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ANALYSIS AND DESIGN OF A DUPLEX BUILDING USING STAAD.PRO

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Abstract : The aim of the project is to do analysis and design of a Duplex building using software. Design for beams, columns and footings were carried out using the Software STAAD Pro. Drawings were done using Auto-CAD. AutoCAD is a software application for 2D and 3D design and drafting and STAAD pro is a structural analysis and design computer program. It is one of the leading structural analysis and design software which supports more than 100 steel, concrete and timber design codes and has the largest worldwide user base.The building will be designed for static loads i.e., dead load live load and floor load etc. The detailed study of seismology will also be taken into consideration. The dead loads, live loads and seismic load will be determined using IS-456, IS-875, IS-13920, and IS-1893. Structural design was accomplished for reinforced concrete slabs, beams, columns and footings, based on this stress analysis and its resultants. Design drawings were prepared, and specifications for construction. In the final analysis of the project, we will be able to get find the detailing of reinforcement of the beams, columns footing from the STAAD Pro. the slabs form the manual designing. This reinforcement detailing will be clearly shown using the AutoCAD.

Index Term: -AutoCAD 2006, Dead load, Live load, Combination load, STAAD Pro.

INTRODUCTION

Building construction is the engineering deals with the construction of building such as Residential houses, Apartments and Duplex houses. In this report we are dealing with designing and analysis of Duplex building. Simply building can be define as an enclose space by walls with roof, food, cloth and the basic needs of human beings. In the early ancient times humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed now-a-days into beautiful houses. Rich people live in sophisticated condition houses.

Buildings are the important indicator of social progress of the county. Every human has desire to own comfortable homes on an average generally one spends his two-third life times in the houses. The security civic sense of the responsibility. These are the few reasons which are responsible that the person do utmost effort and spend hard earned saving in owning houses.

Now-a-days 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. Draughts men 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.

A building frame consists of number of bays and storey. A duplex building, multi-panelled frame is a complicated statically intermediate structure. A design of R.C building of G+1 story's frame work is taken up. The building in plan (67' x 36') consists of columns built monolithically forming a network. The size of building is 67' x 36' feet. The number of columns is 14. It is duplex structure.
The design is made using software on structural analysis design (staad-pro). The building subjected to both the vertical loads as well as horizontal loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc. and live loads. The horizontal load consists of the wind forces thus building is designed for dead load, live load and wind load as per IS 875.
The building is designed as two dimensional vertical frame and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per IS 456-2000. The help is taken by software available in institute and the computations of loads, moments and shear forces and obtained from this software.

Early modern and the industrial age:
With the emerging knowledge in scientific fields and the rise of new materials and technology, architecture engineering began to separate, and the architect began to concentrate on aesthetics and the humanist aspects, often at the expense of technical aspects of building design. Meanwhile, the industrial revolution laid open the door for mass production and consumption. Aesthetics became a criterion for the middle class as ornamental products, once within the province of expensive craftsmanship, became cheaper under machine production.
Vernacular architecture became increasingly ornamental. House builders could use current architectural design in their work by combining features found in pattern books and architectural journals.
Modern architecture:
The Bauhaus Dessau architecture department from 1925 by Walter Gropius. The dissatisfaction with such a general situation at the turn of the 20th century gave rise to many new lines of thought that served as precursors to modern architecture. Notable among these is detachers' derkbund, formed in 1907 to produce better-quality machine-made objects. The rise of the profession of industrial design is usually placed here. Following this lead, the Bauhaus school, founded in Weimar, Germany in 1919, redefined the architectural bounds prior set throughout history viewing the creation of a building as the ultimate synthesis—the apex—of art, craft and technology.
When modern architecture was first practiced, it was an avant-garde moment with moral, philosophical, and aesthetic underpinning. Immediately after World War-I, pioneering modernist architects sought to develop a completely new style appropriate for a new post-war social and economic order, focused on meeting the needs of the middle and working classes. They rejected the architectural practice of the academic refinement of historical styles which served the rapidly declining aristocratic order.
Statement of project
Salient features:
Utility of building : Duplex House
No of stories : G+1
Type of construction : R.C.C framed structure
Types of walls : brick wall

Geometric details:
Plinth Height : 1.5

Ground floor : 3m
Floor-to-floor height : 3m.

Materials:
Concrete grade : M30
All steel grades : Fe415 grade

LITERATURE REVIEW:

Method of analysis of statistically indeterminate portal frames:
1. Method of flexibility coefficients.
2. Slope displacements methods (iterative methods)
3. Moment distribution method
4. Kane's method
5. Cantilever method
6. Portal method
7. Matrix method
8. STAAD Pro

Method of flexibility coefficients:
The method of analysis is comprises reducing the hyper static structure to a determinate structure form by:
Removing the redundant support (or) introducing adequate cuts (or) hinges.
Limitations:
It is not applicable for degree of redundancy>3

Slope displacement equations:
It is advantageous when kinematic indeterminacy <static indeterminacy. This procedure was first formulated by axle bender in 1914 based on the applications of compatibility and equilibrium conditions.
The method derives its name from the fact that support slopes and displacements are explicitly comported. Set up simultaneous equations is formed the solution of these parameters and the joint moment in each element or computed from these values.
Limitations:
A solution of simultaneous equations makes methods tedious for manual computations. This method is not recommended for frames larger than too bays and two storey's.

Iterative methods:
This method involves distributing the known fixed and moments of the structural member to adjacent members at the joints in order satisfy the conditions of compatibility.

Limitations of hardy cross method:
It presents some difficulties when applied to rigid frame especially when the frame is susceptible to side sway. The method cannot be applied to structures with intermediate hinges.

Kani's method:
This method over comes some of the disadvantages of hardy cross method. Kani's approach is similar to H.C.M to that extent it also involves repeated distribution of moments at successive joints in frames and continues beams. However, there is a major difference in

distribution process of two methods. H.C.M distributes only the total joint moment at any stage of iteration.

The most significant feature of kani's method is that process of iteration is self-corrective.

Any error at any stage of iterations corrected in subsequent steps consequently skipping a few steps error at any stage of iteration is corrected in subsequent consequently skipping a few steps of iterations either by over sight of by intention does not lead to error in final end moments.

Advantages:

It is used for side way of frames.

