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Analysis and Design of shopping mall against lateral forces

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ABSTRACT: *The paper presents the plan, model, analyze and design of a vertical irregular shopping mall structure of G+10 storey and investigate its performance under various lateral loading conditions. The main goal is to assess current Indian Standard design practice and to provide design guidelines using ETABS and to find a detailing strategy which will ensure a sufficient level of safety for various levels of loading demands.*

KEYWORDS: *RCC structure, multi-storey building, AutoCAD, seismic co-efficient method, ETABS*

I. INTRODUCTION

In metropolitan cities, very limited areas are available and sold at high cost. This paper will help to built buildings within this limited area satisfying each of every need of the people. It is also designed in such a way that it would be economical. The civil engineers have to think of construction of high rise structures, instead of the traditional type of reinforced concrete skeletal structure enclosed by thick walls of bricks or any other construction materials. A civil engineer must be familiar with planning, analysis and design of such structures against various loading such as lateral forces, etc. Hence it was proposed to choose a problem, involving analysis and design of multistoried framed structure as the project work. The proposed site is approximately flat i.e. Tambaram, Chennai. Good soil having sufficient bearing capacity is available at shallow depth. The proposed site accommodates proper important facilities such as 24 hours transport facilities, proper drinking water facilities, communication facilities, electrical facilities, nearest railway station available at Tambaram, underground drainage facilities, etc.

II. PLANNING

The proposed ten storied commercial building consist of area of floor is 1220 m^2 with 3000m^2 plot size. A building should be planned to make it comfortable, economical and to meet all the requirements of the people. The efforts of the planner should be to obtain maximum comfort with limited available resources.The shopping mall to be analyzed and designed as per BIS specifications is plan and drawn using computer-aided drafting software program, AutoCAD, to create precise drawings used in construction and manufacturing.

1) In ground and first floor entrance foyer, coffee shop, various shops, escalator, lift, toilet blocks are provided. With entrancefoyer of 25 m^2, coffee shop 120 m^2, and 20 shops of 500 m^2.(fig.1)
2) In second and third floor various shops, super market, food court, escalator, lift, toilet blocks are provided with super market and food court of 200 $m^2$and shops of 300 m^2. (fig.2)
3) In fourth and fifth floor office with conference hall and store, escalator, lift, toilet blocks are provided with office area about 300 m^2, conference hall area about 80 m^2.(fig.3)
4) In sixth to tenth floor net point, Table tennis court, Snooker corner, various Shops, Escalator, Lift, Toilet blocks are provided. With Table tennis court and Snooker corner of 150sq.m, net point of 220 m^2, and shops of 150 m^2.(fig.4)

