Purbanchal University

P.U SCHOOL OF ENGINEERING

BIRATNAGAR, MORANG

A

PROJECT REPORT

ON

ANALYSIS AND DESIGN OF INSTITUTIONAL BUILDING (HOSTEL) FOR EARTHQUAKE RESISTANCE

GROUP 'G'

Submitted By:-

Name	Symbol No:
SURENDRA PRASAD MAHATO	(380117)
RUPESH YADAV	(380107)
SHIV SHANKAR MEHTA	(381782)
SUJAN CHAUDHARY	(380115)
SAMJHANA SAH	(380110)
SATISH CHAUDHARY	(380112)
RISHI RAJ RAM	(381781)

Submitted To:-

DEPARTMENT OF CIVIL ENGINEERING
PURBANCHAL UNIVERSITY
SCHOOL OF ENGINEERING

CERTIFICATE

This is to certify that the project entitled "ANALYSIS & DESIGN OF HOSTEL BUILDING FOR EARTHQUAKE RESISTANCE", submitted by group members SURENDRA PRASAD MAHATO (380117), RUPESH YADAV (380107), SHIVSHANKAR MEHTA (381782), SUJAN CHAUDHARY (380115), SAMJHANA SAH (380110), SATISH CHAUDHARY (380112), RISHI RAJ KUMAR RAM (381781) students of BCE 2019 batch, is accepted as their final project report for the award of degree in Bachelors in Civil Engineering under purwanchal University.

The project is carried under my supervision and the materials they have included in this report are the outcome of three months authentic work.

....

Er. RABIN BHATTARAI

(Advisor/ supervisor)

Date: ....

....

(External Examiner)

Date: 2081/05/04

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Name	Signature
Surendra Prasad Mahato (380117)	....
Rupesh Yadav (380107)	....
Shivshankar Mehata (381782)	....
Samjhana Sah (380110)	....
Sujan Chaudhary (380115)	....
Satish Chaudhary(380112)	....
Rishi Raj Kumar Ram	....

Date: ....

ABSTRACT

The report presents the analysis and design of a hostel building located in the Kathmandu valley, at Kirtipur undertaken as a partial fulfillment of Bachelor in Civil Engineering (BCE) 8th semester of course requirement. In the view of seismic vulnerability of the country, seismic load on the building was given due consideration, in addition to the wind load. Load calculation was done as according to IS: 875 – 1987 (Code of practice for Design Loads for building & structure) and IS 1893 – 2002 (Criteria for Earthquake resistant – Design and Structure). Modeling & Analysis was done with the help of ETABS structural analysis software. Design is based on Limit State of Method. Detailing has been carried out as according to SP 34 (S & T) – 1987 (Handbook on concrete Reinforced & Detailing) and IS 13920 – 1993 (Ductile Detailing of RC Structure subjected to seismic forces).

LIST OF SYMBOLS

A_{st}	=	Area of steel
b_f	=	Breadth of slab/compression face/flange
b_w	=	Breadth of web or rib
D	=	Overall depth of beam or slab
D_f	=	Thickness of flange
DL	=	Dead Load
d	=	Effective depth of beam or slab
d'	=	Depth of compression reinforcement
E_c	=	Modulus of elasticity of concrete
EL	=	Earthquake load
E_s	=	Modulus of elasticity of steel
e	=	Eccentricity
f_{ck}	=	Characteristic cube compressive strength of concrete
f_y	=	Characteristic strength of steel
I	=	Moment of inertia
k	=	Constant or coefficient or factor
L_d	=	Development Length
LL	=	Live Load or imposed load
l_{eff}	=	Effective span of beam or slab or effective length of column
l_x	=	Length of shorter side of slab
l_y	=	Length of longer side of slab
α_x, α_y	=	Bending moment Coefficients
l_0	=	Distance between points of zero moments in a beam
M	=	Bending moment
P	=	Axial load on a compression member
q_o	=	Calculated maximum bearing pressure of soil
A_{sv}	=	Total cross-sectional area of stirrup legs or bent-up bars within a distance s_v
A_c	=	Area of concrete
A_{sv}	=	Area of longitudinal reinforcement for columns
s_v	=	Spacing of stirrups
V_{us}	=	Strength of shear reinforcement
T	=	Torsional moment

T	=	Thickness of wall
V	=	Shear force
W	=	Total Load
WL	=	Wind Load
w	=	Uniformly distributed load
w_u	=	Ultimate load
M_u	=	Ultimate bending moment
M_{lim}	=	Limiting bending moment
x	=	Depth of neutral axis
x_{lim}	=	limiting neutral axis depth
τ_{bd}	=	Design bond stress
τ_c	=	Shear stress in concrete
$\tau_{c,max}$	=	Maximum shear stress in concrete with shear reinforcement
τ_v	=	Nominal shear stress
ϕ	=	Diameter of bar

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CHAPTER-1

INTRODUCTION

1.1 GENERAL

Nowadays, for the development of any nation, it is essential to construct the infrastructures regarding various constructions works. To carry out such works engineers and various technicians play an important role entirely through the governmental or private sector. Government having inadequate resources, nowadays, private sectors are immensely activated towards the construction works on the contract basis.

In this scenario, regarding several projects which were offered to us, we have chosen the project entitled "Analysis and Design of Office Building of Earthquake Resistance". Comparing various models of building structures, we found public building as the most challenging project. Thus, we have given preference to the construction of the frame structured municipal building which is a frame structure of six-stories with basement. There are total 34 frames. These frames are analyzed for various vertical (Live, Dead) and horizontal (Earthquake, wind) loads. The site is located in Biratnagar Metropolitan. According to IS 1893-2002 (Criteria for Earthquake Resistant design of structures), Biratnagar lying on Vth zone, earthquake load was found to be pre-dominant in case of lateral load.

Earthquake is a natural phenomenon as old as the history of the earth itself. It occurs rarely at any particular location. However the effects of these events are very destructive. Amongst the other natural disasters, earthquake is the most unpredictable one with maximum risk. Massive loss of lives and properties occurs. Now a days, designers and engineers are giving more emphasis towards the earthquake resistance while analyzing and designing any structure to minimize the seismic impact.

Various types of loads during the design phase are considered. While analyzing the structure, internal forces in various structural members are discussed. Structural design deals with the designing various members of the structure to resist these internal forces to which they might be subjected during the life period of the structure.

While analysis, frames are analyzed for earthquake as lateral or horizontal load. During the earthquake, structural and non-structural damages occur in which both of them are hazardous to occupants. When earthquake shaking occurs, a building gets thrown from side to side or up and down. i.e. ground moves violently side by side and building stay at rest. Thus the building gets thrown back and forth by the motion of the ground with some part of building lagging behind and then moving in the opposite direction. The level of damage depends upon how well the building has been designed and constructed.

In our context, the analysis of earthquake is based on seismic coefficient design method as described in IS 1893: 2002. The lumped masses are calculated in floor level and with the help of horizontal base shear, the lateral load (earthquake load) is calculated as well as distributed.

The project report has been prepared in complete conformity with various provisions in Indian Standards as Code of practice for plain & reinforced concrete IS 456-2000; Code of practice for Design loads IS 875 (Part 2)-1987: Design Aids for Reinforcement Concrete (SP 16) IS 456-1978; Handbook on Concrete Reinforcement and Detailing SP 34 (1987) are thoroughly referred for proper analysis, design and detailing of structural elements viz. beam, slab, column, staircase, foundation, basement wall with respect to safety, strength, stability, ductility & economy in addition to adequate serviceability requirements of cracking and deflection in concrete structures. All the codes are based on the principles of limit state of design.

The project report posse modeling output (ETABS 2018), analysis results, load calculations, architectural drawings, structural drawings and sample calculations of various structural elements and their detailing as well.

1.2 OBJECTIVES

The main objective is to achieve a practical knowledge on structural analysis, design and detailing of a building

- To estimate the various loads on the building
- To determine the dimensions of the structural elements of the building
- To design the structural elements of the building
- To make detailing of the structure system
- To design the structure on the basis of allowable material stresses, the section sizes, concrete strengths & amounts, reinforcements
- To estimate the load effects that can be exerted to each critical section in the structure under design loads (BM, SF, thrust)
- To know the methodology for carrying out the structural analysis and detailing in a real practice

1.3 SALIENT FEATURES

Building type	:	Office/Public building
Structural system	:	RCC Frame structure
No. of Storey	:	6 (excluding staircase covering) + Basement
Floor Height	:	Floor – 3.3 m (11')
		Basement – 3.3m (11')
Length	:	25.576 m
Breadth	:	10.566 m
Plinth area	:	270.4896 sq. m
Type of staircase	:	Open – well staircase
Type of foundation	:	Mat foundation
Type of sub-soil	:	Medium Sub-soil (Bearing Capacity = 130 KN/m^2)

FRAME SYSTEM

Direction	Frame Naming
Transverse	[illegible], 3-3, 4-4, 5-5, 6-6, 7-7, 8-8, 9-9, 10-10
Longitudinal	A-A, B-B, C-C, D-D, E-E, F-F, G-G,

1.4 METHODOLOGY

a) Study of the Architectural Drawing

Initially, the architectural drawing of the building was studied. Rooms within this office building were allocated to various purposes such as staff room, administration, seminar hall, storage etc.

b) Preliminary Design

Estimation of various structural elements such as beam and slab were designed and checks were done with the help of deflection criteria and moment criteria. For the column, vertical axial capacity was taken for the design and percentage of steel was checked.

c) Load Calculation

After the study architectural drawing and preliminary design, load calculation was done. In vertical, dead load was obtained by the sized determined in preliminary design and live load was determined by using code for design loads (IS 875 part 2) for various types and purposes of rooms. In horizontal load, earthquake load was determined by calculating lumped mass at floor level and horizontal base shear (IS 1893). It was done by Seismic Coefficient Method. Wind load (IS 875 Part 3) was obtained by design wind speed and design wind pressure. Earthquake load being the pre-dominant one between the two lateral loads, hence its effect was only considered.

d) Modeling & Analysis

For the purpose of Seismic analysis of our building we have used the structural analysis program ETABS. It has a special option for modeling horizontal rigid floor diaphragm system. A floor diaphragm is modeled as a rigid horizontal plane parallel to global X-Y plane, so that all points on any floor diaphragm cannot displace relative to each other in X-Y plane. Initially, the characteristics of the materials used were defined such as concrete – M20 and M25 for colume reinforcement – Fe500. Then, the load cases as well as their combinations with load factors were introduced. Next, structures were analyzed for different load combinations and the final output was determined in the form of SF, BM and AF etc.

e) Design

Design was done on the basis of limit state of design for collapse and serviceability. The sample calculations of various structural elements were done with numerous checks and with the help of MS-excel, the formulation was done for each and every structural member in the building.

f) Detailing

Detailing was to done by determining number, size, layout and location of reinforcement, given the element dimensions and areas of steel required. Certain details such as lap and development lengths, hook requirements, cut-off points etc. were covered by the code.

CHAPTER-2

ANALYSIS OF BUILDING

The analysis of the building was done by the estimation of dimensions of various structural members such as slab, beam, column, staircase, foundation, and basement wall with the help of preliminary design. And different types of loads such as vertical load (Dead + finishes, and Live) and Lateral Load (earthquake and wind load) were calculated. Earthquake being pre-dominant, only its effect was taken for lateral loads. Also combinations of such loads were taken into consideration. With the help of Etabs 2018, element stresses in beams and column were calculated in the provision of rigid diaphragm with.

2.1 PRELIMINARY DESIGN

Preliminary design is carried out to estimate approximate size of the structural members. Grid diagram is taken as basic guideline for analysis. Preliminary design of flexural members of the structural system i.e. for beam and slab are done as per the limit state of serviceability. Work out is done from deflection criteria and moment criteria. And for column, it was done from net vertical axial load capacity assuming suitable percentage of steel.

SLAB DESIGN

Reference	Step	Calculation	Remarks
		Slab (big Hall) dimension 13'4" *13'7"	
		From deflection criteria, we have,	
		$d \geq \frac{l_x}{\alpha\beta\gamma\lambda\delta}$, l_x = 13'4" = 4.064m	
IS 456-2000 Clause 23.2 (fig. 4)		where,	
		α = 26 (for continuous slab two way)	
		δ = 1 (for compression steel)	
		β = 1 (for span less than 10m)	
		λ = 1 (for no web flange)	
		Fs = 0.58*500*1 =290	
		Assumed 0.4% of tensile	
		Steel and fy = 500 grade	
ode IS456: 2000		γ = 1.33 from graph page no 38	
		$\therefore$ d = 4.064*1000/26*1*1*1*1.33 = 177.5mm ≈ 120 mm	
		Adopt overall depth (D) = **130 mm**	
		$\therefore$ Effective depth (d) = 130-10-5 mm =115mm	
		Check by Moment Criteria	
		Calculation of Load	
		For slab (floor)	
		1. Dead load	
		i) R.C.C Slab = γ*t = 25*0.13 = 3.25 KN/m^2	
		ii) 15 mm marble = γ_m*t = 27*0.015 = 0.405 KN/m^2	
		iii) 25 mm screed = γ_s*t = 21*0.025 = 0.525 KN/m^2	
		$\therefore$ Total dead load = 4.18 KN/m^2	
		Live load = 3 KN/m^2	
		$\therefore$ Total load (W) = 7.18 KN/m^2 per m ≈ 7.18 KN/m	
		$\therefore$ Ultimate load (W_u) = 1.5*7.18 = 10.77 KN/m	
		For roof slab	
		1. Dead Load	
		I. R.C.C Slab = γ*t = 25*0.13 = 3.25 KN/m^2	
		II. 25 mm plaster = γ*t = 22*0.025 = 0.55 KN/m^2	
		Total dead load (W) = 3.6 KN/m^2	
		Ultimate load (W_u) = 3.6*1.5 = 5.4 KN/m^2	

	Let us take Maximum Moment (Fig.) $M_x = \alpha_x w_u l_x^2$ $= 0.039*10.77*4.064^2$ $= 6.9$ KN–m $M_y = \alpha_y w_u l_x^2$ $= 0.032*10.77*4.064^2$ $= 5.7$ KN-m $\therefore M = 6.9$ KN-m $\because M_u = 0.133 f_{ck} bd^2$ or, $6.9*10^6 = 0.133*25*1000*d^2$ ⇨ **d = 46 mm < 115 mm (OK)**	
	Next Slab: Effective length (l_x) = 11'7"= 3.5 m. **From deflection criteria**	
IS 456-2000 Annex D Table 26	$d \geq \frac{lx}{\alpha\beta\gamma\lambda\delta}$ Where, α = 26 (for continuous slab two way) δ = 1 (for compression steel) β = 1 (for span less than 10m) λ = 1 (for no web flange) $\gamma = 0.55 + \frac{477 - \sigma_s}{120\left(0.9 + \frac{Mu}{bd2}\right)} \leq 2.0$ $\sigma_s = \sigma_{y/n}\left(\frac{A_{reqd}}{A_{taken}}\right)\left(\frac{1}{\beta_b}\right)$	
IS 456-2000 Clause 23.2 (fig. 4)	$= (500/1.8) *1$ $= 277.77$ N/mm^2 **For Tension side:** $M_r = 0.87 f_y A_{st} (d - 0.42x_{u,l})$ $= 0.87*500*(P/100)*bd (d-0.42*0.46d)$ $= 0.87*500*(0.4/100)*bd (d-0.42*0.46d)$ $= 1.4 bd^2$ **For Compression side:**	
BS 8110-1985	$M_c = Kf_{ck}bd^2$	

Clause 3.4.5.6	Equating both, we get,	
	$Kf_{ck} = 1.4$	
	$M_u = Kf_{ck}bd^2$	
(A.K. Jain Pg. 187)	$M_u/bd^2 = 1.4$	
	$\gamma = 0.55 + \dfrac{477 - 277.77}{120(0.9 + 1.4)}$	
	γ = 1.272 < 2.0 (OK)	
IS 456-2000 Annex G	$\therefore d = \dfrac{3.5}{26 * 1.272}$ =105> d ≥ 0.110 m.	
	∴Overall depth (D) = 110+10 +10 = **130 mm.**	
	Effective depth (d) = 130-10-5 = 115 n mm	
IS 456-2000 Annex G	**<u>Check by Moment Criteria</u>**	
	Calculation of load:	
	For Slab	
	1. Dead load	
	I. R.C.C Slab = γ*t = 25*0.125 = 3.125 KN/m^2	
	II. 15 mm Marble = γ*t = 27*0.015 = 0.405 KN/m^2	
	Total dead load = 3.53 KN/m^2	
	Live load = 3 KN/m^2	
	Total load (W) = 6.53 KN/m^2 per m	
	Ultimate load (W_u) = 1.5*6.53 = 9.8 KN/m	
	Max. Moment	
	$M = \alpha_x w_u l_x^2$	
	= 0.032*9.85*3.5^2	
	= 3.84 KN-m.	
	Now,	
	$M_u = 0.133\ f_{ck}\ bd^2$	
IS 456-2000 Annex D Table 26	Or, 3.84*10^6 = 0.133*20*1000*d^2	
	d = 38 mm < 115 mm (OK)	

BEAM DESIGN

Reference	Step	Calculation	Remarks
	1	**Beam: Seminar Hall**	
IS 456-2000 Clause 23.1.2.a		$b_f = \frac{l_0}{6} + b_w + 6D_f = \frac{0.7*4.140*10^3}{6} + 300 + 6*130$	
		$= 1663$ mm	
		$(l_0 = l_e * 0.7)$ & $(l_e = 4.140*0.7$ m$)$	
		$d \geq \frac{l}{\alpha\beta\lambda\delta\gamma}$	
IS 456-2000 Clause 23.2 (fig. 4)		Where, $\alpha = 26$ (for continuous)	
		$\beta = 1$ (span < 10m)	
		$\gamma = 0.55 + \frac{477 - \sigma_s}{120\left(0.9 + \frac{M_u}{bd^2}\right)} \leq 2$	
BS 8110-1985 Clause 3.4.5.6		$\gamma = 0.82$ for 2% tensile steel	
		$\sigma = 1.08$ for Pc = 0.25%	
		$\lambda = 0.8$ for $\frac{b_w}{b_f} = \frac{300}{1663} = 0.18039$	
		$\therefore d \geq \frac{4.140*10^3}{26*0.82*1.08} = 179.79$ mm	
		$\therefore$ Adopt **D = 180 mm**	
	2	**Check by Moment Criteria:**	
		Total area of trapezoid = ½(a+b)*h	
		= 0.5(1.43 + 4.14)*1.39	
		$\therefore A_1 = 4$ m^2 $A_2 = 4.28$ m^2	
		Total Area = 8.28 m^2	
		Slab:	
		Live Load = 3 KN/m^2	
		Dead Load = γ*A*t = 25*8.28 *0.13 =26.91 KN	
		$\therefore$ Live Load = 3*8.28 = 24.84KN	
		Total Load = 51.75 KN	
		$\therefore$ UDL = (51.75/4.14) = 12.5 KN/m	
		Floor Finish:	
		1. Screed (25mm) = 8.28*21*0.025 = 4.347 KN	

2. Marble (15mm) = 27*8.28*0.015 = 3.35 KN

Total floor finish load = 7.7 KN

$\therefore$ UDL = 1.86 KN/m

<u>Self wt. of beam</u> = 25*0.4*(0.3-0.13)*4.14= 7.038KN

$\therefore$ UDL = 7.3038/4.14 = 1.7 KN/m

<u>Wall load on beam</u> = 19*0.4*4.14*0.7*(3.302-0.3)

= 66.07 KN

$\therefore$ UDL = 15.96 KN/m

Hence, total UDL = 30.32 KN/m

And Ultimate UDL (W_u) = 30.32 *1.5 = 45.48 KN/m

Ultimate Moment (M_u) = $W_u l^2 / 8 = \frac{45.48 * 4.14^2}{8}$

= 97.43 KN-m

Also, we have $M_u = 0.133 f_{ck} b d^2$

IS 456-2000 Annex G

$$\therefore d = \sqrt{\frac{M_u}{0.138 f_{ck} b}} = \sqrt{\frac{97.43 * 10^6}{0.133 * 20 * 300}}$$

=349 mm ≈ 350mm

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<u>Beam No. 2</u>

For l_e = 13'4" = 4.06m

$$B_f = \frac{l_0}{6} + b_w + 6D_f = \frac{0.7 * l_e}{6} + 300 + 6 * 130$$

= 1080.47 mm = 1.08 m

IS 456-2000 Clause 23.1.2

$$D = \frac{l}{10} \text{ to } \frac{l}{15} = 406 \text{ mm}$$

$d \geq l/26$ = 15.61 mm

According to deflection criteria;

$$l/d \leq \alpha\beta\gamma\delta\lambda$$

IS 456-2000 Clause 23.2.1

where; α = 26 (for continuous)

β = 1 (span < 10m)

γ = 0.82 for 2% tensile steel

σ =1.08 for Pc = 0.25%

$\lambda = 0.8$ for $\frac{b_w}{b_f} = \frac{300}{1080.47} = 0.277$

$$\therefore d \geq \frac{4.06 * 10^3}{26 * 0.82 * 1.08 * 0.8} = 220.40 \text{ mm}$$

≈ 232 mm

∴ Adopt D = (232+25+8) mm = **265 mm**

Check by Moment Criteria:

4 Total area of trapezoid = ½(a+b)*h

∴ A_1 = ½*(4.06) * (1/2)*(4.06) = 4.12 m^2 (triangular) &

A_2 = ½(a+b)*H m^2 (trapezoidal)

= ½(4.06+ 0.68)*1.76

Total Area = 8.44m^2

Slab:

Live Load = 3 KN/m^2*8.44 m2 = 25.32 KN

Dead Load = 25*8.44*0.130 = 27.43 KN

Total Load = 58.08 KN

∴ UDL = 58.08/4.06 KN/m = 14.3 KN/m

Floor Finish:

Marble (15 mm) = 27*8.44*0.015 = 3.402 KN

Screed (25 mm) = 21*8.44*0.025 = 4.431 KN

Total floor finish load = 7.832 KN

∴ UDL = 7.832/4.06 = 1.929 KN/m

Self wt. of Beam = 25*0.3*(0.265-0.13)*4.06

= 4.11 KN

∴ UDL =1.01 KN/m

Wall Load on beam reduced 30% =

19*0.3*0.7*4.06*(3.302-0.265)

= 49.16 KN

∴ UDL = 49.16/4.06 = 12.1 KN/m

Hence, total UDL = 29.33 KN/m

And Ultimate UDL (W_u) = 29.33*1.5 = 44 KN/m

Ultimate Moment (M_u) = $W_u l^2 / 8$ = 90.95 KN-m

Also, we have $M_u = 0.133 f_{ck} b d^2$

$$\therefore d = \sqrt{\frac{M_u}{0.133 f_{ck} b}} = 336.46 \text{ mm} \approx 340 \text{ mm}$$

IS 456-2000 Annex G — Hence, Adopt **D = 350 mm**

COLUMN DESIGN

Reference	Step	Calculation	Remarks
IS 456-2000 Clause 39.3	1	**Column Design** Here, Area = 28.084 m^2 Load Calculation Slab Live Load = 3 KN/m^2 * 28.084 m^2 = 84.252 KN Dead Load = 28.084*25*0.13 = 105.32 KN Dead Load of Beam = (2.0735+2+1.75+0.95)*25*(0.4-0.13)*0.3 = 13.74KN Wall Load = 19.6*(2.0735+2+1.75+0.95)*0.25*3 = 99.57 KN After deducting 30% = 0.7*99.57 = 69.699 KN Floor Finish 15 mm Marble = 27*19.509*0.015 = 7.901 KN 25 mm Screed = 21*19.509*0.025 = 10.242 KN Hence, Total Load (P) = 291.15 KN Total load including self wt. = 1.1*291.15 = 320.265KN And Ultimate load (P_u) = 1.5*320.265 = 480.397 KN For six storey (P_u) = 6*480.397 =2882.385KN Then, We have, $P_u = 0.4f_{ck}A_c + 0.67f_yA_{st}$ (for Fe500) $=0.4*25*(A_g-A_{st}) + 0.67*500*A_{st}$ $3868.16*10^3 = 0.4*25*(A_g-\frac{2}{100}A_g) + 0.67*500*2/100*A_g$ $\therefore A_g = 174690\ mm^2$ = 418*418 Hence, Adopt = **450 mm*450 mm**	
	2	**Check for % of Steel** $2882.385*10^3 = 0.4*25\,(450*450 - A_{st}) + 0.67*500*A_{st}$ $\therefore A_{st} = 2638.1\ mm^2$ % of steel = $\frac{2638.1}{202500}$ * 100 % = 1.3027 % $\therefore$0.8% < 1.3027% < 4% **So, OK**	

STAIRCASE DESIGN

Reference	Step	Calculation	Remarks
	1	**Staircase Design** General considerations: For office buildings: Width of Stairs (b) = 1800 to 2400 mm Trade (T) = 270 to 300 mm Then, we have, 2*R + T = 600 to 640 mm And R*T = 40000 to 42000 mm^2 Now, We have, Floor height = 10'6" = 3.2 m No. of Riser = 17 ∴ Riser (R) = Floor ht./No. of Riser = 3.2/17 = 188mm Trade (T) = 10" = 254 mm For span AB (L_e) = 11' = 3.3 m Let, Waist slab thickness (D) = Span/20 = 3.3/20 = 165 mm Hence, **Adopt D = 165 mm** Also $\sqrt{R^2+T^2} = \sqrt{188^2+254^2} = 316$ mm **For Inclined portion**	
	2	1) Self wt. of slab = (D*0.316)*25 = (0.165*0.316)*25 = 1.3035 KN/m = 1.3035/0.254 = 5.13 KN/m^2 2) Self wt. of steps = ½ *0.188*0.254*25 = 0.6KN/m = 0.6/0.254 = 2.35 KN/m^2 3) Finishes = 1 KN/m^2 4) Live Load = 3.0 KN/m^2 (for hall building) Hence, Total load = 11.48 KN/m^2 Taking 1 m width of flight W = 1*11.48 =11.48 KN/m W_u = 1.5*11.48 = 17.22 KN/m (Per m width)	

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For Landing zone

1) Self wt. = $0.165*1*25 = 4.125$ KN/m^2
2) Finishes = 1 KN/m^2
3) Live load = 3.0 KN/m^2

Total load = 8.125 KN/m^2

W = 8.125 KN/m (per m width)

Ultimate load (W_u) = $1.5*8.125 = 12.19$ KN/m

Now,

$R_A + R_B = 12.19*1.524 + 17.22*1.183$

$R_A + R_B = 47.53$ KN ....(1)

Taking Moment about B (clockwise positive)

$R_A (1.524+1.183) - 15.56*1.524(1.183+1.524/2) - 20.13*1.183*1.183/2 = 0$

$\therefore R_A = 22.24$ KN

$R_A + R_B = 47.53$

$\therefore R_B = 47.53 - 22.24 = 25.288$ KN

For the point of Maximum Bending Moment,

$R_A - 15.56*1.524 - 20.13(x=1.524) = 0$ $\Rightarrow$ (x>1.524m)

$22.24 - 15.56*1.524 - 20.13(x - 1.524) = 0$

$\therefore x = 1.45$ m

Moment at (x = 1.45)

$M_x = 22.24*1.45 - 15.56*1.45*1.45/2$

$\therefore M_x = 15.89$ KN-m

$M_u = 0.133\, f_{ck}\, bd^2$

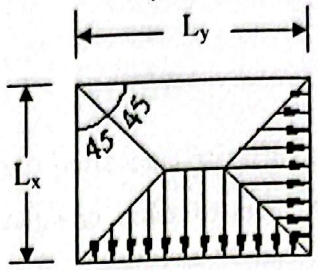
$15.89*10^6 = 0.133*25*1000*d^2$

$\therefore d = 70$ mm < 165 mm **So, OK**

OUTPUTS

Slab (long hall) thickness	=	**130 mm**
Slab (Others) thickness	=	**130 mm**
Beam	=	**300 mm x 400 mm**
Column	=	**450 mm x 450 mm**
Staircase (waist slab)	=	**165 mm**

2.2 VERTICAL LOADS



DEAD LOAD

- Dead load from slab is trapezoidal acts on beams
- Dead load from walls are UDL also acts on beams
- Self wt. of beam is UDL and acts on the same beam
- Self wt. of columns are considered point loads action on joints
- Dead load intensity of floor slab

  = Unit wt. of concrete*thickness [RCC + floor finishes (Marble +screed)]

  = 4.68 KN/m^2 (Seminar hall)

  = 4.305 KN/m^2 (Others)
- Dead load intensity of roof slab

  = Unit wt. of concrete*thickness [RCC + floor finishes (Plaster)]

  = 4.3 KN/m2

  - Unit wt. of different materials (γ)
    - $\gamma_{\text{Reinforced Concrete}}$ = 25 KN/m^3
    - γ_{marble} = 27 KN/m^3
    - γ_{screed} = 21 KN/m^3
    - γ_{plaster} = 22 KN/m^3
    - γ_{brick} = 20 KN/m^3
    - $\gamma_{\text{Cement Concrete}}$ = 24 KN/m^3

LIVE LOAD

- Live load is acted directly on slab
- In structural modeling it is considered trapezoidal loads in beams supporting the slab
- Intensity of Live load in slab differ with type of room

For e.g.			
	Room	=	2 KN/m^2
	Passage	=	3.0 KN/m^2
	Staircase	=	3.0 KN/m^2
	Storage room	=	5.0 KN/m^2
	Toilet	=	2.0 KN/m

IS 875 (Part 2) – 1987 (Code of practice for Design Loads for building & structure)

2.3 HORIZONTAL LOADS

While analyzing, we are concerned with various types of vertical and horizontal/lateral loads. Earthquake load as a lateral load should be considered during design in order to meet the acceptable level of responses. The main objective of design is to emphasize the probable deformation or response to their considerable limit within their lifetime. The structural elements should sustain entire possible loads within the suitable degree of safety, upgrade the durability of structure, and be resistive towards misuse and fire.

(A) EARTHQUAKE LOAD

For the lateral load calculation, the ***lumped weight*** of each floor (including basement) is determined. Due to the ***moderate building (<40 m), Seismic Coefficient method*** is followed for an ease (Referring IS: 1893 – 1975)

LUMPED WEIGHT CALCULATION (Floor-wise)

A) First FLOOR:

1) BEAM:

Grid No.	*Length (m)*	*Grid No.*	*Length (m)*
A-A	25.29	1-1	10.14
B-B	25.29	2-2	10.14
C-C	25.29	3-3	10.14
D-D	25.29	4-4	10.14
		5-5	10.14
		6-6	10.14
		7-7	10.14
		8-8	10.14
Total	**101.16**		**81.12**

Total length of beam: 101.16+81.12 = 182.8

Dead Load of Beam: 0.3*0.4*182.28*25 = **548.4 KN**

(Unit wt. of concrete = 25 KN/m^3)

2) **COLUMN:**

Dead Load of Column: 32*0.4*0.4*3.2*25 = 409.6 **KN**

No of column = 32Nos

3) **WALL:**

a) Height of the wall 3.2-0.4= 2.8m
b) Wall having opening (10' wall) = 71 m

Reducing 30% opening = 71 *0.7 = 49.7 m

Example

i) 5' wall = 68.18 m
ii) 10' wall = 49.7 m

Dead Load (DL):

Load of 10" wall = 49.7*0.254*2.8*20=706.9 KN

Load of 5" wall = 68.2*0.127*2.8*20 =484.9 KN

Hence, total wall load = **706.9+484.9 = 1191.79. KN**

4) **SLAB:**

a) Dead Load = Total area*Depth*Unit wt.

= 258.06*0.130*25

= **838.7 KN**

b) Live Load = Σ (Intensity of individual room as per code * Internal area of slab excluding area of beam & column) [Take 50% of Live Load for value ≥3 KN/m^2 and 25% of Live Load for the value < 3KN/m^2]

= **258.7*0.5*3 KN**

= **281.6 KN**

6) **FLOOR FINISH:**

a) Marble = Total area*thickness*Unit wt. of marble (γ_{marble} = 27 KN/m^3)

= 48.07*0.015*27

= 19.5 KN

b) Screed = Total area*thickness*Unit wt. of screed (γ_{screed} = 21 KN/m^3)

= 209.5*0.025*21

= 109.98 KN

Total Floor finish (DL) = 19.5+109.98 = **129.5KN**

HENCE, TOTAL LOAD ON GROUND FLOOR/First floor (W_0) = 3399.6 KN

B) Second Floor :

1) BEAM:

Grid No.	*Length (m)*	*Grid No.*	*Length (m)*
A-A	25.29	1-1	10.14
B-B	25.29	2-2	10.14
C-C	25.29	3-3	10.14
D-D	25.29	4-4	10.14
		5-5	10.14
		6-6	10.14
		7-7	10.14
		8-8	10.14
Total	**101.16**		**81.12**

Total length of beam: 101.16+81.12 = 182.8

Dead Load of Beam: 0.3*0.4*182.28*25 = **548.4 KN**

(Unit wt. of concrete = 25 KN/m^3)

2) COLUMN:

Dead Load of Column: 32*0.4*0.4*3.2*25 = 409.6 **KN**

No of column = 32Nos

3) WALL:

c) Height of the wall 3.2-0.4= 2.8m

d) Wall having opening (10' wall) = 71 m

Reducing 30% opening = 71 *0.7 = 49.7 m

Example

i) 5' wall = 68.18 m

ii) 10' wall = 49.7 m

Dead Load (DL):

Load of 10" wall = 49.7*0.254*2.8*20=706.9 KN

Load of 5" wall = 68.2*0.127*2.8*20 =484.9 KN

Hence, total wall load = **706.9+484.9 = 1191.79. KN**

4) SLAB:

a) Dead Load = Total area*Depth*Unit wt.

= 258.06*0.130*25

= **838.7 KN**

b) Live Load = Σ (Intensity of individual room as per code * Internal area of slab excluding area of beam & column) [Take 50% of Live Load for value ≥3 KN/m^2 and 25% of Live Load for the value < 3KN/m^2]

= 258.7*0.5*3 KN

= 281.6 KN

6) FLOOR FINISH:

a) Marble = Total area*thickness*Unit wt. of marble (γ_{marble} = 27 KN/m^3)

= 48.07*0.015*27

= 19.5 KN

b) Screed = Total area*thickness*Unit wt. of screed (γ_{screed} = 21 KN/m^3)

= 209.5*0.025*21

= 109.98 KN

Total Floor finish (DL) = 19.5+109.98 = **129.5KN**

HENCE, TOTAL LOAD ON SECOND FLOOR (W_0) = 3399.6 KN

C) Third Floor :

1) BEAM:

Grid No.	*Length (m)*	*Grid No.*	*Length (m)*
A-A	25.29	1-1	10.14
B-B	25.29	2-2	10.14
C-C	25.29	3-3	10.14
D-D	25.29	4-4	10.14
		5-5	10.14
		6-6	10.14
		7-7	10.14
		8-8	10.14
Total	**101.16**		**81.12**

Total length of beam: 101.16+81.12 = 182.8

Dead Load of Beam: 0.3*0.4*182.28*25 = **548.4 KN**

(Unit wt. of concrete = 25 KN/m^3)

2) **COLUMN:**

Dead Load of Column: 32*0.4*0.4*3.2*25 = 409.6 **KN**

No of column = 32Nos

3) **WALL:**

e) Height of the wall 3.2-0.4= 2.8m

f) Wall having opening (10' wall) = 71 m

Reducing 30% opening = 71 *0.7 = 49.7 m

Example

i) 5' wall = 68.18 m

ii) 10' wall = 49.7 m

Dead Load (DL):

Load of 10" wall = 49.7*0.254*2.8*20=706.9 KN

Load of 5" wall = 68.2*0.127*2.8*20 =484.9 KN

Hence, total wall load = **706.9+484.9 = 1191.79. KN**

4) **SLAB:**

a) Dead Load = Total area*Depth*Unit wt.

= 258.06*0.130*25

= **838.7 KN**

b) Live Load = Σ (Intensity of individual room as per code * Internal area of slab excluding area of beam & column) [Take 50% of Live Load for value ≥3 KN/m^2 and 25% of Live Load for the value < 3KN/m^2]

= **258.7*0.5*3 KN**

= **281.6 KN**

6) **FLOOR FINISH:**

a) Marble = Total area*thickness*Unit wt. of marble (γ_{marble} = 27 KN/m^3)

= 48.07*0.015*27

= 19.5 KN

b) Screed = Total area*thickness*Unit wt. of screed (γ_{screed} = 21 KN/m^3)

= 209.5*0.025*21

= 109.98 KN

Total Floor finish (DL) = 19.5+109.98 = **129.5KN**

HENCE, TOTAL LOAD ON THIRD FLOOR (W_0) = 3399.6 KN

D)

D) Forth FLOOR:

1) BEAM:

Grid No.	*Length (m)*	*Grid No.*	*Length (m)*
A-A	25.29	1-1	10.14
B-B	25.29	2-2	10.14
C-C	25.29	3-3	10.14
D-D	25.29	4-4	10.14
		5-5	10.14
		6-6	10.14
		7-7	10.14
		8-8	10.14
Total	**101.16**		**81.12**

Total length of beam: 101.16+81.12 = 182.8

Dead Load of Beam: 0.3*0.4*182.28*25 = **548.4 KN**

(Unit wt. of concrete = 25 KN/m^3)

2) COLUMN:

Dead Load of Column: 32*0.4*0.4*3.2*25 = 409.6 **KN**

No of column = 32Nos

3) WALL:

g) Height of the wall 3.2-0.4= 2.8m

h) Wall having opening (10' wall) = 71 m

Reducing 30% opening = 71 *0.7 = 49.7 m

Example

i) 5' wall = 68.18 m

ii) 10' wall = 49.7 m

Dead Load (DL):

Load of 10" wall = 49.7*0.254*2.8*20=706.9 KN

Load of 5" wall = 68.2*0.127*2.8*20 =484.9 KN

Hence, total wall load = **706.9+484.9 = 1191.79. KN**

4) **SLAB:**

a) **Dead Load** = Total area*Depth*Unit wt.

= 258.06*0.130*25

= **838.7 KN**

b) **Live Load** = Σ (Intensity of individual room as per code * Internal area of slab excluding area of beam & column) [Take 50% of Live Load for value ≥3 KN/m^2 and 25% of Live Load for the value < 3KN/m^2]

= **258.7*0.5*3 KN**

= **281.6 KN**

6) **FLOOR FINISH:**

a) Marble = Total area*thickness*Unit wt. of marble (γ_{marble} = 27 KN/m^3)

= 48.07*0.015*27

= 19.5 KN

b) Screed = Total area*thickness*Unit wt. of screed (γ_{screed} = 21 KN/m^3)

= 209.5*0.025*21

= 109.98 KN

Total Floor finish (DL) = 19.5+109.98 = **129.5KN**

HENCE, TOTAL LOAD ON FORTH FLOOR (W_0) = 3399.6 KN

E) Fifth FLOOR:

1) **BEAM:**

Grid No.	*Length (m)*	*Grid No.*	*Length (m)*
A-A	25.29	1-1	10.14
B-B	25.29	2-2	10.14
C-C	25.29	3-3	10.14
D-D	25.29	4-4	10.14
		5-5	10.14
		6-6	10.14
		7-7	10.14
		8-8	10.14
Total	**101.16**		**81.12**

Total length of beam: 101.16+81.12 = 182.8

Dead Load of Beam: 0.3*0.4*182.28*25 = **548.4 KN**

(Unit wt. of concrete = 25 KN/m^3)

2) COLUMN:

Dead Load of Column: 32*0.4*0.4*1.6*25 = 204.8 **KN**

No of column = 32Nos

3) WALL:

i) Height of the wall= 0.8m (parapet wall)

j) Wall having opening (5' wall) = 55 m

Dead Load (DL):

Load of 10" wall = 16*0.254*3*20*0.7=170.688 KN

Load of 5" wall = 55*0.127*0.8*20 =111.76 KN

Hence, total wall load =170.688+111.76= 282.448 KN

4) SLAB:

a) Dead Load = Total area*Depth*Unit wt.

