lateral ties @ 288mm c/c

c. Footing
Provide 12mmϕ @ 160mmc/c
Provide 2legged-6mmϕ @300mmc/c

d. Slab
Provide 12mmϕ @ 270mmc/c
Provide 12mmϕ @ 280mmc/c
Provide 8mmϕ @ 350mmc/c

9. Reinforcement sketches

10. Slab

11. Kitchen room

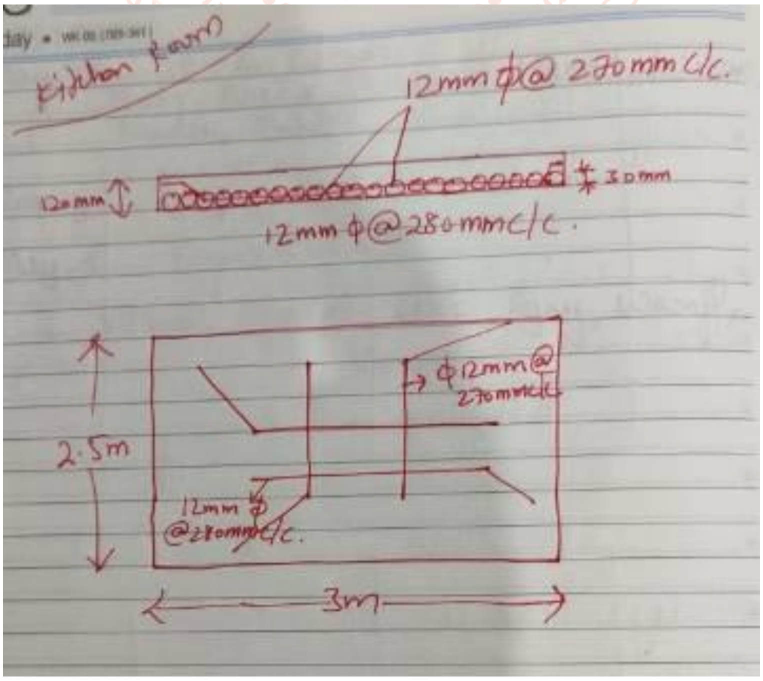

FIG.3

12. Other Rooms

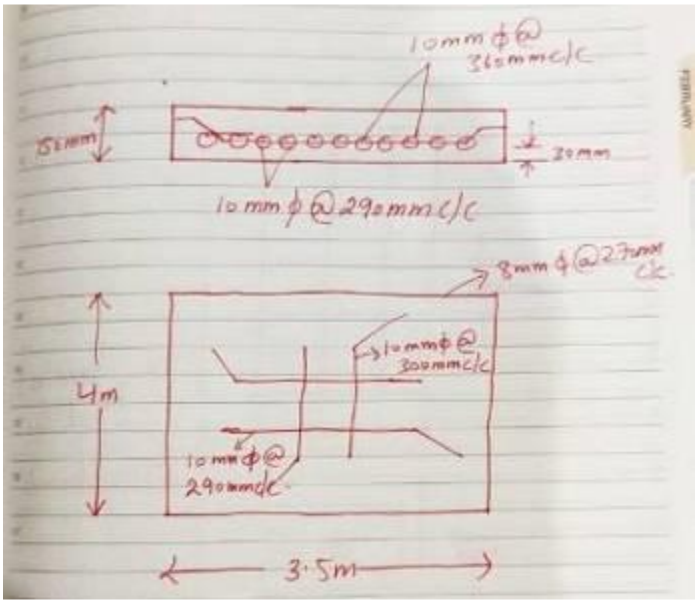

FIG.4

13. Columns

