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Planning, Analysis and Designing of Multi-Speciality Hospital Building

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Abstract— ***Multispecialty hospital building provides medical service to the people. The main purpose of our project is satisfies the medical needs of people. In this project we concerned about the plan, analysis and design of Multispecialty hospital building. The plan of the hospital building is done by using AUTO CADD software. The analysis of structures were done by using E-tabs as well as IS 456: 2000 Code, for plain and reinforced cemen concrete. The design of RCC slab, beam, column, footing and stair case is based on limit state method as per IS 456:2000 code. The main aim of this journal is to analyse the plan of hospital building by using software techniques. The design of hospital building should be developed with following disciplinaries. The design was developed by using IS codes for better output of design considerations. Here the hospital building was designed and analyzed for C+G+5 story structure. Nowadays, the software techniques were highly involved in a construction field for swift and finer accuracy of an analysis and to execute the given project effectively. The most prominent using software for design and analysis of the respective buildings by E-tabs software for accuracy and safety regards. In this paper, ETABS software was used for analysis and design purpose mainly for the result of shear force and maximum bending moment. RCC detailing is of most important concern for clear understanding and also in executing the reinforcement work without any difficulty.***

Key words: ETABS, AUTOCAD, Planning, Analysis and Designing

I. INTRODUCTION

A Hospital is structure that is built, staffed and furnished for the diagnosis of disease, for the treatment, both medical and surgical of the ill and injured and for their accomodation during the process. Multi specialty hospital is one which has all the different branches of medicine and surgery under one roof. To elaborate with few examples of specialty there are, General medicine, general surgery, neuro physician, neuro surgeon, gastro physician, cardiologist, ENT, pulmonology, opthamology, rheumatology, etc

A building is a structure resting at one place, built up of different structural members like slabs, beams, columns, footings, etc,. with different sizes and shapes and made of different building materials available, weather conditions, land prices, ground conditions, specific uses and aesthetic reasons. To better understand the term building compares the list of structures. Buildings serve several needs of society –

primarily as shelter from weather, security, living space, privacy, to store belongings, and to comfortably live and work. A building as a shelter represents a physical division of the human habitat (a place of comfort and safety) and the outside (a place that at times may be harsh and harmful). Ever since the first cave paintings, buildings have also become objects or canvases of artistic expression. In recent years, interest in sustainable planning and building practices has also become an intentional part of the design process of many new buildings. A slab is a flat two dimensional planar structural element having thickness small compared to its other two dimensions. It provides a working flat surface or a covering shelter in buildings. It primarily transfers the load by bending in one or two directions. Reinforced concrete is used for floors, roofs and walls of buildings and for the decks of bridges. The floor of a structure can be made in many forms such as insitu slab, ribbed slab or pre-cast units. Slabs may be supported on monolithic concrete beam, steel beams, walls or directly over the columns. Concrete slab behave primarily as flexural members and the design is similar to that of beams.

II. LITERATURE REVIEW

K. E. PRAVIN (2018) analyzed various studies carried out over planning, designing and analyzing a structure with the help of different software. All the studies he considered gives a suggestion of adopting STAAD.Pro over other software for analyzing a building structure. Due to its flexibility and its provision for economic sections both in terms of steel and concrete, STAAD.Pro is adopted for further analysis procedure.

C. PRIYANKA and all (2018) emphasized the structural analysis and design of 4 storey hospital building of capacity 300 beds with the basic requirements taken from IS 12433 (part-3 2001) and the members were designed using IS 456 2000, she also gathered technical information for the design and analysis of ramp using codal provisions (APPENDIX A to Part 1191).

TEJAS GORLE and all (2018) analyzed G+8 RC frame building for earthquake zones of ii, iii, iv, v., and found that steel quantities increased with respect to the increase in the corresponding zone value as the displacements values are less for lower zones and goes on increasing for higher zones. The Lateral seismic forces of RC frame is carried out using linear static method as per IS 1893(part 1) : 2002 for different earthquake zones.

J. SANKAR (2016) stated that a deformation-based analysis and design is more rational and meaningful than a force-based analysis and design. Such an analysis helps in evaluating the location and degree of damage and thus evaluates the performance of the structure.

