



STRUCTURAL DESIGN AND ANALYSIS OF SCHOOL BUILDING

B. LALITHA, Department Of CIVIL, SICET, Hyderabad

D. VIJAY KUMAR, N. NAGARAJU, S.SURESH, T. GEETANJALI

Department Of CIVIL, SICET, Hyderabad

Abstract: The main aim while designing a reinforced concrete structure is to provide safe, serviceable, durable, economical and aesthetically pleasing structure. In order to satisfy the safe condition, the structure should resist all types of worst loading conditions. One of the most important factors is cost. The structure should be economical in terms of construction as well as maintenance cost. The project work includes modelling, analysis and design of an Educational building at Kadammanitta, Pathanamthitta. The building consists of ground + 1 stories of moment resisting frame supported on footing. The beam-column layouts should be fixed and the modelling should be done using ETABS 2016. During analysis, dead loads and live loads should be calculated from IS: 875 (Part 1) – 1987 and IS: 875 (Part 2) – 1987 respectively and their combinations should be applied as per IS 456: 2000. The load combinations were taken to obtain the maximum design loads, moments and shear forces. Wind force should be calculated using IS:875(Part3)–1987. The design should be carried out as per IS 456: 2000 for the above load combinations. Earthquake design of the structure should be done as per IS 1893 (Part 1): 2002 and the detailing as per IS 13920: 1993. Detailing of reinforcement should be done using AutoCAD 2018 as per SP 34: 1987.

Keywords – ETABS, IS 875, Design, Analysis, Educational building

1.

INTRODUCTION

The term building in Civil Engineering is a structure having various components like foundation, walls, columns, floors, roofs, doors, windows, ventilators, stairs, lifts, various types of surface finishes etc. Structural analysis and design are used to produce a structure capable of resisting all applied loads without any failure during its intended life. Structural engineers are facing the challenges of striving for most efficient and economical design with accuracy in solution while ensuring that the final design of a building and the building must be serviceable for its intended function over its design life time. Now a days various software packages are available in market for analyzing and designing practically all types of structures. With the advancement of technology and newer methods of construction, vertical expansion of building has become a simple process. The non-availability of land and increase in population catalyzed the above process. The technology for building tall structure is developing rapidly. For analyzing a multi-storied building, one has to consider all the possible loadings and see that the structure is safe against all possible loading conditions.

In the present study, it is planned to design a G+1 educational building, at Kadammanitta, Pathanamthitta. The planning is done as per the requirements and regulations given by Kerala Panchayat Building Rules (KPBR) for educational building. Extended 3D Analysis of Building System (ETABS) is the present-day leading design software in the market. It can analyze all the members like beam, column, slab, shear walls etc.

2. NEED AND SCOPE

The existing higher secondary school building was constructed in the year 1929 and is 92 years old. The structure is very old and has cracks on the walls. The building has 13 rooms in total out of which only 9 rooms are in use. The classroom lacks proper lighting facilities. It also lacks proper sanitation facilities a proper wash area. The size of classroom is small which leads to space congestion. Also the building has no special rooms for IED students. The roof provided is of clay roof tile. It causes water leakage from roof during rainy season. Doors are not in good condition.

As per the Smart classroom initiative of Government of Kerala, the classrooms are provided with smart class facilities. The current structure is inefficient to have smart classrooms. The classrooms are provided with smart class facilities in the new building. In this project work analysis is done using ETABS. Analysis is done to find out the Shear Forces and Bending Moments. Designing is done to find out the size of load bearing members and its reinforcement. Detailing is the transformation of design into drawings.

The scope of the project is :

- To apply class room knowledge in the real world by designing a RCC school building.
- To effectively apply and getting familiar with IS codes and standards
- To understand the synthesis of structural analysis and design that occurs in the professional practice.
- Approach for professional practice in the field of structural engineering.



3. METHODOLOGY

The whole project work is divided into the following sequential steps.

3.1 PREPARATION OF PLAN USING AUTOCAD

The plan of the educational building is drafted using the drafting software AutoCAD. The centre line diagram of the building, layout and reinforcement detailing etc. is drawn. The design and analysis of the building is made as per the plan.

3.2 IMPORTING TO ETABS

After drafting the layout of a multi-storied educational building in AutoCAD it is imported to ETABS.