= 258.06*0.130*25

= **838.7 KN**

b) Live Load = Σ (Intensity of individual room as per code * Internal area of slab excluding area of beam & column) [Take 50% of Live Load for value ≥3 KN/m^2 and 25% of Live Load for the value < 3KN/m^2]

= **258.7*0*3 KN**

= **0 KN**

6) FLOOR FINISH:

a) Screed = Total area*thickness*Unit wt. of screed (γ_{screed} = 21 KN/m^3)

= 209.5*0.025*21

= 109.98 KN

Total Floor finish (DL) = **109.98 KN**

HENCE, TOTAL LOAD ON FIFTH FLOOR (W_0) = 1984.32 KN

F) ROOF FLOOR:

Total length of beam: =3.5*2+4.5*2=16m

Dead Load of Beam: 0.3*0.4*16*25 = **48 KN**

(Unit wt. of concrete = 25 KN/m^3)

2) **COLUMN:**

Dead Load of Column: 4*0.4*0.4*1.6*25 = 25.6 **KN**

No of column = 4 Nos

3) **WALL:**

k) Height of the wall =0.8m (parapet wall)

Length of wall = 16 m

Dead Load (DL):

Load of 5" wall = 16*0.127*0.8*20 =32.5 KN

Hence, total wall load=32.5 **KN**

4) **SLAB:**

a) **Dead Load** = Total area*Depth*Unit wt.

= 3.5*4.5*0.130*25

= **51.2 KN**

b) **Live Load** = Σ (Intensity of individual room as per code * Internal area of slab excluding area of beam & column) [Take 50% of Live Load for value ≥3 KN/m^2 and 25% of Live Load for the value < 3KN/m^2]

= **258.7*0*3 KN**

= **0 KN**

6) **FLOOR FINISH:**

b) Screed = Total area*thickness*Unit wt. of screed (γ_{screed} = 21 KN/m^3)

= 3.5*4.5*0.025*21

= 8.26 KN

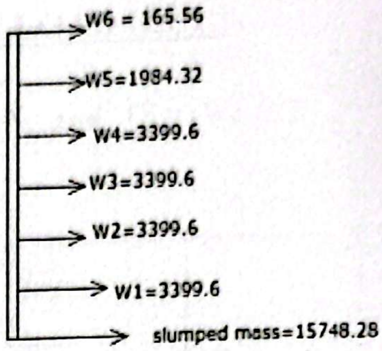
Total Floor finish (DL) = 8.26 **KN**

HENCE, TOTAL LOAD ON ROOF FLOOR (W_0) = 165.56 KN

TABLE-1 RESULT TABLE

Floor	Beam KN	Column KN	Wall KN	Slab (KN)		Floor finish (KN)	TOTAL (KN)
				DL	LL		
First Floor	548.4	409.6	1191.79	838.7	281.6	129.5	**3399.6**
Second Floor	548.4	409.6	1191.79	838.7	281.6	129.5	**3399.6**
Third Floor	548.4	409.6	1191.79	838.7	281.6	129.5	**3399.6**
Fourth Floor	548.4	409.6	1191.79	838.7	281.6	129.5	**3399.6**
Fifth floor	548.4	204.8	282.448	838.7	0	109.98	**1984.32**
Six Floor (roof)	48	25.6	32.5	51.2	0	8.26	**165.56**
						Total =	**15748.28KN**

HORIZONTAL BASE SHEAR CALCULATION



Then, the ***horizontal base shear*** is determined,

It is given by

$V_b = A_h * W$

Where, V_b = Horizontal Base Shear

A_h = Design horizontal seismic Coefficient

W = Total lumped weight of building

Again, $A_h = \frac{ZI}{2R} * \frac{S_a}{g}$

Where, Z = Zone factor (Table 2) = Zone 5 = 0.36 (= very severe)

I = Importance factor (Table 6) = 1.5 (=Community building)

R = Response Reduction factor (Table)

= 5.0 (= special RC moment resisting frame)

S_a/g = Average Response Acceleration Coefficient

= Depends upon Time period (T)

= T = Fundamental natural period

Also we have, $T = 0.075h^{0.75}$ where, h = ht. of building = 19.2 m

$\therefore T = 0.687$ (lies between 0.67 and 4.00)

Hence, $S_a/g = 1.67/T = 1.67/0.687 = 2.43$

And, $A_h = \frac{0.36*1.5}{2*5} * 2.43 = 0.13122$

Lastly, Horizontal base shear (V_b) = A_h*W = 0.13122*15748.28 = **2063.025 KN**

After determining the Horizontal base shear, the distribution of lateral (earthquake) load on different floor is determined as follows:

$$\mathbf{Qi} = \frac{W_i h_i^2}{\Sigma W_i h_i^2} * \mathbf{V_b}$$

where, Q_i = Horizontal/Lateral force acting at any i^{th} floor

W_i = Lumped weight of i^{th} floor

h_i = Ht. of each floor above base

V_b = Horizontal base shear

TABLE-2 CALCULATION OF SEISMIC LOAD (EQL)

Base Shear $V_b = A_h * W = 0.13122 * 15748.28 =$ **2063.025 KN** and $Qi = (W_i h_i^2 / \Sigma W_i h_i^2) * V_b$

Floor	Mass of each floor (W_i)	Cum. Height from ground (h_i)	$W_i h_i^2$	Q_i (KN)	Remarks
6th Floor	**165.56**	19.2	61032.0384	**78.041**	
5th Floor	**1984.32**	16	507985.92	**649.562**	
4th Floor	**3399.6**	12.8	556990.5	**712.224**	
3th Floor	**3399.6**	9.6	313307.136	**400.626**	
2nd Floor	**3399.6**	6.4	139247.61	**178.056**	
FIRST FLOOR	**3399.6**	3.2	34811.9	**44.514**	
			=Σ1613375.098	**2063.025**	

(All values are in KN)

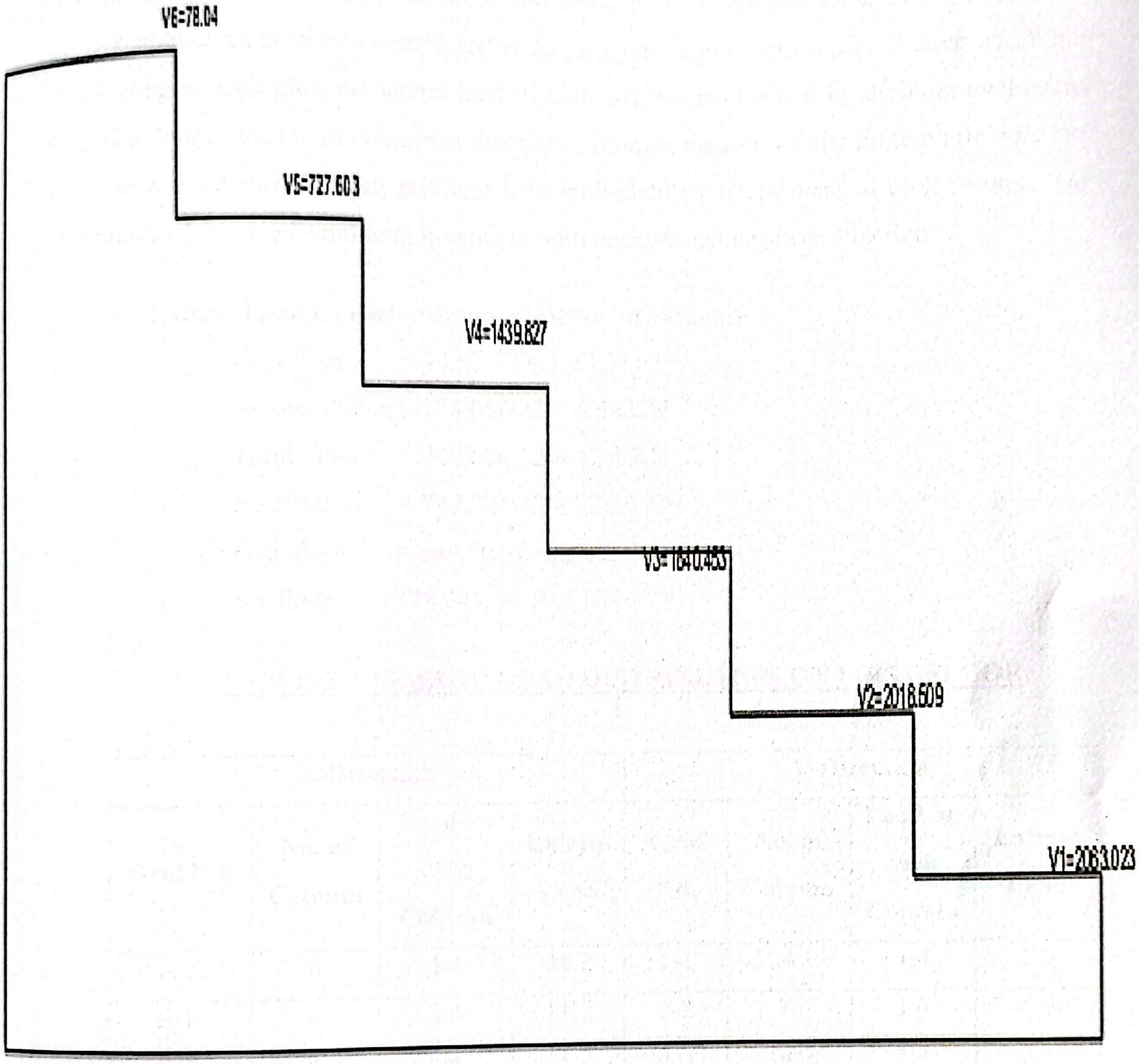


fig :- Base shear for all stores

SEISMIC LOAD DISTRIBUTION

The lateral seismic load obtained from the calculation of lumped mass at floor level and horizontal base shear is then distributed within the building in both X and Y direction. While distributing in each grid, the lateral load in each column is obtained by dividing total lateral load in a floor to the no. of column in that floor. Then, at the time of distribution grid wise, no. of column is counted in each grid and it is multiplied by lateral load in each column. The magnitude of seismic lateral load is same in both positive and negative direction.

Lateral Load on each column = (Qi/No. of column)

First floor = 44.51/32 = 1.4 KN

Second Floor = 178.056/32 = 5.56 KN

Third Floor = 400.626/32 = 12.5 KN

Fourth floor = 712.224/32 = 22.25 KN

Fifth floor = 649.56/32=20.3 KN

Six floor = 78.041/4= 19.5 KN

TABLE-3 SEISMIC LOAD DISTRIBUTION ON FIRST FLOOR

X-Direction				Y-Direction			
Grid No.	**No. of Column**	**Load on each Column**	**Lateral Load**	**Grid No.**	**No. of Column**	**Load on each Column**	**Lateral Load**
A-A	8	1.4	11.2	1-1	4	1.4	5.6
B-B	8	1.4	11.2	2-2	4	1.4	5.6
C-C	8	1.4	11.2	3-3	4	1.4	5.6
D-D	8	1.4	11.2	4-4	4	1.4	5.6
				5-5	4	1.4	5.6
				6-6	4	1.4	5.6
				7-7	4	1.4	5.6
				8-8	4	1.4	5.6
Total	**32**	**44.8**	**203.11**		**32**		**44.8**

(For both EQL-Positive and EQL-Negative)

TABLE-4 SEISMIC LOAD DISTRIBUTION ON SECOND FLOOR

X-Direction				Y-Direction			
Grid No.	No. of Column	Load on each Column	Lateral Load	Grid No.	No. of Column	Load on each Column	Lateral Load
A-A	8	5.56	44.5	1-1	4	5.56	22.24
B-B	8	5.56	44.5	2-2	4	5.56	22.24
C-C	8	5.56	44.5	3-3	4	5.56	22.24
D-D	8	5.56	44.5	4-4	4	5.56	22.24
				5-5	4	5.56	22.24
				6-6	4	5.56	22.24
				7-7	4	5.56	22.24
				8-8	4	5.56	22.24
Total	32		178.24		32		178

(For both EQL-Positive and EQL-Negative)

TABLE-5 SEISMIC LOAD DISTRIBUTION ON THIRD FLOOR

X-Direction				Y-Direction			
Grid No.	No. of Column	Load on each Column	Lateral Load	Grid No.	No. of Column	Load on each Column	Lateral Load
A-A	8	12.5	100	1-1	4	12.5	50
B-B	8	12.5	100	2-2	4	12.5	50
C-C	8	12.5	100	3-3	4	12.5	50
D-D	8	12.5	100	4-4	4	12.5	50
				5-5	4	12.5	50
				6-6	4	12.5	50
				7-7	4	12.5	50
				8-8	4	12.5	50
Total	32		400		32		400

(For both EQL-Positive and EQL-Negative)

TABLE-6 SEISMIC LOAD DISTRIBUTION ON SIX FLOOR

X-Direction				Y-Direction			
Grid No.	No. of Column	Load on each Column	Lateral Load	Grid No.	No. of Colu mn	Load on each Column	Lateral Load
C-C	2	19.5	39	4-4	2	19.5	39
D-D	2	19.5	39	5-5	2	19.5	39
Total	**4**		**78**		**4**		**78**

(For both EQL-Positive and EQL-Negative)

2.4 LOAD CASES AND LOAD COMBINATIONS

LOAD CASES:

1. Dead Load
2. Live Load
3. Earthquake Load

LOAD COMBINATIONS

A. 1.5(DL + LL)

B. 0.9 DL ± 1.5 EQ (both +ve and –ve)

C. 1.2 (DL + LL) ± 1.2 EQ both +ve and –ve)

D. 1.5(DL± EQ x,y) (both +ve and –ve)

E. Envolve (A+B+C+D)

F. (Total no.´of combinations = 13)

STOREY DRIFT

The maximum displacement value is within the limit as per IS code 1893 (part 1): 2002 cl.7.11.1 i.e should not exceed 0.004 times the storey height. Hence, the building is within the storey drift limitation.

TABLE-8 STOREY DRIFT

Floor (1)	Storey Drift (m) (2)	Storey Height (m) (3)	Permissible limit = 0.004*storey height (m) (4)	Remarks (5)
Ground to First	0.001973-0.000=0.001973	3.2	0.004*3.2=0.0128	(4)>(2) OK
First to Second	0.00286-0.00197=0.00089	3.2	0.004*3.2=0.0128	(4)>(2) OK
Second to Third	0.00286-0.00286=0.000	3.2	0.004*3.2=0.0128	(4)>(2) OK
Third to fourth	0.00286-0.00286=0.00	3.2	0.004*3.2=0.0128	(4)>(2) OK
Fourth to fifth	0.00286-0.00286=0.00	3.2	0.004*3.2=0.0128	(4)>(2) OK
Fifth to six	0.01125-0.00286=0.00839	3.2	0.004*3.2=0.0128	(4)>(2) OK

The above values obtained from modeling analysis are less than the permissible limits. Hence it is further proceeded for the designing of the building structural elements.

TIME PERIOD

The time period we used for the base shear calculation is 0.687 sec calculated as per IS Code 1893 (part 1): 2002 but as we perform dynamic analysis of the structure the time period was found to be 0.376 sec, which is lesser than the earlier one. For the more precise result we can adopt the new time period for the base shear recalculation and this will give new base shear, which will be less than that we calculated earlier

CHAPTER-3

MODELING

3.1 INTRODUCTION

For the purpose of Seismic analysis of our building we have used the Structural Analysis Program (ETABS 2018). It has a special option for modeling horizontal rigid floor diaphragm system. A floor diaphragm is modeled as a rigid horizontal plane parallel to global X-Y plane, so that all points on any floor diaphragm cannot displace relative to each other in X-Y plane. Initially, the characteristics of the materials used were defined such as concrete – M20 and reinforcement – Fe500. Then, the load cases as well as their combinations with load factors were introduced. Next, structures were analyzed for different load combinations and the final output was determined in the form of SF, BM and AF etc.

The concept of Finite Element Method is also used thoroughly. This method deals with the elementary analysis of any structure. While analyzing the building, it was divided into no. of structural elements. For example, during calculation of lumped mass, the whole building mass was calculated as the summation of masses at floor level. Similarly, various structural elements such as beam, slab, column, and foundation were analyzed in the elementary basis.

The building was restrained at the basement. During seismic analysis, while calculating base shear, the time period was dependent upon the height of the building. In our context, the height of basement storey was included due to presence of ventilation in the basement wall. If the whole basement storey was of RCC wall without ventilation, then it was possible to restrain at the ground level.

3.2 SAMPLE INPUT

Input figures (unreformed shape from ETABS 2018)

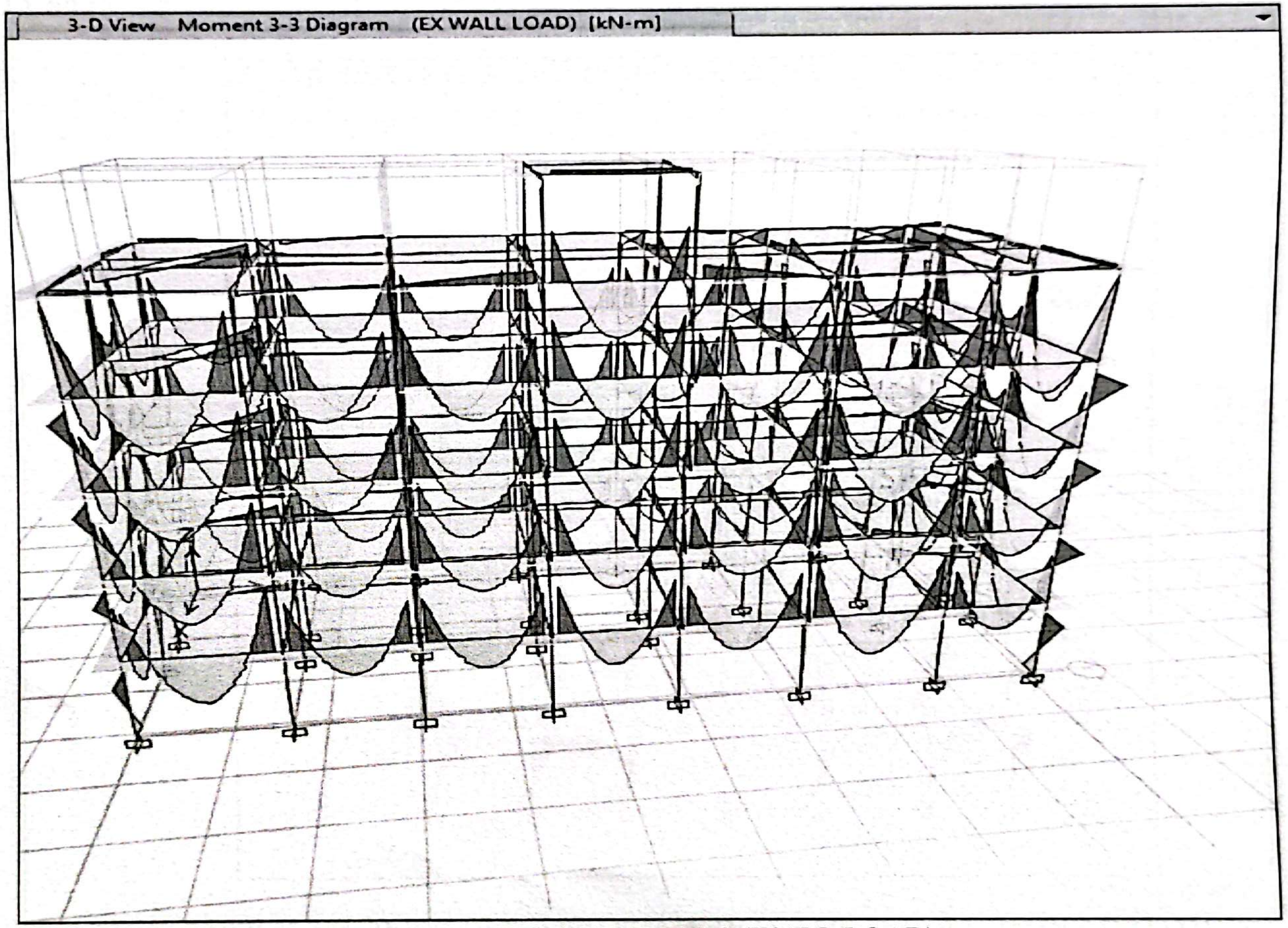


FIG 4. FRAME 3-3 (WALL LOAD)

3.2 SAMPLE OUTPUT

Deformed shape due to load cases

1) Dead Load

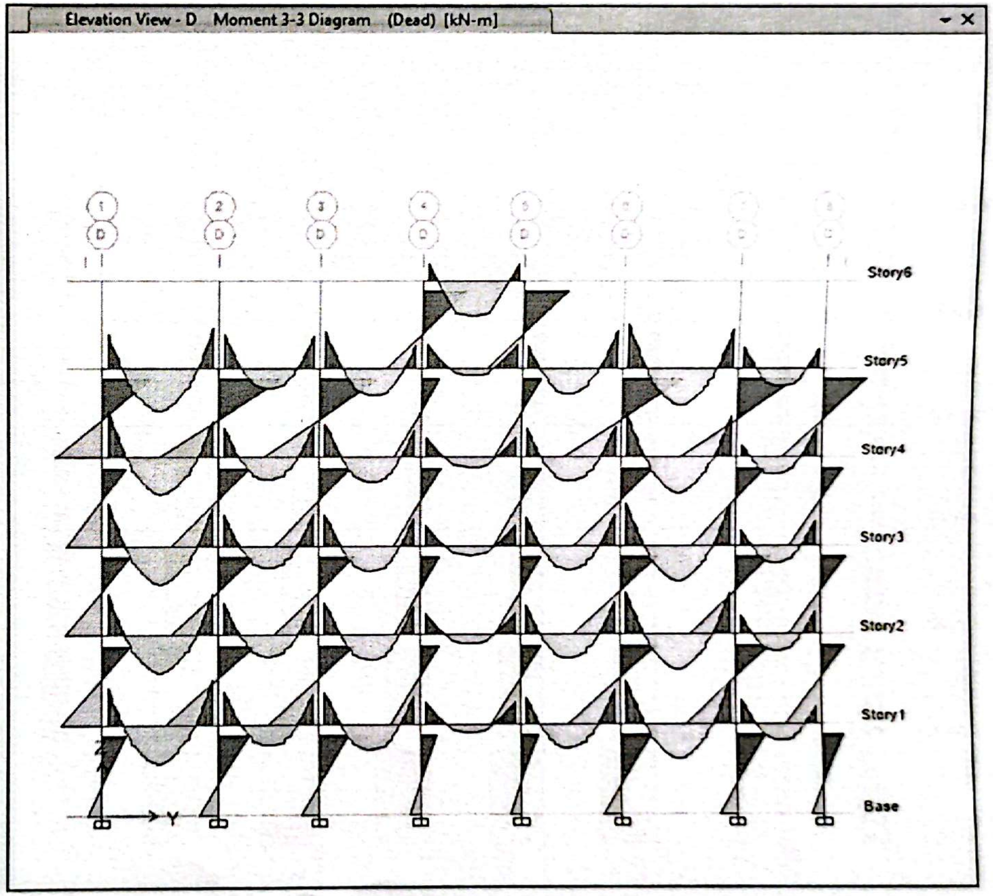
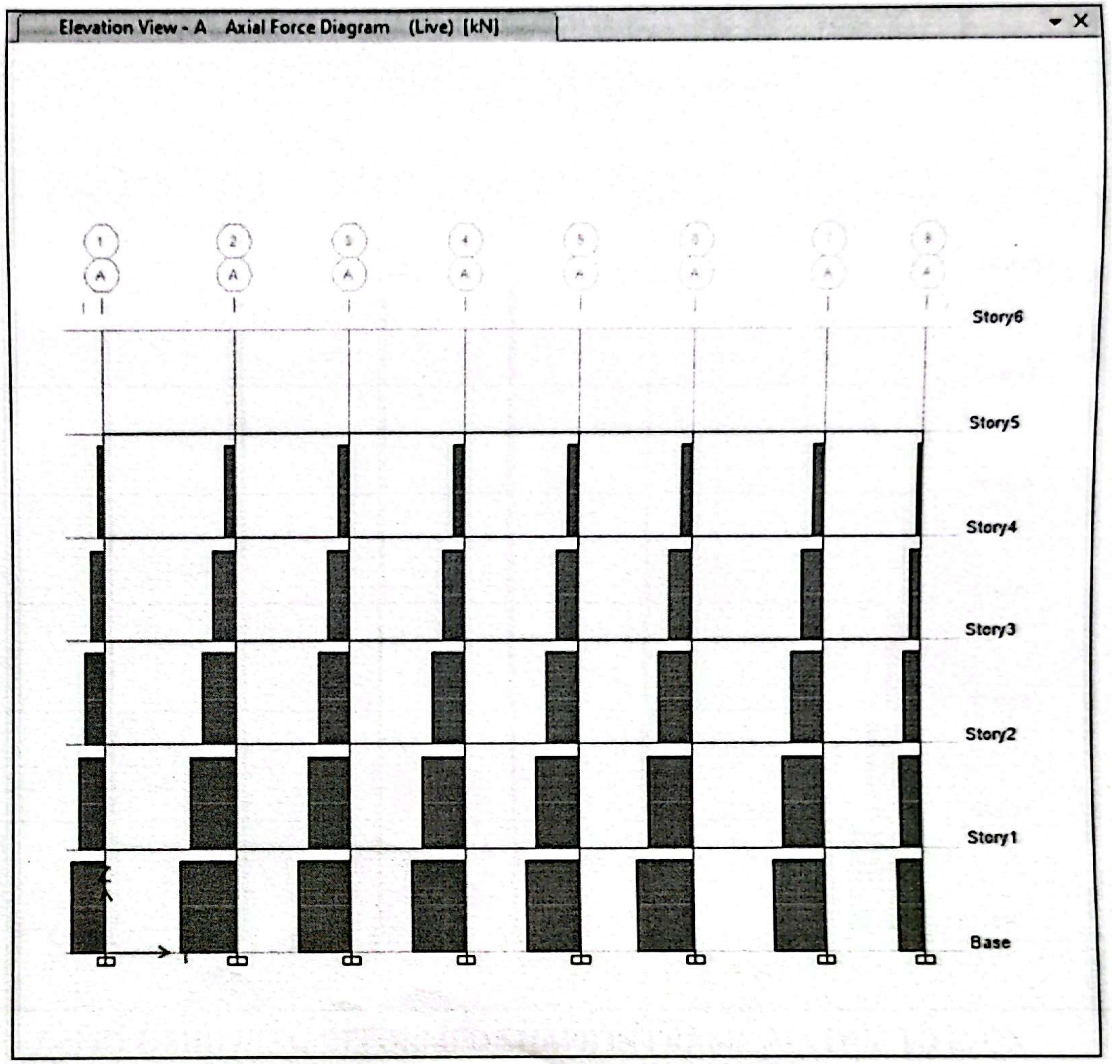


FIG 5. SHOWING DEFOMED SHAPE IN FRAME A-A DUE TO DEAD LOAD

2) Live Load



IG 6. SHOWING DEFORMED SHAPE IN FRAME A-A DUE TO LIVE LOAD

3) EQPy

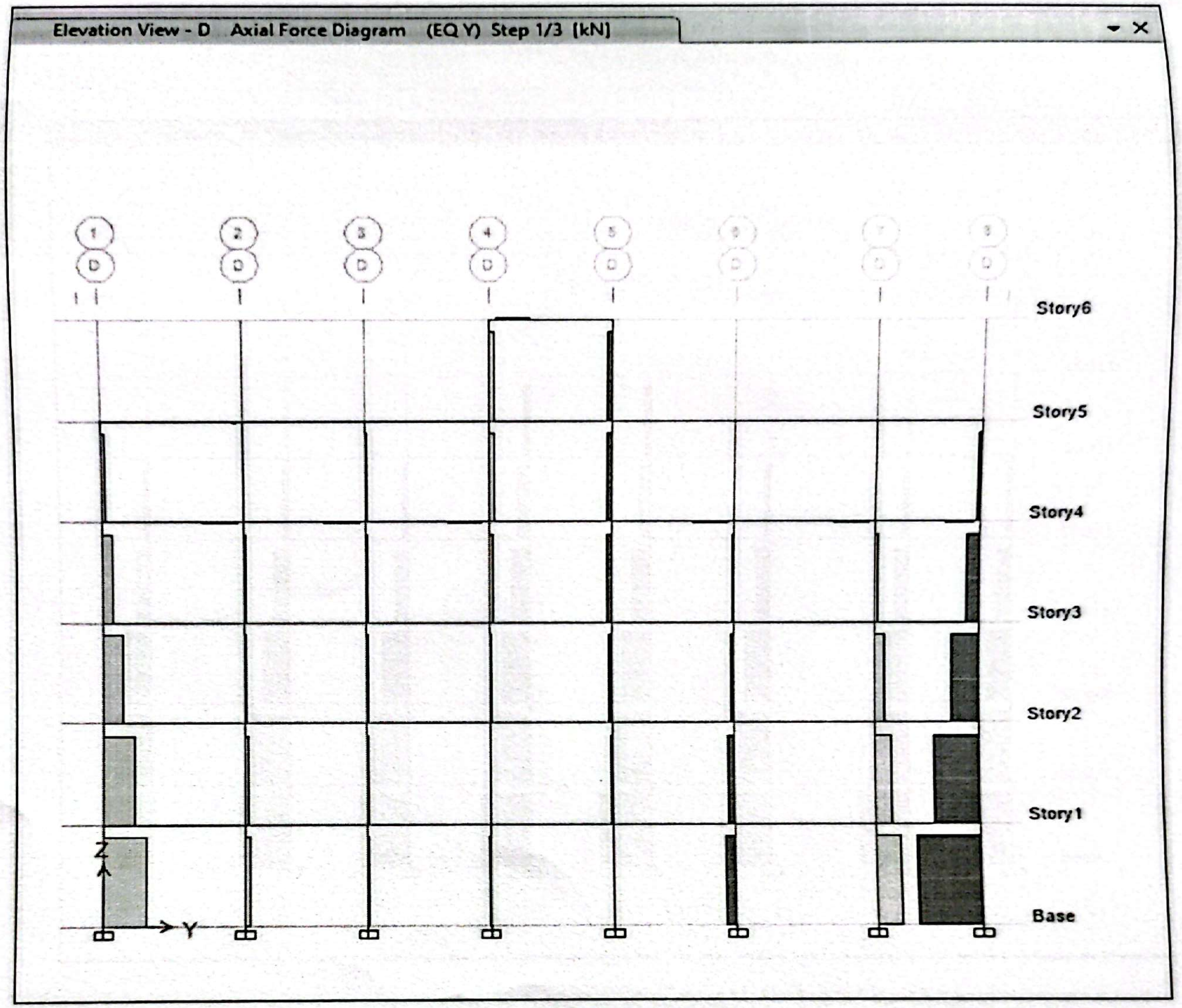


FIG 7. SHOWING DEFORMED SHAPE IN FRAME A-A DUE TO EPQX

3) EQPX

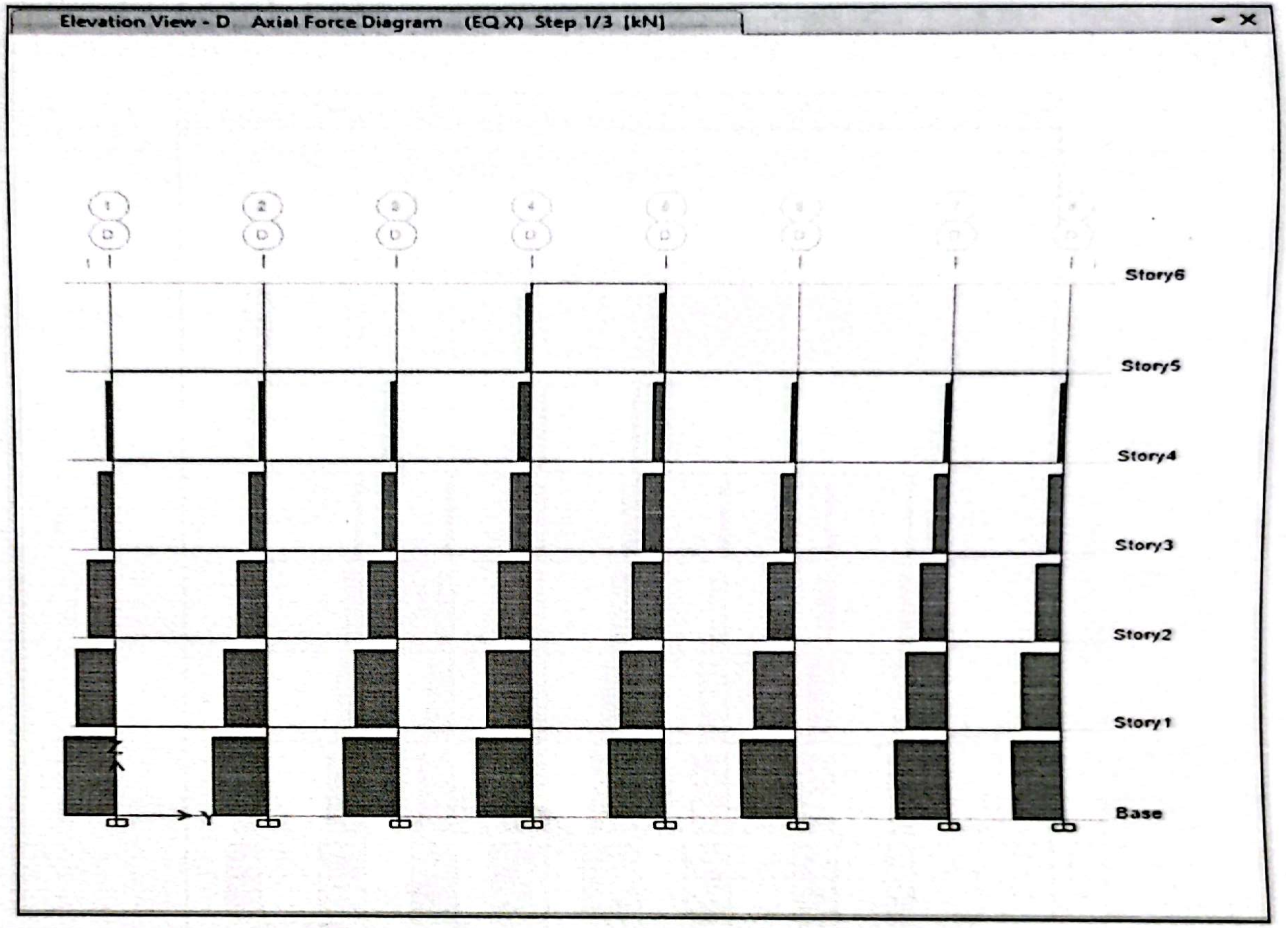


FIG 8. SHOWING DEFORMED SHAPE IN FRAME 4-4 DUE TO EQPY

Deformed shape due to load combinations

1) Combination 1 = 1.5 (DL + LL)