DR. ASHOK KUMAR N and all analyzed the hospital building frame by using the substitute frame method for easy and accurate result. By considering any floor of the frame the moments can be calculated and results can be obtained in good agreement with the results from rigorous analysis. The moments carried from floor to floor through columns are very small as com-pared to the beam moments. The method is very effective in analyzing any framed structure under vertical loadings. This work is focused to check its ap-plicability and efficacy under the lateral loading conditions.

III. METHODOLOGY

PLANNING

The ideal structural system in Hospital Buildings

A multi speciality hospital has different departments like medical care, rehabilitation and service for the patients which helps medical and non medical staff in diagnosis and treatment to the patients. It has different departments serving the patients in registration, documentation and all for both inpatients and outpatients. The main departments are as follows:

- Diagnostic department
- Treatment department
- Administration department
- Service department

The above departments have their own requirements which are to be achieved depend on medical equipment and staff for each department. To obtain all of such requirements, every department shall have their own capacity and volume as concerned with the capacity and specialty in the hospital which depend upon the space grid columns.

Inpatient ward

The dimensions required for the patient room with single bed is (3.60m*3.00m), two beds (3.60m*4.8m), four beds (7.20m*4.8m.

Operation theatre

For normal operation the area required is (5.40m*5.40m). whereas for more complicated operation which require additional medical staff as compared to normal operation theatre, required area is (5.4*7.2).

Recovery hall

The area required for clinical services is (2.10m*2.70m).to increase the capacity of the hall to accommodate 6 beds it requires area of (7.20m*7.20m).

Intensive care unit.

The dimensions required for one bed is (3.60m*4.80m), two beds (7.20m*7.20m).

Out patient department

The required area for out patient department is (3.60m*4.80m)**.**

And for free circulation in the corridors the width of corridor shall not be less than 2.70m.

Fig : Ground floor plan

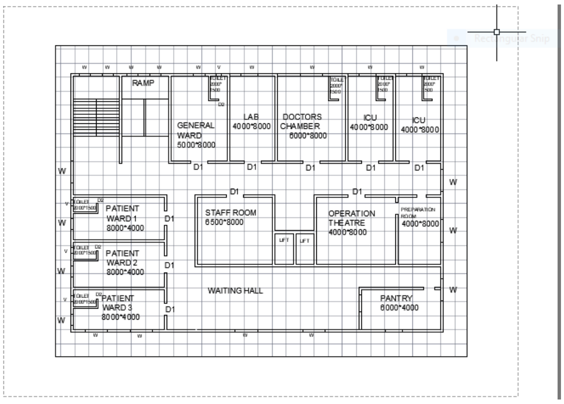

Fig : First floor plan

ANALYSIS

Modelling of R.C. moment resisting frame structure

In this present study G+5 conventional building is considered. The construction Technology is R.C.C frame structure and slabs. The modelling is done in ETABS as follows.

- The structure is divided into beam and column elements.
- The nodes are created as plan architect plan and node are connected through beam command, columns also connected.
- Boundary conditions are assigned to the nodes wherever it is required. Boundary conditions are assigned at the bottom of the structure i.e., at ground level where restraints should be against all movements to imitate the behavior of structure.
- The material properties are defined such as mass, weight, modulus of elasticity, Poisson's ratio, strength characteristics etc. The material properties used in the models.
- The geometric properties of the elements are dimensions for the section.
- Elements are assigned to structure.
- Loads are assigned to the joints as they will be applied in the real structure.

The model should be ready to be analyzed forces, stresses and displacements

Structural analysis may be said as the determination of effects (like shear force, bending moment, deflection, etc..) of different loads acting on the structures and on their corresponding elements. Structures like buildings, bridges, flyovers, tunnels, towers, etc,. done with the analysis must withstand the forces acting on it by ensuring the safety to the occupants. Structural analysis is the integration of various fields like applied mechanics, material science and applied mathematics to compute a structure's deformations, internal forces, support reactions, stress, accelerations, and stability. The results of this analysis are used to assess the structure's caliber for use. Structural analysis thus plays a vital role in the engineering design of structures.