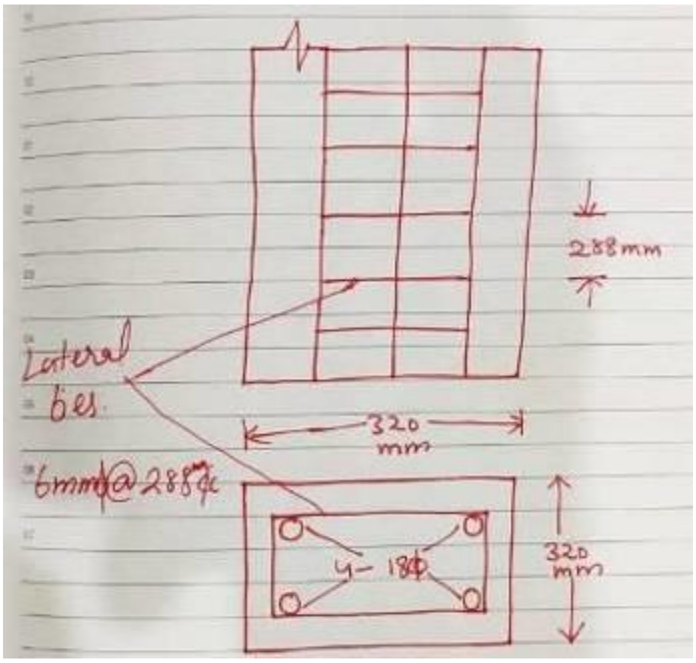

FIG.5

14. Footings

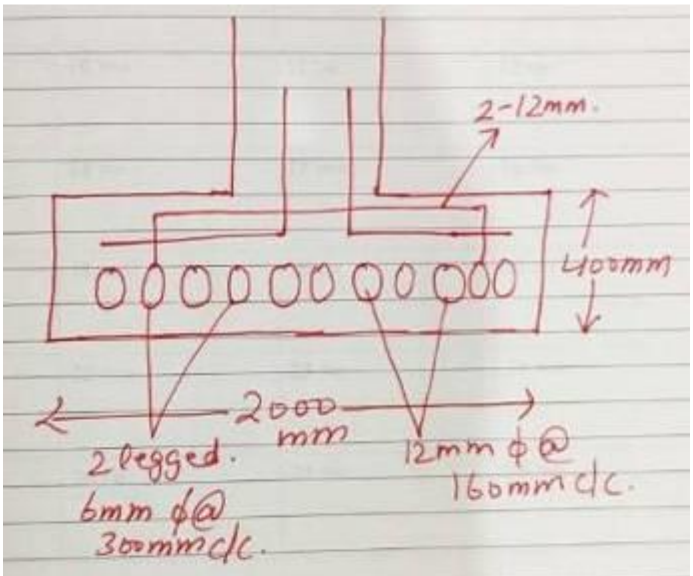

FIG.6

15. Stair cases

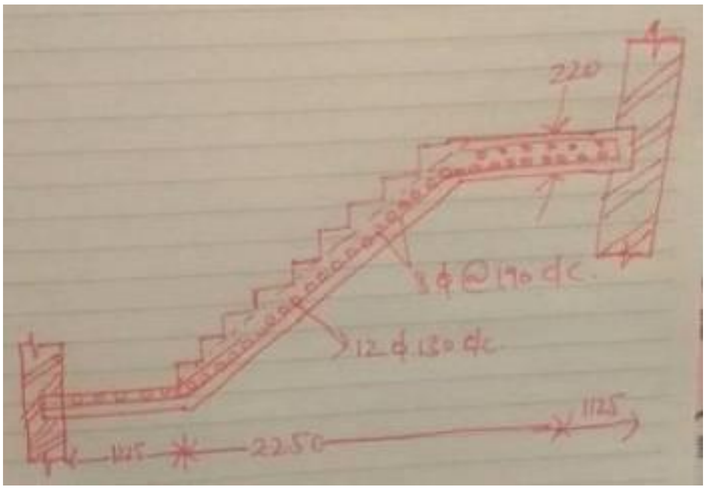

FIG.7

16. Results

The results shown are based on analysis of designed model in STAAD Pro software. The model generated in STAAD Pro is shown in figure below as position of beams and column.

