Design of Multi-Story Residential Building and its Foundation

Project Report submitted in partial fulfillment of the requirement for the

degree of

Bachelor of Technology

in

Civil Engineering

under the supervision of

Dr. S.K. Jain

By

Avik Kumar (111706)

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to

Jaypee University of Information Technology

Waknaghat, Solan – 173234, Himachal Pradesh

Candidate's Declaration

I hereby declare that the work presented in the project entitled "**Design of Multi-Story Residential Building and its Foundation**" submitted towards the completion in eighth semester at **Jaypee University of Information Technology, Waknaghat**, is an authentic record of my original work carried out under the guidance of **Prof. S.K. Jain**, Jaypee University, Anoopshahr.

I have not submitted the matter embodied in this project for the award of any other degree.

Signature	Signature
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Date :	Date :

Certificate

This is to certify that project report entitled "**Design of Multi-Storey building and its foundation**", submitted by Avik Kumar and Samrat Jain in partial fulfillment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

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Acknowledgement

There are many people who are associated with this project directly or indirectly whose help and timely suggestions are highly appreciable for completion of this project. First of all, we would like to thank our supervisor Prof. S.K. Jain (Project Guide), Prof. Mani Mohan and Prof. Saurabh Rawat for their supervision, encouragement, and support which has been instrumental for the success of this project. It was an invaluable experience for us to be one of their students. Because of them, we have gained a careful research attitude.

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Abstract

This project is about designing a multi-story residential building that can also act as working place for freelancers such as architects, web designers, authors, etc. Due to the continuous increase in population and less availability of land especially in the metropolitan city there comes a great demand of building multi-story buildings. So there is a great need for urban planning to provide various facilities to the people living in the city and avoid problems like traffic. Middle-class people having limited money so can merge their office with home and can save travel time in traffic dominated city. Till a few years ago most of the Multi-story buildings were analyzed by approximate methods such as moment distribution method. Nowadays the buildings are analyzed by more advanced methods like finite element analysis and softwares like StaadPro, Ansys, etc. During this project we used softwares such as StaadPro, Autocad, Microsoft-Excel and Staad Foundation v8i to analyze & design the structure. During the project superstructure as well as substructure is analyzed & designed according to the soil-profile of the location. This project helps to cover basic concepts of Reinforced Cement Concrete (RCC), Geotechnical Engineering, and Foundation Engineering which are one of the important aspects of Civil Engineering. In this project we calculated the bearing capacity of soil on the basis of shear criteria and settlement criteria with the help of SPT & Plate Load Test value of site using Terzaghi's Analysis and IS Code Method. We also created an excel formula sheet to calculate the bearing capacity of soil as per IS 6403 (1981), created the plan of the residential building and designed its elements beams, columns, slab and foundation. We designed Raft Foundation manually for the superstructure.

Introduction

Due to the continuous increase in population and less availability of land especially in the metropolitan city there comes a great demand of building multi-storey buildings. So there is a great need for Urban Planning to provide various facilities to the people living in the city and avoid problems like traffic. Middle-class people having limited money can merge their office with home and can save travel time in traffic dominated city. Multi-story buildings aim to increase the floor area of the building without increasing the area of the land the building is built on, hence saving land and, in most cases, money (depending on material used and land prices in the area).

A building frame is a three-dimensional structure or a space structure. It is idealized as a system of interconnected two-dimensional vertical frames along the two mutually perpendicular horizontal axes for analysis. These frames are analyzed independently of each other. In frames where the columns are arranged on a rectangular grid, loading patterns giving biaxial bending need not be considered except for corner columns.

The degree of sophistication to which a structural analysis is carried out depends on the importance of the structure. A wide range of approaches have been used for buildings of varying heights and importance, from simple approximate methods which can be carried out manually, or with the aid of a pocket calculator, to more refined techniques involving computer solutions. Till a few years ago most of the Multi-storey buildings were analyzed by approximate methods such as moment distribution method. Nowadays the buildings are analyzed by more advanced methods like finite element analysis and softwares like StaadPro, Ansys,etc.

CHAPTER
1. Superstructure

1.1 Structural Elements:

1.1.1 Beam

A beam is a structural element that is capable of withstanding load primarily by resisting bending.

The bending force induced into the material of the beam as a result of the external loads, own weight, span and external reactions to these loads is called a bending moment.

Beams generally carry vertical gravitational forces but can also be used to carry horizontal loads (i.e., loads due to an earthquake or wind). The loads carried by a beam are transferred to columns, walls, or girders, which then transfer the force to adjacent structural compression members. In light frame construction the joists rest on the beam.

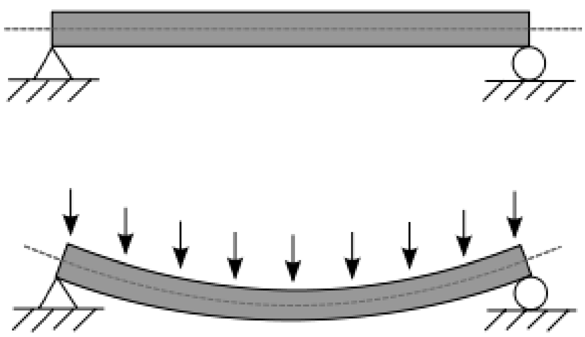


Fig.1

Types of Beams-

1. Simply supported beam
2. Fixed beam
3. Over hanging beam
4. Continuous beam
5. Cantilever beam

1.1.2 General Shapes:

Most beams in reinforced concrete buildings have rectangular cross sections, but a more efficient cross section for a beam is an I or H section which is typically seen in steel construction. Because of the parallel axis theorem and the fact that most of the material is away from the neutral axis, the second moment of area of the beam increases, which in turn increases the stiffness.

1.1.3 Column:

Column is a structural element that transmits, through compression, the weight of the structure above to other structural elements below. In other words, a column is a compression member. The term column applies especially to a large round support with a capital and base and made of stone, or appearing to be so. A small wooden or metal support is typically called a post, and supports with a rectangular or other non-round section are usually called piers. For the purpose of wind or earthquake engineering, columns may be designed to resist lateral forces. Other compression members are often termed "columns" because of the similar stress conditions. Columns are frequently used to support beams or arches on which the upper parts of walls or ceilings rest.

1.1.4 Slab :

A slab is a common structural element of modern buildings. Horizontal slabs of steel reinforced concrete, typically between 100 and 500 millimeters thick, are most often used to construct floors and ceilings, while thinner slabs are also used for exterior paving. In many domestic and industrial buildings a thick concrete slab, supported on foundations or directly on the subsoil, is used to construct the ground floor of a building. These can either be "ground- bearing" or "suspended" slabs. In high rise buildings and skyscrapers, thinner, pre-cast concrete slabs are slung between the steel frames to form the floors and ceilings on each level.

1.2 Reinforcement design

A one way slab needs moment resisting reinforcement only in its short-direction because the moment along long axes is so small that it can be neglected. When the ratio of the length of long direction to short direction of a slab is greater than 2 it can be considered as a one way slab. A two way slab needs moment resisting reinforcement in both directions. If the ratio of the lengths of long and short side is less than two then movement in both direction should be considered in design.

1.3Loads

Dead Loads –

Dead loads are static forces that are relatively constant for an extended time. They can be in tension or compression. The term can refer to a laboratory test method or to the normal usage of a material or structure.

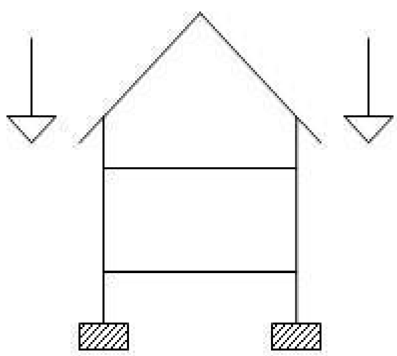


Fig.2

The dead load includes loads that are relatively constant over time, including the weight of the structure itself, and immovable fixtures such as walls, plasterboard or carpet. Roof is also a dead load. Dead loads are also known as Permanent loads.

The designer can also be relatively sure of the magnitude of dead loads as they are closely linked to density and quantity of the construction materials. These have a low variance and the designer is normally responsible for specifying these components.

Live Loads -

• Live loads are usually unstable or moving loads. These dynamic loads may involve considerations such as impact, momentum, vibration, slosh dynamics of fluids, etc. An impact load is one whose time of application on a material is less than one-third of the natural period of vibration of that material.

• Live loads, or imposed loads, are temporary, of short duration, or moving. These dynamic loads may involve considerations such as impact momentum vibration slosh dynamics of fluids, fatigue, etc.

• Live loads, sometimes also referred to as probabilistic loads include all the forces that are variable within the object's normal operation cycle not including construction or environmental loads.

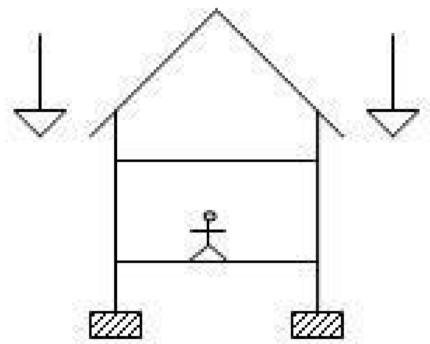


Fig. 3

- Roof and Floor and materials
- During the life of the structure by movable objects such as planters and by people.
- Bridge live loads are produced by vehicles traveling over the deck of the bridge.

Wind Loads -

The force on a structure arising from the impact of wind on it. The force on a structure arising from the impact of wind on it. Prevailing winds generally blow in one direction. The windward side is the side that receives the wind. The leeward side is the other side where the mountain blocks the winds.

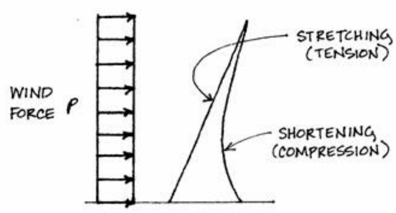


Fig.4

CHAPTER
2. Sub structure

2.1 Shallow foundations:

Shallow foundations are a type of foundation that transfers building load to the very near the surface, rather than to a subsurface layer. Shallow foundations typically have a depth to width ratio of less than 1.

2.2 Footings:

Footings (often called "spread footings" because they spread the load) are structural elements which transfer structure loads to the ground by direct areal contact. Footings can be isolated footings for point or column loads, or strip footings for wall or other long (line) loads. Footings are normally constructed from reinforced concrete cast directly onto the soil, and are typically embedded into the ground to penetrate through the zone of frost movement and/or to obtain additional bearing capacity.

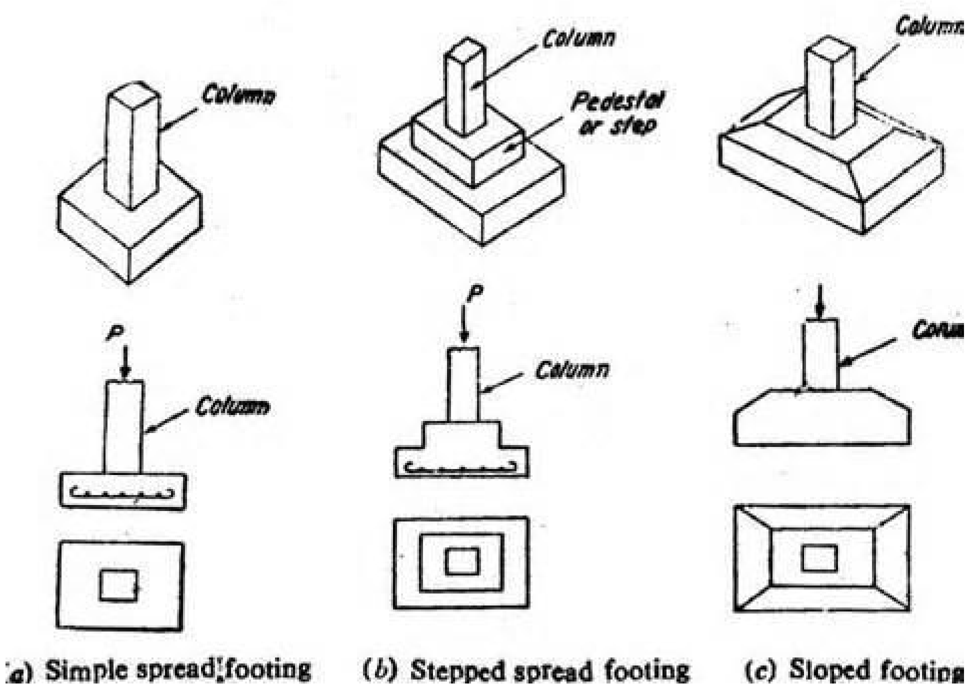


Fig.5

Shallow Foundations support structures at a shallow depth below the ground surface or at a shallow depth below the deepest basement of a building. There are three main types of shallow foundations

Following are the types of shallow foundation

1. Strip Footing:

A strip footing is provided for a load-bearing wall. A strip footing is also provided for a row of columns which are so closely spaced that their spread footings overlap or nearly touch each other. In such a case, it is more economical to provide a strip footing than to provide a number of spread footings in one line. A strip footing is also known as continuous footing.

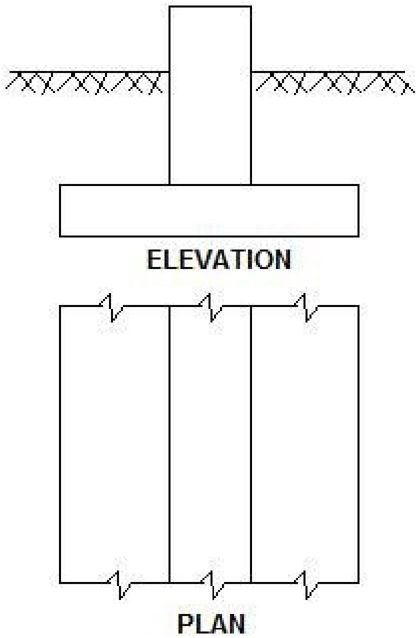


Fig.6

2. Spread or Isolated Footing:

A spread footing (or isolated or pad) footing is provided to support an individual column. A spread footing is circular, square or rectangular slab of uniform thickness. Sometimes, it is stepped or hunched to spread the load over a large area.

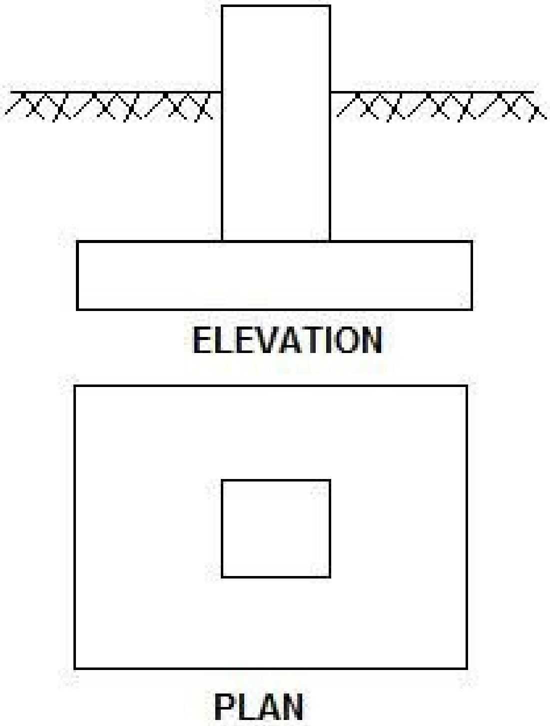


Fig.7

3. Combined Footing:

A combined footing supports two columns. It is used when the two columns are so close to each other that their individual footings would overlap. A combined footing is also provided when the property line is so close to one column that a spread footing would be eccentrically loaded when kept entirely within the property line. By combining it with that of an interior column, the load is evenly distributed. A combined footing may be rectangular or trapezoidal in plan.

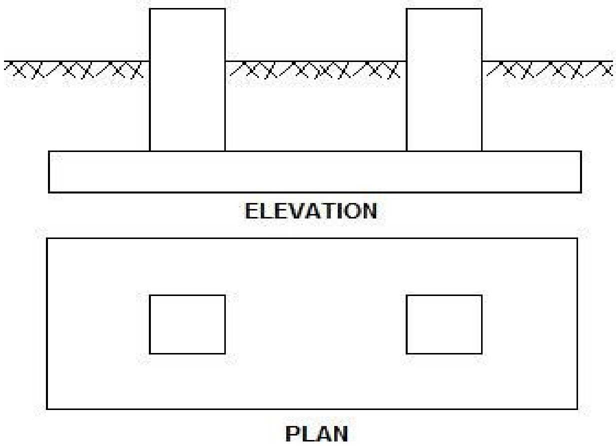


Fig.8

4. Strap or Cantilever footing:

A strap (or cantilever) footing consists of two isolated footings connected with a structural strap or a lever. The strap connects the two footings such that they behave as one unit. The strap is designed as a rigid beam. The individual footings are so designed that their combined line of action passes through the resultant of the total load. a strap footing is more economical than a combined footing when the allowable soil pressure is relatively high and the distance between the columns is large.

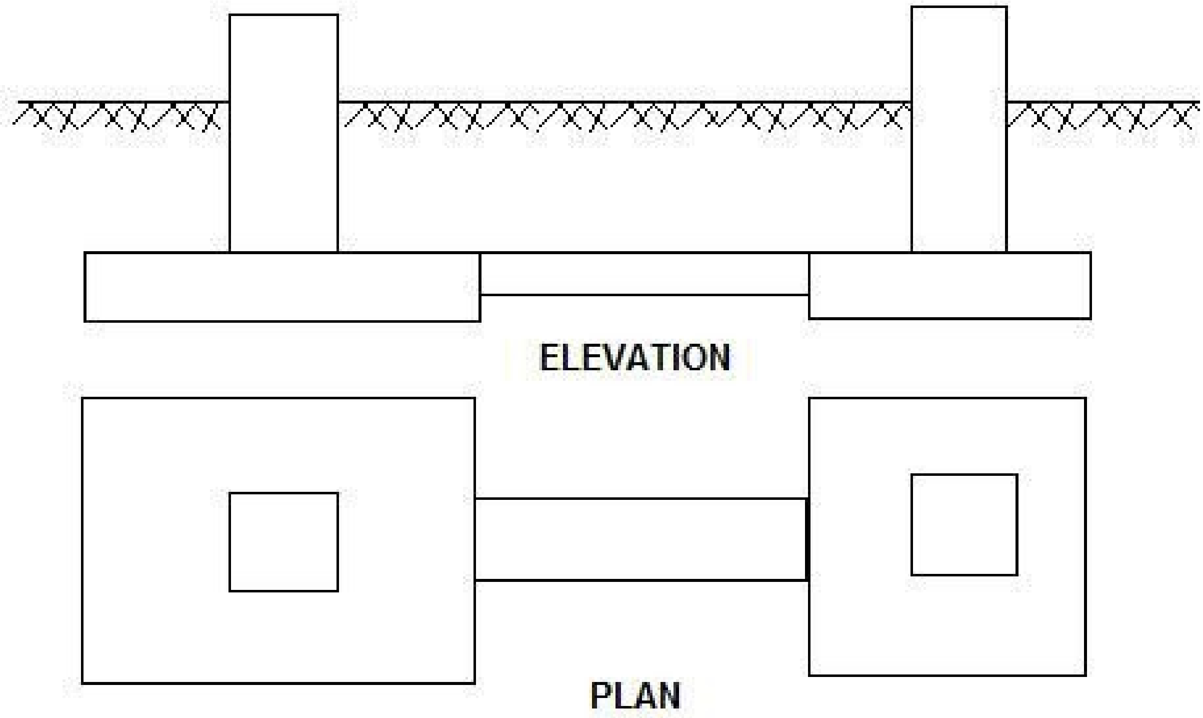


Fig.9

5. Mat or Raft Foundations:

A mat or raft foundation is a large slab supporting a number of columns and walls under the entire structure or a large part of the structure. A mat is required when the allowable soil pressure is low or where the columns and walls are so close that individual footings would overlap or nearly touch each other.