3.3 BUILDING MODELLING IN ETABS

The modelling of the above building is done using ETABS. 3D view of the building model is obtained.

3.4 ASSIGNING OF LOAD

The loads are assigned as per IS provisions. For analysing a multi-storeied building one has to consider all possible loads and see that the structure is safe against all possible loading conditions.

3.5 ANALYSE THE BUILDING MODEL USING ETABS

After assigning the load the analysis of the structure is done in ETABS. The analysis method adopted is Equivalent Static analysis

4. DETAILS OF EXISTING BUILDING AND PROPOSED BUILDING

4.1 EXISTING BUILDING

The existing building as shown in Fig 4.1, is an educational building located at Kadammanitta, Pathanamthitta. It has a plinth area of 1200m². The footing of the existing building is isolated footing. Car parking's are provided in the open ground of the existing building. Rain water harvesting system constructed on the surrounding stores water during rain, which can be used whenever required.



Fig 4.1 : Existing Building

4.2 PROPOSED BUILDING

The building plan of the proposed building is drawn up-to a scale of 1:100. The detailed figure of the floor plan is shown in figure 4.2

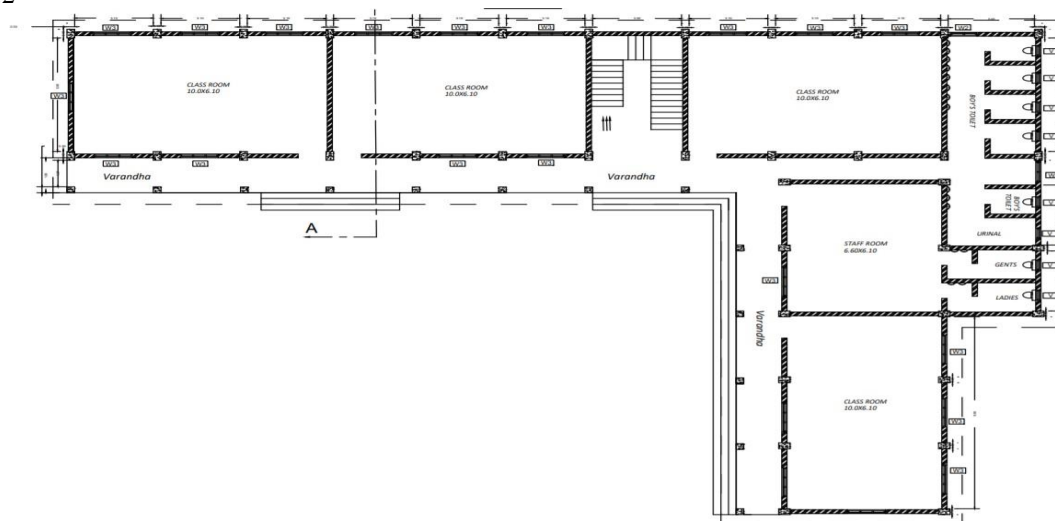
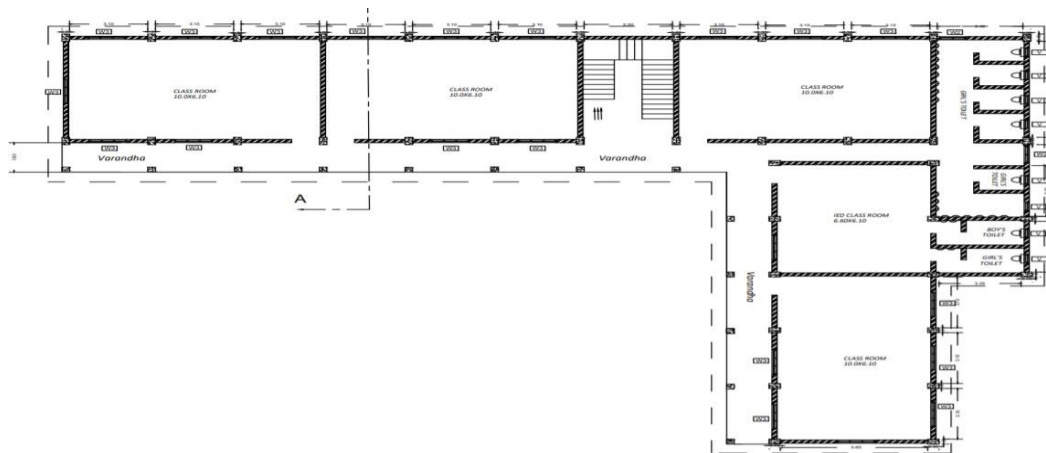