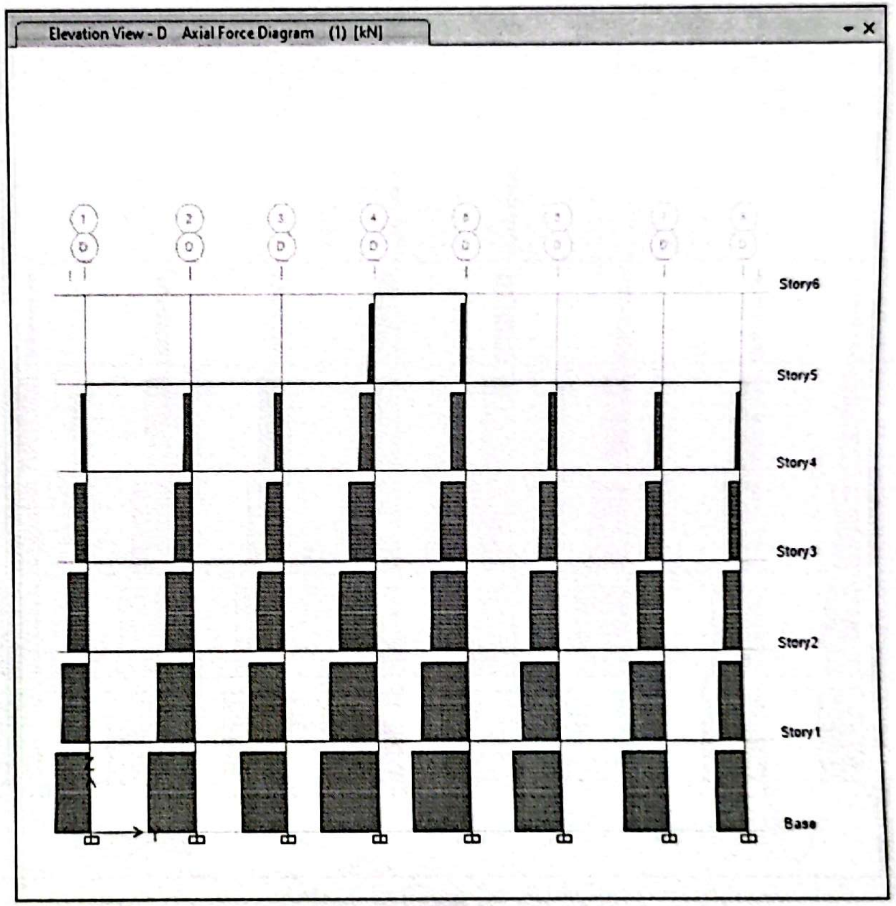


FIG 9. SHOWING DEFORMED SHAPE IN FRAME A-A DUE TO COMBINATION 1

2) **Combination 2 = 0.9 DL + 1.5 EQPX**

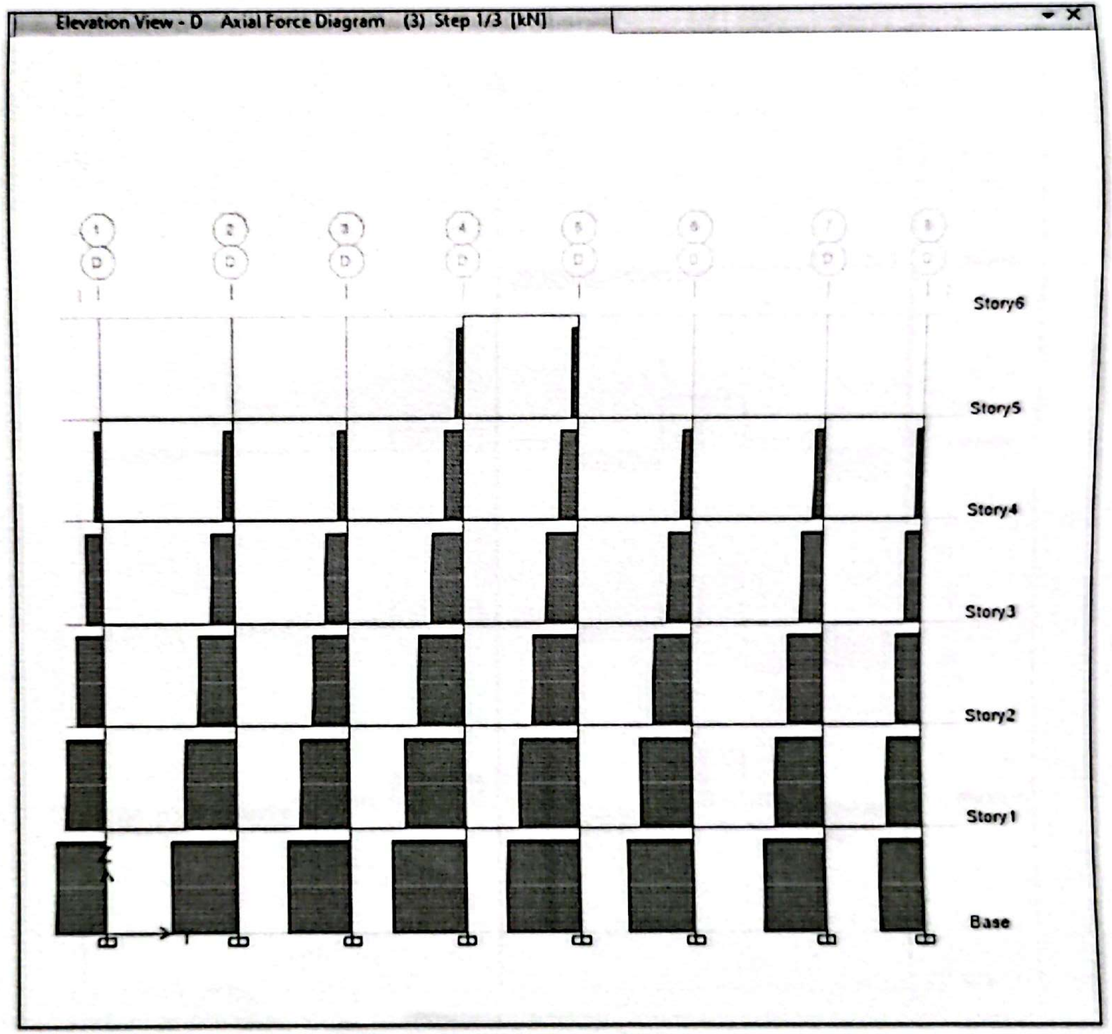


FIG 10. SHOWING DEFORMED SHAPE IN FRAME A-A DUE TO COMBINATION 2

3) **Combination 9 = 1.2 (DL + LL + EQNY)**

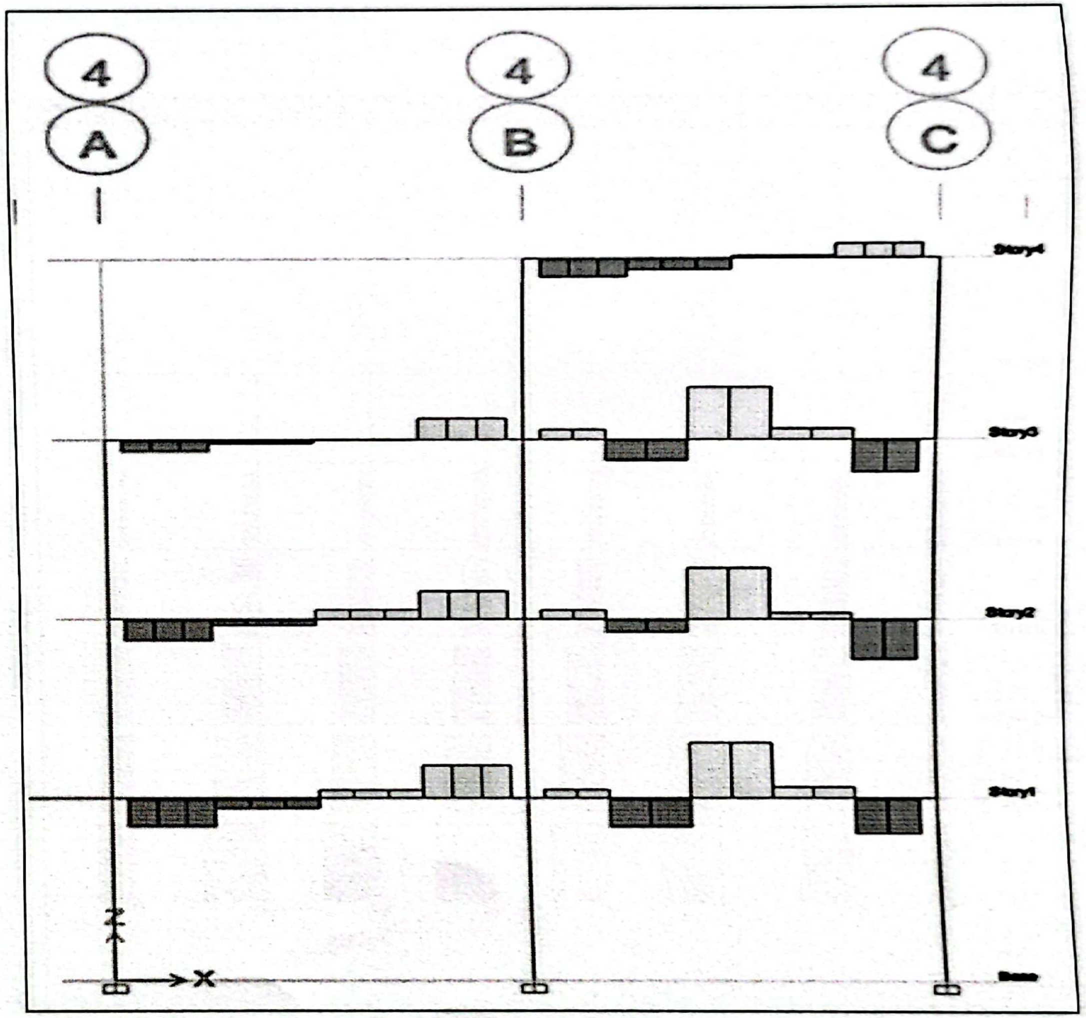


FIG 11. SHOWING DEFORMED SHAPE IN FRAME 4-4 DUE TO COMBINATION 9

Member forces

1) Axial Load

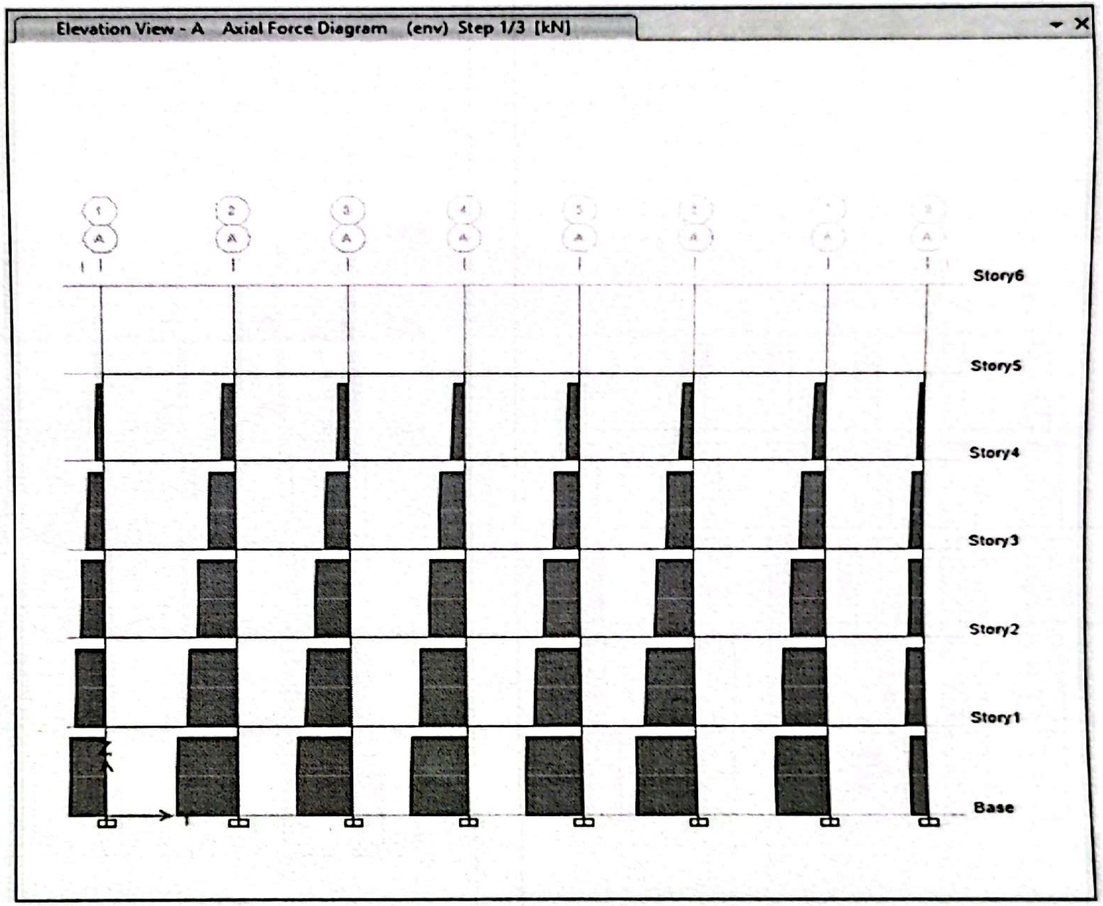
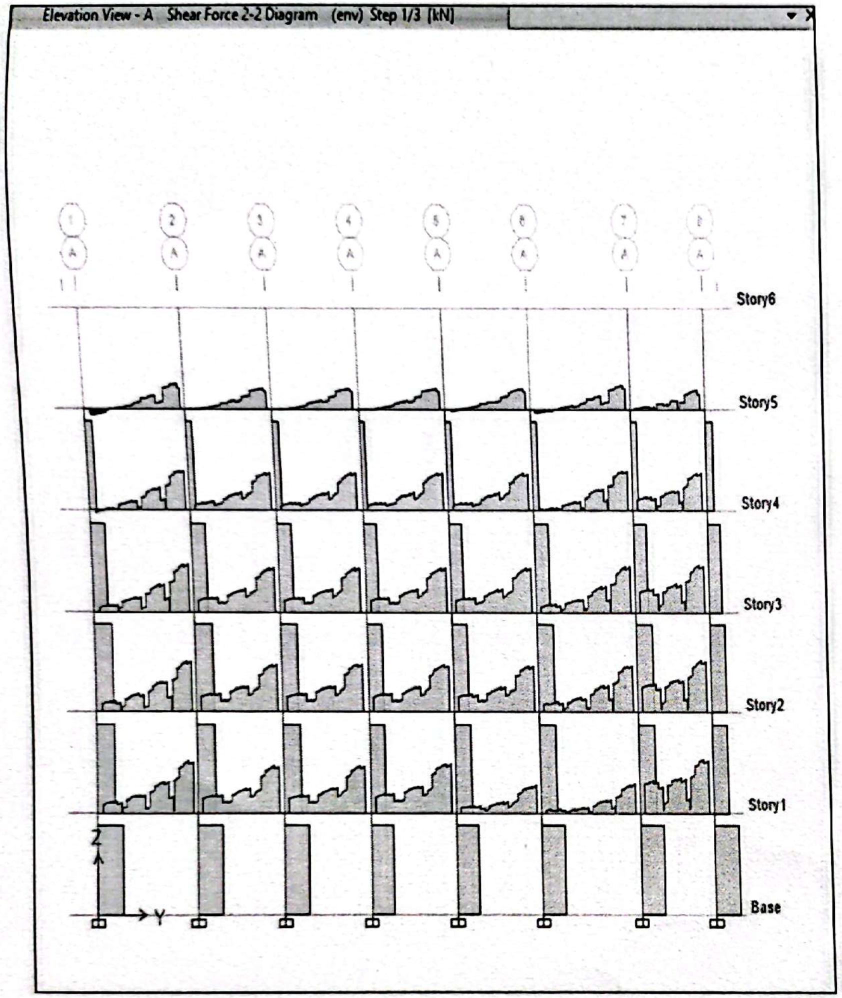


FIG 12. SHOWING AXIAL LOAD ON THE FRAME A-A DUE TO COMBINATION 1

2) *Shear force*



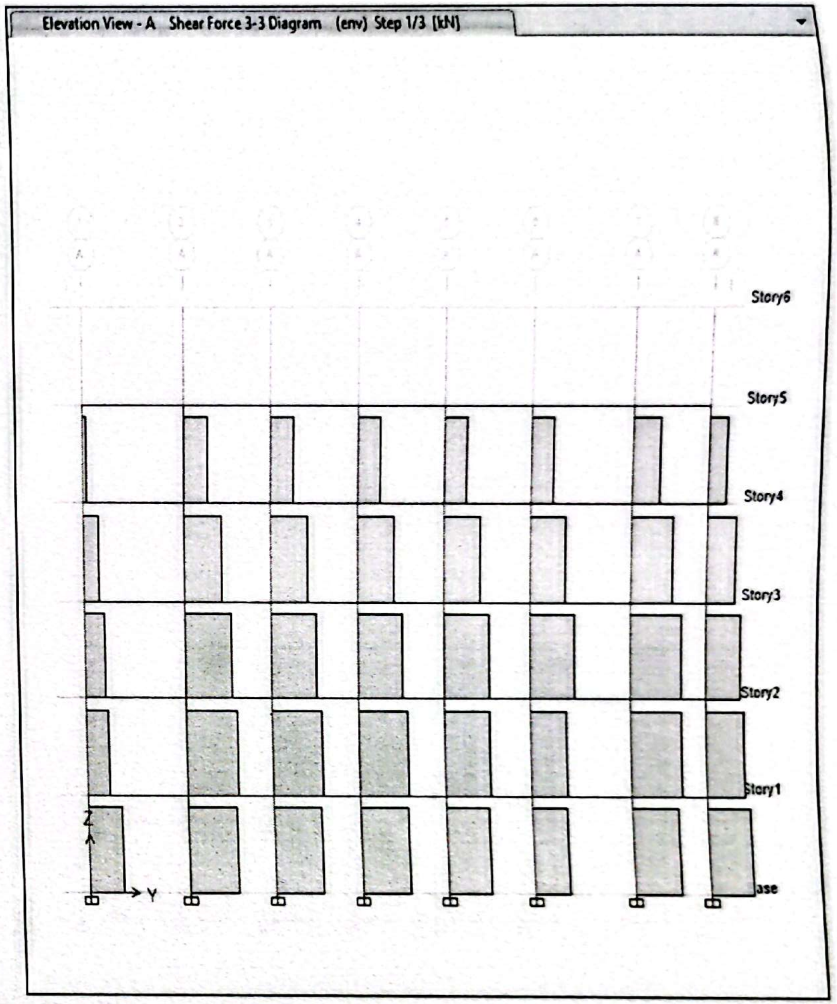


FIG 13. SHOWING SHEAR FORCE 2-2 ON THE FRAME 3-3 DUE TO COMBINATION 1

3) Bending Moment

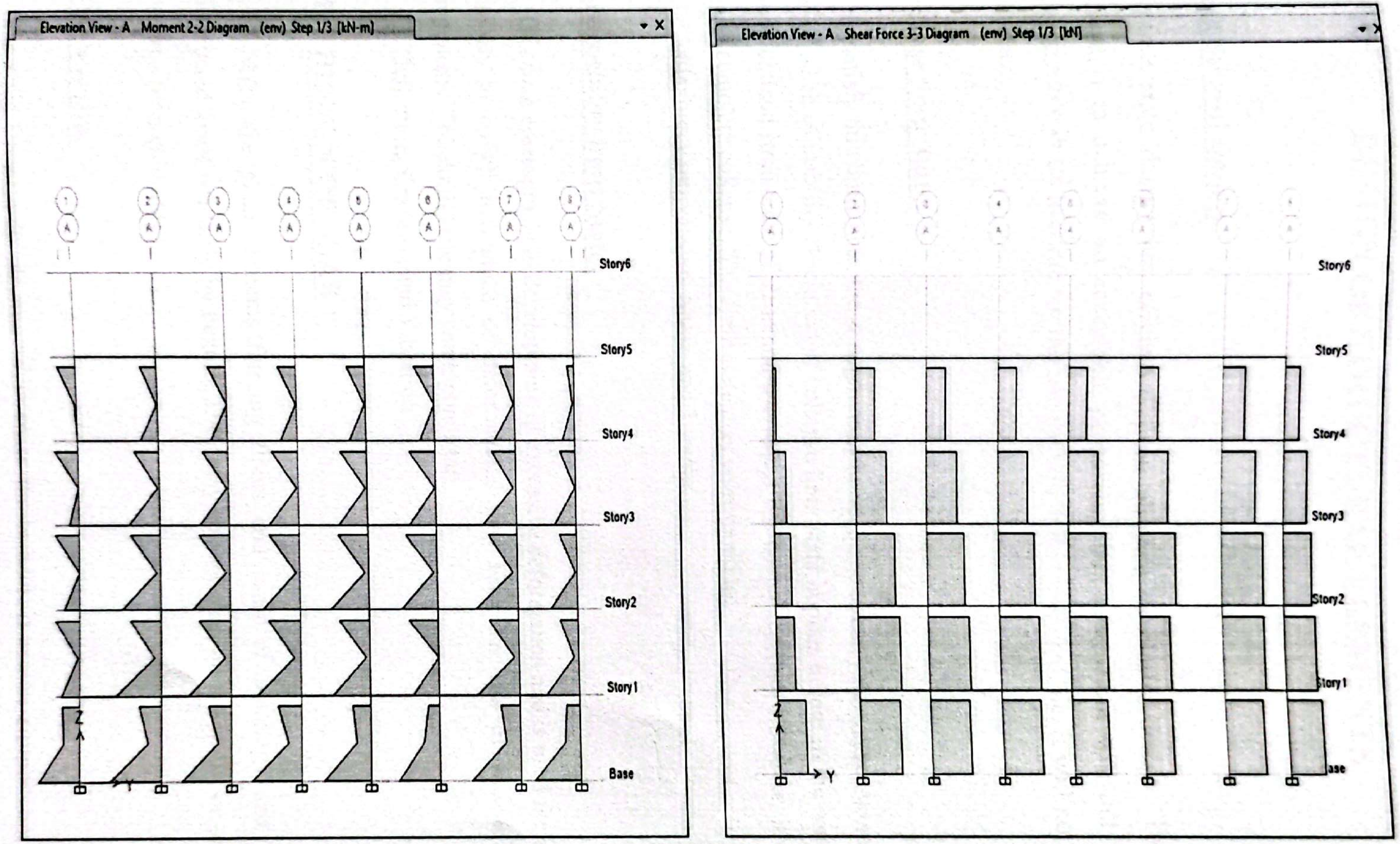


FIG 15. SHOWING BENDING MOMENT 2-2 ON THE FRAME 3-3 DUE TO COMBINATION 1

CHAPTER-4

DESIGN OF STRUCTURAL ELEMENTS

Limit State of Design

Limit state design has originated from ultimate or plastic design. The basic concept is to achieve an acceptable probability that a structure will not become unserviceable in its lifetime for the use for which it is intended, i.e. it will not reach a limit state.

Collapse limit State:

To satisfy this limit state, the strength must be adequate to carry the loads. Account must also be taken of stability. 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. This limit state may correspond to:

Flexure, Compression, Shear, and Torsion

Serviceability limit State:

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

Deflection, Cracking and Vibration

4.1 DESIGN OF SLAB

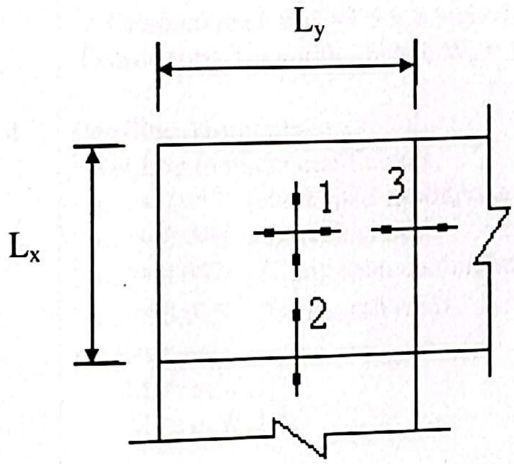
Slabs are plate elements forming floors and roofs of buildings and carrying distributed loads primarily by flexure. They may be supported on the walls, or on beams, or directly on columns.

One way slab:

These slabs have the length more than twice the breadth. It can be simply supported or continuous spanning in one direction only.

Two way slab:

When slabs are supported on four sides two spanning action occurs. These slabs may be simply supported or continuous on any or all sides. The deflection and bending moment in those slabs and considerably reduced as compared to one-way slab. Thus, a thinner slab can carry the same load when supported on all the four edges. It may be considered to consist of a series of interconnected beams with unit width and will transfer the load to the respective supports. It should also satisfy both serviceability and strength requirements.



1. Positive moments at midspan in the long and short spans
2. Negative moment in the short span
3. Negative moment in the long span
4. Zero moment at discontinuous edge (Coefficient = 0)

Fig. Direction of positive and negative moment coefficients

For S1 panel (two adjacent edges discontinuous) :

Ground floor (Room no 8)

Sample Calculation

Reference	Step	Calculation	Output
	1	**Type of slab:-** l_y(long span) = 4.06 m l_x(short span) = 4.14 m $\frac{l_y}{l_x} = 1.01 < 2$ Hence, two way slab.	

From preliminary design	2	**Thickness of slab:-** Overall depth (D) = 130mm Use dia.(Ø) = 10 mm Cover = 20 mm ∴Effective Depth (d) = 130 - 10/2 - 20 = 105 mm	D = 135 mm d = 111 mm
IS 456 table 18	3	**Design load:-** Dead load = 25 x 0.13 = 3.375 KN/m^2 Live load = 3 KN/m^2 Floor finish load = 0.025 x 21 + 0.015 x 27 = 0.93 KN/m^2 ∴ Total design load = 7.305 KN/m^2 ∴Factored load(W_u) =1.5 x 7.305 =10.95KN/m^2 Considering 1m width of slab, W_u = 10.95 KN/m^2 x 1m = 10.95 KN/m	W_u = 10.95 KN/m
IS 456 table 26	4	**Bending Moment:-** Bending moment coefficients; α_{x-} = 0.053 (short span continuous edge0 α_{x+} = 0.040 (short span mid) α_{y-} = 0.047 (Long span continuous edge) α_{y+} = 0.035 (Long span mid) we have, $M_x = \alpha_x W_u l_x^2$ $M_y = \alpha_y W_u l_x^2$ Now, $M_{x-} = \alpha_{x-} W_u l_x^2$ = 0.053 x 10.95x 4.06^2 = 9.566 KN-m $M_{x+} = \alpha_{x+} W_u l_x^2$ = 0.040 x 10.95 x 4.06^2 = 7.21 KN-m $M_{y-} = \alpha_{y-} W_u l_x^2$ = 0.047 x 10.95 x 4.06^2 = 8.48 KN-m $M_{y+} = \alpha_{y+} W_u l_x^2$ = 0.035 x 10.95 x 4.06^2 = 6.31 KN-m	M_{x-} = 9.566 KN-m M_{x+} = 7.21 KN-m M_{y-} = 8.48KN-m M_{y+} = 6.31 KN-m
IS 456-2000 Annex G	5	**Check for effective depth for max. bending moment;-** For f_y = 500 & fck = 20 $M_{max} = 0.133 f_{ck} bd^2$ $9.56*10^6 = 0.133*20*1000*d^2$ d= 59.94 mm < 105 mm Hence, safe	d is enough
IS 456-2000 Annex G	6	**Area of steel Reinforcement:-** (a) For short span (x-direction) (i) Continuous edge $M_{u,x-} = 0.87 f_y A_{st} d_x [1- \frac{f_y A_{st}}{f_{ck} .b.d_x}]$ $9.56 *10^6 = 0.87*500*A_{st}*105*[1- \frac{A_{st} *500}{20*1000*105}]$	

By solving ,we get

$A_{st,x-} = 220.92\ mm^2$

Check for spacing:

Spacing (S) = 1000*Area of one bar/$A_{st,x-}$

$= 1000* \frac{\pi * 10^2/4}{220.92}$

=355.5 mm

Adopt spacing(s) = 350mm ≥ (3*105=315mm or 300 mm whichever is grater)

so adopt spacing 300 mm

$A_{st,x-}$ =220.92mm^2

$\therefore$ Area provided, $A_{st,x-} = 1000* \frac{\pi * 10^2/4}{300}$

$= 261.79\ mm^2 > 220.92\ mm^2$

Check for minimum steel area percentage:

$p\% = A_{st}*100/b.D = \frac{261.79}{1000*130}*100$

$= 0.20\ \% > 0.12\%$

$A_{st,x-}$ provided =261.79mm^2

Hence O.K.

$\therefore$Use 10 mm Ø bar@300 mm c/c.

(a) For short span

(i) For mid span of slab:

IS 456-2000 Annex G

$M_{u,x+} = 0.87\ f_y A_{st}\ d_x\ [\ 1- \frac{f_y A_{st}}{f_{ck}\ b.d_x}\ ]$

$7.21*10^6 = 0.87*500*A_{st}*105[\ 1- \frac{500*A_{st}}{20*1000*105}\ ]$

By solving,we get

$A_{st,x+}$ =164.28 mm^2

Check for spacing:

Spacing(s)= $1000* \frac{\pi * 10^2/4}{164.28}$ =478.085 mm

Adopt spacing(s) = 270 mm < 300 mm

$\therefore$Area provided,$A_{st,x+} = 1000* \frac{\pi * 8^2/4}{270}$

$= 186.168\ mm^2 > 164.28\ mm^2$

Check for minimum steel area percentage

$p\% = \frac{186.168}{1000*130}*100 = 0.143\% > 0.12\%$

Hence, O.K.

$\therefore$Use 10 mm ϕ bar@ 270 mm c/c.

(a) For long span (y-direction):-

(i) For continuous edge:

Use 8 mm Ø bar for longer direction

IS 456-2000
Annex G

$\therefore d_y = 105 - 10/2 - 10/2 = 95$ mm

$M_{u,y-} = 0.87\, f_y A_{st} d_x \left[1 - \frac{f_y A_{st}}{f_{ck}\, b. d_y} \right]$

$8.48*10^6 = 0.87*500*A_{st}*95 \left[1 - \frac{500 * A_{st}}{20*1000*95} \right]$

By solving ,we get

$A_{st,y-} = 217.67\ mm^2$

T8 at 270mm, $186.168 mm^2$

Check for spacing:

Spacing(s) $= 1000* \frac{\pi * 8^2 / 4}{217.67} = 230.92$ mm

Adopt spacing(s) = 230 mm < 300 mm

$\therefore$ Area provided, $A_{st,y-} = 1000* \frac{\pi * 8^2/4}{230}$

$= 218.54\ mm^2 > 217.67\ mm^2$

Check for minimum steel area percentage

$p\% = \frac{218.54}{1000*130} * 100 = 0.168\% > 0.12\%$

Hence, O.K.

$\therefore$ Use 8 mm Ø bar@230 mmc/c.

IS 456-2000
Annex G

(b) For long span:-

(i) For mid span of slab:

$M_{u,y+} = 0.87\, f_y A_{st} d_y \left[1 - \frac{f_y A_{st}}{f_{ck}\, b. d_y} \right]$

$6.31*10^6 = 0.87*500*A_{st}*95 \left[1 - \frac{500 * A_{st}}{20*1000*95} \right]$

By solving ,we get

$A_{st,y+} = 159.37\ mm^2$

Check for spacing:

Spacing (s) $= 1000* \frac{\pi * 8^2/4}{159.37} = 315.40$mm

Adopt spacing(s) = 270 mm < 300 mm

$\therefore$ Area provided, $A_{st,y+} = 1000* \frac{\pi * 8^2/4}{270}$

$= 186.168\ mm^2 > 159.37\ mm^2$

Check for minimum steel area percentage

$p\% = \frac{186.168}{1000*130} * 100\% = 0.143\% > 0.12\%$

Hence, O.K.

$\therefore$ Use 8 mm Ø bar@270 mmc/c.

IS 456-2000 Clause 40.1 IS 456-2000 Table 19 IS 456-2000 Clause 40.2.1.1.	7	**Check for shear force at short edge:-** Maximum shear force: $V=1/2*W_u.l_x$ $=1/2*10.95*4.06$ $=22.22$ KN Nominal shear stress: $\tau_v = \frac{V}{bd} = \frac{22.22*1000}{1000*105} = 0.2117\ N/mm^2$ Percent tensile steel $= 100\frac{A_s}{bd} = \frac{100*261.79}{1000*105} = 0.259\%$ Shear strength of M20 concrete for 0.188% steel, $\tau_c = 0.36 + \frac{0.48-0.36}{0.50-.0.25}*(0.259-0.25)$ $\tau_c = 0.364\ N/mm^2$ Shear strength in slab, $\tau_c' = k\tau_c$ for D = 130 mm, k = 1.3 $\therefore \tau_c' = 1.3*0.364$ $= 0.473\ N/mm^2$ $\tau_v = 0.154\ N/mm^2 < \tau_c' = 0.473\ N/mm^2$ Hence, safe $\therefore$No shear reinforcement is required.	
IS 456-2000 Clause 40.1 IS 456-2000 Clause 40.2.1.1	8	**Check for shear force at long edge:-** Maximum shear force: $V=1/2*W_u.l_x$ $=1/2*10.95*4.06$ $=22.22$ KN Nominal shear stress: $\tau_v=V/bd=22.22*1000/(1000*105)=0.2116\ N/mm^2$ percent tensile steel$=100A_s/bd$ $=100*261.79/1000*105$ $=0.259\%$ Shear strength of M20 concrete for 0.188% steel, $\tau_c=0.36+(0.48-0.36)*(0.259-0.25)/(0.50-0.25)$ $\tau_c=0.364\ N/mm^2$ Shear strength in slab, $\tau_c'= k\tau_c$ for D=135mm, k=1.3 $\therefore \tau_c'=1.3*0.364$ $=0.473 N/mm^2$ $\tau_v=0.154\ N/mm^2 < \tau_c'=0.473\ N/mm^2$ Hence safe $\therefore$No shear reinforcement is required.	
	9	**Check for Development length: at short edge:-** M_1 at support: Moment of resistance offered by 8mm dia bars @240mmc/c	

IS 456-2000 Annex G		$M_{1,x}$= 0.87 f_y A_{st} d_y $[\ 1-\frac{f_y A_{st}}{f_{ck}.b.d_y}\ ]$ $= 0.87*500*261.79/2*\ [\ 1-\frac{500*261.79/2}{20*1000*105}\ ]*105$ = 5792302.301 N-mm = $5.8*10^6$ N-mm Maximum shear force, V = 22.22 KN = $22.22*10^3$ N Development length of bar,	
IS 456-2000 Clause 26.2.1		$L_d = \frac{\phi\sigma_s}{4\tau_{bd}} = \frac{\phi*0.87*f_y}{4\tau_{bd}}$ For M20, τ_{bd} = 1.2*1.6=1.92 L_d = 0.87*500* Ø/4*1.2*1.6 = 56.64Ø= 57@	
IS 456-2000 Clause 26.2.3.3.c		Anchorage value of bar bent at 90° including 60mm straight length, L_o = 60+8*8 = 124 mm $L_d \le 1.3*\frac{M_1}{V}+L_o$ $57Ø \le 1.3*\frac{5.8*10\text{^}6}{22.22*10^3}+124$ 57Ø ≤ 339.33+124 Ø = 8.12 mm > provided Ø = 8 mm Hence, safe in development length. Dia of bar is 8mm which is less than 8.12 mm ∴**O.K.**	
	10	**Calculation for Torsion Reinforcement** l_x = 4060 mm Length of Torsion reinforcement in both directions = $0.2l_x$ = 0.2*4060 = 812 mm Maximum positive steel Area, A_{st} = 186.16 mm^2 **In** corner of two edges discontinuous, i.e. corner ID: A-2 Steel Area required = 0.75*A_{sst} = 0.75*186.16 = 139.62mm^2 Dia. of Bar (ϕ) = 8 mm So, spacing required (s) = $812*\frac{\pi*8^2/4}{139.62}$ = 292.33mm Spacing adopted = 280 mm c/c < 3d or 300 mm whichever is smaller **In** corner of one edge discontinuous, i.e. corner ID B-2 and A-3 Steel Area required = 0.75*A_{st}/2 = 0.75*186.16/2 = 69.81 mm^2 So, spacing required (s) = $812*\frac{\pi*8^2/4}{69.81}$ = 584.66 mm Spacing adopted = 280 mm c/c < 3d or 300 mm whichever is smaller	

DESIGN OF SLAB

For Ground Floor

For Panel S1(Two Adjacent edges discontinuous)

Panel ID No.	D	Ly	Lx	ly/lx	Edge	Moment coefficient		Design load	Factored load (Wu)	Moment	Bar Dia	Bar area	Effec. Depth (d)	a	b	c	1st value	2nd value	Ast req	Spacing required	Spacing Provided	Actual Ast	Ast Per.	Max. Shear force	Nominal Shear Stress	% tensile steel	Shear strength for M20	Shear strength for D = 135 mm	Moment of resistance	Ld	Obtained diameter	ratio of eff. span to eff. depth	constant value
	mm	m	m		Edge			KN/m	KN/m	KN-m	mm	mm^2	mm	a	b	c	1st value	2nd value	mm^2	mm	mm	mm^2	P%	V (KN)	τ_v (N/mm²)		τ_c (N/mm²)	τ_c' (N/mm²)	M1	Ld	φ	Lx/d	α β γ δ λ
1	130	4.140	3.048	1.36	Short	Neg. at con. edge =αx (-ve)	0.071	6.55	9.83	6.5	8	50.27	106	0.000236	-1	141	4094.288	145.712	145.71	344.97	229	219.50	0.17	15	0.1413	0.207	0.3257	0.423358	4929580.77	552	9.746	28.7547	39.1
			3.048			Pos. at mid span =αx (+ve)	0.053	6.55	9.83	4.830	8	50.27	106	0.000236	-1	105	4132.531	107.469	107.47	467.72	280	179.52	0.14										
			3.048		Long	Neg. at con. edge =αy (-ve)	0.047	6.55	9.83	4.290	8	50.27	98	0.000255	-1	101	3816.641	103.359	103.36	486.32	254	197.90	0.15										
			3.048			Pos. at mid span =αy (+ve)	0.035	6.55	9.83	3.195	8	50.27	98	0.000255	-1	75	3843.570	76.430	76.43	657.66	254	197.90	0.15										
2	130	4.140	4.064	1.019	Short	Neg. at con. edge =αx (-ve)	0.048	6.55	9.83	7.809	8	50.27	106	0.000236	-1	169	4063.283	176.717	176.72	284.44	127	395.79	0.30	20	0.1883	0.373	0.4192	0.544994	8699072.11	690.4	12.19	38.3396	39.1
			4.064			Pos. at mid span =αx (+ve)	0.038	6.55	9.83	6.125	8	50.27	106	0.000236	-1	133	4102.712	137.288	137.29	366.13	153	328.53	0.25										
			4.064		Long	Neg. at con. edge =αy (-ve)	0.047	6.55	9.83	7.627	8	50.27	98	0.000255	-1	179	3732.087	187.913	187.91	267.49	153	328.53	0.25										
			4.064			Pos. at mid span =αy (+ve)	0.035	6.55	9.83	5.679	8	50.27	98	0.000255	-1	133	3781.908	138.092	138.09	364.00	204	246.40	0.19										
3	130	3.353	3.353	1.000	Short	Neg. at con. edge =αx (-ve)	0.047	6.805	10.2	5.393	8	50.27	106	0.000196	-1	141	4963.400	145.033	145.03	346.58	280	179.52	0.14	17.1	0.1614	0.169	0.2955	0.384132	4051206.01	431.8	9.184	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.035	6.805	10.2	4.016	8	50.27	106	0.000196	-1	105	5001.248	107.186	107.19	468.95	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.805	10.2	5.393	8	50.27	98	0.000212	-1	152	4565.208	157.684	157.68	318.77	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.805	10.2	4.016	8	50.27	98	0.000212	-1	114	4606.521	116.371	116.37	431.94	280	179.52	0.14										
4	130	4.572	3.353	1.364	Short	Neg. at con. edge =αx (-ve)	0.069	6.805	10.2	7.897	8	50.27	106	0.000196	-1	206	4893.019	215.415	215.41	233.34	240	209.44	0.16	17.1	0.1614	0.198	0.3181	0.413488	3925604.52	422.2	8.981	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.052	6.805	10.2	5.915	8	50.27	106	0.000196	-1	155	4948.908	159.526	159.53	315.09	254	197.90	0.15										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.805	10.2	5.393	8	50.27	98	0.000212	-1	152	4565.208	157.684	157.68	318.77	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.805	10.2	4.016	8	50.27	98	0.000212	-1	114	4606.521	116.371	116.37	431.94	280	179.52	0.14										
4	130	4.267	2.743	1.556	Short	Neg. at con. edge =αx (-ve)	0.077	8.305	12.5	7.218	8	50.27	106	0.000196	-1	189	4912.293	196.140	196.14	256.27	254	197.90	0.15	17.1	0.1612	0.187	0.3094	0.402162	3713511.34	406.5	8.647	25.8792	39.1
			2.743			Pos. at mid span =αx (+ve)	0.058	8.305	12.5	5.396	8	50.27	106	0.000196	-1	141	4963.331	145.102	145.10	346.41	280	179.52	0.14										
			2.743		Long	Neg. at con. edge =αy (-ve)	0.047	8.305	12.5	4.406	8	50.27	98	0.000212	-1	125	4594.900	127.992	127.99	392.72	280	179.52	0.14										
			2.743			Pos. at mid span =αy (+ve)	0.035	8.305	12.5	3.281	8	50.27	98	0.000212	-1	93	4628.266	94.626	94.63	531.20	280	179.52	0.14										
5	130	3.962	3.353	1.182	Short	Neg. at con. edge =αx (-ve)	0.059	8.305	12.5	8.224	8	50.27	106	0.000196	-1	215	4883.655	224.779	224.78	223.62	204	246.40	0.19	20.9	0.197	0.232	0.346	0.44975	4601301.52	410.4	8.73	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.044	8.305	12.5	6.174	8	50.27	106	0.000196	-1	161	4941.656	166.777	166.78	301.39	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	8.305	12.5	6.582	8	50.27	98	0.000212	-1	186	4528.908	193.984	193.98	259.12	254	197.90	0.15										
			3.353			Pos. at mid span =αy (+ve)	0.035	8.305	12.5	4.901	8	50.27	98	0.000212	-1	139	4580.049	142.843	142.84	351.89	280	179.52	0.14										
6	130	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.064	8.305	12.5	8.912	8	50.27	106	0.000196	-1	233	4863.875	244.559	244.56	205.54	204	246.40	0.19	20.9	0.197	0.232	0.346	0.44975	4601301.52	410.4	8.73	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.048	8.305	12.5	6.709	8	50.27	106	0.000196	-1	175	4926.662	181.772	181.77	276.53	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	8.305	12.5	6.582	8	50.27	98	0.000212	-1	186	4528.908	193.984	193.98	259.12	254	197.90	0.15										
			3.353			Pos. at mid span =αy (+ve)	0.035	8.305	12.5	4.901	8	50.27	98	0.000212	-1	139	4580.049	142.843	142.84	351.89	280	179.52	0.14										
13	130	3.962	3.353	1.182	Short	Neg. at con. edge =αx (-ve)	0.059	6.805	10.2	6.739	8	50.27	106	0.000196	-1	176	4925.830	182.604	182.60	275.27	280	179.52	0.14	17.1	0.1614	0.169	0.2955	0.384132	3374863.87	380.4	8.091	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.044	6.805	10.2	5.059	8	50.27	106	0.000196	-1	132	4972.630	135.804	135.80	370.13	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.805	10.2	5.393	8	50.27	98	0.000212	-1	152	4565.208	157.684	157.68	318.77	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.805	10.2	4.016	8	50.27	98	0.000212	-1	114	4606.521	116.371	116.37	431.94	280	179.52	0.14										
14	130	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.064	6.805	10.2	7.302	8	50.27	106	0.000196	-1	191	4909.925	198.509	198.51	253.22	254	197.90	0.15	17.1	0.1614	0.187	0.3094	0.402162	3713511.34	406.1	8.639	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.048	6.805	10.2	5.497	8	50.27	106	0.000196	-1	144	4960.509	147.925	147.92	339.80	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.805	10.2	5.393	8	50.27	98	0.000212	-1	152	4565.208	157.684	157.68	318.77	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.805	10.2	4.016	8	50.27	98	0.000212	-1	114	4606.521	116.371	116.37	431.94	280	179.52	0.14										
17	130	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.064	6.805	10.2	7.302	8	50.27	106	0.000196	-1	191	4909.925	198.509	198.51	253.22	254	197.90	0.15	17.1	0.1614	0.187	0.3094	0.402162	3713511.34	406.1	8.639	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.048	6.805	10.2	5.497	8	50.27	106	0.000196	-1	144	4960.509	147.925	147.92	339.80	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.805	10.2	5.393	8	50.27	98	0.000212	-1	152	4565.208	157.684	157.68	318.77	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.805	10.2	4.016	8	50.27	98	0.000212	-1	114	4606.521	116.371	116.37	431.94	280	179.52	0.14										