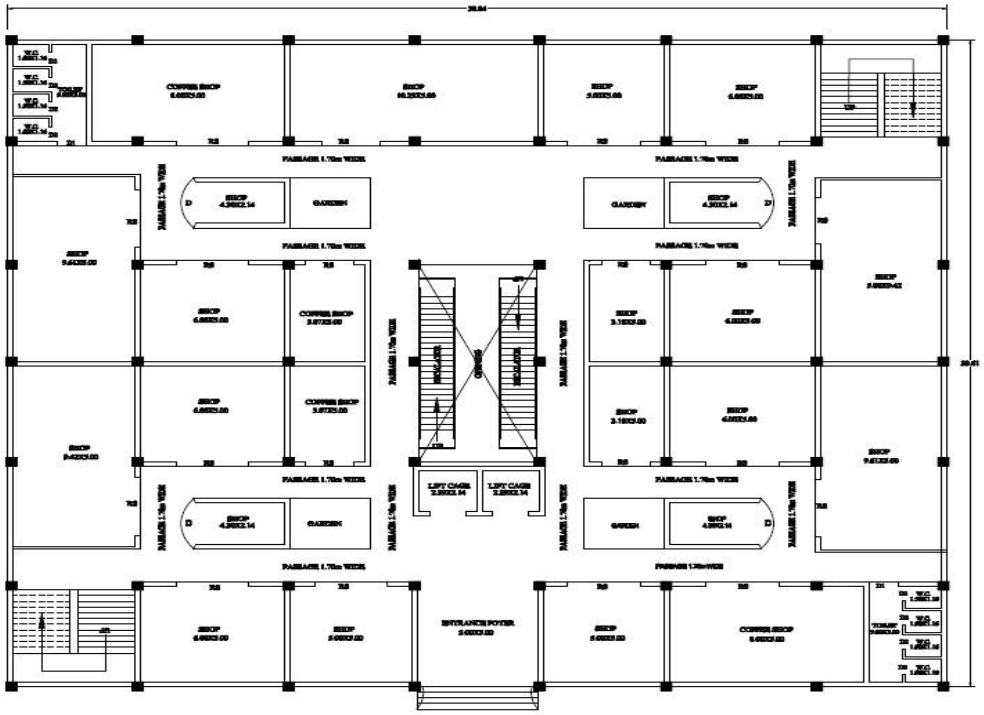


Fig.1

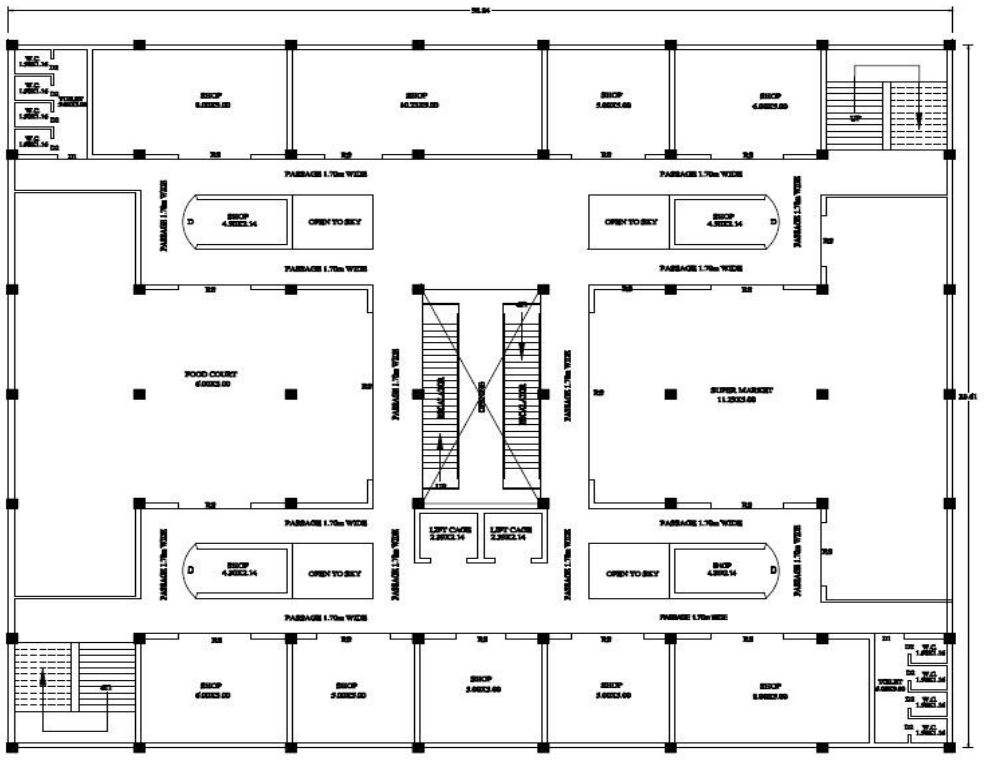


Fig.2

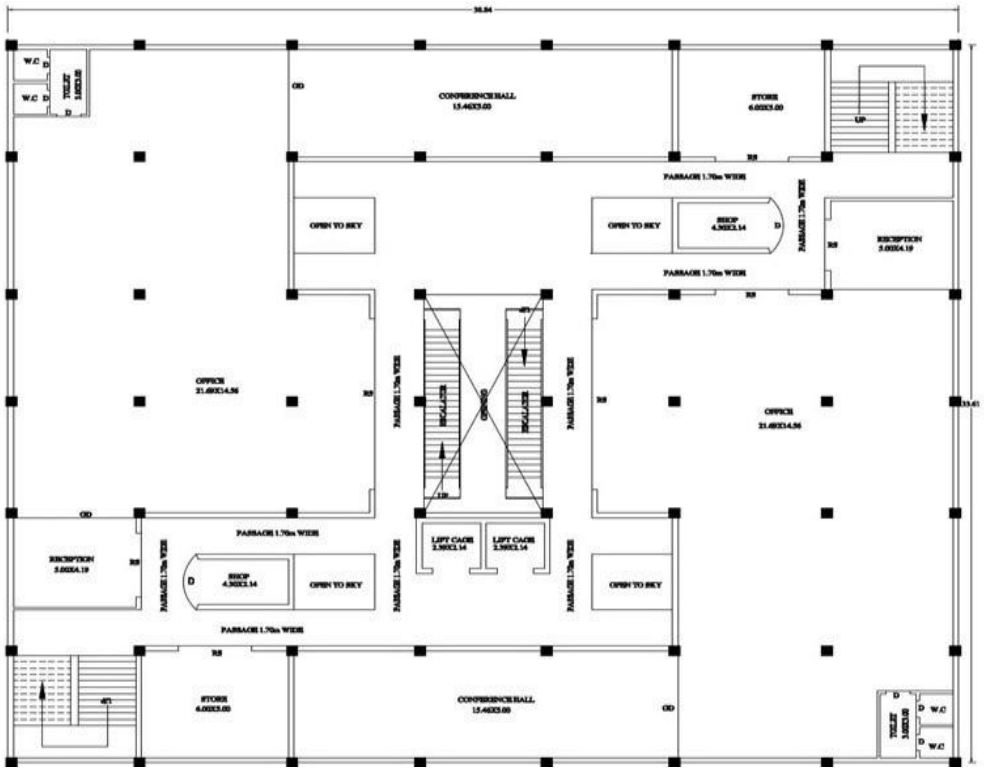


Fig.3

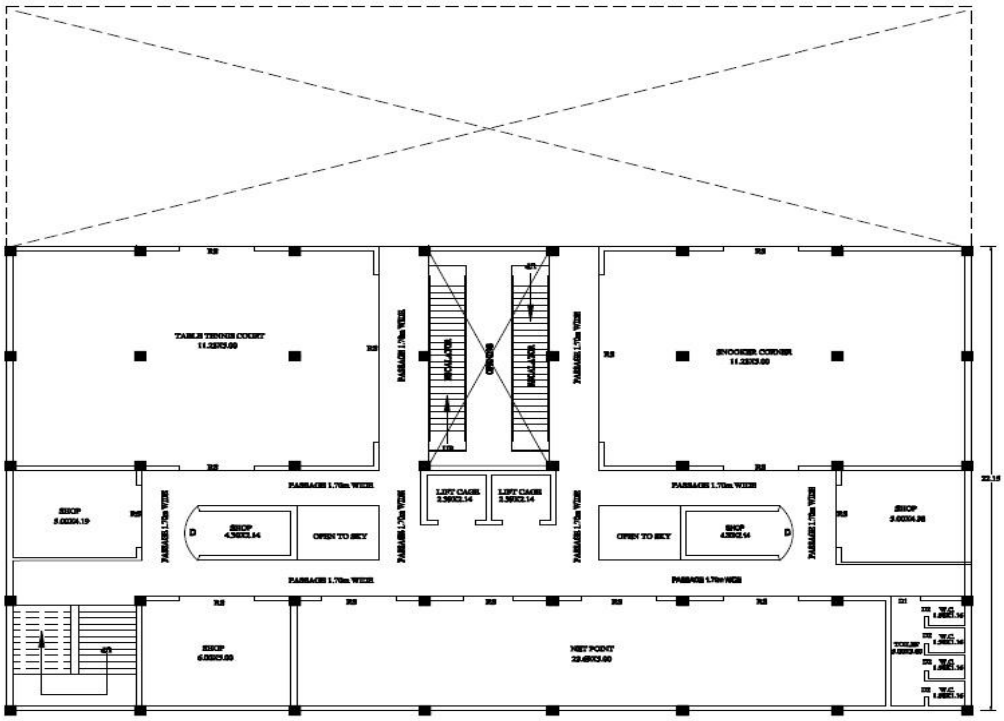


Fig.4

The minimum width of staircase should be 0.9m clear of railing and many ranges up to 1.5m. There should be a clear headway of 2.1m above each step and landing.The soil at the site is hard soil having a safe bearing of 200KN/m^2 in Tambaram. Two pipe systems have to be provided to remove and treat the sullage and human excreta, one septic tank were provided in the commercial building for economical and efficient treatment of waste. The quality of water is calculated as per IS 1172-1963. The tank is provided at the terrace of the

building with a capacity of 50000 liters. The water form corporation main line is stored in the ground level sump and pumped to the over head tanks. The electrical installation shall generally be carried out in conformity with the requirements of Indian electricity act 1910 and Indian electricity rule 1956. In all buildings, sufficient automatic fire detecting and alarm facilities shall be provided, where necessary to warn out occupant existence of fire so that they may escape.

III. MODELLING AND ANALYSIS USING ETABS

The salient features of the G+10 storied building consist of basement floor of 1.20m above the existing ground level and remaining floors with 3.60m ceiling height which is modeled using ETABS.

3.1 Input analysis using ETABS

a) Material:

Grade of reinforcement: Fe415, Grade of concrete: M25, Density of concrete: 2500Kg/m^3

b) Loading:

Dead load: Partition wall and other external walls, floor finish etc. as per the provisions of IS: 875-1987(part I)

Superimposed load: As per the provisions of IS: 875-1987(part II), uniformly distributed load of 4.0 KN/m^2

Seismic load: Dead load + part of live load = DL+0.5LL

c) Partial safety factors:

Load factors: For dead load= 1.50; for live load= 1.50;

Material safety factor: For reinforcement steel= 0.15; for concrete = 1.50.

d) Seismic coefficient:

Seismic zone factor= 0.16; soil type= II; Importance factor= 1; Response reduction(R) =5