Fig 4.2 Ground Floor Plan



4.3 First Floor Plan

As per the KPBR rules for educational building a size of $1m^2$ is required for each student and a higher secondary classroom contains a maximum of 60 students that is, the size adopted for a higher secondary classroom is $60m^2$. For practical convenience we usually adopt a minimum size of $10m \times 6m$ for a higher secondary classroom.

The size of the proposed classroom is $10m \times 6.1m$.

Preparation of Plan

- Classroom – $10m \times 6.1m$
- Staffroom – $7m \times 6.1m$
- IED Classroom – $7m \times 6.1m$
- Height of the building - 3.6m (ceiling height)Sanitary facilities
- Bathroom - not less than $1.5m^2$
- Bathroom including water closet - not less than $2.2m^2$
- Height of bathroom - not less than 2.2mStaircase
- Minimum width of tread - 30cm
- Maximum height of rise -15cm

Table 4.1 Rooms Provided on Each Floor

Ground Floor	First Floor
Classroom	Classroom
Staffroom	IED Classroom
Stair	Stair
Boy's Toilet	Girl's Toilet
Attached Toilet (Staffroom)	Attached Toilet (IED Classroom)

5. ANALYSIS OF STRUCTURE USING ETABS

5.1 ETABS

The innovative and revolutionary new ETABS is the ultimate integrated software package for the structure analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object-based modelling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily understand analysis and design results.

5.2 BUILDING MODELLING IN ETABS

5.2.1 Data For Modelling

- i. Concrete Grade- M30
 $f_{ck} = 30 \text{ N/mm}^2$
- ii. Rebar Grade-HYSD 500
 $f_y = 500 \text{ N/mm}^2$
- iii. Beam Dimensions
Longer floor beams = $200mm \times 550mm$



Shorter floor beams = 200mm×285mm
Longer plinth beams = 200mm×420mm
Shorter plinth beams = 200mm×230mm

- iv. Column Dimensions
Column 1 = 300mm×450mm
Column 2 = 300mm×300mm
- v. Slab Dimensions
Floor slabs = 200mm

5.2.2 Beam Column Layout

The beam column layout drawing in AutoCAD is given in Fig 5.1.

