STRUCTURAL ECONOMICS OF EARTHQUAKE RESISTANT DESIGN OF RC BUILDING

A DISSERTATION

Submitted in partial fulfilment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY

in

EARTHQUAKE ENGINEERING

(With Specialization in Structural Dynamics)

By

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation titled STRUCTURAL ECONOMICS OF EARTHQUAKE RESISTANT DESIGN OF RC BUILDING, in partial fulfillment of the requirements for the award of the Degree of MASTER OF TECHNOLOGY in Earthquake Engineering, with specialization in Structural Dynamics, submitted to the Department of Earthquake Engineering, Indian Institute of Technology Roorkee, Roorkee, is the record of my own work carried out during the period from August 2003 to June 2004 under the supervision of Dr. S. Basu, Professor and Head and Dr. G. I. Prajapati, Professor, Department of Earthquake Engineering, Indian Institute of Technology Roorkee, Roorkee.

This matter embodied in this dissertation has not been submitted for the award of any other degree.

Dated: 30 June 2004
Place: Roorkee

(PRASHANT T. V.)

CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of our knowledge.

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I am extremely grateful to my parents for their love and support. I am also grateful to all my friends and other hostel mates who supported me during the difficult periods.

(PRASHANT T. V.)

ABSTRACT

The RC building analyzed and designed to resist the conventional loads, i.e., gravity loads and imposed load possesses adequate strength and stiffness to resist the vertical loads. Such building will not suffer damage as long as the dead loads and imposed loads are equal to or less than the loads considered for the design. Such building does not have adequate strength and stiffness when it is subjected to additional lateral loads induced by the earthquake. During earthquake, the building, which is not designed to resist the earthquake loads, gets damaged. Our country experienced many earthquakes in the past, including Gujarat earthquake of January 26, 2001.

To minimize the economic loss and loss of lives caused by earthquake, the building should be analyzed, designed and detailed such that the building does not collapse when subjected to the most severe ground motion. The simplest procedure for considering the earthquake effect is to compute design lateral loads which are considered along with the conventional loads. This procedure is valid when the building is of regular type, i.e., having symmetric plan and uniform distribution of mass and stiffness along the height of the building. For a particular building, the magnitude of the lateral loads will depend on the zone in which the building is located and the type of soil on which the building is supported.

The variation in the design lateral loads due to seismic zone and the type of soil will affect the size of the structural members like beams, columns and foundations, which in turn will influence the structural cost of the building that has been calculated by considering the cost of the materials which are structural steel and concrete. The other factors such as labour, non structural members, electrical and water fittings, etc., have not been considered.

An attempt has been made to study the structural economics of the building, i.e., the change in the structural cost when the building having the same plan dimension and height is analyzed, designed, detailed for three cases: 1) gravity loads and imposed load, i.e., conventional load using IS 456: 2000 [3], 2) conventional load and earthquake load for Zone II and 3) conventional load and earthquake load for Zone V.

The quantity of the steel and concrete for each of these three cases has been computed and the structural cost of these two materials has been found. The comparison of the structural cost has been made between case 1 and case 2 considering the material cost of beam, columns and foundation. Further, the comparison has also been made among all the three cases considering the cost of the superstructure only.

CONTENTS

LIST OF SYMBOLS

A_h	Design horizontal seismic coefficient.
A_{sc}	Area of compression reinforcement
A_{st}	Area of tension reinforcement
DBE	Design Basis Earthquake. The spectral acceleration for DBE is specified as half of the value for MCE in IS 1893:2002.
DL	Dead load
d	Base dimension of the building at plinth level in meters, along the considered direction of the lateral force.
d'	Effective cover
EL	Earthquake load
$e_{x,min}$	Minimum eccentricity on x-axis
$e_{y,min}$	Minimum eccentricity on y-axis
f_{ck}	Characteristic compressive strength of concrete
f_y	Yield strength of steel
H	Height of building in meters.
I	Importance factor depending upon the functional use of the structure.
IL	Imposed load
MCE	Maximum Considered Earthquake.
M_x	Major axis moment
M_y	Minor axis moment
M_{ex}	Moment due to minimum eccentricity on x-axis
M_{ey}	Moment due to minimum eccentricity on y-axis
M_{ux} M_{uy}	Moment about x and y axes due to design loads
M_{ux1} M_{uy1}	Max. uniaxial moment capacity for P_u, bending about x and y axis
M^{Ah}_{ulim}	Hogging moment of resistance of beam at end A
M^{As}_{ulim}	Sagging moment of resistance of beam at end A
M^{Bh}_{ulim}	Hogging moment of resistance of beam at end B
M^{Bs}_{ulim}	Sagging moment of resistance of beam at end B
M^{bL}_{ulim}	Moment of resistance of beam framing into column from the left.
M^{bR}_{ulim}	Moment of resistance of beam framing into column from the right
P_c	Percentage of compression reinforcement

P_t	Percentage of tension reinforcement
P_u	Axial load on the member
p	Percentage of reinforcement
R	Response reduction factor depending on the perceived seismic damage and performance of the structure.
RC	Reinforced concrete
$\frac{Sa}{g}$	Average response acceleration coefficient.
S_v	Spacing of stirrups.
UDL	Uniform distributed load
$V_a^{(D+L)}$	Shear at end A of beam due to dead load and live load.
$V_b^{(D+L)}$	Shear at end B of beam due to dead load and live load.
V_{us}	Shear force to be resisted by reinforcement
Z	Zone factor for MCE.
τ_c	Shear strength of concrete
τ_v	Nominal shear stress
τ_{bd}	Design bond stress

LIST OF FIGURES

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INTRODUCTION

1.1 GENERAL

The RC building designed for the conventional loads, i.e., dead load and imposed load possess adequate strength to resist vertical loads without suffering damage during its service period. If the building is not designed for resisting the lateral loads caused by earthquake, the building is likely to suffer damage resulting into loss of life and economic loss. Our country is vulnerable to earthquakes and the past experience has shown that the buildings which were not designed to resist earthquake loads have either got damaged or collapsed resulting into economic loss and loss of lives as happened during Gujarat Earthquake of January 26, 2001 [1, 2]. Therefore, earthquake resistant design of buildings is very important. For this, India is divided into four seismic zones, zone II being the least susceptible to earthquakes and zone V being the most susceptible to earthquake. Every building is subjected to lateral forces either in the form of ground shaking or wind effect. The consideration of the lateral forces induced by wind or by earthquake increases the analysis, design and construction cost of the building.

It is, therefore, necessary to study the structural economics with regard to cost of construction when the conventional loads are considered and when conventional loads and loads induced by earthquake are considered. The simplest way to find the difference in the cost of construction is by determining the cost of materials which are used for the construction of the structural members of the RC building.

1.2 OBJECTIVE OF THE PRESENT STUDY

A G + 3 RC framed building is considered and is analyzed, designed and detailed for the following three cases:

*Number in the square brackets indicates references

1. Gravity loads and imposed loads, i.e., conventional loads using IS 456: 2000 [3],
2. Conventional loads and earthquake loads for seismic zone II using IS 1893: 2002 (Part 1) [4] and
3. Conventional loads and earthquake loads for seismic zone V using IS 1893: 2002 (Part 1) [4] and IS 13920: 1993 [5]

The building is founded on the hard rock for all the three cases. The structural cost of the building is worked out by computing the total quantity of the concrete and steel required for constructing the structural members – beams, columns and footing. The slab and roof which are also the structural members, have not been considered for computing the structural cost because their sizes are not likely to be affected when designed for resisting conventional loads and conventional loads along with earthquake loads.

1.3 ORGANIZATION

This dissertation is organized in six chapters. Chapter 2 gives the description of the building that has been considered for analysis and design. The lumped mass models used for computing the design lateral loads for zone II and zone V are given in Chapter 3.

Three analyses: 1) Gravity loads and imposed loads, 2) Gravity loads, imposed loads and designed lateral loads due to earthquake for zone II and 3) Gravity loads, imposed loads and designed lateral loads due to earthquake for zone V are carried out and design and detailing of the building for these three cases are given in Chapter 4. In Chapter 5, the quantity of steel and concrete are calculated and their cost have been determined for the three cases. The comparison of the cost for these three cases has also been made. The conclusions based on the present study are given in Chapter 6. The sample calculations for the design of the beam, column and footings are given in an APPENDIX A.

DESCRIPTION AND MODELING FOR ANALYSIS AND DESIGN OF BUILDING

2.1 DESCRIPTION OF THE BUILDING

The building considered for the analysis and design is a G + 3 residential reinforced concrete building. The analysis and design is considered for the following three cases:

1. Gravity loads or conventional loads vertical loads, i.e., dead load and imposed coming on frames of the building.
2. Conventional loads and lateral loads for zone II.
3. Conventional loads and lateral loads for zone V.

The building is supported by hard rock type soil for all three above cases.

2.2 SELECTION OF SHAPE AND PLAN OF BUILDING

The building having a regular grid plan symmetric about both axes, i.e., all columns are equally spaced. Such building is known to have better earthquake resistance as compared to irregular building.

2.3 PRELIMINARY DATA

The details of the building dimensions, location, unit weight of the material, loads, etc., are given below:

1	Type of structure	RC moment resisting frame
2	Zone	II, V
3	Layout	As shown in Fig. 2.1 and Fig. 2.2
4	Plan dimensions	16 m x 16 m
5	Total height	14.1 m
6	Number of stories	G + 3

7	External wall	230 mm thick including plaster
8	Internal wall	150 mm thick including plaster
9	Live load	3 and 1.5 KN/m^2 on floor and roof, respectively
10	Depth of slab	150 mm
11	Design philosophy	mit state method conforming to IS 456: 2000]
12	Seismic analysis	Equivalent static method conforming to IS 1893: 2002 [4] and Response spectrum analysis.
13	Ductility design	IS 13920: 1993 [5]
14	Footing design	Isolated footing
12	Beam-Column connection	Fully restrained
13	RCC	25.00 KN / m^3
14	Brick masonry	19.00 KN / m^3
15	Mud phuska	16.67 KN / m^3
16	Ceiling and Finishing	0.33 KN / m^2
17	Imposed load at floor	3.00 KN / m^2
18	Imposed load at roof (Assuming access provided)	1.5 KN / m^2

2.4 DEAD LOADS

It includes the load of wall, column, beam, parapet wall, slab, mud phuska, ceiling and finishing. The dead loads due to self weight of wall and self weight of beam are in the form of uniformly distributed loads. The column load is taken as a point load and is applied at the node. The slab weight, mud phuska and finishing are distributed as per yield line theory as triangular load on the beams.

2.5 IMPOSED LOADS

It is distributed as per yield line theory and loaded as triangular load on the beams.

2.6 EARTHQUAKE LOADS

Earthquake load on a building depends upon its geographical location, lateral stiffness and mass. Its effect should be considered along both axes of a building taken one at a time. The point of application of earthquake force is at center of gravity of the mass on each floor of the building. This force is resisted by the building and the resisting force acts at the center of rigidity at each floor of the building at each story. The building is designed to undergo inelastic deformations.

2.7 LOAD COMBINATIONS

The following load combination as given in IS: 1893-2002 (Part 1) [4] are considered for the design purpose:

1. 1.5 (DL + IL)
2. 1.2 (DL + IL + EL)
3. 1.2 (DL + IL - EL)
4. 1.5 (DL+EL)
5. 1.5 (DL-EL)
6. 0.9 DL + 1.5 EL
7. 0.9 DL - 1.5 EL

Where DL, IL and EL are dead loads, imposed loads and earthquakes loads, respectively.

2.8 MODELING OF BUILDING

A building frame is a three dimensional structure. It is idealized as a system of interconnected two-dimensional vertical frames along the two mutually perpendicular horizontal axes for analysis. These frames are analyzed independently of each other. The building considered is having a symmetric plan, uniform distribution of mass and stiffness along the height. Therefore, it can be analyzed as a 2D frame.

For preliminary analysis and verification, we can adopt approximate methods like substitute frame, moment distribution, portal and cantilever method, however, STAAD Pro [13] package has been used for carrying out the preliminary and final analysis. The building is modeled as a 2D plane frame consisting beams and columns. The length of the member is measured from center to center. The

preliminary section of column is estimated by calculating the expected axial load on the column and the beam section by calculating the expected bending moment. These sections are used for the analysis. The floor is modeled as the rigid diaphragm to get equal horizontal displacement of all nodes at the same floor level. The supports are assumed to be fixed.