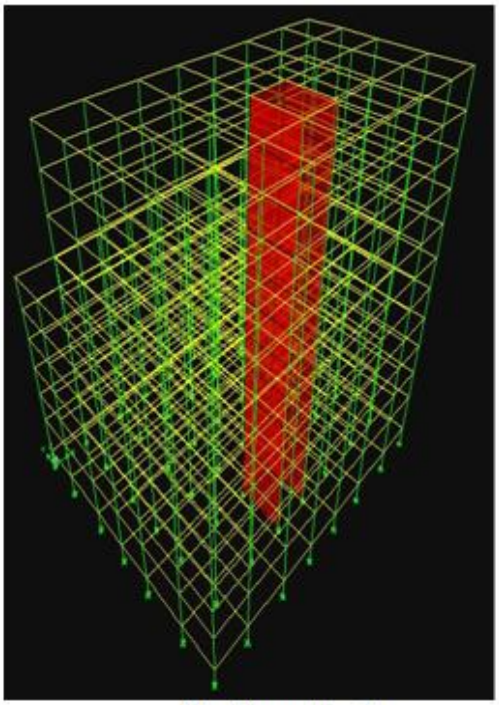


Fig. 5 Isometric view

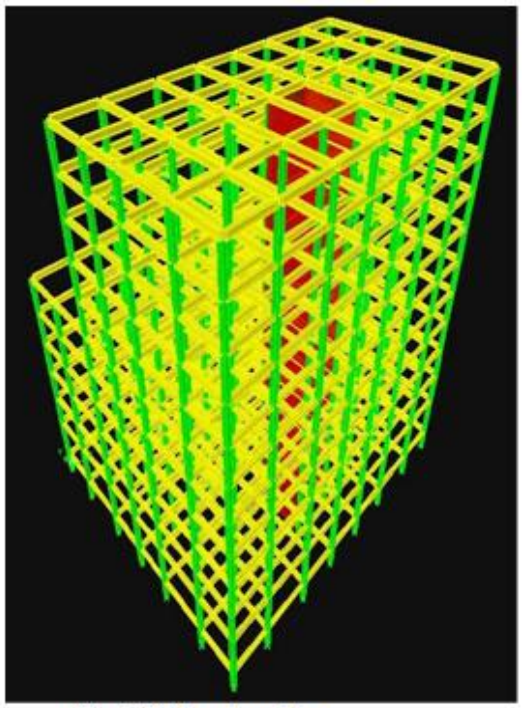


Fig. 6 3D Rendered view

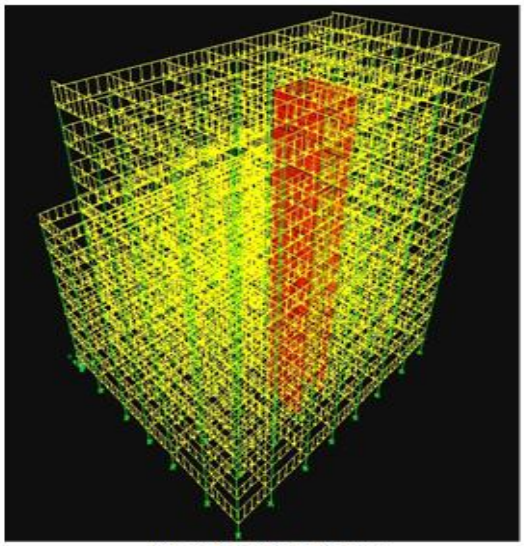


Fig. 7 Loading diagram

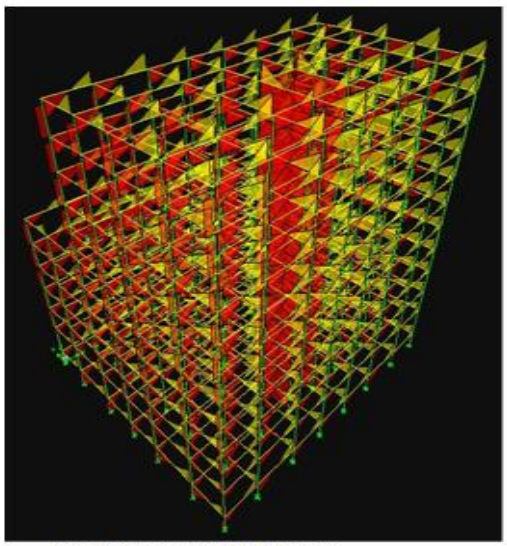


Fig. 8 Shear forces diagram

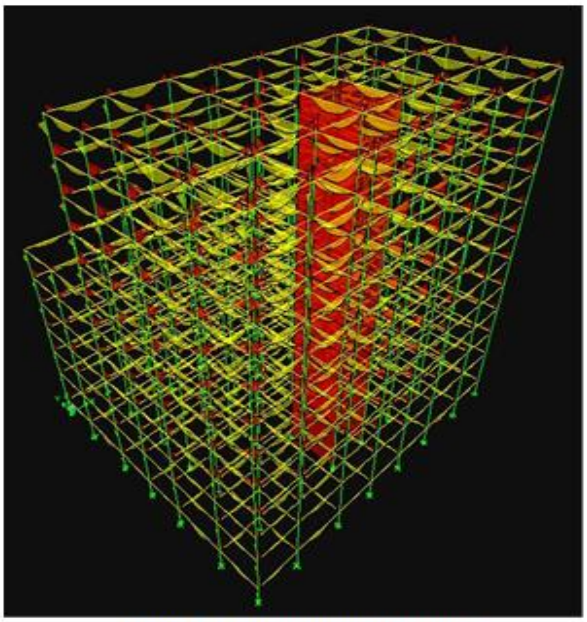


Fig. 9 Bending moment diagram

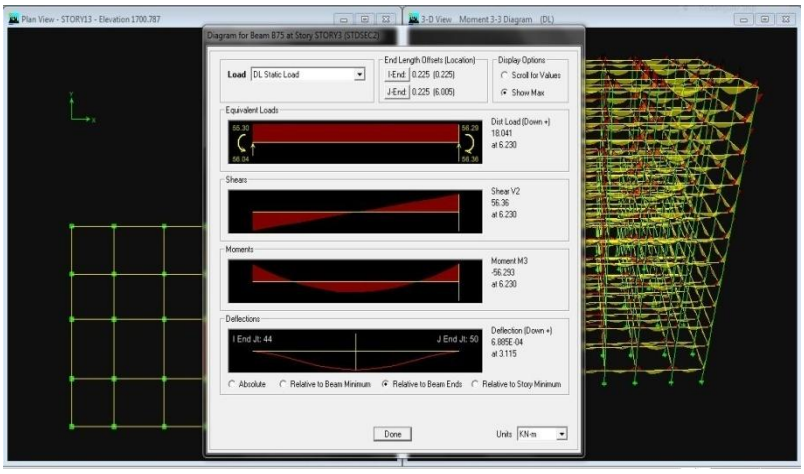


Fig. 1 DL static load

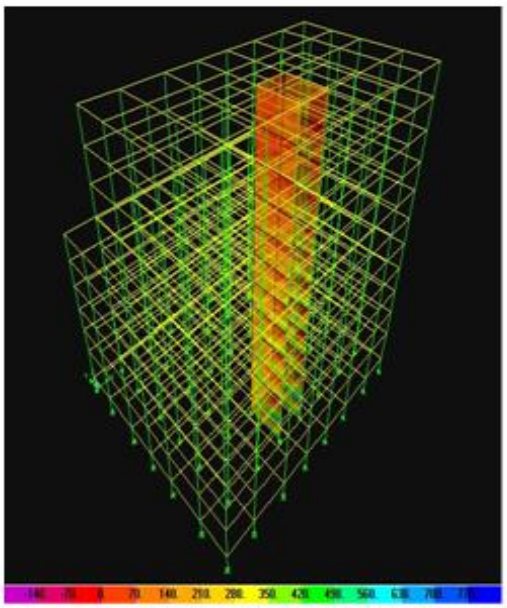


Fig. 11 Max.stress developed (X direction)