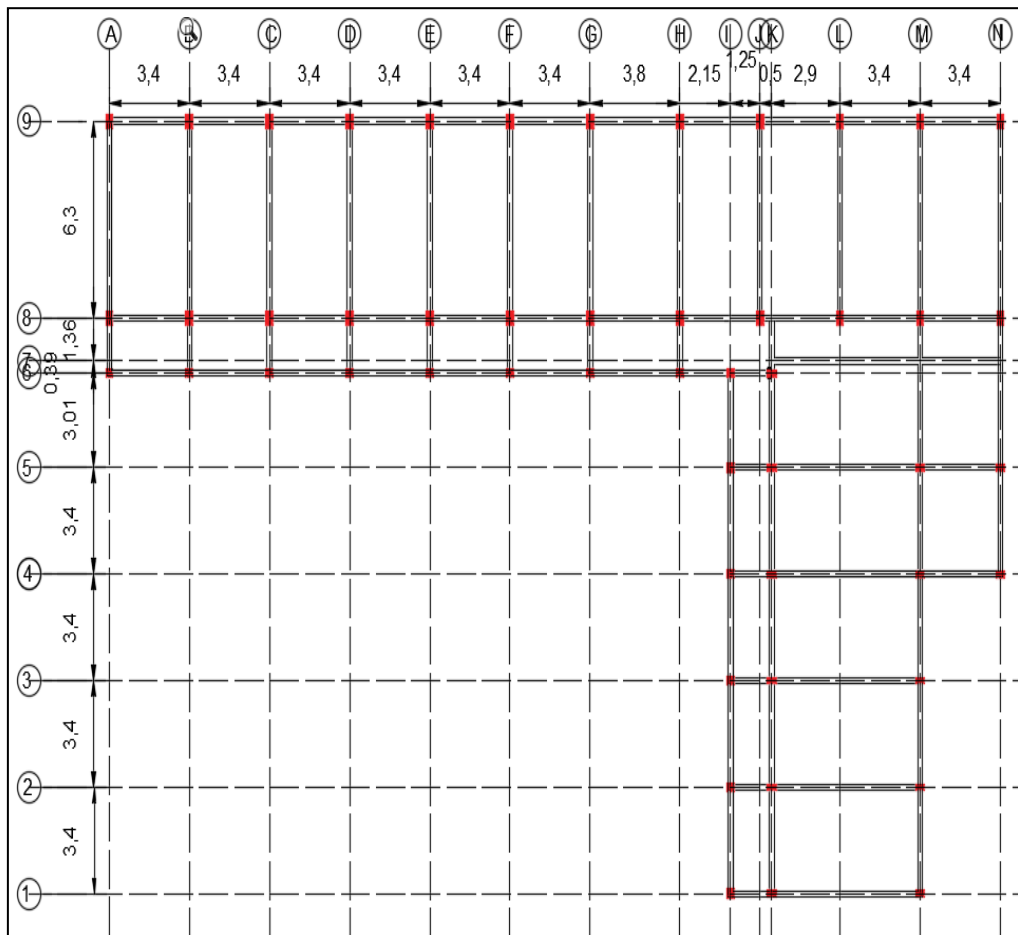


Fig 5.1 : Beam Column Layout



5.2.3 Floor Plan in ETABS

The floor plan drawn in ETABS is given in Fig 5.2.

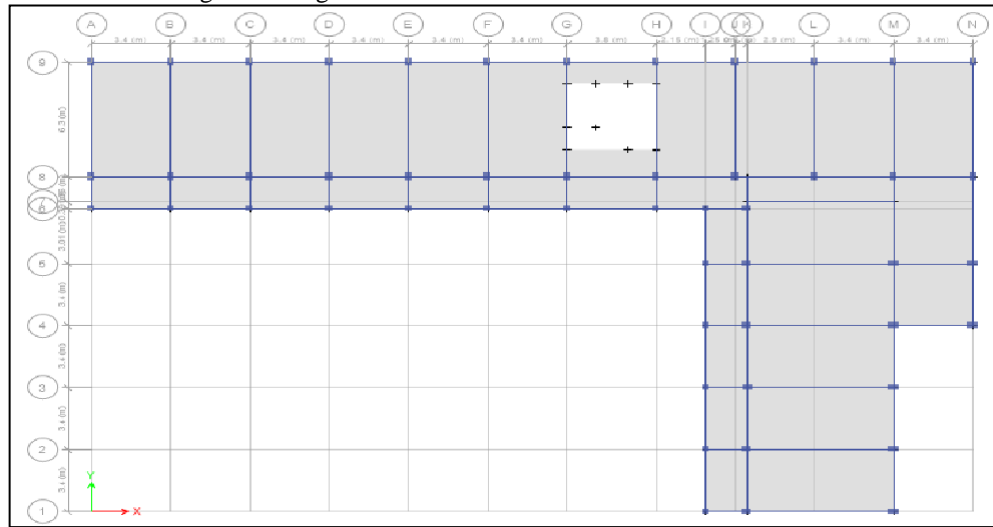


Fig:5.2 Floor Plan in ETABS

5.2.4 3D View In Etabs

The 3D view of the building model obtained in ETABS is shown in Fig 5.3.