Mat foundations are useful in reducing the differential settlements on non-homogeneous soils or where there is a large variation in the loads on individual columns.

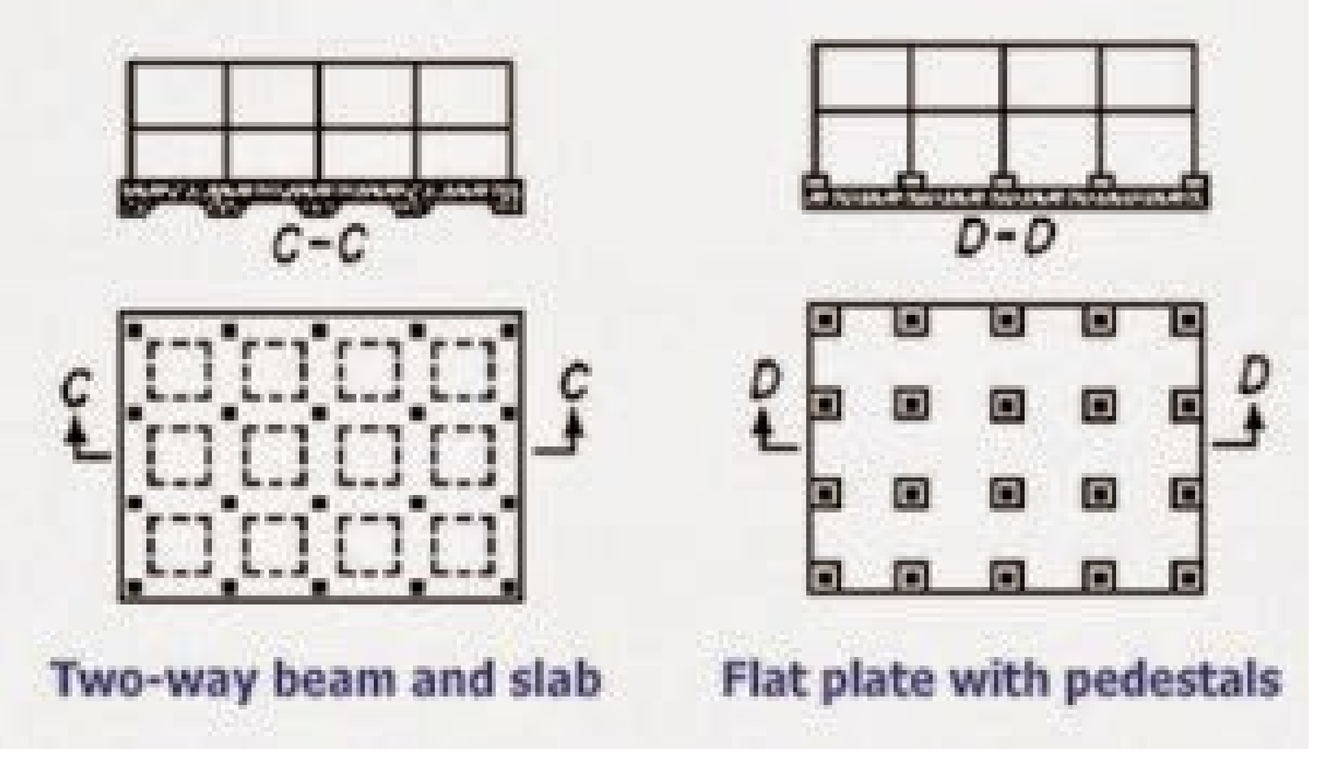


Fig.10

The design of a spread footing is relatively simple compared to the rigorous analysis necessary for the design of a mat foundation. Mat analyses require estimates of the elastic modulus of the subgrade soil to determine the distribution of loading to the subgrade, bending moments and shear for design of the mat foundation. Mat foundation design usually involves use of one of a number of computer programs.

2.3 Raft Foundation:

Raft foundation is a thick concrete slab reinforced with steel which covers the entire contact area of the structure like a thick floor. Sometimes area covered by raft may be greater than the contact area depending on the bearing capacity of the soil underneath. The reinforcing bars runs normal to each other in both top and bottom layers of steel reinforcement.

Raft foundations are preferred in the soil that are suspected to subsidence. Subsidence may occur from different sources like change in ground water level due to climatic change specially in case expansive soil or foundation in mining area.In one words, where deep foundation like pile foundation are not economical and feasible and isolated column footing is impracticable due to large footing size or over-lapping of neighbor footing , raft foundation is the economical solution.

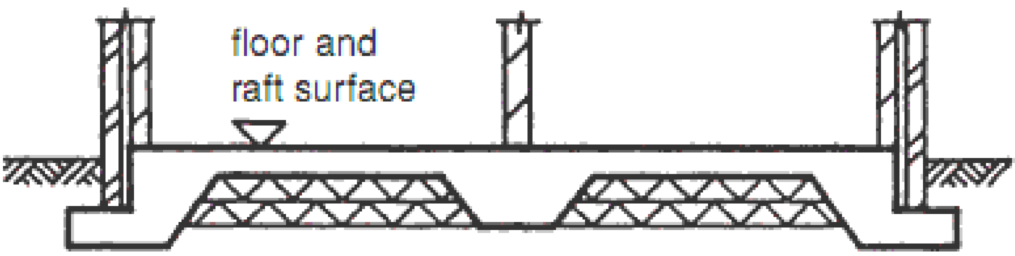


Fig.11

Constrution Site

Pratap Vihar

District: Ghaziabad

State: Uttar Pradesh

Fig. 12

CHAPTER
3. Geotechnical investigation

Geotechnical engineers perform geotechnical investigations to obtain information on the physical properties of soil and rock underlying (and sometimes adjacent to) a site to design earthworks and foundations for proposed structures, and for repair of distress to earthworks and structures caused by subsurface conditions. A geotechnical investigation will include surface exploration and subsurface exploration of a site. Sometimes, geophysical methods are used to obtain data about sites. Subsurface exploration usually involves in-situ testing (two common examples of in-situ tests are the standard penetration test and cone penetration test). In addition site investigation will often include subsurface sampling and laboratory testing of the soil samples retrieved. The digging of test pits and trenching (particularly for locating faults and slide planes) may also be used to learn about soil conditions at depth. Large diameter borings are rarely used due to safety concerns and expense, but are sometimes used to allow a geologist or engineer to be lowered into the borehole for direct visual and manual examination of the soil and rock stratigraphy. A variety of soil samplers exist to meet the needs of different engineering projects. The standard penetration test (SPT), which uses a thick- walled split spoon sampler, is the most common way to collect disturbed samples. Piston samplers, employing a thin-walled tube, are most commonly used for the collection of less disturbed samples. More advanced methods, such as ground freezing and the Sherbrooke block sampler, are superior, but even more expensive. Atterberg limits tests, water content measurements, and grain size analysis, for example, may be performed on disturbed samples obtained from thick walled soil samplers. Properties such as shear strength, stiffness hydraulic conductivity, and coefficient of consolidation may be significantly altered by sample disturbance. To measure these properties in the laboratory, high quality sampling is required. Common tests to measure the strength and stiffness include the triaxial shear and unconfined compression test.

Surface exploration can include geologic mapping, geophysical methods, and photogrammetry; or it can be as simple as an engineer walking around to observe the physical conditions at the site. Geologic mapping and interpretation of geomorphology is typically completed in consultation with a geologist or engineering geologist.

Geophysical exploration is also sometimes used. Geophysical techniques used for subsurface exploration include measurement of seismic waves (pressure, shear, and Rayleigh waves)

3.1 Site Data

TEST OBSERVATIONS

1) Sub soil characteristic at B-2 Pratap Vihar (Ref. Jain etal)

DEPTH (m)	I. S. CLASSIFICATION		GRAIN SIZE ANALYSIS			MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %
	DESCRIPTION	HATCHING	GRAVELS %	SAND %	FINES %			
	CLAY OF LOW COMPRESSIBILITY (CL)		—	22	78	15·9	23·3	15·3
1·5	CLAYEY SILT OF LOW COMPRESSIBILITY (CL–ML)		—	19	81	10·18	22·1	17·4
			—	11	89	14·02	23·6	17·7
3·0	POORLY GRADED SILTY SAND (SP–SM)		—	94	6	22·52	—	—
4·5			—	90	10	23·05	—	—
6·0			—	92	8	23·19	—	—
7·5								
9·0								

FIG. 18 SUB SOIL CHARACTERISTICS AT B-2

Fig.13

2) Standard Penetration Resistance versus Depth

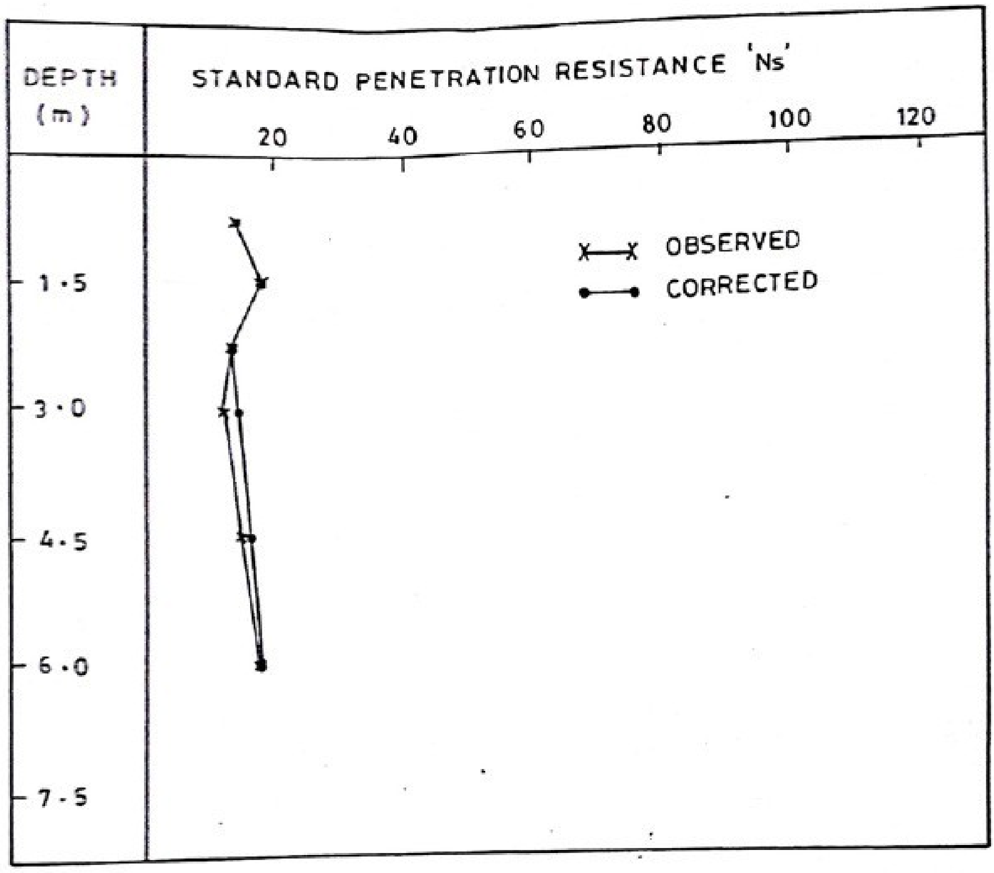


FIG. 5 STANDARD PENETRATION RESISTANCE VERSUS DEPTH

Fig.14

4) Pressure Settlement curve from plate load test.

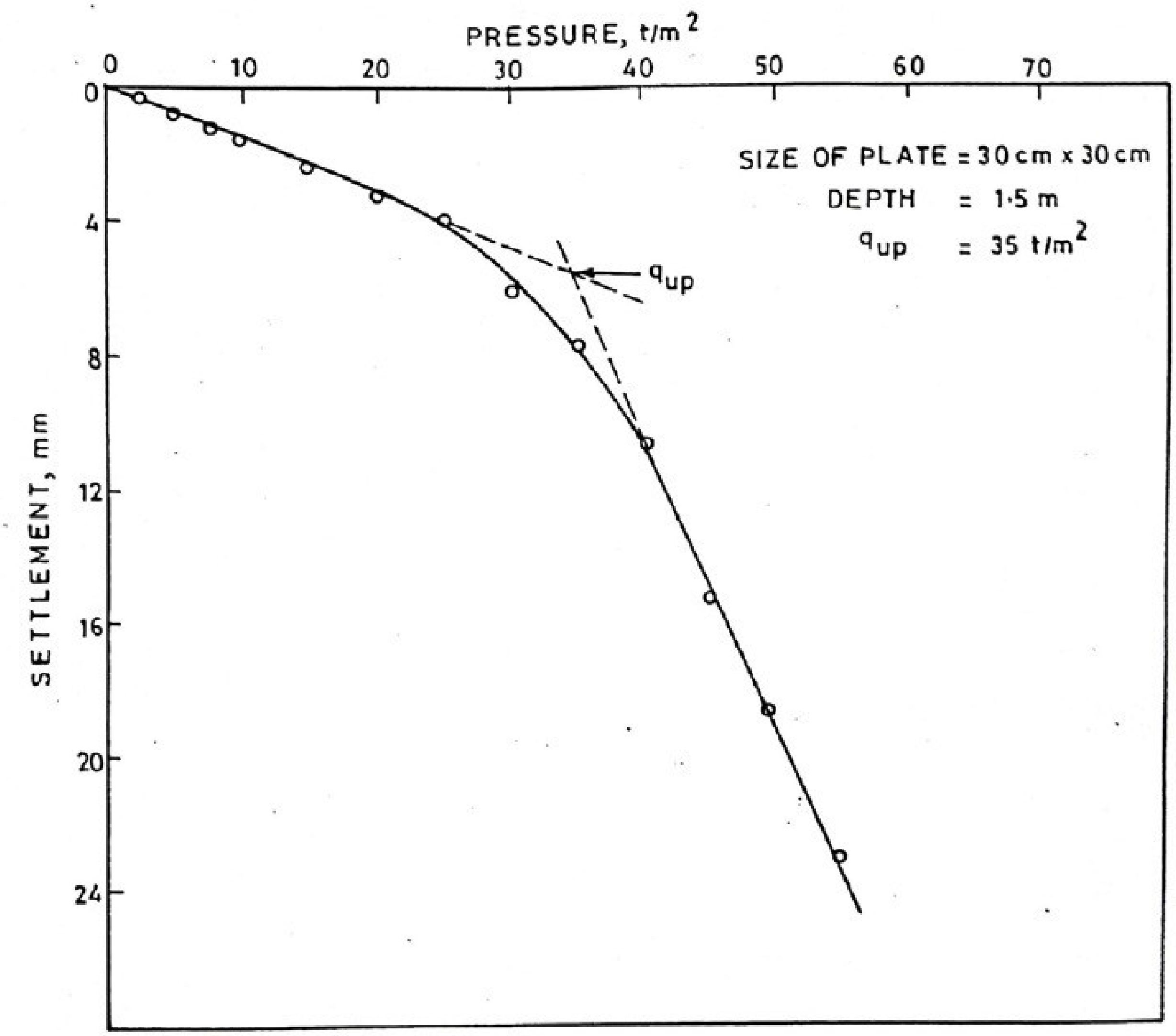


Fig.15

al failure : As stated earlier, local shear

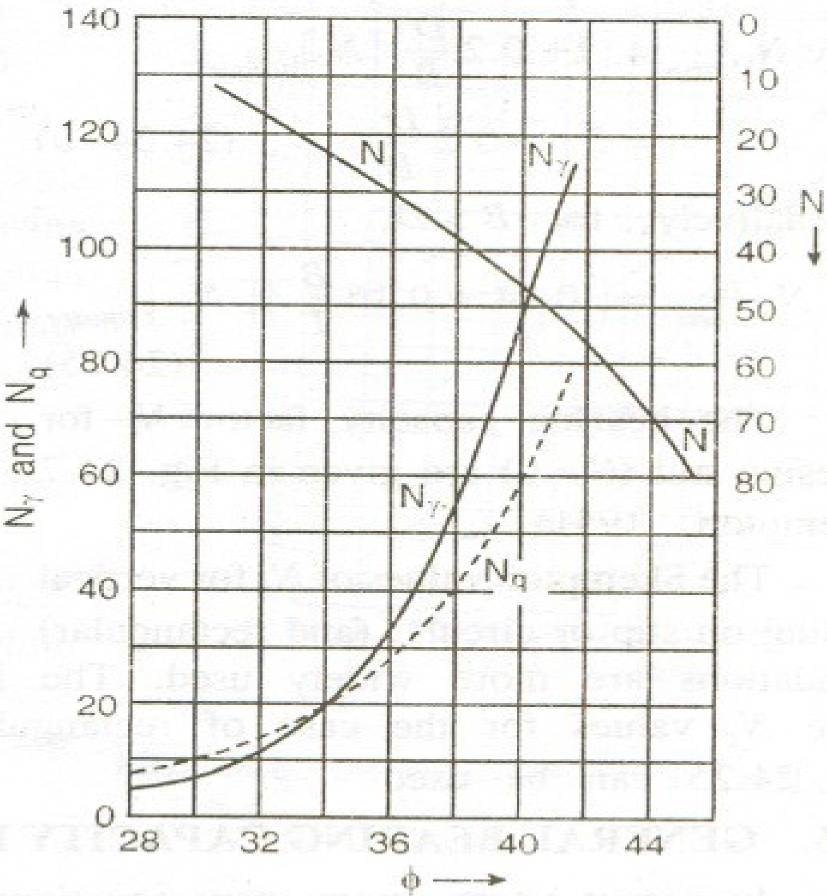


FIG. 24.6. TERZAGHI'S BEARING CAPACITY FACTORS FOR TRANSITIONAL STATE.