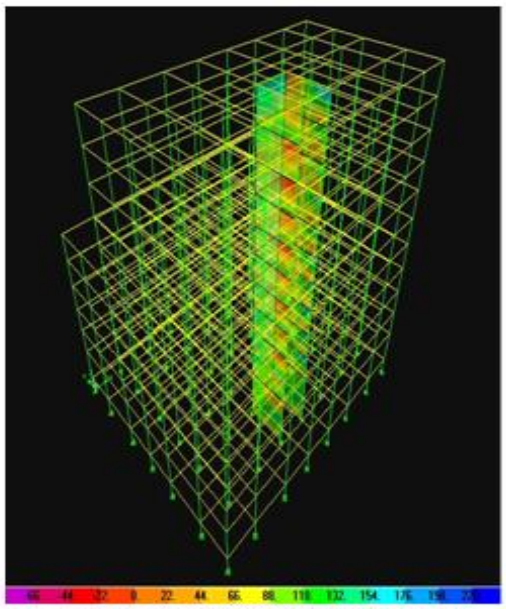


Fig. 12 Max.stress developed (Y direction)

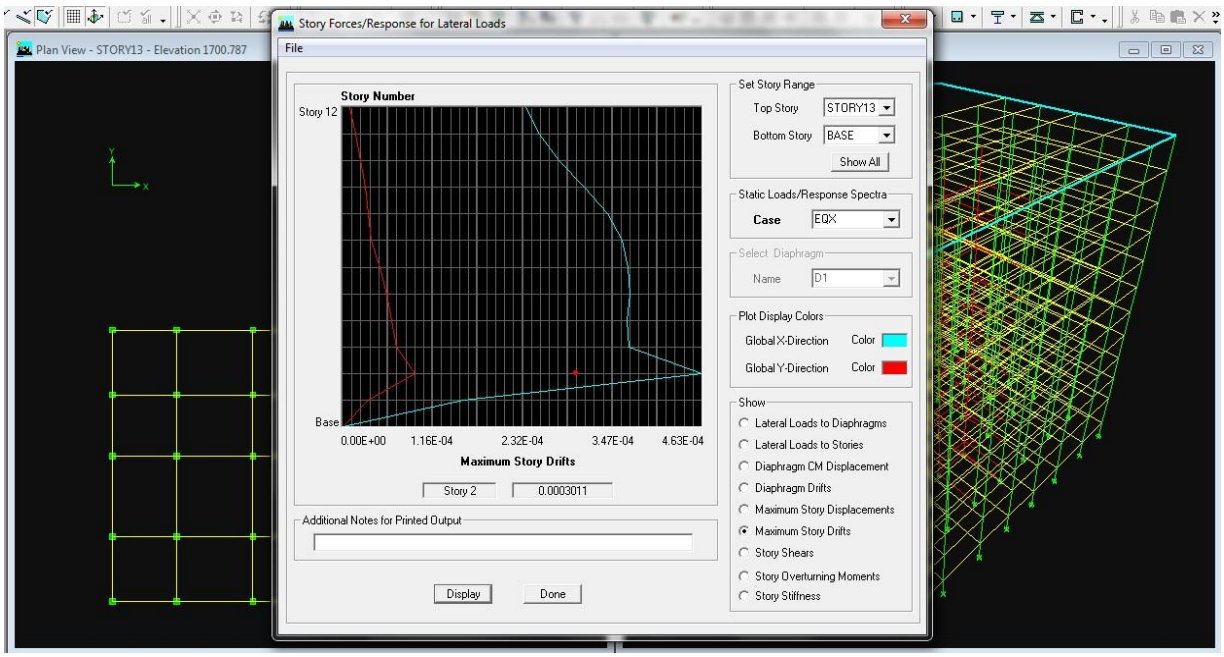


Fig. 2 Storey drift

IV. DESIGNING

The entire limit state that are relevant are considered in the design to ensure an adequate degree of safety and serviceability, the structure in general shall be designed on the basis of the most critical state and shall also be checked for other limit states.

4.1 The Indian Standard (IS) code used for the design:

Minimum design loads for Buildings other than seismic loads

a) IS 875 (Part 1): 1987 Dead loads
b) IS 875 (Part 2): 1987 Imposed loads
c) IS 875 (Part 3): 1987 Wind loads
d) IS 875 (Part 5): 1987 Special loads and load combinations

Seismic Provisions for buildings

a) IS 1893: 2002 Criteria for earthquake resistance design of structure

b) IS 13920: 1993 Ductile Detailing of Reinforced concrete Structures subjected for Seismic forces- Code of Practice

Building code requirements for Structural Concrete:

a) IS 456: 2000 Plain and Reinforced Concrete - Code of practice
b) SP 16: Structural use of concrete. Design charts for singly reinforced beams, doubly reinforced beams and columns.
c) SP 34: Handbook on Concrete Reinforcement & Detailing.

4.2 ETABS design output of beam and column:

Indian IS 456-2000 BEAM SECTION DESIGN Type: Ordinary Frame Units: N-mm (Flexural Details)

Level	: STORY2	L=6230.000			
Element	: B73	D=600.000	B=300.000	bf=300.000	
Section ID	: STDSEC2	ds=0.000	dct=25.000	dcb=25.000	
Combo ID	: 3	E=25000.000	fc=25.000	Lt.Wt. Fac.=1.000	
Station Loc	: 225.000	fy=500.000	fys=415.000		

Gamma(Concrete): 1.500
Gamma(Steel) : 1.150

LONGITUDINAL REINFORCEMENT FOR MOMENT AND TORSION, (Mu3, Tu)

	Required Rebar	+veMoment Rebar	-veMoment Rebar	Minimum Rebar
Top (+2 Axis)	1220.017	0.000	1220.017	306.000
Bottom (-2 Axis)	0.000	0.000	0.000	0.000