All dimensions are in mm

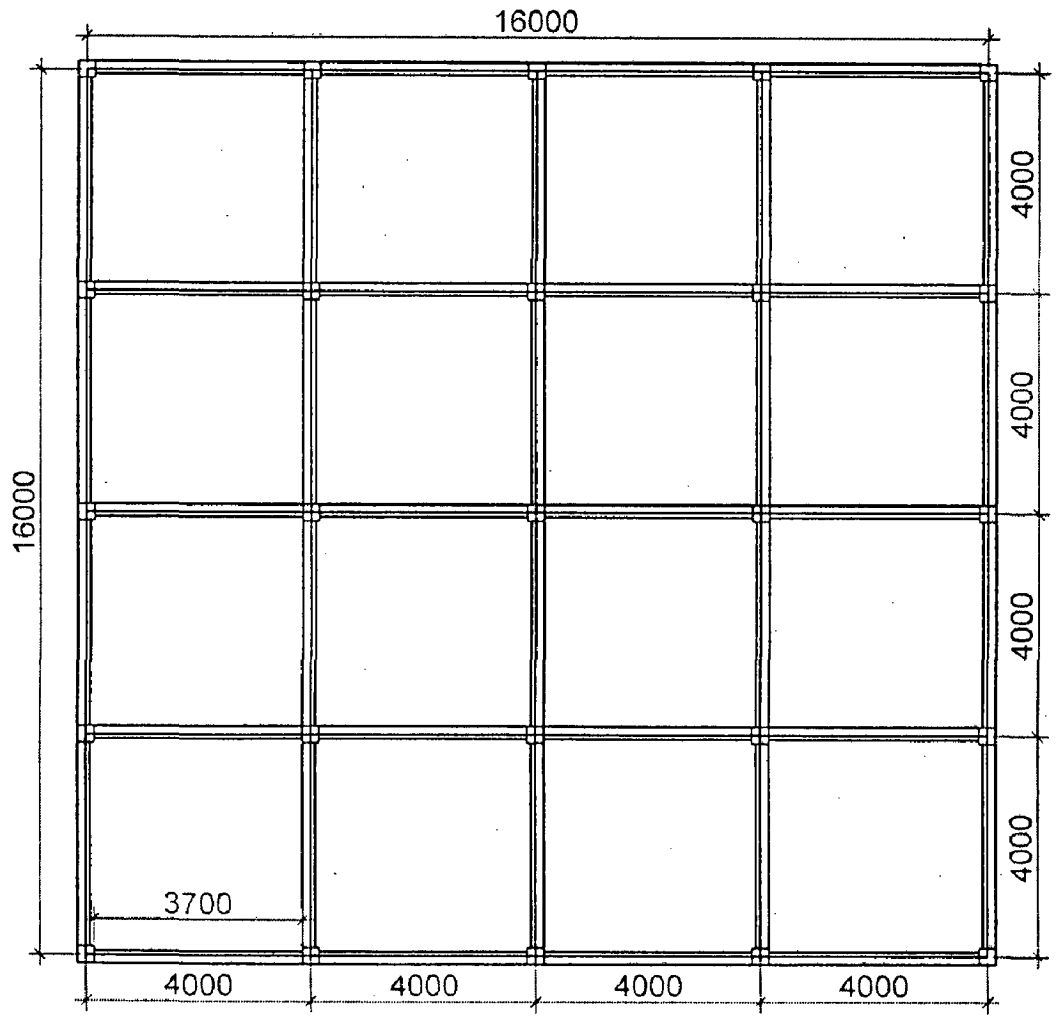

Fig. 2.1: Plan of the building

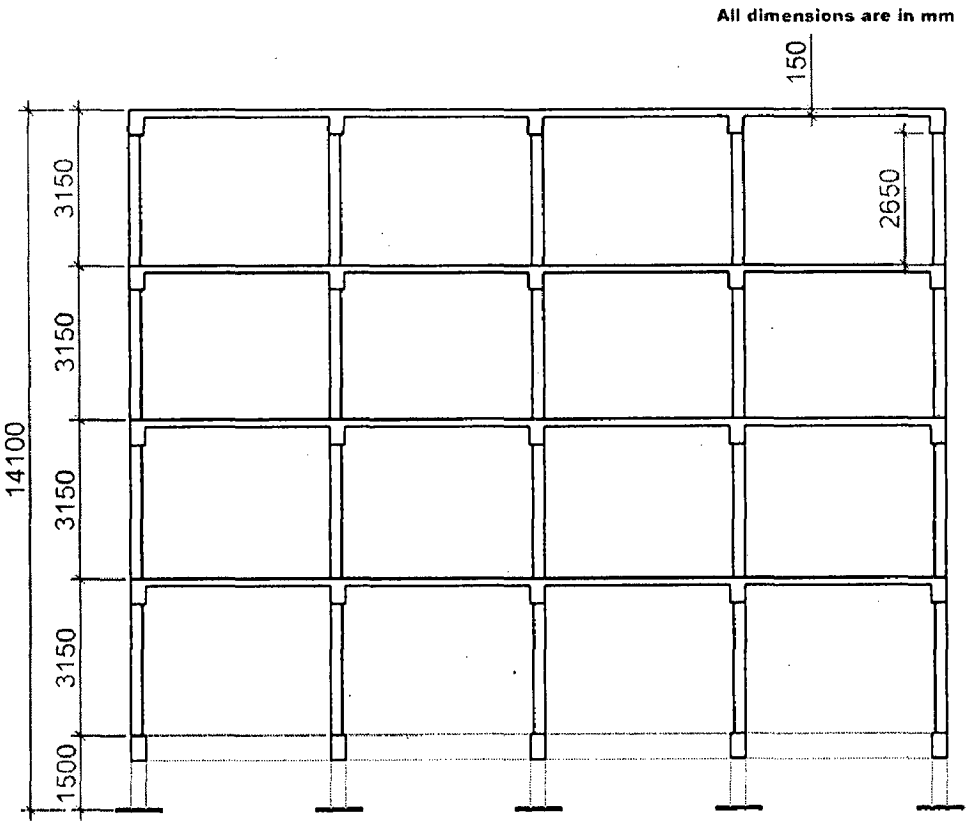

Fig. 2.2: Elevation of the building

Sl.No.	Description	L	B	D	Density	No	Load	Units	Load Type
	Panel(4x4)								
1	**Slab**								
	L&T Beam	Per m	2.00	0.15	25.00	2.00	15.00	kN/m	Triangular
2	**Mud Phuska**								
		2.00	-	0.15	16.67	2.00	10.00	kN/m	Triangular
3	**Celing & Finishing**								
	L&T Beam	2.00	-	-	0.33	2.00	1.32	kN/m	Triangular
4	**Flooring**								
	L&T Beam	2.00	0.05	-	24.00	2.00	4.80	kN/m	Triangular
5	**DL of Beam**								
	L&T Beam	Per m	0.30	0.45	25.00	1.00	3.38	kN/m	UDL
6	**Wall**								
	Interior Wall Load	Per m	0.15	3.00	20.00	1.00	9.00	kN/m	UDL
	Parapet Wall Load	Per m	0.15	1.00	20.00	-	3.00	kN/m	UDL
7	**DL of column**								
	at nodes	3.15	0.40	0.40	25.00		12.60	kN	Point Load
	at tie beam nodes	1.50	0.40	0.40	25.00		6.00	kN	Point Load

Table 2.1: Dead load calculations for Interior frame [6]

L = Length, B = Breadth, D = Depth

L & T Beam = Longitudinal and Transverse beams

Sl.No.	Description	L	B	D	Density	Load	Units	Load Type
	Panel(4x4)							
1	**Slab and Floor**		**ordinate (m)**	**thickness (m)**	**kN/m^3**			
	L&T Beam	Per m	2	0.15	25	7.50	kN/m	Triangular
2	**Mud Phuska**							
		Per m	2	0.15	16.67	5.00	kN/m	Triangular
3	**Celing & Finishing**				**kN/m^3**			
	L&T Beam		2	-	0.33	0.66	kN/m	Triangular
4	**Flooring**				**kN/m^3**			
	L&T Beam		2	0.05	24	2.40	kN/m	Triangular
5	**DL of Beam**							
	L&T Beam	Per m	0.3	0.45	25	3.38	kN/m	UDL
6	**Wall**							
	Exterior Wall Load	Per m	0.23	3	20	13.8	kN/m	UDL
	Parapet Wall Load	Per m	0.15	1	20	3	kN/m	UDL
7	**DL of column**							
	at nodes	3.15	0.3	0.3	25	7.0875	kN	Point Load
	at tie beam nodes	1.5	0.4	0.4	25	6	kN	Point Load

Table 2.2: Dead load calculations for exterior frame [6]

LOAD PER UNIT LENGTH = ORDINATE *THICKNESS*DENSITY

LOAD PER UNIT LENGTH = ORDINATE *THICKNESS*SURFACE LOAD

Sl.No.	Description	L	B	Intensity	Load	Units	Load Type
1	Live load on floors						
	Panel(4x4)						
	L&T Beam	Per m	4	3 kN/m^2	12.00	kN/m	Triangular
	L&T Beam	Per m	2	3 kN/m^2	6.00	kN/m	Triangular
2	Live load on roof						
	Panel(4x4)						
	L&T Beam	Per m	4	1.5KN/m2	6.00	kN/m	Triangular
	L&T Beam	Per m	2	1.5 KN/m2	3.00	kN/m	Triangular

Table 2.3: Live load calculations for interior and exterior frame [7]

SEISMIC ANALYSIS PROCEDURE FOR MULTISTORY RC BUILDING

To carry out the earthquake resistant analysis of a multistory reinforced concrete building, one must know the building configuration, location and soil condition.

3.1 IS 1893: 2002 (PART 1) [4] PROCEDURE

Calculate the total seismic weight W of the building by considering all dead load and percentage of the live load. The weight to lump at individual floor is calculated and the total weight W is calculated by adding all the lumped floor weights.

1) The stiffness at each floor in X and Y directions load is calculated by adding stiffness of all the columns in X and Y directions, respectively.
2) A lumped mass model of the building having floor masses obtained from the floor weight calculated in step 1) and stiffness calculated in step 2) is considered. Each lumped mass has one degree of freedom as the floor is treated as a rigid diaphragm. Thus no. of degree of freedom is equal to the no. of lumped masses.
3) Using CAL 89 program [11], the dynamic analysis of the lumped mass model is carried out. The eigenvalues, eigenvectors (mode shapes), natural frequencies and time periods are obtained.
4) From the results of the dynamic analysis in the step 4), mode participation factors and the design lateral force at each floor in each mode are obtained.
5) From the lateral forces computed in the step 5), the storey shear forces in each mode are computed.
6) The storey shear forces computed for each mode in step 6) are combined using Square Root of Sum of Squares (SRSS) method to obtain shear forces due to all modes.
7) From the storey shear computed in the step 7), the design lateral forces at various floor levels and roof level are obtained.

8) The lateral forces for each individual frame at floor levels and roof level are obtained by dividing the lateral forces computed in the step 8), by no. of frames in a particular direction.

9) The base shear is also calculated by approximate fundamental formula for the moment resisting frame with infill walls.

10) If the base shear, $\overline{V}_B$, obtained by using the approximated fundamental period as IS 1893: 2002 [4] is more than the base shear, V_B, obtained in the step 7), then the lateral forces at the floor levels and roof level are to be increased by the factor $\overline{V}_B / V_B$.

Using MATLAB [15] a program is written for the above procedure. The final output obtained from this program is the scaled lateral forces at the floor levels. These lateral loads are applied at nodes of the moment resisting frame and analyzed for the combination of loads that are given in IS 875 (part 5): 1987 [8].

DEAD LOAD CALCULATIONS			
	Height/Length (m)	Width (m)	Depth (m)
Column	3.15	0.4	0.4
Beam	4	0.3	0.45
	Height	Length	Thickness
Wall	3.15	3.6	0.23/0.15
		Surface load (kN/m2)	
Live load except ground and top floor		3	

% OF IMPOSED LOADS TO BE CONSIDERED IN SEISMIC WEIGHT CALCULATION

Imposed uniform distirbuted floor loads (kN/m^2)		% OF IMPOSED LOADS
LESSTHAN OR EQUAL TO	3	25.00%
GREATER	3	50.00%

	No. of elements	No.of storeys	Length (m)	Width (m)	Depth (m)	Density (kN/m^3)			Weight kN	Mass tonnes
Beam Size (meters)	40	4	4	0.3	0.45	25	Roof (14.1)	M4	3420.792	348.7046
Column size (meters)	25	4	3.15	0.4	0.4	25				
Slab/Floor	1	4	16	16	0.15	25	G+3(10.95)	M3	4095.648	417.4972
Flooring	1	3	16	16	0.05	24				
Mud phuska (kN/m3)	1	1	16	16	0.15	16.67	G+2(7.8)	M2	4095.648	417.4972
Inner Walls	24	3	3.7	0.15	3.15	20				
Outer Walls	16	3	3.7	0.23	3.15	20	G+1(4.65)	M1	4095.648	417.4972
Parapet wall	1	1	63.4	0.15	1	20				
					Surface load (kN/m^2)		G.Floor(1.5)			
Finishing & Celling	1	4	16	16	0.33					
		No.of storeys	Length (m)	Width (m)	Surface load	Reduction factor	Basement		15707.736	1601.196
Live load except ground floor level and top floor		3	16	16	3	0.25				

Table 3.1: Calculation of floor weight for lumped mass model

Seismic weight for whole structure									
Wt. of Column (kN) equal to B	Wt. of Infill wall (kN) equal to C	Wt. of slab/Floor (kN) equal to D	Wt. of flooring (kN) equal to E	Wt. of mudphuska (kN) equal to F	Wt. of beam (kN) equal to G	Wt. of parapet wall (kN) equal to H	Wt. of finishing & ceiling (kN) equal to I	percentage of live load (kN) equal to J	Total Seismic wt.
1260	5090.904	3840	921.6	640.128	2160	190.2	337.92	576	15016.8

Floor wise load distribution									
315	1696.968	960	307.2	640.128	540	190.2	84.48	192	4925.98

	width(mm)	depth(mm)
column size	400	400
fck (N/mm^2)	20	

Elasticity modulus of concrete (N/mm^2)	Moment of inertia of column (mm^4)	Height of column (mm)	Stiffness of column (N/mm)
22360.68	2.13E+09	3150	457860.64

stiffness in N/mm (k) =

9.16E+05	-4.58E+05	0.0	0.0	G+3
-4.58E+05	9.16E+05	-4.58E+05	0.0	G+2
0.0	-4.58E+05	9.16E+05	-4.58E+05	G+1
0.0	0.0	-4.58E+05	4.58E+05	Roof

Mass in tons (m) =

417.50	0	0	0
0	417.50	0	0
0	0	417.50	0
0	0	0	348.70

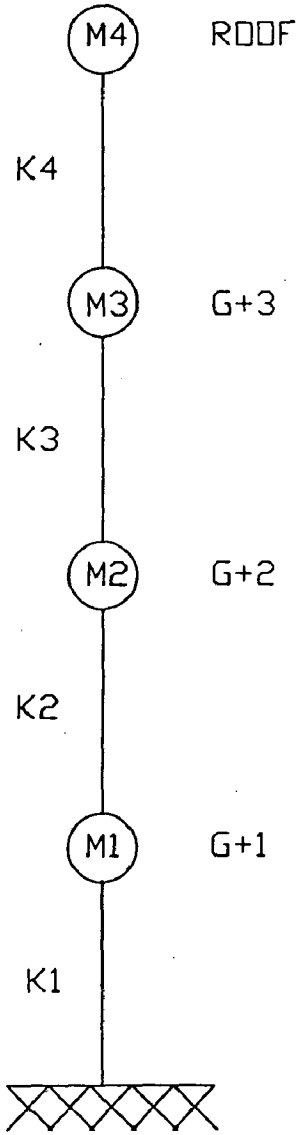

Fig. 3.1: Lumped mass model for computing natural frequencies and mode shapes

ANALYSIS, DESIGN AND DETAILING WITH CODAL PROVISIONS

4.1 ANALYSIS FOR CONVENTIONAL LOADS AND LATERAL LOADS

A building frame is a highly indeterminate structure, which may be analyzed exactly or approximately. An approximate method used for analyzing continuous beams which frame into column is to use a substitute frame model in which beams at a given floor level together with columns above and below with far ends fixed and arrangement of live loads to cause maximum effect at a given section. For detailed analysis of large frames, computer based matrix methods are ideally suitable. A large number of software packages are available for carrying out the analysis.

The given building is symmetric with respect to lateral stiffness and mass. The center of mass and center of rigidity coincide at each floor and hence, there is no torsion in the building. However, the effect of accidental torsion is considered.

The earthquake loads affect the design bending moments in the beams and columns. Since reinforced concrete is relatively less ductile in compression and shear, the dissipation of seismic energy is best achieved by flexural yielding. A frame comprising flexural members and columns designed and detailed to accommodate reversible lateral displacements after the formation of plastic hinges, is known as a ductile moment resisting frame.

Beam column junction is a very critical element in reinforced concrete construction where the elements intersect in all three directions. Joints are most critical because they ensure continuity of a structure and transverse forces that are present at the end of the members into and through the joint hence a joint should be designed so that it is stronger than members framing into it and it should maintain its integrity [9].

4.2 DESIGN AND DUCTILE DETAILING

The objective of the special design and detailing provisions of IS 13920: 1993 [5] is to ensure adequate toughness and detailing provisions for individual members such as beams, columns and walls and to prevent other non ductile types of failure.
Ductility may be defined as the capacity of structure to undergo inelastic deformations without significant decrease in stiffness and load resistance ability.
The ductile design and detailing include: (1) use of low tension steel ratio with relatively low grade steel, (2) provision of adequate stirrups to ensure that shear failure does not follow by flexural failure and (3) detailing provision with regard to anchorage, splicing, minimum reinforcement, etc. The Zone V, which is known to be the most severe earthquake prone area, the structure is designed to resist seismic forces in a ductile manner because large lateral deformations will occur, resulting in the development of reversible plastic hinges at various locations in ductile frames [10].