For Panel S2L (One long edge discontinuous)

Panel ID No.	D	Ly	Lx	ly/lx	Edge	Moment coefficient		esign lo	Factored load (Wu)	Moment	Bar Dia.	Bar area	Effec. Depth h (d)						Ast req.	Spacing required	Spacing Provided	Actual Ast	st Pe	Max. Shear force	Nominal Shear Stress	% tensile steel	Shear strength for M20	Shear strength for D = 135 mm	Moment of resistance		Obtained diameter	ratio of eff. span to eff. depth	constant value
	mm	m	m					KN/m	KN/m	KN-m	mm	mm^2	mm	a	b	c	1st value	2nd value	mm²	mm	mm	mm^2	P%	V	τ_v (N/mm^2)		τ_c (N/mm^2)	τ_c' (N/mm^2)	M1	Ld	ϕ	Lx/d	α β γ δ λ
7	135	4.572	3.353	1.364	Short	Neg. at con. edge =αx (-ve)	0.061	8.305	12.5	8.517	8	50.27	106	0.000196	-1	223	4875.251	233.183	233.18	215.56	204	246.40	0.19	20.9	0.197	0.232	0.346	0.44975	4601301.52	410.4	8.73	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.046	8.305	12.5	6.429	8	50.27	106	0.000196	-1	168	4934.528	173.906	173.91	289.04	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.037	8.305	12.5	5.181	8	50.27	98	0.000212	-1	146	4571.607	151.284	151.28	332.26	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.028	8.305	12.5	3.921	8	50.27	98	0.000212	-1	111	4609.344	113.548	113.55	442.68	280	179.52	0.14										
8	135	3.962	3.353	1.182	Short	Neg. at con. edge =αx (-ve)	0.051	8.305	12.5	7.078	8	50.27	106	0.000196	-1	185	4916.254	192.180	192.18	261.55	229	219.50	0.17	20.9	0.197	0.207	0.3257	0.423358	4110034.72	379.8	8.08	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.038	8.305	12.5	5.309	8	50.27	106	0.000196	-1	139	4965.735	142.699	142.70	352.25	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.037	8.305	12.5	5.181	8	50.27	98	0.000212	-1	146	4571.607	151.284	151.28	332.26	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.028	8.305	12.5	3.921	8	50.27	98	0.000212	-1	111	4609.344	113.548	113.55	442.68	280	179.52	0.14										
9	135	5.182	4.267	1.214	Short	Neg. at con. edge =αx (-ve)	0.053	8.305	12.5	11.958	8	50.27	106	0.000196	-1	312	4774.110	334.324	334.32	150.35	153	328.53	0.25	26.6	0.2507	0.31	0.3888	0.5054	6084530.19	421.6	8.968	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.040	8.305	12.5	9.009	8	50.27	106	0.000196	-1	235	4861.064	247.370	247.37	203.20	204	246.40	0.19										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.037	8.305	12.5	8.393	8	50.27	98	0.000212	-1	237	4472.400	250.491	250.49	200.67	204	246.40	0.19										
			4.267			Pos. at mid span =αy (+ve)	0.028	8.305	12.5	6.351	8	50.27	98	0.000212	-1	180	4535.988	186.904	186.90	268.94	254	197.90	0.15										
10	135	4.267	3.962	1.077	Short	Neg. at con. edge =αx (-ve)	0.042	7.305	11	7.292	8	50.27	106	0.000196	-1	191	4910.212	198.221	198.22	253.58	229	219.50	0.17	21.7	0.2048	0.207	0.3257	0.423358	4110034.72	370.1	7.873	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.032	7.305	11	5.479	8	50.27	106	0.000196	-1	143	4961.023	147.410	147.41	340.99	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.037	7.305	11	6.365	8	50.27	98	0.000212	-1	180	4535.559	187.333	187.33	268.32	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.028	7.305	11	4.817	8	50.27	98	0.000212	-1	136	4582.581	140.311	140.31	358.24	280	179.52	0.14										
11	135	4.267	3.962	1.077	Short	Neg. at con. edge =αx (-ve)	0.042	7.305	11	7.292	8	50.27	106	0.000196	-1	191	4910.212	198.221	198.22	253.58	229	219.50	0.17	21.7	0.2048	0.207	0.3257	0.423358	4110034.72	370.1	7.873	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.032	7.305	11	5.479	8	50.27	106	0.000196	-1	143	4961.023	147.410	147.41	340.99	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.037	7.305	11	6.365	8	50.27	98	0.000212	-1	180	4535.559	187.333	187.33	268.32	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.028	7.305	11	4.817	8	50.27	98	0.000212	-1	136	4582.581	140.311	140.31	358.24	280	179.52	0.14										
15	135	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.056	6.805	10.2	6.384	8	50.27	106	0.000196	-1	167	4935.790	172.644	172.64	291.15	280	179.52	0.14	17.1	0.1614	0.169	0.2955	0.384132	3374863.87	380.4	8.091	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.043	6.805	10.2	4.892	8	50.27	106	0.000196	-1	128	4977.231	131.202	131.20	383.11	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.037	6.805	10.2	4.246	8	50.27	98	0.000212	-1	120	4599.688	123.203	123.20	407.99	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.028	6.805	10.2	3.213	8	50.27	98	0.000212	-1	91	4630.272	92.619	92.62	542.71	280	179.52	0.14										
16	135	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.056	6.805	10.2	6.384	8	50.27	106	0.000196	-1	167	4935.790	172.644	172.64	291.15	280	179.52	0.14	17.1	0.1614	0.169	0.2955	0.384132	3374863.87	380.4	8.091	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.043	6.805	10.2	4.892	8	50.27	106	0.000196	-1	128	4977.231	131.202	131.20	383.11	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.037	6.805	10.2	4.246	8	50.27	98	0.000212	-1	120	4599.688	123.203	123.20	407.99	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.028	6.805	10.2	3.213	8	50.27	98	0.000212	-1	91	4630.272	92.619	92.62	542.71	280	179.52	0.14										

For Panel S2S (One short edge discontinuous)

Panel ID No.	D	Ly	Lx	ly/lx	Edge	Moment coefficient		esign loa	Factored load (Wu)	Moment	Bar Dia.	Bar area	Effec. Depth h (d)						Ast req	Spacing required	Spacing Provided	Actual Ast	st Pe	Max. Shear force	Nominal Shear Stress	% tensile steel	Shear strength for M20	Shear strength for D = 135 mm	Moment of resistance		Obtained diameter	ratio of eff. span to eff. depth	constant value
	mm	m	m					KN/m	KN/m	KN-m	mm	mm^2	mm	a	b	c	1st value	2nd value	mm^2	mm	mm	mm^2	P%	V	τ_v (N/mm^2)		τ_c (N/mm^2)	τ_c' (N/mm^2)	M1	Ld	ϕ	Lx/d	α β γ δ λ
18	135	4.572	3.962	1.154	Short	Neg. at con. edge =αx (-ve)	0.046	6.805	10.2	7.323	8	50.27	106	0.000196	-1	191	4909.334	199.100	199.10	252.46	229	219.50	0.17	20.2	0.1908	0.207	0.3257	0.423358	4110034.72	388.2	8.258	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.034	6.805	10.2	5.474	8	50.27	106	0.000196	-1	143	4961.166	147.267	147.27	341.32	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.037	6.805	10.2	5.930	8	50.27	98	0.000212	-1	168	4548.893	173.999	174.00	288.88	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.028	6.805	10.2	4.487	8	50.27	98	0.000212	-1	127	4592.466	130.426	130.43	385.40	280	179.52	0.14										
19	135	4.572	4.267	1.071	Short	Neg. at con. edge =αx (-ve)	0.041	6.805	10.2	7.674	8	50.27	106	0.000196	-1	201	4899.370	209.064	209.06	240.43	229	219.50	0.17	21.8	0.2055	0.207	0.3257	0.423358	4110034.72	369.3	7.856	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.031	6.805	10.2	5.735	8	50.27	106	0.000196	-1	150	4953.898	154.536	154.54	325.27	280	179.52	0.14										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.037	6.805	10.2	6.877	8	50.27	98	0.000212	-1	194	4519.795	203.097	203.10	247.50	254	197.90	0.15										
			4.267			Pos. at mid span =αy (+ve)	0.028	6.805	10.2	5.204	8	50.27	98	0.000212	-1	147	4570.916	151.976	151.98	330.75	280	179.52	0.14										
28	135	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.050	8.305	12.5	7.027	8	50.27	106	0.000196	-1	184	4917.692	190.742	190.74	263.53	229	219.50	0.17	20.9	0.197	0.207	0.3257	0.423358	4110034.72	379.8	8.08	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.038	8.305	12.5	5.347	8	50.27	106	0.000196	-1	140	4964.678	143.756	143.76	349.66	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.037	8.305	12.5	5.181	8	50.27	98	0.000212	-1	146	4571.607	151.284	151.28	332.26	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.028	8.305	12.5	3.921	8	50.27	98	0.000212	-1	111	4609.344	113.548	113.55	442.68	280	179.52	0.14										

For Panel S3 (Interior Panel)

Panel ID No.	D	Ly	Lx	ly/lx	Moment coefficient			Design load	Factored load (Wu)	Moment	Bar Dia.	Bar area	Effec. Depth (d)						Ast req	Spacing required	Spacing Provided	Actual Ast	Ast Per	Max. Shear force	Nominal Shear Stress	% tensile steel	Shear strength for M20	Shear strength for D = 135 mm	Moment of resistance		Obtained diameter	ratio of eff. span to eff. depth	constant value
	mm	m	m		Edge			KN/m	KN/m	KN-m	mm	mm^2	mm	a	b	c	1st value	2nd value	mm^2	mm	mm	mm^2	P%	V	τv (N/mm^2)		τc (N/mm^2)	τc' (N/mm^2)	M1	Ld	φ	Lx/d	α β γ δ λ
20	135	5.182	4.572	1.133	Short	Neg. at con. edge =αx (-ve)	0.039	9.305	14	11.378	8	50.27	106	0.000196	-1	297	4791.454	316.980	316.98	158.58	153	328.53	0.25	31.9	0.301	0.31	0.3888	0.5054	6084530.19	371.9	7.911	36.675	39.1
			4.572			Pos. at mid span =αx (+ve)	0.029	9.305	14	8.558	8	50.27	106	0.000196	-1	224	4874.062	234.372	234.37	214.47	204	246.40	0.19										
			4.572		Long	Neg. at con. edge =αy (-ve)	0.032	9.305	14	9.336	8	50.27	98	0.000212	-1	264	4442.368	280.524	280.52	179.18	178	282.39	0.22										
			4.572			Pos. at mid span =αy (+ve)	0.024	9.305	14	7.002	8	50.27	98	0.000212	-1	198	4515.926	206.966	206.97	242.87	254	197.90	0.15										
21	135	5.182	3.962	1.308	Short	Neg. at con. edge =αx (-ve)	0.047	9.305	14	10.367	8	50.27	106	0.000196	-1	271	4821.425	287.009	287.01	175.14	179	280.81	0.22	27.7	0.2609	0.265	0.3672	0.477309	5225841.8	369.7	7.863	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.036	9.305	14	7.940	8	50.27	106	0.000196	-1	207	4891.789	216.645	216.65	232.02	229	219.50	0.17										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.032	9.305	14	7.013	8	50.27	98	0.000212	-1	198	4515.604	207.287	207.29	242.49	229	219.50	0.17										
			3.962			Pos. at mid span =αy (+ve)	0.024	9.305	14	5.259	8	50.27	98	0.000212	-1	149	4569.251	153.640	153.64	327.16	280	179.52	0.14										
22	135	5.182	3.353	1.545	Short	Neg. at con. edge =αx (-ve)	0.054	8.305	12.5	7.600	8	50.27	106	0.000196	-1	199	4901.459	206.975	206.97	242.86	229	219.50	0.17	20.9	0.197	0.207	0.3257	0.423358	4110034.72	379.8	8.08	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.042	8.305	12.5	5.843	8	50.27	106	0.000196	-1	153	4950.891	157.542	157.54	319.06	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.032	8.305	12.5	4.481	8	50.27	98	0.000212	-1	127	4592.651	130.241	130.24	385.94	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.024	8.305	12.5	3.361	8	50.27	98	0.000212	-1	95	4625.913	96.978	96.98	518.32	280	179.52	0.14										
23	135	3.962	3.962	1.000	Short	Neg. at con. edge =αx (-ve)	0.032	6.805	10.2	5.128	8	50.27	106	0.000196	-1	134	4970.719	137.715	137.72	365.00	229	219.50	0.17	20.2	0.1908	0.207	0.3257	0.423358	4110034.72	388.2	8.258	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.024	6.805	10.2	3.846	8	50.27	106	0.000196	-1	101	5005.873	102.561	102.56	490.10	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.032	6.805	10.2	5.128	8	50.27	98	0.000212	-1	145	4573.206	149.686	149.69	335.81	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.024	6.805	10.2	3.846	8	50.27	98	0.000212	-1	109	4611.561	111.330	111.33	451.50	280	179.52	0.14										
24	135	3.962	3.353	1.182	Short	Neg. at con. edge =αx (-ve)	0.042	7.805	11.7	5.516	8	50.27	106	0.000196	-1	144	4960.004	148.429	148.43	338.65	254	197.90	0.15	19.6	0.1852	0.187	0.3094	0.402162	3713511.34	370	7.87	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.031	7.805	11.7	4.116	8	50.27	106	0.000196	-1	108	4998.529	109.905	109.91	457.35	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.032	7.805	11.7	4.211	8	50.27	98	0.000212	-1	119	4600.706	122.185	122.19	411.39	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.024	7.805	11.7	3.159	8	50.27	98	0.000212	-1	89	4631.869	91.023	91.02	552.23	280	179.52	0.14										
25	135	4.267	3.962	1.077	Short	Neg. at con. edge =αx (-ve)	0.036	7.305	11	6.167	8	50.27	106	0.000196	-1	161	4941.865	166.569	166.57	301.77	229	219.50	0.17	21.7	0.2048	0.207	0.3257	0.423358	4110034.72	370.1	7.873	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.027	7.305	11	4.658	8	50.27	106	0.000196	-1	122	4983.669	124.765	124.77	402.88	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.032	7.305	11	5.505	8	50.27	98	0.000212	-1	156	4561.806	161.085	161.09	312.04	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.024	7.305	11	4.129	8	50.27	98	0.000212	-1	117	4603.163	119.728	119.73	419.83	280	179.52	0.14										
26	135	4.267	3.962	1.077	Short	Neg. at con. edge =αx (-ve)	0.036	8.305	12.5	7.011	8	50.27	106	0.000196	-1	183	4918.149	190.284	190.28	264.16	204	246.40	0.19	24.7	0.2328	0.232	0.346	0.44975	4601301.52	366.4	7.793	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.027	8.305	12.5	5.296	8	50.27	106	0.000196	-1	138	4966.087	142.347	142.35	353.12	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.032	8.305	12.5	6.259	8	50.27	98	0.000212	-1	177	4538.828	184.064	184.06	273.09	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.024	8.305	12.5	4.694	8	50.27	98	0.000212	-1	133	4586.272	136.620	136.62	367.92	280	179.52	0.14										
27	135	4.267	3.962	1.077	Short	Neg. at con. edge =αx (-ve)	0.036	8.305	12.5	7.011	8	50.27	106	0.000196	-1	183	4918.149	190.284	190.28	264.16	204	246.40	0.19	24.7	0.2328	0.232	0.346	0.44975	4601301.52	366.4	7.793	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.027	8.305	12.5	5.296	8	50.27	106	0.000196	-1	138	4966.087	142.347	142.35	353.12	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.032	8.305	12.5	6.259	8	50.27	98	0.000212	-1	177	4538.828	184.064	184.06	273.09	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.024	8.305	12.5	4.694	8	50.27	98	0.000212	-1	133	4586.272	136.620	136.62	367.92	280	179.52	0.14										
29	135	4.267	4.267	1.000	Short	Neg. at con. edge =αx (-ve)	0.032	8.305	12.5	7.259	8	50.27	106	0.000196	-1	190	4911.147	197.287	197.29	254.78	178	282.39	0.22	26.6	0.2507	0.266	0.3731	0.485062	5254366.06	381	8.104	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.024	8.305	12.5	5.444	8	50.27	106	0.000196	-1	142	4961.984	146.449	146.45	343.23	280	179.52	0.14										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.032	8.305	12.5	7.259	8	50.27	98	0.000212	-1	205	4507.959	214.932	214.93	233.87	229	219.50	0.17										
			4.267			Pos. at mid span =αy (+ve)	0.024	8.305	12.5	5.444	8	50.27	98	0.000212	-1	154	4563.660	159.232	159.23	315.68	280	179.52	0.14										
30	135	4.267	4.267	1.000	Short	Neg. at con. edge =αx (-ve)	0.032	8.305	12.5	7.259	8	50.27	106	0.000196	-1	190	4911.147	197.287	197.29	254.78	178	282.39	0.22	26.6	0.2507	0.266	0.3731	0.485062	5254366.06	381	8.104	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.024	8.305	12.5	5.444	8	50.27	106	0.000196	-1	142	4961.984	146.449	146.45	343.23	280	179.52	0.14										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.032	8.305	12.5	7.259	8	50.27	98	0.000212	-1	205	4507.959	214.932	214.93	233.87	229	219.50	0.17										
			4.267			Pos. at mid span =αy (+ve)	0.024	8.305	12.5	5.444	8	50.27	98	0.000212	-1	154	4563.660	159.232	159.23	315.68	280	179.52	0.14										
31	135	4.267	4.267	1.000	Short	Neg. at con. edge =αx (-ve)	0.032	7.805	11.7	6.822	8	50.27	106	0.000196	-1	178	4923.489	184.945	184.94	271.79	178	282.39	0.22	25	0.2357	0.266	0.3731	0.485062	5254366.06	397.5	8.454	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.024	7.805	11.7	5.116	8	50.27	106	0.000196	-1	134	4971.052	137.381	137.38	365.88	280	179.52	0.14										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.032	7.805	11.7	6.822	8	50.27	98	0.000212	-1	193	4521.504	201.387	201.39	249.60	254	197.90	0.15										
			4.267			Pos. at mid span =αy (+ve)	0.024	7.805	11.7	5.116	8	50.27	98	0.000212	-1	145	4573.571	149.321	149.32	336.63	280	179.52	0.14										
32	135	4.267	4.267	1.000	Short	Neg. at con. edge =αx (-ve)	0.032	7.805	11.7	6.822	8	50.27	106	0.000196	-1	178	4923.489	184.945	184.94	271.79	178	282.39	0.22	25	0.2357	0.266	0.3731	0.485062	5254366.06	397.5	8.454	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.024	7.805	11.7	5.116	8	50.27	106	0.000196	-1	134	4971.052	137.381	137.38	365.88	280	179.52	0.14										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.032	7.805	11.7	6.822	8	50.27	98	0.000212	-1	193	4521.504	201.387	201.39	249.60	254	197.90	0.15										

			Lx	ly/lx	Edge	Moment coefficient		Design load	Factored load (Wu)	Moment	Bar Dia.	Bar area	Effec. Depth (d)	a	b	c	1st value	2nd value	Ast req	Spacing required	Spacing Provided	Actual Ast	Ast Per	Max. Shear force	Nominal Shear Stress	% tensile steel	Shear strength for M20	Shear strength for D = 135 mm	Moment of resistance	Ld	Obtained diameter	ratio of eff. span to eff. depth	constant value
			4.267			Pos. at mid span =αy (+ve)	0.024	7.805	11.7	5.116	8	50.27	98	0.000212	-1	145	4573.571	149.321	149.32	336.63	280	179.52	0.14										

For Third (Terrace) Floor

For Panel S1(Two Adjacent edges discontinuous)

Panel ID No.	D	Ly	Lx	ly/lx	Moment coefficient			Design load	Factored load (Wu)	Moment	Bar Dia.	Bar area	Effec. Depth (d)						Ast req	Spacing required	Spacing Provided	Actual Ast	Ast Per	Max. Shear force	Nominal Shear Stress	% tensile steel	Shear strength for M20	Shear strength for D = 135 mm	Moment of resistance		Obtained diameter	ratio of eff. span to eff. depth	constant value
	mm	m	m		Edge			KN/m	KN/m	KN-m	mm	mm^2	mm	a	b	c	1st value	2nd value	mm^2	mm	mm	mm^2	P%	V (KN)	τv (N/mm^2)		τc (N/mm^2)	τc' (N/mm^2)	M1	Ld	ϕ'	Lx/d	α β γ δ λ
5	135	4.267	2.743	1.556	Short	Neg. at con. edge =αx (-ve)	0.077	6.422	9.63	5.582	8	50.27	106	0.000196	-1	146	4958.168	150.266	150.27	334.51	254	197.90	0.15	13.2	0.1246	0.187	0.3094	0.402162	3713511.34	489.4	10.41	25.8792	39.1
			2.743			Pos. at mid span =αx (+ve)	0.058	6.422	9.63	4.172	8	50.27	106	0.000196	-1	109	4996.986	111.447	111.45	451.02	280	179.52	0.14										
			2.743		Long	Neg. at con. edge =αy (-ve)	0.047	6.422	9.63	3.407	8	50.27	98	0.000212	-1	96	4624.554	98.337	98.34	511.15	280	179.52	0.14										
			2.743			Pos. at mid span =αy (+ve)	0.035	6.422	9.63	2.537	8	50.27	98	0.000212	-1	72	4650.063	72.828	72.83	690.19	280	179.52	0.14										
6	135	3.962	3.353	1.182	Short	Neg. at con. edge =αx (-ve)	0.059	6.422	9.63	6.359	8	50.27	106	0.000196	-1	166	4936.479	171.955	171.95	292.32	204	246.40	0.19	16.1	0.1523	0.232	0.346	0.44975	4601301.52	494.4	10.52	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.044	6.422	9.63	4.774	8	50.27	106	0.000196	-1	125	4980.475	127.959	127.96	392.83	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.422	9.63	5.089	8	50.27	98	0.000212	-1	144	4574.381	148.510	148.51	338.46	254	197.90	0.15										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.422	9.63	3.790	8	50.27	98	0.000212	-1	107	4613.230	109.662	109.66	458.37	280	179.52	0.14										
12	135	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.064	6.422	9.63	6.891	8	50.27	106	0.000196	-1	180	4921.540	186.894	186.89	268.95	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.048	6.422	9.63	5.188	8	50.27	106	0.000196	-1	136	4969.075	139.359	139.36	360.69	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.422	9.63	5.089	8	50.27	98	0.000212	-1	144	4574.381	148.510	148.51	338.46	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.422	9.63	3.790	8	50.27	98	0.000212	-1	107	4613.230	109.662	109.66	458.37	280	179.52	0.14										
14	135	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.064	6.422	9.63	6.891	8	50.27	106	0.000196	-1	180	4921.540	186.894	186.89	268.95	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.048	6.422	9.63	5.188	8	50.27	106	0.000196	-1	136	4969.075	139.359	139.36	360.69	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.422	9.63	5.089	8	50.27	98	0.000212	-1	144	4574.381	148.510	148.51	338.46	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.422	9.63	3.790	8	50.27	98	0.000212	-1	107	4613.230	109.662	109.66	458.37	280	179.52	0.14										
17	135	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.064	6.422	9.63	6.891	8	50.27	106	0.000196	-1	180	4921.540	186.894	186.89	268.95	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.048	6.422	9.63	5.188	8	50.27	106	0.000196	-1	136	4969.075	139.359	139.36	360.69	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.422	9.63	5.089	8	50.27	98	0.000212	-1	144	4574.381	148.510	148.51	338.46	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.422	9.63	3.790	8	50.27	98	0.000212	-1	107	4613.230	109.662	109.66	458.37	280	179.52	0.14										
28	135	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.064	6.422	9.63	6.891	8	50.27	106	0.000196	-1	180	4921.540	186.894	186.89	268.95	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.048	6.422	9.63	5.188	8	50.27	106	0.000196	-1	136	4969.075	139.359	139.36	360.69	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.047	6.422	9.63	5.089	8	50.27	98	0.000212	-1	144	4574.381	148.510	148.51	338.46	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.035	6.422	9.63	3.790	8	50.27	98	0.000212	-1	107	4613.230	109.662	109.66	458.37	280	179.52	0.14										

For Panel S2L (One long edge discontinuous)

Panel ID No.	D	Ly	Lx	ly/lx	Moment coefficient			Design load	Factored load (Wu)	Moment	Bar Dia.	Bar area	Effec. Depth (d)						Ast req	Spacing required	Spacing Provided	Actual Ast	Ast Per	Max. Shear force	Nominal Shear Stress	% tensile steel	Shear strength for M20	Shear strength for D = 135 mm	Moment of resistance		Obtained diameter	ratio of eff. span to eff. depth	constant value
	mm	m	m		Edge			KN/m	KN/m	KN-m	mm	mm^2	mm	a	b	c	1st value	2nd value	mm^2	mm	mm	mm^2	P%	V	τv (N/mm^2)		τc (N/mm^2)	τc' (N/mm^2)	M1	Ld	ϕ'	Lx/d	α β γ δ λ
9	135	5.182	4.267	1.214	Short	Neg. at con. edge =αx (-ve)	0.053	6.422	9.63	9.246	8	50.27	106	0.000196	-1	242	4854.176	254.258	254.26	197.69	204	246.40	0.19	20.6	0.1939	0.232	0.3516	0.45705	4601301.52	415	8.828	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.040	6.422	9.63	6.966	8	50.27	106	0.000196	-1	182	4919.419	189.014	189.01	265.93	254	197.90	0.15										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.037	6.422	9.63	6.490	8	50.27	98	0.000212	-1	183	4531.730	191.161	191.16	262.95	254	197.90	0.15										
			4.267			Pos. at mid span =αy (+ve)	0.028	6.422	9.63	4.911	8	50.27	98	0.000212	-1	139	4579.746	143.146	143.15	351.15	280	179.52	0.14										
10	135	4.267	3.962	1.077	Short	Neg. at con. edge =αx (-ve)	0.042	6.422	9.63	6.410	8	50.27	106	0.000196	-1	167	4935.050	173.384	173.38	289.91	254	197.90	0.15	19.1	0.18	0.187	0.3094	0.402162	3713511.34	377	8.018	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.032	6.422	9.63	4.817	8	50.27	106	0.000196	-1	126	4979.318	129.116	129.12	389.30	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.037	6.422	9.63	5.596	8	50.27	98	0.000212	-1	158	4559.052	163.840	163.84	306.80	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.028	6.422	9.63	4.235	8	50.27	98	0.000212	-1	120	4600.008	122.883	122.88	409.05	280	179.52	0.14										

11	135	4.267	3.962	1.077	Short	Neg. at con. edge =αx (-ve)	0.042	6.422	9.63	6.410	8	50.27	106	0.000196	-1	167	4935.050	173.384	173.38	289.91	254	197.90	0.15	19.1	0.18	0.187	0.3094	0.402162	3713511.34	377	8.018	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.032	6.422	9.63	4.817	8	50.27	106	0.000196	-1	126	4979.318	129.116	129.12	389.30	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.037	6.422	9.63	5.596	8	50.27	98	0.000212	-1	156	4559.052	163.840	163.84	306.80	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.028	6.422	9.63	4.235	8	50.27	98	0.000212	-1	120	4600.008	122.883	122.88	409.05	280	179.52	0.14										
15	135	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.056	6.422	9.63	6.025	8	50.27	106	0.000196	-1	157	4945.838	162.596	162.60	309.14	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.043	6.422	9.63	4.617	8	50.27	106	0.000196	-1	121	4984.804	123.630	123.63	406.58	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.037	6.422	9.63	4.007	8	50.27	98	0.000212	-1	113	4606.802	116.090	116.09	432.99	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.028	6.422	9.63	3.032	8	50.27	98	0.000212	-1	86	4635.585	87.306	87.31	575.74	280	179.52	0.14										
16	135	4.267	3.353	1.273	Short	Neg. at con. edge =αx (-ve)	0.056	6.422	9.63	6.025	8	50.27	106	0.000196	-1	157	4945.838	162.596	162.60	309.14	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.043	6.422	9.63	4.617	8	50.27	106	0.000196	-1	121	4984.804	123.630	123.63	406.58	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.037	6.422	9.63	4.007	8	50.27	98	0.000212	-1	113	4606.802	116.090	116.09	432.99	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.028	6.422	9.63	3.032	8	50.27	98	0.000212	-1	86	4635.585	87.306	87.31	575.74	280	179.52	0.14										
22	135	5.182	3.353	1.545	Short	Neg. at con. edge =αx (-ve)	0.069	6.422	9.63	7.452	8	50.27	106	0.000196	-1	195	4905.667	202.767	202.77	247.90	254	197.90	0.15	16.1	0.1523	0.187	0.3094	0.402162	3713511.34	422.9	8.997	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.052	6.422	9.63	5.680	8	50.27	106	0.000196	-1	148	4955.433	153.001	153.00	328.53	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.037	6.422	9.63	4.007	8	50.27	98	0.000212	-1	113	4606.802	116.090	116.09	432.99	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.028	6.422	9.63	3.032	8	50.27	98	0.000212	-1	86	4635.585	87.306	87.31	575.74	280	179.52	0.14										
24	135	3.962	3.353	1.182	Short	Neg. at con. edge =αx (-ve)	0.051	6.422	9.63	5.473	8	50.27	106	0.000196	-1	143	4961.172	147.261	147.26	341.33	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.038	6.422	9.63	4.105	8	50.27	106	0.000196	-1	107	4998.819	109.614	109.61	458.57	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.037	6.422	9.63	4.007	8	50.27	98	0.000212	-1	113	4606.802	116.090	116.09	432.99	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.028	6.422	9.63	3.032	8	50.27	98	0.000212	-1	86	4635.585	87.306	87.31	575.74	280	179.52	0.14										

For Panel S3 (Interior Panel)

Panel ID No.	D	Ly	Lx	ly/lx	Moment coefficient			esign loa	Factored load (Wu)	Moment	Bar Dia.	Bar area	Effec. Depth (d)						Ast req	Spacing required	Spacing Provided	Actual Ast	Ast Pe	Max. Shear force	Nominal Shear Stress	% tensile steel	Shear strength for M20	Shear strength for D = 135 mm	Moment of resistance		Obtained diameter	ratio of eff. span to eff. depth	constant value
	mm	m	m		Edge			KN/m	KN/m	KN-m	mm	mm^2	mm	a	b	c	1st value	2nd value	mm^2	mm	mm	mm^2	P%	V	τv (N/mm^2)		τc (N/mm^2)	τc' (N/mm^2)	M1	Ld	ϕ'	Lx/d	α β γ δ λ
25	135	4.267	3.962	1.077	Short	Neg. at con. edge =αx (-ve)	0.036	6.422	9.63	5.422	8	50.27	106	0.000196	-1	142	4962.611	145.823	145.82	344.70	254	197.90	0.15	19.1	0.18	0.187	0.3094	0.402162	3713511.34	377	8.018	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.027	6.422	9.63	4.095	8	50.27	106	0.000196	-1	107	4999.088	109.346	109.35	459.69	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.032	6.422	9.63	4.840	8	50.27	98	0.000212	-1	137	4581.899	140.993	140.99	356.51	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.024	6.422	9.63	3.630	8	50.27	98	0.000212	-1	103	4617.973	104.919	104.92	479.09	280	179.52	0.14										
26	135	4.267	3.962	1.077	Short	Neg. at con. edge =αx (-ve)	0.036	6.422	9.63	5.422	8	50.27	106	0.000196	-1	142	4962.611	145.823	145.82	344.70	254	197.90	0.15	19.1	0.18	0.187	0.3094	0.402162	3713511.34	377	8.018	37.3811	39.1
			3.962			Pos. at mid span =αx (+ve)	0.027	6.422	9.63	4.095	8	50.27	106	0.000196	-1	107	4999.088	109.346	109.35	459.69	280	179.52	0.14										
			3.962		Long	Neg. at con. edge =αy (-ve)	0.032	6.422	9.63	4.840	8	50.27	98	0.000212	-1	137	4581.899	140.993	140.99	356.51	280	179.52	0.14										
			3.962			Pos. at mid span =αy (+ve)	0.024	6.422	9.63	3.630	8	50.27	98	0.000212	-1	103	4617.973	104.919	104.92	479.09	280	179.52	0.14										
29	135	4.267	4.267	1.000	Short	Neg. at con. edge =αx (-ve)	0.032	6.422	9.63	5.613	8	50.27	106	0.000196	-1	147	4957.298	151.136	151.14	332.59	229	219.50	0.17	20.6	0.1939	0.207	0.3257	0.423358	4110034.72	384	8.167	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.024	6.422	9.63	4.210	8	50.27	106	0.000196	-1	110	4995.959	112.475	112.47	446.91	280	179.52	0.14										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.032	6.422	9.63	5.613	8	50.27	98	0.000212	-1	159	4558.535	164.356	164.36	305.83	229	219.50	0.17										
			4.267			Pos. at mid span =αy (+ve)	0.024	6.422	9.63	4.210	8	50.27	98	0.000212	-1	119	4600.755	122.136	122.14	411.55	280	179.52	0.14										
30	135	4.267	4.267	1.000	Short	Neg. at con. edge =αx (-ve)	0.032	6.422	9.63	5.613	8	50.27	106	0.000196	-1	147	4957.298	151.136	151.14	332.59	229	219.50	0.17	20.6	0.1939	0.207	0.3257	0.423358	4110034.72	384	8.167	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.024	6.422	9.63	4.210	8	50.27	106	0.000196	-1	110	4995.959	112.475	112.47	446.91	280	179.52	0.14										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.032	6.422	9.63	5.613	8	50.27	98	0.000212	-1	159	4558.535	164.356	164.36	305.83	280	179.52	0.14										
			4.267			Pos. at mid span =αy (+ve)	0.024	6.422	9.63	4.210	8	50.27	98	0.000212	-1	119	4600.755	122.136	122.14	411.55	280	179.52	0.14										
31	135	4.267	4.267	1.000	Short	Neg. at con. edge =αx (-ve)	0.032	6.422	9.63	5.613	8	50.27	106	0.000196	-1	147	4957.298	151.136	151.14	332.59	229	219.50	0.17	20.6	0.1939	0.207	0.3257	0.423358	4110034.72	384	8.167	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.024	6.422	9.63	4.210	8	50.27	106	0.000196	-1	110	4995.959	112.475	112.47	446.91	280	179.52	0.14										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.032	6.422	9.63	5.613	8	50.27	98	0.000212	-1	159	4558.535	164.356	164.36	305.83	280	179.52	0.14										
			4.267			Pos. at mid span =αy (+ve)	0.024	6.422	9.63	4.210	8	50.27	98	0.000212	-1	119	4600.755	122.136	122.14	411.55	280	179.52	0.14										
32	135	4.267	4.267	1.000	Short	Neg. at con. edge =αx (-ve)	0.032	6.422	9.63	5.613	8	50.27	106	0.000196	-1	147	4957.298	151.136	151.14	332.59	229	219.50	0.17	20.6	0.1939	0.207	0.3257	0.423358	4110034.72	384	8.167	40.2566	39.1
			4.267			Pos. at mid span =αx (+ve)	0.024	6.422	9.63	4.210	8	50.27	106	0.000196	-1	110	4995.959	112.475	112.47	446.91	280	179.52	0.14										
			4.267		Long	Neg. at con. edge =αy (-ve)	0.032	6.422	9.63	5.613	8	50.27	98	0.000212	-1	159	4558.535	164.356	164.36	305.83	280	179.52	0.14										
			4.267			Pos. at mid span =αy (+ve)	0.024	6.422	9.63	4.210	8	50.27	98	0.000212	-1	119	4600.755	122.136	122.14	411.55	280	179.52	0.14										

For Panel S4s (One short edge continuous i.e. three edges discontinuous)

Panel ID No.	D	Ly	Lx	ly/lx	Moment coefficient			esign lo	Factored load (Wu)	Moment	Bar Dia.	Bar area	Effec. Depth (d)						Ast req	Spacing required	Spacing Provided	Actual Ast	Ast Pe	Max. Shear force	Nominal Shear Stress	% tensile steel	Shear strength for M20	Shear strength for D = 135 mm	Moment of resistance		Obtained diameter	ratio of eff. span to eff. depth	constant value
	mm	m	m		Edge			KN/m	KN/m	KN-m	mm	mm^2	mm	a	b	c	1st value	2nd value	mm^2	mm	mm	mm^2	P%	V	τv (N/mm^2)		τc (N/mm^2)	τc' (N/mm^2)	M1	Ld	φ'	Lx/d	α β γ δ λ
3	135	3.353	3.353	1.000	Short	Neg. at con. edge =αx (-ve)	0	6.422	9.63	0.000	8	50.27	106	0.000196	-1	0	5108.434	0.000	162.00	310.28	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.043	6.422	9.63	4.656	8	50.27	106	0.000196	-1	122	4983.722	124.711	124.71	403.05	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.057	6.422	9.63	6.172	8	50.27	98	0.000212	-1	174	4541.478	181.413	181.41	277.08	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.043	6.422	9.63	4.656	8	50.27	98	0.000212	-1	132	4587.406	135.485	135.49	371.00	280	179.52	0.14										
4	135	4.572	3.353	1.364	Short	Neg. at con. edge =αx (-ve)	0	6.422	9.63	0.000	8	50.27	106	0.000196	-1	0	5108.434	0.000	162.00	310.28	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.069	6.422	9.63	7.452	8	50.27	106	0.000196	-1	195	4905.667	202.767	202.77	247.90	254	197.90	0.15										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.057	6.422	9.63	6.172	8	50.27	98	0.000212	-1	174	4541.478	181.413	181.41	277.08	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.043	6.422	9.63	4.656	8	50.27	98	0.000212	-1	132	4587.406	135.485	135.49	371.00	280	179.52	0.14										
13	135	3.962	3.353	1.182	Short	Neg. at con. edge =αx (-ve)	0	6.422	9.63	0.000	8	50.27	106	0.000196	-1	0	5108.434	0.000	162.00	310.28	280	179.52	0.14	16.1	0.1523	0.169	0.2955	0.384132	3374863.87	395.7	8.417	31.6302	39.1
			3.353			Pos. at mid span =αx (+ve)	0.058	6.422	9.63	6.231	8	50.27	106	0.000196	-1	163	4940.062	168.372	168.37	298.54	280	179.52	0.14										
			3.353		Long	Neg. at con. edge =αy (-ve)	0.057	6.422	9.63	6.172	8	50.27	98	0.000212	-1	174	4541.478	181.413	181.41	277.08	280	179.52	0.14										
			3.353			Pos. at mid span =αy (+ve)	0.043	6.422	9.63	4.656	8	50.27	98	0.000212	-1	132	4587.406	135.485	135.49	371.00	280	179.52	0.14										

4.2 DESIGN OF BEAM

Beam is a reinforced concrete flexural member. It carry load by bending action. The beam may be rectangle, L and T section consisting of singly and doubly reinforcement. Design of the beam element requires the determination of the cross sectional dimensions and reinforcement details. It should satisfy both serviceability and strength requirements.