Factored Forces and Moments

Factored Mu3	Factored Tu	Torsion Mt
-261116069.7	67788.400	119626.588

Design Moments, Mu3

Design +veMoment	Design -veMoment
0.000	-261235696.3

Fig. 3 Flexural detailing of a beam section

Indian IS 456-2000 BEAM SECTION DESIGN Type: Ordinary Frame Units: N-mm (Shear Details)

Level	: STORY2	L=6230.000			
Element	: B73	D=600.000	B=300.000	bf=300.000	
Section ID	: STDSEC2	ds=0.000	dct=25.000	dcb=25.000	
Combo ID	: 3	E=25000.000	fc=25.000	Lt.Wt. Fac.=1.000	
Station Loc	: 1381.000	fy=500.000	fys=415.000		

Gamma(Concrete): 1.500
Gamma(Steel) : 1.150

SHEAR/TORSION DESIGN FOR Vu2 and Tu

Rebar Asv/s	Rebar Asvt/s	Design Vu	Design Tu	Design Pu
0.639	0.000	186515.548	67788.400	0.000

Design Forces

Factored Vu	Factored Tu	Equivalent Ve
186515.548	67788.400	186877.086

Design Basis

Lt.Wt.Reduc Factor	Strength fy	Strength fck	Area Ag
1.000	415.000	25.000	180000.000

Concrete Capacity

Conc.Area Ac	Tensn.Rein Area Ast	Ast %	Allowable Tau_c(MPa)	Allowable Tau_c	CompFactor Delta	DepthFactr k	Strengh Factor
172500.000	306.000	0.177	0.309	0.309	1.016	1.000	1.000

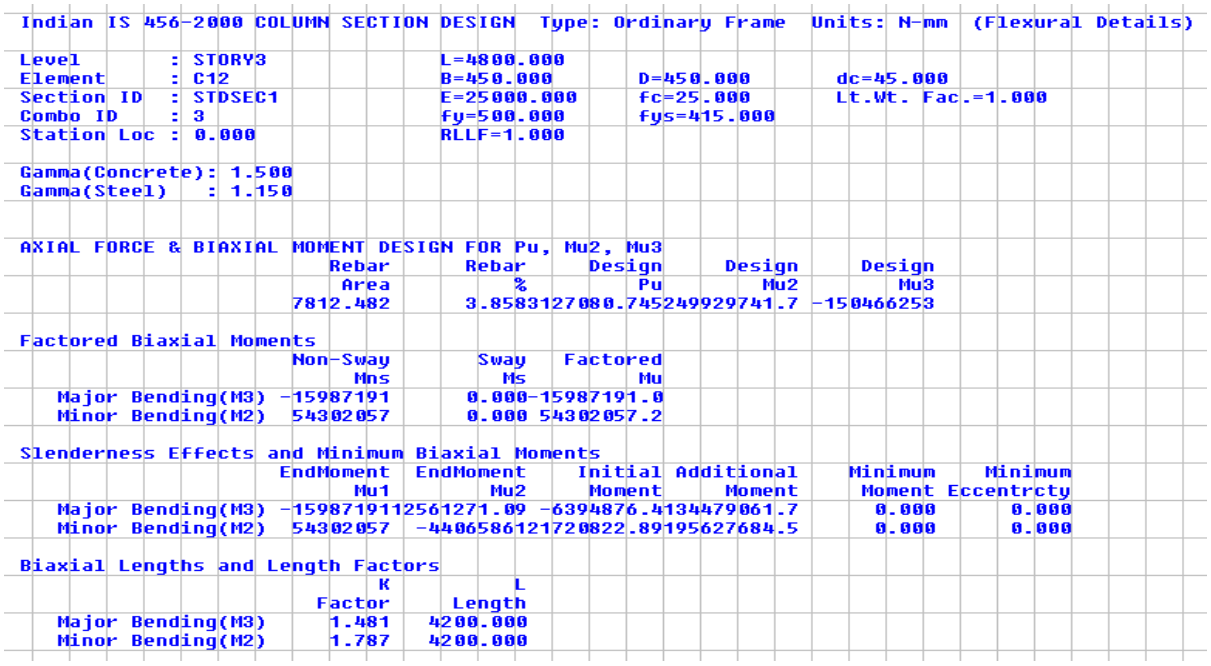
Shear Rebar Design

Design Ve	Stress Tau	Conc.Cpcty Tau_cd	Uppr.Limit Tau_c,max	RebarArea Asv/s	Shear Vc	Shear Vs	Shear Vn
186877.086	1.083	0.314	3.100	0.639	54210.959	132666.127	186877.086

Torsion Reinforcement

Rebar Asvt/s	Torsion Tu	Shear Vu	Core b1	Core d1
0.000	67788.400	186515.548	200.000	500.000

Fig. 4 Shear detailing of a beam section



Indian IS 456-2000 COLUMN SECTION DESIGN Type: Ordinary Frame Units: N-mm (Flexural Details)

Level : STORY3 L=4800.000
Element : C12 B=450.000 D=450.000 dc=45.000
Section ID : STDSEC1 E=25000.000 fc=25.000 Lt.Wt. Fac.=1.000
Combo ID : 3 fy=500.000 fys=415.000
Station Loc : 0.000 RLLF=1.000

Gamma(Concrete): 1.500
Gamma(Steel) : 1.150

AXIAL FORCE & BIAXIAL MOMENT DESIGN FOR Pu, Mu2, Mu3

	Rebar Area	Rebar %	Design Pu	Design Mu2	Design Mu3
	7812.482	3.858312	7080.745	249929741.7	-150466253

Factored Biaxial Moments

	Non-Sway Mns	Sway Ms	Factored Mu
Major Bending(M3)	-15987191	0.000	-15987191.0
Minor Bending(M2)	54302057	0.000	54302057.2