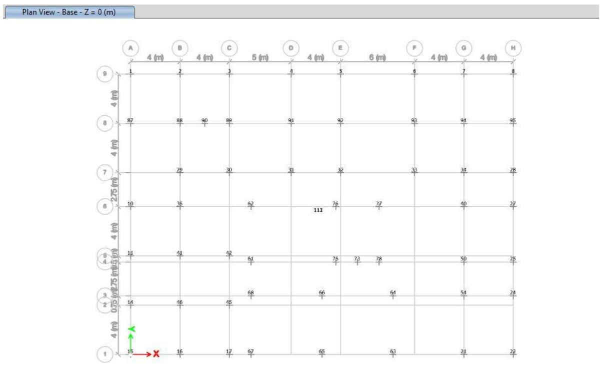

Fig : support reactions

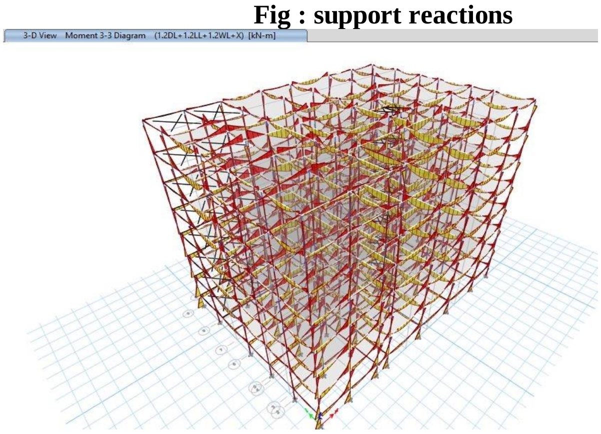

Fig: Bending moment diagram

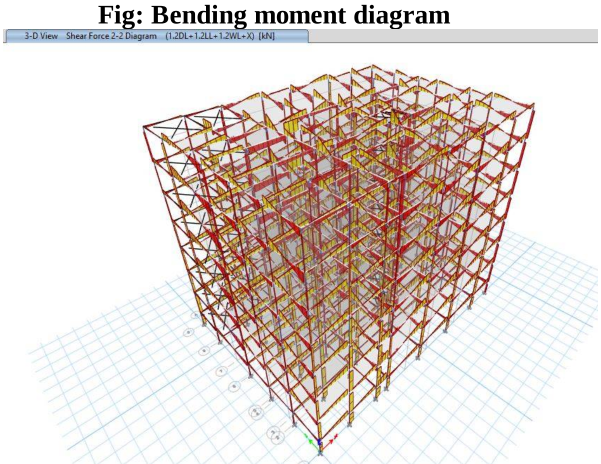

Fig : Shear force diagram

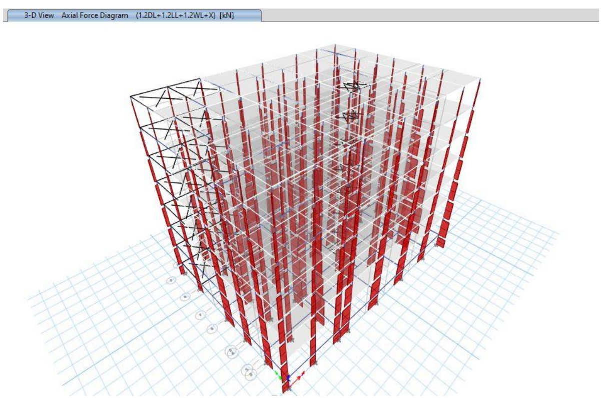

Fig : Axial force diagram

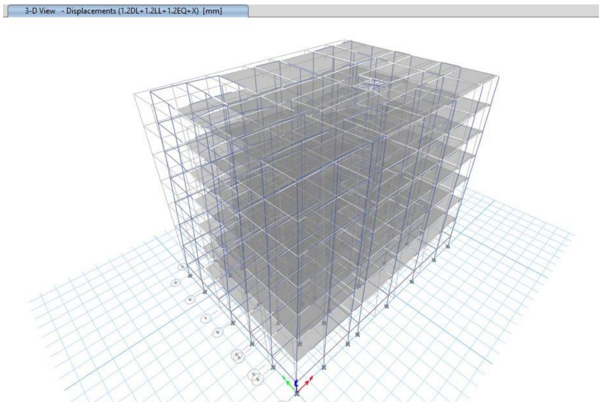

Fig : deformed shape

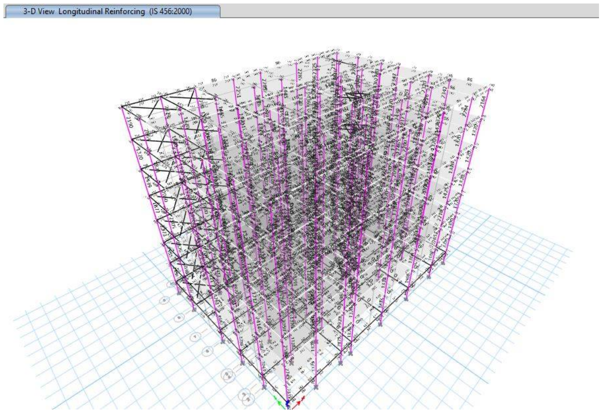

Fig : Longitudinal reinforcement

Table : Storey definitions

Tower	Name	Height M	Master Story	Similar To	Splice Story	Color
T1	Story8	3.5	Yes	None	No	Yellow
T1	Story7	3.5	No	Story8	No	Gray8Dark
T1	Story6	3.5	No	Story8	No	Blue
T1	Story5	3.5	No	Story8	No	Green
T1	Story4	3.5	No	Story8	No	Cyan
T1	Story3	3.5	No	Story8	No	Red
T1	Story2	3.5	No	Story8	No	Magenta

Table : Load pattern definitions

Name	Is Auto Load	Type	Self Weight Multiplier	Auto Load
~LLRF	Yes	Other	0	
Dead	No	Dead	1	
EQ+X	No	Seismic	0	IS 1893:2016
EQ+Y	No	Seismic	0	IS 1893:2016
EQ-X	No	Seismic	0	IS 1893:2016
EQ-Y	No	Seismic	0	IS 1893:2016
FF	No	Super Dead	0	
Live	No	Live	0	
WL+X	No	Wind	0	Indian IS 875:2015

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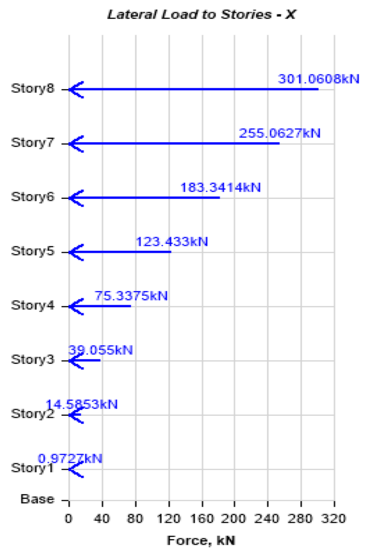