Fig.16

3.2 Interpretation of data through graphs

6.1 USING STANDARD PENETRATION TEST

Calculating allowable bearing pressure of soil

(a) Bearing capacity of soil at a depth of 3m using footing size of 3m*3m Using terzaghi's equation :

$(q_u)=cN_c+qN_q+0.5ɣBN_ɣ$

From the data obtained, $N_{Corrected}$=14 at a depth of 3m

Using graph ; $Φ=32^o$ for N=14 For $Φ=32^o$; $N_q=25;N_q=10$

For $Φ=32^o$;we use interpolation & get

N_q(for $Φ=32^o$) =16.4 $N_ɣ$(for $Φ=32^o$)=15.4

Soil profile is poorly graded silty sand at 3m depth. Since $q_{nu}=cN_c+(N_q-1)q+0.5ɣBN_ɣ$ Here,c=0(sand);$q=ɣD_f$=17*3

Therefore qnu=1064.91 kN/m^2

New, $q_{ns}=q_{nu}/FOS$=1064.91/3 kN/m^2=35.4t/m^2

(b) Bearing pressure using settlement criteria : Let allowable settlement =50mm

Using IS code settlement curve
$(q_{np})=25t/m^2$

Applying water table depth correction factor we get, $(q_{np})=25*0.75=18.75t/m^2$

Nabp=min(q_{ns},q_{np})=18.75t/m^2

*When water table rises to base of footing

$(q_{ns})=33.4t/m^2$ $(q_{np})=12.75t/m^2$

$Nabp=min(q_{np},q_{ns})=12.75t/m^2$

6.2 USING PLATE LOAD TEST

Plotting graph between load and settlement & applying the two tangent method,we get

$(q_{nu})_{plate}=35t/m^2$

At a depth of 1.5m & size of footing 1.5m*1.5m

6.3 CALCULATION OF C_u

$(q_u)=1.2cN_c+qN_q+0.4ɣBN_ɣ$ $C=C_u$; $Φ_u=0$; $N_q=1$; $N_ɣ=0$; $N_c=5.7$ $(q_u)=1.2C_u(5.7)+q$

$(q_u-q)=6.8C_u$ $(q_{nu})=6.8C_u$

$C_u=q_{nu}/6.8$ at 1.5m

Given; $q_{up}=350kPa$ $(35t/m^2)$;($q_{nu}=350-ɣD_f$)

Similarly on calculating C_u for various depths using this concept At depth 1.125m ;

$C_u=48.37$ kPa

At depth 2.875m ; $C_u=89.28$ kPa

3.3 Theoretical terms used in the design of idealised soil profile :

Liquid limit- It is the water content at which soil changes from liquid state to plastic state. At this water content, a soil sample changes from possessing no shear strength to having infinitesimal shear strength.

Plastic Limit- It is water content at which a soil changes from plastic to a semisolid state.

Plasticity Index (I_p) – It is the range of moisture content over which a soil exhibits plasticity. I_p = (Liquid Limit – Plastic limit)

I_p	Soil description
0	Non plastic
< 7	Low plastic
7-17	Medium plastic
>17	Highly plastic

Table 1

Consistency index - It tells us how far a soil is from its liquid state.

ic = (Liquid Limit-Natural water content) / Plasticity Index = (WL-Wn)/Ip

Description	Ic
Very soft	0-0.25
soft	0.25-0.50
Medium stiff	0.50-0.75
stiff	0.75-1.0

Table 2

CHAPTER
4. Design of superstructure :

4.1 Dimensions :

Cross section of the building: 11m x 8 m Max. Length of the beam:5 m

Height of the column: 3 m

Cross section of the beam (Used in STAAD PRO) : 350mm x 400mm Cross section of the column(Used in STAAD PRO): 300mm x 500mm

Various loads acting on the superstructure:

4.2 Imposed load or Live Load : Imposed load in our case is taken on the basis of occupancy. Our building is a residential building. From IS 875-part 2, we took the imposed load for residential building as 3 kN/m2.

NOTE: We have not taken snow and rain load, so to compensate these loads and to accommodate processes like expansion of concrete etc. we have taken the same maximum value of imposed load even on the roof top.

4.3 Dead load : Regarding input of dead load in STAAD PRO, it can be done automatically but for the manual considerations we use the following method:

Unit weight of concrete: 25kN/m3

Dead load of an element: 25 x section of element For slab of thickness 125 mm dead load is 3.25kN/m2

Brick load on the structure is 18kN/m Parapet wall load is 0.75kN/m

All loads are in accordance with IS 875-part 1

4.4 Wind load : Wind load is applied to take in account the static and dynamic effects of wind forces on the structures. Wind load will be estimated taking in account the variation in the wind speed with time. the effect of wind on the structure is determined by the combined action of external and internal pressures acting upon it.

Wind load is calculated in accordance to the IS: 875-part 3.

Wind load intensity is kept constant up to 10m as given in IS 875-part 3. After 10m intensity is calculated as

$V_z = V_b * k_1 * k_2 * k_3$

V_z =design wind speed at any height z in m/s; k_1=probability factor;

k_2=terrain height and structure size factor; k_3=topography factor;

V_b= basic wind speed.

Using above formula and evaluating the values of k_1, k_2 , k_3 and V_b, the value of design speed can be calculated. The wind pressure is given

$P_z = 0.6 V_z^2$

From IS Code 875-3, we got the speed at concerned site as 47 m/s. We took the Terrain Category as 1 and Class as A and we computed the wind intensity as follows:

Height(m)	K_1	K_2	K_3	V_b(m/s)	V_z(m/s)	P_z(kN/m2)
10	1	1.05	1	47	49.35	1.461
15	1	1.09	1	47	51.23	1.574

Table 3

4.5 Slab Design

Slab has been designed according to largest area of slab i.e. critical slab

Depth of slab = 200mm

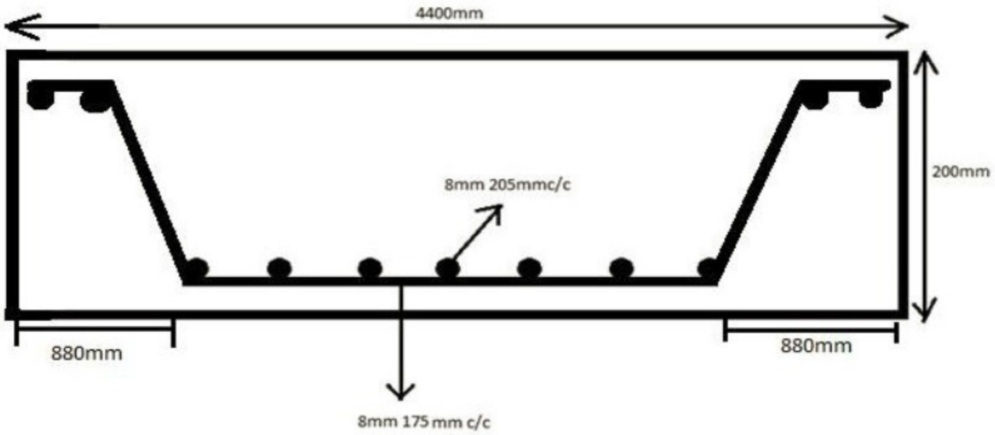


Fig.17

4.6 Modeling the structure via Staad Pro:

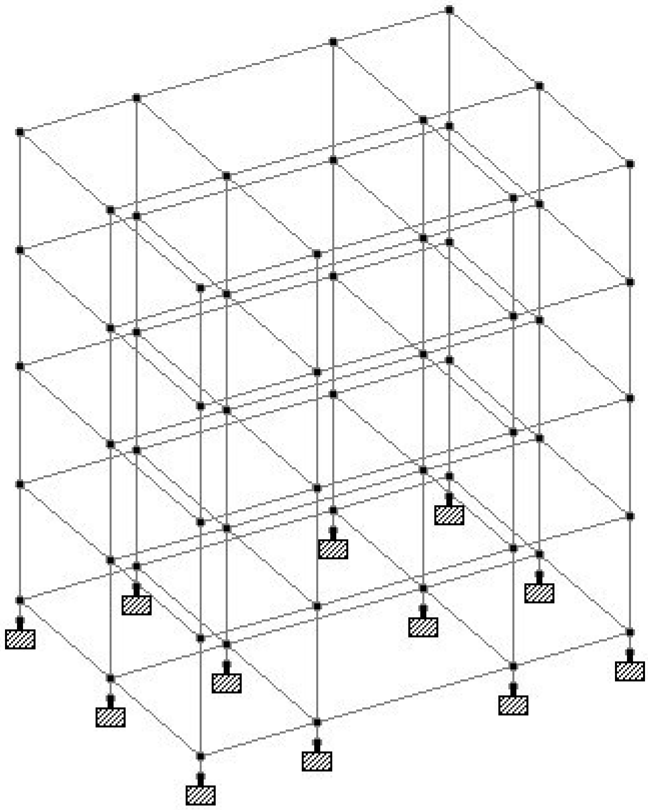


Fig.18 ISOMETRIC VIEW

Software licensed to	Job No	Sheet No 1	Rev
	Part		
Job Title	Ref		
	By	Date 25-Mar-15	Chd
Client	File rcc final.std	Date/Time 17-May-2015 10:04	

Job Information

	Engineer	Checked	Approved
Name:			
Date:	25-Mar-15		

Structure Type	SPACE FRAME

Number of Nodes	72	Highest Node	72
Number of Elements	145	Highest Beam	145

Number of Basic Load Cases	6
Number of Combination Load Cases	20

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DEAD LOAD
Primary	2	LIVE LOAD
Primary	3	WIND LOAD +X
Primary	4	WIND LOAD -X
Primary	5	WIND LOAD +Z
Primary	6	WIND LOAD -Z
Combination	7	GENERATED INDIAN CODE GENRAL_S1
Combination	8	GENERATED INDIAN CODE GENRAL_S1
Combination	9	GENERATED INDIAN CODE GENRAL_S1
Combination	10	GENERATED INDIAN CODE GENRAL_S1
Combination	11	GENERATED INDIAN CODE GENRAL_S1
Combination	12	GENERATED INDIAN CODE GENRAL_S1
Combination	13	GENERATED INDIAN CODE GENRAL_S1
Combination	14	GENERATED INDIAN CODE GENRAL_S1
Combination	15	GENERATED INDIAN CODE GENRAL_S1
Combination	16	GENERATED INDIAN CODE GENRAL_S1
Combination	17	GENERATED INDIAN CODE GENRAL_S1
Combination	18	GENERATED INDIAN CODE GENRAL_S1
Combination	19	GENERATED INDIAN CODE GENRAL_S1
Combination	20	GENERATED INDIAN CODE GENRAL_S1
Combination	21	GENERATED INDIAN CODE GENRAL_S1
Combination	22	GENERATED INDIAN CODE GENRAL_S1
Combination	23	GENERATED INDIAN CODE GENRAL_S1
Combination	24	GENERATED INDIAN CODE GENRAL_S1
Combination	25	GENERATED INDIAN CODE GENRAL_S1
Combination	26	GENERATED INDIAN CODE GENRAL_S1

Table.4

Combination Load Cases

Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
7	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
		2	LIVE LOAD	1.50
8	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.20
		2	LIVE LOAD	1.20
		3	WIND LOAD +X	1.20
9	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.20
		2	LIVE LOAD	1.20
		4	WIND LOAD -X	1.20
10	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.20
		2	LIVE LOAD	1.20
		5	WIND LOAD +Z	1.20
11	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.20
		2	LIVE LOAD	1.20
		6	WIND LOAD -Z	1.20
12	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.20
		2	LIVE LOAD	1.20
		3	WIND LOAD +X	-1.20
13	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.20
		2	LIVE LOAD	1.20
		4	WIND LOAD -X	-1.20
14	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.20
		2	LIVE LOAD	1.20
		5	WIND LOAD +Z	-1.20
15	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.20
		2	LIVE LOAD	1.20
		6	WIND LOAD -Z	-1.20
16	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.20
		2	LIVE LOAD	1.20
17	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
		3	WIND LOAD +X	1.50
18	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
		4	WIND LOAD -X	1.50
19	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
		5	WIND LOAD +Z	1.50
20	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
		6	WIND LOAD -Z	1.50
21	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
		3	WIND LOAD +X	-1.50
22	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
		4	WIND LOAD -X	-1.50
23	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
		5	WIND LOAD +Z	-1.50
24	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
		6	WIND LOAD -Z	-1.50
25	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	1.50
26	GENERATED INDIAN CODE GENRAL_ST	1	DEAD LOAD	0.90