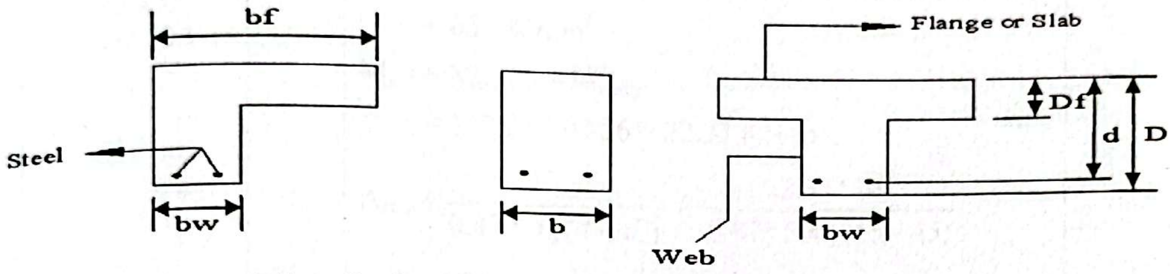


Fig. L-beam, rectangular beam and T- beam

Material characteristics

Concrete Grade = M25 (f_{ck} = 25 N/mm^2)

Steel Grade = Fe500

(f_y = 500 N/mm^2)

Beam Section

Width of Beam (b_w) = 300 mm

Overall depth (D) = 400 mm

Effective cover (d') = 45 mm

Effective depth (d) = 355 mm

Depth of flange (D_f) = 135 mm (Ground floor)

Sample Calculation

Beam No. B15(239)

Reference	Step	Calculation	Remarks
IS 456-2000 Annex G Clause 38.1	1.	**Design of beam at support (Rectangular beam)** b_w = 300 mm d = 355 mm **Limiting moment capacity of the Rectangular Beam** $M_{u,lim} = 0.133 f_{ck} bd^2$ (for Fe500) $= 0.133*25*300*355^2$ = 100567950 N-mm = 100.56 KN-m $M_{u,\,given}$ = 122.3 KN-m $M_{u,lim} < M_{u,given}$	

		Hence, doubly reinforced beam	
IS 456-2000 Pg. 70 (Clause 38.1)	2.	**Balanced Depth of Neutral Axis** $(X_{u,lim}) = 0.456d = 0.456*355 = 161.88mm$	
IS 456-2000 Annex G Clause 38.1 SP 16 Clause 2.3.2	3.	**Calculation of tension steel reinforcement** $A_{st1} = \frac{M_{u,lim}}{0.87*f_y(d-0.416x_{u,lim})}$ 100567950=0.87*500*Ast*d(1-Ast*500/300*355*25) $= 651.46mm^2$ $M_{u,2} = M_{u,given} - M_{u,lim}$ $= 122.23\text{-}100.56 = 22.33$ KN-m $A_{st2} = \frac{M_{u,2}}{0.87*f_y(d-d')} = \frac{22.33*10^6}{0.87*500(355-45)}$ $= 165.6\ mm^2$ Total tension reinforcement $A_{st} = A_{st1} + A_{st2}$ $= 165.6+654.5$ $= 817.1\ mm^2$	
SP 16 Clause 2.3.2 SP 16 Table F	4.	**Calculation of compression steel reinforcement** $A_{sc} = \frac{0.87*f_y*A_{st2}}{(f_{sc}-f_{cc})}$ Where, from table For d/d' = 45/355 = 0.13 $f_{sc} = 400$ And $f_{cc} = 0.446f_{ck} = 0.446*25 = 11.15$ $\therefore A_{sc} = \frac{0.87*500_y*165.6}{(400-11.15)} = 185.25\ mm^2$	
IS 456-2000 Clause 26.5.1.1.a	5.	**Check for Minimum Reinforcement** $A_{st,min} = (0.85*b_w*d)/f_y$ $= (0.85*300*355)/500$ $= 181.05\ mm^2 < A_{st}\ (817.1\ mm^2)$ **O.K.**	
IS 456-2000 Clause 26.5.1.1.b	6.	**Check for Maximum Reinforcement** $A_{st,max} = 0.04*b_w*D = 0.04*230*400$ $= 4140\ mm^2 > Ast\ (= 817.1\ mm^2)$ **O.K.** Now, Provide tension steel = 4 Nos. 12 mm ϕ bars and 2 Nos. 16 mm ϕ bars Hence, actual steel area provided = $854.4\ mm^2$	

		Design of beam at mid section (T-beam design)	
	7.	**Calculation of effective span (l_{eff})** We have, c/c span of beam, L = 4140 mm From code, for continuous beam, Clear span = 4140 – 400 = 3740 mm	
IS 456-2000 Clause 22.2.b		Since, Support width = 400 mm > [1/12*clear span =1/12*3740 = 311.67 mm or 600 mm whichever is less] Then, Effective span (l_{eff}) = clear span = 3740 mm Hence, Distance between zero moments, $l_o = 0.7*l_{eff}$ = 0.7*3740 = 2618 mm	
IS 456-2000 Clause 23.1.2	8.	**Calculation of flange width (b_f)** Depth of flange (D_f) = Overall depth of slab = 130 mm $\therefore b_f = l_o/6 + b_w + 6D_f$ = 2618/6 + 300 + 6*130 = 1516.33 mm	
IS 456-2000 Annex G.2.2.1	9.	**Calculation of Limiting Moment** D_f/d = 130/355 = 0.366 > 0.2 $M_{u,lim} = 0.36f_{ck}*x_{u,l}*b_w*(d-0.416x_{u,l})+0.446f_{ck}(b_f-b_w)y_f*(d-y_f/2)$ Where, yf = (0.15xu,l + 0.65Df) ≤ D_f = (0.15*161.88 + 0.65*130) = 108.78 mm ≤ D_f (=130 mm) Mu,lim = 0.36*25*161.88*300(355 – 0.416*161.88) + 0.446*25*(1516.33-300)*108.78*(355-108.78/2) = 569202259.8 N-mm = 569.2 KN-m Since, $M_{u,given}$ = 116.6 KN-m < $M_{u,lim}$ = 569.2 KN-m Hence, Singly reinforced section	
IS 456-2000 Annex G	10.	**Calculation of Actual Depth of Neutral Axis** $M_u = 0.36f_{ck}*x_u*b_f(d-0.416*x_u)$ $116.6*10^6 = 0.36*25*x_u*1516.33*(355 - 0.416*x_u)$ $\therefore x_u$ =841.5 mm > D_f (= 135 mm) Hence, Neutral Axis lies in the flange	
	11.	**Calculation of Tension Steel Reinforcement** $M_u = 0.87f_yA_{st}(d – 0.416x_u)$ $116.6*10^6 = 0.87*500*A_{st}(355 – 0.416*841.5)$ $\therefore$ Ast = 54304.3 mm^2 **Check for Minimum Reinforcement**	

IS 456-2000 Annex G IS 456-2000 Clause 26.5.1.1.a	12. 13.	$A_{st,min} = (0.85*b_w*d)/f_y = (0.85*300*355)/500$ $= 181.05\ mm^2 < A_{st}\ (=54304.3\ mm^2)$ Hence, safe So, Adopt Minimum steel area, $A_{st} = 181.05\ mm^2$ **Check for Maximum Reinforcement** $A_{st,max} = 0.04*b_w*D = 0.04*300*400$ $= 4800mm^2 > A_{st}\ (= 181.05mm^2)$ **So, O.K.**	
IS 456-2000 Clause 26.5.1.1.a IS 456-2000 Clause 40.1 IS 456-2000 Table 19 IS 456-2000 Clause 40.4.c IS 456-2000 Clause 40.4.a (pg.73) IS 456-2000	14. 15.	Now, Provide tension steel = 1 Nos. 16 mm ϕ bars $\therefore$ Actual steel area provided =201.06 mm^2 **Design of Shear Reinforcement** At support Shear force, $V_u = 92.7$ KN Nominal shear stress, $\tau_v = V_u/bd$ $= 92.78*10\^3/(300*355)$ $= 0.87\ N/mm^2$ Ast provided, 201.06 mm^2 Percentage of steel = $100A_s/bd$ $= (100*201.06)/(300*355)$ $= 0.19\ \%$ For M25 concrete and % of steel, $\tau_c = 0.325\ N/mm^2$ For M20 concrete, $\tau_{c,max} = 3.1$ N/mm2 Since, $\tau_{c,max} = 3.1\ N/mm^2 > \tau_v\ (= 0.87N/mm^2) > \tau\ (=0.325\ N/mm^2)$ **So,** Design of Shear reinforcement is required Providing 8 mm dia. Bars as 2-legged vertical stirrup Hence, Area of stirrups, $A_{sv} = 2*\pi*8^2/4 = 100.53\ mm^2$ Shear strength, $V_{us} = V_u - \tau_c*b_w*d$ $= (92.7*1000 - 0.325*300*355)$ $= 58087.5$ N And, Spacing of stirrups, $S_v = (0.87*f_y*A_{sv}*d)/V_{us}$ $= (0.87*500*100.53*355)/58087.5$ $= 267.25mm \approx 270$ mm c/c **Check for Maximum spacing** The maximum spacing of shear reinforcement along the axis of member shall not exceed following a) $0.75*d = 0.75*405 = 307.75$ mm b) 300 mm (Whichever smaller) Since, $S_v = 270$ mm c/c < (300 mm) **O.K.**	

Clause 26.5.1.5

16. Check for Development Length

$A_{st} = 201.06\ mm^2$

IS 456-2000 Annex G

$$M_1 = 0.87*f_y*A_{st}\left(d - \frac{f_y * A_{st}}{b_w * f_{ck}}\right)$$

$$= 0.87*500*201.06\left(355 - \frac{500*201.06}{300*25}\right)$$

$$= 29.87*10^6$$

$$= 29.87\ KN\text{-}m$$

$V_u = 92.7\ KN$

Condition to be satisfied:

$L_d \leq 1.3M_1/V + L_o$

$$L_d = \frac{\phi\sigma_s}{4\tau_{bd}} = \frac{0.87*f_y\phi}{4\tau_{bd}} = \frac{0.87*500*12}{4*1.2*1.6} = 679.7\ mm$$

IS 456-2000 Clause 26.2.1

$1.3M_1/V_u + L_o = (1.3*29.87*10^6)/(92.7*10^3) + d$

(d=355mm)

IS 456-2000 Clause 26.2.3.3.c

$= 418.88 + 355 = 773.88mm$

So, L_d (= 679.7mm) < $(1.3M_1/V_u + L_o)$(=773.88mm)

So, O.K.

17. Check for Deflection

Condition to be satisfied

$l_{eff}/d \leq \alpha\beta\gamma\delta\lambda$

$l_{eff}/d = 2618/355 = 7.37$

IS 456-2000 Clause 23.2 (fig. 4)

$\alpha = 26$ for continuous beam

$\beta = 1$ for span less than 10 m

$$\gamma = 0.55 + \frac{477 - f_s}{120\left(0.9 + \frac{M}{b_w d^2}\right)} \leq 2$$

BS 8110-1985 Clause 3.4.5.6

$$\text{where, } f_s = 0.58*f_y*\frac{A_s(required)}{A_s(provided)}*[illegible]$$

$$= 0.58*500*181.05/201.06*[illegible]$$

$$= 260.43$$

(A.K. Jain Pg. 187)

$$\text{So, } \gamma = 0.55 + \frac{477 - 127.224_s}{120\left(0.9 + \frac{17.404*10^6}{230*405^2}\right)} = 2.69$$

Hence, Adopt Max. $\gamma = 2$

$\delta = 1$

$\lambda = 0.83$

$\therefore \alpha\beta\gamma\delta\lambda = 26*1*2*1*0.83 = 43.16$

Since, $l_{eff}/d = 7.37 < 43.16$ (= $\alpha\beta\gamma\delta\lambda$) **So, O.K.**

(b_w) = 300 mm
(D) = 400 mm
Clear cover 25 mm
Eff. Cover 45 mm
(d) = 355 mm
(D_f) = 130 mm
f_y = 500 N/mm²
f_{ck} = 25 N/mm²
$(x_{u,l})$ = 161.9 mm
$(M_{u,l})$ = 100.6 KN-m (For rectangular beam)

6 th floor

Beam ID No.	Span (mm)	Eff. Span (L_{eff}) mm	Dist. Bet" zero moments (l_0) mm	Eff. Flange width (b_f) mm	Df/d	Yf	Mu,lim for T-beam or L beam (KN-m)	Beam type	location	Design moment M_u (KN-m) + ve	Design moment M_u (KN-m) - ve	Type of design + ve	Type of design - ve	xu1+ (N.A lies in flange)	xu2+ (N.A lies in web)	xu1- (N.A lies in flange)	xu2- (N.A lies in web)	for + ve: Ast1	for + ve: Ast2	for + ve: Asc	for - ve: Ast1	for - ve: Ast2	for - ve: Asc	Actual depth of N.A. (mm) + ve	Actual depth of N.A. (mm) - ve
10	4140	3867.5	2707.3	915.6	0.37	108.78	280.15	Rectangle	Left end	7.9	43.65	Singly	Singly	3.8804237	-183.101	3.33	-184	51.65626471	0	0	360.7466	0	0	6.2393	47.7619797
								L - beam	Mid	11.3	9.71	Singly	Singly					73.50894017	0	0	76.05411	0	0	11.836	10.15002705
								Rectangle	Right end	10.82	41.45	Singly	Singly					71.0088283	0	0	341.4835	0	0	11.326	45.21134471
15	4140	3690	2583	905.25	0.37	108.78	277.13	Rectangle	Left end	6.86	43.65	Singly	Singly	3.36704782	-181.511	3.12	-182	44.79795981	0	0	360.7291	0	0	7.1454	47.75965313
								L - beam	Mid	9.7	8.989	Singly	Singly					75.97889593	0	0	70.38921	0	0	10.139	9.367854234
								Rectangle	Right end	9.77	41.48	Singly	Singly					77.14860492	0	0	341.7453	0	0	10.214	45.24601118
39	3530	3080	2156	869.67	0.37	108.78	266.75	Rectangle	Left end	22.5	20.78	Singly	Singly	0.05038833	-179.006	0.37	-178	180.6046996	0	0	166.4217	0	0	23.91	22.03267459
								L - beam	Mid	0.14	1.03	Singly	Singly					1.092340353	0	0	8.039523	0	0	0.1446	1.065181469
								Rectangle	Right end	23.89	34.31	Singly	Singly					192.1150259	0	0	279.8345	0	0	25.434	37.04658915
40	3530	3080	2156	869.67	0.37	108.78	266.75	Rectangle	Left end	22.21	21.26	Singly	Singly	0.12238199	-178.859	0.47	-178	178.2067514	0	0	170.3731	0	0	23.593	22.5558279
								L - beam	Mid	0.34	1.31	Singly	Singly					2.653050408	0	0	10.22623	0	0	0.3513	1.355207261
								Rectangle	Right end	23.58	34.61	Singly	Singly					189.5441901	0	0	282.3988	0	0	25.094	37.38811135

Beam ID No.	location	location	Area of steel (mm²) + ve	Area of steel (mm²) - ve	Final steel reinforcement (mm²)	Minimum steel required	Check for min. tension steel	steel provided, mm²	Maximum steel required	Steel dia. provided	No. of bars	Steel dia. provided	No. of bars	Actual steel provided	Shear force V, KN	Nominal shear stress τ_v (N/mm²)	Per. of steel P_t, %	Dia. of stirrups mm	Area of stirrups A_{sv} (mm²)	Spacing of stirrups S_v (mm)	Spacing S_v (mm)	From ductility design S_v (mm)	Spacing provided S_v (mm)
10	Left end	top	0	360.746624	360.75	181.05	O.K.	360.746624	4800	12	3	0	0	339.29	61.45	0.577	0.32	8	100.53	675.86	280	89.5	89.5
		bottom	51.656	0	51.656	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Mid	top	0	76.0541126	76.054	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	40.12	0.377	0.21	8	100.53	2691.1	280	179	179
		bottom	73.509	0	73.509	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Right end	top	0	341.483486	341.48	181.05	O.K.	341.483486	4800	12	3	0	0	339.29	6.09E+01	0.572	0.32	8	100.53	698.87	280	204	204
		bottom	71.009	0	71.009	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
15	Left end	top	0	360.729053	360.73	181.05	O.K.	360.729053	4800	12	3	0	0	339.29	61.43	0.577	0.32	8	100.53	676.57	280	89.5	89.5
		bottom	44.798	0	44.798	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Mid	top	0	70.3892081	70.389	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	40.13	0.377	0.21	8	100.53	2884.6	280	179	179
		bottom	75.979	0	75.979	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Right end	top	0	341.745299	341.75	181.05	O.K.	341.745299	4800	12	3	0	0	339.29	60.88	0.572	0.32	8	100.53	696.69	280	89.5	89.5
		bottom	77.149	0	77.149	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
39	Left end	top	0	166.421715	166.42	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	58.9	0.553	0.21	8	100.53	554.52	280	89.5	89.5
		bottom	180.6	0	180.6	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Mid	top	0	8.0395233	8.0395	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	50	0.469	0.21	8	100.53	898.75	280	179	179
		bottom	1.0923	0	1.0923	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Right end	top	0	279.834532	279.83	181.05	O.K.	279.834532	4800	12	2	0	0	226.19	58.9	0.553	0.21	8	100.53	554.52	280	89.5	89.5
		bottom	192.12	0	192.12	181.05	O.K.	192.115026	4800	12	1	10	1	191.84									
40	Left end	top	0	170.373128	170.37	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	58.98	0.554	0.21	8	100.53	552.62	280	89.5	89.5
		bottom	178.21	0	178.21	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Mid	top	0	10.2262341	10.226	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	50.084	0.47	0.21	8	100.53	893.51	280	179	179
		bottom	2.6531	0	2.6531	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Right end	top	0	282.398806	282.4	181.05	O.K.	282.398806	4800	12	2	0	0	226.19	58.99	0.554	0.21	8	100.53	552.38	280	89.5	89.5
		bottom	189.54	0	189.54	181.05	O.K.	189.54419	4800	12	2	0	0	226.19									

5 th floor

Beam ID No.	Span (mm)	Eff. Span (L_{eff}) mm	Dist. Bet" zero moments (l_0) mm	Eff. Flange width (b_f) mm	Df/d	Yf	Mu,lim for T-beam or L beam (KN-m)	Beam type	location	Design moment M_u (KN-m) + ve	Design moment M_u (KN-m) - ve	Type of design + ve	Type of design - ve	xu1+ (N.A lies in flange)	xu2+ (N.A lies in web)	xu1- (N.A lies in flange)	xu2- (N.A lies in web)	for + ve: Ast1	for + ve: Ast2	for + ve: Asc	for - ve: Ast1	for - ve: Ast2	for - ve: Asc	Actual depth of N.A. (mm) + ve	Actual depth of N.A. (mm) - ve
1	4140	3690	2583	905.25	0.37	108.78	277.13	Rectangle	Left end	6.72	47.45	Singly	Singly	2.52104107	-183.287	1.46	-185	52.86276106	0	0	394.3284	0	0	6.9983	52.20861433
								L - beam	Mid	7.27	4.26	Singly	Singly					56.88836633	0	0	33.29396	0	0	7.5763	4.422960777
								Rectangle	Right end	13.15	47.9	Singly	Singly					104.2830166	0	0	398.296	0	0	13.806	52.73398226
2	1905	1455	1018.5	774.88	0.37	108.78	239.1	Rectangle	Left end	3.59	4.17	Singly	Singly	1.14463453	-150.979	1.23	-151	28.13184681	0	0	32.7001	0	0	3.7243	4.32903823
								L - beam	Mid	2.83	3.05	Singly	Singly					22.10923171	0	0	23.83046	0	0	2.9331	3.161969544
								Rectangle	Right end	6.51	6.38	Singly	Singly					51.19746359	0	0	50.167	0	0	6.7779	6.6414422
3	4140	3690	2583	1510.5	0.37	108.78	453.68	Rectangle	Left end	5.63	47.56	Singly	Singly	1.75244188	-326.642	1.3	-328	44.22856219	0	0	395.3064	0	0	5.8553	52.33612076
								T - beam	Mid	8.44	6.28	Singly	Singly					65.98413282	0	0	49.07132	0	0	8.8084	6.536533176
								Rectangle	Right end	8.84	48.31	Singly	Singly					69.72359102	0	0	401.9839	0	0	9.2305	53.22231826

Beam ID No.	location	location	Area of steel (mm²) + ve	Area of steel (mm²) - ve	Final steel reinforcement (mm²)	Minimum steel required	Check for min. tension steel	steel provided, mm²	Maximum steel required	Steel dia. provided	No. of bars	Steel dia. provided	No. of bars	Actual steel provided	Shear force V, KN	Nominal shear stress τ_v (N/mm²)	Per. of steel P_t, %	Dia. of stirrups mm	Area of stirrups A_{sv} (mm²)	Spacing of stirrups S_v (mm)	Spacing S_v (mm)	From ductility design S_v (mm)	Spacing provided S_v (mm)
1	Left end	top	0	394.328376	394.33	181.05	O.K.	394.328376	4800	12	3	0	0	339.29	60.62	0.569	0.32	8	100.53	706.62	280	89.5	89.5
		bottom	52.863	0	52.863	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Mid	top	0	33.293958	33.294	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	46.98	0.441	0.21	8	100.53	1140.6	280	179	179
		bottom	56.888	0	56.888	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Right end	top	0	398.296	398.3	181.05	O.K.	398.296	4800	12	2	12	1	339.29	62.69	0.589	0.32	8	100.53	634.58	280	89.5	89.5
		bottom	104.28	0	104.28	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
2	Left end	top	0	32.7001009	32.7	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	80.19	0.753	0.21	8	100.53	289.38	280	89.5	89.5
		bottom	28.132	0	28.132	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Mid	top	0	23.8304624	23.83	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	78.86	0.722	0.21	8	100.53	312.77	280	179	179
		bottom	22.109	0	22.109	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Right end	top	0	50.1670032	50.167	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	82.016	0.77	0.21	8	100.53	277.98	280	89.5	89.5
		bottom	51.197	0	51.197	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
3	Left end	top	0	395.30642	395.31	181.05	O.K.	395.30642	4800	12	2	12	1	339.29	62.63	0.588	0.32	8	100.53	636.46	280	89.5	89.5
		bottom	44.229	0	44.229	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Mid	top	0	49.0713159	49.071	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	45.87	0.431	0.21	8	100.53	1262.4	280	179	179
		bottom	65.984	0	65.984	181.05	Not O.K.	181.05	4800	12	4	0	0	452.39									
	Right end	top	0	401.983948	401.98	181.05	O.K.	401.983948	4800	12	2	12	1	339.29	61.36	0.576	0.32	8	100.53	679.06	280	89.5	89.5
		bottom	69.724	0	69.724	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									

1st floor

Beam ID No.	Span (mm)	Eff. Span (L_{eff}) mm	Dist. Bet" zero moments (l_0) mm	Eff. Flange width (b_f) mm	Df/d	Yf	Mu,lim for T-beam or L-beam (KN-m)	Beam type	location	Design moment M_u (KN-m) + ve	Design moment M_u (KN-m) - ve	Type of design + ve	Type of design - ve	xu1+ (N.A lies in flange)	xu2+ (N.A lies in web)	xu1- (N.A lies in flange)	xu2- (N.A lies in web)	for + ve: Ast1	for + ve: Ast2	for + ve: Asc	for - ve: Ast1	for - ve: Ast2	for - ve: Asc	Actual depth of N.A. (mm) + ve	Actual depth of N.A. (mm) - ve
1	4140	3690	2583	1510.5	0.37	108.78	453.68	Rectangle	Left end	78.35	115.8	Singly	Doubly	12.6746595	-295.371	8.46	-306	683.8451582	0	0	968.3133	135.733591	143.4493838	90.548	161.88
								T - beam	Mid	60.26	40.4	Singly	Singly					477.2348948	0	0	318.3538	0	0	67.605	44
								Rectangle	Right end	65.3	105.9	Singly	Doubly					557.732471	0	0	968.3133	47.4605876	50.15849065	73.847	161.88
2	1905	1455	1018.5	1249.8	0.37	108.78	377.62	Rectangle	Left end	88.8	101.9	Singly	Doubly	0.25677962	-272.926	0.83	-271	789.543051	0	0	968.3133	11.8118749	12.48332236	104.55	161.88
								T - beam	Mid	1.025	3.3	Singly	Singly					7.999426693	0	0	25.77149	0	0	1.06	3.422198513
								Rectangle	Right end	87.23	104.4	Singly	Doubly					773.3717003	0	0	968.3133	34.4161965	36.37258947	102.41	161.88
3	4140	3690	2583	1510.5	0.37	108.78	453.68	Rectangle	Left end	65.31	108.1	Singly	Doubly	12.7750414	-295.081	8.39	-308	557.8268231	0	0	968.3133	49.4261808	52.23581823	73.859	161.88
								T - beam	Mid	60.73	40.1	Singly	Singly					481.0145404	0	0	315.9661	0	0	68.182	43.65460841
								Rectangle	Right end	78.75	115.1	Singly	Doubly					687.8098385	0	0	968.3133	129.836811	137.2174008	91.073	161.88
4	4140	3690	2583	1510.5	0.37	108.78	453.68	Rectangle	Left end	59.46	101.4	Singly	Doubly	12.3416515	-296.332	1.35	-328	503.1901829	0	0	968.3133	7.61265306	8.045395273	66.624	161.88
								T - beam	Mid	58.7	6.5	Singly	Singly					464.6962522	0	0	50.7931	0	0	65.695	6.787367682
								Rectangle	Right end	73.52	110.1	Singly	Doubly					636.4516748	0	0	968.3133	85.342929	90.19425846	84.271	161.88
5	1905	1455	1018.5	1249.8	0.37	108.78	377.62	Rectangle	Left end	80.17	96.42	Singly	Singly	0.7670399	-271.631	1.18	-271	701.9348347	0	0	869.6102	0	0	92.944	115.1521272
								T - beam	Mid	3.06	4.7	Singly	Singly					23.89550765	0	0	36.71998	0	0	3.1724	4.882439217
								Rectangle	Right end	79.98	96.63	Singly	Singly					700.0402842	0	0	870.786	0	0	92.693	115.3078694
6	4140	3690	2583	1510.5	0.37	108.78	453.68	Rectangle	Left end	73.87	112.2	Singly	Doubly	12.4014025	-296.16	1.22	-328	639.8567437	0	0	968.3133	103.479993	109.3623265	84.722	161.88
								T - beam	Mid	58.96	5.9	Singly	Singly					466.9460356	0	0	46.09776	0	0	66.037	6.138117948
								Rectangle	Right end	59.05	101.6	Singly	Doubly					499.4020677	0	0	968.3133	9.57824624	10.12272285	66.122	161.88
7	4140	3690	2583	1510.5	0.37	108.78	453.68	Rectangle	Left end	71.39	111.5	Singly	Doubly	12.1668491	-296.831	1.76	-327	615.8253402	0	0	968.3133	97.672559	103.2247878	81.54	161.88
								T - beam	Mid	57.89	8.5	Singly	Singly					458.1897761	0	0	66.45418	0	0	64.707	8.871722368
								Rectangle	Right end	56.1	99.9	Singly	Singly					472.2999857	0	0	907.0978	0	0	62.533	120.1176697
8	1905	1455	1018.5	1249.8	0.37	108.78	377.62	Rectangle	Left end	77.15	94.3	Singly	Singly	0.87744684	-271.351	1.1	-271	671.9881195	0	0	847.0631	0	0	88.978	112.1658488
								T - beam	Mid	3.5	4.4	Singly	Singly								34.37311		0	3.6306	4.569104123

Beam ID No.	location	location	Area of steel (mm²) + ve	Area of steel (mm²) - ve	Final steel reinforcement (mm²)	Minimum steel required	Check for min. tension steel	steel provided, mm²	Maximum steel required	Steel dia. provided	No. of bars	Steel dia. provided	No. of bars	Actual steel provided	Shear force V, KN	Nominal shear stress τ_v (N/mm²)	Per. of steel P_t, %	Dia. of stirrups mm	Area of stirrups A_{sv} (mm²)	Spacing of stirrups S_v (mm)	Spacing S_v (mm)	From ductility design S_v (mm)	Spacing provided S_v (mm)
1	Left end	top	0	1104.04692	1104	181.05	O.K.	1104.04692	4800	16	2	16	3	1005.3	108.66	1.02	0.94	8	100.53	294.69	280	89.5	89.5
		bottom	683.85	143.449384	683.85	181.05	O.K.	683.845158	4800	16	2	12	2	628.32									
	Mid	top	0	318.353803	318.35	181.05	O.K.	318.353803	4800	12	2	0	0	226.19	87.55	0.822	0.21	8	100.53	248.33	229	179	179
		bottom	477.23	0	477.23	181.05	O.K.	477.234895	4800	16	2	0	0	402.12									
	Right end	top	0	1015.77392	1015.8	181.05	O.K.	1015.77392	4800	16	2	16	3	1005.3	111.19	1.044	0.94	8	100.53	278.57	280	89.5	89.5
		bottom	557.73	50.1584907	557.73	181.05	O.K.	557.732471	4800	16	2	12	1	515.22									
2	Left end	top	0	980.125209	980.13	181.05	O.K.	980.125209	4800	16	3	12	3	942.48	193.49	1.817	0.88	8	100.53	99.087	102	89.5	89.5
		bottom	789.54	12.4833224	789.54	181.05	O.K.	789.543051	4800	12	4	12	3	791.68									
	Mid	top	0	25.7714853	25.771	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	186.38	1.75	0.21	8	100.53	85.494	102	179	102
		bottom	7.9994	0	7.9994	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Right end	top	0	1002.72953	1002.7	181.05	O.K.	1002.72953	4800	12	4	12	4	904.78	198.24	1.843	0.85	8	100.53	98.33	102	89.5	89.5
		bottom	773.37	36.3725895	773.37	181.05	O.K.	773.3717	4800	12	4	12	3	791.68									
3	Left end	top	0	1017.73951	1017.7	181.05	O.K.	1017.73951	4800	12	4	12	5	1017.9	111.54	1.047	0.98	8	100.53	278.23	280	89.5	89.5
		bottom	557.83	52.2358182	557.83	181.05	O.K.	557.826823	4800	12	4	12	1	565.49									
	Mid	top	0	315.966075	315.97	181.05	O.K.	315.966075	4800	12	2	0	0	226.19	87.98	0.826	0.21	8	100.53	246.39	229	179	179
		bottom	481.01	0	481.01	181.05	O.K.	481.01454	4800	12	2	12	2	452.39									
	Right end	top	0	1098.15015	1098.2	181.05	O.K.	1098.15015	4800	12	4	12	5	1017.9	108.98	1.022	0.98	8	100.53	295.32	280	89.5	89.5
		bottom	687.81	137.217401	687.81	181.05	O.K.	687.809836	4800	16	2	12	2	628.32									
4	Left end	top	0	975.925987	975.93	181.05	O.K.	975.925987	4800	12	4	12	4	904.78	113.14	1.062	0.85	8	100.53	254.33	254	89.5	89.5
		bottom	503.19	8.04539527	503.19	181.05	O.K.	503.190183	4800	12	2	12	2	452.39									
	Mid	top	0	50.7931007	50.793	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	91.13	0.856	0.21	8	100.53	232.31	229	179	179
		bottom	464.7	0	464.7	181.05	O.K.	464.696252	4800	12	4	0	0	452.39									
	Right end	top	0	1053.65626	1053.7	181.05	O.K.	1053.65626	4800	16	3	12	4	1055.6	112.34	1.055	0.99	8	100.53	279.6	280	89.5	89.5
		bottom	636.45	90.1942585	636.45	181.05	O.K.	636.451675	4800	12	4	12	1	565.49									
5	Left end	top	0	869.610163	869.61	181.05	O.K.	869.610163	4800	20	2	12	2	854.51	173.89	1.631	0.8	8	100.53	114.51	102	89.5	89.5
		bottom	701.93	0	701.93	181.05	O.K.	701.934835	4800	16	2	16	1	603.19									
	Mid	top	0	36.7199799	36.72	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	168.79	1.585	0.21	8	100.53	98.78	102	179	102
		bottom	23.896	0	23.896	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
	Right end	top	0	870.785963	870.79	181.05	O.K.	870.785963	4800	16	2	12	4	854.51	173.91	1.633	0.8	8	100.53	114.29	102	89.5	89.5
		bottom	700.04	0	700.04	181.05	O.K.	700.040284	4800	16	2	20	1	716.28									
6	Left end	top	0	1071.79333	1071.8	181.05	O.K.	1071.79333	4800	20	2	16	1	1030.4	115.67	1.086	0.97	8	100.53	256.93	254	89.5	89.5
		bottom	639.86	109.362327	639.86	181.05	O.K.	639.856744	4800	16	2	16	1	603.19									
	Mid	top	0	46.0977599	46.098	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	90.42	0.849	0.21	8	100.53	235.32	229	179	179
		bottom	466.95	0	466.95	181.05	O.K.	466.946036	4800	16	2	0	0	402.12									
	Right end	top	0	977.89158	977.89	181.05	O.K.	977.89158	4800	16	2	16	2	804.25	114	1.07	0.76	8	100.53	237.7	229	89.5	89.5
		bottom	499.4	10.1227228	499.4	181.05	O.K.	499.402068	4800	16	2	0	0	402.12									
7	Left end	top	0	1065.98589	1066	181.05	O.K.	1065.98589	4800	12	6	12	3	1017.9	116	1.089	0.96	10	157.08	398.54	280	89.5	89.5
		bottom	615.83	103.224768	615.83	181.05	O.K.	615.82534	4800	12	3	12	2	565.49									
	Mid	top	0	66.4541885	66.454	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	88.26	0.829	0.21	10	157.08	382.64	280	179	179
		bottom	458.19	0	458.19	181.05	O.K.	458.189776	4800	12	3	12	1	452.39									
	Right end	top	0	907.097751	907.1	181.05	O.K.	907.097751	4800	12	5	12	3	904.78	112.34	1.055	0.85	10	157.08	403.77	280	89.5	89.5
		bottom	472.3	0	472.3	181.05	O.K.	472.299986	4800	12	3	12	1	452.39									
8	Left end	top	0	847.063088	847.06	181.05	O.K.	847.063088	4800	12	4	12	3	791.68	168.85	1.585	0.74	8	100.53	117.77	102	89.5	89.5
		bottom	671.99	0	671.99	181.05	O.K.	671.98812	4800	12	4	12	2	678.58									
	Mid	top	0	34.3731128	34.373	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	163.69	1.537	0.21	8	100.53	100.65	102	179	102

Beam ID No.	Span (mm)	Eff Span (Leff) mm	Dist Bet" zero moment (L0) mm	Eff Flange width (bf) mm	Df/d	Yf	Mu,lim for T-beam or L-beam (KN-m)	Beam type	location	Design moment Mu (KN-m) + ve	Design moment Mu (KN-m) - ve	Type of design + ve	Type of design - ve	xu1+ (N.A lies in flange)	xu2+ (N.A lies in web)	xu1- (N.A lies in flange)	xu2- (N.A lies in web)
9	3363	2903	2032.1	899.34	0.37	108.78	263.74	L - beam	Mid	87.7	10.39	Singly	Singly	21.8801845	-132.121	3.79	-169
								Rectangle	Right end	70.45	109	Singly	Doubly				