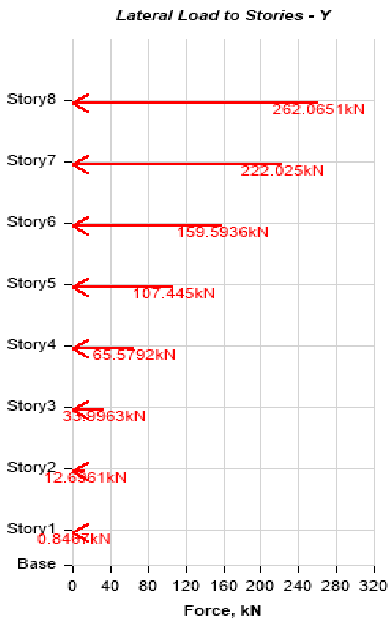
Name	Is Auto Load	Type	Self Weight Multiplier	Auto Load
WL+Y	No	Wind	0	Indian IS 875:2015
WL-X	No	Wind	0	Indian IS 875:2015
WL-Y	No	Wind	0	Indian IS 875:2015

Table : Load case definition-summary





DESIGN

Design of Beam

Beam Design

Beam Data

width	300 mm			
depth	650 mm	d'	41 mm	.= cc+ sdia + mdia/2
clear cover to main	25 mm	eff depth	609 mm	.= d - d'

Material Grades

Concrete	25 MPa
Steel	415 MPa

Moment	153 KN-m	Mu/bd^2	1.38	
		xumax	292	.= (700/(1100 * (0.87 * fy)) * d
		Mulim	384	.= 0.36*fck*b*xumax*(d-(0.42*xumax))
		Mulim/bd^2	3.45	

Beam is designed as Singly Reinforced Beam

Area of Steel	Tension (Ast)	Compr (Asc)
Percentage	0.409 %	-------
Area of Steel	747 sqmm	

Refer Table 2 SP 16 pg 48

Tension Reinforcement

Type	Bar dia	Nos	Area of Steel	
Layer 1	16 mm	2	402 sqmm	
Layer 2	20 mm	2	628 sqmm	
Layer 3	20 mm	2	628 sqmm	
		Total Steel Provided	1659 sqmm	0.908 %

Provided Steel OK

Compression Reinforcement

Type	Bar dia	Nos	Area of Steel	
Layer 1	16 mm	2		
Layer 2	12 mm	2		
Layer 3				
		Total Steel Provided		#VALUE!