Table.5

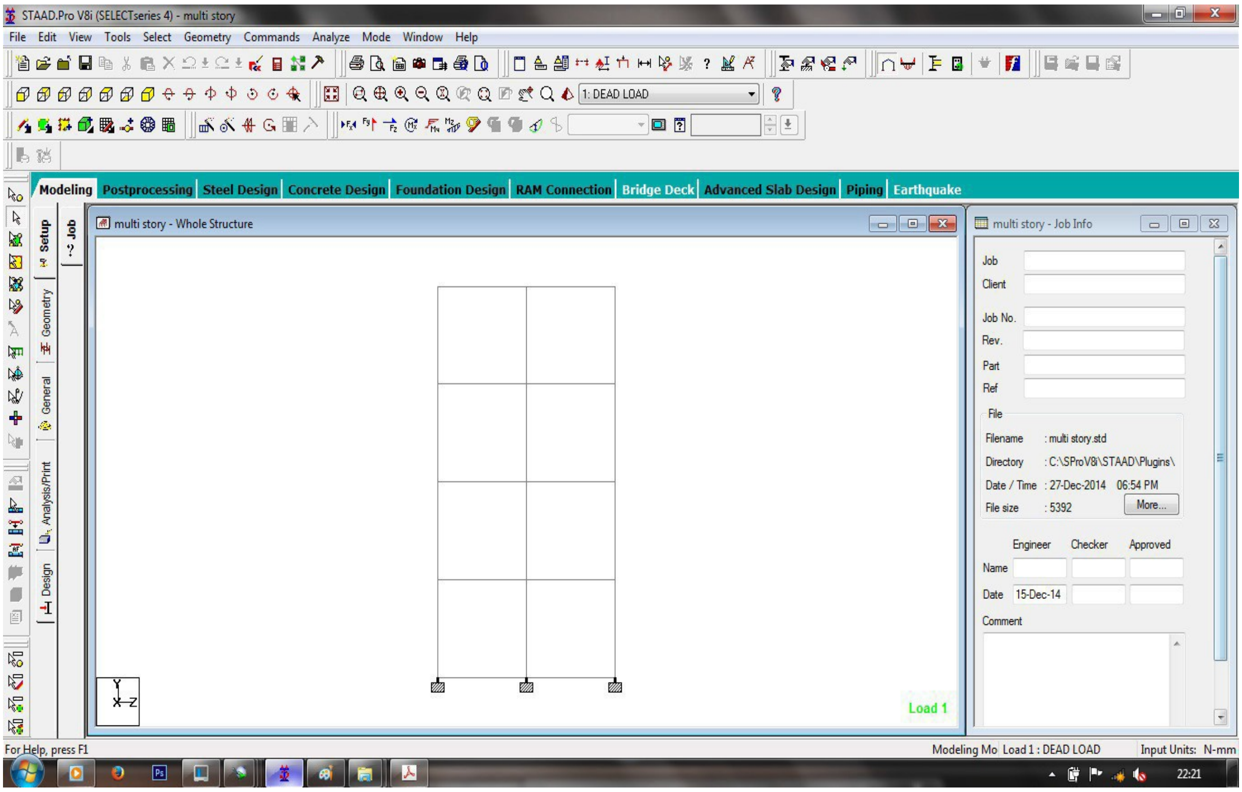


Fig.19 SIDE VIEW

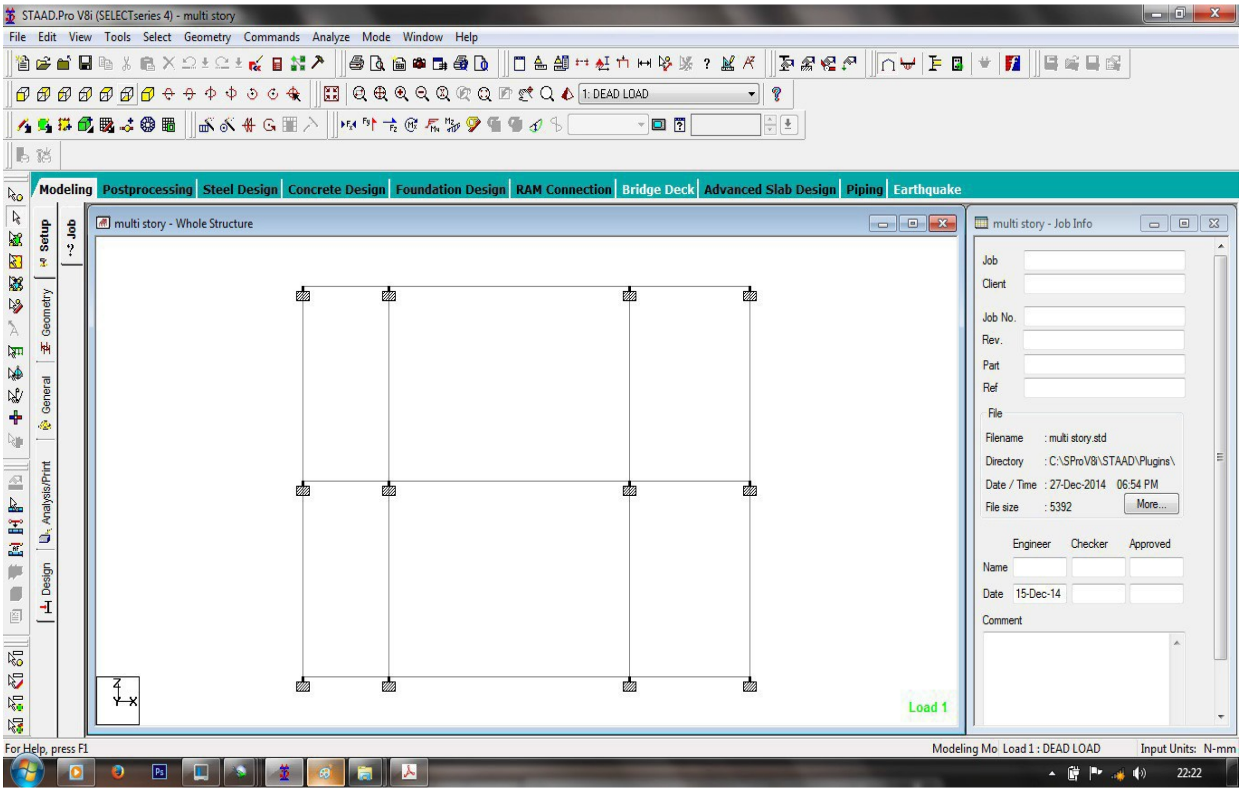


Fig.20 TOP VIEW

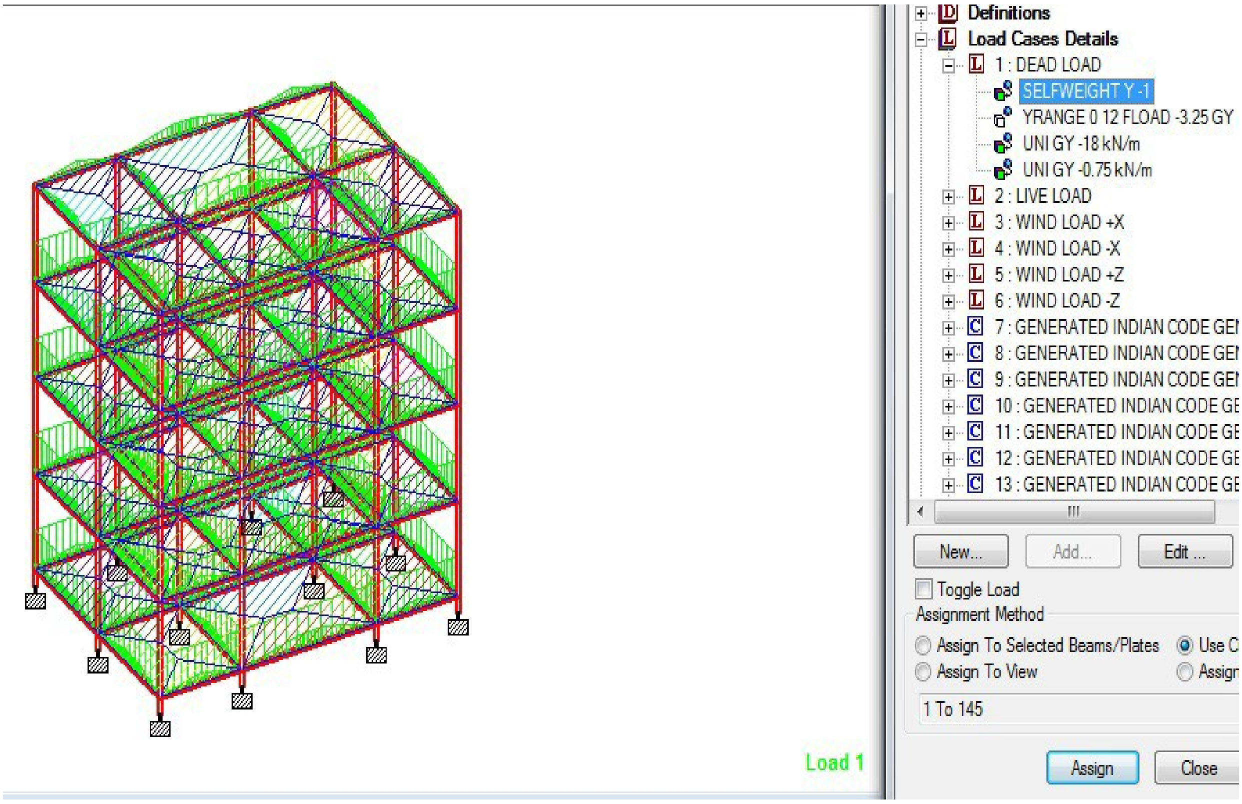


Fig.21 Dead load

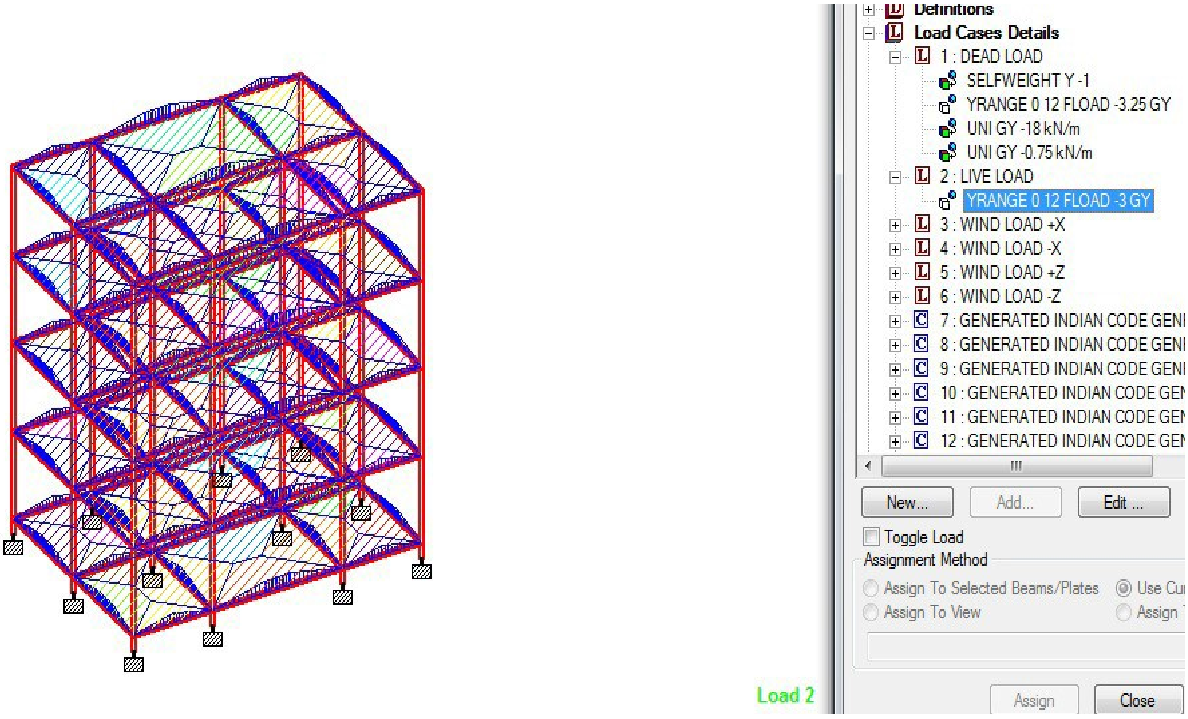


Fig.22 Live Load (3 kN/m2)

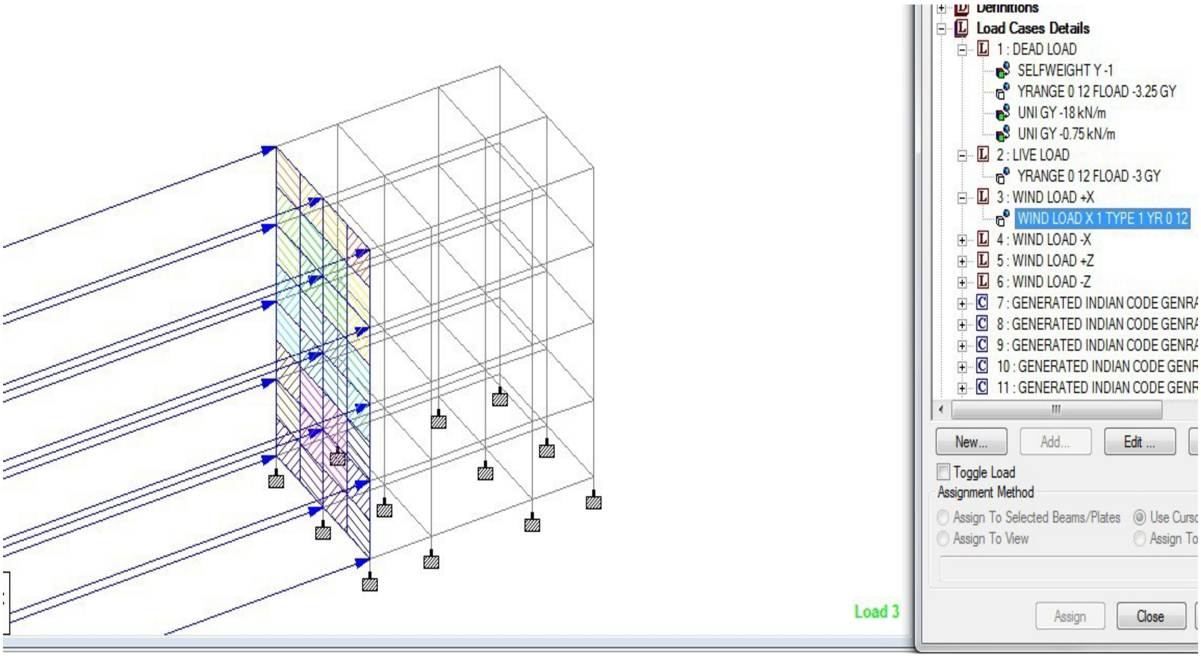


Fig.23 Wind load in +x direction (Exposure 1)

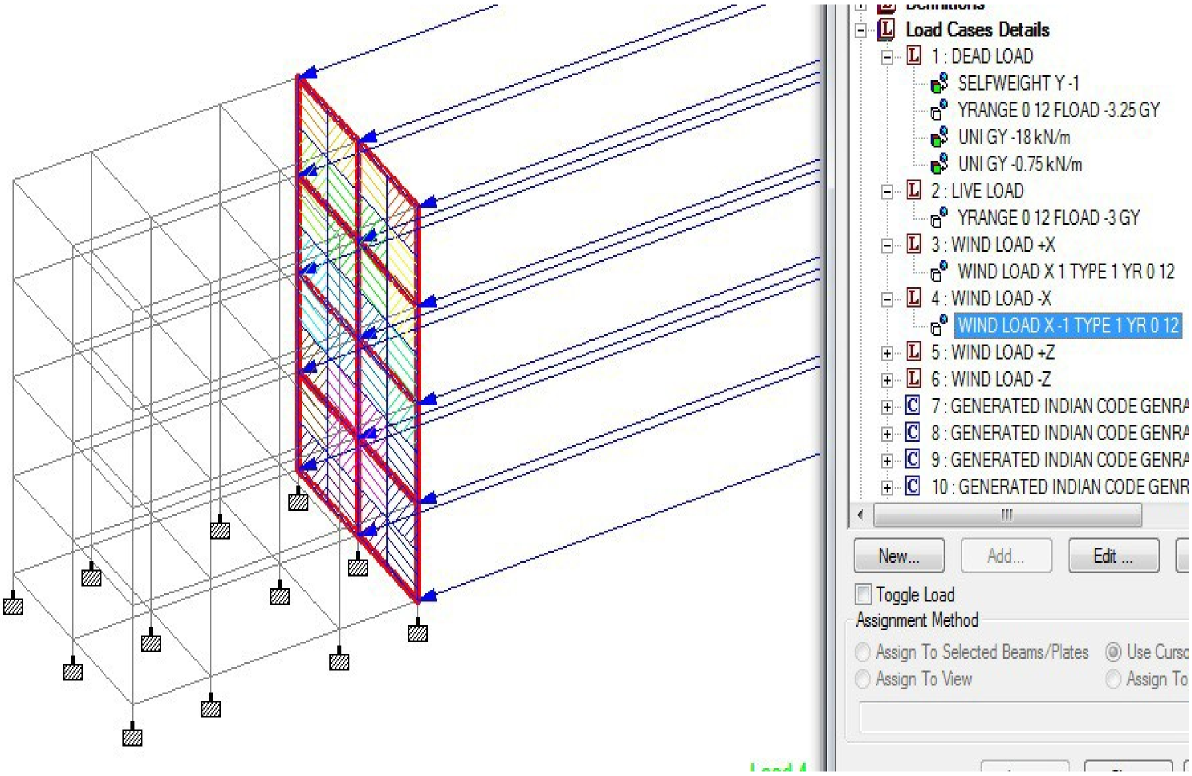


Fig.24 Wind load in -x direction (Exposure 1)

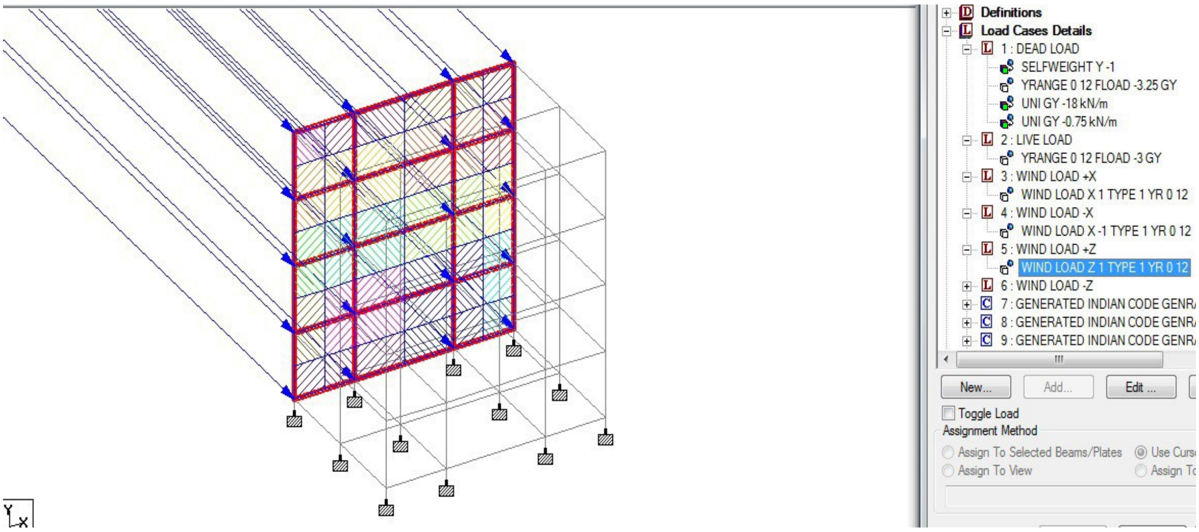


Fig.25 Wind load in +Z direction (Exposure 1)

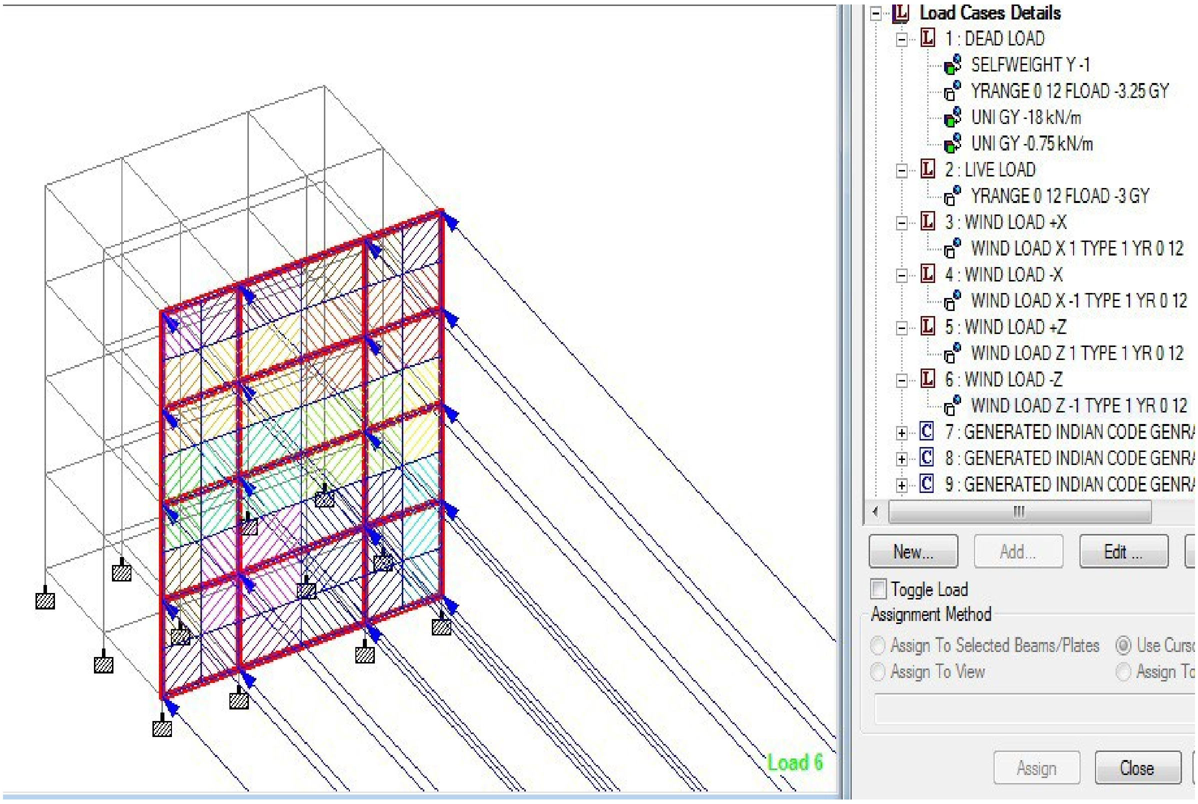


Fig.26 Wind load in -Z direction (Exposure 1)

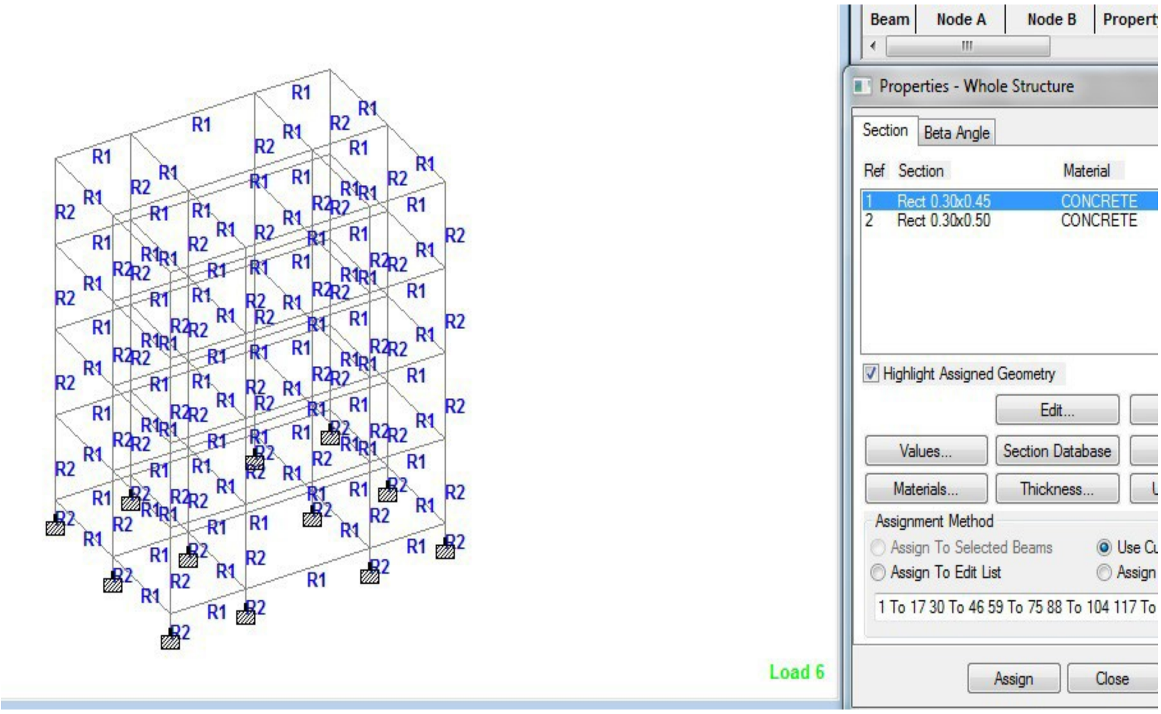


Fig. 27 Properties of RCC Member (R1 - Beam , R2 – Column)