4.3 FOUNDATIONS

It is important to ensure that the foundation of a structure does not fail prior to the possible failure of the superstructure. As plastic deformations are permitted to occur at suitable locations in superstructure under severe earthquake, the maximum seismic forces transmitted to the foundation will be governed by lateral loads at which actual yielding takes place in the structural elements transferring the lateral loads to the foundation.

4.4 ANALYSIS OF FRAMES

For all the three cases one external frame and internal frame are analyzed using STAAD PRO [13]. The effect of accidental torsion is also considered.

4.5 DESIGN OF FRAMES

For case 1, the structural drawings for the exterior and the interior frames are shown in Fig. 4.1 and 4.2, respectively. Further, the details of beam and column reinforcement of exterior and interior frame for case 1 are given in Table 4.1, 4.2, 4.3

and 4.4. The structural drawings for the isolated footings for the exterior frame and for the interior frame are shown in Fig. 4.3 and 4.4, respectively. The details of footing reinforcement of interior and exterior frames for case 1 are given in Table 4.13. The design and detailing are carried out as per IS 456:2000 [3].

For case 2, the structural drawings for the exterior and the interior frame are shown in Fig 4.5 and 4.6, respectively, while structural drawings for the isolated footings for the exterior frame and the interior frame are shown in Fig. 4.7 and 4.8, respectively. Further the details of beam, column and footing reinforcement of exterior and interior frame for case 2 are shown in Table 4.5, 4.6, 4.7, 4.8 and 4.14.

For case 3, the structural drawings for the exterior and the interior frames are shown in Fig 4.9 and 4.10, respectively. Further, the details of beam and column reinforcement of exterior and interior frames for case 3 are shown in Table 4.9, 4.10, 4.11 and 4.12. The structural drawings for the foundation have not been included as the foundation required to support the columns could not be adopted in the form of isolated footings. For this case, the foundation other than the isolated footings such as raft or mat foundation is required. The sample calculations for the design of the beam, column and footing are given in an APPENDIX. A.

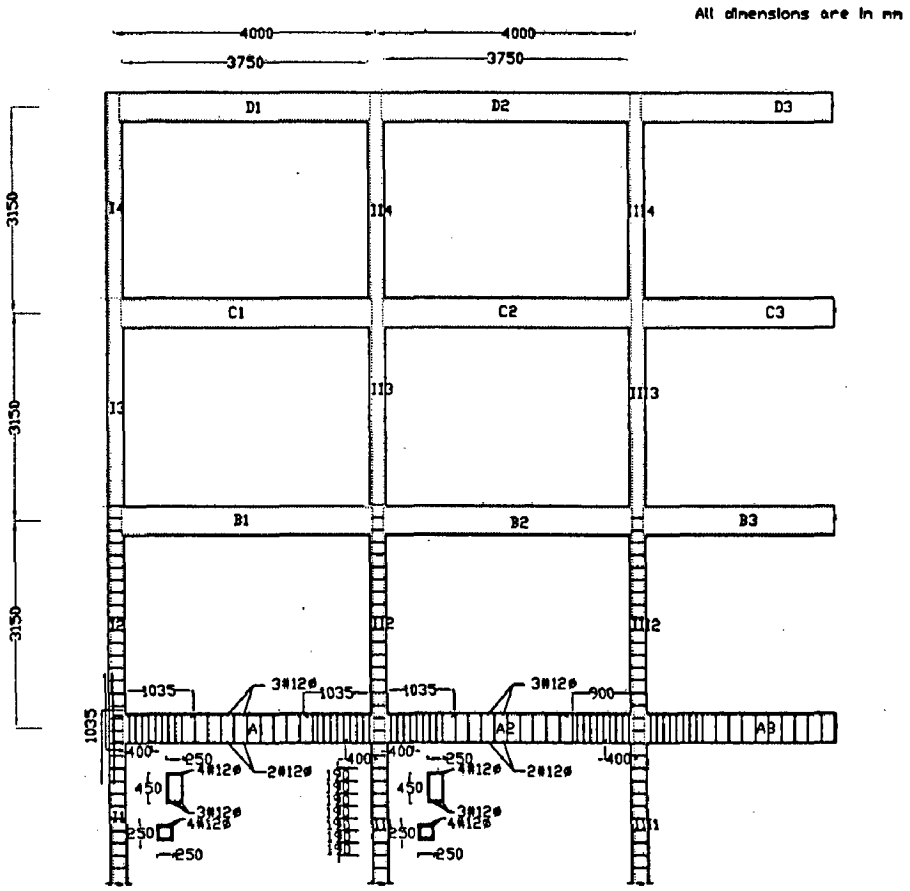

Fig. 4.1: Details of beam and column reinforcement of exterior frame for static case

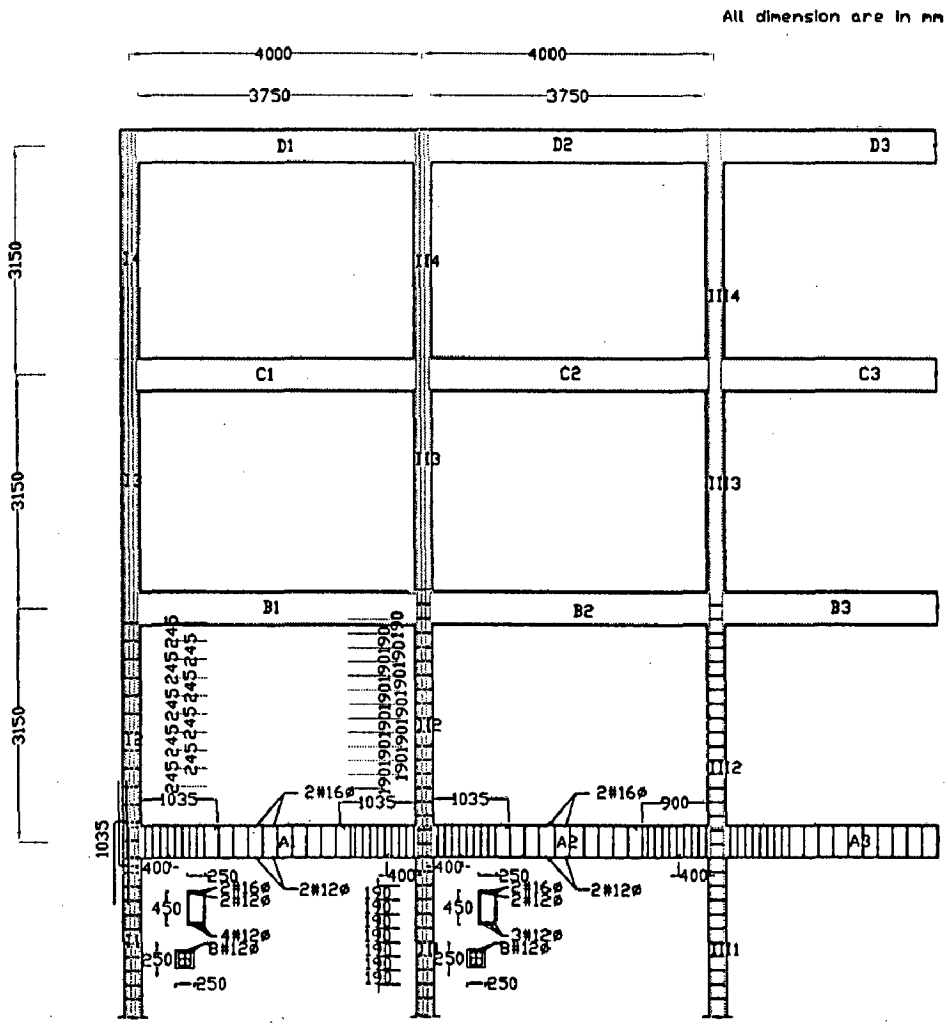

Fig. 4.2: Details of beam and column reinforcement of interior frame for static case

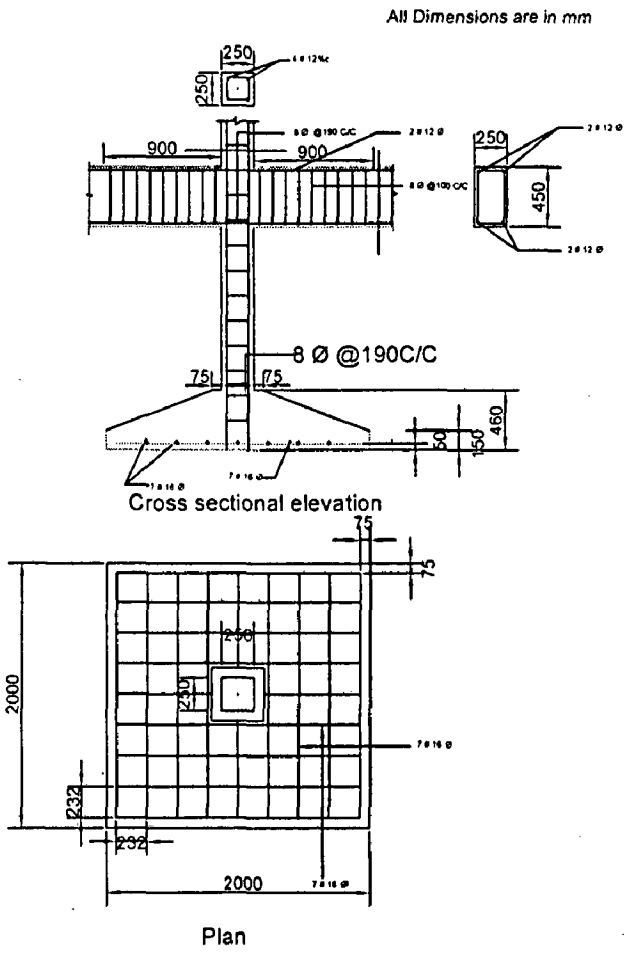

Fig. 4.3: Details of column and footing reinforcement of exterior frame for static case

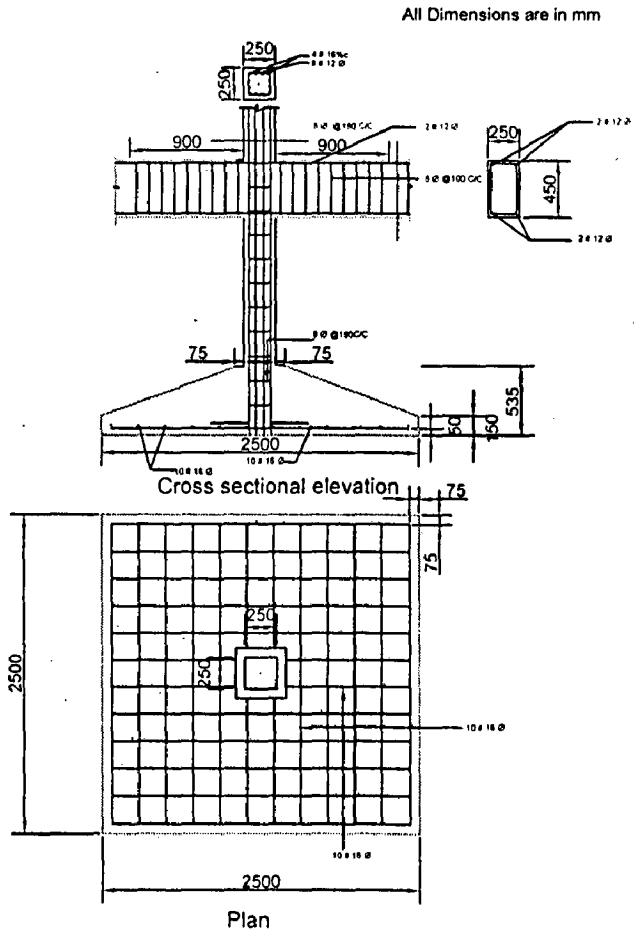

Fig. 4.4: Details of column and footing reinforcement of interior frame for static case