Limitations:

The rotational of columns of any story should be functioning a single rotation value of same story.

The beams of story should not undergo rotation when the column undergoes translation. That is the column should be parallel.

Frames with intermediate hinges cannot be analysis.

Approximate method:

Approximate analysis of hyper static structure provides a simple means of obtaining a quick Solution for preliminary design. It makes some simplifying assumptions regarding Structural behavior so to obtain a rapid solution to complex structures.

The usual process comprises reducing the given indeterminate configuration to determine structural system by introducing adequate no of hinges. It is possible to sketch the deflected profile of the structure for the given loading and hence by locate the print inflection

Since each point of inflection corresponds to the location of zero moment in the structures. The inflection points can be visualized as hinges for the purpose of analysis. The solution of structures is sundered simple once the inflection points are located. The loading cases are arising in multi-frames namely horizontal and vertical loading. The analysis carried out separately for these two cases.

Horizontal cases:

The behavior of a structure subjected to horizontal forces depends upon its heights to width ratio among their factor. It is necessary to differentiate between low rise and high rise frames in this case.

Low rise structures:

Height < width

It is characterized predominately by shear deformation.

High rise buildings

Height > width

It is dominated by bending action

Matrix analysis of frames:

The individual elements of frames are oriented in different directions unlike those of continues beams so their analysis is more complex. Never the less the rudimentary flexibility and stiffness methods are applied to frames stiffness method is more useful because its adaptability to computer programming stiffness method is used when degree of redundancy is greater than degree of freedom. However stiffness method is used degree of freedom is greater than degree of redundancy especially for computers.

Design of Duplex building:

General:
There are three paramount design principles which must be taken into consideration when designing a duplex or a triplex. These are:
Neighborhood context – the design should be consistent with, complement, or improve upon the design character of the immediate neighborhood.

variety in design – the duplex or triplex should incorporate design elements which help break up the mass of the building, provide for individuality in the design of each dwelling unit, and which are interesting to look at.
landscaping – the design should incorporate front yard landscaping that reinforces the individuality of the dwelling units, softens the edges of the building, and screens parking areas/driveways.
Civil engineering structures are created to serve some specific functions like human habitation, transportation, bridges, storage etc. in a safe and economical way. A structure is an assemblage of individual elements like pinned elements (truss elements), beam element, column, shear wall slab cable or arch. Structural engineering is concerned with the planning, designing and thee construction of structures.
Structure analysis involves the determination of the forces and displacements of the structures or components of a structure. Design process involves the selection and detailing of the components that make up the structural system.
The main object of reinforced concrete design is to achieve a structure that will result in a safe economical solution.
The objective of the design is:
1. Foundation design
2. Column design
3. Beam design
4. Slab design
These all are designed under limit state method.

Limit state method:
The object of design based on the limit state concept is to achieve an acceptability that a structure will not become unserviceable in its life time for the use for which it is intended. It will not reach a limit state. In this limit state method, all relevant states must be considered in design to ensure a degree of safety and serviceability.

Limit state:
The acceptable limit for the safety and serviceability requirements before failure occurs is called a limit state.

Limit state of collapse:
This is corresponds to the maximum load carrying capacity.
Violation of collapse limit state implies failures in the source that a clearly defined limit state of structural usefulness has been exceeded. However, it does not mean complete collapse.
This limit state corresponds to:
a) Flexural

b) Compression
c) Shear
d) Torsion

Limit state of serviceability:

This state corresponds to development of excessive deformation and is used for checking member in which magnitude of deformations may limit the rise of the structure of its components.

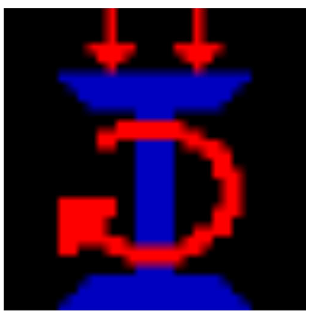
a) Deflection
b) Cracking
c) Vibration

SOFTWARES

This project is mostly based on software and it is essential to know the details about these software's.

List of software's used

1. Staad pro (v8i)
2. Staad foundations 5(v8i)
3. Auto cad



Staad pro

Staad Foundations

Auto Cad

STAAD

Staad is powerful design software licensed by Bentley .Staad stands for structural analysis and design.

Any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, whereas analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage. Design phase is designing the type of materials and its dimensions to resist the load. This we do after the analysis.

To calculate shear force and bending moment of a complex loading beam it takes about an hour. So, when it comes into the building with several members it will take a week. Staad pro is a very powerful tool which does this job in just an hour's staad is a best alternative for high rise buildings.

Now-a-days most of the high-rise buildings are designed by staad which makes a compulsion for a civil engineer to know about this software.

This software can be used to carry rcc, steel, bridge, truss etc. according to various country codes.

AutoCAD:

AutoCAD is powerful software licensed by auto desk. The word auto came from Auto Desk Company and cad stands for computer aided design. AutoCAD is used for drawing different layouts, details, plans, elevations, sections and different sections can be shown in Auto Cad.

It is very useful software for civil, mechanical and also electrical engineer.

The importance of this software makes every engineer a compulsion to learn this software's.

We used AutoCAD for drawing the plan, elevation of a residential building. We also used AutoCAD to show the reinforcement details and design details of a stair case.

AutoCAD is a very easy software to learn and much user friendly for anyone to handle and can be learn quickly.

Learning of certain commands is required to draw in AutoCAD.

PLAN AND ELEVATION

PLAN

The auto cad plotting represents the plan of a g+1duplex building. The plan clearly shows that it is a combination staircase and plan. We can observe there is a combination between each apartment.

The plan shows the details of dimensions of each and every room and the type of room and orientation of the different rooms like bed room, bathroom, kitchen, hall etc. All the five apartments have similar room arrangement.

The entire plan area is about 1100 m2. There is some space left around the building for parking of cars. The plan gives details of arrangement of various furniture like sofa etc. The plan also gives the details of location of stair cases in different blocks. We have 2 stair cases for each block and designing of stair case is shown in AutoCAD plot no.3

In the middle we have a small construction which consists of four lifts and those who want to fly through lift can use this facility and we know for a building with more than g+4 floors should compulsory have lift and the charges for the facilities is collected by all the members.

At that junction we have a club for our enjoyment and charges are collected by all the building occupants every month.

