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ANALYSIS OF MULTI-STOREY BUILDING WITH FLOATING COLUMN USING E-TABS

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ABSTRACT: Many urban multi-story buildings in India today have open first story as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first story. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height. In present scenario buildings with floating column is a typical feature in the modern multi-story construction in urban India. Such features are highly undesirable in building built in seismically active areas. This study highlights the importance of explicitly recognizing the presence of the floating column in the analysis of building. Alternate measures, involving stiffness balance of the first story and the story above, are proposed to reduce the irregularity introduced by the floating columns. In this paper a MULTI STOREY FRAMED STRUCTURE WITH A FLOATING COLUMN IS TAKEN AND ANALYSED IN ETABS.

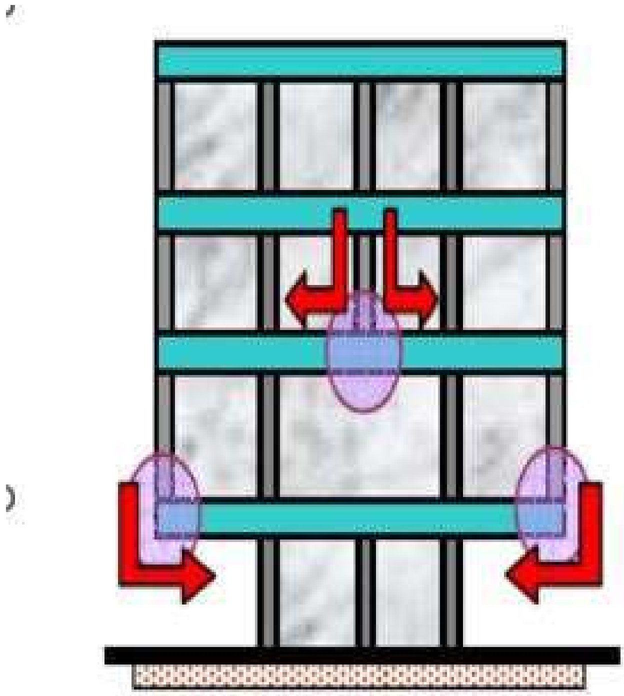
INTRODUCTION

Many urban multistorey buildings in India today have open first story as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first story. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height.

The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks (like the hotel buildings with a few stories wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular story or with unusually tall story tend to damage or collapse which is initiated in that story. Many buildings with an open ground story intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. Buildings with columns that hang or float on beams at an intermediate story and do not go all the way to the foundation, have discontinuities in the load transfer path.

What is floating column

A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it.



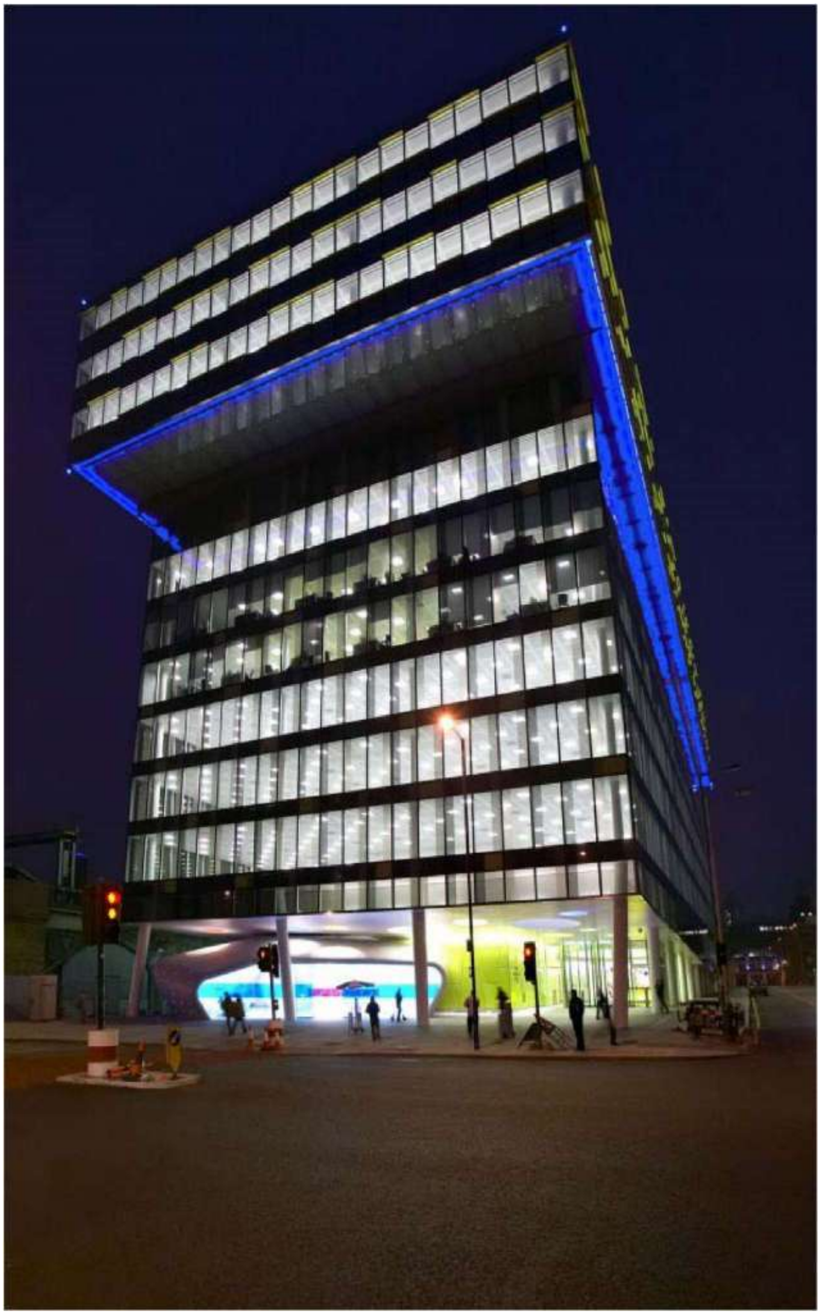
Hanging or Floating Columns

There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. These open spaces may be required for assembly hall or parking purpose. The transfer girders have to be designed and detailed properly, especially in earth quake zones. The column is a concentrated load on the beam which supports it. As far as analysis is concerned, the column is often assumed pinned at the base and is therefore taken as a point load on the transfer beam. STAAD Pro, ETABS and SAP2000 can be used to do the analysis of this type of structure. Floating columns are competent enough to carry gravity loading but transfer girder must be of adequate dimensions (Stiffness) with very minimal deflection.

Looking ahead, of course, one will continue to make buildings interesting rather than monotonous. However, this need not be done at the cost of poor behavior and earthquake safety of buildings. Architectural features that are detrimental to earthquake response of buildings should be avoided. If not, they must be minimized. When irregular features are included in buildings, a considerably higher level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features.

Hence, the structures already made with these kinds of discontinuous members are endangered in seismic regions. But those structures cannot be demolished, rather study can be done to strengthen the structure or some remedial features can be suggested. The columns of the first story can be made stronger, the stiffness of these columns can be increased by retrofitting or these may be provided with bracing to decrease the lateral deformation.