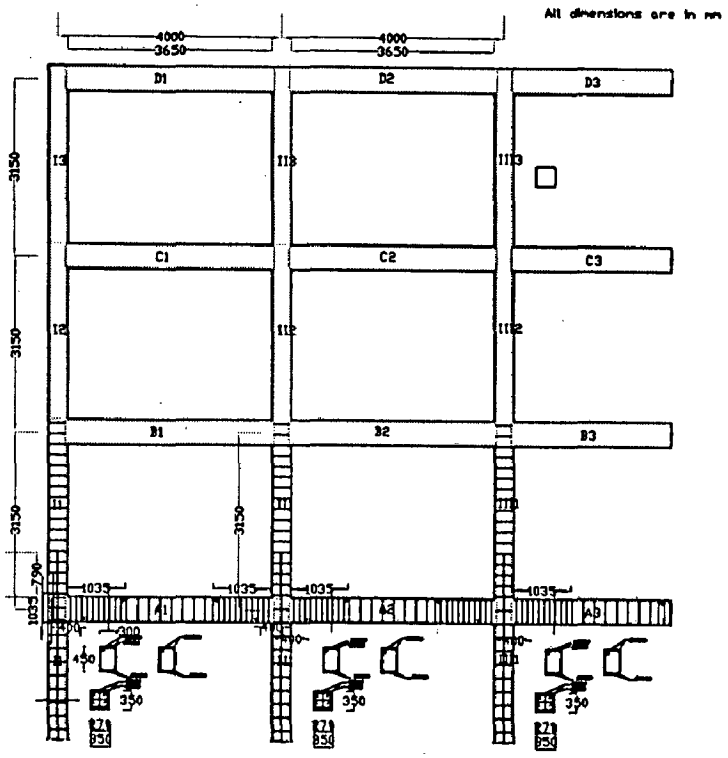

Fig. 4.5: Details of beam and column reinforcement of exterior frame for Zone II

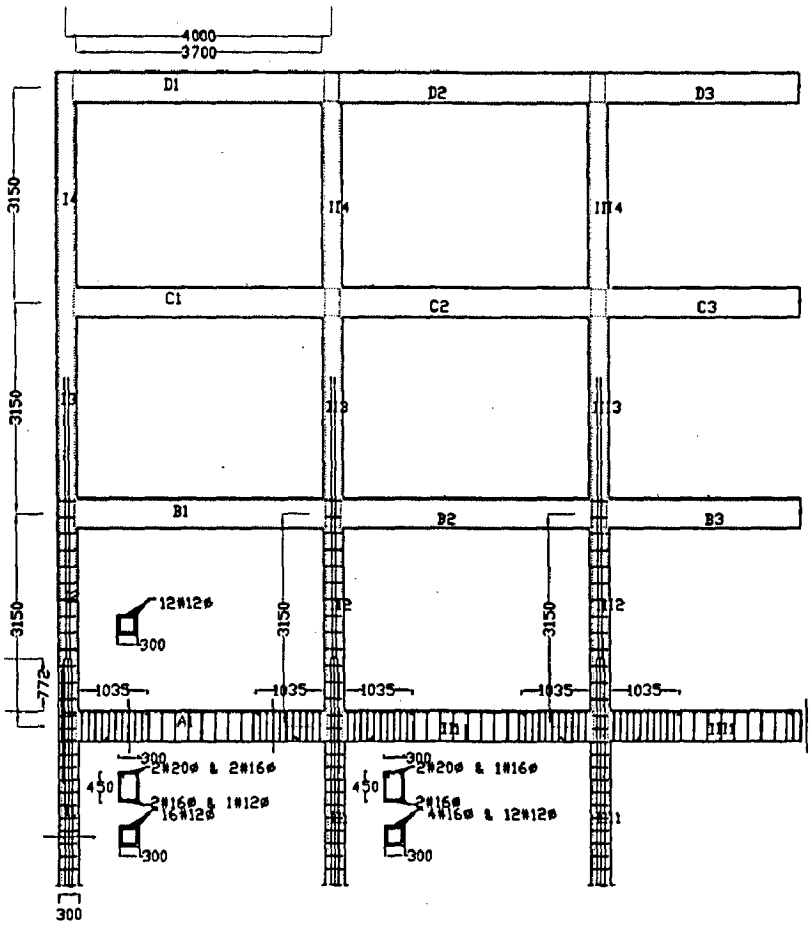

Fig. 4.8: Details of beam and column reinforcement of exterior frame for Zone II

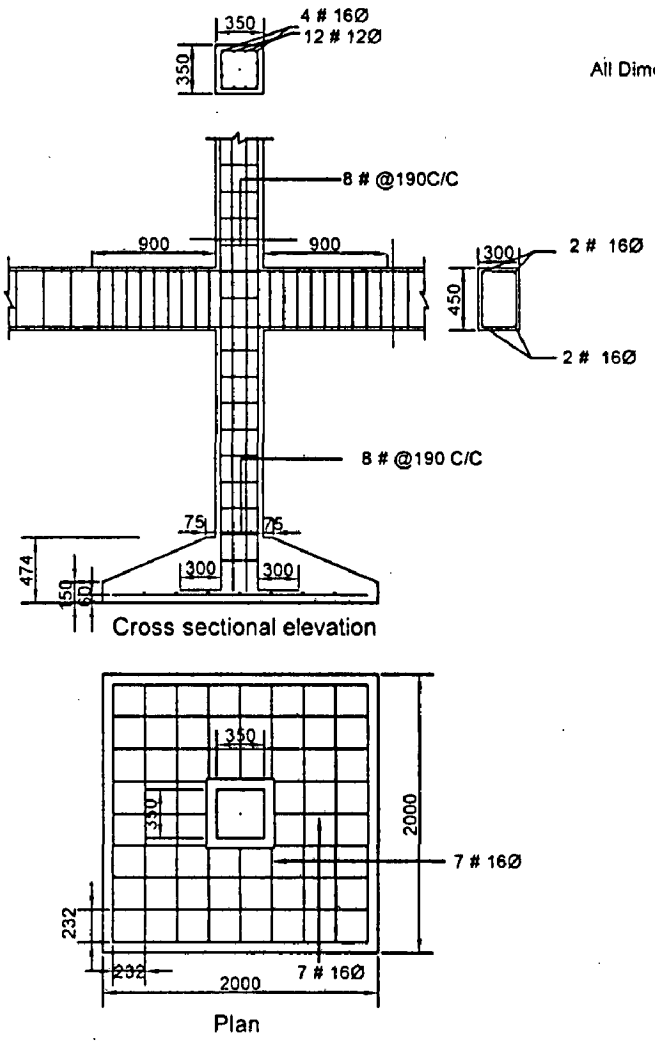

Fig. 4.7: Details of column and footing reinforcement of exterior frame for Zone II

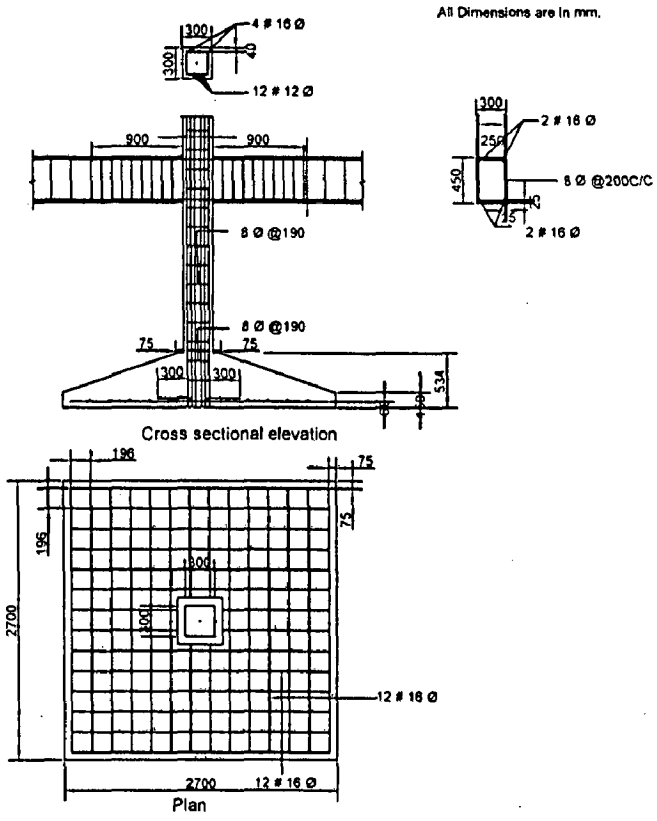

Fig. 4.8 Details of column and footing reinforcement of interior frame for Zone II

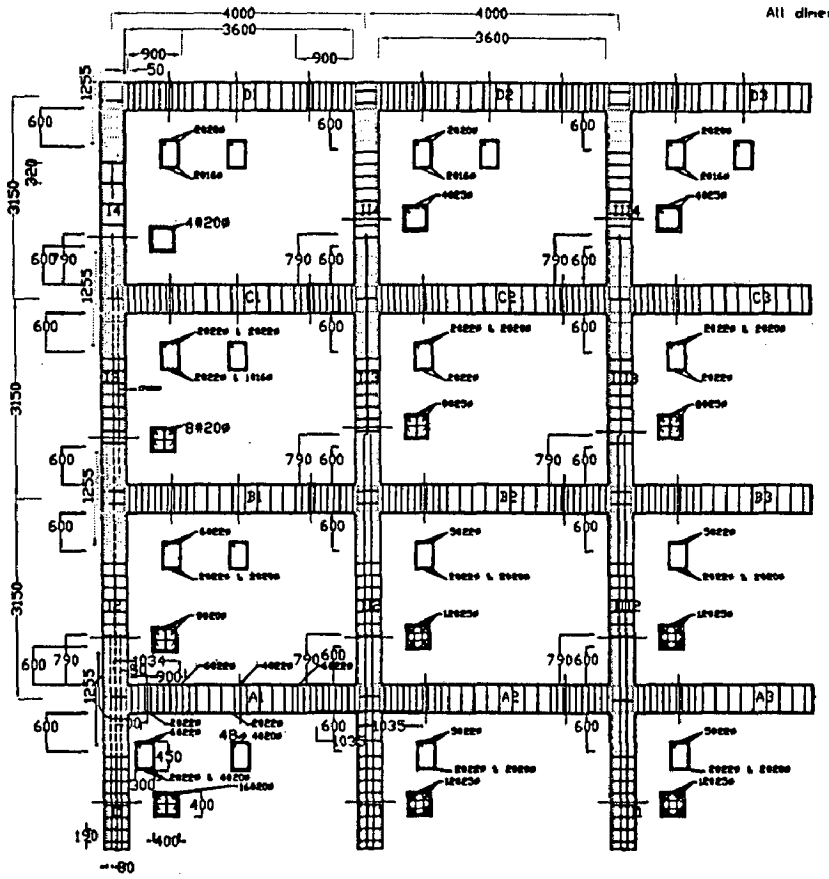

Fig. 4.9: Details of beam and column reinforcement of exterior frame for Zone V

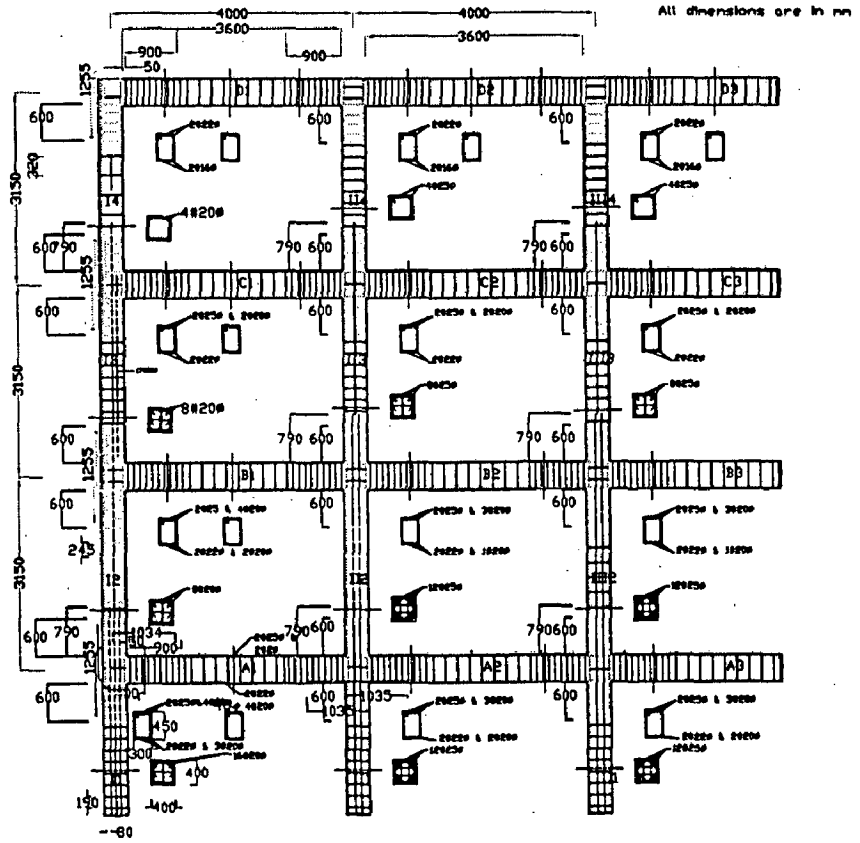

Fig. 4.10: Details of beam and column reinforcement of interior frame for Zone V

Beam Detailing												
Flexural Member	230	231	232	239	240	241	248	249	250	257	258	259
Beam Identity	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
Area of Steel Reuired at Top	443	426	426	410	402	402	394	402	402	267	267	267
No. of Bars and ø for Longitudinal Reinforcement	4 # 12 ø	4 # 12 ø	4 # 12 ø	4 # 12 ø	4 # 12 ø	4 # 12 ø	4 # 12 ø	4 # 12 ø	4 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø
Area of Steel Provided at Top	453	453	453	453	453	453	453	453	453	340	340	340
Area of Steel Reuired at Bottom	301	267	267	293	267	267	301	267	267	267	267	267
No. of Bars and ø for Longitudinal Reinforcement	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø
Area of Steel Provided at Bottom	340	340	340	340	340	340	340	340	340	340	340	340
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Stirrups Provided up to 2d	100	100	100	100	100	100	100	100	100	100	100	100
Spacing of Stirrups Provided in Middle	200	200	200	200	200	200	200	200	200	200	200	200
Development Length Ld	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035
Maximum of 40 % of Top Steel Bars Curtailment at 0.15 l or Ld from the face of an inner supports	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3 # 12 ø	3# 12ø	3 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø
70 % of Bottom Steel Bars Cutailment at 0.1 l from mid span	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø

Table 4.1: Details of beam reinforcement of exterior frame for static case

Note: Area is in sq. mm and spacing, length, size of the bar are in mm in all tables, i.e., Table 3.1 through Table 3.12

Beam Detailing												
Flexural Member	118	119	120	127	128	129	136	137	138	145	146	147
Beam Identity	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
Area of Steel Reuired at Top	543	526	526	501	492	492	478	501	501	316	347	347
No. of Bars and ø for Longitudinal Reinforcement	2 # 16 ø 2 # 12 ø	2 # 16 ø 2 # 12 ø	2 # 16 ø 2 # 12 ø	2 # 16 ø 1 # 12 ø	2 # 16 ø 1 # 12 ø	2 # 16 ø 1 # 12 ø	2 # 16 ø 1 # 12 ø	2 # 16 ø 1 # 12 ø	2 # 16 ø 1 # 12 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø
Area of Steel Provided at Top	628	628	628	515	515	515	515	515	515	402	402	402
Area of Steel Reuired at Bottom	378	267	267	370	268	268	378	268	268	301	268	268
No. of Bars and ø for Longitudinal Reinforcement	4# 12ø	3# 12ø	3# 12ø	4# 12ø	3# 12ø	3# 12ø	4# 12ø	3# 12ø	3# 12ø	3# 12ø	3# 12ø	3# 12ø
Area of Steel Provided at Bottom	453	340	340	453	340	340	453	340	340	340	340	340
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Stirrups Provided up to 2d	100	100	100	100	100	100	100	100	100	100	100	100
Spacing of Stirrups Provided in Middle	200	200	200	200	200	200	200	200	200	200	200	200
Development Length Ld	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035
Maximum of 40 % of Top Steel Bars Curtailment at 0.15 l or Ld from the face of an inner supports	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø
70 % of Bottom Steel Bars Cutailment at 0.1 l from mid span	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø	2 # 12 ø

Table 4.2: Details of beam reinforcement of interior frame for static case

Column Detailing												
Compression Member No.	225	234	243	252	226	235	244	253	227	236	245	254
Column Identity	I1	I2	I3	I4	II1	II2	II3	II4	III1	III2	III3	III4
Area of Steel Required	243	425	436	408	1200	451	229	84	1050	403	226	84
No. of Bars and ø for Longitudinal Reinforcement	4 # 12 ø	4 # 12 ø	4 # 12 ø	4 # 12 ø	12 # 12 ø	4 # 12 ø	4 # 12 ø	4 # 12 ø	12 # 12 ø	4 # 12 ø	4 # 12 ø	4 # 12 ø
Actual Area of Steel Provided	453	453	453	453	1359	906	453	453	1359	906	453	453
Development Length Ld	790	790	790	790	790	790	790	790	790	790	790	790
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Transverse Reinforcement	190	190	190	190	190	190	190	190	190	190	190	190

Table 4.3: Details of column reinforcement of exterior frame for static case

Column Detailing												
Compression Member No.	113	122	131	140	114	123	132	141	115	124	133	142
Column Identity	I1	I2	I3	I4	II1	II2	II3	II4	III1	III2	III3	III4
Area of Steel Required	279	635	606	568	1650	756	279	114	1500	690	272	111
No. of Bars and ø for Longitudinal Reinforcement	4 # 12 ø	8 # 12 ø	8 # 12 ø	8 # 12 ø	8 # 12 ø 4 # 16 ø	8 # 12 ø	4 # 12 ø	4 # 12 ø	8 # 12 ø 4 # 16 ø	8 # 12 ø	4 # 12 ø	4 # 12 ø
Actual Area of Steel Provided	453	906	906	906	1711	906	453	453	1711	906	453	453
Development Length Ld	790	790	790	790	790	790	790	790	790	790	790	790
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Transverse Reinforcement	190	245	245	245	190	190	190	190	245	245	190	190