Beam ID No.	Span (mm)	Eff Span (Leff) mm	Dist Bet" zero moment (L0) mm	Eff Flange width (bf) mm	Df/d	Yf	Mu,lim for T-beam or L-beam (KN-m)	Beam type	location	Design moment Mu (KN-m) + ve	Design moment Mu (KN-m) - ve	Type of design + ve	Type of design - ve	xu1+ (N.A lies in flange)	xu2+ (N.A lies in web)	xu1- (N.A lies in flange)	xu2- (N.A lies in web)	Asc: for + ve Ast1	Asc: for + ve Ast2	Asc: for + ve Asc	Ast1 / Ast2: for - ve Ast1	Ast1 / Ast2: for - ve Ast2	Asc: for - ve Asc	Actual depth of N.A. (mm) + ve	Actual depth of N.A. (mm) - ve	location	Area of steel (mm²) + ve	Area of steel (mm²) - ve	Final steel reinforcement (mm²)	Minimum steel required	Check for min. tension steel	steel provided, mm²	Maximum steel required	Steel dia provided	No. of bars	Steel dia provided	No. of bars	Actual steel provided	Shear force V, KN	Nominal shear stress τv (N/mm²)	Per of steel P, %	Dia of stirrups mm	Area of stirrups Asv (mm²)	Spacing of stirrups Sv (mm)	Spacing Sv (mm)	From ductility usage Sv (mm)	Sv provided (mm)
45	4084	3614	2529.8	1501.6	0.37	108.78	451.09	Rectangle	Left end	0	54.26	Singly	Singly	4.3880884	-317.347	1.86	-325			0	455.7118	0		0	60.33876886	top	0	455.711826	455.71	181.05	O.K.	455.711826	4800	12	2	12	2	452.39	58.64	0.551	0.42	8	100.53	1180.3	280	89.5	89.5
																		0	0				0			bottom	0	0	0	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
								T - beam	Mid	20.84	7.48	Singly	Singly							0	58.23083	0		22.098	7.785815982	top	0	58.2308323	58.231	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	42.78	0.402	0.21	8	100.53	1815.8	280	179	179
																		163.429215	0				0			bottom	163.43	0	163.43	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
								Rectangle	Right end	0	80.84	Singly	Singly							0	424.627	0		0	86.22080831	top	0	424.62705	424.63	181.05	O.K.	424.62705	4800	12	2	12	1	339.29	59.42	0.558	0.32	8	100.53	756.4	280	89.5	89.5
																		0	0				0			bottom	0	0	0	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
46	4084	3614	2529.8	1501.6	0.37	108.78	451.09	Rectangle	Left end	52.1	87.27	Singly	Singly	6.15043116	-306.565	4.92	-316			0	773.8132	0		87.723	102.4636651	top	0	773.813187	773.81	181.05	O.K.	773.813187	4800	16	3	12	1	716.28	92.6	0.869	0.67	8	100.53	364.19	280	89.5	89.5
																		435.972499	0				0			bottom	435.97	0	435.97	181.05	O.K.	435.972499	4800	16	2	0	0	402.12									
								T - beam	Mid	38.73	23.45	Singly	Singly							0	184.0163	0		42.081	24.95137452	top	0	184.016285	184.02	181.05	O.K.	184.016285	4800	16	1	0	0	201.06	74.99	0.704	0.19	8	100.53	313.45	280	179	179
																		305.0841498	0				0			bottom	305.08	0	305.08	181.05	O.K.	305.08415	4800	16	1	0	0	201.06									
								Rectangle	Right end	50.61	86.12	Singly	Singly							0	762.0026	0		58.947	100.8994002	top	0	762.002628	762	181.05	O.K.	762.002628	4800	16	3	12	1	716.28	92.6	0.869	0.67	8	100.53	364.19	280	89.5	89.5
																		422.5610178	0				0			bottom	422.56	0	422.56	181.05	O.K.	422.561018	4800	16	2	0	0	402.12									
43	4084	3614	2529.8	1501.6	0.37	108.78	451.09	Rectangle	Left end	52.99	95.83	Singly	Singly	6.58626544	-305.319	5.06	-315			0	864.3796	0		58.786	114.4593124	top	0	864.37984	864.38	181.05	O.K.	864.37984	4800	16	3	12	2	829.38	97.97	0.92	0.78	8	100.53	343.78	280	89.5	89.5
																		444.0142723	0				0			bottom	444.01	0	444.01	181.05	O.K.	444.014272	4800	16	2	0	0	402.12									
								T - beam	Mid	40.78	24.12	Singly	Singly							0	189.3054	0		44.436	25.68712237	top	0	189.30542	189.31	181.05	O.K.	189.30542	4800	16	1	0	0	201.06	78.084	0.714	0.19	8	100.53	305.33	280	179	179
																		321.3981487	0				0			bottom	321.4	0	321.4	181.05	O.K.	321.398149	4800	16	1	12	1	314.16									
								Rectangle	Right end	52.05	93.65	Singly	Singly							0	840.1928	0		57.663	111.2556593	top	0	840.192845	840.19	181.05	O.K.	840.192845	4800	16	2	16	2	804.25	97.88	0.919	0.78	8	100.53	338.3	280	89.5	89.5
																		435.5214026	0				0			bottom	435.52	0	435.52	181.05	O.K.	435.521403	4800	16	2	0	0	402.12									
52	3048	2596	1818.6	1363.1	0.37	108.78	416.51	Rectangle	Left end	82.749	108.1	Singly	Doubly	11.6596347	-272.18	8.75	-280			0	968.3133	49.3868609		96.369	161.88	top	0	1017.7002	1017.7	181.05	O.K.	1017.7002	4800	16	2	16	3	1005.3	132.46	1.244	0.94	8	100.53	190.82	178	89.5	89.5
																		727.7932475	0				52.19427167			bottom	727.79	52.1942717	727.79	181.05	O.K.	727.793247	4800	16	2	12	3	741.42									
								T - beam	Mid	50.82	38.28	Singly	Singly							0	301.7543	0		56.197	41.5658704	top	0	301.754302	301.75	181.05	O.K.	301.754302	4800	16	1	0	0	201.06	115.8	1.087	0.19	8	100.53	157.3	153	179	153
																		401.9885535	0				0			bottom	401.99	0	401.99	181.05	O.K.	401.988553	4800	16	2	0	0	402.12									
								Rectangle	Right end	68.92	105.4	Singly	Doubly							0	968.3133	43.1720207		104.71	161.88	top	0	1011.48535	1011.5	181.05	O.K.	1011.48535	4800	16	3	16	2	1005.3	131.44	1.234	0.94	8	100.53	193.75	178	89.5	89.5
																		790.7835047	0				45.62613958			bottom	790.78	45.6261396	790.78	181.05	O.K.	790.783505	4800	16	2	16	2	804.25									
30	3531	3080.6	2156.4	1439.4	0.37	108.78	432.94	Rectangle	Left end	25.53	48.27	Singly	Singly	4.15162811	-304.766	1.94	-311			0	401.6096	0		27.24	53.17274778	top	0	401.609589	401.61	181.05	O.K.	401.609589	4800	12	2	12	1	339.29	98.79	0.929	0.32	8	100.53	228.44	204	89.5	89.5
																		205.752029	0				0			bottom	205.75	0	205.75	181.05	O.K.	205.752029	4800	12	2	0	0	226.19									
								T - beam	Mid	19	8.9	Singly	Singly							0	69.59572	0		20.099	9.293868536	top	0	69.595724	69.596	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19	81.74	0.768	0.21	8	100.53	279.65	280	179	179
																		148.9621388	0				0			bottom	148.96	0	148.96	181.05	Not O.K.	181.05	4800	12	2	0	0	226.19									
								Rectangle	Right end	28.65	51.97	Singly	Singly							0	434.7998	0		30.82	57.56764529	top	0	434.7998	434.8	181.05	O.K.	434.7998	4800	12	2	16	1	427.26	98.5	0.925	0.4	8	100.53	248.39	229	89.5	89.5
																		233.5491052	0				0			bottom	233.55	0	233.55	181.05	O.K.	233.549105	4800	12	2	0	0	226.19									
34	3531	3081	2156.7	1439.5	0.37	108.78	432.95	Rectangle	Left end	64.62	95.52	Singly	Singly	9.06112097	-291.12	5.76	-300			0	860.012	0		72.998	113.860792	top	0	860.011986	860.01	181.05	O.K.	860.011986	4800	16	3	12	2	829.38	92.5	0.869	0.78	8	100.53	402.5	280	89.5	89.5
																		551.3243491	0				0			bottom	551.32	0	551.32	181.05	O.K.	551.324349	4800	16	2	12	1	515.22									
								T - beam	Mid	41.23	26.31	Singly	Singly							0	206.6647	0		44.957	28.10152049	top	0	206.664685	206.66	181.05	O.K.	206.664685	4800	16	1	0	0	201.06	79.06	0.742	0.19	8	100.53	285.21	280	179	179
																		325.1274759	0				0			bottom	325.13	0	325.13	181.05	O.K.	325.127476	4800	16	1	12	1	314.16									
								Rectangle	Right end	71.826	101.2	Singly	Doubly							0	968.3133	6.00444045		82.097	161.88	top	0	974.317775	974.32	181.05	O.K.	974.317775	4800	16	3	12	3	942.48	93.62	0.879	0.88	8	100.53	426.71	280	89.5	89.5
																		620.034132	0				6.345763621			bottom	620.03	6.34576362	620.03	181.05	O.K.	620.034132	4800	16	2	16	1	603.19									
13	3531	3081	2156.7	1439.5	0.37	108.78	432.95	Rectangle	Left end	62.015	92.47	Singly	Singly	7.98505909	-294.121	4.64	-303			0	827.7711	0		69.766	109.6103668	top	0	827.771117	827.77	181.05	O.K.	827.771117	4800	16	2	16	2	804.25	165.35	1.553	0.78	8	100.53	122.07	102	89.5	89.5
																		526.916593	0				0			bottom	526.92	0	526.92	181.05	O.K.	526.916593	4800	16	2	12	1	515.22									
								T - beam	Mid	36.38	21.23	Singly	Singly							0	166.5416	0		38.397	22.52311095	top	0	166.541645	166.54	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	170.38	1.6	0.19	8	100.53	94.4	102	179	102
																		286.5166591	0				0			bottom	286.52	0	286.52	181.05	O.K.	286.516659	4800	16	1	0	0	201.06									
								Rectangle	Right end	61.22	92.45	Singly	Singly							0	827.5611	0		68.785	109.5825542	top	0	827.561135	827.56	181.05	O.K.	827.561135	4800	16	2	16	2	804.25	115.2	1.082	0.78	8	100.53	232.55	229	89.5	89.5
																		519.511685	0				0			bottom	519.51	0	519.51	181.05	O.K.	519.511685	4800	16	2	12	1	515.22									
12	3531	3081	2156.7	1439.5	0.37	108.78	432.95	Rectangle	Left end	60.88	94.46	Singly	Singly	7.13263061	-296.495	4.8	-303			0	848.7573	0		66.367	112.3900512	top	0	848.757276	848.76	181.05	O.K.	848.757276	4800	16	3	12	2	829.38	109.8	1.031	0.78	8	100.53	281.3	254	89.5	89.5
																		516.3509938	0				0			bottom	516.35	0	516.35	181.05	O.K.	516.350994	4800	16	2	12	1	515.22									
								T - beam	Mid	32.53	21.94	Singly	Singly							0	172.143	0		35.04	23.29812516	top	0	172.143	172.14	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	85.13	0.799	0.19	8	100.53	251.43	229	179	179
																		255.9373418	0				0			bottom	255.94	0	255.94	181.05	O.K.	255.937342	4800	16	1	0	0	201.06									
								Rectangle	Right end	62.14	92.63	Singly	Singly							0	829.4516	0		69.92	109.8329555	top	0	829.451638	829.45	181.05	O.K.	829.451638	4800	16	3	12	2	829.38	108.5	1.019	0.78	8	100.53	268.37	280	89.5	89.5
																		528.0827387	0				0			bottom	528.08	0	528.08	181.05	O.K.	528.082739	4800	16	2	12	1	515.22									
6	4084	3614	2529.8	900.82	0.37	108.78	275.84	Rectangle	Left end	68.42	105.4	Singly	Doubly	19.4597055	-146.352	8.57	-169			0	968.3133	42.725295		77.767	161.88	top	0	1011.03863	1011	181.05	O.K.	1011.03863	4800	16	3	12	3	942.48	115.67	1.086	0.88	8	100.53	246.62	229	89.5	89.5
																		587.3342824	0				45.15401968			bottom	587.33	45.1540197	587.33	181.05	O.K.	587.334282	4800	16	2	12	1	515.22									
								L - beam	Mid	54.73	24.43	Singly	Singly							0	192.5367	0		60.879	26.02800098	top	0	192.536689	192.54	181.05	O.K.	192.536689	4800	16	1	0	0	201.06	90.42	0.849	0.19	8	100.53	227.91	204	179	179
																		436.9661917	0				0			bottom	436.97	0	436.97	181.05	O.K.	436.966192	4800	16	2	0	0	402.12									
								Rectangle	Right end	57	101.8	Singly	Doubly							0	968.3133	11.1864588		63.625	161.88	top	0	979.499793	979.5	181.05	O.K.	979.499793	4800	16	4	12	1	917.35	114.04	1.071	0.86	8	100.53	251.45	229	89.5	89.5
																		480.5400134	0				11.8223545			bottom	480.54	11.8223545	480.54	181.05	O.K.	480.540013	4800	16	2	0	0	402.12									

4 th floor

Beam ID No.	Span (mm)	Eff Span (Leff) mm	Dist Bet" zero moment (L0) mm	Eff Flange width (bf) mm	Df/d	Yf	Mu,lim for T-beam or L-beam (KN-m)	Beam type	location	Design moment Mu (KN-m) + ve	Design moment Mu (KN-m) - ve	Type of design + ve	Type of design - ve	xu1+ (N.A lies in flange)	xu2+ (N.A lies in web)	xu1- (N.A lies in flange)	xu2- (N.A lies in web)	Asc: for + ve Ast1	Asc: for + ve Ast2	Asc: for + ve Asc	Ast1 / Ast2: for - ve Ast1	Ast1 / Ast2: for - ve Ast2	Asc: for - ve Asc	Actual depth of N.A. (mm) + ve	Actual depth of N.A. (mm) - ve	location	Area of steel (mm²) + ve	Area of steel (mm²) - ve	Final steel reinforcement (mm²)	Minimum steel required	Check for min. tension steel	steel provided, mm²	Maximum steel required	Steel dia provided	No. of bars	Steel dia provided	No. of bars	Actual steel provided	Shear force V, KN	Nominal shear stress τv (N/mm²)	Per of steel P, %	Dia of stirrups mm	Area of stirrups Asv (mm²)	Spacing of stirrups Sv (mm)	Spacing Sv (mm)	From ductility usage Sv (mm)	Sv provided (mm)
42	4084	3614	2529.8	1501.6	0.37	108.78	451.09	Rectangle	Left end	0	75	Singly	Singly	5.90827815	-312.86	3.14	-321			0	650.861	0		0	86.18240187	top	0	650.881042	650.88	181.05	O.K.	650.881042	4800	16	2	12	2	628.32	84.8	0.796	0.6	8	100.53	423.76	280	89.5	89.5
																		0	0				0			bottom	0	0	0	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06									
								T - beam	Mid	28.15	15	Singly	Singly							0	117.4615	0		30.141	15.785422	top	0	117.461489	117.46	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	62.7	0.589	0.2	8	100.53	447.13	280	179	179
																		221.1566452	0				0			bottom	221.16	0	221.16	181.05	O.K.	221.156645	4800	16	1	0	0	201.06									
								Rectangle	Right end	0	74.25	Singly	Singly							0	643.5588	0		0	85.21207629	top	0	643.558768	643.56	181.05	O.K.	643.558768	4800	16	2	12	2	628.32	84.82	0.798	0.6	8	100.53	423.48	280	89.5	89.5
																		0	0				0			bottom	0	0	0	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06									
40	4084	3614	2529.8	1501.6	0.37	108.78	451.09	Rectangle	Left end	27.96	68.88	Singly	Singly	5.52166862	-314.051	3.39	-320			0	591.7268	0		29.93	78.34645031	top	0	591.726837	591.73	181.05	O.K.	591.726837	4800	16	2	16	1	603.19	79.72	0.749	0.6	8	100.53	492.02	280	89.5	89.5
																		226.0721813	0				0			bottom	226.07	0	226.07	181.05	O.K.	226.072181	4800	16	1	0	0	201.06									
								T - beam	Mid	26.32	16.16	Singly	Singly							0	126.5815	0		28.113	17.03154158	top	0	126.581451	126.58	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	62.11	0.583	0.2	8	100.53	456.48	280	179	179
																		206.6852095	0				0			bottom	206.69	0	206.69	181.05	O.K.	206.685209	4800	16	1	0	0	201.06									
								Rectangle	Right end	33.16	68.38	Singly	Singly							0	587.0481	0		35.75	77.72884127	top	0	587.048086	587.05	181.05	O.K.	587.048086	4800	16	2	16	1	603.19	79.87	0.75	0.6	8	100.53	489.22	280	89.5	89.5
																		270.0254469	0				0			bottom	270.03	0	270.03	181.05	O.K.	270.025447	4800	16	1	0	0	201.06									
41	3531	3080.6	2156.4	1439.4	0.37	108.78	432.94	Rectangle	Left end	32.13	70.75	Singly	Singly	5.2663678	-301.673	2.26	-310			0	609.6596	0		34.59	80.72329837	top	0	609.659582	609.66	181.05	O.K.	609.659582	4800	16	2	16	1	603.19	97.89	0.919	0.6	8	100.53	290.48	280	89.5	89.5
																		261.2675034	0				0			bottom	261.27	0	261.27	181.05	O.K.	261.267503	4800	16	1	0	0	201.06									
								T - beam	Mid	24.07	10.39	Singly	Singly							0	81.04292	0		25.632	10.83834474	top	0	81.0429182	81.043	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	69.4	0.652	0.2	8	100.53	362.79	280	179	179
																		188.959552	0				0			bottom	188.96	0	188.96	181.05	O.K.	188.959552	4800	16	1	0	0	201.06									
								Rectangle	Right end	35.08	70.8	Singly	Singly							0	610.1311	0		38.056	80.78574766	top	0	610.131133	610.13	181.05	O.K.	610.131133	4800	16	2	16	1	603.19	97.965	0.919	0.6	8	100.53	290.64	280	89.5	89.5
																		294.9962191	0				0			bottom	295	0	295	181.05	O.K.	294.996219	4800	16	1	0	0	201.06									
15	4140	3880	2583	1510.5	0.37	108.78	453.88	Rectangle	Left end	0	81.56	Singly	Singly	9.25485642	-305.218	1.82	-326			0	715.7382	0		0	94.77198106	top	0	715.738245	715.74	181.05	O.K.	715.738245	4800	12	3	12	3	716.28	95.5	0.897	0.7	8	100.53	336.6	280	89.5	89.5
																		0	0				0			bottom	0	0	0	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06									
								T - beam	Mid	44.18	9.26	Singly	Singly							0	72.40942	0		48.379	9.674186087	top	0	72.4094229	72.409	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	77.6	0.729	0.2	8	100.53	294.74	280	179	179
																		348.4702573	0				0			bottom	348.47	0	348.47	181.05	O.K.	348.470257	4800	16	1	12	1	314.16									
								Rectangle	Right end	44.47	83.37	Singly	Singly							0	734.0599	0		48.717	97.19854015	top	0	734.059884	734.06	181.05	O.K.	734.059884	4800	16	3	12	2	741.42	101.67	0.955	0.7	8	100.53	264.91	280	89.5	89.5
																		367.8597797	0				0			bottom	367.86	0	367.86	181.05	O.K.	367.85978	4800	16	1	12	1	314.16									
10	4140	3880	2583	1510.5	0.37	108.78	453.88	Rectangle	Left end	0	81.27	Singly	Singly	9.22203125	-305.312	1.99	-326			0	712.9314	0		0	94.40024125	top	0	712.93141	712.93	181.05	O.K.	712.93141	4800	16	3	12	1	716.28	95.31	0.895	0.7	8	100.53	338.28	280	89.5	89.5
																		0	0				0			bottom	0	0	0	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06									
								T - beam	Mid	44.025	8.57	Singly	Singly							0	74.83917	0		48.198	10.00182308	top	0	74.8391685	74.839	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	77.4	0.727	0.2	8	100.53	296.09	280	179	179
																		347.7341888	0				0			bottom	347.23	0	347.23	181.05	O.K.	347.234189	4800	16	1	12	1	314.16									
								Rectangle	Right end	44.29	83	Singly	Singly							0	730.3242	0		48.507	96.70378077	top	0	730.324241	730.32	181.05	O.K.	730.324241	4800	16	2	12	3	741.42	101.45	0.953	0.7	8	100.53	266.4	280	89.5	89.5
																		366.3748432	0				0			bottom	366.37	0	366.37	181.05	O.K.	366.374843	4800	16	1	12	1	314.16									
3	3531	3080.6	2156.4	1439.4	0.37	108.78	432.94	Rectangle	Left end	26.17	63.8	Singly	Singly	4.95386511	-302.541	2.74	-309			0	543.6173	0		27.947	71.97740185	top	0	543.617302	543.62	181.05	O.K.	543.617302	4800	16	1	12	3	515.22	82.198	0.772	0.5	8	100.53	403.84	280	89.5	89.5
																		211.090536	0				0			bottom	211.09	0	211.09	181.05	O.K.	211.090538	4800	16	1	0	0	201.06									
								T - beam	Mid	22.66	12.56	Singly	Singly							0	98.30839	0		24.075	13.17655105	top	0	98.3083655	98.308	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	60.65	0.569	0.2	8	100.53	481.38	280	179	179
																		177.7464619	0				0			bottom	177.75	0	177.75	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06									
								Rectangle	Right end	[illegible]	[illegible]	[illegible]	[illegible]							0	544.8377	0		[illegible]	[illegible]	top	0	544.837671	544.84	181.05	O.K.	544.837671	4800	16	1	12	3	515.22	82.2	0.772	0.5	8	100.53	403.81	280	89.5	89.5

[illegible]																		21.4727823	0					bottom	21.471	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
								Rectangle	Right end	40.9	84.1	Singly	Singly					0		454.0788	0	44.461	80.12023833	top	0	454.018642	454.02	181.05	O.K.	454.018642	4800	16	2	0	0	402.12	97.7	0.917	0.4	8	100.53	[illegible]	229	89.5	89.5
																		335.8187074	0	0				bottom	335.82	0	335.82	181.05	O.K.	[illegible]	4800	16	1	12	1	314.16									
32	3048	2598	1818.6	1383.1	0.37	108.78	416.51	Rectangle	Left end	39.7	85.74	Singly	Singly	9.2462107	-286.942	5.98	-288	0		469.0109	0	43.195	82.09781834	top	0	469.010881	469.01	181.05	O.K.	469.010881	4800	16	[illegible]	0	0	402.12	83.5	0.784	0.4	8	100.53	[illegible]	280	89.5	89.5
																		326.252036	0	0				bottom	326.25	0	326.25	181.05	O.K.	326.252036	4800	16	1	12	1	314.16									
								T - beam	Mid	27.4	26.36	Singly	Singly					0		206.3267	0	26.309	28.04823364	top	0	206.326871	206.33	181.05	O.K.	206.326871	4800	16	1	0	0	201.06	71.68	0.675	0.2	8	100.53	339.11	280	179	179
																		215.3502454	0	0				bottom	215.35	0	215.35	181.05	O.K.	215.350245	4800	16	1	0	0	201.06									
								Rectangle	Right end	41.7	67.7	Singly	Singly					0		560.4736	0	45.5	76.858196	top	0	560.473646	560.47	181.05	O.K.	560.473646	4800	16	2	12	1	515.22	98.27	0.879	0.5	8	100.53	339.27	280	89.5	89.5
																		343.865987	0	0				bottom	343.87	0	343.87	181.05	O.K.	343.865987	4800	16	1	12	1	314.16									
30	1803	1453	1018.5	774.88	0.37	108.78	239.1	Rectangle	Left end	42.72	88.59	Singly	Singly	0.93003415	-181.387	1.55	-150	0		467.8416	0	46.882	61.9164831	top	0	467.84158	467.84	181.05	O.K.	467.84158	4800	16	2	0	0	402.12	100	0.939	0.4	8	100.53	236.34	229	89.5	89.5
																		352.5877921	0	0				bottom	352.59	0	352.59	181.05	O.K.	352.587792	4800	16	1	12	1	314.16									
								L - beam	Mid	2.3	3.83	Singly	Singly					0		29.93591	0	2.3622	3.874408368	top	0	29.9359146	29.936	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	98.56	0.907	0.2	8	100.53	205.58	204	179	179
																		17.98410995	0	0				bottom	17.984	0	17.984	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06									
								Rectangle	Right end	42.02	58.55	Singly	Singly					0		476.4169	0	45.871	63.07852089	top	0	476.416908	476.42	181.05	O.K.	476.416908	4800	16	1	12	2	427.26	101.23	0.951	0.4	8	100.53	235.97	229	89.5	89.5
																		346.462005	0	0				bottom	346.46	0	346.46	181.05	O.K.	346.462005	4800	16	1	12	1	314.16									

2 th floor

28	4084	3614	2529.8	1501.6	0.37	108.78	451.09	Rectangle	Left end	66.96	108.6	Singly	Doubly	11.1723436	-297.911	5.27	-315	0		968.3133	71.762467	75.927	161.88	top	0	1040.0758	1040.1	181.05	O.K.	1040.0758	4800	16	4	16	1	1005.3	108.2	1.016	0.9	8	100.53	297.82	280	89.5	89.5
																		873.4409593	0	75.84181339				bottom	573.44	75.8418134	573.44	181.05	O.K.	573.440959	4800	16	2	12	1	515.22									
								T - beam	Mid	52.9	25.15	Singly	Singly					0		197.4399	0	58.66	26.82084223	top	0	197.439936	197.44	181.05	O.K.	197.439936	4800	16	1	0	0	201.06	84.9	0.797	0.2	8	100.53	252.57	229	179	179
																		418.1993404	0	0				bottom	418.2	0	418.2	181.05	O.K.	418.19934	4800	16	2	0	0	402.12									
								Rectangle	Right end	59.8	101.9	Singly	Doubly					0		968.3133	11.5438394	67.04	161.88	top	0	979.857173	979.86	181.05	O.K.	979.857173	4800	16	3	12	3	942.48	107.37	1.008	0.9	8	100.53	293.2	280	89.5	89.5
																		506.3355549	0	12.20005042				bottom	506.34	12.2000504	506.34	181.05	O.K.	506.335555	4800	16	2	12	1	515.22									
29	3531	3080.6	2156.4	1439.4	0.37	108.78	432.94	Rectangle	Left end	65.5	97	Singly	Singly	8.22248981	-293.449	5.06	-302	0		875.8165	0	74.097	115.9741946	top	0	875.816474	875.82	181.05	O.K.	875.816474	4800	16	3	12	2	829.38	108.66	1.002	0.8	8	100.53	279.07	280	89.5	89.5
																		559.6201485	0	0				bottom	559.62	0	559.62	181.05	O.K.	559.620149	4800	16	2	12	1	515.22									
								T - beam	Mid	37.45	23.14	Singly	Singly					0		181.6148	0	40.617	24.61141023	top	0	181.614828	181.61	181.05	O.K.	181.614828	4800	16	1	0	0	201.06	83.3	0.782	0.2	8	100.53	280.74	254	179	179
																		295.0264797	0	0				bottom	295.03	0	295.03	181.05	O.K.	295.02648	4800	16	1	0	0	201.06									
								Rectangle	Right end	65.14	96.7	Singly	Singly					0		872.6043	0	73.847	115.5467156	top	0	872.604265	872.6	181.05	O.K.	872.604265	4800	16	3	12	2	829.38	106.87	1.003	0.8	8	100.53	277.8	280	89.5	89.5
																		556.2232916	0	0				bottom	556.22	0	556.22	181.05	O.K.	556.223292	4800	16	2	12	1	515.22									
36	3531	3080.6	2156.4	1439.4	0.37	108.78	432.94	Rectangle	Left end	65.7	96.6	Singly	Singly	8.32227381	-293.171	5.06	-302	0		871.5345	0	74.347	115.4070188	top	0	871.534505	871.53	181.05	O.K.	871.534505	4800	16	3	12	2	829.38	107.08	1.005	0.8	8	100.53	276.55	280	89.5	89.5
																		561.5091656	0	0				bottom	561.51	0	561.51	181.05	O.K.	561.509166	4800	16	2	12	1	515.22									
								T - beam	Mid	37.9	23.22	Singly	Singly					0		182.2465	0	41.131	24.69911538	top	0	182.246492	182.25	181.05	O.K.	182.246492	4800	16	1	0	0	201.06	84	0.789	0.2	8	100.53	257.1	254	179	179
																		298.6067801	0	0				bottom	298.61	0	298.61	181.05	O.K.	298.60678	4800	16	1	0	0	201.06									
								Rectangle	Right end	65.9	96.9	Singly	Singly					0		874.7452	0	74.597	115.8323034	top	0	874.745249	874.75	181.05	O.K.	874.745249	4800	16	3	12	2	829.38	107.14	1.008	0.8	8	100.53	276.19	280	89.5	89.5
																		563.3995251	0	0				bottom	563.4	0	563.4	181.05	O.K.	563.399525	4800	16	2	12	1	515.22									
37	3531	3080.6	2156.4	1439.4	0.37	108.78	432.94	Rectangle	Left end	65.27	95.8	Singly	Singly	8.32227381	-293.171	4.91	-303	0		864.0598	0	73.809	114.4169453	top	0	864.059782	864.06	181.05	O.K.	864.059782	4800	16	3	12	2	829.38	106.48	1	0.8	8	100.53	280.16	280	89.5	89.5
																		557.4494347	0	0				bottom	557.45	0	557.45	181.05	O.K.	557.449435	4800	16	2	12	1	515.22									
								T - beam	Mid	37.9	22.47	Singly	Singly					0		176.3257	0	41.131	23.87763057	top	0	176.325678	176.33	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	83.1	0.78	0.2	8	100.53	281.8	254	179	179
																		298.6067801	0	0				bottom	298.61	0	298.61	181.05	O.K.	298.60678	4800	16	1	0	0	201.06									
								Rectangle	Right end	64.24	95.5	Singly	Singly					0		859.7991	0	72.525	113.8525989	top	0	859.799136	859.8	181.05	O.K.	859.799136	4800	16	3	12	2	829.38	106.28	0.998	0.8	8	100.53	281.38	280	89.5	89.5
																		547.7500288	0	0				bottom	547.75	0	547.75	181.05	O.K.	547.750029	4800	16	2	12	1	515.22									
52	3048	2598	1818.6	1383.1	0.37	108.78	416.51	Rectangle	Left end	73.24	94.6	Singly	Singly	11.3758953	-272.957	8.92	-280	0		850.2407	0	83.911	112.5865351	top	0	850.240685	850.24	181.05	O.K.	850.240685	4800	16	3	12	2	829.38	123.57	1.16	0.8	8	100.53	204.26	204	89.5	89.5
																		633.7308457	0	0				bottom	633.73	0	633.73	181.05	O.K.	633.730846	4800	16	2	12	1	515.22									
								T - beam	Mid	49.6	39	Singly	Singly					0		307.4905	0	54.748	42.39082388	top	0	307.490503	307.49	181.05	O.K.	307.490503	4800	16	1	12	1	314.16	108.63	1.02	0.29	8	100.53	190.63	178	179	178
																		392.2060841	0	0				bottom	392.21	0	392.21	181.05	O.K.	392.206084	4800	16	1	12	1	314.16									
								Rectangle	Right end	83.48	105.5	Singly	Doubly					0		968.3133	44.0654721	97.346	161.88	top	0	1012.37881	1012.4	181.05	O.K.	1012.37881	4800	16	4	12	1	917.35	125.94	1.183	0.86	8	100.53	204.08	204	89.5	89.5
																		735.1715628	0	46.57037939				bottom	735.17	46.5703794	735.17	181.05	O.K.	735.171563	4800	16	3	12	1	716.28									
1	4140	3690	2583	1510.5	0.37	108.78	453.68	Rectangle	Left end	76.13	132.8	Singly	Doubly	14.5882413	-289.838	2.84	-324	0		968.3133	287.977717	87.649	161.88	top	0	1256.29105	1256.3	181.05	O.K.	1256.29105	4800	16	4	12	4	1256.6	137.05	1.287	1.2	8	100.53	193.03	178	89.5	89.5
																		661.9528273	0	304.3478466				bottom	661.95	304.347847	661.95	181.05	O.K.	661.952827	4800	16	2	12	2	628.32									
								T - beam	Mid	69.2	13.67	Singly	Singly					0		107.0093	0	78.754	14.36132349	top	0	107.009314	107.01	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	104	0.977	0.48	8	100.53	239.91	229	179	179
																		549.2863757	0	0				bottom	549.29	0	549.29	181.05	O.K.	549.286376	4800	16	2	12	1	515.22									
								Rectangle	Right end	0	126.8	Singly	Doubly					0		968.3133	234.102595	0	161.88	top	0	1202.41593	1202.4	181.05	O.K.	1202.41593	4800	16	4	12	4	1256.6	145.47	1.366	1.18	8	100.53	171.41	153	89.5	89.5
																		0	0	247.4101863				bottom	0	247.410186	247.41	181.05	O.K.	247.410186	4800	16	1	0	0	201.06									
3	4140	3690	2583	1510.5	0.37	108.78	453.68	Rectangle	Left end	73.11	112.6	Singly	Doubly	12.8968137	-294.73	8.93	-306	0		968.3133	107.76856	83.744	161.88	top	0	1076.08189	1076.1	181.05	O.K.	1076.08189	4800	16	4	12	2	1030.4	115.12	1.081	0.97	8	100.53	259.77	254	89.5	89.5
																		632.4685757	0	113.8948776				bottom	632.47	113.894678	632.47	181.05	O.K.	632.468576	4800	16	2	12	2	628.32									
								T - beam	Mid	61.3	42.86	Singly	Singly					0		336.353	0	68.884	46.61207188	top	0	336.353006	336.35	181.05	O.K.	336.353006	4800	16	1	12	1	314.16	91.5	0.859	0.38	8	100.53	279.99	280	179	179
																		485.5995961	0	0				bottom	485.6	0	485.6	181.05	O.K.	485.599596	4800	16	[illegible]	[illegible]	[illegible]	402.12									
								Rectangle	Right end	82.4	122.2	Singly	Doubly					0		968.3133	193.093174	95.903	161.88	top	0	1161.40651	1161.4	181.05	O.K.	1161.40651	4800	16	4	12	3	1143.5	113.6	1.067	1.07	8	100.53	282.61	280	89.5	89.5
																		724.2783216	0	204.0895791				bottom	724.28	204.089579	724.28	181.05	O.K.	724.278322	4800	16	3	12	1	716.28									

3 th floor

43	3531	3080.7	2156.5	1439.4	0.37	108.78	432.94	Rectangle	Left end	54.5	80.5	Singly	Singly	6.08832512	-299.393	4.24	-305	0		705.2268	0	60.602	93.38008681	top	0	705.228761	705.23	181.05	O.K.	705.228761	4800	16	3	12	1	716.28	93.45	0.877	0.67	8	100.53	355.64	280	89.5	89.5
																		457.711699	0	0				bottom	457.71	0	457.71	181.05	O.K.	457.711699	4800	16	2	0	0	402.12									
								T - beam	Mid	27.8	18.4	Singly	Singly					0		152.1139	0	29.753	20.53236874	top	0	152.113913	152.11	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	75.98	0.713	0.19	8	100.53	308.23	280	179	179
																		218.4533294	0	0				bottom	218.45	0	218.45	181.05	O.K.	218.453329	4800	16	1	0	0	201.06									
								Rectangle	Right end	53.8	81.7	Singly	Singly					0		717.2432	0	59.76	94.87130034	top	0	717.243201	717.24	181.05	O.K.	717.243201	4800	16	3	12	1	716.28	93.46	0.878	0.67	8	100.53	355.54	280	89.5	89.5
																		451.3534785	0	0				bottom	451.35	0	451.35	181.05	O.K.	451.353478	4800	16	2	0	0	402.12									
47	4084	3614	2529.8	900.82	0.37	108.78	275.84	Rectangle	Left end	48.8	84.56	Singly	Singly	11.624201	-162.991	8.02	-171	0		746.1127	0	53.801	98.79486587	top	0	746.112749	746.11	181.05	O.K.	746.112749	4800	16	3	12	1	716.28	90	0.845	0.67	8	100.53	393.27	280	89.5	89.5
																		406.3551525	0	0				bottom	406.36	0	406.36	181.05	O.K.	406.355153	4800	16	2	0	0	402.12									
								L - beam	Mid	33	22.87	Singly	Singly					0		180.1242	0	35.569	24.31554673	top	0	180.124221	180.12	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	72.5	0.681	0.19	8	100.53	333.66	280	179	179
																		261.0205399	0	0				bottom	261.02	0	261.02	181.05	O.K.	261.02054	4800	16	1	0	0	201.06									
								Rectangle	Right end	48.29	83.6	Singly	Singly					0		736.3849	0	53.199	97.50646886	top	0	736.384871	736.38	181.05	O.K.	736.384871	4800	16	[illegible]	[illegible]	[illegible]	716.28	90.25	0.847	0.67	8	100.53	390.1	280	89.5	89.5
																		401.8056755	0	0				bottom	401.81	0	401.81	181.05	O.K.	401.805676	4800	16	2	0	0	402.12									
50	3048	2775.5	1942.9	851.9	0.37	108.78	261.57	Rectangle	Left end	60	74.78	Singly	Singly	14.9505529	-143.951	12	-150	0		648.731	0	67.266	85.89766246	top	0	648.731015	648.73	181.05	O.K.	648.731015	4800	16	[illegible]	[illegible]	2	628.32	104.5	0.981	0.59	8	100.53	257.16	254	89.5	89.5
																		508.1874768	0	0				bottom	508.19	0	508.19	181.05	O.K.	508.187477	4800	16	[illegible]	12	1	515.22									
								L - beam	Mid	39.98	32.33	Singly	Singly					0		255.8499	0	43.517	34.81513322	top	0	255.849884	255.85	181.05	O.K.	255.849884	4800	16	[illegible]	0	0	201.06	93.8	0.881	0.29	8	100.53	244.21	229	179	179
																		317.4649606	0	0				bottom	317.48	0	317.48	181.05	O.K.	317.464961	4800	16	1	12	1	314.16									
								Rectangle	Right end	67.15	86.86	Doubly	Singly					-315.5455865		769.5762	0	161.88	101.9024838	top	315.55	769.576131	769.58	181.05	O.K.	769.576131	4800	16	[illegible]	[illegible]	[illegible]	741.42	107.7	1.011	0.7	8	100.53	259.15	254	204	204
																		968.3133541	-298.57316	0				bottom	669.74	0	669.74	181.05	O.K.	669.740176	4800	16	[illegible]	[illegible]	[illegible]	628.32									
23	4140	3690	2583	905.25	0.37	108.78	277.13	Rectangle	Left end	65.35	108.5	Singly	Doubly	20.8970696	-144.318	2.95	-162	0		968.3133	79.80353	73.909	161.88	top	0	1048.11686	1048.1	181.05	O.K.	1048.11686	4800	16	4	12	2	1030.4	113.8	1.069	0.97	8	100.53	266.88	280	89.5	89.5
																		558.204265	0	84.33997185				bottom	558.2	84.3399717	558.2	181.05	O.K.	558.204265	4800	16	2	12	1	515.22									
								L - beam	Mid	58.96	8.5	Singly	Singly					0		66.54672	0	66.012	8.871722368	top	0	66.5467201	66.547	181.05	Not O.K.	181.05	4800	16	1	0	0	201.06	91	0.854	0.38	8	100.53	283.07	280	179	179
																		471.5514475	0	0				bottom	471.55	0	471.55	181.05	O.K.	471.551447	4800	16	2	0	0	402.12									
								Rectangle	Right end	78.5	116	Singly	Doubly					0		968.3133	137.877874	90.745	161.88	top	0	1106.19121	1106.2	181.05	O.K.	1106.19121	4800	16	4	12	2	1030.4	114	1.07	0.97	8	100.53	285.79	254	89.5	89.5
																		685.3311862	0	145.7155591				bottom	685.33	145.715559	685.33	181.05	O.K.	685.331186	4800	16	2	12	2	628.32									

4.3 DESIGN OF COMPRESSION MEMBER

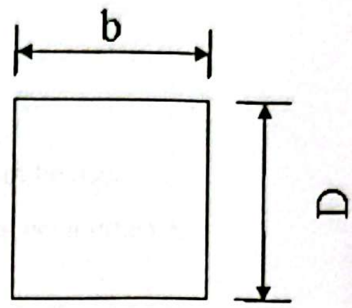


Fig. Square Column

Column may be defined as a structural element used primarily to support axial compressive loads and with a height of at least three times its dimension. A compression member subject to pure axial load rarely occurs in practice. All columns are subjected to same moment which may be due to accidental eccentricity or due to end restraint imposed by monolithically placed beams or slabs. The strength of columns depends on the strength of materials, shape and size of the cross-section, length and the degree of positional and directional restraints at its ends.

SUBJECTED TO BIAXIAL BENDING:

Exact design of members subject to axial load and biaxial bending is extremely laborious. Therefore, the IS Code 456: 2000 permits the design of such members by the following equation:

$$\left(\frac{M_{ux}}{M_{ux1}}\right)^{\alpha} + \left(\frac{M_{uy}}{M_{uy1}}\right)^{\alpha_n} \leq 1.0$$

Where,

M_{ux}, M_{uy} are the moments about x and y axes respectively due to design loads M_{ux1}, M_{uy1} are the maximum uniaxial moment capacities with an axial load P_u, bending about x and y axes respectively and α_n is an exponent whose value depends on P_u/P_{uz} (see table below) where,

$$P_{uz} = 0.45*f_{ck}*Ac + 0.75*f_y*A_{st}$$

Where,

A_c = Gross X-section area of column

A_{st} = Area of reinforcement bars.

f_{ck} = Characteristics strength of Concrete.

f_y = Characteristics strength of reinforcement bar (rebar).