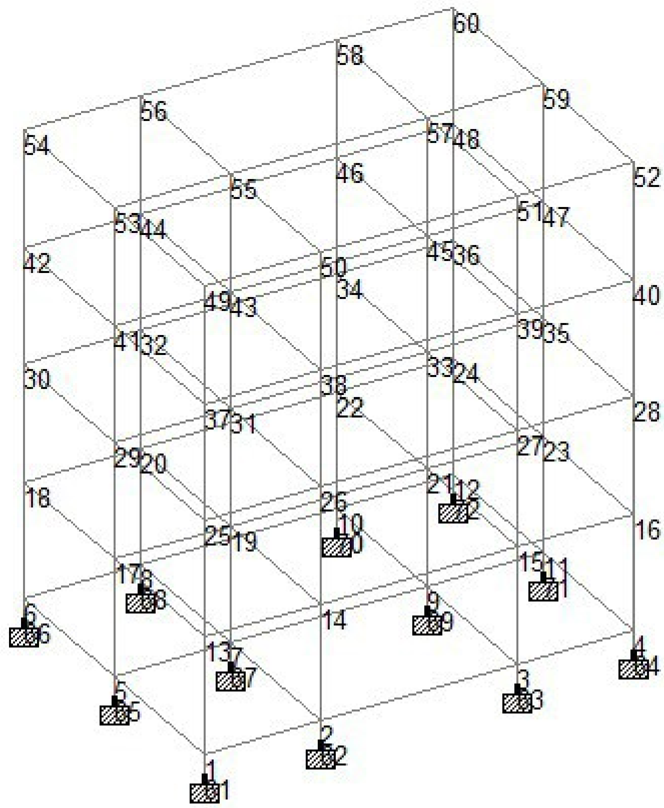


Fig. 28 Node Positions

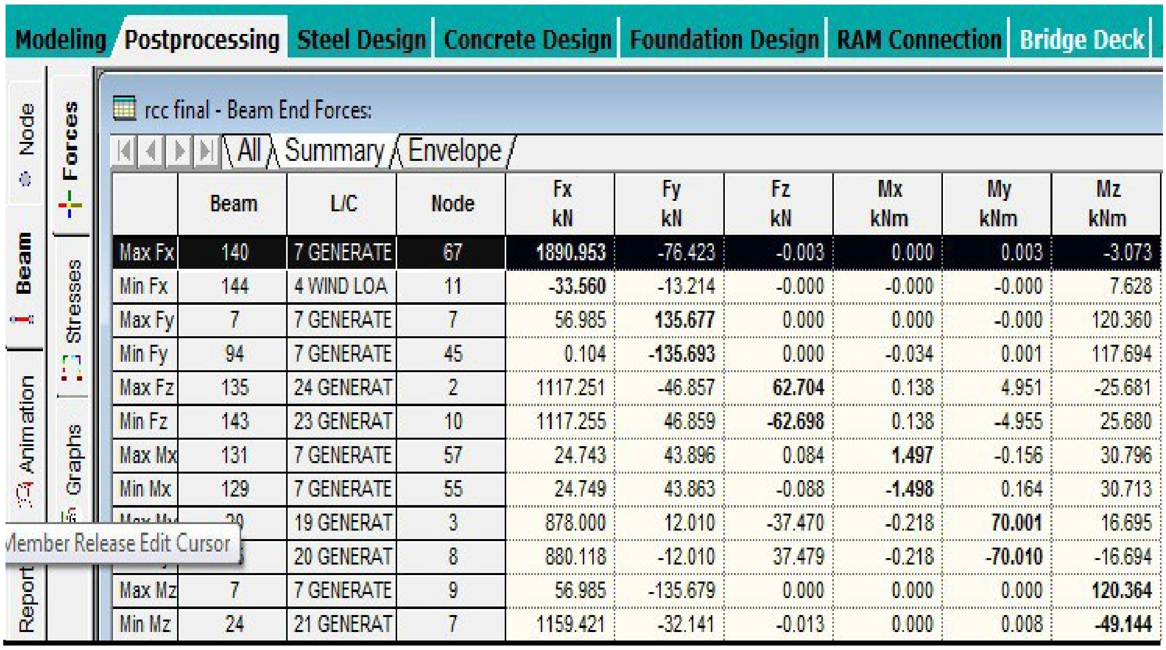
4.7 Analysis for frame via staad pro v8i :

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm	Rotational rX rad	rY rad	rZ rad
Max X	53	17 GENERAT	8.654	-1.496	-0.002	8.782	0.000	-0.000	-0.000
Min X	59	18 GENERAT	-8.649	-1.496	0.000	8.777	0.000	-0.000	0.000
Max Y	54	5 WIND LOA	0.002	0.052	6.153	6.153	0.000	-0.000	0.000
Min Y	55	7 GENERATE	0.032	-3.340	-0.001	3.340	0.000	-0.000	-0.001
Max Z	58	19 GENERAT	-0.015	-1.768	9.433	9.598	0.000	0.000	0.000
Min Z	50	20 GENERAT	0.020	-1.768	-9.435	9.599	-0.000	0.000	-0.000
Max rX	20	19 GENERAT	-0.001	-0.891	2.769	2.909	0.001	-0.000	-0.000
Min rX	14	20 GENERAT	-0.001	-0.889	-2.769	2.908	-0.001	0.000	-0.000
Max rY	25	20 GENERAT	0.002	-0.745	-5.668	5.717	-0.001	0.000	-0.000
Min rY	28	20 GENERAT	-0.001	-0.745	-5.667	5.716	-0.001	-0.000	0.000
Max rZ	21	18 GENERAT	-3.110	-1.346	-0.000	3.388	-0.000	-0.000	0.001
Min rZ	19	17 GENERAT	3.110	-1.348	-0.000	3.390	-0.000	-0.000	-0.001
Max Rs	55	23 GENERAT	0.024	-2.622	-9.396	9.755	-0.000	0.000	-0.000

Fig.29 Maximum node displacement

	Node	L/C	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN	Moment Mx kNm	My kNm	Mz kNm
Max Fx	67	21 GENERAT	80.239	1497.206	0.003	-0.003	0.000	-17.577
Min Fx	69	22 GENERAT	-80.239	1495.179	0.001	0.000	0.000	17.579
Max Fy	67	7 GENERATE	76.423	1890.953	0.003	-0.003	0.000	3.073
Min Fy	71	4 WIND LOA	13.214	-33.560	0.000	0.000	-0.000	-14.235
Max Fz	70	23 GENERAT	-46.859	1119.906	62.698	36.304	0.138	-2.250
Min Fz	62	24 GENERAT	46.857	1119.902	-62.704	-36.302	0.138	2.253
Max Mx	62	20 GENERAT	46.789	1033.359	-3.788	64.155	-0.130	2.288
Min Mx	70	19 GENERAT	-46.792	1033.363	3.782	-64.153	-0.130	-2.285
Max My	66	19 GENERAT	8.744	545.160	6.545	-56.663	0.178	5.968
Min My	72	19 GENERAT	-8.743	545.062	6.544	-56.668	-0.178	-5.967
Max Mz	65	17 GENERAT	-11.034	870.980	0.002	0.003	0.000	28.226
Min Mz	71	18 GENERAT	11.036	870.885	-0.000	-0.000	0.000	-28.225

Fig.30 Maximum Support Reactions



	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	140	7 GENERATE	67	1890.953	-76.423	-0.003	0.000	0.003	-3.073
Min Fx	144	4 WIND LOA	11	-33.560	-13.214	-0.000	-0.000	-0.000	7.628
Max Fy	7	7 GENERATE	7	56.985	135.677	0.000	0.000	-0.000	120.360
Min Fy	94	7 GENERATE	45	0.104	-135.693	0.000	-0.034	0.001	117.694
Max Fz	135	24 GENERAT	2	1117.251	-46.857	62.704	0.138	4.951	-25.681
Min Fz	143	23 GENERAT	10	1117.255	46.859	-62.698	0.138	-4.955	25.680
Max Mx	131	7 GENERATE	57	24.743	43.896	0.084	1.497	-0.156	30.796
Min Mx	129	7 GENERATE	55	24.749	43.863	-0.088	-1.498	0.164	30.713
Max My	20	19 GENERAT	3	878.000	12.010	-37.470	-0.218	70.001	16.695
[illegible]	[illegible]	20 GENERAT	8	880.118	-12.010	37.479	-0.218	-70.010	-16.694
Max Mz	7	7 GENERATE	9	56.985	-135.679	0.000	0.000	0.000	120.364
Min Mz	24	21 GENERAT	7	1159.421	-32.141	-0.013	0.000	0.008	-49.144

Fig.31 Maximum Beam End Forces

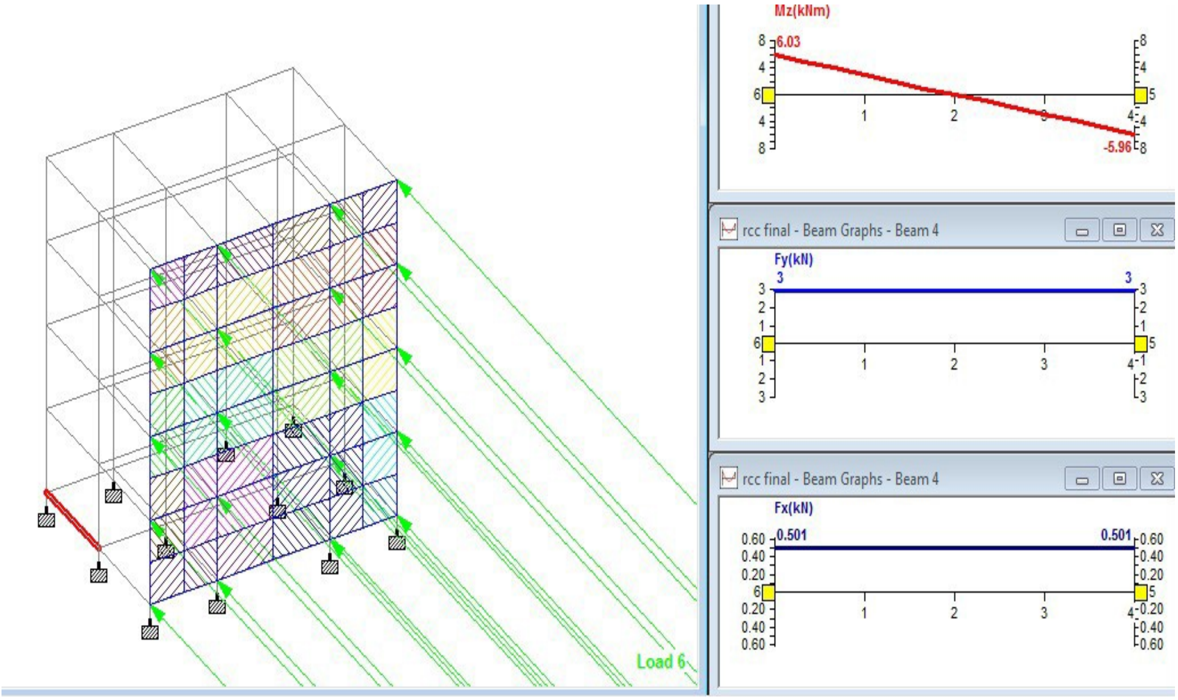


Fig.32 Beam Graphs

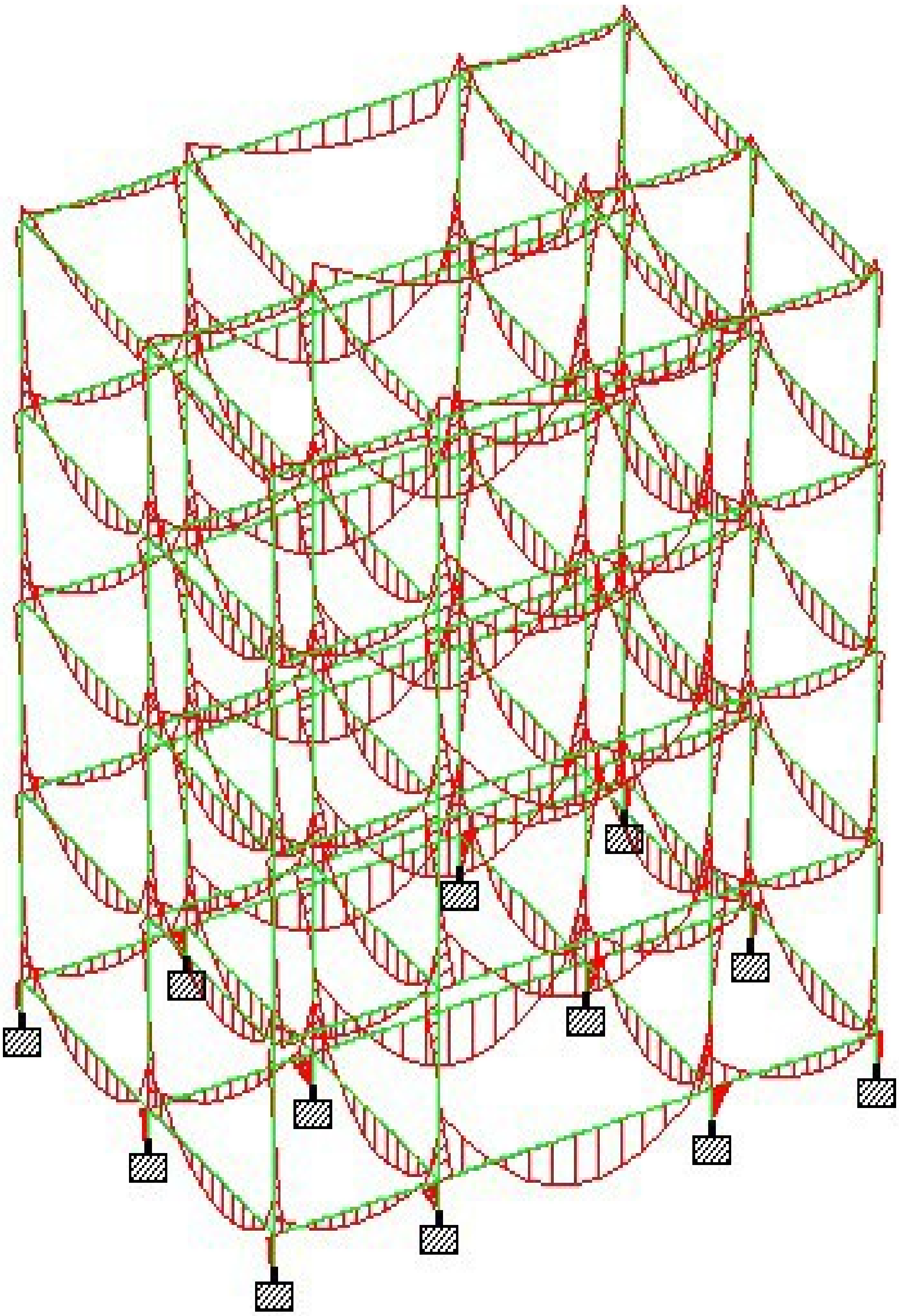


Fig.33 Bending moment in Z direction (Load Case 1 & Scale 50kNm/m))

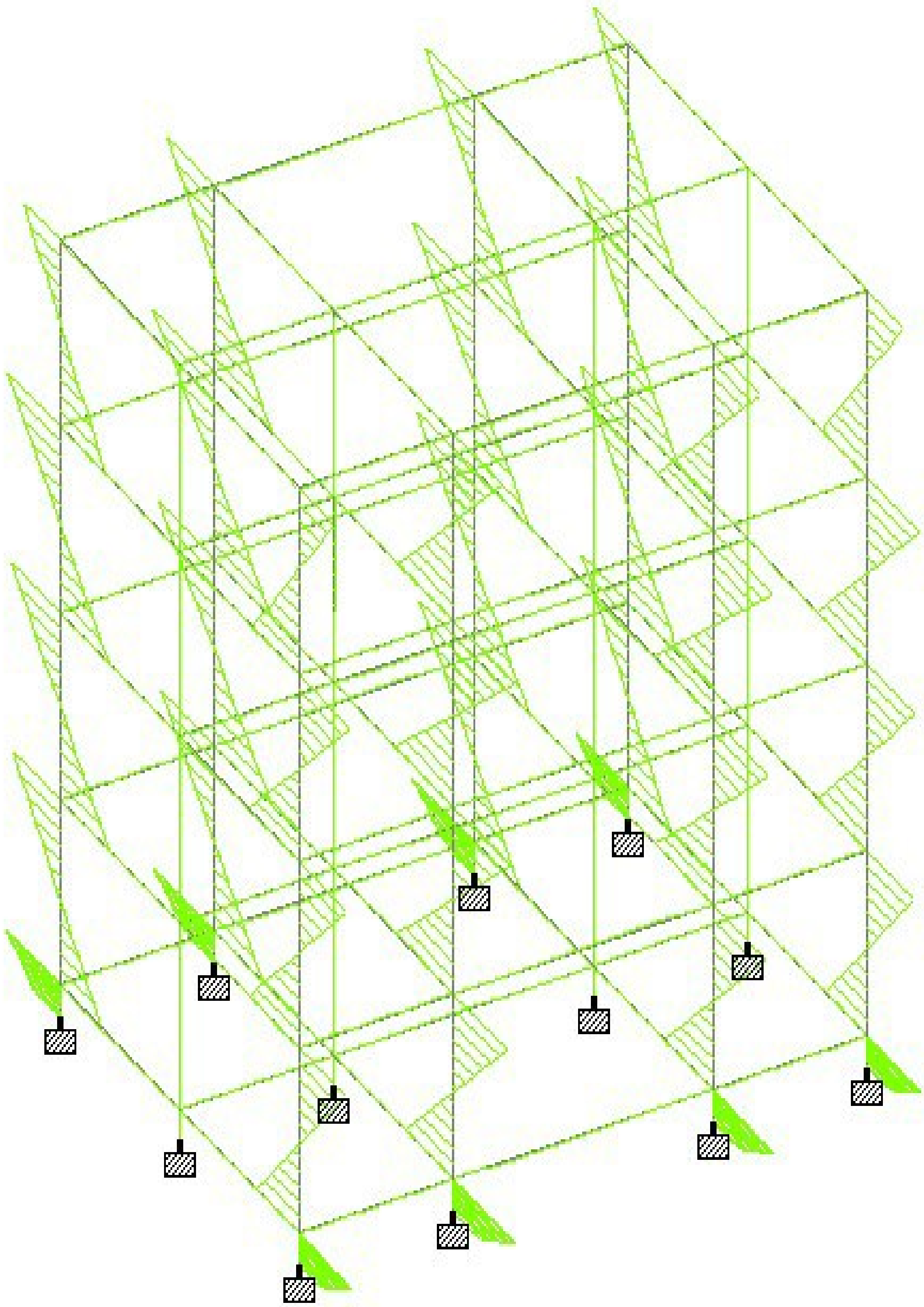


Fig.34 Bending moment in Y direction (Load Case 1 & Scale of 10kNm/m)