Table 4.4: Details of column reinforcement of interior frame for static case

Beam Detailing												
Flexural Member	230	231	232	239	240	241	248	249	250	257	258	259
Beam Identity	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
Area of Steel Reuired at Top	861	776	772	772	729	736	599	606	606	321	321	321
No. of Bars and ø for Longitudinal Reinforcement	2 # 20 ø 3 # 12 ø	2 # 20 ø 2 # 12 ø	2 # 20 ø 2 # 12 ø	2 # 20 ø 2 # 12 ø	2 # 20 ø 2 # 12 ø	2 # 20 ø 2 # 12 ø	2 # 16 ø 2 # 12 ø	2 # 16 ø 2 # 12 ø	2 # 16 ø 2 # 12 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø
Area of Steel Provided at Top	968	854	854	854	854	854	628	628	628	402	402	402
Area of Steel Reuired at Bottom	373	321	321	321	321	321	321	321	321	321	321	321
No. of Bars and ø for Longitudinal Reinforcement	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø
Area of Steel Provided at Bottom	402	402	402	402	402	402	402	402	402	402	402	402
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Stirrups Provided up to 2d	100	100	100	100	100	100	100	100	100	100	100	100
Spacing of Stirrups Provided in Middle	200	200	200	200	200	200	200	200	200	200	200	200
Development Length Ld	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035
Maximum of 40 % of Top Steel Bars Curtailment at 0.15 l or Ld from the face of an inner supports	2 # 20 ø	2 # 20 ø	2 # 20 ø	2 # 20 ø	2 # 20 ø	2 # 20 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø
70 % of Bottom Steel Bars Cutailment at 0.1 l from mid span	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø

Table 4.5: Details of beam reinforcement of exterior frame for Zone II

Beam Detailing												
Flexural Member	118	119	120	127	128	129	136	137	138	145	146	147
Beam Identity	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
Area of Steel Reuired at Top	926	804	804	799	754	754	623	640	640	361	381	381
No. of Bars and ø for Longitudinal Reinforcement	2# 20ø 2# 16ø	2# 20ø 1# 16ø	2# 20ø 1# 16ø	4# 16ø	4# 16ø	4# 16ø	2# 16ø 2# 12ø	2# 16ø 3# 12ø	2# 16ø 3# 12ø	2# 16ø	2# 16ø	2# 16ø
Area of Steel Provided at Top	1030	829	829	804	804	804	629	742	742	402	402	402
Area of Steel Reuired at Bottom	486	321	321	340	321	321	342	321	321	321	321	321
No. of Bars and ø for Longitudinal Reinforcement	2# 16 ø 1# 12ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16 ø	2# 16 ø	2# 16 ø
Area of Steel Provided at Bottom	515	402	402	402	402	402	402	402	402	402	402	402
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Stirrups Provided up to 2d	100	100	100	100	100	100	100	100	100	100	100	100
Spacing of Stirrups Provided in Middle	200	200	200	200	200	200	200	200	200	200	200	200
Development Length Ld	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035
Maximum of 40 % of Top Steel Bars Curtailment at 0.15 l or Ld from the face of an inner supports	2# 20ø	2# 20ø	2# 20ø	3# 16ø	3# 16ø	3# 16ø	2# 16ø	2# 16ø 1# 12ø	2# 16ø 1# 12ø	2# 16ø	2# 16ø	2# 16ø
70 % of Bottom Steel Bars Cutailment at 0.1 l from mid span	2# 16 ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16ø	2# 16 ø	2# 16 ø	2# 16 ø

Table 4.6: Details of beam reinforcement of interior frame for Zone II

Column Detailing												
Compression Member No.	225	234	243	252	226	235	244	253	227	236	245	254
Column Identity	I1	I2	I3	I4	II1	II2	II3	II4	III1	III2	III3	III4
Area of Steel Required	982	720	719	625	960	795	615	393	936	738	589	383
No. of Bars and ø for Longitudinal Reinforcement	4 # 12 ø 4 # 16 ø	4 # 16 ø	4 # 16 ø	4 # 16 ø	4 # 12 ø 4 # 16 ø	4 # 16 ø	4 # 16 ø	4 # 16 ø	4 # 12 ø 4 # 16 ø	4 # 16 ø	4 # 16 ø	4 # 16 ø
Actual Area of Steel Provided	1258	805	805	805	1258	805	805	805	1258	805	805	805
Development Length Ld	790	790	790	790	790	790	790	790	790	790	790	790
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Transverse Reinforcement	245	190	190	190	245	190	190	190	245	190	190	190

Table 4.7: Details of column reinforcement of exterior frame for Zone II

Column Detailing												
Compression Member No.	113	122	131	140	114	123	132	141	115	124	133	142
Column Identity	I1	I2	I3	I4	II1	II2	II3	II4	III1	III2	III3	III4
Area of Steel Required	1564	1295	1053	835	1965	1341	860	443	1846	1190	828	448
No. of Bars and ø for Longitudinal Reinforcement	16 # 12 ø	12 # 12 ø	12 # 12 ø	8 # 12 ø	12 # 12 ø 4 # 16 ø	8 # 12 ø 4 # 16 ø	8 # 12 ø	4 # 12 ø	12 # 12 ø 4 # 16 ø	8 # 12 ø 4 # 16 ø	8 # 12 ø	4 # 12 ø
Actual Area of Steel Provided	1811	1359	1257	906	2164	1711	906	453	2164	1711	906	453
Development Length Ld	790	790	790	790	790	790	790	790	790	790	790	790
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Transverse Reinforcement	190	245	245	245	190	190	190	190	245	245	190	190

Table 4.8: Details of column reinforcement of interior frame for Zone II

Beam Detailing												
Flexural Member	230	231	232	239	240	241	248	249	250	257	258	259
Beam Identity	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
Area of Steel Reuired at Top	2164	1899.7	1899.7	2031	1782	1782	1450	1361	1361	614	614	614
No. of Bars and ø for Longitudinal Reinforcement	2 # 22 ø 4 # 22 ø	2 # 22 ø 3 # 22 ø	2 # 22 ø 3 # 22 ø	2 # 22 ø 4 # 22 ø	2 # 22 ø 3 # 22 ø	2 # 22 ø 3 # 22 ø	2 # 22 ø 2 # 22 ø	2 # 22 ø 2 # 20 ø	2 # 22 ø 2 # 20 ø	2 # 20 ø	2 # 20 ø	2 # 20 ø
Area of Steel Provided at Top	2280	1902	1902	2280	1902	1902	1522	1388	1388	628	628	628
Area of Steel Reuired at Bottom	1708	1338.3	1338.3	1841	1220	1220	836	666	666	321	321	321
No. of Bars and ø for Longitudinal Reinforcement	2 # 22 ø 4 # 20 ø	2 # 22 ø 2 # 20 ø	2 # 22 ø 2 # 20 ø	2 # 22 ø 4 # 20 ø	2 # 22 ø 2 # 20 ø	2 # 22 ø 2 # 20 ø	2 # 22 ø 1 # 16 ø	2 # 22 ø	2 # 22 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø
Area of Steel Provided at Bottom	2015.88	1388	1388	2015.88	1388	1388	961	761	761	402	402	402
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Stirrups Provided up to 2d	100	100	100	100	100	100	100	100	100	100	100	100
Spacing of Stirrups Provided in Middle	200	200	200	200	200	200	200	200	200	200	200	200
Development Length Ld	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035
Maximum of 40 % of Top Steel Bars Curtailment at 0.15 l or Ld from the face of an inner supports	2 # 22 ø 2 # 22 ø	2 # 22 ø 1 # 22 ø	2 # 22 ø 1 # 22 ø	2 # 22 ø 2 # 22 ø	2 # 22 ø 1 # 22 ø	2 # 22 ø 1 # 22 ø	2 # 22 ø 1 # 22 ø	2 # 22 ø 1 # 20 ø	2# 22 ø 1# 20ø	2 # 20 ø	2 # 20 ø	2 # 20 ø
70 % of Bottom Steel Bars Cutailment at 0.1 l from mid span	2 # 22 ø	2 # 22 ø	2 # 22 ø	2 # 22 ø	2 # 22 ø	2 # 22 ø	2 # 22 ø	2 # 22 ø	2 # 22 ø	2 # 16 ø	2 # 16 ø	2 # 16 ø

Table 4.9: Details of beam reinforcement of exterior frame for Zone V

Beam Detailing												
Flexural Member	118	119	120	127	128	129	136	137	138	145	146	147
Beam Identity	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
Area of Steel Reuired at Top	2122	1863	1863	1944	1752	1752	1432	1342	1342	633	648	648
No. of Bars and ø for Longitudinal Reinforcement	2 # 25 ø 4 # 20 ø	2 # 25 ø 3 # 20 ø	2 # 25 ø 3 # 20 ø	2# 25ø 4# 20ø	2# 25ø 3# 20ø	2# 25ø 3# 20ø	2# 25ø 2# 20ø	2# 25ø 2# 20ø	2# 25ø 2# 20ø	2# 22ø	2# 22ø	2# 22ø
Area of Steel Provided at Top	2234	1924	1924	2234	1924	1924	1610	1610	1610	760	760	760
Area of Steel Reuired at Bottom	1634	1258	1258	1399	1118	1118	756	606	606	321	321	321
No. of Bars and ø for Longitudinal Reinforcement	2# 22 ø 3# 20ø	2# 22 ø 2# 20ø	2# 22 ø 2# 20ø	2# 22 ø 2# 20ø	2# 22 ø 1# 20ø	2# 22 ø 1# 20ø	2# 22 ø	2# 22 ø	2# 22 ø	2# 16 ø	2# 16 ø	2# 16 ø
Area of Steel Provided at Bottom	1702	1388	1388	1610	1296	1296	760	760	760	402	402	402
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Stirrups Provided up to 2d	100	100	100	100	100	100	100	100	100	100	100	100
Spacing of Stirrups Provided in Middle	200	200	200	200	200	200	200	200	200	200	200	200
Development Length Ld	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035
Maximum of 40 % of Top Steel Bars Curtailment at 0.15 l or Ld from the face of an inner supports	2# 25ø 2# 20ø	2# 25ø 1# 20ø	2# 25ø 1# 20ø	2# 25ø 2# 20ø	2# 25ø 1# 20ø	2# 25ø 1# 20ø	2# 25ø	2# 25ø	2# 25ø	2# 22ø	2# 22ø	2# 22ø
70 % of Bottom Steel Bars Cutailment at 0.1 l from mid span	2# 22 ø	2# 22 ø	2# 22 ø	2# 22 ø	2# 22 ø	2# 22 ø	2# 22 ø	2# 22 ø	2# 22 ø	2# 16 ø	2# 16 ø	2# 16 ø

Table 4.10: Details of beam reinforcement of interior frame for Zone V

Column Detailing												
Compression Member No.	225	234	243	252	226	235	244	253	227	236	245	254
Column Identity	I1	I2	I3	I4	II1	II2	II3	II4	III1	III2	III3	III4
Area of Steel Required	4910	2510	2078	1251	5659	4206	3067	1620	5509	4056	3003	1622
No. of Bars and ø for Longitudinal Reinforcement	16 # 20 ø	8 # 20 ø	8 # 20 ø	4 # 20 ø	12 # 25 ø	12 # 25 ø	8 # 25 ø	4 # 25 ø	12 # 25 ø	12 # 25 ø	8 # 25 ø	4 # 25 ø
Actual Area of Steel Provided	5030	2516	2516	1257	5895	5895	3930	1965	5895	5895	3930	1965
Development Length Ld	790	790	790	790	790	790	790	790	790	790	790	790
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Transverse Reinforcement	190	245	245	245	190	190	190	190	245	245	190	190
Special Confining Reinforcement as per IS13920 (Cl 7.4.1) lo	600	600	600	600	600	600	600	600	600	600	600	600

Table 4.11: Details of column reinforcement of exterior frame for Zone V

Column Detailing												
Compression Member No.	113	122	131	140	114	123	132	141	115	124	133	142
Column Identity	I1	I2	I3	I4	II1	II2	II3	II4	III1	III2	III3	III4
Area of Steel Required	4736	2440	2010	1248	5341	3965	2881	1481	5234	3800	2808	1498
No. of Bars and ø for Longitudinal Reinforcement	16 # 20 ø	8 # 20 ø	8 # 20 ø	4 # 20 ø	12 # 25 ø	8 # 25 ø	8 # 25 ø	4 # 25 ø	12 # 25 ø	8 # 25 ø	8 # 25 ø	4 # 25 ø
Actual Area of Steel Provided	5030	2516	2516	1257	5895	3930	3930	1965	5895	3930	3930	1965
Development Length Ld	790	790	790	790	790	790	790	790	790	790	790	790
ø for Transverse Reinforcement	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø	8 ø
Spacing of Transverse Reinforcement	190	245	245	245	190	190	190	190	245	245	190	190
Special Confining Reinforcement as per IS13920 (Cl 7.4.1) lo	600	600	600	600	600	600	600	600	600	600	600	600

Table 4.12: Details of column reinforcement of interior frame for Zone V

Footing Detailing						
	Interior frame			Exterior frame		
Footing identity	F1	F2	F3	F1	F2	F3
Dimension of column (mm)	250 x 250	250 x 250	250 x 250	250 x 250	250 x 250	250 x 250
Width of square footing (m)	1.5	2.5	2.5	1.5	2	2
Total depth (mm)	310	535	520	310	460	440
Area of steel required (mm^2)	916	2160	2091	905	1570	1750
Number and ø (mm) of bars	5 # 16 ø	10 # 16 ø	10 # 16 ø	4 # 16 ø	7 # 16 ø	8 # 16 ø
Spacing provided in both	300	213	242	338	232	232
Volume of concrete (cum)	0.522	2.07	2.11	0.522	1.25	1.19
Weight of steel (kN)	0.23	0.83	0.79	0.204	0.47	0.52

Table 4.13: Details of footing reinforcement of interior and exterior frame for Static case

Footing Detailing						
	Interior frame			Exterior frame		
Footing identity	F1	F2	F3	F1	F2	F3
Dimension of column (mm)	300 x 300	300 x 300	300 x 300	350 x 350	350 x 350	350 x 350
Width of square footing (m)	2	2.7	2.6	1.5	2	2
Total depth (mm)	400	510	500	430	474	510
Area of steel required (mm^2)	1688	2619	2501	796	1782	1770
Number and ø (mm) of bars	8 # 16 ø	12 # 16 ø	12 # 16 ø	4 # 16 ø	7 # 16 ø	5 # 16 ø
Spacing provided in both	241	209	215	330	232	360
Volume of concrete (cum)	1.11	2.42	2.21	0.67	1.16	1.34
Weight of steel (kN)	0.5	1.07	0.96	0.21	0.48	0.34

Table 4.14: Details of footing reinforcement of interior and exterior frame for Zone II

ESTIMATION OF STRUCTURAL COST

The total quantities of the material, i.e., M20 concrete and structural steel (Fe 415) have been computed considering beams, columns and footings for case 1 and case 2. The quantities of materials have also been computed for all the three cases considering the superstructure only.