TABLE

P_u/P_{uz}	α_n
≤ 0.2	1.0
≥ 0.8	2.0

For intermediate values, linear interpolation may be done. Chart 63 can be used for evaluating P_{uz}. For different values of Pu/P_{uz} the appropriate values of α_n has been taken and curves for the equation

$$\left(\frac{M_{ux}}{M_{ux1}}\right)^{\alpha} + \left(\frac{M_{uy}}{M_{uy1}}\right)^{\alpha_n} = 1.0 \text{ has been plotted in Chart 64}$$

Material Characteristics:

Concrete Grade: M20

Steel Grade Fe: 415

Section Characteristics:

Size of column = 450*450 mm^2

Effective Cover (d') = 40 mm

Effective Depth (d) = 450 -40 = 410 mm

$\frac{d'}{D} = 0.089 \approx 0.1$ for all Column

Sample Calculation

Reference	Step	Calculation	Remarks
	1.	**Design Parameters:** Factored load, $P_u = 174.5$ KN Factored moment , $M_{ux} = 116.16$ KN-m $M_{uy} = 3.5$ KN-m Reinforcement is distributed equally on four sides.	All the Design Parameters are taken from the output of Structural Analysis Program.
IS 456:2000 CI. 25. 1.2	2.	**Slenderness Ratio Consideration:** $\frac{L_e}{D} = \frac{3200}{400} = 8 \leq 12$ Hence, the Column is Short Column	
IS 456:2000 CI. 25. 4	3.	**Eccentricity Consideration:** Minimum Eccentricity: $e_{min} = \frac{l}{500} + \frac{b}{30}$ or 2.0 cm whichever is less	

		Where, l is unsupported length of column b is lateral dimension of column. $e_{min} = \frac{3200}{500} + \frac{400}{30} = 19.7$ mm or 20mm Thus, $e_{min} = 19.7$mm Eccentricity due to design moment, e $= M_u / P_u$ $= \frac{3.5*10^6}{174.5*10^3}$ =20.05mm Eccentricity due to design moment is greater than the minimum eccentricity and 0.05 times the lateral dimension. Hence the column is design for given axial load and biaxial moments.	
IS 456:2000 Cl. 39.3	4.	**Calculation of % Reinforcement:** Assume percentage reinforcement (p_t) = 2% Then, $\frac{p_t}{f_{ck}} = 0.1$	
IS 456:1978 (SP - 16) CHART 44		$\frac{P_u}{f_{ck} * b * D} = \frac{174.5*10^3}{25*400*400} = 0.043$ $\frac{M_u}{f_{ck} * b * D} = 0.875$ $M_{ux1} = M_{uy1} = 174.5$ KN-m	
	5.	**Calculations:** $P_{uz} = 0.45*f_{ck}*A_c+0.75*f_y*A_{st}$ $=0.45*25*400*400+0.75*500*(2/100*400^2)$ = 3000 KN $\frac{P_u}{P_{uz}} = \frac{174.5}{3000} = 0.058$ For this α_n is interpolated from Table - 1	
IS 456: 2000 Cl.39.6		$\left(\frac{M_{ux}}{M_{ux1}}\right)^{\alpha_n}\left(\frac{M_{uy}}{M_{uy1}}\right)^{\alpha_n} \leq 1.0$ $\left(\frac{3.5}{174.5}\right)^{0.058} + \left(\frac{116.7}{174.5}\right)^{0.05} = 1.788 <1.0$ **O.K.** Hence 2% reinforcement is provided for the given column. A_{st} = 2% of bD $= 2/100*400^2$ $= 3200mm^2$	

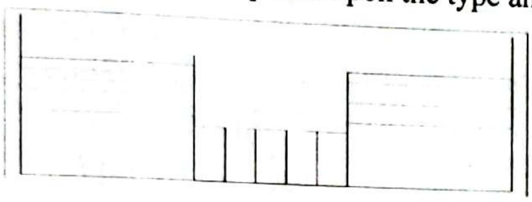
		Provide 4-25mmΦ +4-20mmΦ bars Provided A_{st} = 3199.45 mm^2	
	6.	**Check for % steel:** $P_t = \frac{3199.45}{400*400}*100$ $= 1.99\%$ 0.8 %< 1.99 %< 4% **O.K.**	
IS 456: 2000 Cl. 26.5.3.2C	**7.**	**Design for Transverse Reinforcement:** Dia. of Transverse reinforcement, $\Phi_t < 6mm$ < 1/4 times larger longitudinal bar = 28/4 = 7m Provided dia. of transverse reinforcement = 8mm Φ bars.	
	8.	**Spacing of Transverse reinforcement:** Spacing is minimum of: S_v> minimum dimension of column i.e.400mm > 16 times smaller dia. of longitudinal bar i.e. 16*25 = 400mm >300mm whichever is less. Provided 8mmΦ bars @ 300mm c/c. **O.K.**	
IS 456: 2000 Table 19 BS 8110	**9.**	**Shear Check in column** M_{1x} (Moment at top of the column) = 3.45 KN-m M_{2x} (Moment at bottom of the column) =3.45 KN-m P_u = 174.5 KN Column height h= 3.2 m $\Rightarrow V = (M_{1x} + M_{2x})/h = (3.5 + 3.5)/3.2 = 2.18$ KN Shear stress V or $\tau_v = V/bd = 2.18*10^3/400^2$ $= 0.014\ N/mm^2$ ⇒ Find τ_c' value: b = 400 mm, d = 400 mm P_t = 2% (assumed) τ_c for f_{ck} (= 25 N/mm^2) = 0.82 N/mm^2 ⇒ Increased shear due to compression $\tau_c' = \tau_c + 0.75(P/A_c)(Vd/M) \leq 0.8\sqrt{f_{ck}}$ or 5 N/mm^2 So, $\tau_c' = 0.82 + 0.75(1356*10^3/400^2)(2.98*10^3*400/7.41*10^6)$ $= 1.699 \approx 1.7\ N/mm^2$ ⇒ **Check against maximum shear** $\tau_{c,max} = 0.8\sqrt{f_{ck}} = 0.8\sqrt{25} = 4\ N/mm^2 < 5\ N/mm^2$ $\tau_v < \tau_c' < \tau_{c,max}$ Hence, section is safe in shear, Only nominal shear steel is required.	

4.4 DESIGN OF STAIRCASE

Staircase is an inclined structural system to provide pedestrian access to different levels within a building. The geometrical forms of staircase may be quiet different depending on the individual circumstances involved. The stairs and landing slab can angled in different form to get different types of staircase. The shape and structural arrangement of the staircase would generally depend on two main factors.

a) Type of construction of the structure around the staircase
b) Availability of space

The value of riser and tread to be adopted depends upon the type and use of the building.



Open well staircase

Sample Calculation for Open well staircase

Reference	Step	Calculation	Remarks
	1	**For inclined portion** L_e = 5.313m 1) Superimposed load = 5 KN/m2 Dead load 2) Finishes = 27*0.015 + 21*0.025 = 0.93 KN/m2 Fy = 500, fck = 25 Floor ht. = 3.2 m No. of riser = 17 ∴Riser (R) = Floor height/No. of riser = 3.2/17 = 188 mm Tread (T) = 10" = 254 mm Slab thickness (Waist slab) = 5"= 127 mm So, Adopt (D) =127 mm $X = \sqrt{((254)^2 + (188)^2)} = 316$ mm 3) Self wt. of slab = D*0.316*25 = 1.003 KN/m = 1.56/0.316 = 3.17 KN/m^2 4) Self wt. of step = 1/2 *0.188*0.316*25 = 0.74 KN/m = 0.74/0.316 = 2.34 KN/m^2 Total load = 5 + (0.93 ≈ 1) + 3.17+2.34 = 11.5 KN/m^2 Taking 1 m width of flight	

Total wt. (W) = 1*11.5 KN/m

$W_U = 1.5*11.5 =$ **17.27 KN/m**

For landing zone

2 Live load = 5 KN/m^2 (Assuming 1m of width of slab)

Finishes = 1 KN/m^2

Self wt. of slab = 25*1.5*1.9=71.25 ∴

Step wt. = 0.74*4=2.96 KN/m

Hence, Total wt. (W) = 80.21 KN/m

$W_U = 1.5*80.21 = 120.31$ KN/m

$R_A = R_B = Wl/2 = 20.1$ KN

So, Maximum Moment = $Wl^2/8 = (20.1*5.3^2/8$

$\therefore M_u = 70.57$ KN-m

<u>Check for depth</u>

$M_u = 0.138 f_{ck} bd^2$

IS 456-2000 Annex G

$$\text{So, } d = \sqrt{\frac{70.57*10^6}{0.138*25*1000}}$$

= 145.7 mm < 175 mm **not O.K.**

Adopt d = 140 mm and D = 150 mm

IS 456-2000 Annex G

$$\therefore M_u = 0.87*f_y*A_{st}\left(d - \frac{f_y A_{st}}{f_{ck} b}\right)$$

$$70.57*10^6 = 0.87*500*A_{st}\left(140 - \frac{500*A_{st}}{25*1000}\right)$$

Hence, Ast = 5534.33 mm^2

Providing the 20 mm dia. Bar

$$\text{So, No. of bars} = \frac{5534.33}{\pi*20^2/4} = 17.6 \approx 18 \text{ Nos.}$$

Provide 20 mm ϕ bars @ 140 mm c/c

<u>Check for shear</u>

τ_v = Nominal shear stress

$= V_u/bd$

$= (33.75*1000)/(1000*120) = 0.2812 \ N/mm^2$

IS 456-2000 Clause 40.1

$$\text{Steel Percentage} = 100A_{st}/bd = \frac{100*7*\pi*12^2}{1000*120*4} = 0.66\%$$

For M20 concrete

Design shear strength $(\tau_c) = 0.5312 \ N/mm^2$

$\tau_c' = k*\tau_c = 1.3*0.5312 = 0.69 \ N/mm^2$

$\tau_v < \tau_c'$ **O.K.** (No. shear reinforcement required)

IS 456-2000 Table 19

<u>Check for Development length</u>

IS 456-2000 Clause

$$L_d = \frac{\phi\sigma_s}{4\tau_{bd}} = \frac{0.87*f_y\phi}{4\tau_{bd}} = \frac{0.87*415*\phi}{4*1.2*1.6} = 47\phi$$

$L_d = 47*12 = 564$ mm

40.2.1.1

$L_d = 1.3M_1/V + L_o$ (let L_o anchorage length = 0)

$= (1.3*28.29*10^6)/(33.75*10^3) + 0$

$= 1089.69$ mm

Since, $47\phi < 1.3M_1/V$ **O.K.**

IS 456-2000 Clause 26.2.1

IS 456-2000 Clause 26.2.3.3.c

Cantilever portion

Total wt. of slab = 0.15*25*1.524*3.048 = 17.45 KN

Total wt. of brick step = 2*1/2*1.524*1.3716*.183*19

= 7.268 KN

3

Total wt. of the RCC step = ½*0.3048*0.183*1.524*25

= 1.06KN

Hence, Total wt. = 25.778 KN

And Ultimate load = 25.778*1.5 = 38.667 KN

UDL (W_u) = 38.667/(1.524*3.048) = 8.324 KN/m

$M_u = W_u l^2/2 = (8.324*1.524^2)/2 = 9.66$ KN-m

Check for depth

$M_u = 0.138 f_{ck} b d^2$

$$\text{So, } d = \sqrt{\frac{9.66*10^6}{0.138*20*1000}}$$

$= 59.16 \text{ mm} \not> 127$ mm **O.K.**

Adopt d = 120 mm and D = 150 mm

To find area of steel

IS 456-2000 Annex G

$$\therefore M_u = 0.87*f_y*A_{st}\left(d - \frac{f_y A_{st}}{f_{ck} b}\right)$$

$$9.66*10^6 = 0.87*415*A_{st}\left(120 - \frac{415*A_{st}}{20*1000}\right)$$

Hence, Ast = 232.3 mm^2

Providing the 12 mm dia. Bar

IS 456-2000 Annex G

$$\text{So, No. of bars} = \frac{232.3}{\pi*12^2/4} = 2.053 \approx 3 \text{ No.}$$

Spacing = 1000/3 = 333.33 mm

Adopt spacing = 300 mm

Provide 12 mm ϕ bars @ 300 mm c/c

Check for shear

τ_v = Nominal shear stress

$= V_u/bd$ ($V_u = W_u l = 8.324*1.524 = 12.685$ KN)

$= (12.685*1000)/(1000*120) = 0.105$ N/mm^2

		Steel Percentage = $100A_{st}/bd = \frac{100 * 3 * \pi * 12^2}{1000 * 120 * 4} = 0.282\%$	
		For M20 concrete	
		Design shear strength (τ_c) = 0.375 N/mm^2	
		$\tau_c' = k*\tau_c = 1.3*0.375 = 0.4875$ N/mm^2	
IS 456-2000 Clause 40.1		$\tau_v < \tau_c'$ **O.K.** (No. shear reinforcement required)	
		<u>Check for Development length</u>	
		$L_d = \frac{\phi\sigma_s}{4\tau_{bd}} = \frac{0.87 * f_y\phi}{4\tau_{bd}} = \frac{0.87 * 415 * \phi}{4 * 1.2 * 1.6} = 47\phi$	
IS 456-2000 Table 19		$L_d = 47*12 = 564$ mm	
IS 456-2000 Clause 40.2.1.1		$L_d = 1.3M_1/V + L_o$ (let L_o anchorage length = 0) $= (1.3*9.66*10^6)/(12.685*10^3) + 0$ = 990.63 mm	
IS 456-2000 Clause 26.2.1		Since, $47\phi < 1.3M_1/V$ **O.K.**	
IS 456-2000 Clause 26.2.3.3.c			

4.5 DESIGN OF MAT FOUNDATION

Foundations are structural elements that transfers loads from the buildings or individual columns to the earth. If these loads are to be properly transmitted, foundation must be designed to prevent excessive settlement or rotation to minimize differential settlement and to provide adequate safety against sliding and overturning. If the loads transmitted by the columns in the structure are so heavy or the allowable soil pressure so small that individual footings would cover more than 50% of the whole area it may be better to provide continuous footing under all columns and walls. Such a footing is called a raft or mat foundation. The raft is designed by analyzing it as a series of continuous strips centered on the appropriate column rows in both directions.

Total vertical column load = 22838.22KN

Area of Foundation = 25.45*10.4 =264.

68 m^2

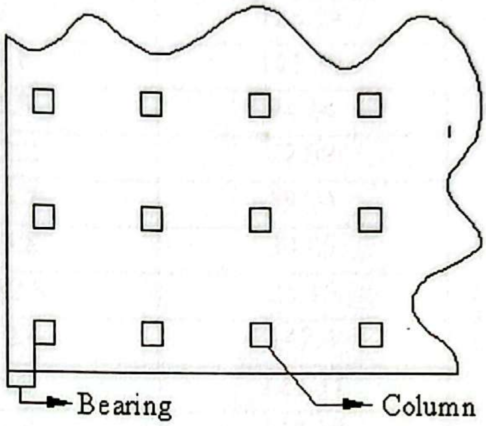


Fig. Mat Foundation (Plan)

Centroid of the plan ($\bar{x}$, $\bar{y}$) is,

$$\bar{x} = \sum_{i=1}^{n} \frac{load * perpendiculardis\tan ce}{totalload} = 12.6\text{m}$$

$$\bar{y} = \sum_{i=1}^{n} \frac{A_i * y_i}{A_i} = 5.1 \text{ m}$$

Moment of inertia about both centroidal x and y axes using parallel axis theorem.

$$I_{xx} = \sum_{i=1}^{n} \left[(I_{xxc})_i + A_i * y_i^2 \right] = 2232.95 \text{ m}^4$$

$$I_{yy} = \sum_{i=1}^{n} \left[(I_{yyc})_i + A_i * x_i^2 \right] = 13683.68 \text{ m}^4$$

Centroid due to load ($\bar{x}_1$, $\bar{y}_1$) is,

$\bar{x}_1$ = 13.08m

$\bar{y}_1$ = 5.3m

Now,

e_x = 13.08-12.6=0.48m

e_y = 5.3-5.1=0.2m

M_x = P*e_y = 22838.22*0.48=10962.4 KN-m

M_y = P* e_x = 22838.22*0.2=4567.64 KN-m

$$\frac{P}{A} = \frac{22838.220}{264.68} = 86.28 \text{ KN/m}^2$$

Soil Pressure at different points are given by,

$$\sigma = \frac{P}{A} + \frac{M_y}{I_y} * x + \frac{M_x}{I_x} * y$$

For corner A-2,

σ = 69.746-7.013+6.155 = 68.888 KN/m^2

Other data are shown in tabular form below,

Position	x(m)	y(m)	σ (KN/M^2)
A-3	5.3	12.4	148.63
A-4	5.3	8.3	128.54
A-5	5.3	4.8	111.39
A-6	5.3	1.3	94.24
A-7	5.3	-2.2	77.09
A-8	5.3	-5.7	59.94
A-9	5.3	-9.8	39.85
A-10	5.3	-12.8	25.15
B-3	1.2	12.4	147.4
B-4	1.2	8.3	127.31
B-5	1.2	4.8	110.16
B-6	1.2	1.3	93.01
B-7	1.2	-2.2	75.86
B-8	1.2	-5.7	58.71
B-9	1.2	-9.8	38.62
B-10	1.2	-12.8	23.92
C-3	-1.2	12.4	146.68
C-4	-1.2	8.3	126.59
C-5	-1.2	4.8	109.44
C-6	-1.2	1.3	92.29
C-7	-1.2	-2.2	75.14
C-8	-1.2	-5.7	57.99
C-9	-1.2	-9.8	37.9
C-10	-1.2	-12.8	23.2
D-3	-5.3	12.4	145.45
D-4	-5.3	8.3	125.36
D-5	-5.3	4.8	108.21
D-6	-5.3	1.3	91.06

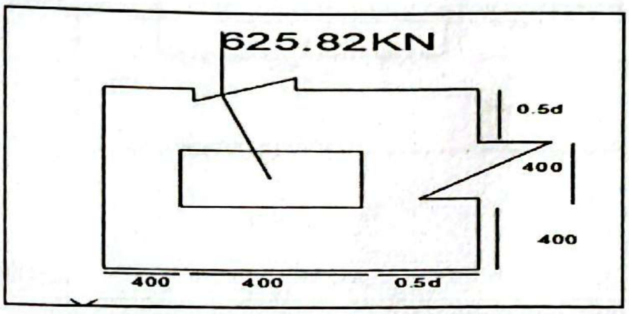
D-7	-5.3	-2.2	73.91
D-8	-5.3	-5.7	56.76
D-9	-5.3	-9.8	36.67
D-10	-5.3	-12.8	21.97

The depth of the mat foundation shall be governed by two way shear also known as punching shear. In case location of critical shear is not obvious it may be necessary to check in all possible direction.

Shear strength of concrete,

$$\tau_c = \tau_c = 0.25\sqrt{f_{ck}}$$
$$= 0.25\sqrt{25}$$
$$= 1.25 \text{ N/mm}^2$$

1) For column A-3:



Perimeter b_o = 2*(400+400+0.5d)

= (1600+d)

$$\tau_c = \frac{V_u}{bd}$$

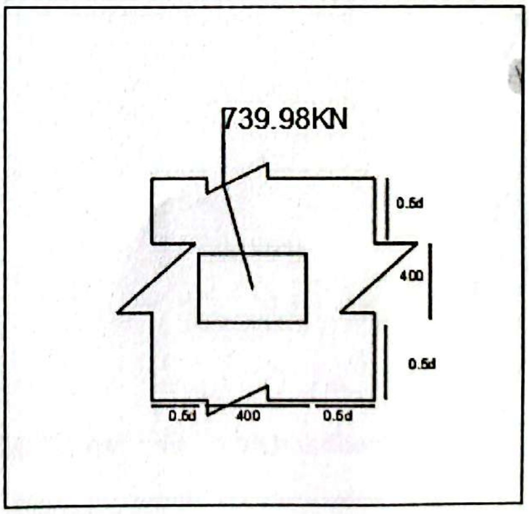
Where,

V_u = Max. Ultimate force at corner edge column.

$$1.25 = \frac{1.5 * 625.82 * 1000}{(1600 + d) * d}$$

Thus, d = 379.4 mm

2) For column C-5:



Perimeter, b_o = 4*(400+d)

= (1600+d)

$$\tau_c = \frac{V_u}{bd}$$

$$1.25 = \frac{1.5 * 739.98 * 1000}{(1600 + d) * d}$$

Thus, d = 436.11 mm

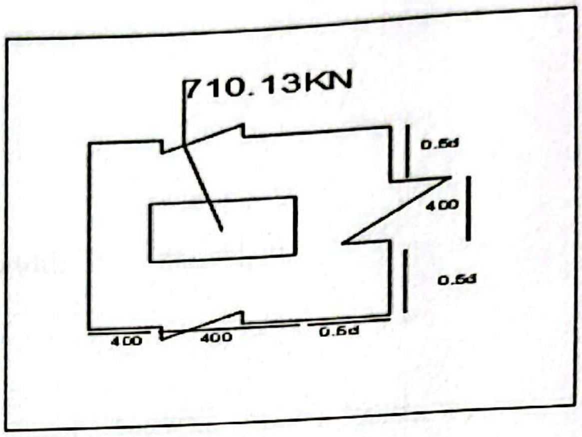
4) For column B-3: (17)

Perimeter, b_o = 2*(400+400+0.5d)+(0.5d+0.5d+400)
= (2000+2d)

$$\tau_c = \frac{V_u}{bd}$$

$$1.25 = \frac{1.5 * 710.13 * 1000}{(2000 + 2d) * d}$$

Thus, d = 322.23 m



Adopt effective depth = 450 mm

Adopt overall depth = 450+2*75 = 600mm

(Taking eff. cover = 75mm)

Calculation of required area of Rebar:

We have,

$$BM = 0.87*f_y*A_{st}*\left[d - \frac{f_y * A_{st}}{f_{ck} * b}\right]$$

Here,

d = 450mm

b = 1000mm

f_y = 500 Mpa

f_{ck} = 25 Mpa

The loading for BM calculation is assumed as UDL having intensity W , which is the max. of intensities at the edges of the corresponding strip.

Along X - direction:

The bending moment (BM) was obtained using the coefficient 1/10 and length (l) as center to center of column distance. (IS: 456:2000 CI.22.5.1121 Table 12)

For strip A-A:

$W = 148.63\ KN/m^2$

$$BM = \frac{Wl^2}{10} = \frac{148.63 * 4.1^2}{10} = 249.84 \text{ KN-m per m width}$$

$A_{st} = 1277.14\ mm^2$

For strip B-B:

$W = 147.4\ KN/m^2$

$$BM = \frac{Wl^2}{10} = \frac{147.4 * 4.1^2}{10} = 247.779 \text{ KN-m per m width}$$

$A_{st} = 1346.35\ mm^2$

For strip C-C :

$W = 146.68\ KN/m^2$

$$BM = \frac{Wl^2}{10} = \frac{146.68 * 4.1^2}{10} = 246.6 \text{ KN-m per m width}$$

$A_{st} = 1339.5\ mm^2$

For strip D-D:

$W = 145.45\ KN/m^2$

$$BM = \frac{Wl^2}{10} = \frac{145.45 * 4.1^2}{10} = 244.5 \text{KN-m per m width}$$

$A_{st} = 1327.34\ mm^2$

Along Y - direction:

The bending moment (BM) was obtained by using coefficient 1/12 and length (l) as center to center of column distance (IS: 456: 2000 CI.22.5.1121 Table 12)

For strip 3-3 :

$W = 148.6\ KN/m^2$

$BM = \frac{148.6 * 4.1^2}{12} = 208.16$ KN-m per m width

$A_{st} = 1119\ mm^2$

For strip 4-4 :

$W = 128.5\ KN/m^2$

$BM = \frac{128.5 * 4.1^2}{12} = 180$ KN-m per m width

$A_{st} = 960.54\ mm^2$

For strip 5-5 :

$W = 111.4\ KN/m^2$

$BM = \frac{111.4 * 4.1^2}{12} = 156.05$ KN-m per m width

$A_{st} = 827.6\ mm^2$

For strip 6-6 :

$W = 94.24\ KN/m^2$

$BM = \frac{94.24 * 4.1^2}{12} = 132.014$ KN-m per m width

$A_{st} = 696.06\ mm^2$

For strip 7-7 :

$W = 77.09\ KN/m^2$

$BM = \frac{77.09 * 4.1^2}{12} = 108$ KN-m per m width

$A_{st} = 960.54\ mm^2$

For strip 8-8 :

$W = 59.54\ KN/m^2$

$BM = \frac{59.54 * 4.1^2}{12} = 83.4$ KN-m per m width

$A_{st} = 434.44\ mm^2$

For strip 9-9 :

W = 39.85 KN/m^2

$$BM = \frac{39.85 * 4.1^2}{12} = 55.82 \text{ KN-m per m width}$$

A_{st} = 288.86 mm^2

For strip 10-10 :

W = 25.15 KN/m^2

$$BM = \frac{25.15 * 4.1^2}{12} = 35.23 \text{ KN-m per m width}$$

A_{st} = 181.43 mm^2

Summary

Required area of Rebar, A_{st} (in mm^2)

Along X - direction:

Strip	Strip	Strip	Strip
A-A	B-B	C-C	D-D
1277.14	1346.35	1339.5	1327.34

Along Y - direction:

Strip	Strip	Strip	Strip	Strip
3-3	4-4	5-5	6-6	7-7
1119	960.54	827.6	696.06	960.54

Strip	Strip	Strip
8-8	9-9	10-10
434.44	288.86	181.43

Calculation of Spacing:

Along x - direction:

Strip	Dia. provided (mm)	Spacing (mm)
A-A	16	157.43
B-B	16	149.33
C-C	16	150.1
D-D	16	151.5

Spacing of Grid A-A to D-D = 16 mm dia. @ 150 mm c/c

Along Y - direction:

Strip	Dia. Provided (mm)	Spacing (mm)
3-3	16	180.6
4-4	16	209.3
5-5	16	242.9
6-6	16	288.85
7-7	16	209.32
8-8	16	462.80
9-9	16	696.046
10-10	16	1108

Spacing of Grid 3-3 TO 10-10 = 16 mm dia. @ 250 mm c/c

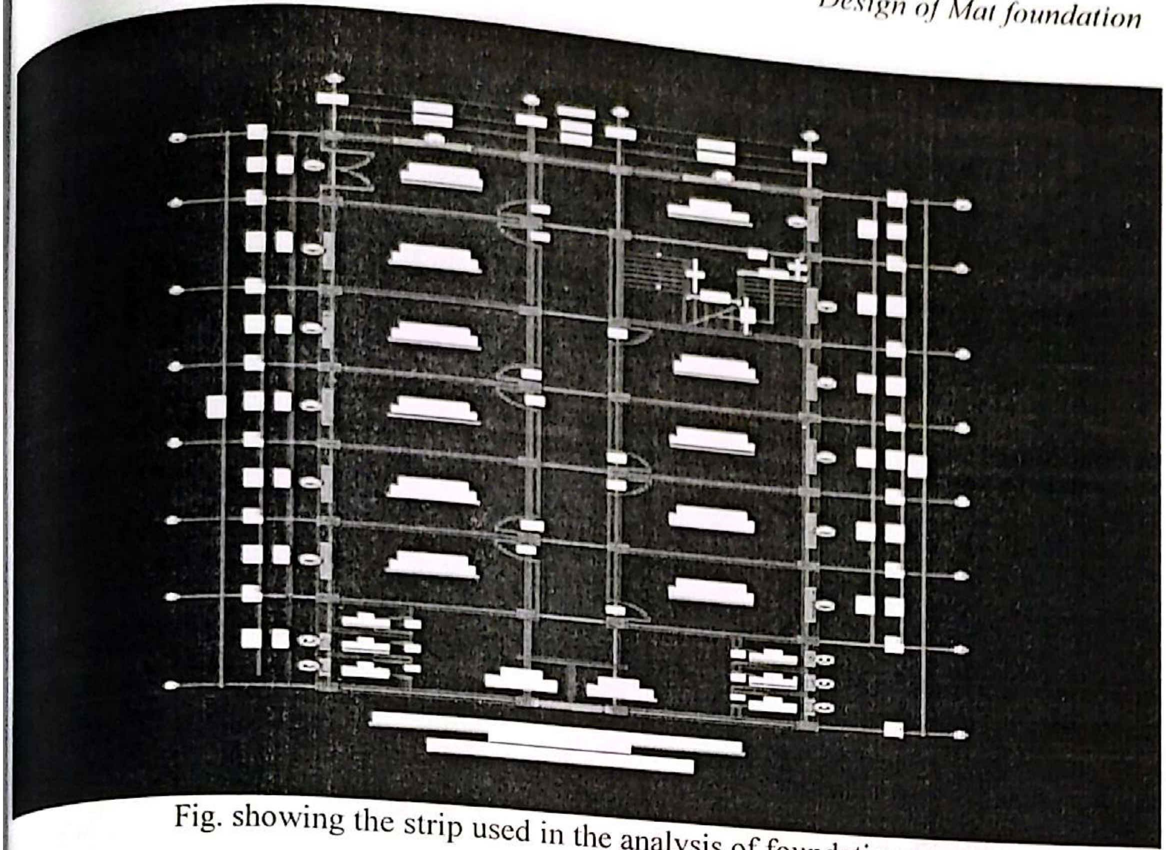


Fig. showing the strip used in the analysis of foundation

- Strips parallel to the Horizontal direction in the above figure are named in the alphabetical order.
- Strips parallel to the Vertical direction in the above figure are named in the numerical order.
- For the analysis of all intermediate strip, 1m strip is taken with its central line corresponding to the centre line of columns.
- For the analysis of the entire edge strip, 1m strip is taken inward from edge of the mat.

4.6 DESIGN OF BASEMENT WALL

Basement wall or retaining wall is a reinforced cement concrete structure generally built beneath the ground level. The main purpose of designing this structural member is to retain the lateral active pressures of earth, seepage as well as surcharge load due to vehicles. It is designed for both moment and shear criteria.

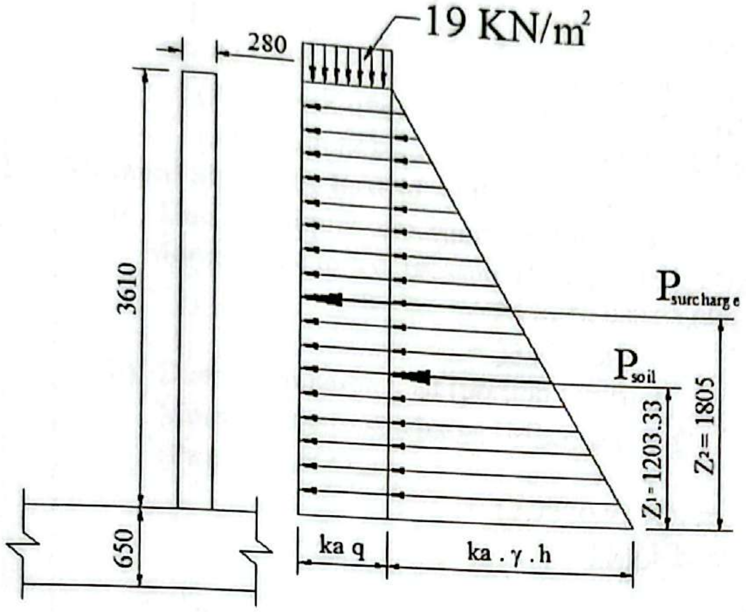


Fig. showing lateral active pressure distribution on basement wall

Design constants:

Cantilever retaining wall

f_y = 500 N/mm ^{2}

f_{ck} = 20 N/mm ^{2}

Specific wt. of soil (γ_s) = 19 KN/m^3

Angle of internal friction of soil (ϕ_s) = 30°

Height of wall (h) = 2.8 m

Specific wt. of water (γ_w) = 10 KN/m^3

Surcharge load (q) = 19KN/m^2 (Considering heavy vehicle like loaded truck)

Then, Coefficient of active earth pressure (k_a) is,

$$K_a = \left(\frac{1 - Sin\phi_s}{1 + Sin\phi_s}\right) = 1/3 = 0.333$$

Sample Calculation

Reference	Step	Calculation	Remarks
	1	**Calculation of Earth pressure** Considering pressure per meter width of wall, Total active earth pressure due to soil, $(Pa)_{soil} = (1/2*k_a\gamma_s h*h)$ $=(1/2*1/3*19*2.8^2)$ $= 24.82$ KN Lever arm $(Z)_{soil} = 1/3*h = 1/3*2.8 = 0.93$ m Total active earth pressure due to surcharge, $(Pa)_{sur} = (k_a q*h) = (1/3*19*2.8) = 17.73$ KN Lever arm $(Z)_{surcharge} = h/2 = (2.8/2) = 1.4$ m	
	2	**Moment about the base of wall** i) Due to soil pressure, (portion II in fig.) Moment due to soil pressure $(M)_{soil} = (Pa)_{soil}*(Z)_{soil}$ $= 24.82*0.93 = 23.09$ KN-m = <u>23 KN-m</u> ii) Due to surcharge load (portion I in fig.) Moment due to surcharge $(M)_{surcharge} =$ $(Pa)_{surcharge}*(Z)_{soil}$ $= 17.73*0.93$ KN-m = <u>16.5 KN-m</u> $\therefore$ Total moment at base (M) = 39.5 KN-m Ultimate Moment $(M_{11}) = 1.5*39.5$ **= 59.25 KN-m**	
IS 456-2000 Clause 32.2.3	3	**Thickness of wall** Assuming height/thickness ratio = 20 Height of basement wall (h) = 2.8m = 2800 mm Then, thickness of wall (d) = (h/20) = (2800/20) = 140 mm Total thickness (D) = d + cover + $\phi/2$ = (140 +50 +16/2) mm = 198 mm Adopt D = 200 mm Then, Thickness (d) = 200– 50 = 150 mm (effective)	
IS 456-2000 Annex G	4	**Calculation of Effective depth (d)** $d = \sqrt{\dfrac{M_u}{0.138bf_{ck}}} = \sqrt{\dfrac{59.25*10^6}{0.133*1000*25}} = 133.5$ mm So, Adopt **d = 150 mm** Overall depth **(D)** = d + 50 (= effective cover) **= 200 mm**	
IS 456-2000 Annex G	5	**Calculation of Limiting Moment ($M_{u,lim}$)** $M_{u,\,lim} = 0.138f_{ck}bd^2$ $= 0.133*25*1000*150*150$ = 75 KN-m Since, Mu,lim > Mu, design is singly reinforced	

IS 456-2000 Annex G	6	**Calculation of main reinforcement (Vertical)** Area of steel required per meter is given by $Mu = 0.87*fy*Ast*(d-\frac{f_y A_{st}}{f_{ck} b})$ i.e $59.25*10^6 = 0.87*500*Ast\left(150-\frac{500*A_{st}}{25*1000}\right)$ Hence, Ast = 6442.98 mm2 Providing 25 mm dia. Bars. No. of bars (N) = $\left(\frac{6442.98}{\pi*25^2/4}\right) = 13.12 \approx 14$ Nos. Spacing required (S) = Ast provided *1000/Ast required =1066.62 mm ≈ 1000 mm Provide 25 mm ϕ bars @ 1000 mm c/c Provided area of steel = 6872.23 mm^2	
IS 456-2000 Cl. 32.5	7	**Check for minimum reinforcement** $A_{st,min}$ = 0.12 % of bD = 0.12/100*1000*200 = 240 mm^2 $A_{st,min} < A_{st,\ provided}$ **O.K.** **Check for Max. dia.** Max. Dia. = 1/8*D = 1/8*200 = 25 mm ≥ 25 mm **O.K.**	
IS 456-2000 32.5.2.a	8	**Check for maximum spacing** The maximum spacing of main reinforcement shall not exceed the following:	
	9	a. 3d = 3*200 = 600 mm b. 450 mm Provided spacing (450 mm) < min. spacing (a & b) **O.K.**	
IS 456-2000 Cl.32.5.2.a IS 456-2000 Cl.32.5 (1)	10	**Area of distribution steel (Horizontal bar)** Providing minimum steel = 0.20% of hD = (0.2/100)*2800*200 mm^2 = 1120 mm^2 As temperature changes occur at front face of retaining wall, 2/3rd of horizontal reinforcement is provided on front face and 1/3rd of horizontal reinforcement is provided on inner face *Front face horizontal reinforcement* = 2/3*1120 = 746.66 mm^2 *Inner face horizontal reinforcement* = 1/3*1120 = 373.33 mm^2 Providing 8 mm dia. Bars. i) In front face, No. of bars (N) = $\left(\frac{746.66}{\pi*8^2/4}\right)$	

		= 14.85 ≈ 15 Nos. Spacing required (S) =Ast provided*1000/Ast req = 150 mm **Provide 8 mm ϕ bars @ 150 mm c/c** ii) In inner face, No. of bars (N) = $\left(\frac{373.33}{\pi * 8^2/4}\right)$ = 7.4≈ 8 No. Spacing required (S) = (Height – 2*cover – dia.)/(N – 1) = (2800 – 2*75 – 8)/(8 – 1) = 18501 mm **Provide 8 mm ϕ bars @ 260 mm c/c**	
	11.	**Check for maximum spacing** The maximum spacing of main reinforcement shall not exceed the following: a. 3d = 3*230 = 690 mm b. 450 mm Provided spacing= 450 (i & ii) < Max. spacing (a & b) **O.K.**	
IS 456-2000 Clause 32.5.(b &d)	**12**	**Inner face vertical reinforcement** To support these horizontal bars on the inner face, vertical bars are used The maximum spacing of main reinforcement shall not exceed the following: a. 3d = 3*230 = 690 mm b. 450 mm **Provide 10 mm ϕ bars @ 450 mm c/c** `	
IS 456 – 2000 Clause 32.5.a (1)	**13.**	**Check for shear** Maximum shear occurs at support (fixed) i.e. at the base of wall Then, V_{max} = (6.333*2.8 +½*21.6*2.8) = KN Nominal shear stress (τ_v) = V_u/bd = $(61.85*10^3)/(1000*230)$ = 0.269 N/mm^2 As provided, area of steel = 2010.62 mm^2 So, 100A_s/bd = (2010.62*100*)/(1000*230) = 0.874% Then, for M20 concrete (from Table 19)	
IS 456-2000 Clause 40.1		Design shear strength (τ_c) = 0.589 N/mm^2 (Interpolating the value in table with respect to M20 and	

IS 456-2000 Table 19 IS 456-2000 Clause 26.2.1	14.	value of $100A_s/bd$) Here, $\tau_c > \tau_v$, So, design is safe in shear and shear reinforcement is not required. **Again,** **Curtailment of Vertical Reinforcement (Outer face)** No bars can be curtailed in less than L_d distance from the bottom Development length of bar, $L_d = \frac{\phi\sigma_s}{4\tau_{bd}} = \frac{\phi * 0.87 * f_y}{4\tau_{bd}}$ For M20, $\tau_{bd} = 1.2*1.6 = 1.92$ $L_d = (0.87*415\ Ø)/(4*1.2*1.6)$ $= 47Ø = 47*16 = 752$ mm **Let** us curtail bars at 1/3rd distance from bottom i.e. 3.61/3 = 1.203 m $Z_3 = 3.61 - 1.203 = 2.407$ m $P'_{soil} = ½*k_a\gamma_s*Z_3^2 = ½*1/3*18*2.407^2*1$ $= 17.38$ KN per m Lever arm $(Z_1') = 2.407/3 = 0.802$ m $P'_{surcharge} = k_a*q*Z_3 = 1/3*19*2.407 = 15.24$ KN Lever arm $(Z_2') = 2.407/2 = 1.203$ m Taking moment at section i.e. 1/3rd height from base Moment = 17.38*0.802 + 15.24*1.203 = 32.27 KN-m Ultimate moment $(M_{22}) = 1.5*32.27 = 48.40$ KN-m Since, $M_{22} <$ 50% of M_{11}, so, spacing of vertical bars are doubled from the height of 1/3rd of base of wall. Hence Adopt **16mm dia. bars @ 200 mm c/c**	

CHAPTER-5

DETAILING OF STRUCTURAL ELEMENTS

Detailing refers primarily to the determination of the number, size, layout and location of reinforcement, given the element dimensions and areas of steel required. While certain details such as lap and development lengths, hook requirements, cut-off points etc. are covered by the code, the logic in many situations has to b e developed individually by the designer on the basis of sound engineering judgment. It is useless if design calculations are represented by a set of poorly detailed drawings.