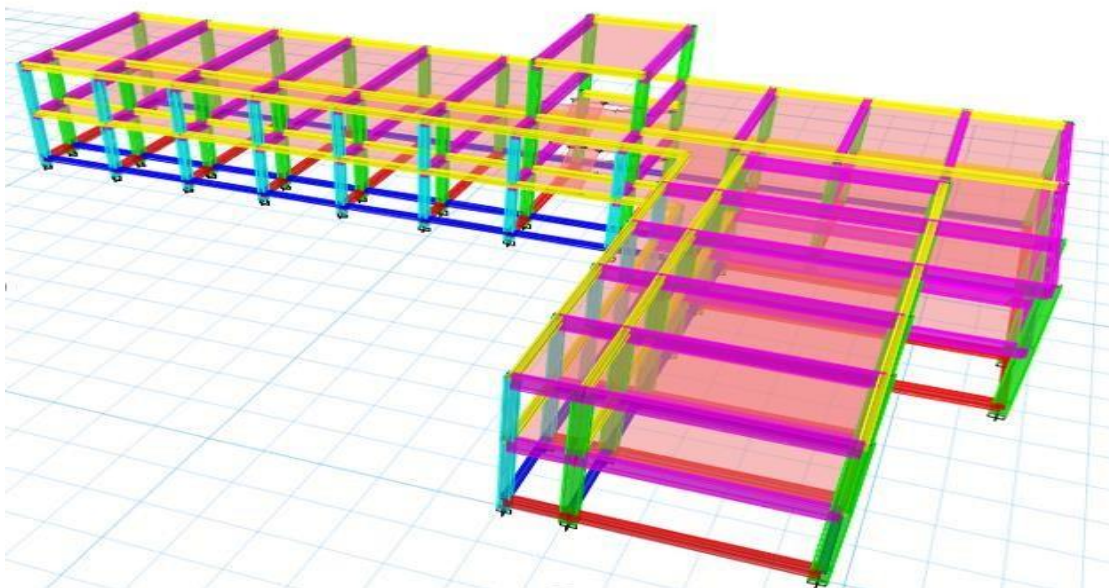


Fig 5.3: 3D view in ETABS

5.3 LOADING DETAILS

The different load cases considered are dead loads, live loads, wind loads and earthquake loads.

Dead load is primarily due to self-weight of structural members, permanent partition walls, fixed permanent equipment and weights of different materials. Loads shall be calculated on the basis of unit weight of materials used and is specified in IS 875 (Part I) 1987



Table 5.1 Dead Loads

SPECIFICATIONS		LOAD
Brick Wall (23cm)	Floor Height =3.6m	14.3kN/m
	Stair room = 2.5m	10 kN/m
Parapet (10 cm)		2.0 kN/m
Steps of Stair case	For 8 Steps	1.20 kN/m ²
	For 12 Steps	1.34 kN/m ²
Floor Finish		1 kN/m ²

Live loads were taken from IS 875 : 1987(Part 2). Table 5.2. shows the uniformly distributed loads in rooms

Table 5.2 Live Loads

SPECIFICATIONS	LOAD (kN/m ²)
Classroom	3
Roof with access	1.5
Staff Room	2.5
Toilets and Bathrooms	2
Corridors, Passages and Staircase	4

The wind load values were generated by the software itself in accordance with IS875(Part 3) -1987. Under the define load command section, in the wind load category, the definition of wind load was supplied.

Basic wind speed - Kerala: 39 m/s

Table 5.3 Wind Loads

TYPE	ANNOTATION	VALUE	SOURCE
Basic Wind Speed(Trivandrum)	V _b	39m/s	clause 5.2
Probability Factor(Design life 50years)	k ₁	1	clause 5.3.1
Terrain, Height AndStructure Height Factor(Height of building=10.3m)	k ₂	1	clause 5.3.2
Topography Factor	k ₃	1	clause 5.3.3

Earthquakes generate beams which moves from the origin of its location with velocities depending on the intensity and magnitude on earthquake. The impact of earthquake on structures depends on the stiffness of the structure, stiffness of the soilmedia, height and location of the structure etc. The earthquake forces are prescribed in IS 1893:2002 Part 1. Since the building is located in Kerala, it is included in zone 3, and the seismic base shear calculation and its distribution is done as per IS 1893:2002 Part 1 Clause 7.5.3.

Table 5.4 Earthquake Loads

TYPE	ANNOTATION	VALUE	SOURCE
Zone Factor(Zone 3)	Z	0.16	Table 2
Importance Factor	I	1	Table 6
Response ReductionFactor, R	R	5	Table 7
Rock and Soil sitefactor	SS	1	Cl. 6.4.2
Live Load ReductionFactor		0.5	Table 8

6.

ANALYSIS RESULT AND DISCUSSION

6.1 MAXIMUM DISPLACEMENT

6.1.1 Deformed Shape

The deformed shape obtained is shown in Fig 6.1.