So these represent the plan of our building and detailed explanation of remaining parts like elevations and designing is carried in the next sections.

Elevation:

AutoCAD plot represents the proposed elevation of building. It shows the elevation of a g+1 building representing the front view which gives the overview of a building block.

The figure represents the site picture of our structure which is taken at the site .the building is actually under constructions and all the analysis and design work is completed before the beginning of the project.

Each floor consists of height 3.5m which is taken as per GHMC rules for residential buildings. The building is not designed for increasing the number of floors in future.so the number of floors is fixed for future also for this building due to unavailability of the permissions of respective authorities.

Also, special materials like fly ash and self-compacted concrete were also used in order to reduce the dead load and increase life of the structure and also improve economy. But these materials were not considered while designing in Staad to reduce the complexity and necessary corrections are made for considering the economy and safety of the structure.

This is regarding the plan and details of the site and next section deals with the design part of the building under various loads for which the building is designed.

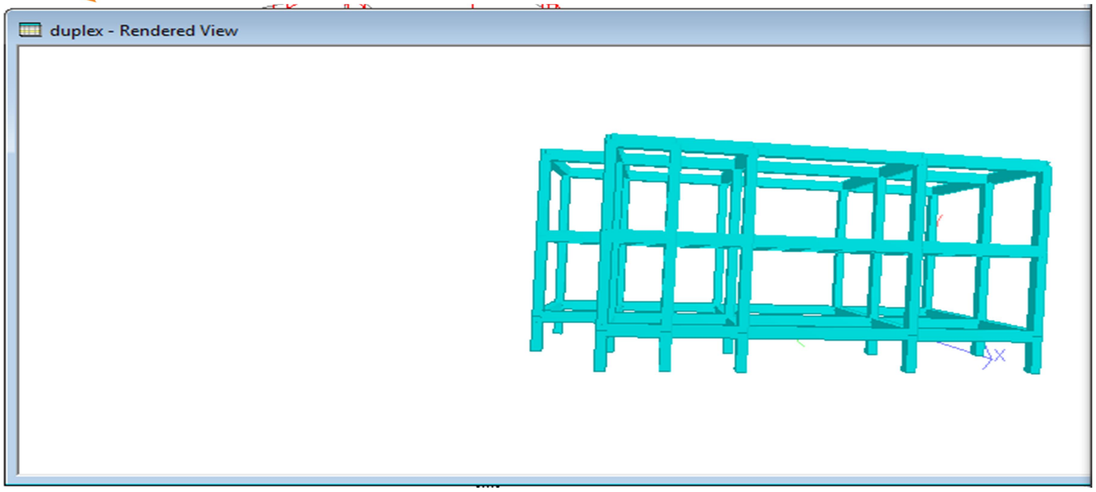


Figure 3.2a Elevation of the building

Center line plan

The figure below (fig3.2b) represents the center-line diagram of our building in Staad pro. Each support represents the location of different columns in the structure. This structure is used in generating the entire structure using a tool called transitional repeat and link steps. After using the tool the structure that is created can be analyzed in Staad pro under various loading cases. Below figure represents the skeletal structure of the building which is used to carry out the analysis of our building.
All the loadings are acted on this skeletal structure (fig.3.2c) to carry out the analysis of our building. This is not the actual structure but just represents the outline of the building in staad pro. A mesh is automatically created for the analysis of these building.