Some pictures showing the buildings built with floating columns:



Palestra in London, United Kingdom

Chongqing Library in Chongqing, China

One-Housing-Group-by-Stock-Woolstencroft-in-London-United-Kingdom

Objective and scope of present work

The objective of the present work is to study the behavior of multistory buildings with floating columns under earthquake excitations.

Finite element method is used to solve the dynamic governing equation. Linear time history analysis is carried out for the multistory buildings under different earthquake loading of varying frequency content. The base of the building frame is assumed to be fixed. Newmark's direct integration scheme is used to advance the solution in time.

Usually all multistoried buildings (structures) are of 3 types they are

1. Load bearing construction
2. Framed construction
3. Composite construction

But among the above 3 types, in the present stage all the multistoried structure are framed construction which are durable.

An engineering structure is an assembly of member of elements transferring the loads and providing a firm space to serve the desired function.

The structural design is a science and art of designing, with economy and elegance, a durable structure is that which can safely carry the forces and can serve the desired function satisfactorily during its expected service life span. The entire process of structural planning and designing requires not only imagination and conceptual thinking (which forms arts of designing) but of practical aspects, such as relevant design codes and bye-laws, backed up by ample experience, institution and judgment.

The process of design commences with planning of a structure, primarily to meet the functional equipment of the user or client. The functional requirements and the aspects of the aesthetics looked in to normally by an architect while the aspect of safety, serviceability, durability and economy of the structure for its intended use over the life span

Building In General:

A building can be defined as a structure broad by consisting of wall, floors, and roofs, erected to provide covered space for different uses such as residence, education, business, manufacturing, storage, hospitalization, entertainment, worship etc.

Normally all building are constructed according to drawings and specifications prepared by architects. Each city has prescribed building bye-laws to which building must confirm. The building bye-laws lay down norms like minimum front, side and rear setbacks, minimum height and area of habitable rooms, kitchen, bath, minimum area of windows, width of staircase etc., apart from respecting the bye-laws the building design should ensure optimum utilization of build up space (i.e. Area under circulation should be minimum) thermal comfort, proper ventilation, desirable illumination and acoustical characteristics and it should satisfy the functional requirements of people who live and work in the building.

Types of Buildings:

Depending upon the character of occupancy or the type of use, different type of buildings have been classified in following group as per national building code.

1. Residential Building.
2. Educational Building.
3. Institutional Buildings.
4. Assembly Buildings
5. Business Buildings.
6. Mercantile Building.
7. Industrial Buildings.
8. Storage Buildings.
9. Hazardous Buildings

Components of a Building:

A building can be broadly divided into two parts viz.

1. Sub-structure
2. Super Structure.

The portion of the building above the ground is termed as super structure. The portion of the building below the ground is termed as sub-structure. The components of a building can be broadly summarized as under.

1. Foundation
2. Plinth
3. Walls
4. Columns
5. Floors
6. Doors/Windows & Ventilators
7. Staircase
8. Roofs
9. Building Finishes
10. Building services.

The object of reinforced concrete design is to achieve a structure that will result in a safe and economical solution. For a given structural system, the design problem consists of the following steps:

1. Idealization of structure for analysis,
2. Estimation of loads,

3. Analysis of idealized structural model to determine axial thrust, shear, bending moments and deflections,

Limit state method:

In the limit state design method, non-deterministic parameters are determined based on observations taken over a period of time. The object of design based on the limit state concept is to achieve an acceptable probability that a structure will not become unserviceable in its life time for the use for which it is intended, that is, it will not reach a limit state. A structure with appropriate degrees of reliability should be able to withstand safely all loads that are liable to act on it throughout its life and it should also satisfy the serviceability requirements, such as limitations on deflections and cracking. It should also be able to maintain the required structural integrity during and after accidents such as fires, explosions and local failure. Due to its realistic approach, limit state method is used in design of structures.

The most important limit state which must be examined in design are as follows:

Limit state of Collapse

This state corresponds to the maximum load carrying capacity. Violation of collapse limit state implies failure in the sense that a clearly defined limit state of structural usefulness has been exceeded. However, it does not mean a complete collapse.

Thus, limit state may correspond to:

- Flexure
- Compression
- Shear
- Torsion

Limit state of serviceability

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

- Deflection
- Cracking
- Vibration

ETABS

In the last 30 years TABS and ETABS have set the international standards in structural analysis and design. They first took into consideration the characteristic properties of a building's mathematical model, thereby allowing the graphical creation of a building's model in the same sequence that will actually be constructed (slab by slab, floor by floor). Worldwide, ETABS is considered the most popular analysis and design software. The "Top Seismic Product of the 20th Century" (2006) and "Honor Award in Engineering Software" (2002) awards, establish it as the innovator in structural analysis and design and the reference point for the entire market. The latest version of ETABS continues in that tradition, incorporating structural element terminology that is used on a daily basis (Columns, Beams, Bracings, Shear Walls etc.), contrary to the common civil engineering programs that use terms such as nodes, members etc. Additionally, it offers many automatic functions for the formation, analysis and design of the structural system in an efficient, fast and easy way. The user can easily create a model, apply any kind of load to it and then take advantage of the superior capabilities of ETABS to perform a start or art analysis and design. ETABS is the solution, whether you are designing a simple 2D frame or performing a dynamic analysis of a complex high-rise that utilizes non-linear dampers for inter-story drift control.

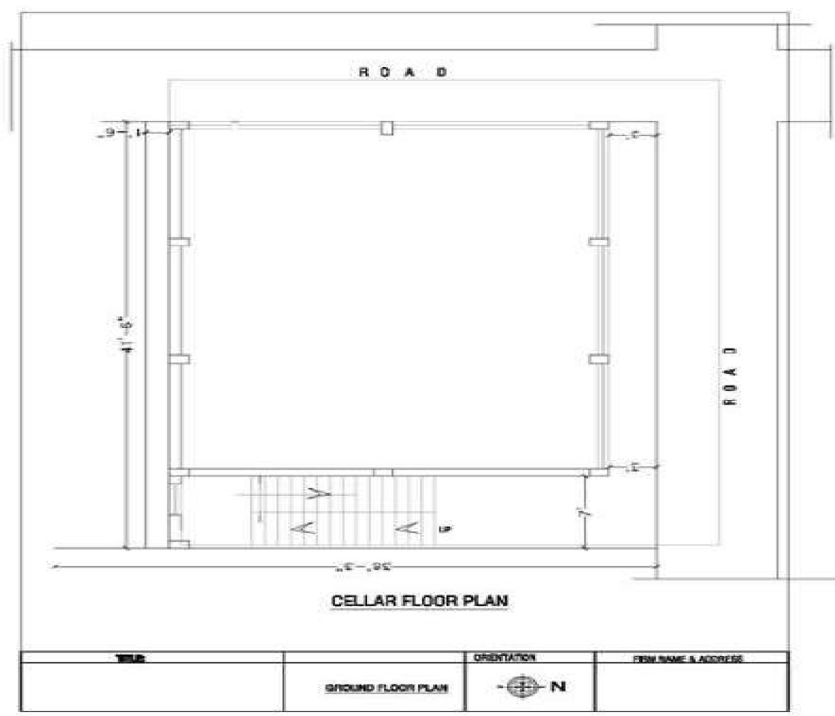
AREAS OF APPLICATION

- Analysis and design of building structures with a structural system consisting of beams, slabs, columns, shear walls and bracings. Different materials can be assigned to the structural elements within the same model such as steel, RC, composite or any other user-defined material
- Easy and automatic generation of gravity and lateral loads (seismic and wind loads) when compared with other FE general analysis programs