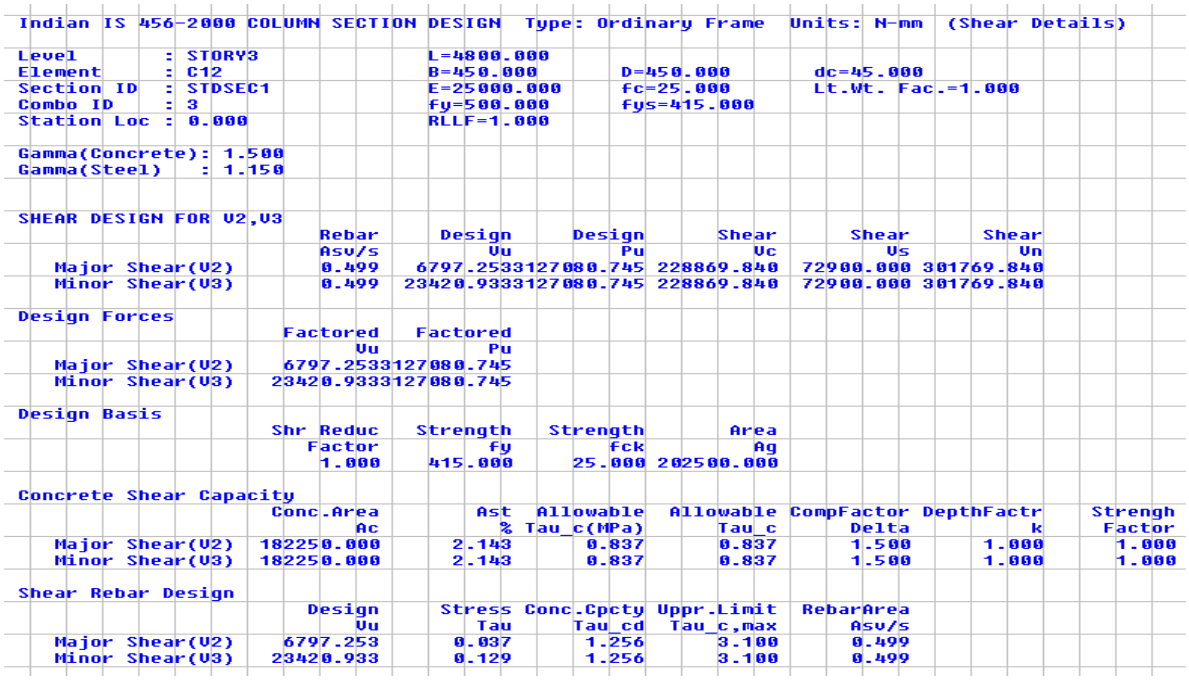
Slenderness Effects and Minimum Biaxial Moments

	EndMoment Mu1	EndMoment Mu2	Initial Moment	Additional Moment	Minimum Moment	Minimum Eccentrcty
Major Bending(M3)	-15987191	12561271.09	-6394876.413	4479061.7	0.000	0.000
Minor Bending(M2)	54302057	-4406586	121720822.8	9195627684.5	0.000	0.000

Biaxial Lengths and Length Factors

	K Factor	L Length
Major Bending(M3)	1.481	4200.000
Minor Bending(M2)	1.787	4200.000

Fig. 5 Flexural detailing of a column section



Indian IS 456-2000 COLUMN SECTION DESIGN Type: Ordinary Frame Units: N-mm (Shear Details)

Level : STORY3 L=4800.000
Element : C12 B=450.000 D=450.000 dc=45.000
Section ID : STDSEC1 E=25000.000 fc=25.000 Lt.Wt. Fac.=1.000
Combo ID : 3 fy=500.000 fys=415.000
Station Loc : 0.000 RLLF=1.000

Gamma(Concrete): 1.500
Gamma(Steel) : 1.150

SHEAR DESIGN FOR V2,V3

	Rebar Asv/s	Design Vu	Design Pu	Shear Vc	Shear Vs	Shear Vn
Major Shear(V2)	0.499	6797.253	3127080.745	228869.840	72900.000	301769.840
Minor Shear(V3)	0.499	23420.933	3127080.745	228869.840	72900.000	301769.840

Design Forces

	Factored Vu	Factored Pu
Major Shear(V2)	6797.253	3127080.745
Minor Shear(V3)	23420.933	3127080.745

Design Basis

	Shr Reduc Factor	Strength fy	Strength fck	Area Ag
	1.000	415.000	25.000	202500.000

Concrete Shear Capacity

	Conc.Area Ac	Ast %	Allowable Tau_c(MPa)	Allowable Tau_c	CompFactor Delta	DepthFactr k	Strengh Factor
Major Shear(V2)	182250.000	2.143	0.837	0.837	1.500	1.000	1.000
Minor Shear(V3)	182250.000	2.143	0.837	0.837	1.500	1.000	1.000