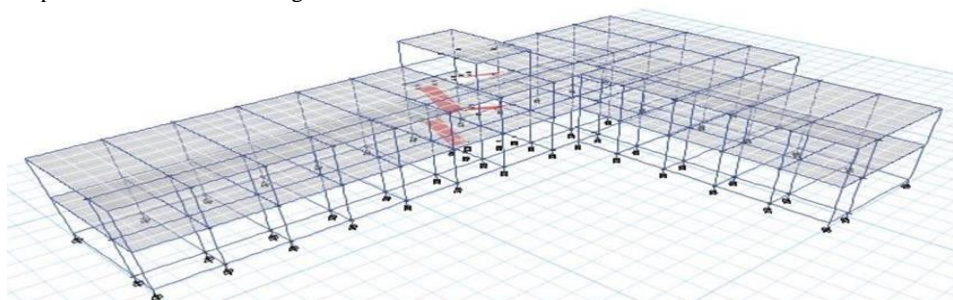


Fig 6.1 Deformed Shape



The Maximum displacement obtained is 7.5mm.

6.2 BENDING MOMENT DIAGRAM (BMD)

The bending moment diagram obtained in the analysis is shown in Fig 6.2.

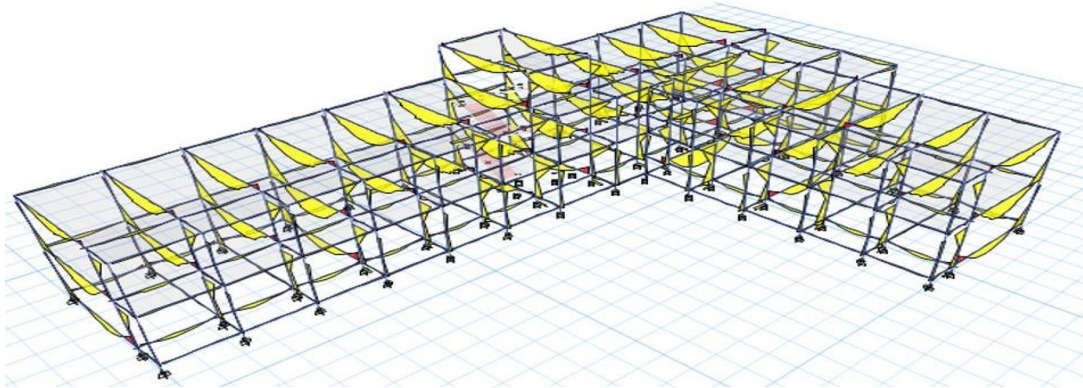


Fig 6.2 Bending Moment Diagram

6.3 SHEAR FORCE DIAGRAM (SFD)

The shear force diagram obtained from analysis is given in Fig 6.3.

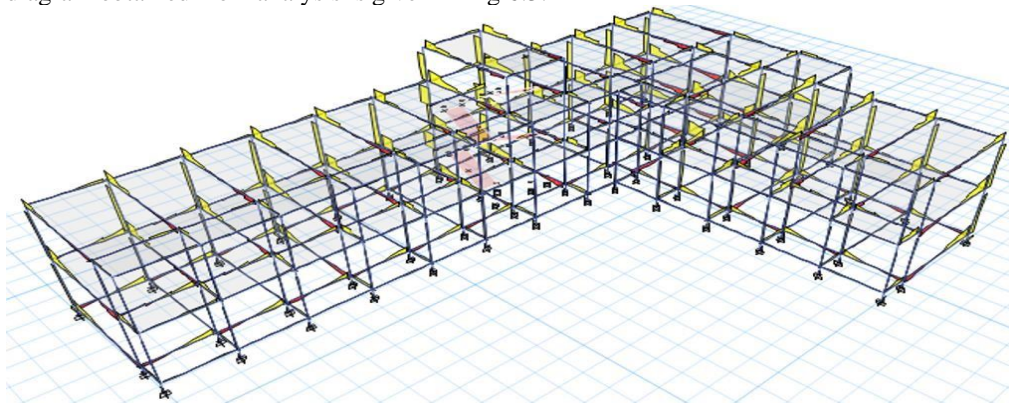


Fig 6.3 Shear Force Diagram

6.4 COLUMN LOADS AND MOMENT

The column loads and moments obtained is shown in the Fig 6.4.