ADVANTAGES

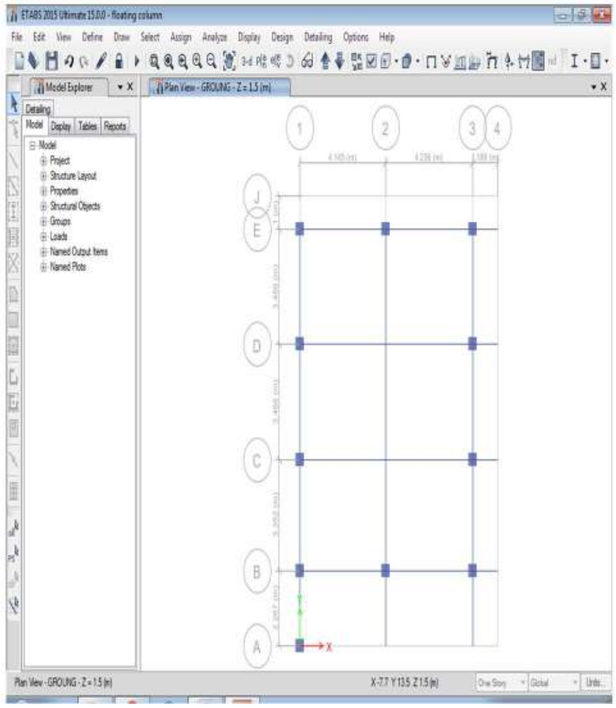
- Graphic input and editing for easy and fast model generation
- 3D generation of the model through plan views and elevations
  Fast model generation using the concept of Similar stories
- Easy editing through the Move, Merge, Mirror and Copy commands
- Accuracy in dimensions by using Snaps (end, perpendicular, middle etc.)
- Fast object creation with one click of the mouse
- Multiple viewing windows.
- 3D view with zoom and pan capability
- 3D axonometric view of the model, plan view, elevation view, elevation development view, custom view defined by the user
- Graphic input of cross sections of any geometry and material (Section Designer)
- Copy and Paste of the geometry of a model to and from spreadsheets
- Export of the model geometry to .dxf files
- Integration with EC – Praxis 3J for the analysis and design of steel connections

- Integration with STEREOSTATIKA for easy import of model geometry and design of RC structures according to Greek Code
- Integration with e-Tools for the design of RC structures according to Greek Code, masonry structures according to Euro code 6, RC jackets according to Greek Code and automatic creation of plastic hinges for pushover analysis
- Integration with SAP2000 for 3D analysis and design of structural elements including bridges, dams, tanks and buildings

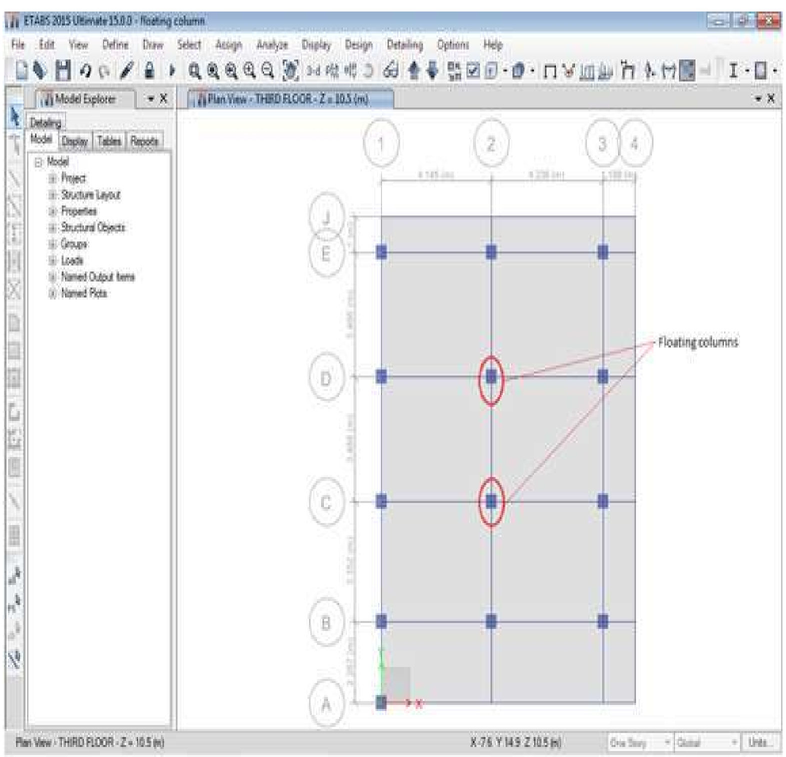


ARCHITECT PLAN

GROUND FLOOR PLANNING



THIRD FLOOR PLANNING



LOADS CONSIDERED

LOADS AND LOAD COMBINATION

GRAVITY LOADS

DEAD LOAD (DL): -

DEAD LOAD is defined as the load on a structure due to its own weight (self-weight). It also added other loads if some permanent structure is added to that structure.

LIVE LOAD (LL): -

LIVE LOAD Or IMPOSED LOAD is defined as the load on the structure due to moving weight. The LIVE LOAD varies according to the type of building. For example, generally for a Residential Building the LIVE LOAD is taken as 2kn/m2.

1. DEAD LOAD CALCULATION:

MAIN WALL LOAD (From above plinth area to below the Roof) should be the cross-sectional area of the wall multiplied by unit weight of the brick. (Unit weight of brick is taken as 19.2 kn/m3).

According to the IS-CODE PLINTH LOAD should be half of the MAIN WALL LOAD. Internal

PLINTH LOAD should be half of the PLINTH LOAD.

PARAPATE LOAD should be the cross sectional is multiplied by unit weight.

SLAB LOAD should be combination of slab load plus floor finishes. SLAB LOAD can be calculated as the thickness of slab multiplied by unit weight of concrete (according to IS-CODE unit weight of concrete is taken as 25 kn/m^3).and FLOOR FINISHES taken as .1.5 kn/m2.

LIVE LOAD CALCULATION:

LIVE LOAD is applied all over the super structure except the plinth. Generally LIVE LOAD varies according to the types of building. For Residential building LIVE LOAD is taken as ----2kn/m2 on each floor and 2kn/m2 on roof.

CRITICAL LOAD COMBINATIONS

While designing a structure, all load combinations, in general are required to be considered and the structure is designed for the most critical of all.

For building up to 4 stories, wind load is not considered, the elements are required to be designed for critical combination of dead load and live load only.

For deciding critical load arrangements, we are required to use maximum and minimum loads. For this code prescribes different load factors as given below:

Maximum load = wmax = 1.5(DL + LL)

Minimum load = wmin = DL

The maximum positive moments producing tension at the bottom will occur when the deflection is maximum or curvature producing concavity upwards is maximum. This condition will occur when maximum load (i.e., both DL and LL) covers the whole span while minimum load (i.e., only DL) is on adjacent spans.