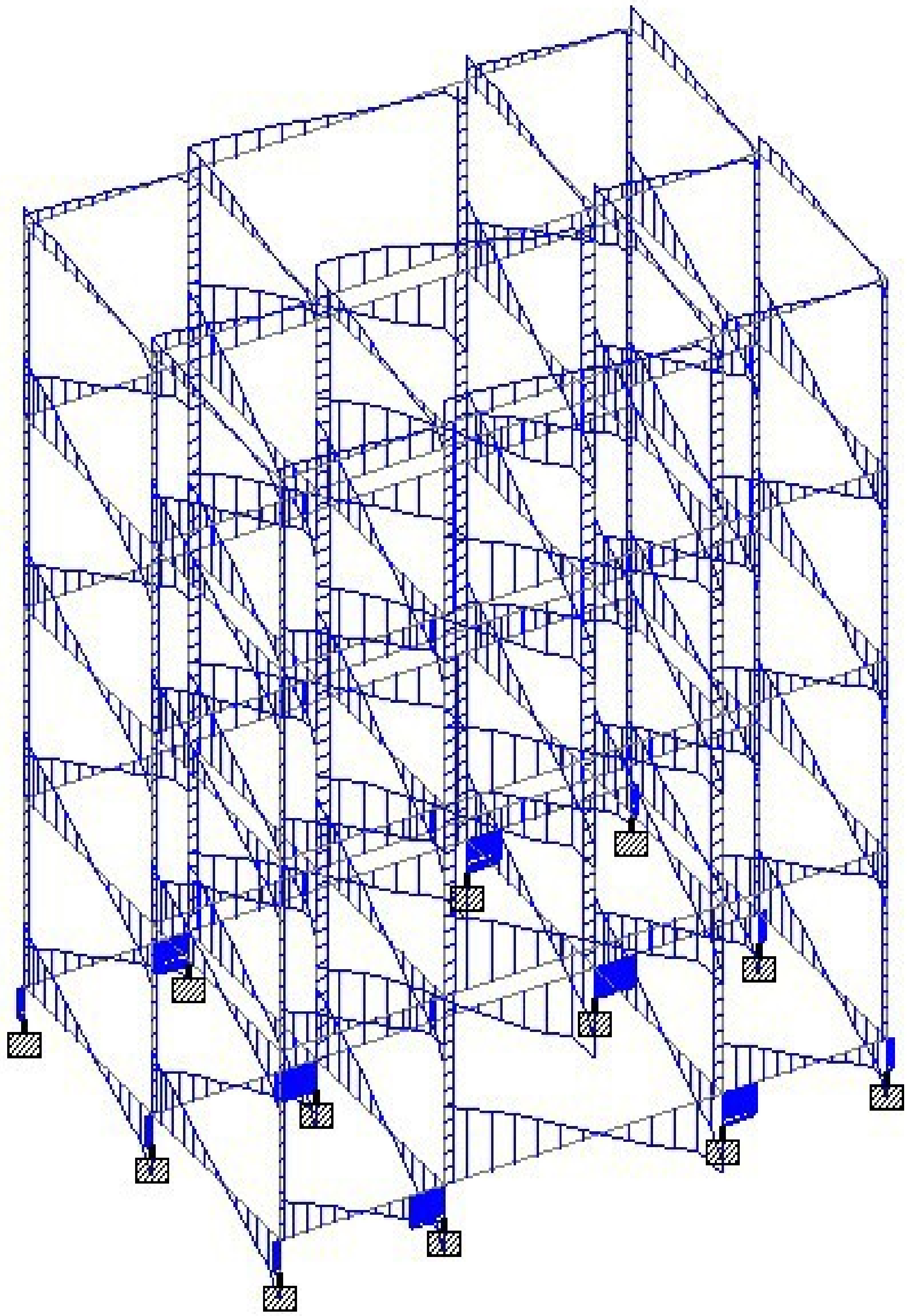


Fig.35 Shear Force in Y direction (Load Case 1 & Scale of 50kN/m)

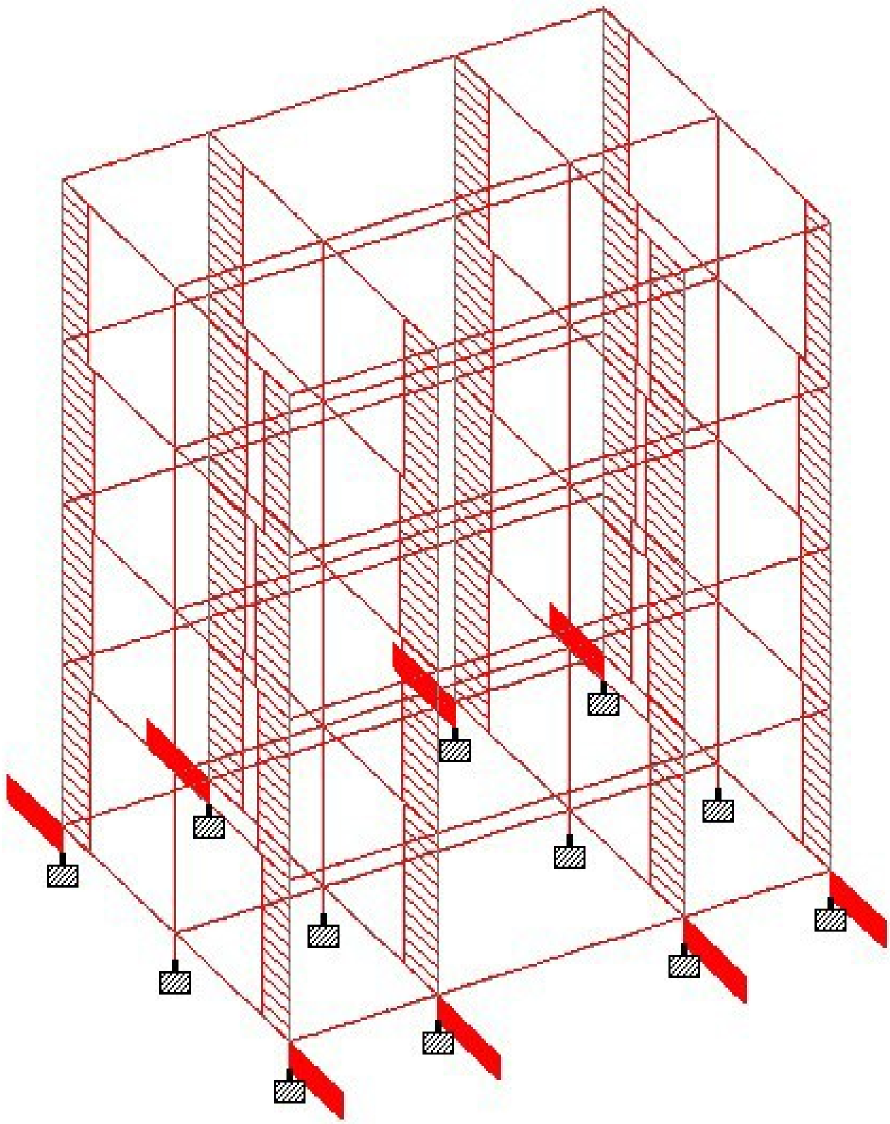


Fig.36 Shear Force in Z direction (Load Case 1 & Scale of 10kN/m)

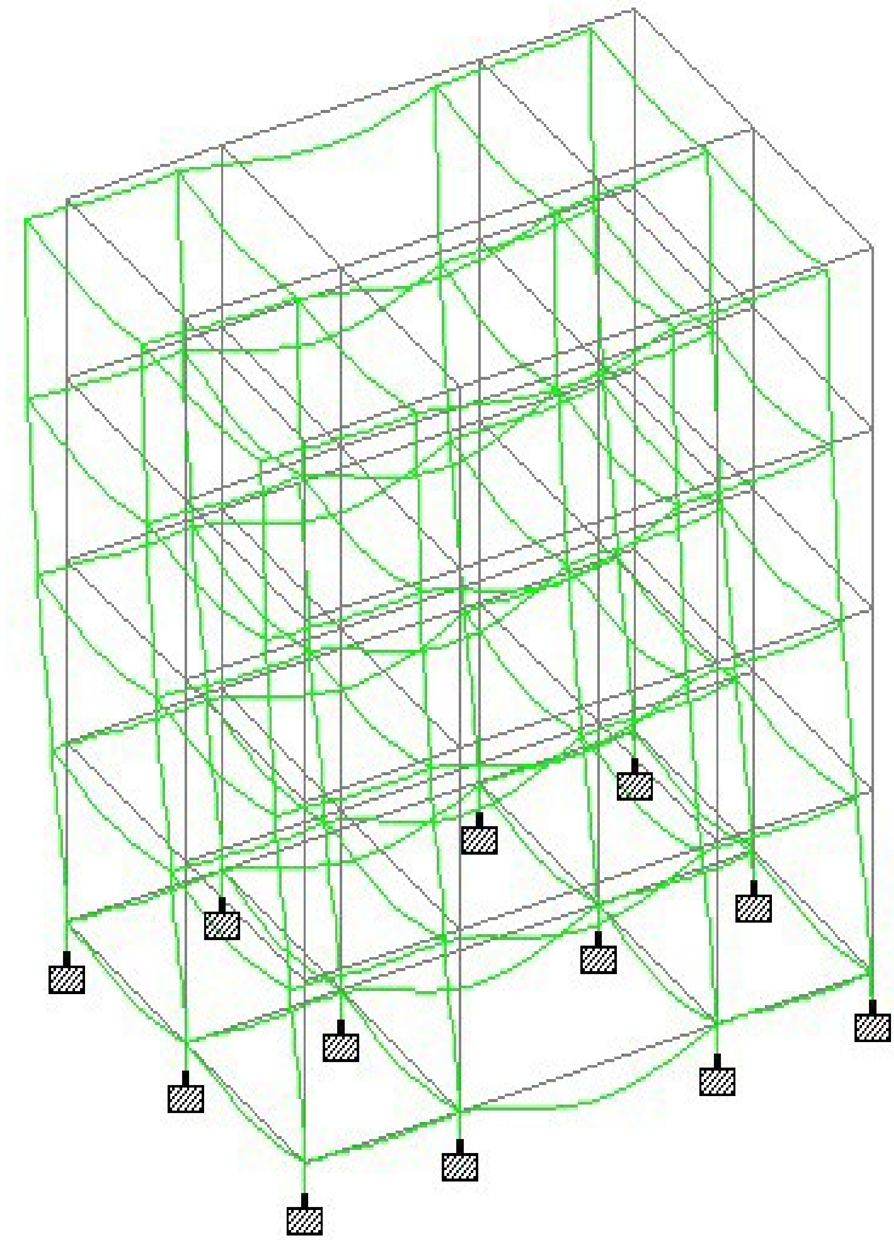


Fig.37 Displacement (Load Case 18 & Scale of 10mm/m)

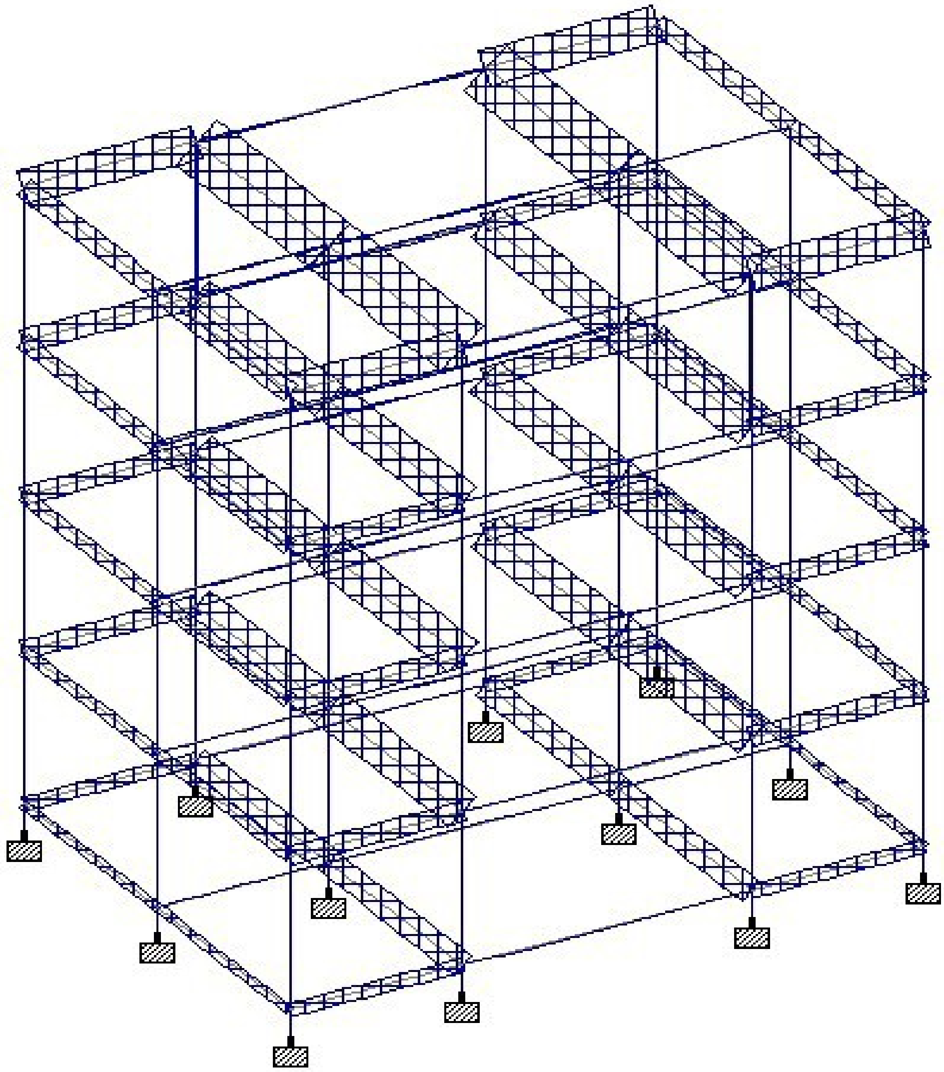


Fig.38 Torsion (Load Case 1 & scale 1kN/m)

4.8 Design for frame via staad pro v8i :

```
NOTE: CONCRETE QUANTITY REPRESENTS VOLUME OF CONCRETE IN BEAMS, COLUMNS, AND PLATES DESIGNED ABOVE.
      REINFORCING STEEL QUANTITY REPRESENTS REINFORCING STEEL IN BEAMS AND COLUMNS DESIGNED ABOVE.
      REINFORCING STEEL IN PLATES IS NOT INCLUDED IN THE REPORTED QUANTITY.

     TOTAL VOLUME OF CONCRETE =        65.5 CU.METER

                    BAR DIA          WEIGHT
                    (in mm)         (in New)
                    --------        --------
                       8             14654
                      10             11228
                      12             20801
                      16               286
                      20              7273
                                 ------------
                   *** TOTAL=        54243

 133. LOAD LIST 1
```

Fig.39 Volume of Concrete and Steel

Beam Design

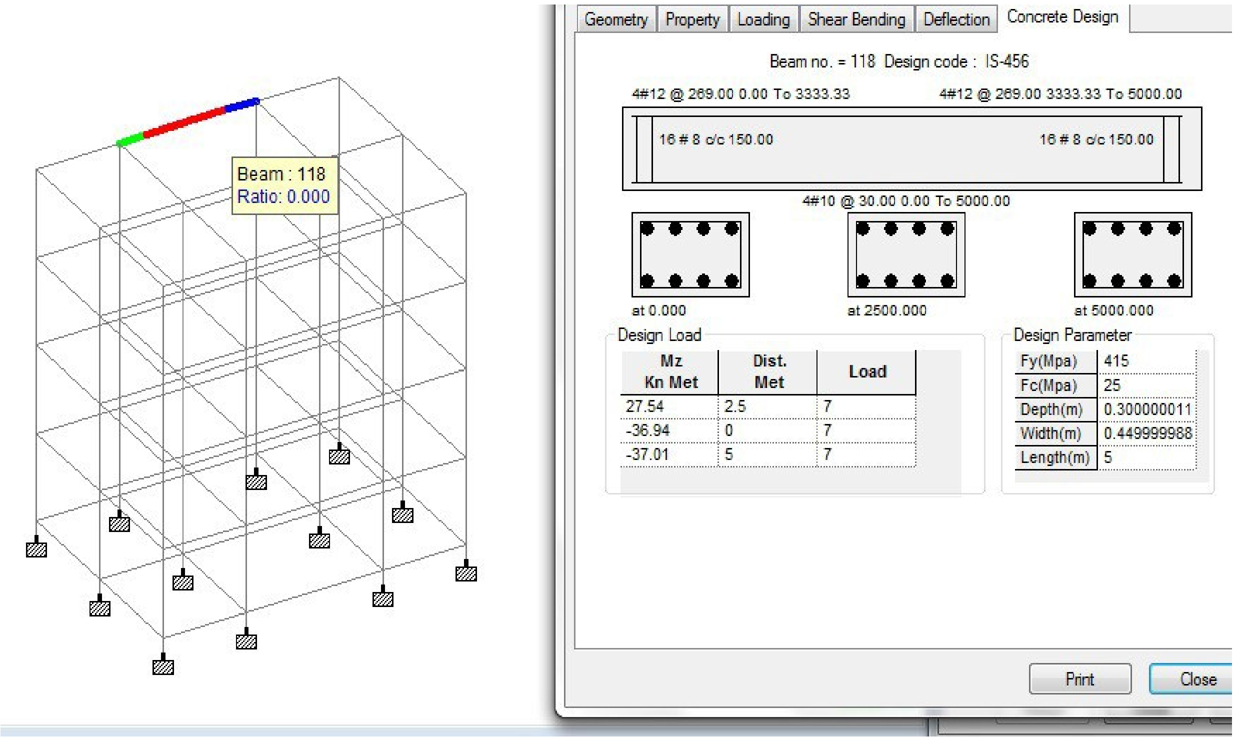


Fig.40 Beam 118 Design

B E A M N O. 118 D E S I G N R E S U L T S

M25   Fe415 (Main)   Fe415 (Sec.)