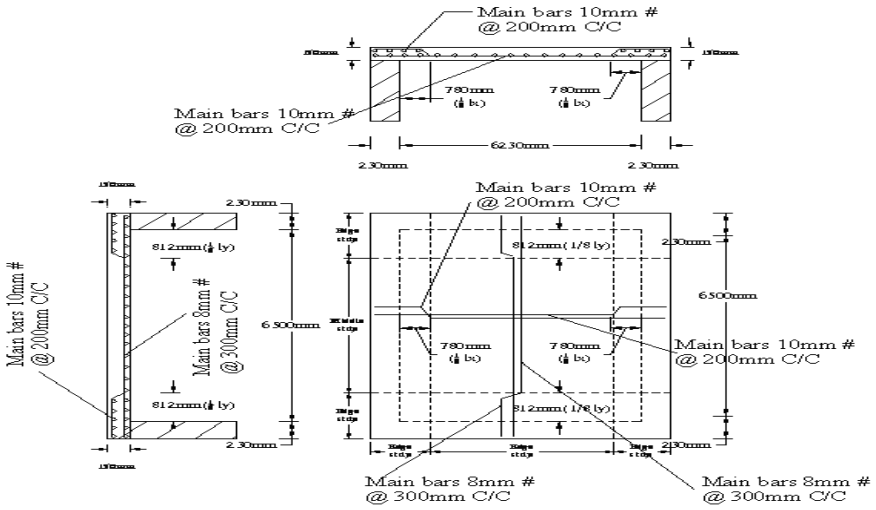
Shear Rebar Design

	Design Vu	Stress Tau	Conc.Cpcty Tau_cd	Uppr.Limit Tau_c,max	RebarArea Asv/s
Major Shear(V2)	6797.253	0.037	1.256	3.100	0.499
Minor Shear(V3)	23420.933	0.129	1.256	3.100	0.499

Fig. 6 Shear detailing of a column section

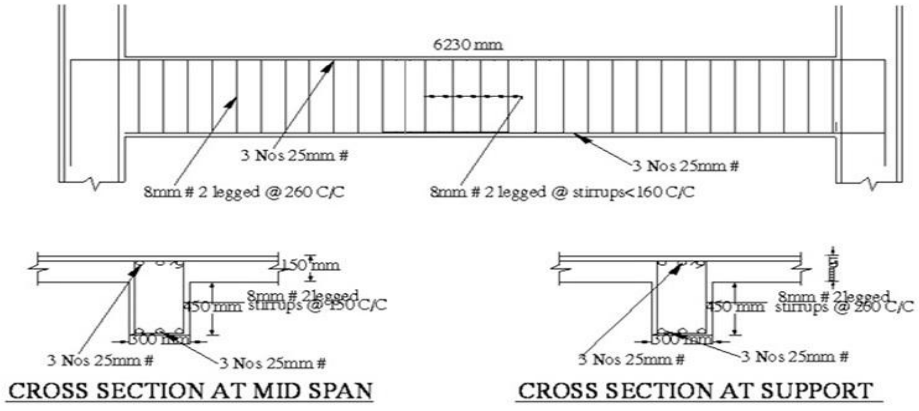
4.3 Manual design result of the parts of the structures with reference to the Indian Standard codes

The following AutoCAD drawings show the manual design result of a particular two way slab, beam, column, foundation and staircase of the shopping mall



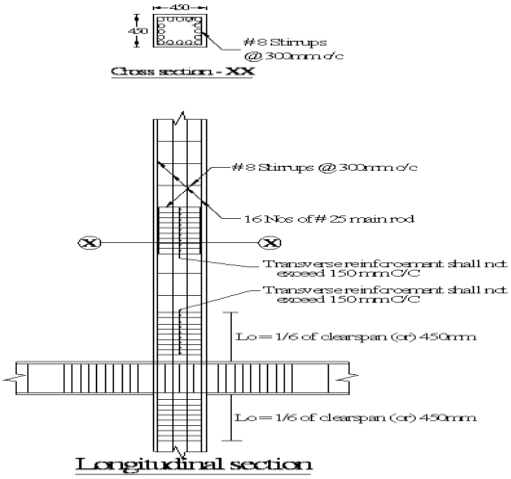
Reinforcement details of Two way slab

Fig. 7 Design of two way slab



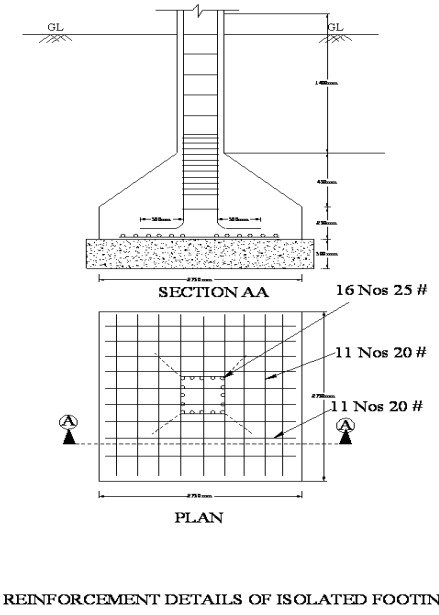
Reinforcement details of beam

Fig. 8 Design of beam



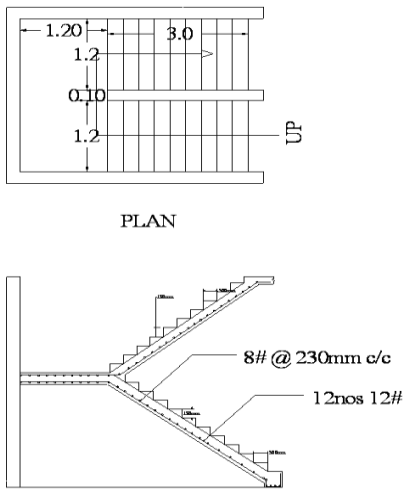
REINFORCEMENT DETAILS FOR COLUMNS

Fig. 9 Design of column



REINFORCEMENT DETAILS OF ISOLATED FOOTING

Fig. 10 Design of foundation



REINFORCEMENT DETAILS OF STAIRCASE

Fig. 11 Design of staircase

V. CONCLUSION

The plan using AutoCAD, modeling of the structure, analysis by seismic coefficient method and design of some selective parts of the shopping mall using ETABS and manual design calculation satisfying the necessary requirements as per BIS specification as well as various Indian standard code specifications have been presented above.

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