Shear Force (Vu)	15 KN		
ζv	0.082	.=Vu / (b * d)	
ζc	0.728	*Refer Table 61 SP 16 pg 179*	or =(0.85 * √(0.8*fck)*√(1+5β -1)) / (6β)
ζcmax	3.1	*Refer Table J SP 16 pg 175*	

Type	Bar Dia	Nos	Area of Steel	
Layer 1	25 mm	2	982 sqmm	
Layer 2	25 mm	2	982 sqmm	
Layer 3	20 mm	2	628 sqmm	
		Total Steel Provided	2592 sqmm	1.419 %

Sectional Dimensions OK

Shear Check OK

Provide Nominal Shear Reinforcement

Type of stirrup	2 legged
Stirrup diameter	8 mm
Spacing	300 c/c

Steel Calculation

Grade Check
7.8

SRB

a	0.60	.=(0.87435/100) * (fy/fck)^2
b	-3.611	.=(0.87/100) * (fy)
c	1.375	.=Mu/bd^2
-p	0.409	.=-(b±√(b^2-4ac))/2a
Ast	747	.=(p*b*d)/100

DRB

a	0.60	.=(0.87435/100) * (fy/fck)^2
b	-3.611	.=(0.87/100) * (fy)
c	3.453	.=Mulim/bd^2
-p	1.194	.=-(b±√(b^2-4ac))/2a
Astlim	2182	.=(p*b*d)/100

Mu2	-231	.=Mu - Mulim
Ast2	-1127	.=Mu2/((0.87*fy)*(d-d'))
Ast	1055	.=Astlim+Ast2

0.0673
0.1

d'/d	0.10	
fsc	353	Refer Table F SP 16 pg 13
fcc	11.15	.=0.466*fck
Asc	-1190	.=Mu2/((fsc-fcc)*(d-d'))

Min steel %	0.205	.=0.85% / fy
Ast	747	
Asc	-1190	
Min Steel	374	.=(0.85*b*d) / fy
Max Steel	7308	.=0.04*b*d)
Ast	747	
Asc		

Shear Calculations

Pt provided	1.419	.=(Ast*100)/(b*d)
Pc provided		.=(Asc*100)/(b*d)
β	2.046	.=(0.8*fck)/(6.89*Pt)

Shear Capacity of Concrete (Vs)	133	.=ζc*b*d
Shear Stg to be caried by Stirrup (Vus)	-118	.=Vu-Vs

Spacing			
actual req	348	.=(Asv*0.87fy*d)/Vus	provide the least of the 4
min	302	.=(Asv*0.87fy)/(b*0.4)	
max	457	.=0.75d	
max	300	.=300mm	

Design of column

Column Design

Design Loads

Load	Pu	3919 KN
Moment	Mu	6 KN-m

Column Data

width	b	300 mm
depth	d	1 mm
length	l	3.00 meters

Grade

Concrete	fck	25 MPa
Steel	fy	415 MPa

Pu/(fckbd)	696.64
Mu/(fckbd^2)	0.00
d'/d	0.05

Minimum eccentricity

ex	1.60 mm	OK
ey	0.60 mm	> 0.05 * d

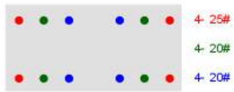
Refer Chart 31 of SP 16, Page no: 116

pt/fck 0.18

pt	4.50%
Ast	10 sqmm

Number of bars

dia	nos	ast
25 mm	4	1963 sqmm
20 mm	4	1257 sqmm
20 mm	4	1257 sqmm
Total	12	4477 sqmm



Steel provided OK

Design of slab

Slab Design

Slab thickness	t	115 mm
Concrete	fck	25 MPa
Steel	fy	415 MPa

Sunken Depth 325 mm

Loading

Slab Load

Dead Load	DL	2.875 KN/m
Live Load	LL	2.000 KN/m
Finishes Load	WL	1.500 KN/m
Total Load	Ws	6.375 KN/m
Factored Load	Wsu	10 KN/m