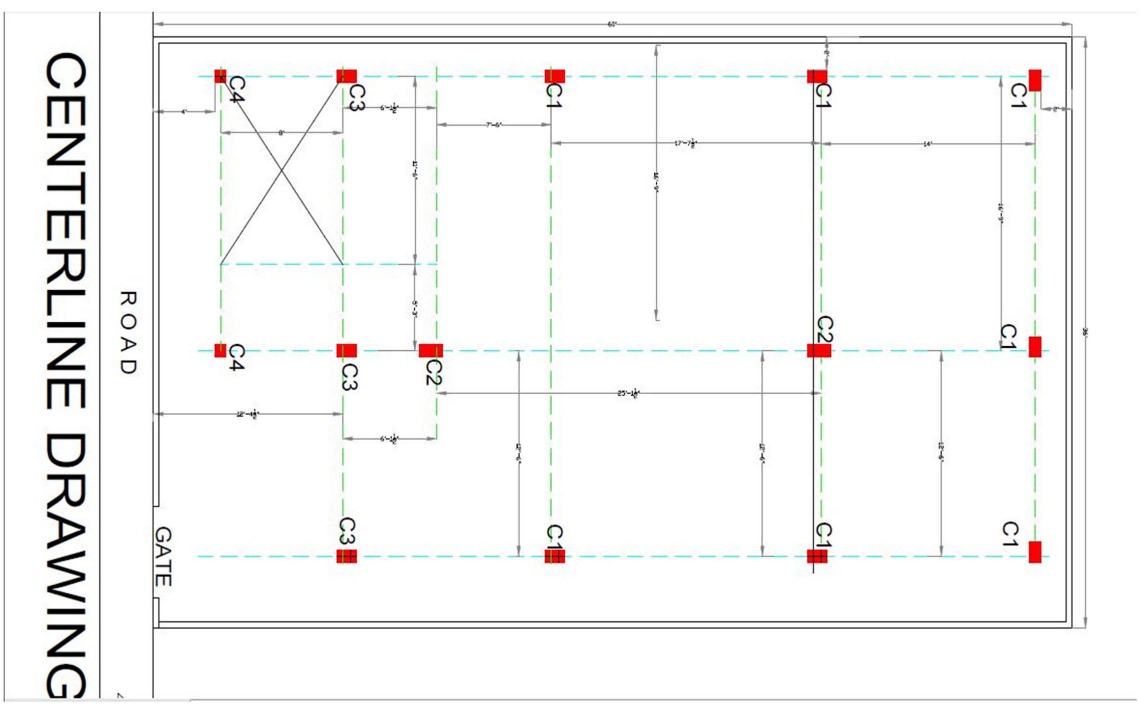


Fig. 3.2b Center line plan

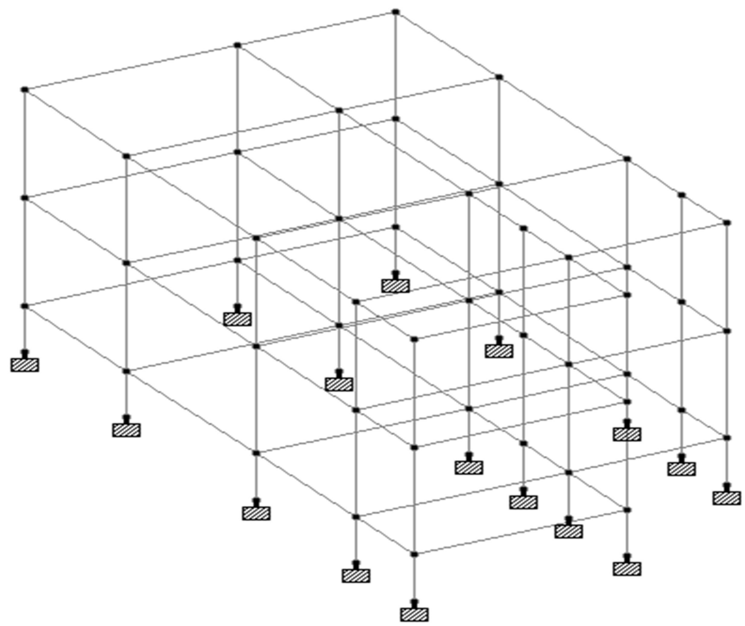


Figure 3.2c Skeletal structure of the building

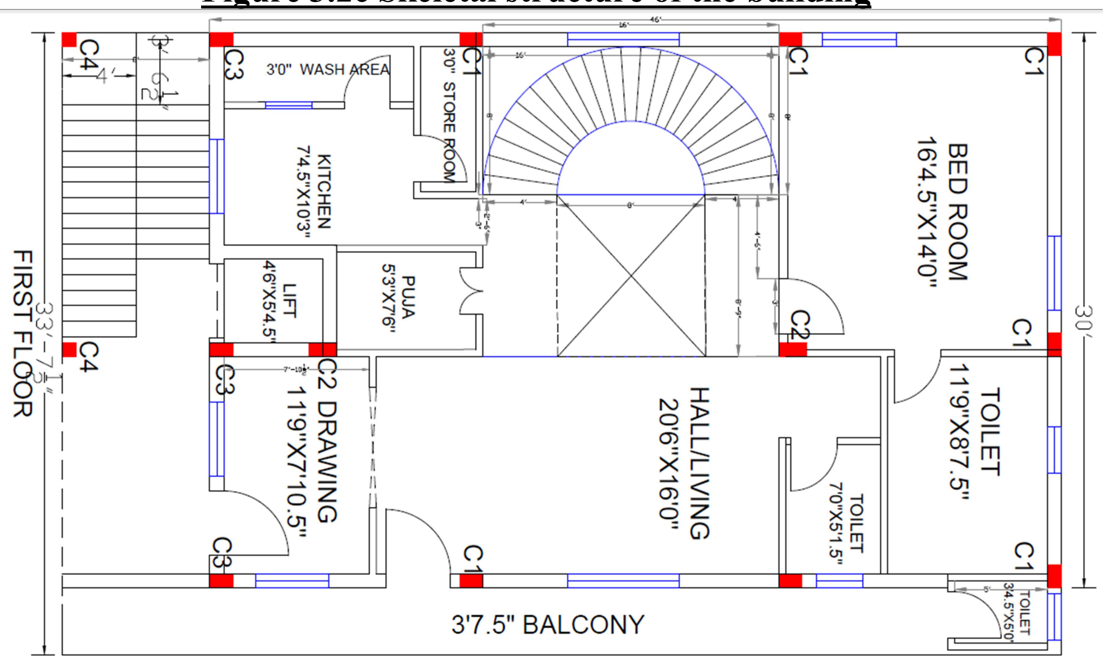


Figure 3.2d Plan of the building

LOADINGS

Load Conditions and Structural System Response:

The concepts presented in this section provide an overview of building loads and their effect on the structural response of typical wood-framed homes. As shown in Table, building loads can be divided into types based on the orientation of the structural action or forces that they induce: vertical and horizontal (i.e., lateral) loads. Classifications of loads are described in the following sections.

Building Loads Categorized by Orientation:
Types of loads on a hypothetical building are as follows.

- Vertical Loads
- Dead (gravity)
- Live (gravity)