- The quantity of steel required for beams of exterior and interior frames including tie beams for case 2 is given in Table 5.1.
- The quantity of steel required for columns of exterior and interior frames including foundation for case 2 is given in Table 5.2.
- The quantity of steel required for beams of exterior and interior frames considering superstructure for case 2 is given in Table 5.3.
- The quantity of steel required for columns of exterior and interior frames considering superstructure for case 2 is given in Table 5.4.
- The total quantity of steel and concrete have been worked out for case 1, case 2 and case 3 considering beams, columns are given in Table 5.5. Further, the total quantity of steel and concrete have been worked out for case 1 and case 2 considering beams, columns and footing s are given in Table 5.6.
- The structural cost is worked out by multiplying total weight of steel in tonnes to the cost of steel per tonne. For this purpose, the cost of steel is taken as Rs. 22000/- tonne. The cost of M20 concrete per cubic meter is taken as Rs. 2500/-.

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
	Z2EXT									
1	A1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.0003	7850	23.848
2	A1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	3	0.012	0.0001	7850	8.803
3	A1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
4	A1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
5	A1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
6	A1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
7	A2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.0003	7850	29.939
8	A2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.0001	7850	4.386
9	A2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
10	A2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
11	A2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
12	A2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
13	A3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.0003	7850	29.939
14	A3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.0001	7850	4.386
15	A3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
16	A3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
17	A3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
18	A3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
19	A4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.0003	7850	23.848
20	A4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	3	0.012	0.0001	7850	8.803
21	A4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
22	A4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
23	A4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
24	A4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
25	B1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.0003	7850	23.848
26	B1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.0001	7850	5.868
27	B1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
28	B1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
29	B1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
30	B1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
31	B2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.0003	7850	29.939
32	B2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.0001	7850	4.386
33	B2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
34	B2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
35	B2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
36	B2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
37	B3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.0003	7850	29.939
38	B3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.0001	7850	4.386
39	B3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
40	B3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
41	B3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
42	B3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
43	B4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.0003	7850	23.848
44	B4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.0001	7850	5.868

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
45	B4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
46	B4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
47	B4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
48	B4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
49	C1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
50	C1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.0001	7850	5.868
51	C1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
52	C1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
53	C1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
54	C1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
55	C2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
56	C2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.0001	7850	4.386
57	C2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
58	C2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
59	C2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
60	C2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
61	C3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
62	C3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.0001	7850	4.386
63	C3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
64	C3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
65	C3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
66	C3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
67	C4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
68	C4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.0001	7850	5.868
69	C4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
70	C4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
71	C4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
72	C4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
73	D1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
74	D1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0	0	7850	0.000
75	D1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
76	D1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
77	D1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
78	D1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
79	D2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
80	D2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0	0	7850	0.000
81	D2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
82	D2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
83	D2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
84	D2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
85	D3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
86	D3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0	0	7850	0.000
87	D3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
88	D3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
89	D3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
90	D3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
91	D4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
92	D4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0	0	7850	0.000
93	D4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
94	D4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
95	D4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
96	D4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
97	T1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
98	T1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0.016	0.0002	7850	0.000
99	T1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
100	T1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
101	T1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	16	0.008	5E-05	7850	8.813
102	T1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	6	0.008	5E-05	7850	3.305
103										
104	T2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
105	T2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0.016	0.0002	7850	0.000
106	T2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
107	T2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
108	T2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	16	0.008	5E-05	7850	8.813
109	T2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	6	0.008	5E-05	7850	3.305
110	T3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
111	T3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0.016	0.0002	7850	0.000
112	T3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
113	T3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
114	T3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	16	0.008	5E-05	7850	8.813
115	T3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	6	0.008	5E-05	7850	3.305
116	T4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
117	T4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0.016	0.0002	7850	0.000
118	T4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
119	T4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
120	T4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	16	0.008	5E-05	7850	8.813
121	T4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	6	0.008	5E-05	7850	3.305
	Z2INT									
1	A1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.0003	7850	23.848
2	A1	300 x 450	40% curtailment at top	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
3	A1	300 x 450	Main bottom steel bars	1.255 + 3.6 + 1.035	5.89	2	0.016	0.0002	7850	18.593
4	A1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	1	0.012	0.0001	7850	2.841
5	A1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
6	A1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
7	A2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.0003	7850	29.939
8	A2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	1	0.016	0.0002	7850	3.898
9	A2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
10	A2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
11	A2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
12	A2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
13	A3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.0003	7850	29.939

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
14	A3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	1	0.016	0.0002	7850	3.898
15	A3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
16	A3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
17	A3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
18	A3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
19	A4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.0003	7850	23.848
20	A4	300 x 450	40% curtailment at top	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
21	A4	300 x 450	Main bottom steel bars	1.255 + 3.6 + 1.035	5.89	2	0.016	0.0002	7850	18.593
22	A4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	1	0.012	0.0001	7850	2.841
23	A4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
24	A4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
25	B1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	3	0.016	0.0002	7850	22.894
26	B1	300 x 450	40% curtailment at top	1.035 + 3.6 + 1.035	5.67	1	0.016	0.0002	7850	8.949
27	B1	300 x 450	Main bottom steel bars	1.255 + 3.6 + 1.035	5.89	2	0.016	0.0002	7850	18.593
28	B1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
29	B1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
30	B1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
31	B2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	3	0.016	0.0002	7850	28.742
32	B2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	1	0.016	0.0002	7850	3.898
33	B2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
34	B2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
35	B2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
36	B2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
37	B3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	3	0.016	0.0002	7850	28.742
38	B3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	1	0.016	0.0002	7850	3.898
39	B3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
40	B3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
41	B3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
42	B3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
43	B4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	3	0.016	0.0002	7850	22.894
44	B4	300 x 450	40% curtailment at top	1.035 + 3.6 + 1.035	5.67	1	0.016	0.0002	7850	8.949
45	B4	300 x 450	Main bottom steel bars	1.255 + 3.6 + 1.035	5.89	2	0.016	0.0002	7850	18.593
46	B4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
47	B4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
48	B4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
49	C1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
50	C1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.0001	7850	5.868
51	C1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
52	C1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
53	C1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
54	C1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
55	C2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
					6.07	1	0.012	0.0001	7850	5.389
56	C2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.0001	7850	4.386
57	C2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
58	C2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
59	C2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
60	C2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
61	C3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
					6.07	1	0.012	0.0001	7850	5.389
62	C3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.0001	7850	4.386
63	C3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
64	C3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
65	C3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
66	C3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
67	C4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
68	C4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.0001	7850	5.868
69	C4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
70	C4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.0003	7850	0.000
71	C4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
72	C4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
73	D1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
74	D1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0	0	7850	0.000
75	D1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
76	D1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
77	D1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
78	D1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
79	D2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
80	D2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0	0	7850	0.000
81	D2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
82	D2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
83	D2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
84	D2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
85	D3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
86	D3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0	0	7850	0.000
87	D3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
88	D3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
89	D3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
90	D3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
91	D4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
92	D4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0	0	7850	0.000
93	D4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
94	D4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
95	D4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
96	D4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
97	T1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
98	T1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0.016	0.0002	7850	0.000
99	T1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
100	T1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
101	T1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	16	0.008	5E-05	7850	8.813

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each m	No. of bars	Diameter of bars m	Area of bars mm^2	Density of steel kg/m^3	Weight kg
			Description of bars	Description of length						
102	T1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	6	0.008	5E-05	7850	3.305
103	T2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
104	T2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0.016	0.0002	7850	0.000
105	T2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
106	T2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
107	T2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	16	0.008	5E-05	7850	8.813
108	T2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	6	0.008	5E-05	7850	3.305
109	T3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
110	T3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0.016	0.0002	7850	0.000
111	T3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
112	T3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
113	T3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	16	0.008	5E-05	7850	8.813
114	T3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	6	0.008	5E-05	7850	3.305
115	T4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
116	T4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0.016	0.0002	7850	0.000
117	T4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
118	T4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
119	T4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	16	0.008	5E-05	7850	8.813
120	T4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	6	0.008	5E-05	7850	3.305
										1144.47

Table 5.1: Quantity of steel for beams of exterior and interior frames including tie beams for Zone II

Sl. No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
	Z2EXT		Main steel bars including steel bars below the tie beam							
1	I1	350 x 350	Main steel bars	0.510 + 1.5 + 3.15	5.16	4	0.016	0.000201062	7850	32.577
2	I1	350 x 350	Curtailed main bars	0.510 + 1.5 + 3.15 +0.225+0.79	6.175	4	0.012	0.000113097	7850	21.929
3	I1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.008	5.02655E-05	7850	19.319
4	I2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
6	I2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
7	I2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
8	I3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
10	I3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
11	I3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
12	I4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
14	I4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
15	I4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	18	0.008	5.02655E-05	7850	8.580
16	II1	350 x 350	Main steel bars	0.66 + 1.5 + 3.15	5.275	4	0.016	0.000201062	7850	33.303
17	II1	350 x 350	Curtailed main bars	0.66 + 1.5 + 3.15 +0.225+0.79	6.29	4	0.012	0.000113097	7850	22.337
18	II1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.008	5.02655E-05	7850	19.319
19	II2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
20	II2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
21	II2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
22	II3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
23	II3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
24	II3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103

Table 5.2: Quantity of steel for columns of exterior and interior frames including column below tie beam for Zone II

Sl. No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
25	II4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
26	II4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
27	II4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	18	0.008	5.02655E-05	7850	8.580
28	III1	350 x 350	Main steel bars	0.75 + 1.5 + 3.15	5.4	4	0.016	0.000201062	7850	34.092
29	III1	350 x 350	Curtailed main bars	0.75 + 1.5 + 3.15 +0.225+0.79	6.415	4	0.012	0.000113097	7850	22.781
30	III1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.016	0.000201062	7850	77.275
									7850	0.000
31	III2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
32	III2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
33	III2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
34	III3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
35	III3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
36	III3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
37	III4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
38	III4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
39	III4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
40	IV1	350 x 350	Main steel bars	0.66 + 1.5 + 3.15	5.275	4	0.016	0.000201062	7850	33.303
41	IV1	350 x 350	Curtailed main bars	0.66 + 1.5 + 3.15 +0.225+0.79	6.29	4	0.012	0.000113097	7850	22.337
42	IV1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.008	5.02655E-05	7850	19.319
43	IV2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
44	IV2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
45	IV2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
46	IV3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
47	IV3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
48	IV3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103

Table 5.2: Quantity of steel for columns of exterior and interior frames including column below tie beam for Zone II

Sl. No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
49	IV4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
50	IV4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
51	IV4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	18	0.008	5.02655E-05	7850	8.580
52	V1	350 x 350	Main steel bars	0.510 + 1.5 + 3.15	5.16	4	0.016	0.000201062	7850	32.577
53	V1	350 x 350	Curtailed main bars	0.510 + 1.5 + 3.15 +0.225+0.79	6.175	4	0.012	0.000113097	7850	21.929
54	V1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.008	5.02655E-05	7850	19.319
55	V2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
56	V2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
57	V2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
58	V3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
59	V3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
60	V3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
61	V4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
62	V4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
63	V4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	18	0.008	5.02655E-05	7850	8.580
										935.392

	Z2INT		Main steel bars including steel bars below the tie beam							
1	I1	300 x 300	Main steel bars	0.66 + 1.5 + 3.15	5.31	12	0.012	0.000113097	7850	56.572
2	I1	300 x 300	Curtailed main bars	0.66 + 1.5 + 3.15 +0.225+0.79	6.325	4	0.012	0.000113097	7850	22.462
3	I1	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (0.68)	1.68	24	0.008	5.02655E-05	7850	15.910
4	I2	300 x 300	Main steel bars	3.15	3.15	12	0.012	0.000113097	7850	33.559
6	I2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.012	0.000113097	7850	2.805
7	I2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.36	17	0.008	5.02655E-05	7850	15.831

Table 5.2: Quantity of steel for columns of exterior and interior frames including column below tie beam for Zone II

Sl. No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
8	I3	300 x 300	Main steel bars	3.15	3.15	8	0.012	0.000113097	7850	22.373
9	I3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
10	I3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.012	0.000113097	7850	2.805
11	I3	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.36	17	0.008	5.02655E-05	7850	15.831
12	I4	300 x 300	Main steel bars	3.15+0.225	3.375	8	0.016	0.000201062	7850	42.615
13	I4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
14	I4	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (0.68)	1.68	18	0.008	5.02655E-05	7850	11.932
15	II1	300 x 300	Main steel bars	0.75 + 1.5 + 3.15	5.4	8	0.016	0.000201062	7850	68.184
16	II1	300 x 300	Main steel bars	0.75 + 1.5 + 3.15	5.4	4	0.012	0.000113097	7850	19.177
17	II1	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	24	0.008	5.02655E-05	7850	22.425
18	II2	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
19	II2	300 x 300	Main steel bars	3.15	3.15	4	0.012	0.000113097	7850	11.186
20	II2	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.016	0.000201062	7850	26.295
21	II2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
22	II2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	17	0.008	5.02655E-05	7850	15.884
23	II3	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
24	II3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
25	II3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
26	II3	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88 + (0.68)	1.688	17	0.008	5.02655E-05	7850	11.323
27	II4	300 x 300	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
28	II4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
29	II4	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88	1.008	18	0.008	5.02655E-05	7850	7.159
30	III1	300 x 300	Main steel bars	0.74 + 1.5 + 3.15	5.39	8	0.016	0.000201062	7850	68.058
31	III1	300 x 300	Main steel bars	0.74 + 1.5 + 3.15	5.39	4	0.012	0.000113097	7850	19.141

Table 5.2: Quantity of steel for columns of exterior and interior frames including column below tie beam for Zone II

Sl. No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
32	III1	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	24	0.008	5.02655E-05	7850	22.425
33	III2	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
34	III2	300 x 300	Main steel bars	3.15	3.15	4	0.012	0.000113097	7850	11.186
35	III2	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.016	0.000201062	7850	26.295
35	III2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
36	III2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	17	0.008	5.02655E-05	7850	15.884
37	III3	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
38	III3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
39	III3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
40	III3	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88 + (0.68)	1.688	17	0.008	5.02655E-05	7850	11.323
41	III4	300 x 300	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
42	III4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
43	III4	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88	1.008	18	0.008	5.02655E-05	7850	7.159
44	VI1	300 x 300	Main steel bars	0.75 + 1.5 + 3.15	5.4	8	0.016	0.000201062	7850	68.184
45	VI1	300 x 300	Main steel bars	0.75 + 1.5 + 3.15	5.4	4	0.012	0.000113097	7850	19.177
46	VI1	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	24	0.008	5.02655E-05	7850	22.425
47	VI2	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
48	VI2	300 x 300	Main steel bars	3.15	3.15	4	0.012	0.000113097	7850	11.186
49	VI2	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.016	0.000201062	7850	26.295
50	VI2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
51	VI2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	17	0.008	5.02655E-05	7850	15.884
52	VI3	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
53	VI3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
54	VI3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
55	VI3	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88 + (0.68)	1.688	17	0.008	5.02655E-05	7850	11.323