Sunken Slab Load

Dead Load	DL	2.875 KN/m
Filler Load	FL	5 KN/m
Live Load	LL	3.0 KN/m
Finishes Load	WL	1.0 KN/m
Total Load	Wsk	11.49 KN/m
Factored Load	Wsku	17 KN/m

Slab Data

Slab Type	Regular
Load	10 KN/m
Longer Span (ly)	4.30 m
Shorter Span (lx)	3.12 m

ly/lx ratio	1.38
Slab type	+

Loading on edges		one way	two way
W_{longer}	12 KN/m	.=w*lx/2	.=(w*lx/2) + (1-(1/3)*(lx/ly)^2)
$W_{shorter}$	10 KN/m		.=w*lx/3

Moments		one way	two way
Mx	8 KN-m	.=w*lx^2 / 8	= αx * w*lx^2
My	5 KN-m		.= αy * w*lx^2

Thickness Check	OK	.=Mulim > Mux or Muy
Deflection	13 mm	.= 5*W*l^4 /(384EI)

Area of Steel	Astx	Asty	
	237 sqmm	156 sqmm	Refer Chart 4 SP 16 pg 21 or Refer Table 5-44 SP 16 pg 51-80

Spacing required in mm

8#		10#		12#		16#	
x	y	x	y	x	y	x	x
212 c/c	322 c/c	331 c/c	503 c/c	477 c/c	724 c/c	848 c/c	1287 c/c

.=ast of bar*1000/ast req

Final Ast provided	x	y

Design of footing

1 Footing Size Design

Load	Pu	3369 KN
Design Load	P	2471 KN
Moment in x dir	Mux	6 KN-m
Moment in y dir	Muy	1 KN-m
Column size	cx	300 mm
	cy	750 mm
SBC	q	150 KN/sqm
Footing Size required	A req	16.47 sqmm
Footing Size Provided	L	5.00 meters
	B	4.00 meters
Area Provided	A prvd	20.00 meters
	Zx	13.33
	Zx	16.67
Net upward pressure	Nup	124 KNm2

Footing Size OK

2 Slab Design

	lx	2.350
	ly	1.625
Bending Moment in x dir	Mx	513 KN-m
Bending Moment in y dir	My	245 KN-m
Concrete	fck	20 MPa
Steel	fy	415 MPa
Minimum Depth Required	dmin	431
Depth Provided	D	900 mm
Clear Cover	c	50 mm
Effective Cover	d'	58 mm
Effective Depth	d'	842 mm

Area of Steel	Spacing c/c in mm		
	12#	16#	20#
1764 sqmm	64 c/c	114 c/c	178 c/c
1010 sqmm	112 c/c	199 c/c	311 c/c

Minimum Ast required across y direcion

Ast across x direction	16 mm dia @ 125 mm c/c	1608 sqmm	X
Ast across y direction	16 mm dia @ 125 mm c/c	1608 sqmm	

3 One Way Shear along x direction

Vu1	1121 KN
ζv	0.333 MPa
ζc	0.333 MPa
Vc1	1121 KN

One Way Shear Check OK

4 One Way Shear along y direction

Vu1	727 KN
ζv	0.173 MPa
ζc	0.260 MPa
Vc1	1096 KN

One Way Shear Check OK

5 Two Way Shear

Vu2	3377 KN
ζv	0.734 MPa
ks*ζc	1.006 MPa
Vc1	4633 KN

Two Way Shear Check OK

IV CONCLUSION

The planning of a building is developed keeping in view, the building bye laws, environmental conditions prevailing in that area. Height of building is restricted as per the municipal authorities of the area. The drawings of plan are developed using auto cad software. The slabs are designed as per the code of practice IS 456 2000 in accordance to LSM. The imposed loads are noted from code of practice IS 875 19987. The analysis of frame is carried out in ETABS and the design of beam and columns are also carried out in ETABS. We can conclude that, hence by using ETABS software, we can analyze and design a building effectively by considering loads like Dead load, Live load, Wind load, Seismic load and their combinations. We can also generate the detailing of different structural elements like beams, columns, etc,. there by a structural engineer can analyze and design a building precisely within hours of time.

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INDIAN STANDARD CODES

- IS CODE 456-2000
- IS CODE 875-1987 PART I
- IS CODE 875-1987 PART II
- IS CODE 875-1987 PART III
- DESIGN AIDS TO IS -456-2000 (SP 16)