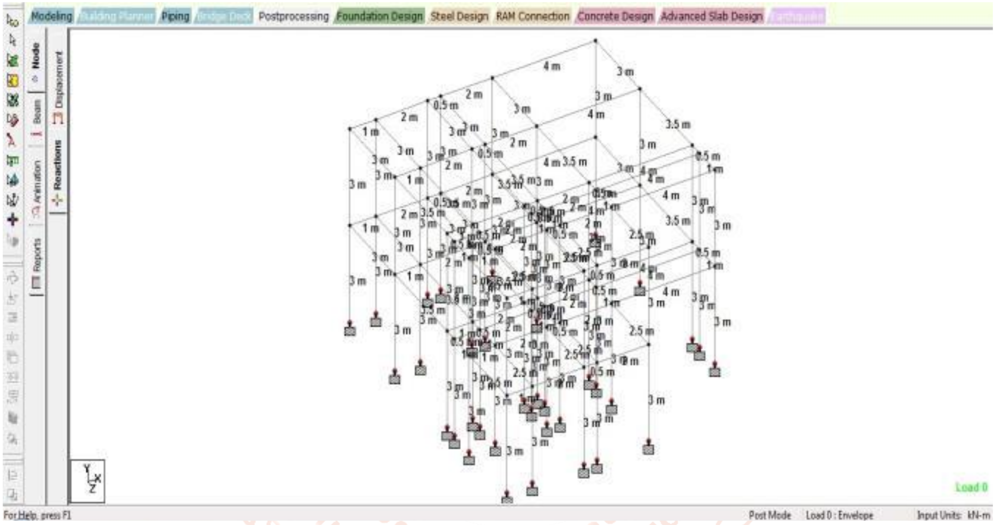

FIG.8

17. Forces

The analysis of buildings start with analysis of forces in each member in their respective axis, then moments, stresses and eventually deflection. First of all the forces are found in X, Y and Z- direction and there diagram are shown below.