(a) consideration may be limited to combination of :

1) Design dead load on all spans will full design live loads on two adjacent spans (for obtaining maximum hogging moment.)

STRUCTURAL PLANNING

Structural planning is first stage in any structural design. It involves the determination of appropriate form of structure, material to be used, the structural system, the layout of its components and the method of analysis.

As the success of any engineering project measured in terms of safety and economy, the emphasis today is being more on economy. Structural planning is the first step towards successful structural design.

Structural Planning of Reinforced Concrete Framed Building:

Structural planning of R.C.C. framed building involves determination of:

1. COLUMN POSITIONS
   - Positioning of columns
   - Orientation of columns
2. BEAM LOCATIONS
3. SPANNING OF SLABS
4. LAYOUT AND PLANNING OF STAIRS
5. TYPE OF FOOTING

COLUMN POSITIONS

- Positioning of columns

Following are some of the guideline's principles for positioning of columns.

1. Column should be preferably located at or near the corner of the building and at intersection of the walls, because the function of the column is to support beams which are normally placed under walls to support them. The columns, which are near to property line, can be exception from above consideration as the difficulties are encountered in providing footing for such columns.
2. When center to center distance between the intersection of the walls is large or where there are no cross walls, the spacing between two column is governed by limitations on spans of supported beams because spacing of column beside the span of the beams. As the span of the beam increase as the required depth increase and hence its self-weight. On the other hand, increase in total load is negligible in case of column due to increase in length. Therefore, column are generally cheaper compared to beams on basis of unit cost. Therefore, large spans of beam should be avoided for economy reasons.

ORIENTATION OF COLUMNS:

Column normally provided in the building are rectangular width of the column not less than the width of support for effective load transfer. As far as possible, the width of the column shall not exceed the thickness of the walls to avoid the offsets. Restrictions on the width of the column necessitate the other side (the depth) of the column to be larger the desired load carrying capacity. This leads to the problems of orientation of columns. The following guidelines are

1. According to requirement of aesthetics and utility, projection of column outside the wall and inside the should be avoided as they are not only give bad appearance but also obstruct the usage of corners and create problems in placing furniture flush with the wall. The depth of column shall be in the plane of the wall to avoid such offsets.
2. When a column is rigidly connected to beam at rigid angles. It is required to carry moments in addition to axial load in such cases, the column should be so oriented that the depth of column perpendicular to the major axis of the building so as to get moment resisting capacity.
3. Also, when the effective length of the column in one plane is greater than that in other plane at right angles, the greater dimension shall be in the plane having larger effective length. The size of columns which have been used for design of Office Building are 300 × 450 and 300 × 600.

POSITION OF BEAMS:

Following are some of the guiding principles for the positioning of beams:

a. Beams shall, normally be provided under the walls and below every concentrated load to avoid these loads directly coming on slabs. Basic principle in deciding the layout of a component member is that heavy loads should be transferred to the foundation along the shortest path.
b. Since beams are primarily provided to support slabs, its spacing shall be decided by the maximum spans of slabs which decides the spacing of beams are governed by loading and limiting thickness. The maximum practical thickness for Residential/Office/Public building is 200mm, while minimum is 100mm.

SPANNING OF SLABS

Span of slabs is decided by the position of supporting beams of walls. The slab can be made to span in one-direction (one-way) or two-direction (two-way), depending on support conditions, aspect ratio that is Ly/Lx, ratio of reinforcement in the two directions. The designer is free to decide as to whether slab should be designed as one way or two ways.

The point to be considered in making a decision i.e. whether slab should be designed as one way or two ways.

The slab acts as two-way slab when (Ly/Lx) < 2.

A slab acts as one-way when (Ly/Lx) > 2

a. A two-way slab is economical compare to one way slab, because steel along with directions acts as main steel and transfers loads to all the supports, while in one-way slab, main steel is provided along short span only and load is transferred to either of two supports.
b. Two way is advantageous, essentially for large spans (greater then 3m) and for live loads greater than 3 KN/sq.M. For short spans and light loads steel required for two way slab does not appreciably differ as compare to steel for one way slab because of requirement of main steel.

ASSUMPTION IN DESIGN

1. Using partial safety factors for loads in accordance with clause 36.4 of IS-456-2000 as $\gamma f = 1.5\gamma$
2. Partial safety factor for material in accordance with clause 36.4.2 is IS-456-2000 is taken as 1.5 for concrete and 1.15 for steel.
3. Using partial safety factors in accordance with clause 36.4 of IS-456-2000 combination of load.
   1.5D.L. +1.5 L.L.
   1.2D.L. +1.2 L.L.

LIVELOADS: In accordance with IS 875-86

i)	Live load on slabs	=	2.0KN/m2
ii)	Live load on passage	=	2.0KN/m2

DESIGN CONSTANTS

Using M20 and Fe 415 grade of concrete and steel for beams, slabs, footings, columns.

Therefore: -

Fck	=	characteristic strength for M20-20 N/mm2
Fy	=	Characteristic strength of steel – 500 N/mm2

ASSUMPTION REGARDING DESIGN

I. Slab is assumed to be continuous over interior support and partially fixed on edges, due to monolithic construction and due to construction of walls over it.
II. Beams are assumed to be continuous over interior support and they frame into the column at ends.

Choice Of Footing Type

Among the various types of footings, the suitable type of footing required for the structure shall be based on the applied loads, moments. Force and the induced reactions and to ensure that settlement of any kind shall be as uniform as possible. For trained structures, isolated column

Footings are usually preferred, except in the case of soil with low bearing capacity of soils is low raft foundations is used. Is any column of a structure is near the property line, combined footing of strap footing may be provided.

ANALYSIS OF STRUCTURE

Analysis of Structure

The primary function of a structure is to receive loads at certain points and transmit them to some other point. In performing this primary function, the structure develops internal forces in its component members known as structural elements. It is the duty of the structural engineer to design it in such a way that the structural elements perform their functions adequately. The inadequacy of one or more structural element may lead to malfunctioning or even collapse of the entire structure. The object of structural analysis is to determine the internal forces and the corresponding displacements of all the structural elements as well as those of the entire structural system. The safety and proper functioning of the structure can be ensured only through a thorough structural analysis. The importance of proper structural analysis cannot, therefore, be over emphasized. A systematic analysis of structural system can be carried out by using matrices. The matrix approach for the solution of structural problems is also eminently suitable for a solution using modern digital computers. Hence the advantage of using the matrix approach for large structural problems is evident.

By using matrix approach, the structural analysis can be performed in two methods:

I. Flexibility method
II. Stiffness method

In this project, the frames have been analyzed by using ETABS., Which uses stiffness method for analysis of structure.

ETABS, over the years, has developed to become the world's most popular and powerful structural engineering software. ETABS features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and seismic analysis capabilities. From model generation, analysis and design to visualization and result verification,

ETABS is the choice of the design professionals around the world for the analysis and design of steel, concrete, composite, timber, aluminum and cold-formed steel structures.

LOADING CONSIDERATION:

This stage involves determination of various types of loads that are acting on the structures. The values of types loads are taken from the relevant IS-codes.