Table 5.2: Quantity of steel for columns of exterior and interior frames including column below tie beam for Zone II

Sl. No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
56	VI4	300 x 300	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
57	VI4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
58	VI4	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88	1.008	18	0.008	5.02655E-05	7850	7.159
59	V1	300 x 300	Main steel bars	0.66 + 1.5 + 3.15	5.31	12	0.012	0.000113097	7850	56.572
60	V1	300 x 300	Curtailed main bars	0.66 + 1.5 + 3.15 +0.225+0.79	6.325	4	0.012	0.000113097	7850	22.462
61	V1	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (0.68)	1.68	24	0.008	5.02655E-05	7850	15.910
62	V2	300 x 300	Main steel bars	3.15	3.15	12	0.012	0.000113097	7850	33.559
63	V2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.012	0.000113097	7850	2.805
64	V2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.36	17	0.008	5.02655E-05	7850	15.831
65	V3	300 x 300	Main steel bars	3.15	3.15	8	0.012	0.000113097	7850	22.373
66	V3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
67	V3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.012	0.000113097	7850	2.805
68	V3	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.36	17	0.008	5.02655E-05	7850	15.831
69	V4	300 x 300	Main steel bars	3.15+0.225	3.375	8	0.016	0.000201062	7850	42.615
70	V4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
71	V4	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (0.68)	1.68	18	0.008	5.02655E-05	7850	11.932
										1342.19

Table 5.2: Quantity of steel for columns of exterior and interior frames including column below tie beam for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars	Density of steel	Weight kg
			Description of bars	Description of length						
	Z2EXT350									
1	A1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.00031	7850	23.848
2	A1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	3	0.012	0.00011	7850	8.803
3	A1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
4	A1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
5	A1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
6.	A1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
7	A2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.00031	7850	29.939
8	A2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.00011	7850	4.386
9	A2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
10	A2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
11	A2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
12	A2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
13	A3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.00031	7850	29.939
14	A3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.00011	7850	4.386
15	A3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
16	A3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
17	A3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
18	A3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
19	A4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.00031	7850	23.848
20	A4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	3	0.012	0.00011	7850	8.803
21	A4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
22	A4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
23	A4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017

Table 5.3: Quantity of steel for beams of exterior and interior frames for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars	Density of steel	Weight kg
			Description of bars	Description of length						
24	A4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
25	B1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.00031	7850	23.848
26	B1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.00011	7850	5.868
27	B1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
28	B1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
29	B1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
30	B1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
31	B2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.00031	7850	29.939
32	B2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.00011	7850	4.386
33	B2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
34	B2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
35	B2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
36	B2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
37	B3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.00031	7850	29.939
38	B3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.00011	7850	4.386
39	B3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
40	B3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
41	B3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
42	B3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
43	B4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.00031	7850	23.848
44	B4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.00011	7850	5.868
45	B4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
46	B4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000

Table 5.3: Quantity of steel for beams of exterior and interior frames for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars	Density of steel	Weight kg
			Description of bars	Description of length						
47	B4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
48	B4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
49	C1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
50	C1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.00011	7850	5.868
51	C1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
52	C1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
53	C1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
54	C1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
55	C2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
56	C2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.00011	7850	4.386
57	C2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
58	C2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
59	C2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
60	C2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
61	C3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
62	C3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.00011	7850	4.386
63	C3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
64	C3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
65	C3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
66	C3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
67	C4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
68	C4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.00011	7850	5.868

Table 5.3: Quantity of steel for beams of exterior and interior frames for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars	Density of steel	Weight kg
			Description of bars	Description of length						
69	C4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
70	C4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.016	0.0002	7850	0.000
71	C4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
72	C4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
73	D1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
74	D1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0	0	7850	0.000
75	D1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
76	D1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
77	D1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
78	D1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
79	D2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
80	D2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0	0	7850	0.000
81	D2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
82	D2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
83	D2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
84	D2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
85	D3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
86	D3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0	0	7850	0.000
87	D3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
88	D3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
89	D3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
90	D3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856

Table 5.3: Quantity of steel for beams of exterior and interior frames for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars	Density of steel	Weight kg
			Description of bars	Description of length						
91	D4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
92	D4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0	0	7850	0.000
93	D4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
94	D4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
95	D4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
96	D4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
										923.484
	Z2INT300									
1	A1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.00031	7850	23.848
2	A1	300 x 450	40% curtailment at top	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
3	A1	300 x 450	Main bottom steel bars	1.255 + 3.6 + 1.035	5.89	2	0.016	0.0002	7850	18.593
4	A1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	1	0.012	0.00011	7850	2.841
5	A1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
6	A1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
7	A2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.00031	7850	29.939
8	A2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	1	0.016	0.0002	7850	3.898
9	A2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
10	A2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
11	A2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
12	A2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
13	A3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.02	0.00031	7850	29.939
14	A3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	1	0.016	0.0002	7850	3.898
15	A3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
16	A3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000

Table 5.3: Quantity of steel for beams of exterior and interior frames for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars	Density of steel	Weight kg
			Description of bars	Description of length						
17	A3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
18	A3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
19	A4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.02	0.00031	7850	23.848
20	A4	300 x 450	40% curtailment at top	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
21	A4	300 x 450	Main bottom steel bars	1.255 + 3.6 + 1.035	5.89	2	0.016	0.0002	7850	18.593
22	A4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	1	0.012	0.00011	7850	2.841
23	A4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
24	A4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
25	B1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	3	0.016	0.0002	7850	22.894
26	B1	300 x 450	40% curtailment at top	1.035 + 3.6 + 1.035	5.67	1	0.016	0.0002	7850	8.949
27	B1	300 x 450	Main bottom steel bars	1.255 + 3.6 + 1.035	5.89	2	0.016	0.0002	7850	18.593
28	B1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
29	B1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
30	B1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
31	B2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	3	0.016	0.0002	7850	28.742
32	B2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	1	0.016	0.0002	7850	3.898
33	B2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
34	B2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
35	B2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
36	B2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
37	B3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	3	0.016	0.0002	7850	28.742
38	B3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	1	0.016	0.0002	7850	3.898
39	B3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263

Table 5.3: Quantity of steel for beams of exterior and interior frames for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars	Density of steel	Weight kg
			Description of bars	Description of length						
40	B3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
41	B3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
42	B3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
43	B4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	3	0.016	0.0002	7850	22.894
44	B4	300 x 450	40% curtailment at top	1.035 + 3.6 + 1.035	5.67	1	0.016	0.0002	7850	8.949
45	B4	300 x 450	Main bottom steel bars	1.255 + 3.6 + 1.035	5.89	2	0.016	0.0002	7850	18.593
46	B4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
47	B4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
48	B4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
49	C1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
50	C1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.00011	7850	5.868
51	C1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
52	C1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
53	C1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
54	C1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
55	C2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
					6.07	1	0.012	0.00011	7850	5.389
56	C2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.00011	7850	4.386
57	C2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
58	C2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
59	C2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
60	C2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856

Table 5.3: Quantity of steel for beams of exterior and interior frames for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars	Density of steel	Weight kg
			Description of bars	Description of length						
61	C3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
					6.07	1	0.012	0.00011	7850	5.389
62	C3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	2	0.012	0.00011	7850	4.386
63	C3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
64	C3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
65	C3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
66	C3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
67	C4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
68	C4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	2	0.012	0.00011	7850	5.868
69	C4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
70	C4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0.02	0.00031	7850	0.000
71	C4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
72	C4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
73	D1	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
74	D1	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0	0	7850	0.000
75	D1	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
76	D1	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
77	D1	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
78	D1	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
79	D2	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
80	D2	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0	0	7850	0.000
81	D2	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
82	D2	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
83	D2	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
84	D2	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856

Table 5.3: Quantity of steel for beams of exterior and interior frames for Zone II

Sl. No.	Beam identity	Beam size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars	Density of steel	Weight kg
			Description of bars	Description of length						
85	D3	300 x 450	Main top steel bars	0.2+3.6/2 + 1.035 + 3.6/2 + 1.0	6.07	2	0.016	0.0002	7850	19.161
86	D3	300 x 450	40% curtailment at top	0.2 + 1.035 + 1.035 + 0.2	2.47	0	0	0	7850	0.000
87	D3	300 x 450	Main bottom steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
88	D3	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
89	D3	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
90	D3	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
91	D4	300 x 450	Main top steel bars	1.035 + 3.6 + 0.2	4.835	2	0.016	0.0002	7850	15.263
92	D4	300 x 450	40% curtailment at top	1.035 + 1.035 + 1.035 + 0.2	3.305	0	0	0	7850	0.000
93	D4	300 x 450	Main bottom steel bars	1.035 + 3.6 + 1.035	5.67	2	0.016	0.0002	7850	17.898
94	D4	300 x 450	70% curtailment at bottom	4 - 2(0.04)	3.2	0	0	0	7850	0.000
95	D4	300 x 450	Stirrups up to L_d from supports	2 (0.25 + 0.4 + (6*0.008))	1.396	20	0.008	5E-05	7850	11.017
96	D4	300 x 450	Stirrups in middle	2 (0.25 + 0.4 + (6*0.008))	1.396	7	0.008	5E-05	7850	3.856
										960.823

Table 5.3: Quantity of steel for beams of exterior and interior frames for Zone II

Sl.No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
	Z2EXT350		Main steel bars							
1	I1	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
2	I1	350 x 350	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
3	I1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.008	5.02655E-05	7850	19.319
4	I2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
6	I2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
7	I2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
8	I3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
10	I3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
11	I3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
12	I4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
14	I4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
15	I4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	18	0.008	5.02655E-05	7850	8.580
16	II1	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
17	II1	350 x 350	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
18	II1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.008	5.02655E-05	7850	19.319
19	II2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
20	II2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
21	II2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
22	II3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
23	II3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
24	II3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103

Table 5.4: Quantity of steel for columns of exterior and interior frames for Zone II

Sl.No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
25	II4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
26	II4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
27	II4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	18	0.008	5.02655E-05	7850	8.580
28	III1	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
29	III1	350 x 350	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
30	III1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.016	0.000201062	7850	77.275
									7850	0.000
31	III2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
32	III2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
33	III2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
34	III3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
35	III3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
36	III3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
37	III4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
38	III4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
39	III4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
40	IV1	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
41	IV1	350 x 350	Curtailed main bars	3.15 +0.225+0.79	4.13	4	0.012	0.000113097	7850	14.667
42	IV1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.008	5.02655E-05	7850	19.319
43	IV2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
44	IV2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
45	IV2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103

Table 5.4: Quantity of steel for columns of exterior and interior frames for Zone II

Sl.No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
46	IV3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
47	IV3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
48	IV3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
49	IV4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
50	IV4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
51	IV4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	18	0.008	5.02655E-05	7850	8.580
52	V1	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
53	V1	350 x 350	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
54	V1	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08 + (0.832)	2.04	24	0.008	5.02655E-05	7850	19.319
55	V2	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
56	V2	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
57	V2	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
58	V3	350 x 350	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
59	V3	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
60	V3	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	17	0.008	5.02655E-05	7850	8.103
61	V4	350 x 350	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
62	V4	350 x 350	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
63	V4	350 x 350	Stirrups provided	0.096 + 0.032 + 1.08	1.208	18	0.008	5.02655E-05	7850	8.580
										831.492

Table 5.4: Quantity of steel for columns of exterior and interior frames for Zone II

Sl.No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
	Z2INT300		Main steel bars							
1	I1	300 x 300	Main steel bars	0.66 + 3.15	3.81	12	0.012	0.000113097	7850	40.591
2	I1	300 x 300	Curtailed main bars	0.66 + 3.15 +0.225+0.79	4.825	4	0.012	0.000113097	7850	17.135
3	I1	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (0.68)	1.68	24	0.008	5.02655E-05	7850	15.910
4	I2	300 x 300	Main steel bars	3.15	3.15	12	0.012	0.000113097	7850	33.559
6	I2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.012	0.000113097	7850	2.805
7	I2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.36	17	0.008	5.02655E-05	7850	15.831
8	I3	300 x 300	Main steel bars	3.15	3.15	8	0.012	0.000113097	7850	22.373
9	I3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
10	I3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.012	0.000113097	7850	2.805
11	I3	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.36	17	0.008	5.02655E-05	7850	15.831
12	I4	300 x 300	Main steel bars	3.15+0.225	3.375	8	0.016	0.000201062	7850	42.615
13	I4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
14	I4	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (0.68)	1.68	18	0.008	5.02655E-05	7850	11.932
15	II1	300 x 300	Main steel bars	0.75 +3.15	3.9	8	0.016	0.000201062	7850	49.244
16	II1	300 x 300	Main steel bars	0.75 + 3.15	3.9	4	0.012	0.000113097	7850	13.850
17	II1	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	24	0.008	5.02655E-05	7850	22.425
18	II2	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
19	II2	300 x 300	Main steel bars	3.15	3.15	4	0.012	0.000113097	7850	11.186
20	II2	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.016	0.000201062	7850	26.295
21	II2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
22	II2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	17	0.008	5.02655E-05	7850	15.884

Table 5.4: Quantity of steel for columns of exterior and interior frames for Zone II

Sl.No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
23	II3	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
24	II3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
25	II3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
26	II3	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88 + (0.68)	1.688	17	0.008	5.02655E-05	7850	11.323
27	II4	300 x 300	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
28	II4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
29	II4	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88	1.008	18	0.008	5.02655E-05	7850	7.159
30	III1	300 x 300	Main steel bars	0.74 + 3.15	3.89	8	0.016	0.000201062	7850	49.118
31	III1	300 x 300	Main steel bars	0.74 + 3.15	3.89	4	0.012	0.000113097	7850	13.814
32	III1	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	24	0.008	5.02655E-05	7850	22.425
33	III2	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
34	III2	300 x 300	Main steel bars	3.15	3.15	4	0.012	0.000113097	7850	11.186
35	III2	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.016	0.000201062	7850	26.295
35	III2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
36	III2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	17	0.008	5.02655E-05	7850	15.884
37	III3	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
38	III3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
39	III3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
40	III3	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88 + (0.68)	1.688	17	0.008	5.02655E-05	7850	11.323
41	III4	300 x 300	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
42	III4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
43	III4	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88	1.008	18	0.008	5.02655E-05	7850	7.159
44	VII	300 x 300	Main steel bars	0.75 + 3.15	3.9	8	0.016	0.000201062	7850	49.244
45	VII	300 x 300	Main steel bars	0.75 + 3.15	3.9	4	0.012	0.000113097	7850	13.850
46	VII	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	24	0.008	5.02655E-05	7850	22.425

Table 5.4: Quantity of steel for columns of exterior and interior frames for Zone II