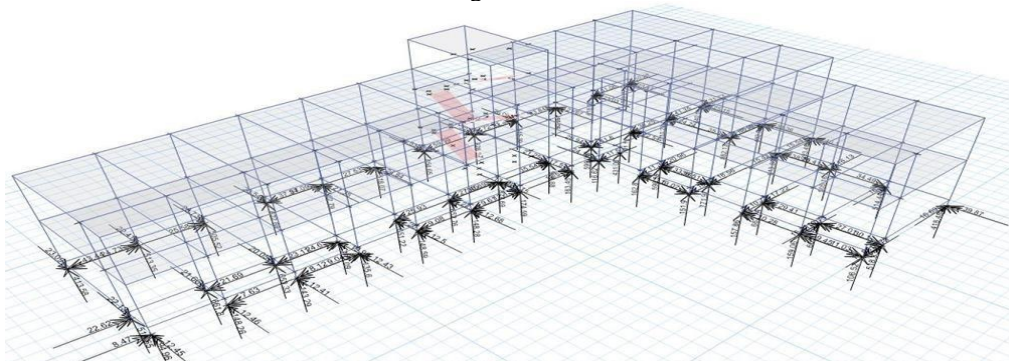


Fig 6.4 Column Loads and Moment



- If the column has axial loads only- Axially Loaded Column
- If the column has axial load and one moment- Uni-axial Column
- If the column has axial load and two moment- Bi-axial Column

7. CONCLUSION

The project work is to analyse a new higher secondary block at G.H.S.S, Kadammanitta and is done as per the requirements and standards. The project helped to gain sufficient exposure to various fields of analysis and design of multi-storied building. The plan, layout, analysis, design and detailing of the educational building is done as per the Kerala Panchayat Building Rules and Indian standard Codes. The plan and detailing is drafted using AutoCAD and the analysis of the structure is done in ETABS. All the structural components were designed manually according to the standard specifications of various codes to the possible extent. From the project work following conclusions were made:

- The ETABS software contains all modelling tools and templates, code-based load prescriptions, analysis methods and solution techniques. It can be used to produce 3D view of the structure, analyze the building model and to calculate the reinforcement for concrete beams, columns, slabs etc.
- A large variety of design codes are available and design can be carried out for different type of loads such as dead loads, live loads, earthquake loads, wind loads etc.
- ETABS software helps produce a more convenient and economical design for multi-storied building. Even though the software is not much use in India, it does help to provide a more accurate design of the structure.
- The errors that happen in manual designing can be avoided in ETABS and a more economical design can be obtained.
- The drawback of designing the foundation in ETABS is that for the full model work together and any change on the foundation sizes or thickness, it changes the stresses on the full system not only the foundation which force to check the model more than one time to make sure the design is safe. Actually, this way leads to perfect design, but it will lose a lot of time in doing the alterations.

The project work helped in acquiring a real life experience in professional practice and to get familiarized with IS codes. It also helped to understand the implementation of structural design softwares in practical work. Various difficulties encountered in the design process and various constraints faced by the structural engineer in designing were well understood.

REFERENCE

- [1] N. Krishnaraju. and R.N. Pranesh, "Reinforced Concrete Design", First edition, Newage International Pvt Ltd. Publishers, 2008.
- [2] Dr. B. C. Punmia, Ashok Kumar Jain and Arun Kumar Jain, *Reinforced Concrete Design*, Laxmi publications Private Limited, New Delhi, Second Edition.
- [3] P.C. Varghese, *Advanced Reinforced Concrete Design*, Prentice-Hall of India Private Limited, New Delhi, 2008..
- [4] IS: 456 - 2000 *Indian Standard Plain and Reinforced Concrete - Code of Practice*, Bureau of Indian Standards, New Delhi.
- [5] IS 875: 1987 (Part I,II,III,V) *Indian Standard Code of Practice for Design loads (Other than Earthquake) for buildings and structures*, Bureau of Indian Standards, New Delhi
- [6] SP: 34 (S&T) - 1987 *Hand Book on Concrete Reinforcement and Detailing*, Bureau of Indian Standards, New Delhi.
- [7] SP16: 1980 *Design Aids for Reinforced Concrete To IS: 456-1978*, Bureau of Indian Standards, New Delhi