Types of loads

Various types of loads on a structure and requiring consideration in design are

1 Dead load
2 Live load

Dead load:

This is the permanent or stationary load like self-weight of structural elements. This includes

1 Self-weight
2 Weight of Finishes

3 Weight of partition walls etc

Dead loads are based on the unit weight of elements, which are established taking into account materials specified for constructions in IS 875-part1 -1987)

Live loads: (as per IS 875 (part 2) – 1987)

These are non-permanent are moving loads. This type of load includes the following

1 Imposed loads (Fixed) weight of fixed seating in auditoriums, fixed machinery, partition walls. This loads, though, fixed in positions cannot be relieved upon to act permanently throughout the life of the structure.
2 Imposed loads (not fixed) these loads change either in magnitude or position very often such as traffic loads, weight of furniture etc.

Loading standards:

The loads that are considered in the design are based on IS-875-1964

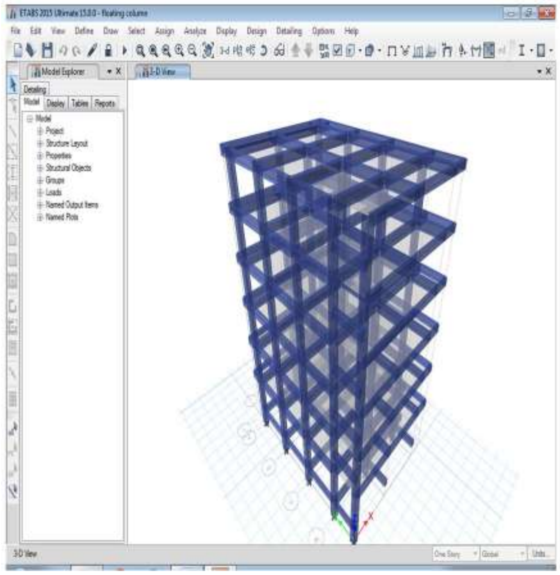
1. The dead loads

R.C.C	25 KN/m3
P.C.C	24 KN/m3
BRICK MASONRY	19 KN/m3
FLOO FINISHES	1.5 KN/m3

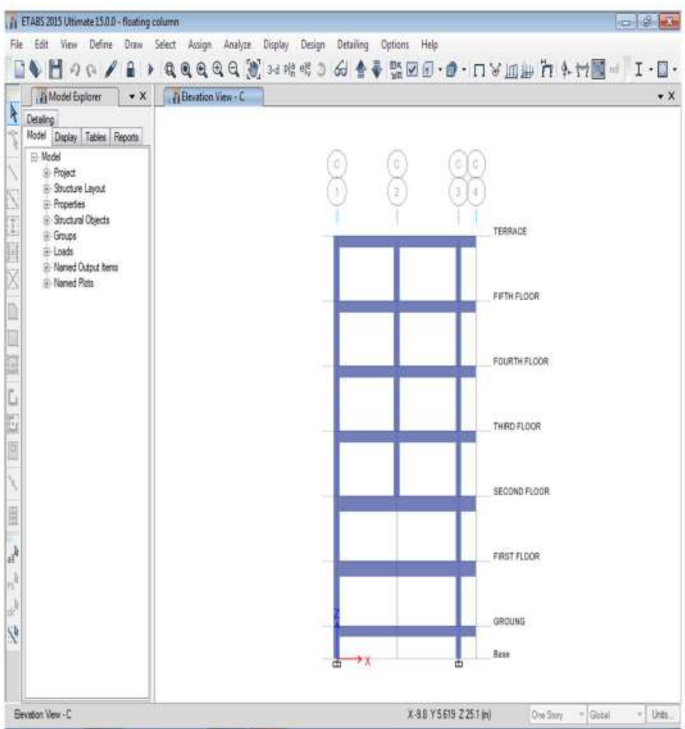
2.The Live loads