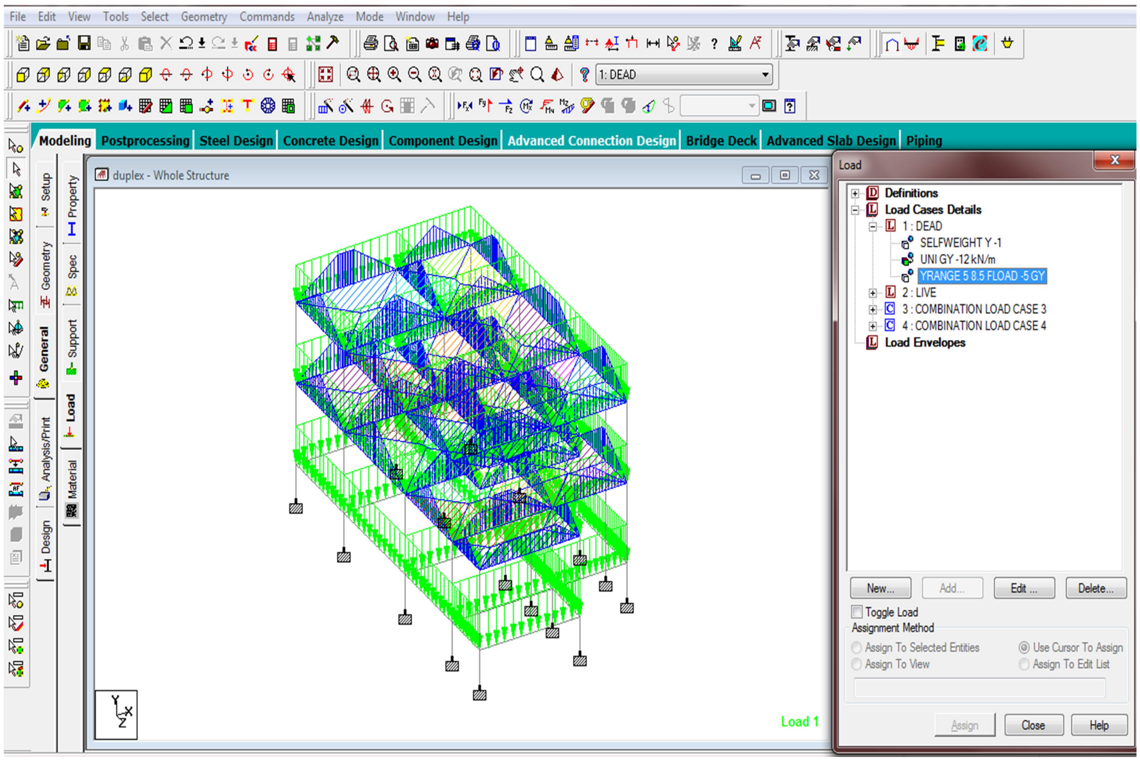


Fig 4.4.1a Diagram of dead load

Dead load calculation:
Weight=Volume x Density
Self-weight floor finish=0.12*25+1=3kN/m2
The above example shows a sample calculation of dead load.
Dead load is calculated as per IS 875 part 1

Live Loads:
For our structure live load is taken as 2kN/m2 for design.
Live loads are calculated as per IS 875 part 2

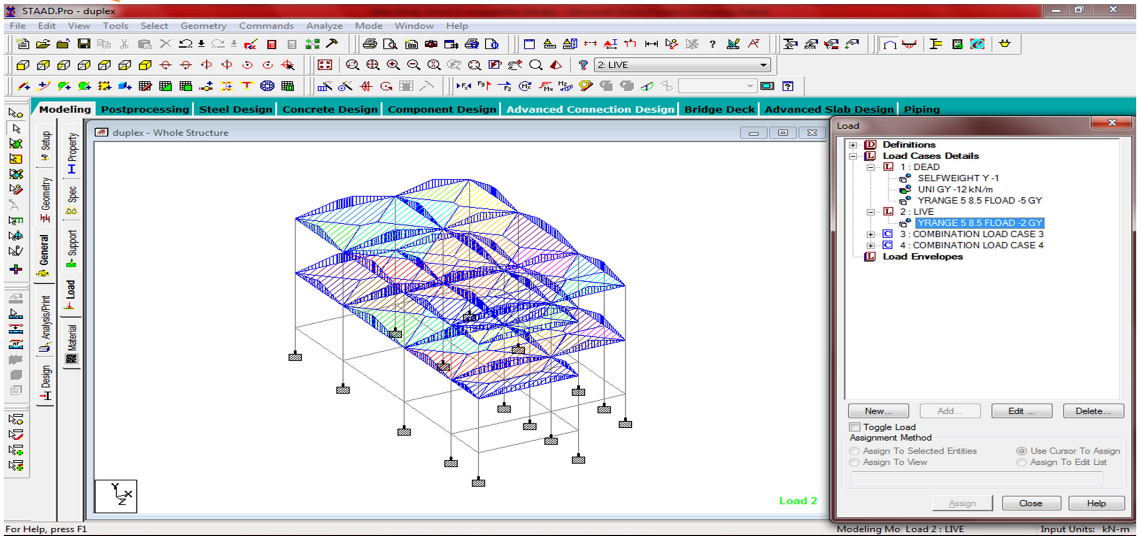


Fig 4.4.2a Diagram of live load

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: -2kN/m2 (-ve sign indicates that floor load is acting downwards.)

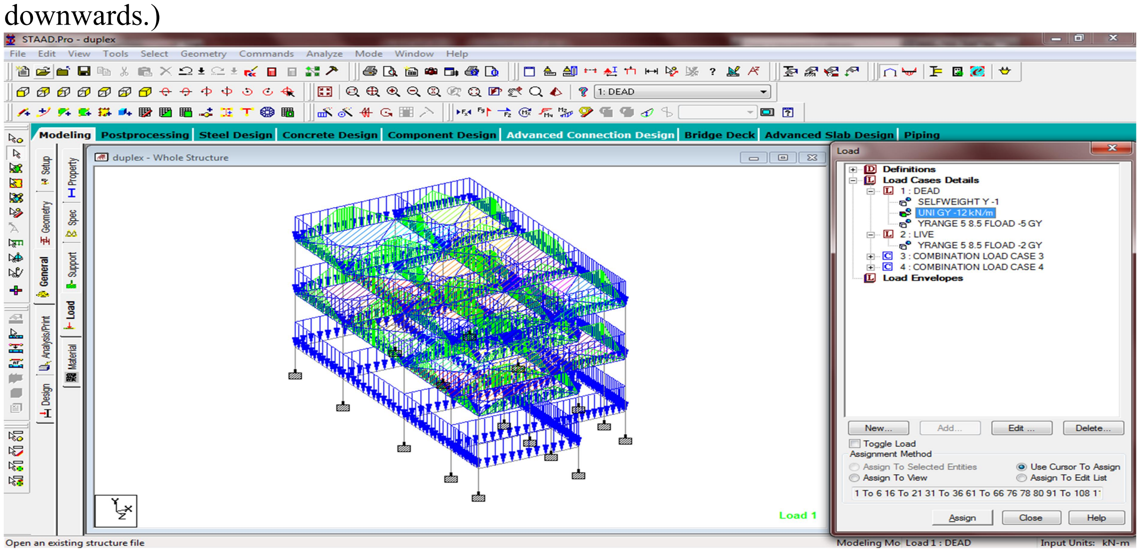


Fig 4.4.3.a Diagram of floor load

Load combinations:

All the load cases are tested by taking load factors and analyzing the building in different load combination as per IS456 and analyzed the building for all the load combinations and results are taken and maximum load combination is selected for the design.

Load factors as per IS456-2000

Live Load	Dead Load
1.5	1.5

When the building is designed for both wind and seismic loads maximum of both is taken. Structure is analyzed by taking all the above combinations.

BEAMS

Beams transfer load from slabs to columns. beams are designed for bending.

In general, we have two types of beams: single and double. Similar to columns geometry and perimeters of the beams are assigned. Design beam command is assigned and analysis is carried out, now reinforcement details are taken.

Beam design:

A reinforced concrete beam should be able to resist tensile, compressive and shear stress induced in it by loads on the beam.