LENGTH: 5000.0 mm   SIZE: 450.0 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 REINF.	403.08 (Sq. mm)	248.86 (Sq. mm)	248.86 (Sq. mm)	248.86 (Sq. mm)	403.92 (Sq. mm)
BOTTOM REINF.	248.86 (Sq. mm)	248.86 (Sq. mm)	294.74 (Sq. mm)	248.86 (Sq. mm)	248.86 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP REINF.	4-12í 1 layer(s)	4-12í 1 layer(s)	4-12í 1 layer(s)	4-12í 1 layer(s)	4-12í 1 layer(s)
BOTTOM REINF.	4-10í 1 layer(s)	4-10í 1 layer(s)	4-10í 1 layer(s)	4-10í 1 layer(s)	4-10í 1 layer(s)
SHEAR REINF.	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c

Fig.41 Beam 118 Design Calculation

Column Design

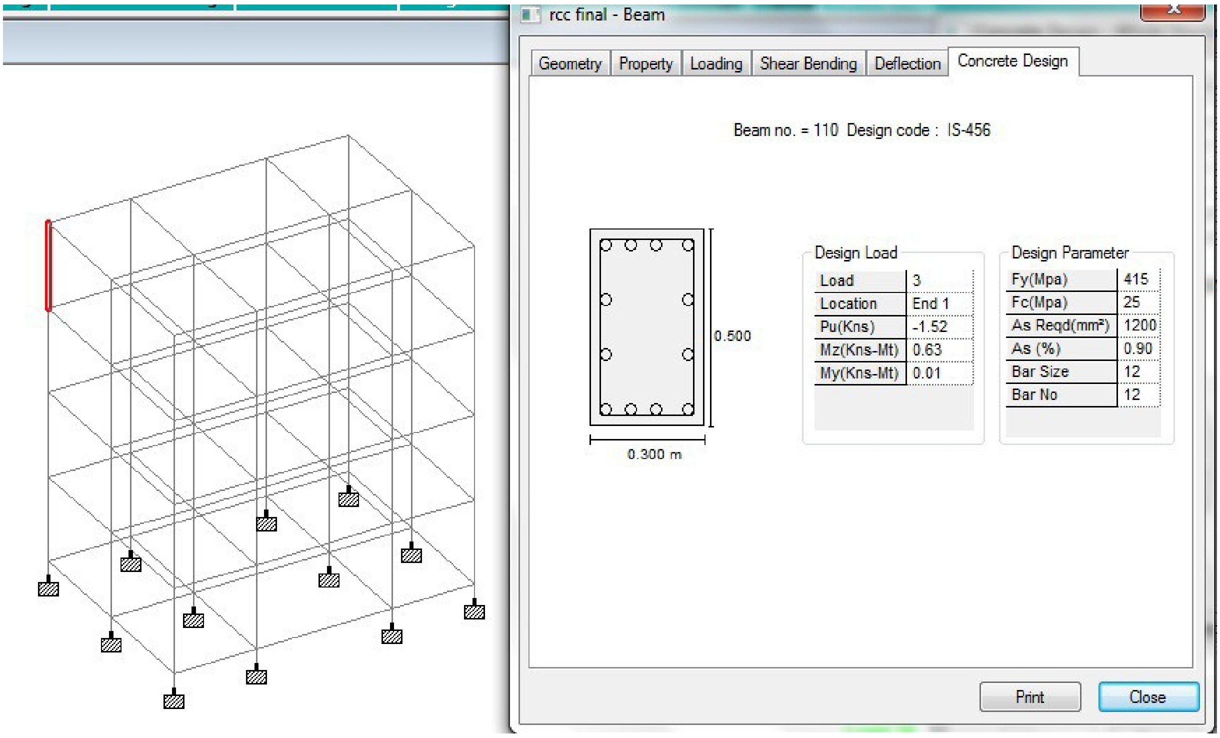


Fig.42 Column 110 Design

```
         C O L U M N   N O.   110  D E S I G N   R E S U L T S

      M25                     Fe415 (Main)             Fe415 (Sec.)

 LENGTH:  3000.0 mm   CROSS SECTION:  500.0 mm X  300.0 mm  COVER: 40.0 mm

 ** GUIDING LOAD CASE:    3 END JOINT:    42  TENSION COLUMN


 REQD. STEEL AREA   :     1200.00 Sq.mm.
 REQD. CONCRETE AREA:   148800.00 Sq.mm.
 MAIN REINFORCEMENT : Provide  12 - 12 dia. (0.90%,   1357.17 Sq.mm.)
                      (Equally distributed)
 TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 190 mm c/c

 SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
 ----------------------------------------------------------
 Puz :   2047.50   Muz1 :     50.68   Muy1 :     91.04

 INTERACTION RATIO: 0.01 (as per Cl. 39.6, IS456:2000)

 SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
 ----------------------------------------------------------
 WORST LOAD CASE:     7
 END JOINT:    42 Puz :   2094.65   Muz :     62.94   Muy :    114.82   IR: 0.45
--------------------------------< PAGE 100 Ends Here >---------------------------
  STAAD SPACE                                            -- PAGE NO.  101
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Fig.43 Column 110 Design Calculation

CHAPTER

5. Design of Substructure

5.1 Design of footing using Staad Foundation

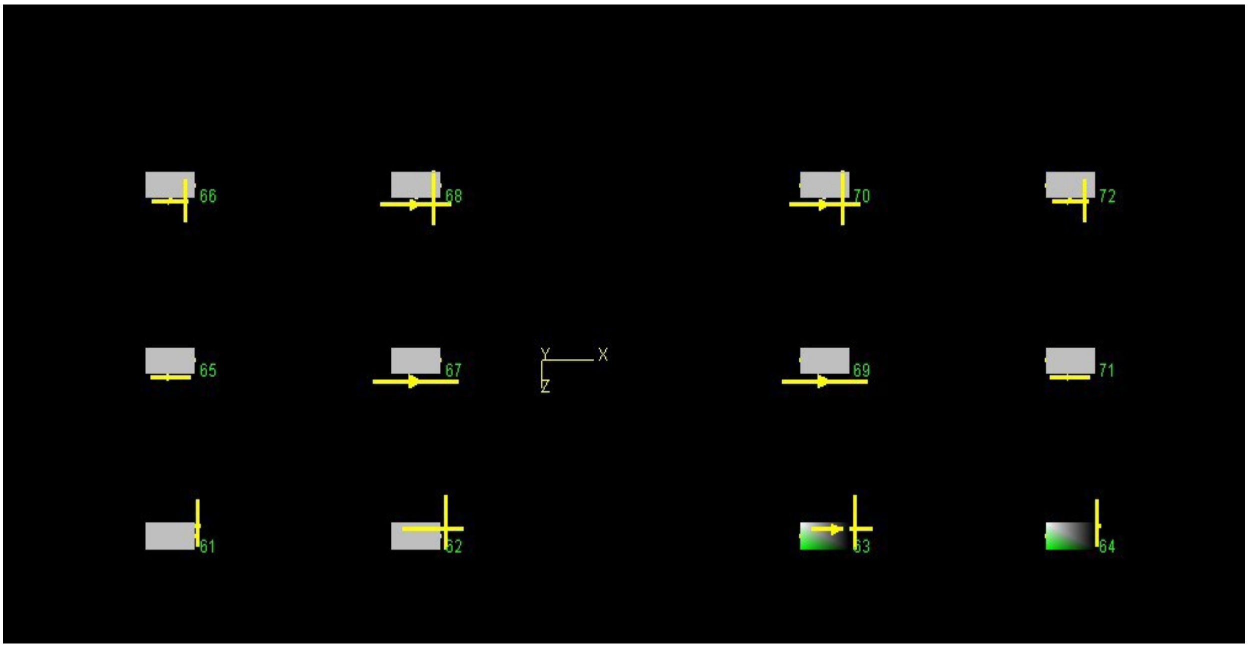

Fig.44 Footing Plan

Fig.45 Footing Isometric View

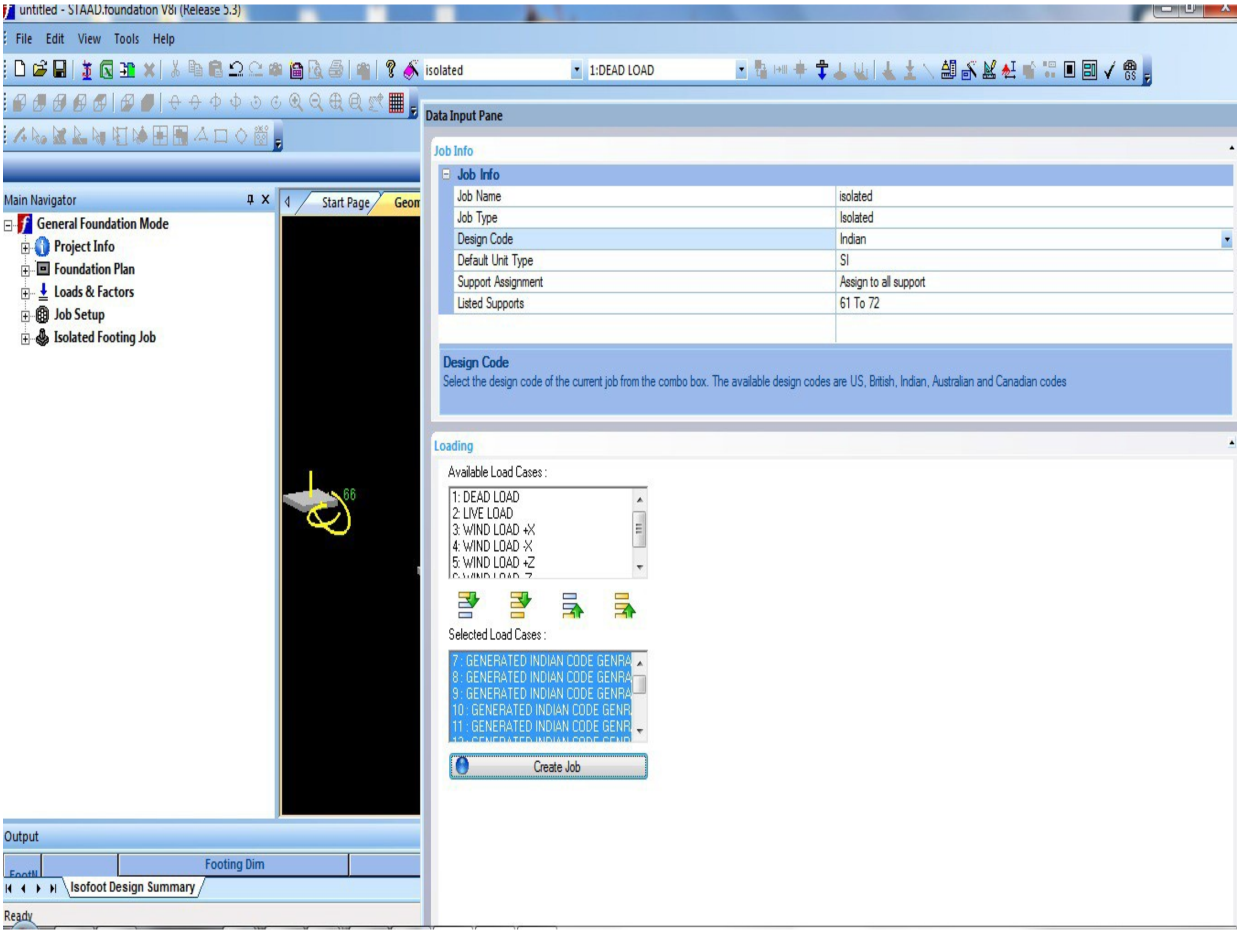

Fig.46 Job Creation for Isolated Footing

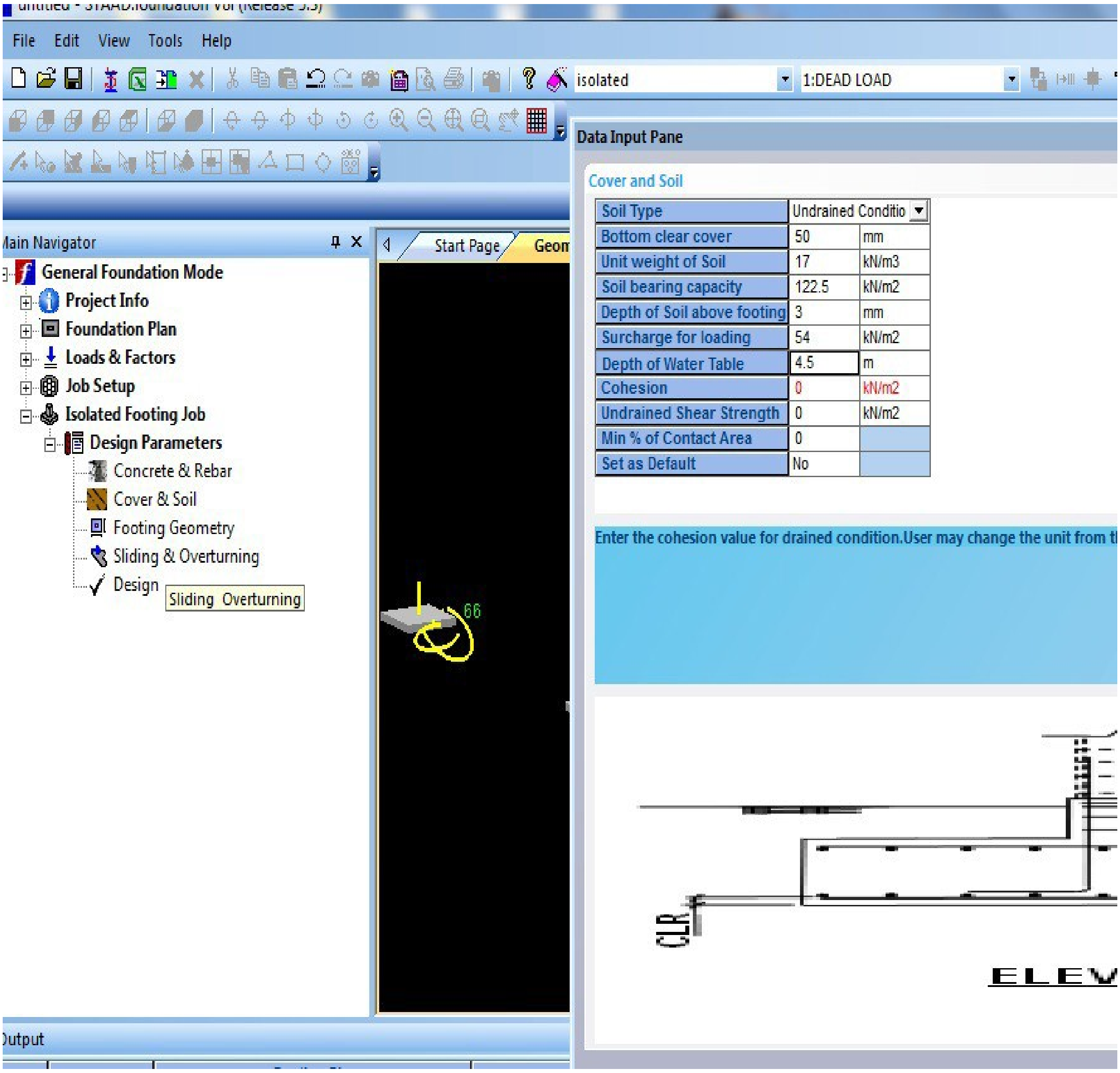

Fig.47 Soil Parameters in Isolated Footing Design

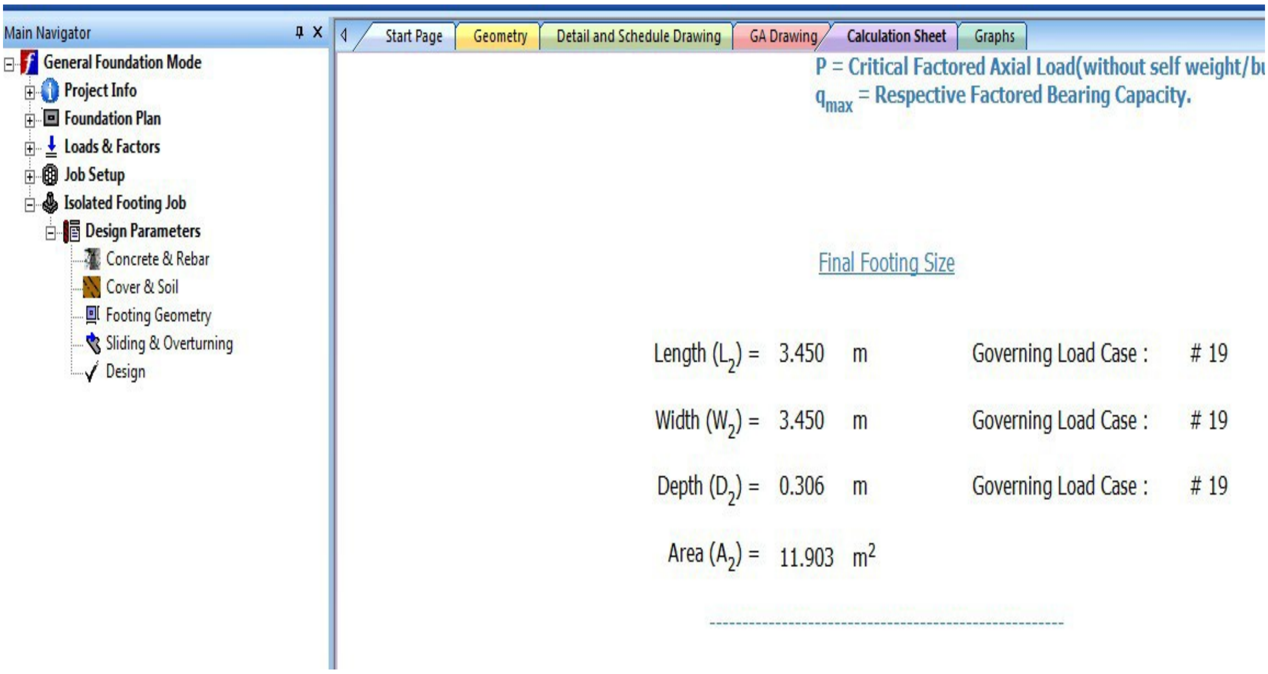

Fig.48 Isolated footing Design Calculations

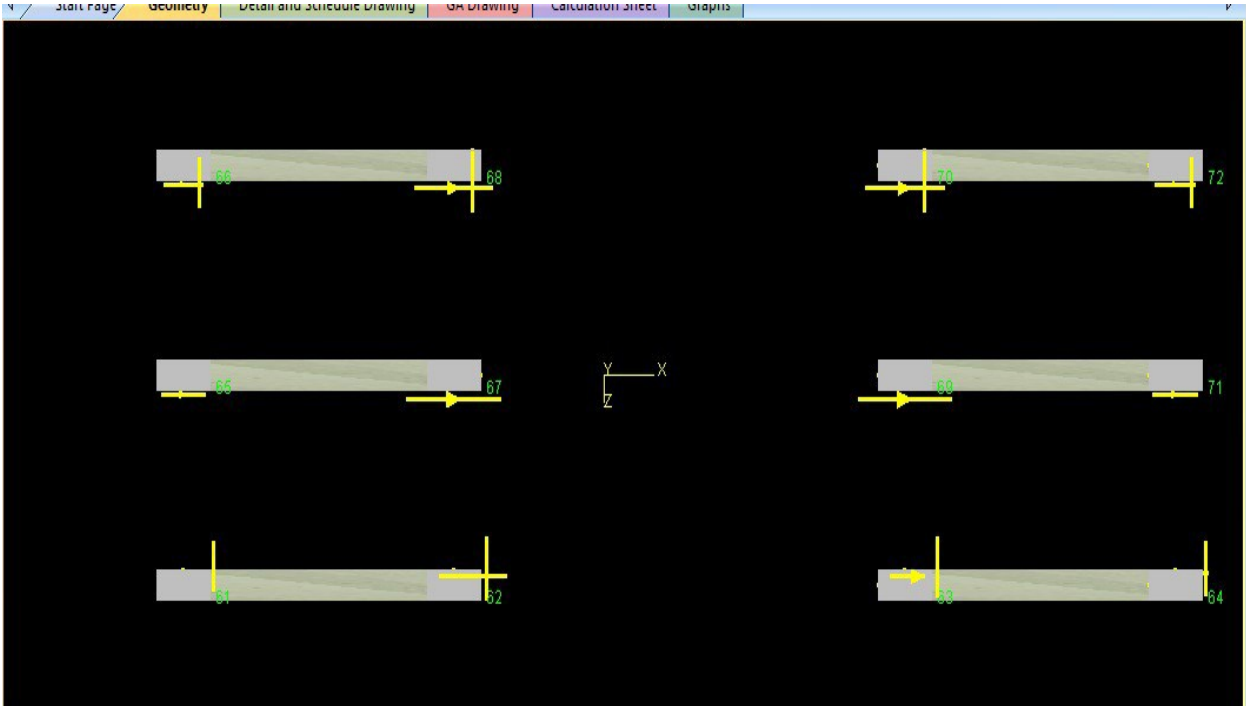

Fig.49 Combined footing Plan

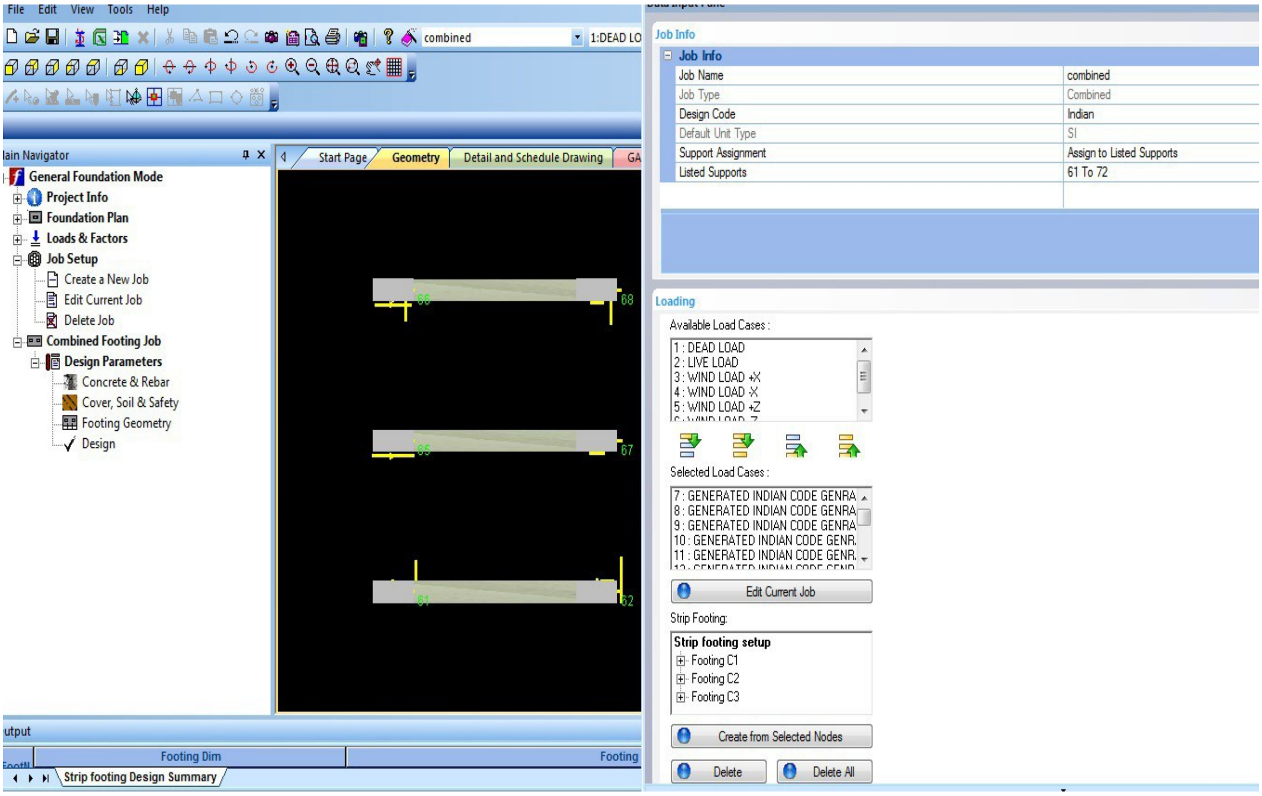

Fig.50 Combined Footing Job creation

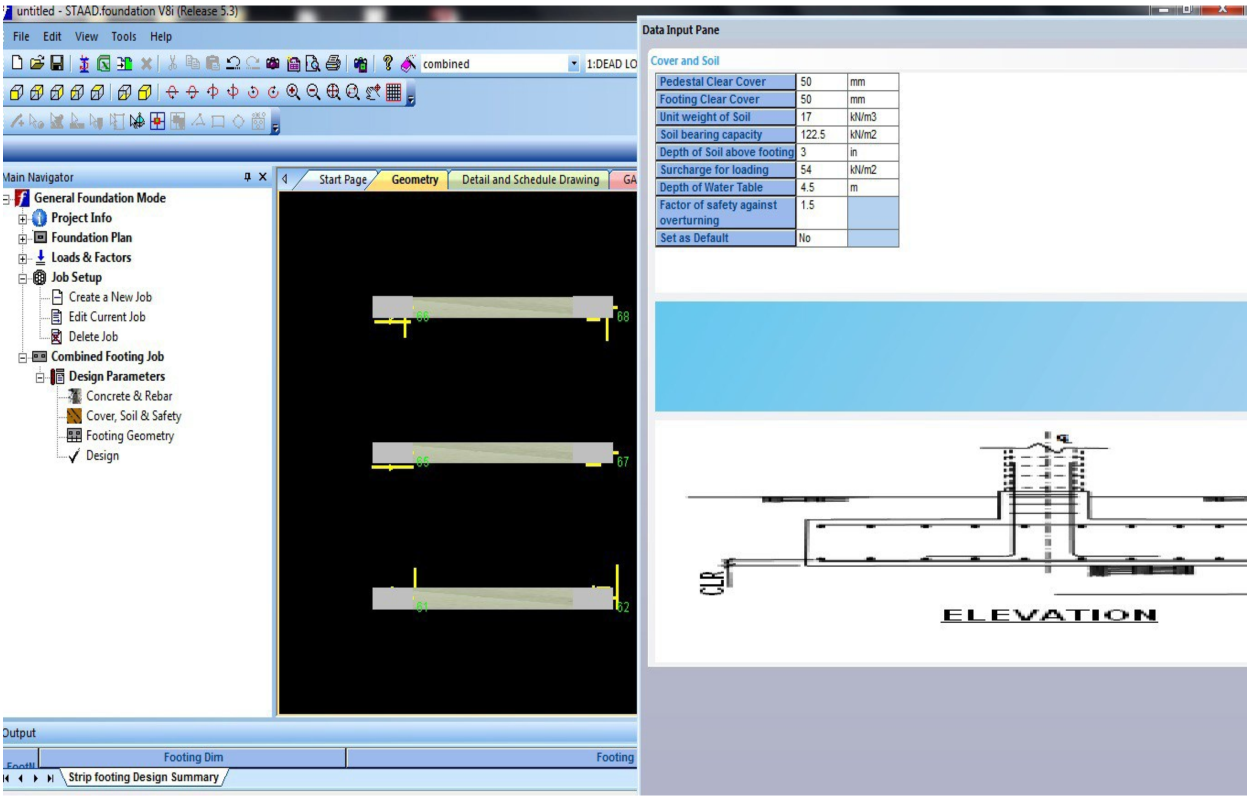

Fig.51 Combined Footing Design Parameters

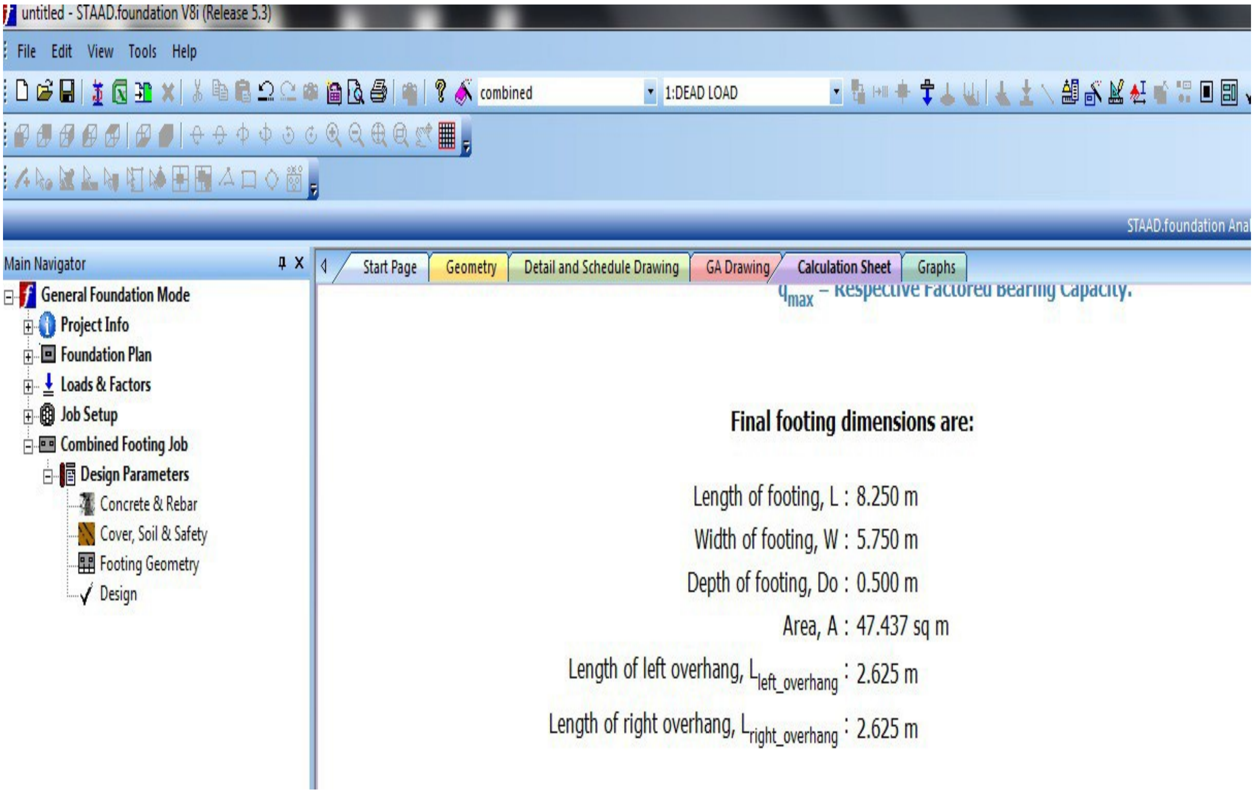

Fig.52 Combined footing calculations

Plan of Raft Foundation

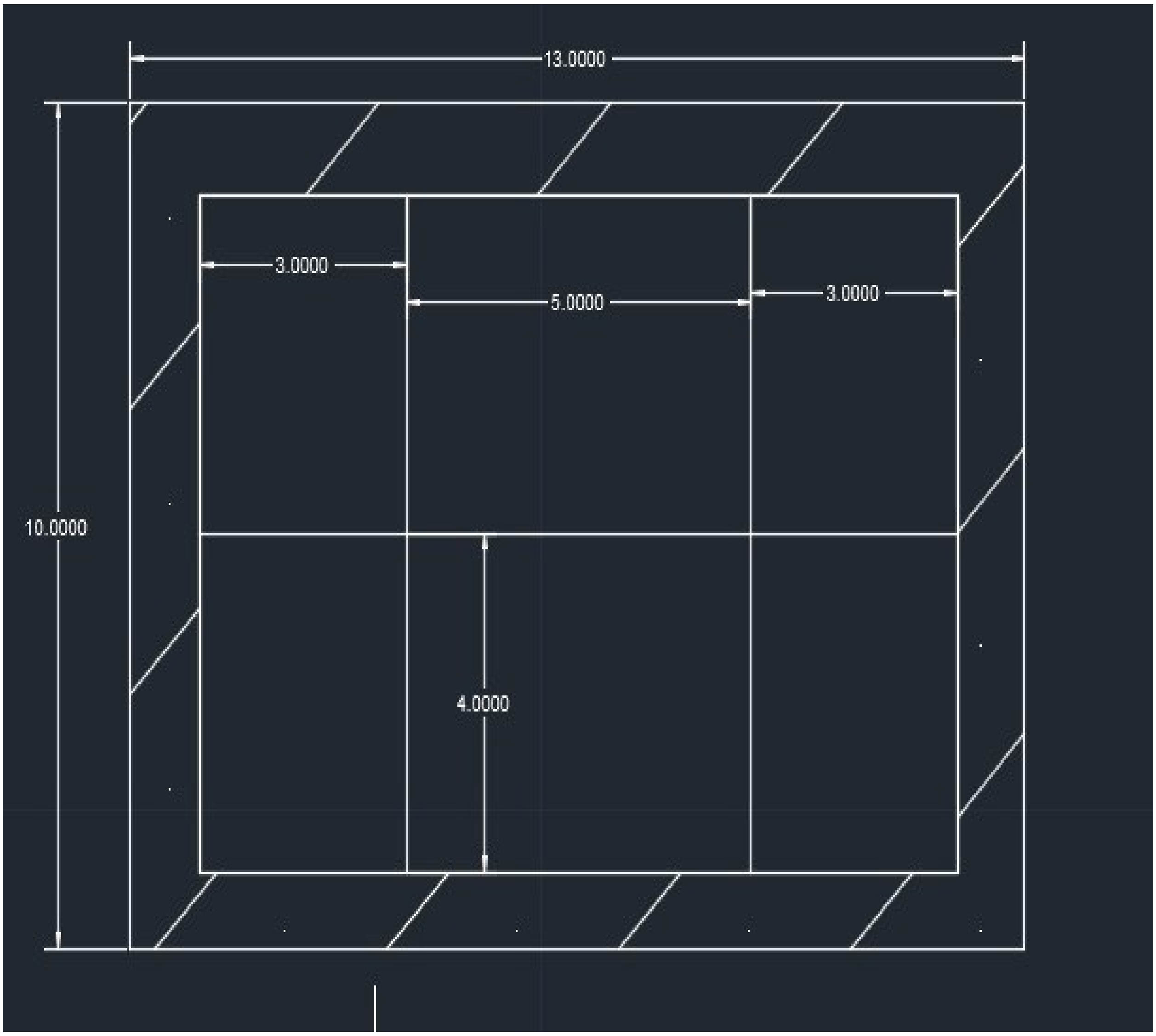

Fig.53 Plan of Raft Foundation

5.2 Raft calculations

$\Sigma V=13702$; $n=12$