On floors	2 KN/m2
On roofs	2 KN/m2

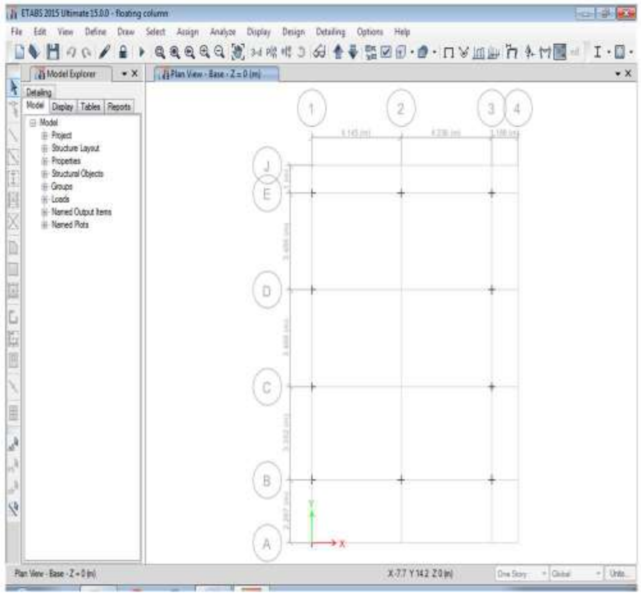
3D VIEW OF THE STRUCTURE



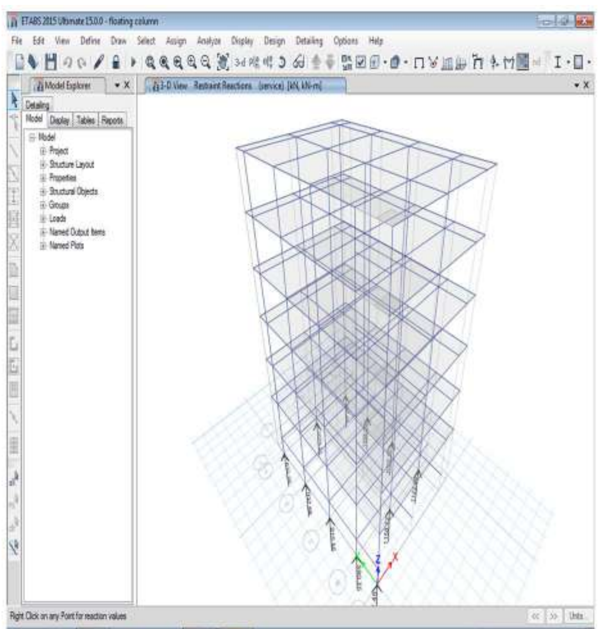
ELEVATION OF THE STRUCTURE



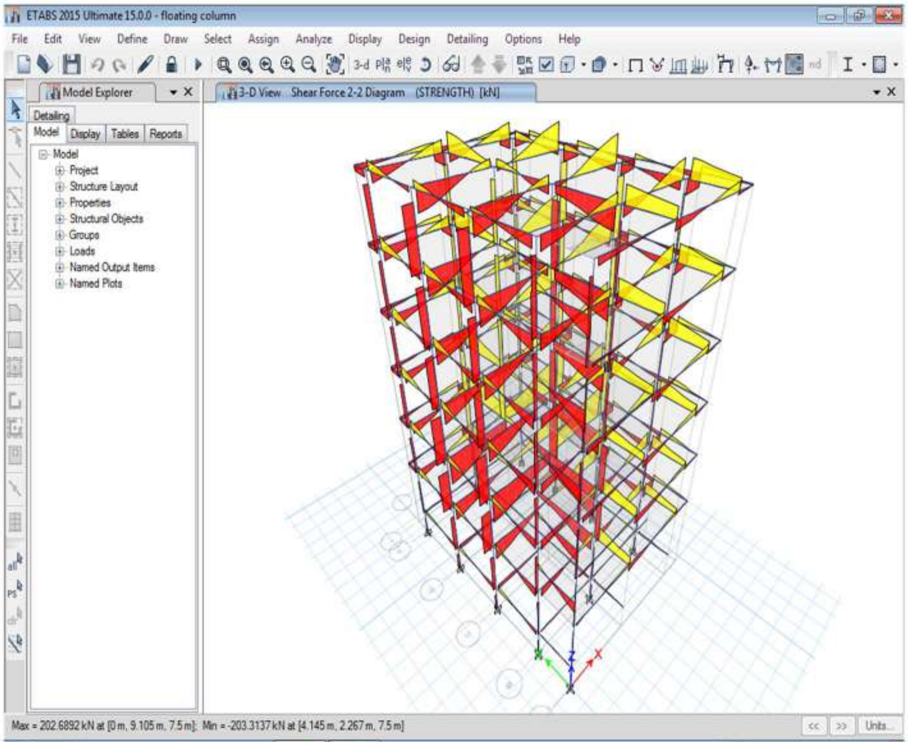
SUPPORTS



BASE REACTIONS



BENDING MOMENT OF THE STRUCTURE


ETABS 2015 Ultimate 15.0.0 - floating column
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Model Explorer
Detailing
Model Display Tables Reports
Model
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Properties
Structural Objects
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3-D View Shear Force 2-2 Diagram (STRENGTH) [kN]
Max = 202.6892 kN at [0 m, 9.105 m, 7.5 m]; Min = -203.3137 kN at [4.145 m, 2.267 m, 7.5 m]
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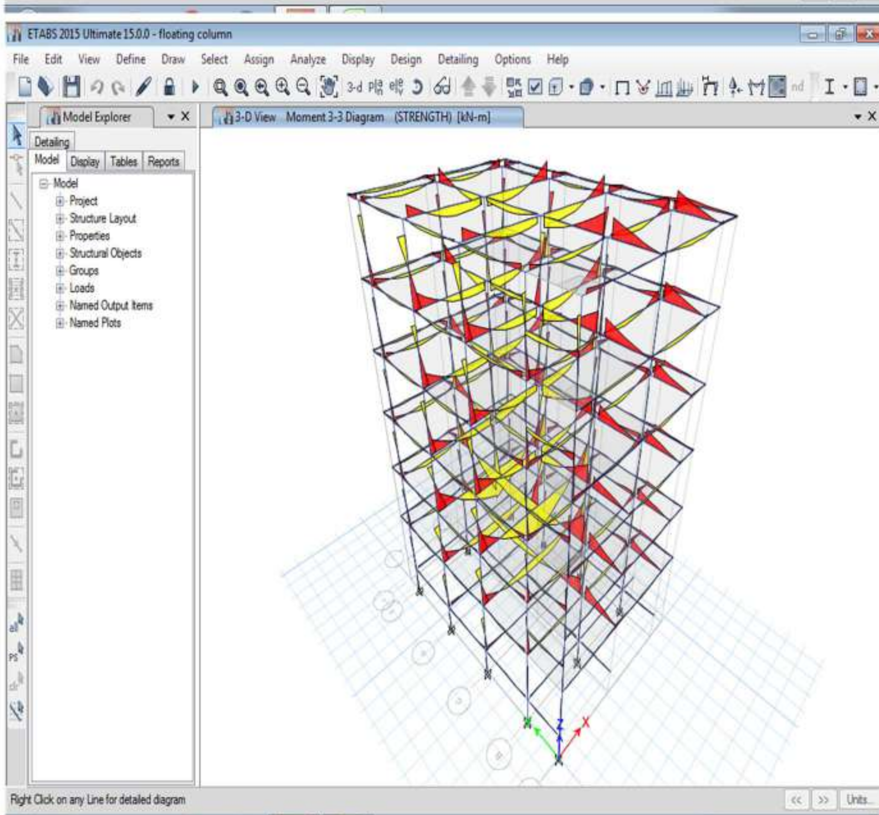
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Properties
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Groups
Loads
Named Output Items
Named Plots
3-D View Moment 3-3 Diagram (STRENGTH) [kN-m]
Right Click on any Line for detailed diagram
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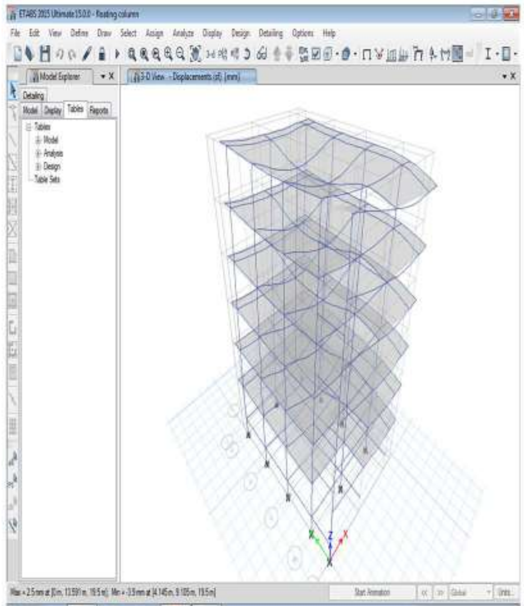
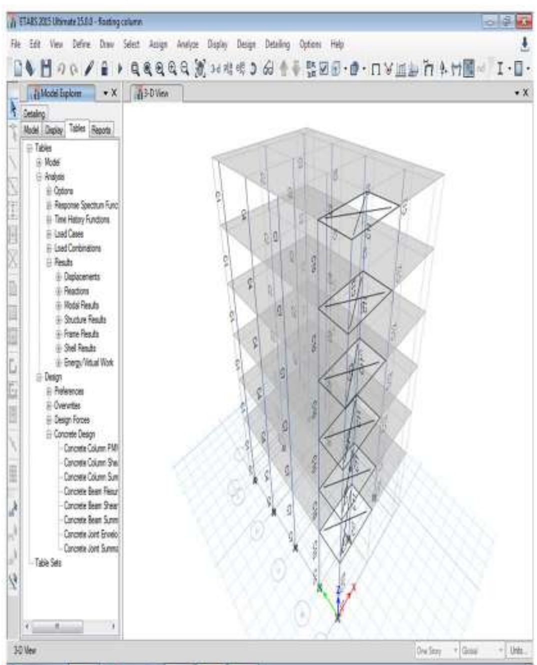
SHEAR FORCE OF THE STRUCTURE