There are three types of reinforced concrete beams

1) Single reinforced beams
2) Double reinforced concrete
3) Flanged beams

Singly reinforced beams:

In singly reinforced simply supported beams steel bars are placed near the bottom of the beam where they are more effective in resisting in the tensile bending stress. I cantilever beams reinforcing bars placed near the top of the beam, for the same reason as in the case of simply supported beam.

Doubly reinforced concrete beams:

It is reinforced under compression tension regions. The necessity of steel of compression region arises due to two reasons. When depth of beam is restricted. The strength availability singly reinforced beam is in adequate. At a support of continuous beam where bending moment changes sign such as situation may also arise in design of a beam circular in plan.

Figure shows the bottom and top reinforcement details at three different sections that are extracted from the Staad Pro. results of concrete designing.

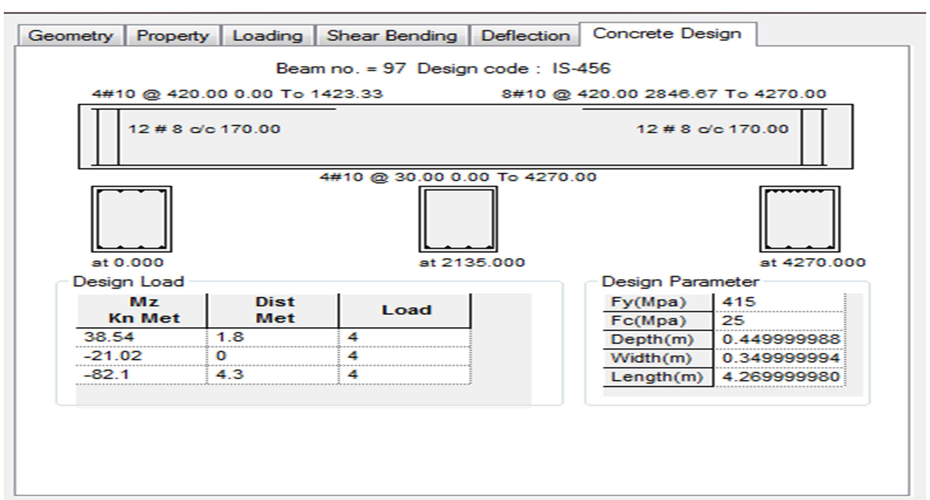


Fig 5.1.2a Diagram of the reinforcement details of beam

The following figure shows the deflection of a same beam:

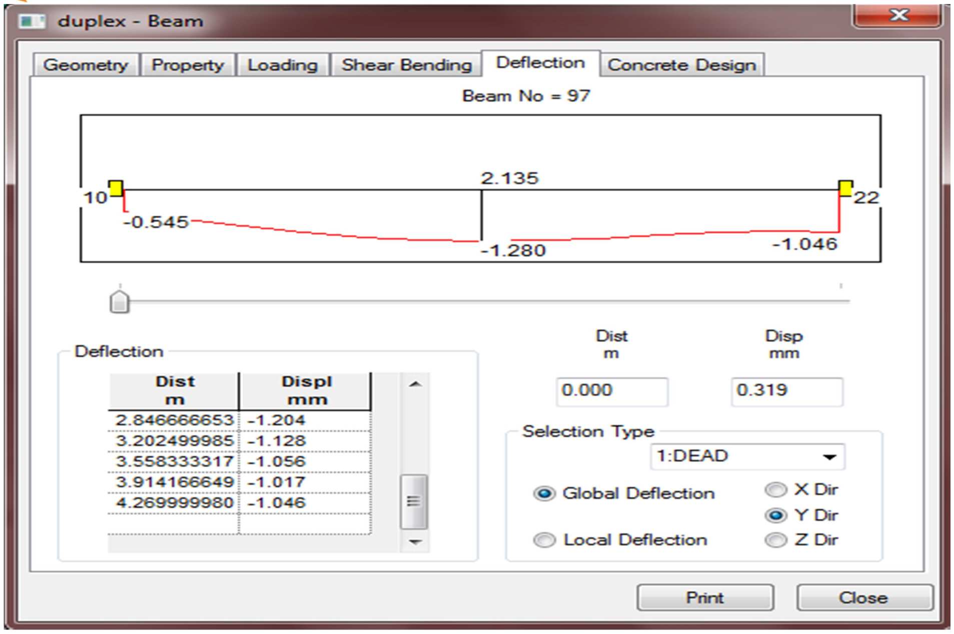


Fig 5.1.2b Diagram for deflection of a beam

Deflection Value Table of beam no.2385

Distance (m)	Displacement
0.000	-0.545
0.356	-0.72
0.712	-0.897
1.067	-1.055
1.423	-1.177
1.779	-1.253
2.135	-1.28
2.491	-1.26
2.847	-1.204
3.202	-1.128
3.558	-1.056
3.914	-1.017
4.270	-1.046

Figure shows the bending moment diagram of the particular beam (no. 2385), from the Staad Pro. result of analysis.