18. Axial Forces in X- direction

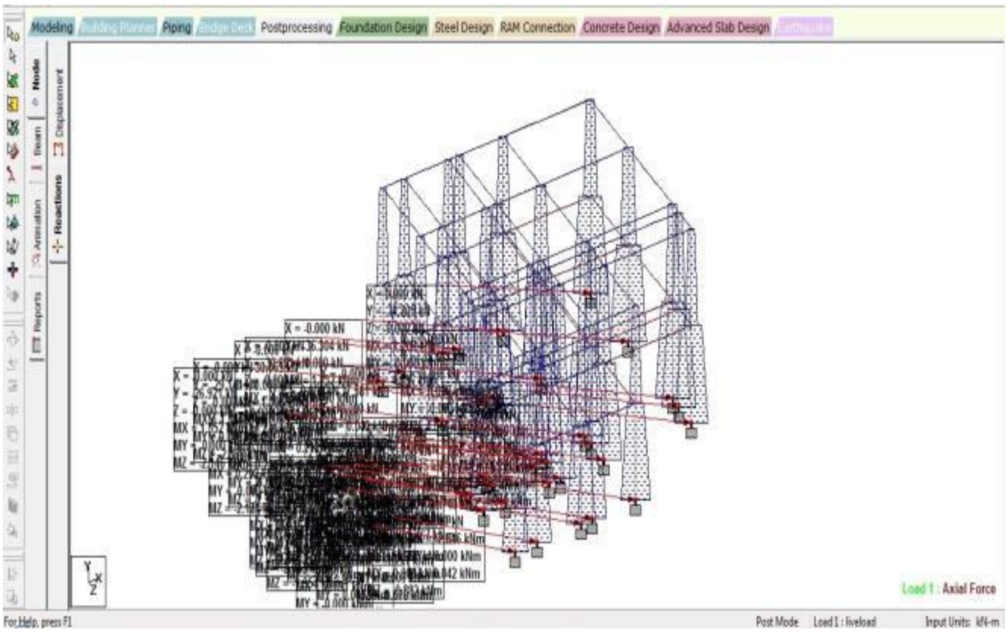

FIG.9

19. Axial Forces in Y-direction

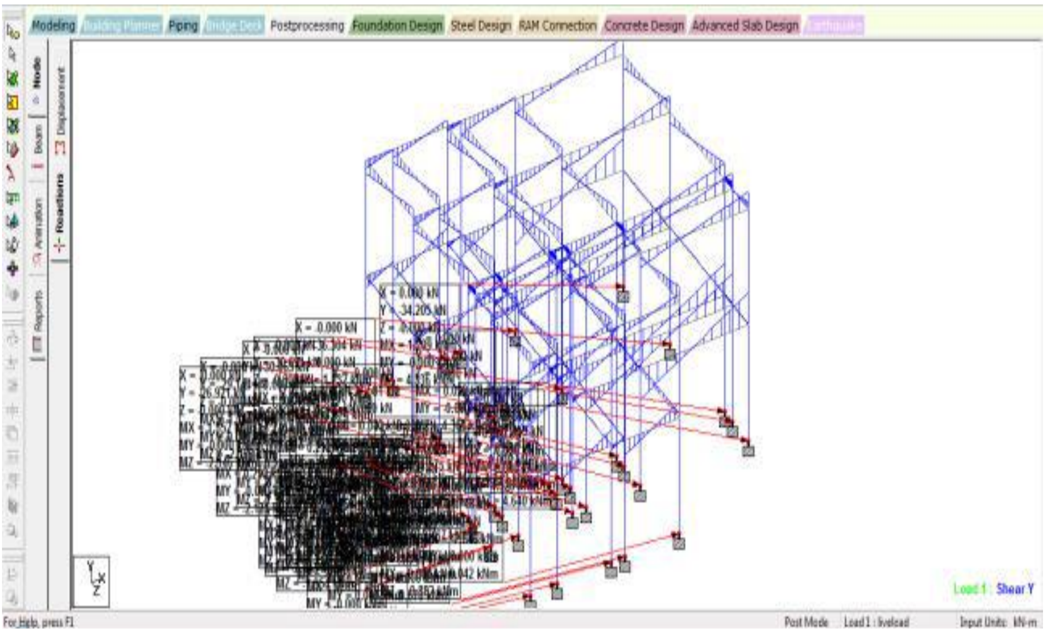

FIG.10

20. Axial Forces in Z-direction

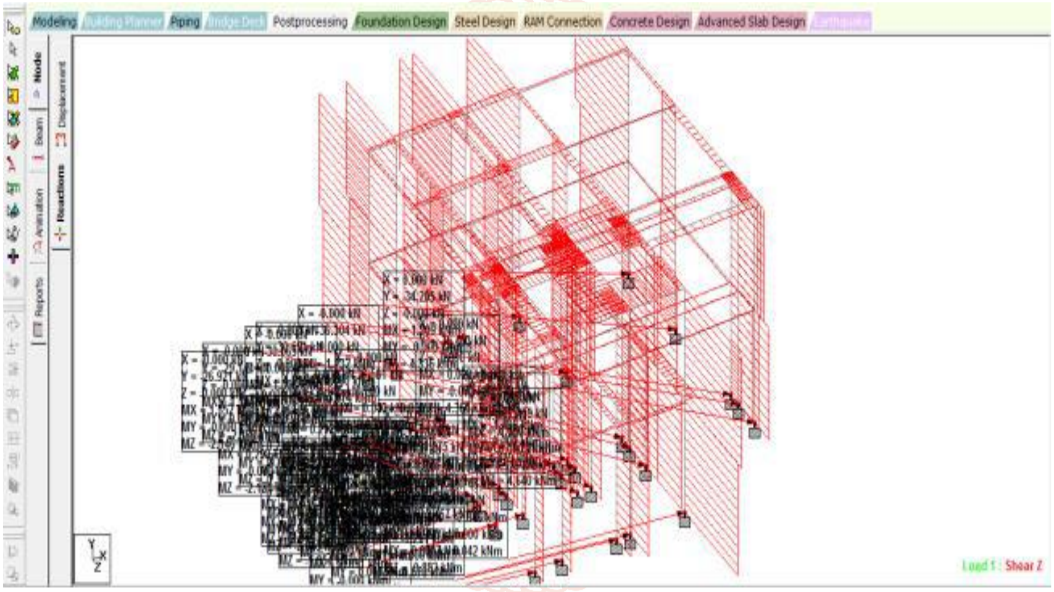

FIG.11

21. The Torsion in X-direction

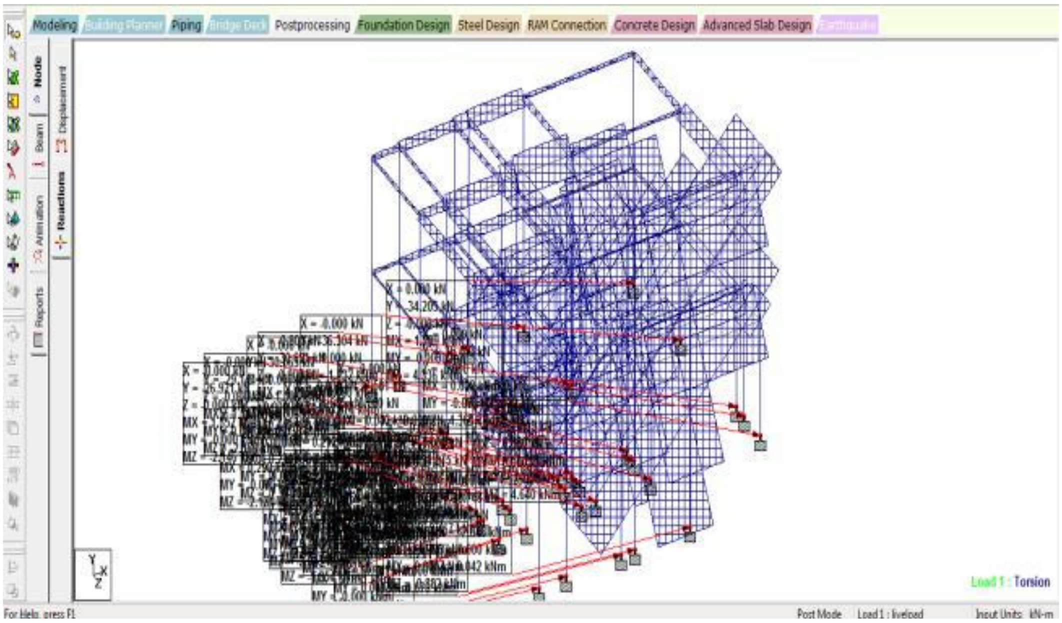

FIG.12

22. The Moment in Y-direction

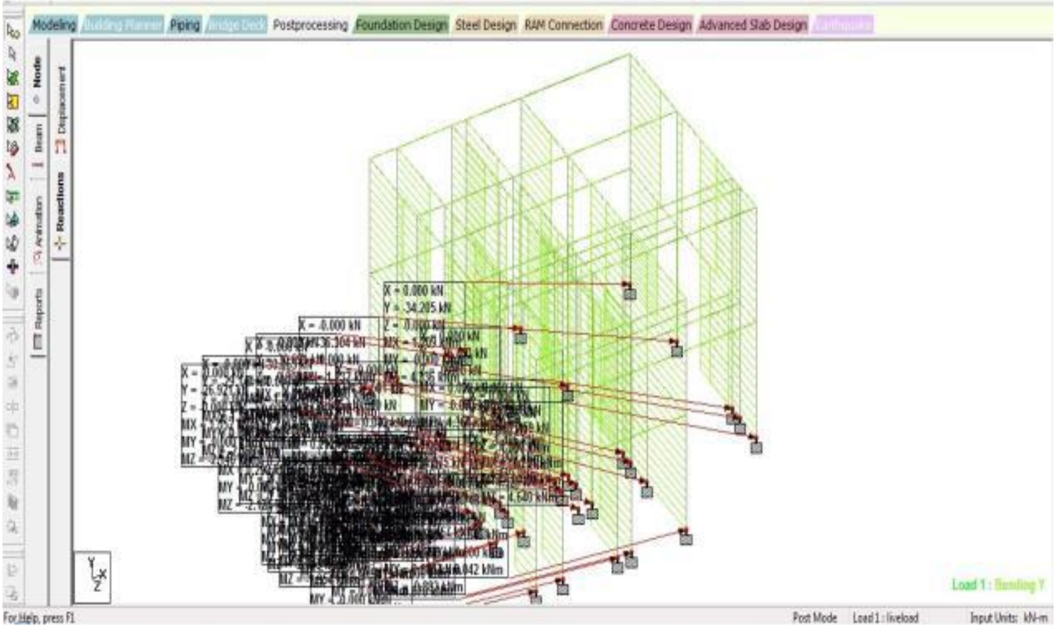

FIG.13