$\Sigma x^2=6(2.5)2 +6(5.5)2 =219$

$\Sigma z^2=8(4)2=128$

P_{61}=13702/12 + (-53.58*-5.5)/219 + (-27.75*4)/128 =1142.31kN
P_{62}=13702/12 + (-57.32*-2.5)/219 + (-34.02*4)/128 =1141.4kN
P_{63}=13702/12 + (-57.3*2.5)/219 + (34.03*4)/128 =1142.2kN
P_{64}=13702/12 + (-53.58*5.5)/219 +(27.75*4)/128 =1142.5kN
P_{65}=13702/12 + (48.35*-5.5)/219 +(-28.89*0) =1140.6kN

Since the effect of bending moment is negligible, so vertical load is almost constant on all columns.

Average load=1142kN
Total load=12*1142=13692kN

Suppose a raft of 13m*10m (q)=13692/(13*10)=105.32kN/m^2

Let depth of raft =2m

Bearing Capacity $N_c=S(1+0.2B/L)(1+0.2D_f/B)=6$

$(q_{ult})=C_uN_c=294$kN/m^2

FOS=294/105.32=2.8 nearly 3

Immediate settlement (q_n)=105.32kN/m^2 B=10m
μ=0.5

If (for L/B=13/10=1.3)=1.3

$C_{u(avg)}$=49kPa

$E=700*49=34300kN/m^2$

$P_i=(q_n*B(1-\mu^2)*I_f)/E=(105.3*10(1-0.52)*1.3)/34300=29mm$

Depth Correction=1 Rigidity correction=0.8

$(P_i)_{corrected}=0.023m=23mm$ Consolidation settlement $P_c=\Sigma(C_c*H/1+e_o)\log(P_o+\Delta P/P_o)$ For clay upto 1.125m

$C_c=0.009(w_l-10)=0.009(15.9-10)=0.053$

Hough Equation $C_c=0.3(e_o-0.27)$
$0.053=0.3(e_o-0.27)$ $(e_o)=0.45$

$P_{c1} = (0.053*1.125/(1+0.45))\log(17*1.125+105.32/(17*1.125))=0.044m=44mm$

For clay between 1.125m-2.75m $C_c=0.009(14-10)=0.036$

$C_c=0.3(e_o-0.27)$ $0.036/0.3=e_o-0.27$ $(e_o)=0.39$

$P_{c2}=(0.036*1.625/(1+0.39))$

$\log((17*1.625+105.32)/(17*1.125)(17*1.625/2))=0.026m=26.2mm$

$P_c=0.044+0.026=0.07m=70mm$

Depth correction=1 Rigidity correction=0.8
Pore Pressure correction=0.7 $(P_c)_{corrected}=0.8*0.7*0.07=0.04$

$P_t=(P_c)_{corrected}+(P_i)_{corrected}=0.04+0.023=0.063m=63mm<125mm$ Hence, design of raft is safe.

Conclusion

The total volume of concrete came out to be 65.5 cubic meter. The designed structure can bear the self-weight, dead load, live load and wind load of a residential building calculated as per IS 875. Wind load is calculated as per IS 875 part 3. The average load considering the vertical load and biaxial effect on each column is 1140 kN. The analysis is done in Staad Pro v8i. But for the design of beam, excel sheet is prepared as the reinforcement given by Staad is inappropriate for practical use. As the soil strength is not so high, isolated and combined footing failed when we designed it in Staad Foundation. So we designed Raft Foundation of dimensions 13m x 11m and thickness 2m. Minimum reinforcement is provided for raft foundation is just to restrict tensile cracks due to self-weight of concrete. We also prepared excel sheet to calculate Bearing Capacity of Shallow Foundations using Terzaghi’s equation. Raft foundation is checked for maximum permissible settlement of 125 mm as defined in IS 1904. Angular distortion is eliminated in raft design. So the raft designed is safe.

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