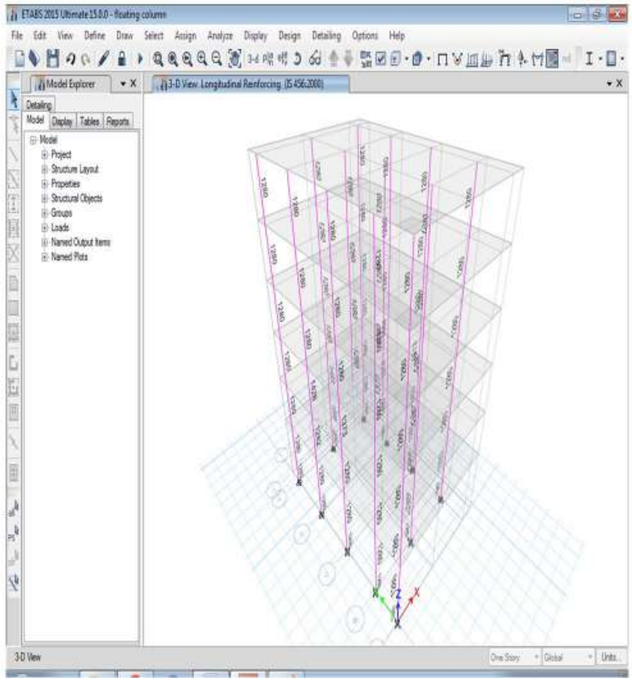
DEFORMED SHAPE OF THE STRUCTURE



COLUMN DESIGN



REINFORCEMENT IN THE COLUMNS



ETABS 2015 Concrete Frame Design

IS 456:2000 Column Section Design (Envelope)

Column Element Details

Level	Element	Section ID	Length (mm)	LLRF
TERRACE	C1	COLUMN 400X400	3000	1

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
400	400	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_C	γ_S
1.5	1.15

Longitudinal Reinforcement Design for P_u - M_{u2} - M_{u3} Interaction

Column End	Rebar Area mm²	Rebar %
Top	1280	0.8
Bottom	1280	0.8

Design Axial Force & Biaxial Moment for P_u - M_{u2} - M_{u3} Interaction

Column End	Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Station Loc mm	Controlling Combo
	kN	kN-m	kN-m	mm	
Top	138.8125	-8.4997	29.3052	2495	STRENGTH
Bottom	152.6831	13.2172	-30.2192	0	STRENGTH

Shear Reinforcement for Major Shear, V_{u2}

Column End	Rebar A_{sv} /s mm²/m	Design V_{u2} kN	Station Loc mm	Controlling Combo
Top	0	0	2495	STRENGTH
Bottom	0	0	0	STRENGTH

Shear Reinforcement for Minor Shear, V_{u3}

Column End	Rebar A_{sv} /s mm²/m	Design V_{u3} kN	Station Loc mm	Controlling Combo
Top	443.37	8.7042	2495	STRENGTH
Bottom	443.37	8.7042	0	STRENGTH

ETABS 2015 Concrete Frame Design

IS 456:2000 Column Section Design (Envelope)

Column Element Details

Level	Element	Section ID	Length (mm)	LLRF
TERRACE	C1	COLUMN 400X400	3000	1

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
400	400	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_C	γ_S
1.5	1.15

Longitudinal Reinforcement Design for P_u - M_{u2} - M_{u3} Interaction

Column End	Rebar Area mm^2	Rebar %
Top	1280	0.8
Bottom	1280	0.8

Design Axial Force & Biaxial Moment for P_u - M_{u2} - M_{u3} Interaction

Column End	Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Station Loc mm	Controlling Combo
	kN	kN-m	kN-m	mm	
Top	138.0125	-8.4997	29.3052	2495	STRENGTH
Bottom	152.6831	13.2172	-30.2192	0	STRENGTH

Shear Reinforcement for Major Shear, V_{u2}

Column End	Rebar A_{sv} /s mm²/m	Design V_{u2} kN	Station Loc mm	Controlling Combo
Top	0	0	2495	STRENGTH
Bottom	0	0	0	STRENGTH

Shear Reinforcement for Minor Shear, V_{u3}

Column End	Rebar A_{sv} /s mm²/m	Design V_{u3} kN	Station Loc mm	Controlling Combo
Top	443.37	8.7042	2495	STRENGTH
Bottom	443.37	8.7042	0	STRENGTH

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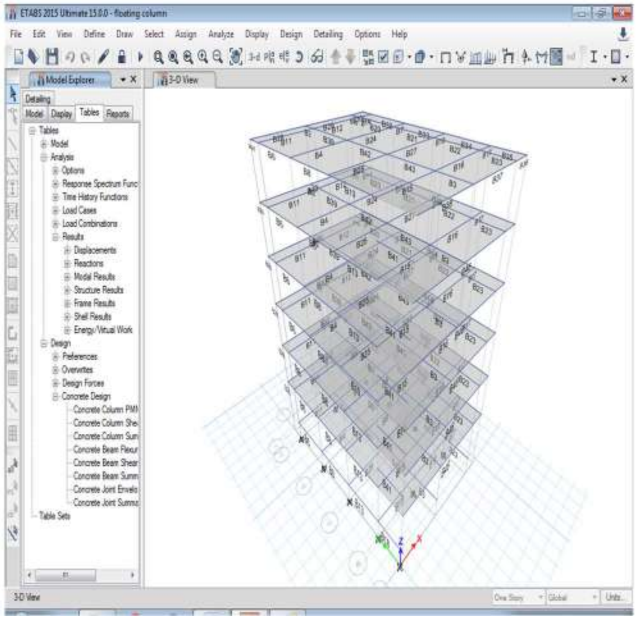
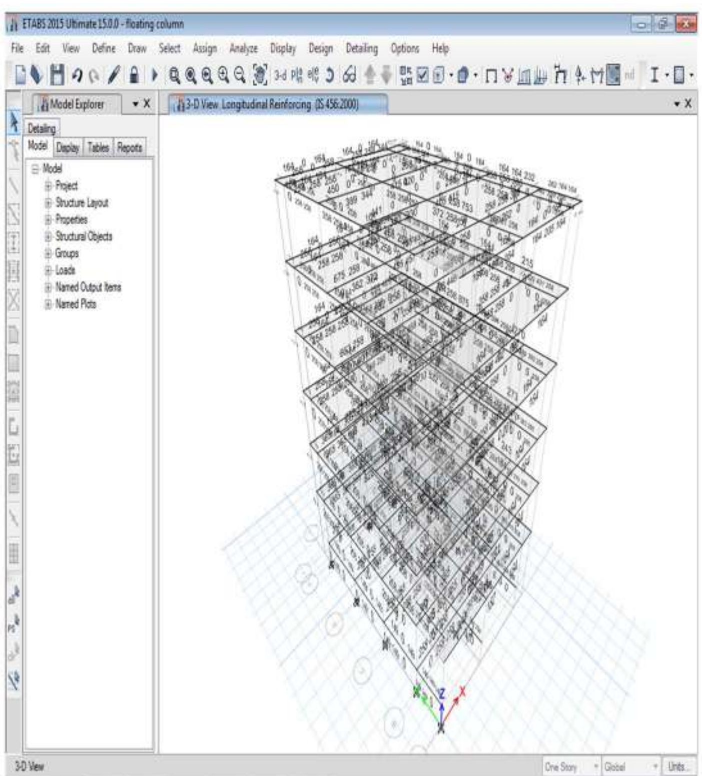
RESULTS