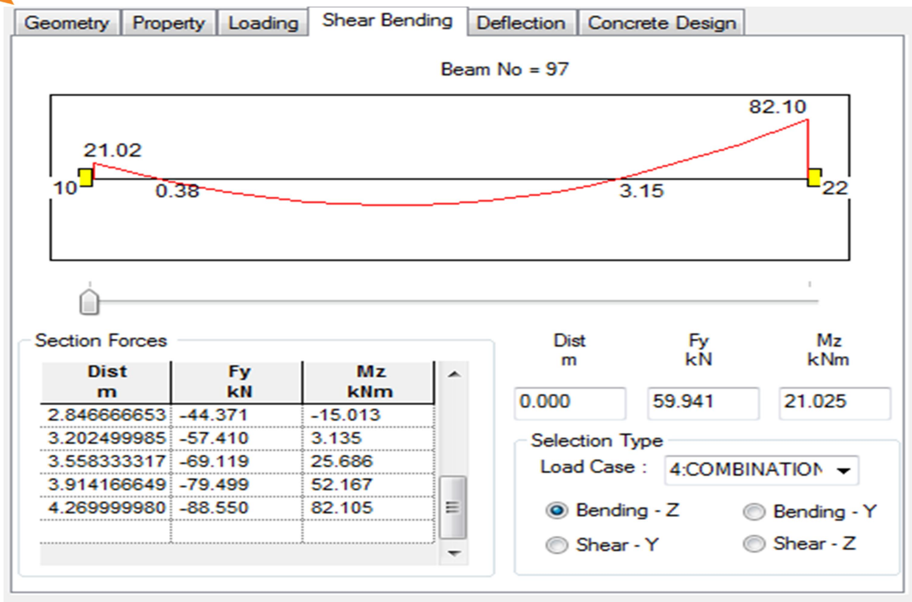


Fig. 5.1.2c Diagram of Bending Moment of Beam

Section Forces Table

Distance	Fy	Mz
0	59.941	21.025
0.355833	50.89	1.267
0.711667	40.51	-15.034
1.0675	28.801	-27.405
1.423333	15.762	-35.373
1.779167	1.393	-38.465
2.135	-14.305	-36.207
2.490833	-30.002	-28.285
2.846667	-44.371	-15.013
3.2025	-57.41	3.135
3.558333	-69.119	25.686
3.914167	-79.499	52.167
4.27	-88.55	82.105

The type of bars to be used, amount of steel and loading on the column is represented in the below figure.

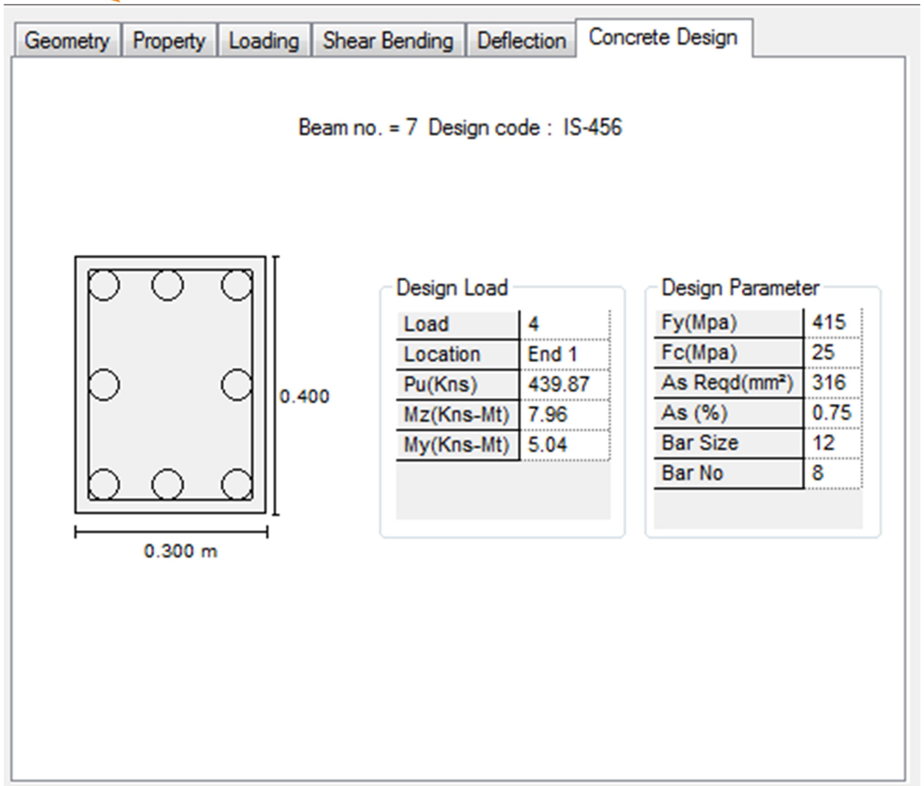


Fig. 6.3a Diagram of Reinforcement Detailing of Column

The following figure shows the bending moment diagram of same column.

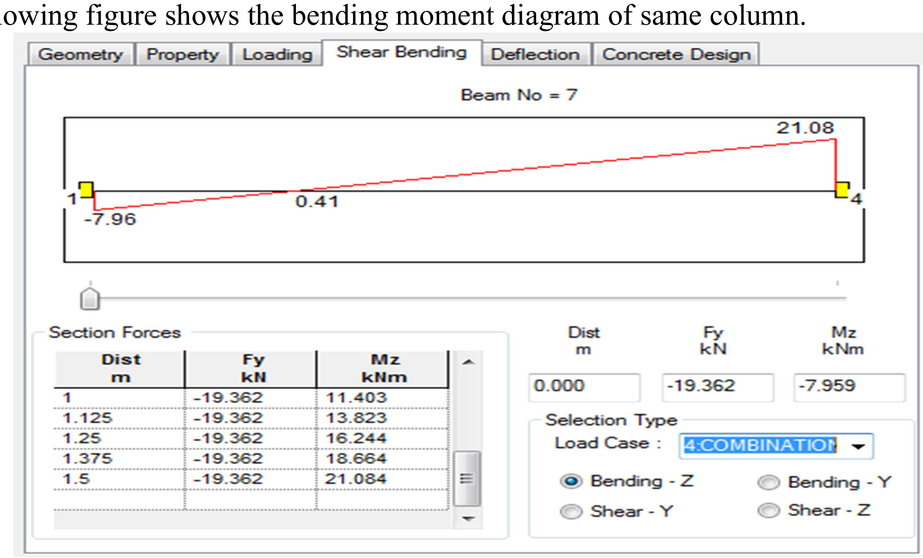


Fig 6.4a Deflection of column

FOOTINGS

Foundations are structural elements that transfer loads from the building or individual column to the earth. If these loads are to be properly transmitted, foundations must be designed to prevent excessive settlement or rotation, to minimize differential settlement and to provide adequate safety against sliding and overturning.

After we import the loads the placement of columns is indicated in the figure.