23. The Moment in Z-direction

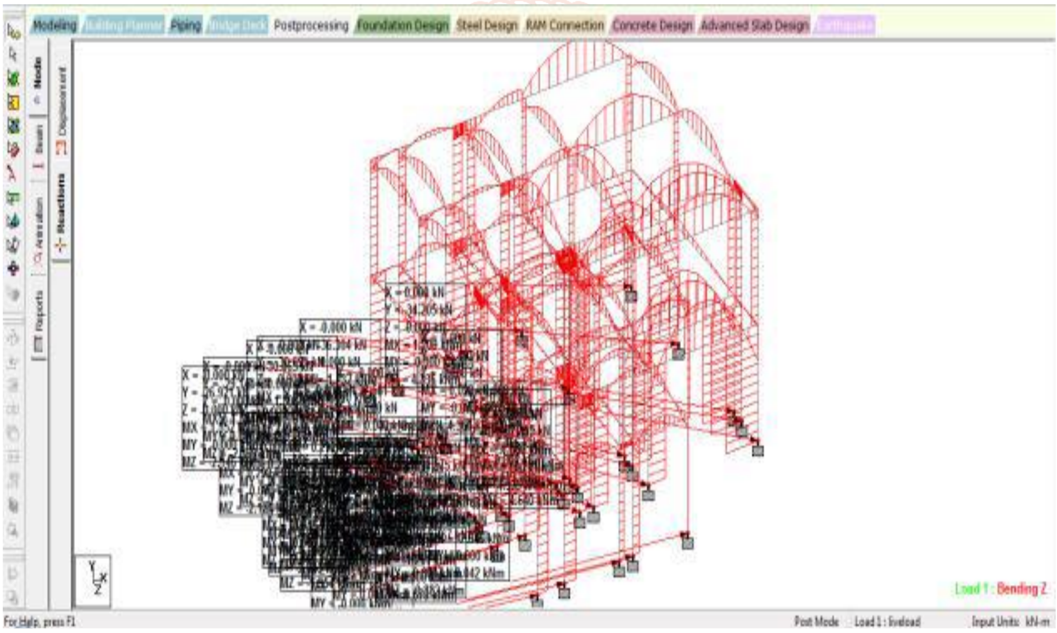

FIG.14

24. Stresses

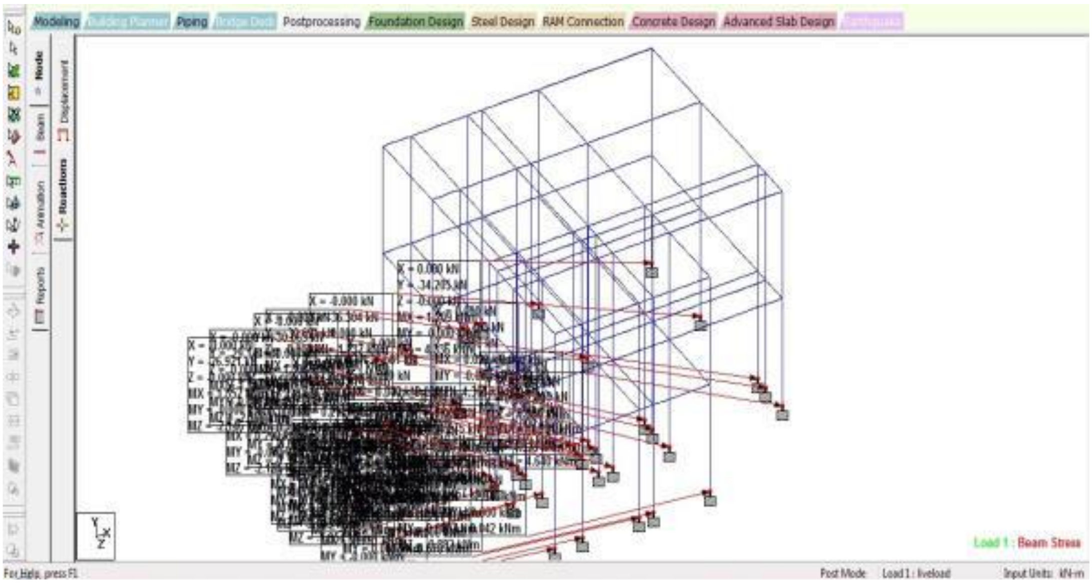

FIG.15

25. Deflection

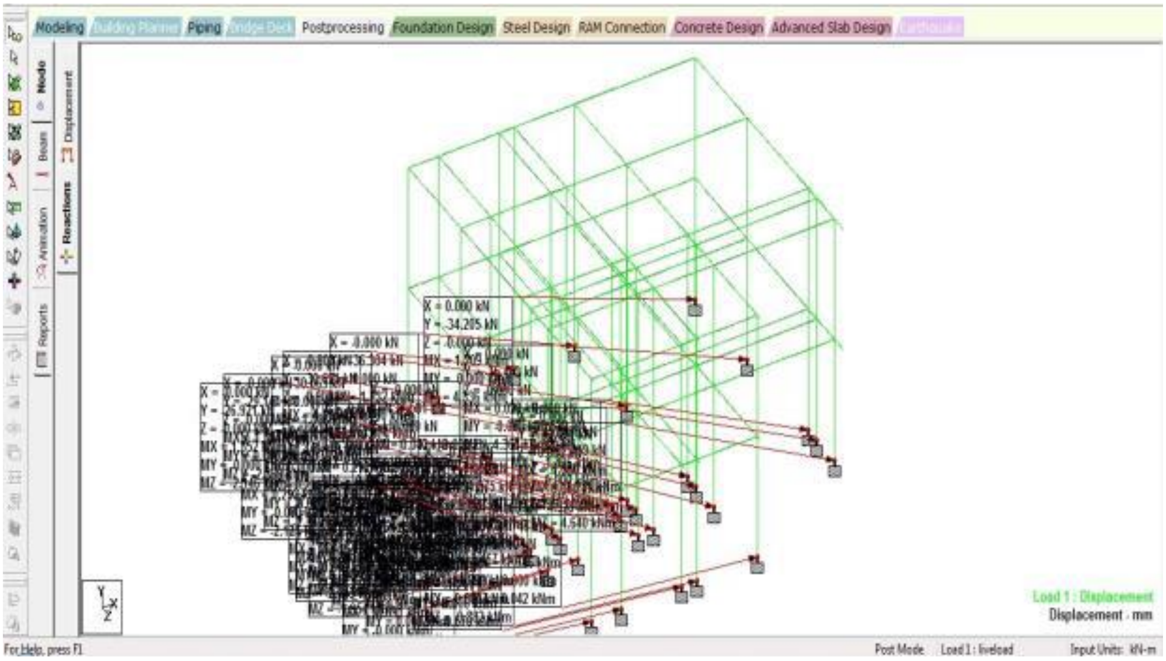

FIG.16

26. Final static report

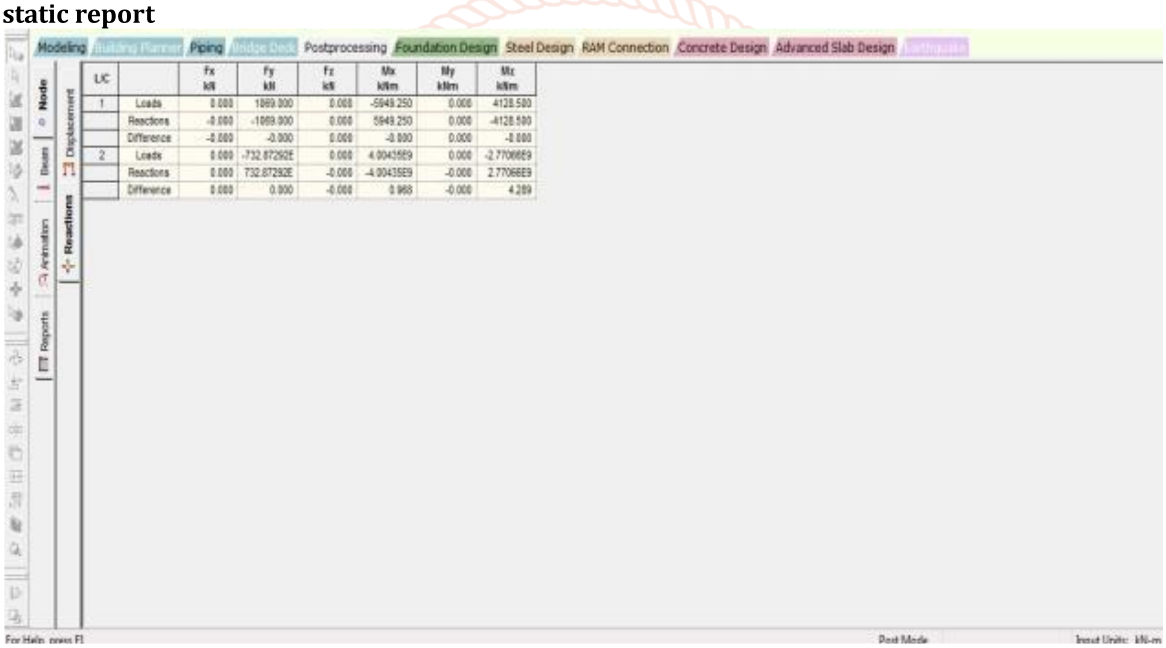

FIG.17

The final static report is given as
Hence all the loads and displacements are resisted by structure itself

V. CONCLUSION

The method used is limit state analysis, the factor of safety for concrete is 1.5 and steel is 1.1 it means 50% more concrete and 10% more steel is consider. In working state method which is broadly followed in our country has factor of safety of 3 for concrete and 1.7 for steel it means 200% more concrete and 70% more steel.

The amount of more concrete and steel, bigger areas can be seen in working stress method. As we can reduce out area by following limit state method and hence also proved as economical.

The design review the study of AUTOCAD 2018 and analysis with STAAD pro and found out the structure is safe in deflections, stresses, loads and moments.

The aspects and prospects are made according to NBC of India, which gives various advantages over random arrangements.

REFERENCES

[1] IS: 456 2000, "Plain and Reinforced concrete"
[2] IS: 875 1987, "Part 1 & 2 for dead and live loads"
[3] Design of column charts, "SP:16 1980"
[4] Aspects, Prospects and Sizes, "National building code of India".
[5] Design of beams, columns, slab and footing BOOK, "Limit state design by A.K.Jain".
[6] Design of columns, stair cases, "Reinforced concrete structures by B.C.Punmia".
[7] https://www.academia.edu/20157844/Design_of_Residential_Building_and_Analysis_with_STAAD_Pro