Beam numbering

BEAM REINFORCEMENT



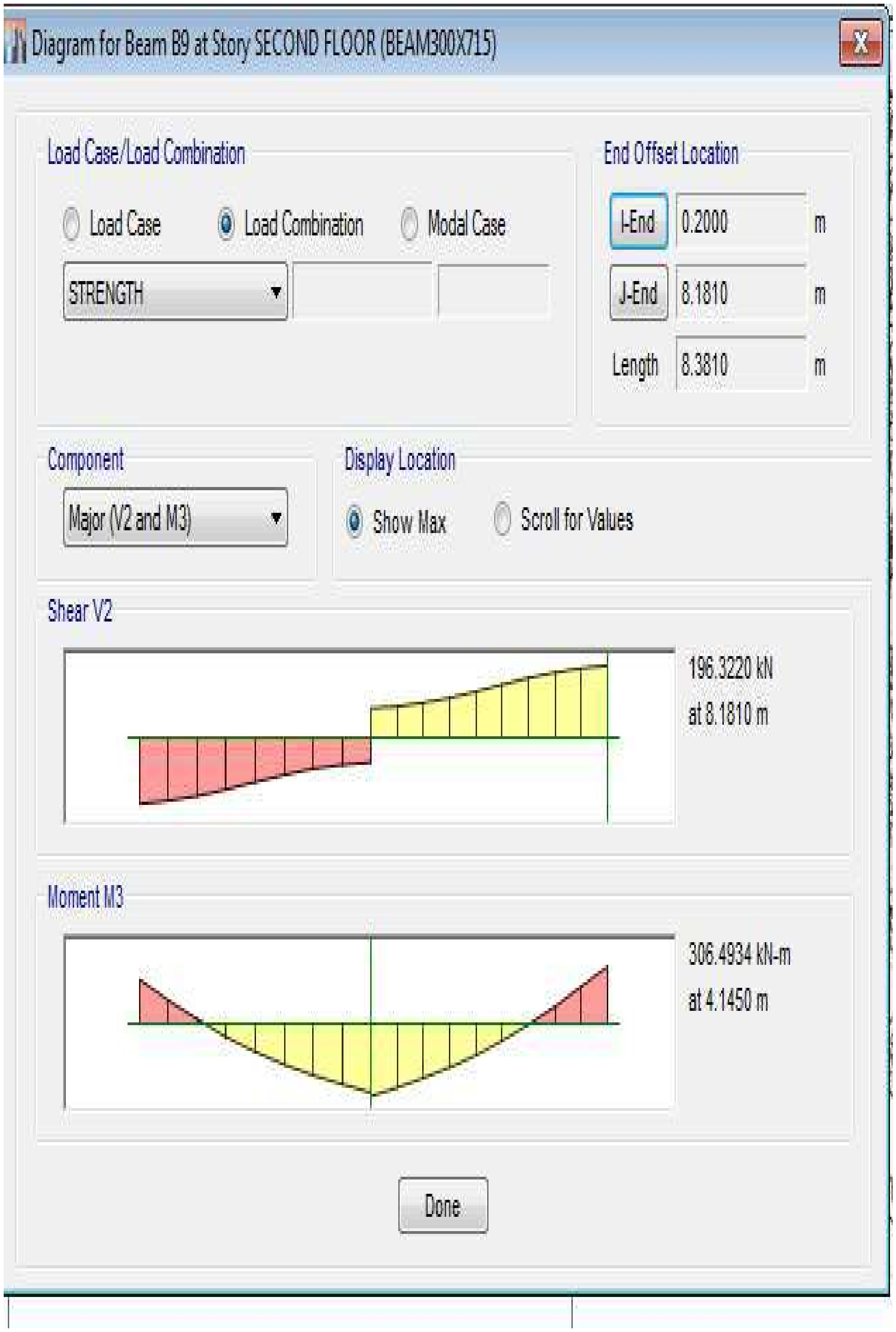


Diagram for Beam B9 at Story SECOND FLOOR (BEAM300X715)
Load Case/Load Combination
Load Case
Load Combination
Modal Case
STRENGTH
End Offset Location
I-End
0.2000
m
J-End
8.1810
m
Length
8.3810
m
Component
Major (V2 and M3)
Display Location
Show Max
Scroll for Values
Shear V2
196.3220 kN
at 8.1810 m
Moment M3
306.4934 kN-m
at 4.1450 m
Done

Design of beam B9

ETABS 2015 Concrete Frame Design

IS 456:2000 Beam Section Design (Envelope)

Beam Element Details

Level	Element	Section ID	Length (mm)	LLRF
SECOND FLOOR	B9	BEAM300X715	8381	0.899

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
300	715	300	0	40	40

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_C	γ_S
1.5	1.15

Flexural Reinforcement for Major Axis Moment, M_{u3}

	End-I Rebar Area mm²	End-I Rebar %	Middle Rebar Area mm²	Middle Rebar %	End-J Rebar Area mm²	End-J Rebar %
Top (+2 Axis)	806	0.38	0	0	1058	0.49
Bot (-2 Axis)	614	0.29	1458	0.68	453	0.21

Flexural Design Moment, M_{u3}

	End-I Design M_u kN-m	End-I Station Loc mm	Middle Design M_u kN-m	Middle Station Loc mm	End-J Design M_u kN-m	End-J Station Loc mm
Top (+2 Axis)	-212.5513	200	0	5938.8	-269.2897	8181
Combo	STRENGTH		STRENGTH		STRENGTH	
Bot (-2 Axis)	166.3735	2172.5	349.8014	4145	125.3113	6387.2
Combo	STRENGTH		STRENGTH		STRENGTH	

Shear Reinforcement for Major Shear, V_{u2}

End-I Rebar A_{sv}/s mm²/m	Middle Rebar A_{sv}/s mm²/m	End-J Rebar A_{sv}/s mm²/m
688.67	468.08	763.38

Design Shear Force for Major Shear, V_{u2}

End-I Design V_u kN	End-I Station Loc mm	Middle Design V_u kN	Middle Station Loc mm	End-J Design V_u kN	End-J Station Loc mm
171.2499	693.1	0.1256	5938.8	177.8021	7284.1
STRENGTH		STRENGTH		STRENGTH	

Torsion Reinforcement

Shear Rebar A_{svt}/s mm^2/m
763.36

Design Torsion Force

Design T_u kN-m	Station Loc mm	Design T_u kN-m	Station Loc mm
13.0865	7284.1	13.0865	8181
STRENGTH		STRENGTH	

CONCLUSION

ETABS software has become more and more critical in the analysis of engineering and scientific problems. Much of the reason for this change from manual methods has been the advancement of computer techniques development by the research community and in particular universities.

As technology and engineering adoptions are advertising new methodology of interlinking and completing the industries via computer applications are created with a similar improvement in hardware capacities.

It is shown by analysis in ETABS that the amount of axial load on the columns as mentioned above is reduced to a larger extent, not only axial load but also the moments i.e. internal stress also reduced to a larger extent in floating columns.

This is turning facilities the implementations of more effective and professional engineering software. As the applications adventure in functionality, one can hope that they will be more affordable to promote their widespread usage amongst civil engineering at a global scale.

Taking into account the technological advance, this project has been dealt with using the latest design software.

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