Requirements of good detailing

A good detailing must fulfill the following requirements:

- Special attention is given at knee joints or corner joints under opening and closing loads
- The ductile detailing is the major part to be improved for improving seismic resistance.
- To improve the seismic performance of the joint
  - ✓ Provide full anchorage to beam bars in column
  - ✓ Provide confinements at the joint also
  - ✓ Put beam bars inside the column bar
  - ✓ Make extra care during concreting to protect form honeycombing
- Reinforcement detailing should be simple for fabrication and placing
- Cracks widths must be within acceptable limits under service conditions. This is achieved by limiting the spacing of reinforcement and minimum amount of reinforcement
- There should be sufficient space for concrete to be properly poured and compacted that is achieved by minimum spacing between bars and thus avoiding congestion of reinforcement
- The detailing should be such that internal forces are safely transferred from one member to another and from reinforcement to concrete
- Detailing of member as per code IS 13920 – 1993 considering the earthquake load and concentrated loads uniformly distributed loads, uniformly varying loads, random loads, internal load and dynamic forces

CHAPTER-6

RESULT

From above project work in building, we had obtained the following result of various structural elements as:

Overall

Beam	=	300 mm ×400 mm
Slab (Seminar hall) thickness	=	130 mm
Slab (Others) thickness	=	130 mm
Column	=	400 mm × 400mm
Staircase (Waist slab thickness)	=	127 mm (5")
Riser	=	155 mm (6")
Tread	=	254 mm (10")
Foundation	=	650 mm

CHAPTER-7

CONCLUSION AND DISCUSSION

1) Seismic analysis was done during the project by taking lateral / earthquake load which makes our building earthquake resistance. Earthquake force in a building was determined by using seismic coefficient method or static method. While comparing between earthquake load and wind load, it was found that earthquake was pre-dominant than the wind load. So, the effect of earthquake load was only considered.

While calculating lateral load, the base shear was obtained by mass lumped at floor level. The value of base shear was 2063.025 KN and total mass of the building was 15748.28 KN.

Also, the storey drift was within the limit i.e. hadn't exceed 0.004 times the storey height. And the time period taken while base shear calculation was 0.6285 sec whereas the time period obtained by ETABS analysis was 0.376 sec

2) Regarding design and detailing, limit state method for collapse and serviceability and ductile detailing were considered. While designing the structural members, in the case of beam, column and foundation, the most dominant combination were 1.2 (DL+ LL ± EL), (0.9 DL± 1.5 EL), 1.5(DL± EQ) and 1.5 (DL+LL) etc respectively.

3) The net bearing capacity of soil was 130 KN/m^2 and the maximum pressure at the edges of the building was 86.037 KN/m^2 which was less than the maximum net bearing capacity, hence concluded that the design was within the limit.

CHAPTER-8

RECOMMEDATIONS

Dynamic Analysis can be recommended.

In our context, we have used seismic coefficient method or static analysis, which is used for only the building within 40 m height. But dynamic analysis or response spectrum method or modal analysis may also be used in which maximum response is represented having certain period of vibration and damping.

Expansion joint may be designed.

Generally, in codes we can find that generally structures exceeding 45 m in length are designed with one or more expansion joints. However, many factors such as location, spacing and nature govern the provision for the expansion joints in RCC structures. It also depends upon the designer judgment. In our project, provision of a single expansion joint can be significant.

Restrained at ground level may be possible.

Due to the presence of ventilation windows in the basement storey, we have restrained our building at the basement level. In the case of lack of ventilation and full basement wall with RCC, then restrained to ground level may be recommended.

Fire Resistance.

A structure may be designed to posses an appropriate degree of resistance to flame penetration.

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Codes of Practice used

IS 456 – 2000 (Code of practice for plain & reinforced concrete)
IS 1893 – 2002 (Criteria for Earthquake resistant – Design of structures)
IS 875 (Part 2) – 1987 (Code of practice for Design loads – Imposed Loads)
IS 875 (Part 3) – 1987 (Code of practice for Design loads – Wind Loads)
IS 456-1978 (SP 16 - Design Aids for Reinforcement Concrete)
SP 34 – 1987 (Handbook on Concrete Reinforcement and Detailing)
IS 13920 – 1993 (Ductile detailing of RC structure subjected to seismic forces)

APPENDIX:

STAIRCASE LOADING ON SUPPORT BEAM

S.N	Discription	Value	Unit	Remarks
1	INPUTED DATA			
	Rise, R	0.15	m	From provided drawings
	Tread, T	0.25	m	
	Steps, S = $\sqrt{R^2+T^2}$	0.30	m	
	Width of staircase, b	1.42	m	
	Unit weight of R.C.C., (γr)	25.00	kN/m^3	
	Live load, LL	3	kN/m^2	
	Floor finishing load , FL	1	kN/m^2	
	Thickness of waist slab, D	127	mm	
	TYPE OF STAIRCASE :	**OPEN WELL**		
2	FOR FIRST FLIGHT AND THRID FLIGHT'S INPUT			
	Length of first flight, l	1.45	m	
	Length of 1st landing,	1.60	m	
	Number of steps in 1st flight, n	6.00	no.s	
	Inclination, θ	32	degree	
	Inclined length of 1st flight, L = l/COS(θ)	1.71	m	
3	FOR MID FLIGHT'S INPUT			
	Length of mid flight,lm	1.24	m	
	Length of mid landing,	1.45	m	
	Number of steps in mid flight,	5	no.s	
	Inclination, θ	32	degree	
	Inclined length of 1st flight, Lm = lm/COS(θ)	1.47	m	
4	LOAD CALCULATION FOR FIRST FLIGHT			
	Volume of concrete for first flight, Vf	0.89	mm^3	
	Total dead load of first flight, DLf = Vf*γr	22.32	kN	
	Dead load per width of staircase, DLw = DLf/b	15.69	kN/m	
	Live load per width of staircase, LLw = LL/b	12.09	kN/m	
	Floor finishing load per width of staircase, FLw = FL/b	4.03	kN/m	
	Total load per widhth of staircase, TLw = DLw +LLw+FLw	31.81	kN/m	
	Load on each beam per width of staircase, Lw = TLw/2	**15.91**	**kN/m**	
5	LOAD CALCULATION FOR MID FLIGHT			
	Volume of concrete for mid flight, Vf	0.67	mm^3	
	Total dead load of mid flight, DLf = Vf*γr	16.65	kN	
	Dead load per width of staircase, DLw = DLf/b	11.71	kN/m	
	Live load per width of staircase, LLw = LL/b	8.75	kN/m	
	Floor finishing load per width of staircase, FLw = FL/b	2.92	kN/m	
	Total load per widhth of staircase, TLw = DLw +LLw+FLw	23.37	kN/m	
	Load on each beam per width of staircase, Lw = TLw/2	**11.68**	**kN/m**	

6	inch
10	inch
feet	inch
4	8

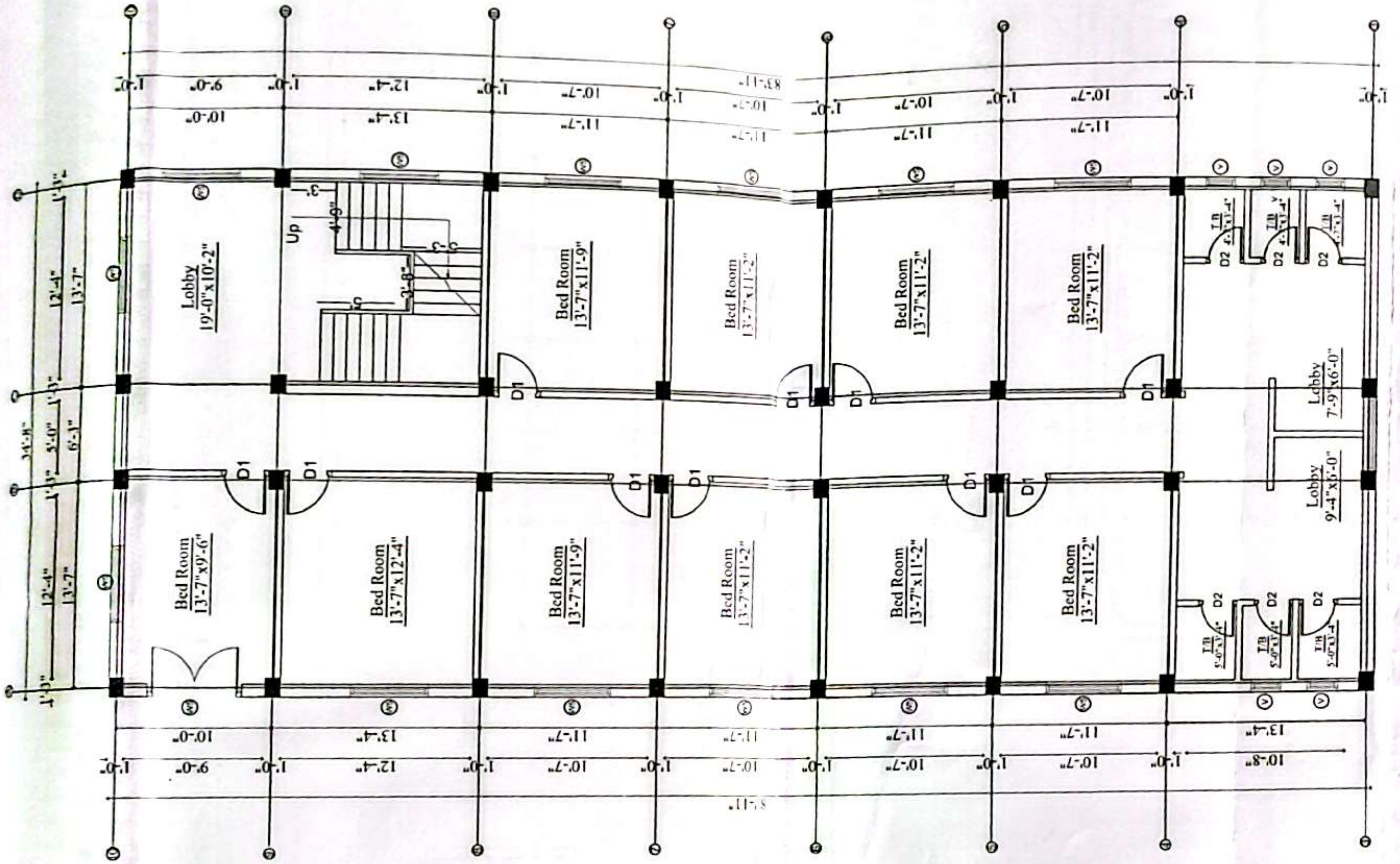
6.944444444

feet	inch
4	9
5	3

feet	inch
4	1
4	9

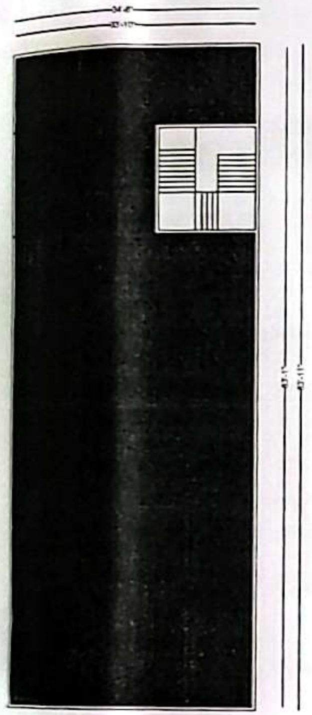
DL	9.860312
LL	6.046972
	15.90728 ok

DL	7.31153
LL	4.373108
	11.68464 ok



GROUND,1ST,2ND,3RD,4TH Floor Plan
Scale:-1"=16'-0"
Area = (2912.094909 square ft.

For office use only
Name of owner:-
location :-Biratnagar, morang
plote no:- scale :-
Area of land :-
Name of project :-Institutional building (Hostel)
Prepared By :- 1 . Surendra prasad mahato 2. Rupesh yadav 3. shivsankar mehta 4. sujan chaudhary 5. samjhana sah 6. satish chaudhary 7.Rishiraj Ram
checked By :-
Project Supervisor:- Er.Rabin bhattarai
Date :-
Approped By :-



5th floor proposed roof plan
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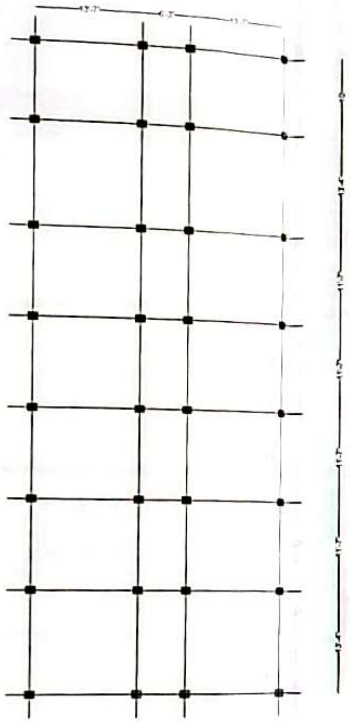

Footing plan of ground
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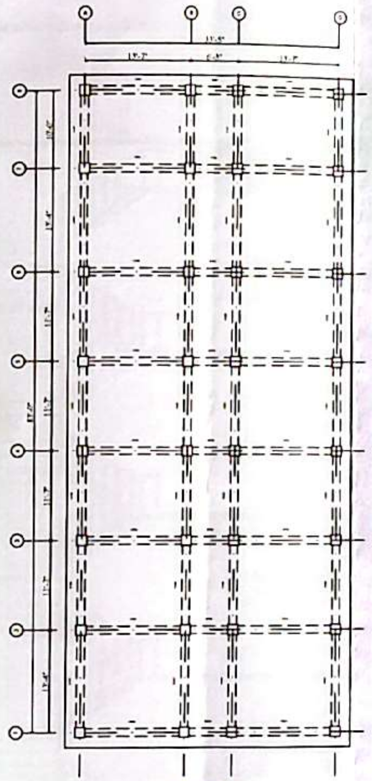
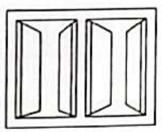
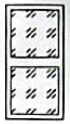
Area = (2912.094909 square ft



Concret Beam Layout
Scale -1"=16'-0"



5*4 WINDOW



VENTILATION (4*2)

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plote no:-	scale :-
Area of land :-	
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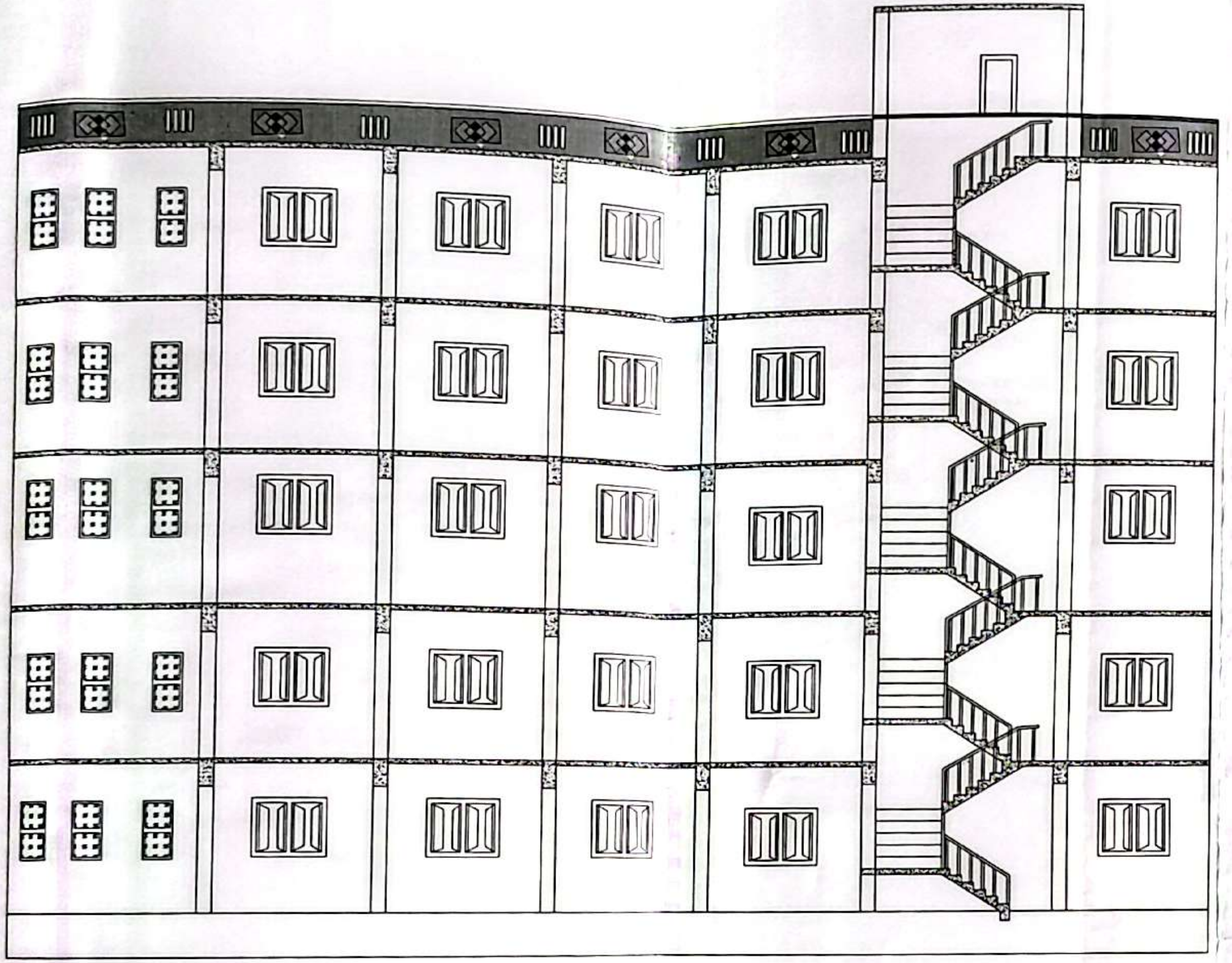
checked By :-	
Project Supervisor:- Er.Rabin bhattarai	
Date :-	
Approped By :-	



# X SECTION OF BUILDING AT AA
scale =1:8'

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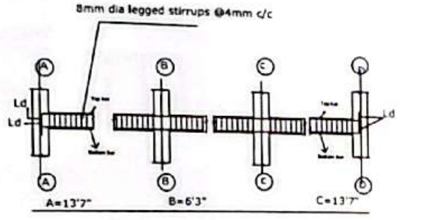
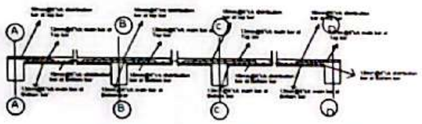
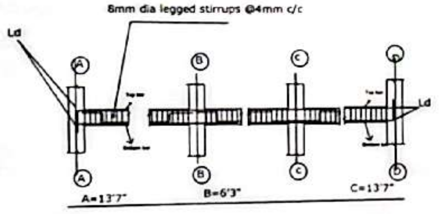
Name of owner:-
location :-Biratnagar, morang
plote no:- scale :-
Area of land :-
Name of project :-Institutional building (Hostel)
Prepared By :- 1 . Surendra prasad mahato 2. Rupesh yadav 3. shivsankar mehta 4. sujan chaudhary 5. samjhana sah 6. satish chaudhary 7. Rishiraj Ram
checked By :-
Project Supervisor:- Er.Rabin bhattarai
Date :-
Approped By :-



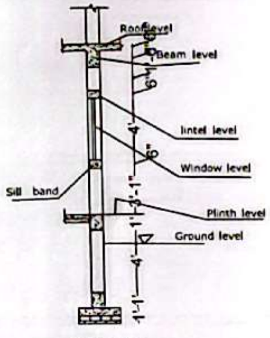
section of Tie beam along Grid A-A,B-B,C-C,D-D
SCALE -1"=2'



SECTION SHOWING SLAB REINFORCEMENT ALONG SHORT DIR.
(SCALE -1"=2')



section of FLOOR beam along Grid A-A,B-B,C-C,D-D
SCALE -1"=2'



Wall section
scale -1"=2'

For office use only

Name of owner:-

location :- Biratnagar , Morang

plote no:- scale :-1:8'

Area of land :-

Name of project :-Institutional Building (Hostel)

Prepared By :-

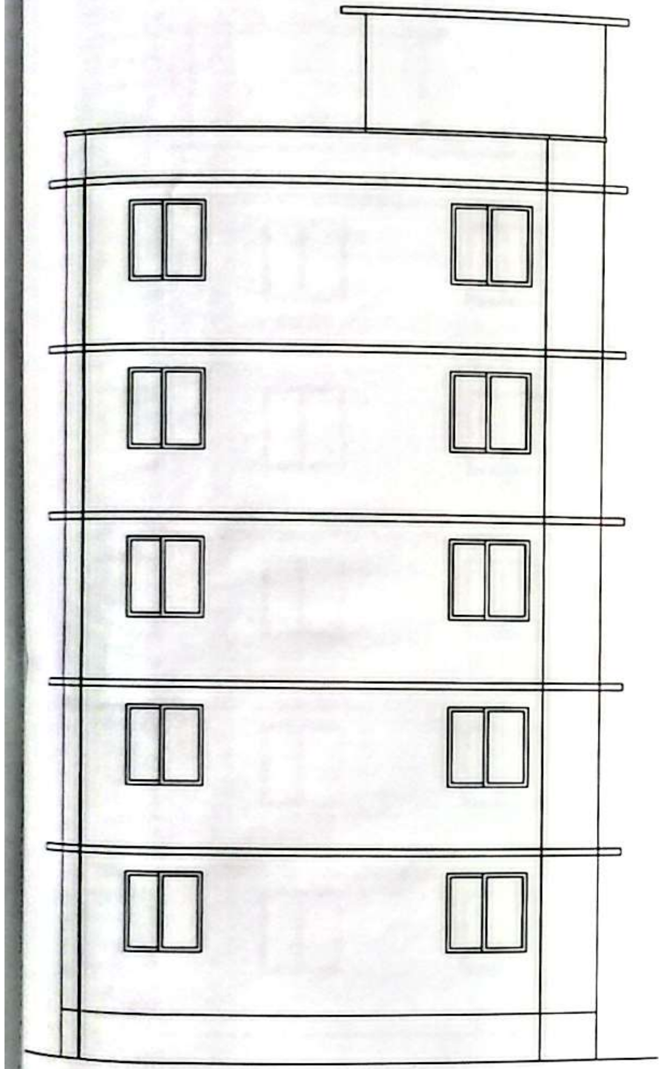
1 . Surendra prasad mahato
2. Rupesh yadav
3. shivsankar mehta
4. sujan chaudhary
5. samjhana sah
6. satish chaudhary
7. Rishiraj Ram

checked By :-

Project Supervisor:- Er.Rabin bhattarai

Date :-

Approped By :-



SOUTH ELEVATION
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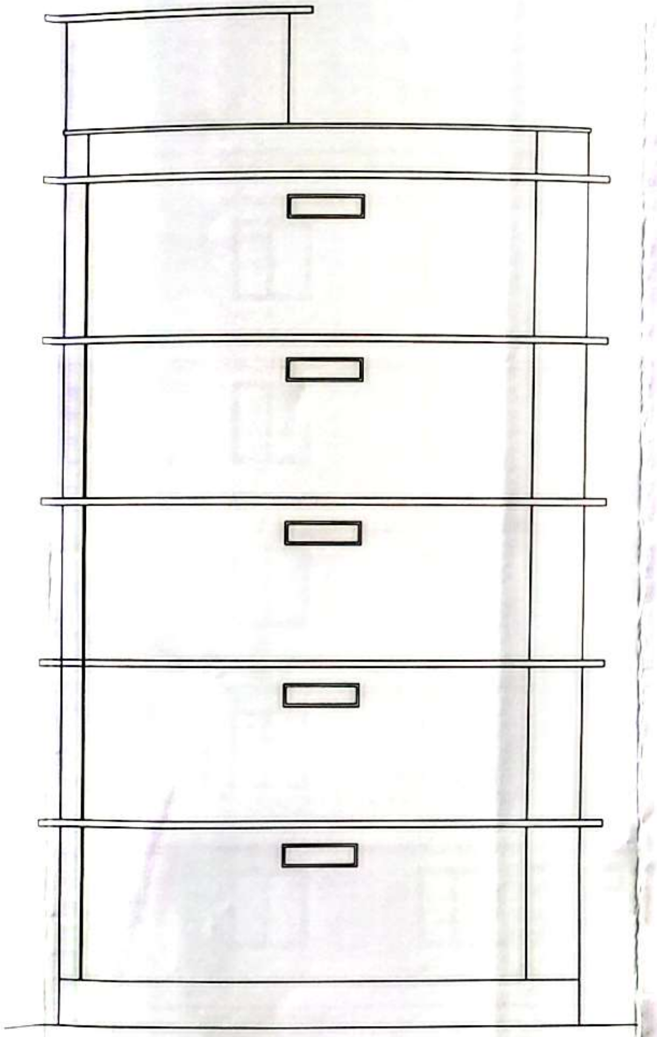

NORTH ELEVATION
Scale:-1"=8'-0"

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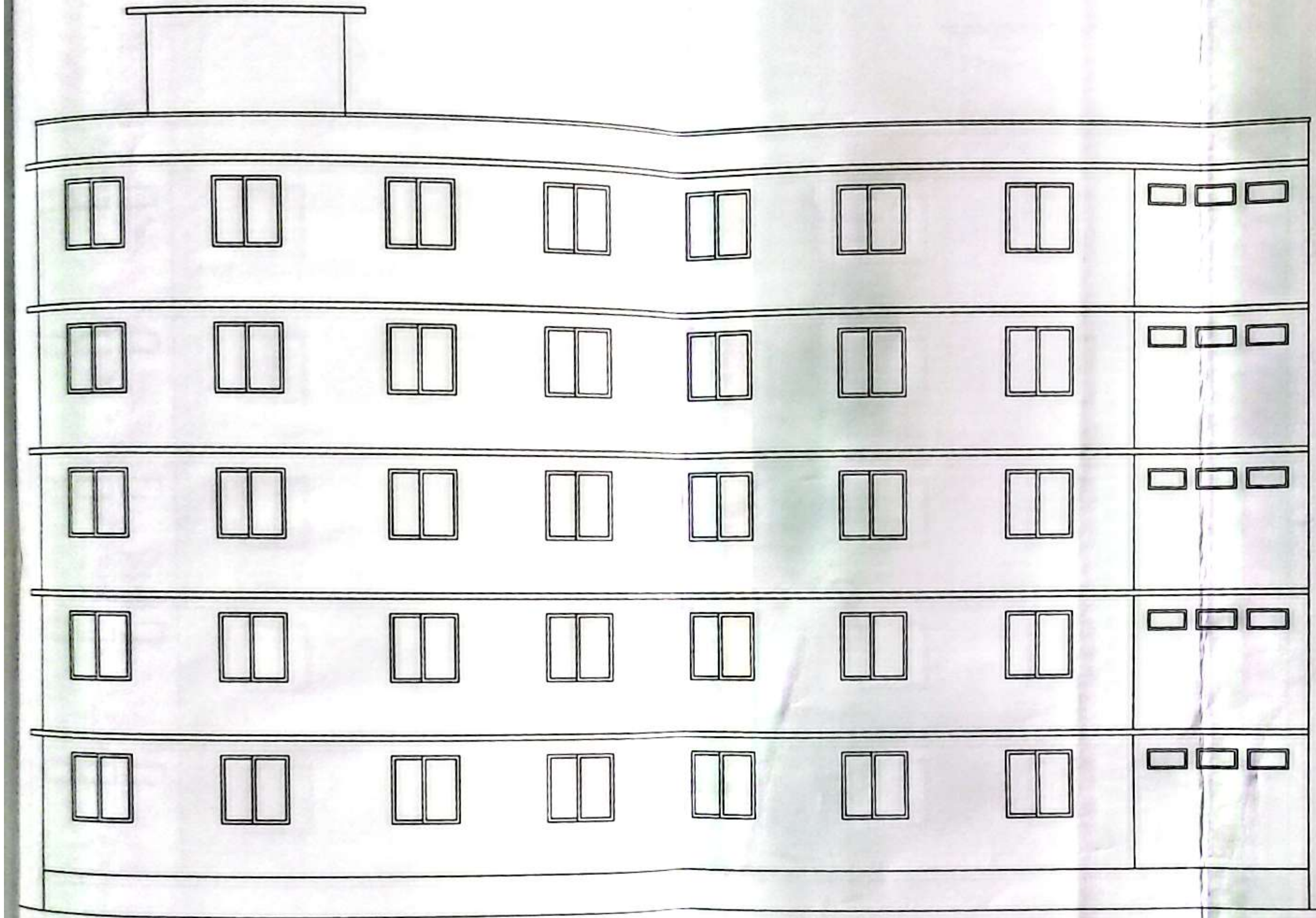
Name of owner:-
location :-Biratnagar, Morang
plote no:- scale :-
Area of land :-
Name of project :- Institutional Building (Hostel)
Prepared By :- 1 . Surendra prasad mahato 2. Rupesh yadav 3. shivsankar mehta 4. sujan chaudhary 5. samjhana sah 6. satish chaudhary 7.Rishiraj ram
checked By :-
Project Supervisor:- Er.Rabin bhattarai
Date :-
Appoved By :-



WEST ELEVATION
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For office use only
Name of owner:-
location :- Biratnagar, Morang
plote no:- scale :-
Area of land :-
Name of project :-Institutional Building (Hostel)
Prepared By :- 1 . Surendra prasad mahato 2. Rupesh yadav 3. shivsankar mehta 4. sujan chaudhary 5. samjhana sah 6. satish chaudhary 7.Rishiraj Ram
checked By :-
Project Supervisor:- Er.Rabin bhattarai
Date :-
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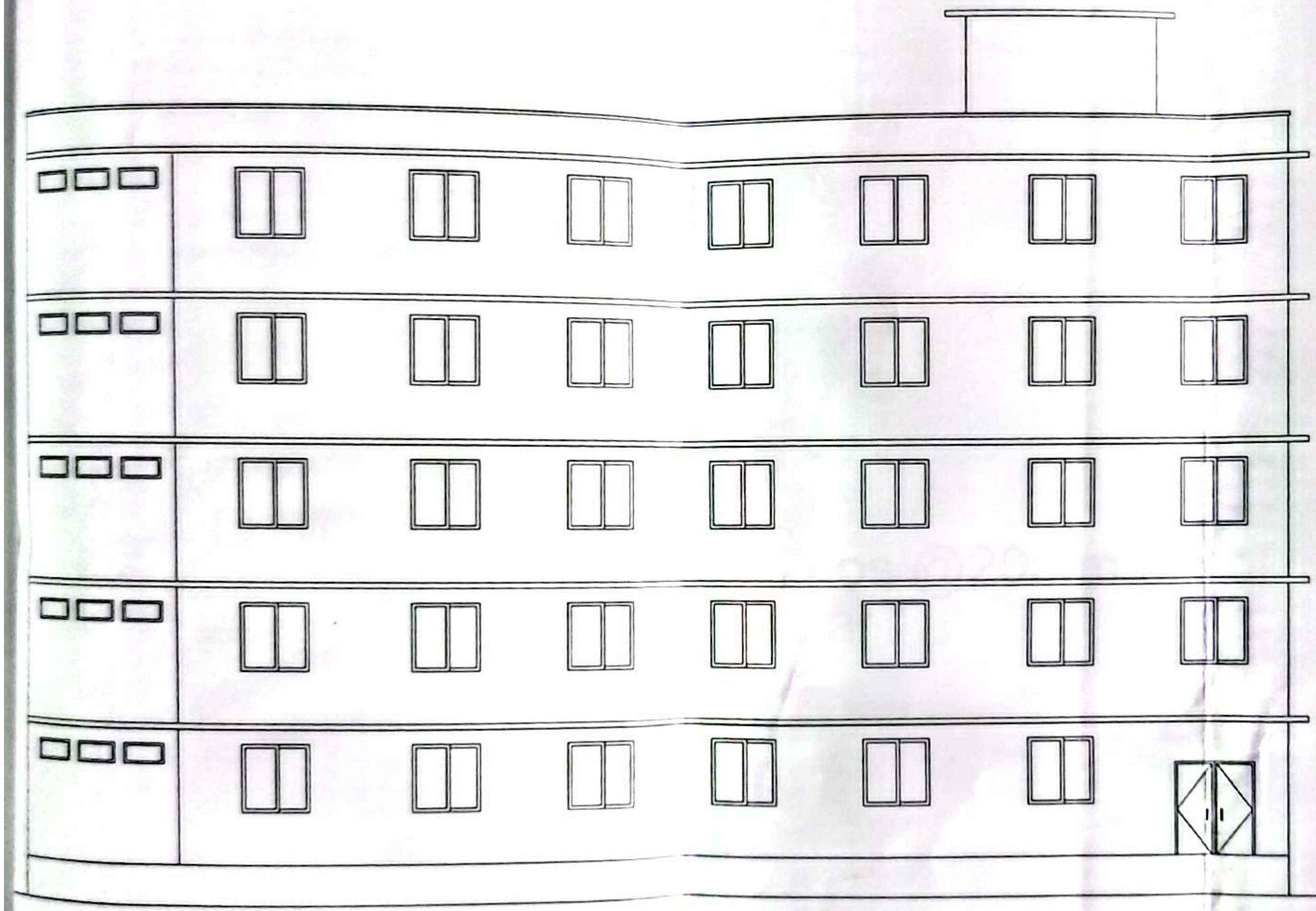

EAST ELEVATION
Scale:-1"=8'-0"

For office use only

Name of owner:-

location :-Biratnagar,Morang

plote no:- scale :-

Area of land :-

Name of project :-Institutional Building (Hostel)

Prepared By :-
1 . Surendra prasad mahato
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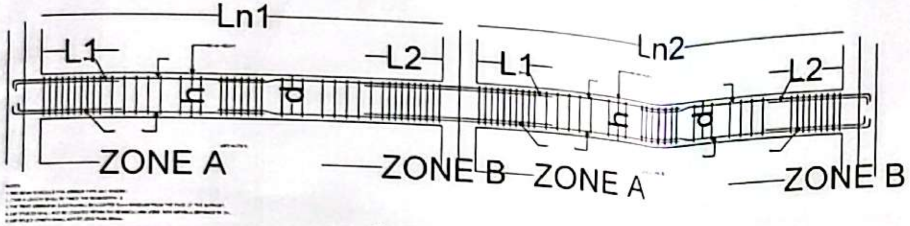
5. samjhana sah
6. satish chaudhary
7.Rishiraj Ram

checked By :-

Project Supervisor:- Er.Rabin bhattarai

Date :-

Approped By :-



Concret Beam Layout
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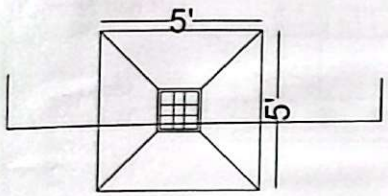
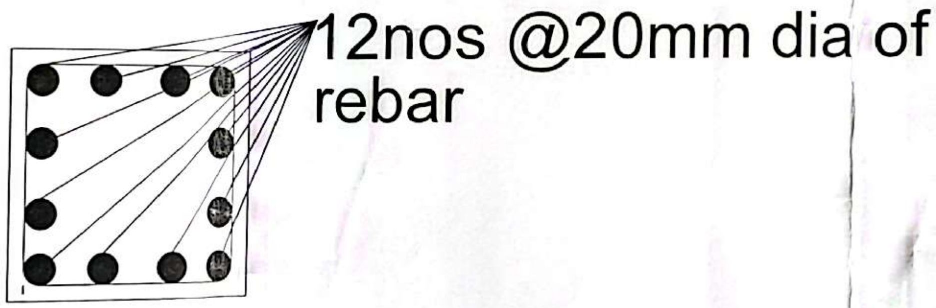


Footing plan
scale - 1"=2'0"



For office use only

Name of owner:-

location :- Biratnagar,Morang

plote no:- scale :-

Area of land :-

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Prepared By :-
1 . Surendra prasad mahato
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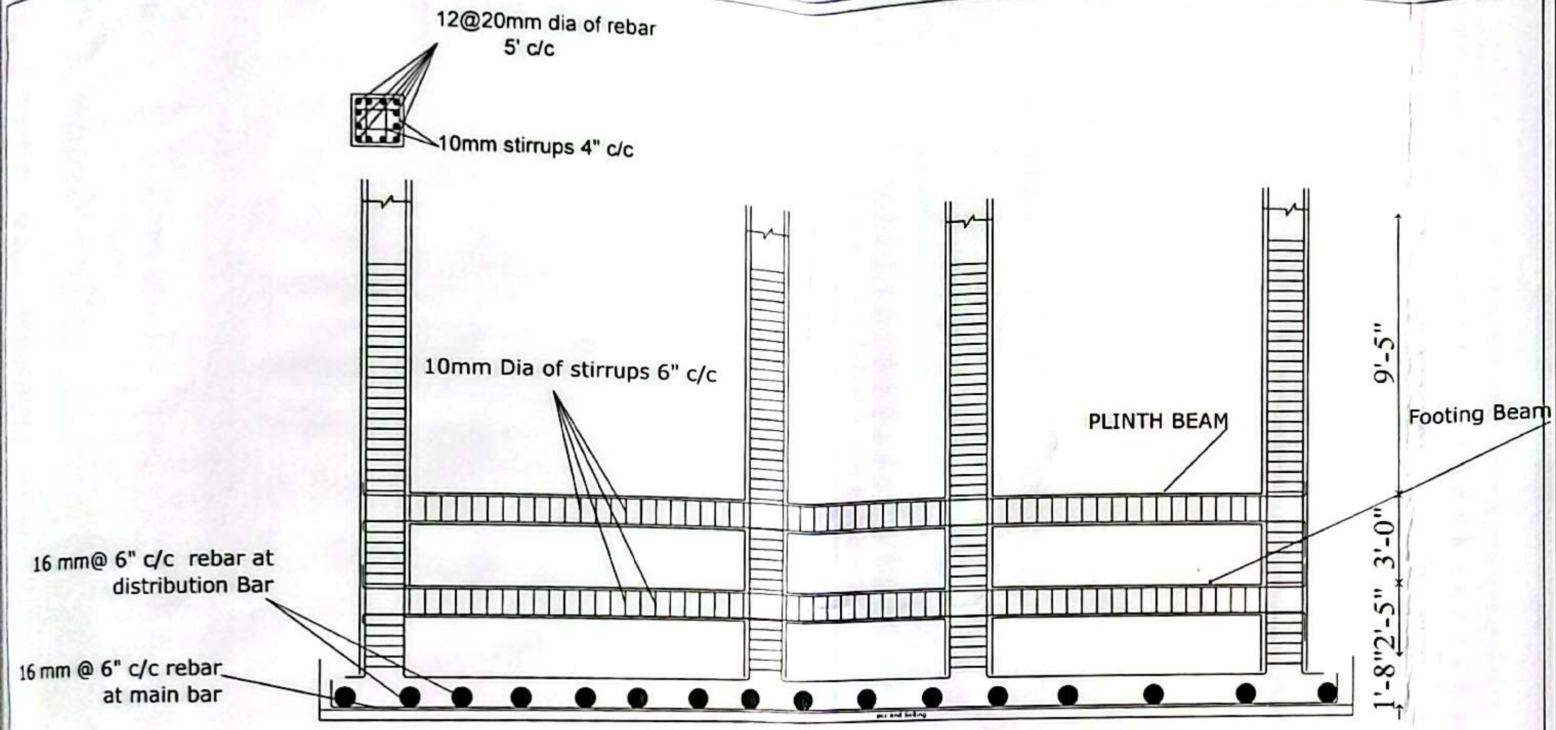
Date :-

Approped By :-



VIEW OF FOOTING ,FOUNDATION ,BEAM & PLINTH BEAM

For office use only
Name of owner:-
location :- Biratnagar,Morang
plote no:- scale :-
Area of land :-
Name of project :-Institutional Building (Hostel)
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