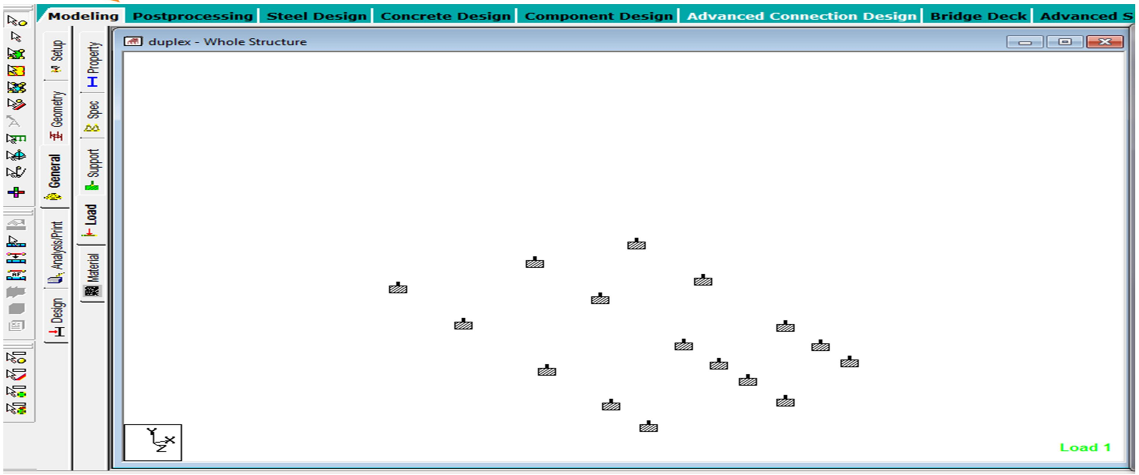


Fig 8.1a Placement of columns

Bending Moment Diagram:

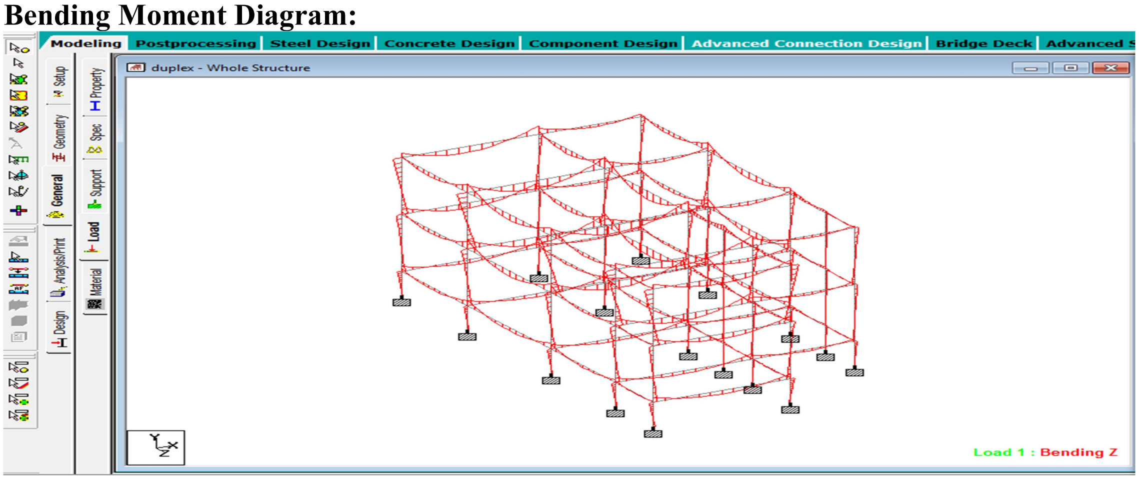


Fig 8.3a Showing bending moments of all the beams

Shear Diagram:

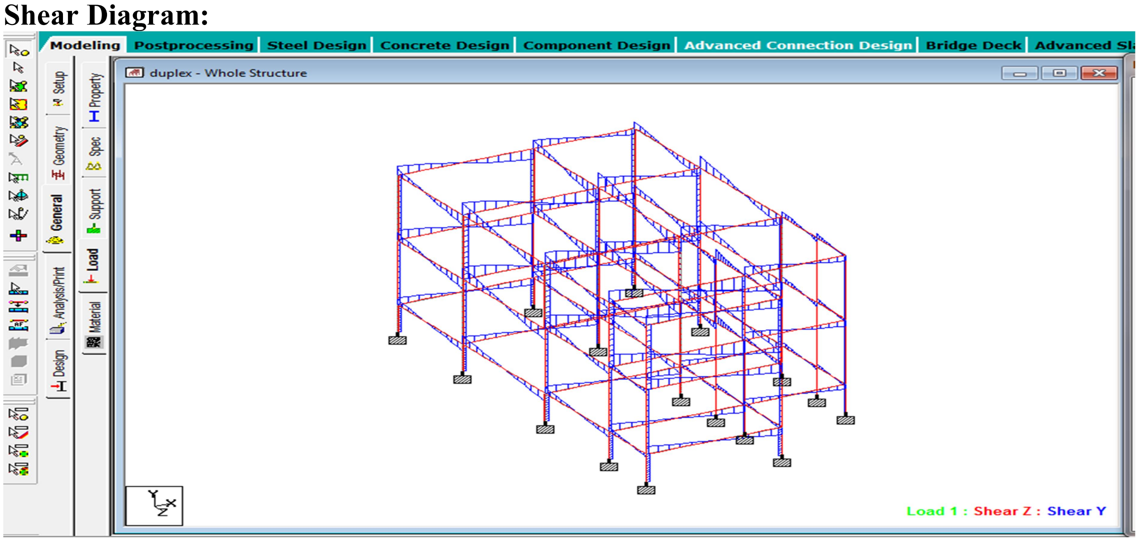


Fig 8.3b Showing Shear Force of all the beams

CONCLUSION & FUTURE SCOPE

CONCLUSION

To bring about a conclusion to this project a few important points are highlighted that has tremendously made it simple to design the building with the help of STAAD Pro with the use of this software it has been possible to check the axial force, shear force, torsion and bending moment of the building structure. It makes it easy to design and also saves a lot of time as designing manually consumes unnecessary amount of time and energy. This project has enabled to emerge out new ideas in the field of designing multistoried buildings.

In this project using this software we have got the structural designing of the whole building which means the reinforcement details of the each and every member in the structure. Here we have determined the reinforcement details of beams, columns from the STAAD Pro. and for slabs and stair case designed manually.

This project presents critical review of recommendations of well-established codes regarding design and detailing aspects of beam column slabs, staircase and footing. The codes of practice considered are IS 456, SP 16. Stress analysis was conducted using STAAD Pro software. Structural design was accomplished for reinforced concrete slabs, beams, columns and footings, based on this stress analysis and its resultants.

Future Scope:

For the extension of the project, we can also design the same building in Staad Pro. using the earthquake analysis and designing and also can go for the ductile detailing as per codes IS 1893 Part-1 and IS 13920 respectively.

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