Sl.No	Column identity	Column size	Schedule of bars		Length of each	No. of bars	Diameter of bars	Area of bars mm2	Density of steel	Weight kg
			Description of bars	Description of length						
47	VI2	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
48	VI2	300 x 300	Main steel bars	3.15	3.15	4	0.012	0.000113097	7850	11.186
49	VI2	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.016	0.000201062	7850	26.295
50	VI2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
51	VI2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.368	17	0.008	5.02655E-05	7850	15.884
52	VI3	300 x 300	Main steel bars	3.15	3.15	4	0.016	0.000201062	7850	19.887
53	VI3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
54	VI3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
55	VI3	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88 + (0.68)	1.688	17	0.008	5.02655E-05	7850	11.323
56	VI4	300 x 300	Main steel bars	3.15+0.225	3.375	4	0.016	0.000201062	7850	21.308
57	VI4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
58	VI4	300 x 300	Stirrups provided	0.096 + 0.032 + 0.88	1.008	18	0.008	5.02655E-05	7850	7.159
59	V1	300 x 300	Main steel bars	0.66 + 3.15	3.81	12	0.012	0.000113097	7850	40.591
60	V1	300 x 300	Curtailed main bars	0.66 + 3.15 +0.225+0.79	4.825	4	0.012	0.000113097	7850	17.135
61	V1	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (0.68)	1.68	24	0.008	5.02655E-05	7850	15.910
62	V2	300 x 300	Main steel bars	3.15	3.15	12	0.012	0.000113097	7850	33.559
63	V2	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.012	0.000113097	7850	2.805
64	V2	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.36	17	0.008	5.02655E-05	7850	15.831
65	V3	300 x 300	Main steel bars	3.15	3.15	8	0.012	0.000113097	7850	22.373
66	V3	300 x 300	Curtailed main bars	3.15 +0.225+0.79	4.165	4	0.012	0.000113097	7850	14.791
67	V3	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.012	0.000113097	7850	2.805
68	V3	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (1.36)	2.36	17	0.008	5.02655E-05	7850	15.831
69	V4	300 x 300	Main steel bars	3.15+0.225	3.375	8	0.016	0.000201062	7850	42.615
70	V4	300 x 300	Spliced bars	0.79+0.79	1.58	2	0.016	0.000201062	7850	4.988
71	V4	300 x 300	Stirrups provided	0.096 + 0.024 + 0.88 + (0.68)	1.68	18	0.008	5.02655E-05	7850	11.932
										1226.777

Table 5.4: Quantity of steel for columns of exterior and interior frames for Zone II

	Total weight of steel in tonne	Total cost of steel @ Rs. 22000/- tonne Rs.	Total volume of concrete in cum	Total cost of concrete @ Rs. 2500/cum Rs.	Total structural cost in Rs.
Static	20.48	434307.36	87.54	218850.00	653157.36
Zone II	32.78	795857.57	112.46	281150.00	1077007.57
Zone V	99.31	2076279.04	132.30	330750.00	2407029.04

Table 5.5: Cost of structural steel and concrete for all cases without considering foundation

	Total weight of steel in tonne	Total cost of steel @ Rs. 22000/- tonne Rs.	Total volume of concrete in cum	Total cost of concrete @ Rs. 2500/cum Rs.	Total structural cost in Rs.
Static	24.56	540323.39	135.55	338862.50	879185.89
Zone II	42.30	930661.03	168.58	421450.00	1352111.03

Table 5.6: Cost of structural steel and concrete for all cases except Zone V considering foundation

CONCLUSIONS

The total quantity of the steel, concrete and the structural cost have been worked out for case 1, case 2 and case 3 considering beams and columns. Further the total quantity of the steel, concrete and the structural cost have also been worked for case 1 and case 2 considering beams, columns and foundation. The following conclusions are made:

- The structural cost for case 1, case 2 and case 3 comes out to be Rs.653157.36, Rs.1077007.57 and Rs.2407029.04 respectively without considering the structural cost of foundation. Thus, the structural cost for case 2 is 1.649 times the structural cost for case 1 and the structural cost for case 3 is 3.685 times the structural cost for case 1.
- The structural cost for case 1 and case 2 works out to be Rs.879185.89 and Rs.1352111.03, respectively, considering foundation. Thus, the structural cost for case 2 is 1.538 times the structural cost for case 1.
- The structural cost of foundation for case1 and case2 works out to be Rs.226028.53 and Rs.275103.46, respectively. Thus the structural cost of foundation for case 2 is 1.217 times the structural cost of foundation for case 1.

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DESIGN OF BEAM, COLUMN AND FOOTING

For identifying the members in the frames, the columns of particular floor are no. as In, IIn, IIIn..., where n represents the floor no. I, II, etc., represent the column no. The beams of the frame are no. as An, Bn, Cn and Dn where A, B, C and D represent the first floor, the second floor, the third floor and the roof while n represents the beam no.

The sample calculations for the design of beam and column for case 3 are given in this APPENDIX. Further, the calculations for the design of footing for case 2 are also given.

A.1 CALCULATIONS FOR THE DESIGN OF BEAM FOR CASE 3

The results of analysis for beam (127) are as follows

	Hogging (kNm)	Sagging (kNm)	Shear (kN)
Left Node	-243.28	170.14	161.08
Right Node	-226.09	145.82	-163.3
Center	0	42.26	--------

Beam Size: 300 mm x 450 mm

Concrete Grade: M20

Steel: Fe415

A.1.1 General

(a) Width/Depth > 0.3 (300/450)

(b) Width > 200 mm

(c) Depth <1/4 (Clear span)

A.1.2 Calculation of Longitudinal Reinforcement

(i) To provide steel for hogging moment, assume 20 mm ø bars with 25 mm clear cover.

Effective depth d = 450-25-20/2 = 415 mm

From Table D of SP16 [11]

$M_{ulim}/bd^2 = 2.76\ N/mm^2$

$M_{ulim} = 2.76 \times 300 \times 415^2\ Nm = 142.6$ kNm

Since the actual Moment is greater than the limiting moment the section is to be designed as a doubly reinforced.

From tables,

$M_u/bd^2 = 243.28 \times 10^6 = 4.708\ N/mm^2$

d'/d = 25+10/415 = 0.08

Now referring to Table 50 of SP 16

for $M_u / bd^2 = 4.708$ and d'/d = .01

gives:

$P_t = 1.5554$, where Pt is % of tension reinforcement.

$P_c = 0.6306$, where Pc is % of compression reinforcement.

Area of steel required at top and bottom to take care of this moment is

$A_{st} = 1.555 \times 300 \times 415/100 = 1936\ mm^2$

$A_{sc} = 0.6306 \times 300 \times 415/100 = 785\ mm^2$

(ii) To provide steel for sagging moment

assume 20 mm ø with 25 mm clear cover.

Effective depth = 450 – 25 - 20/2 = 415 mm

$M_{ulim} = 2.76 \times 300 \times 415^2 = 142.6$ KNm < 170.14 kNm

Hence, the actual moment is greater than the limiting moment the section is to be designed as a doubly reinforced

$M_u/bd^2 = 170.14 \times 10^6/300 \times 415 = 3.293$, say 3.3

d'/d = 35/415 =0.8, say 0.1

Now from Table 50 of SP16 [11]

For $M_u/bd^2 = 3.3$ and

$d'/d = 0.1$

$P_t = 1.122$ and $Pc = 0.174$

Hence the area of steel required at the bottom and top to take care of this moment

$A_{st} = 1396\ mm^2$ (bottom)

$A_{sc} = 216\ mm^2$ (top)

Area of steel to be provided to take care of the hogging moment 243.28 kNm and the sagging moment 170.14 kNm at the left node is maximum of top reinforcement and maximum of bottom reinforcement given by (i) and (ii).

The area of the steel at the top and the bottom are 1936 mm^2 and 1396 mm^2 respectively.

Provide 2 nos 25 mm ∅ + 4 nos 20 mm ∅ at the top (2234 mm^2) and 2 nos 25 mm ∅ + 2 nos 20 mm ∅ at the bottom.

At least 2 bars should run full length at top and bottom. Since the sagging moment at the center of span is less than the sagging moment the supports, the same reinforcement can be provided at the centre of span.

A.1.3 Calculation of Shear Reinforcement

A_{st} (bottom) =1610 mm^2 $P_b = 1.3$

A_{sc} (Top) = 2234 mm^2 $P_t = 1.81$

From Table 50 of SP 16 [11]

for $P_b = 1.3$ and $d'/d = 0.1$

$M_{ulim}/bd^2 = 3.9$

Hence, M_{ulim}= 199.08 KNm (sagging moment)

For $P_t = 1.81$ and $d'/d = 0.1$

$M_{ulim}/bd^2 = 5.535$

Hence, $M_{ulim} = 282.54$ KNm (sagging moment)

Loads on the beam no.127

UDL = 12.4 kN/m

Dead load Triangular = 21.1 kN/m

Live load triangular = 6 kN/m

$V_a^{(D+L)} = V_b^{(D+L)} = 62.28KN$

(i) For sway to the right

$V_{ua} = V_a - 1.4\ [(M^{As}_{ulim} + M^{Bh}_{ulim})/L_{ab}]$

$V_{ub} = V_a + 1.4\ [(M^{As}_{ulim} + M^{Bh}_{ulim})/L_{ab}]$

(ii) For sway to the left

$V_{us} = V_u - 1.4\ [(M^{As}_{ulim} + M^{Bh}_{ulim})/L_{ab}]$

$V_{us} = V_u + 1.4\ [(M^{As}_{ulim} + M^{Bh}_{ulim})/L_{ab}]$

Since the reinforcements provided is the same at both the sides the moment capacity will also be the same.

$V_{ua} = -106.28$ kN

$V_{ub} = 230.85$ kN

$V_u = 230.85$ kN

Area of reinforcement provided at the bottom near supports

$A_{st} = 1610\ mm^2$

$p = 1.3\%$

From IS 456-2000 [3] Table 19

$\tau_c = 0.68\ N/mm^2$

$\tau_v = 1.865$

$\tau_v < \tau_c$, Shear reinforcement is to be provided

$V_{us} = V_u - \tau_c\ b\ d$

Adopting 8 mm ∅ 2 legged stirrups

$A_{sv} = 100.5\ mm^2$

- $S_v = 102.03$
- $S_v = d/4 = 103.125$ mm
- $S_v = 8$ x minimum diameter of longitudinal bar = 160 mm

S_v is lesser of the above

Therefore, provide 8 mm ∅ 2legged stirrups @ 100 mm c/c up to 2d distance from the face of the support

max spacing = d/2 = 206.25

And for the remaining distance provide 8 mm ∅ 2 legged stirrups at 200 mm c/c.

A.2 CALCULATIONS FOR THE DESIGN OF COLUMN FOR CASE 3

The results of analysis for column 115 are as follows:

$P_u = 796$ kN

$M_{uz} = M_x = 167$ kNm

$M_{uy} = M_y = 15.53$ kNm

Column size = 400 x 400

M20, Fe415

A.2.1 General

(a) Allowable axial stress $> 0.1 f_{ck}$

$(796 \times 10^3 / 400 \times 400) = 4.976 > 0.1 \times 20 = 2$ N/mm^2. O.K

(b) Minimum dimension of member > 250 mm . 400mm > 250 mm

(c) Shortest cross section dimension / Perpendicular dimension > 0.4.

i.e., (400/400) = 1 > 0.4. hence, O.K

A.2.2 Calculation for Longitudinal Reinforcement:

$e_{min} = (L/500) + (D/30)$

$e_{x.min} = (3150/500) + (400/30) = 19.63$ mm.

$e_{y.min} = (3150/500) + (400/30) = 19.63$ mm.

Moment due to minimum eccentricity.

$M_{ex} = M_{ey} = 796 \times 10^3 \times 19.63 = 15.625 \times 10^6$ Nmm = 15.63 kNm.

$M_x = 167$ kNm and M_y greater of M_{uy} and M_{ey} which gives.

$M_y = 15.63$ kNm.

The reinforcement is distributed equally on four sides.

As a first trial assume p = 1.5 %.

$(p/f_{ck}) = (1.6/20) = 0.08$.

Now uniaxial moment capacity of the column about x-x axis.

d' = (40 + 20/10) = 50 mm ; (d'/D) = (50/400) = 0.125 = 0.15(approx).

$(P_u / f_{ck} bD) = (796 \times 10^3 / 20 \times 400 \times 400) = 0.248$.

From chart 45 of SP- 16 [11], $f_y = 415$ N/mm^2 and (d'/D) = 0.15.

$(P_u/ f_{ck} bD) = 0.248$ and $(p/f_{ck}) = 0.8$.

$(M_u/ f_{ck} bD^2) = 0.115$.

$M_{ux1} = 0.115 \times 20 \times 400 \times 400^2 = 147.2 \times 10^6 = 147.2$ kNm.

$M_{ux1} < M_{ux}$ increase percentage of steel.

Let p = 2%.

$(p/f_{ck}) = (2/20) = 0.1$.

Now $(M_u/ f_{ck} bD^2) = 0.122$.

$M_{ux1} = 0.122 \times 20 \times 400 \times 400^2$

$= 156.16 \times 10^6 = 156.16$ kNm.

$M_{ux1} < M_{ux}$, again increase percentage of steel.

Let p = 2.2%.

$(p/f_{ck}) = (2.2/20) = 0.11$.

Now $(M_u/ f_{ck} bD^2) = 0.141$.

$M_{ux1} = 0.141 \times 20 \times 400 \times 400^2$

$= 180.48 \times 10^6 = 180.48$ kNm.

Now $M_{ux1} > M_{ux}$, therefore O.K.

Since the column is square cross section the moment capacity is same in x-x axis and y-y axis.

Therefore, $M_{uy1} = 180.48$ kNm.

Calculation of P_{uz}., where $P_{uz} = 0.45 . f_{ck} . A_c + 0.75 f_y . A_{sc}$

$p = 1.6$; $f_y = 415$; $f_{ck} = 20$.

From chart 63.

$P_{uz} = 13.75 A_g = 13.75 \times 400 \times 400 = 2200 \times 10^3$ N = 2200kN.

Now $(P_u / P_{uz}) = (796 \times 10^3 / 2200 \times 10^3) = 0.362$

α_n is related to (P_u / P_{uz}), for values of $P_u / P_{uz} = 0.2$ to 0.8, the values of α_n vary linearly from 1.0 to 2.0. For values less than 0.2, α_n is 1.0: for values greater than 0.8, αn is 2.0.

Now for $P_u / P_{uz} = 0.362$, $\alpha_n = 1 + (1/8.6) \times 0.162 = 1.27$

Safety equation:

$[M_{ux}/ M_{ux1}]^{\alpha n} + [M_{uy}/ M_{uy1}]^{\alpha n} <= 1.0$

$(167/180.48)^{1..27} + (15.63/ 180.48)^{1.27} <= 1.0$

$0.906 + 0.044 <= 1.0$

$0.95 <= 1.0$, hence safe.

$A_{st} = ((2.2 \times 400 \times 400) / 100) = 3520 \text{ mm}^2$

A.2.3 Calculation for Transverse Reinforcement

(i) a) Shear from the analysis $V_u = 132.301$ kN

b) Factored shear force, as per IS 13920:1993 [5]

$V_u = 1.4 [(M^{bL}_{ulim} + M^{bR}_{ulim}) / h_{st}]$

Moment of resistance of beam section due to tension reinforcement 1863 mm^2 and compression reinforcement 1258 mm^2

$M R = M_{ulim} + M_{u2}$

$M_{ulim} = 0.36 \text{ fck} . b . x_{umax} . (d-0.42 x_{umax})$

$= 0.36 \times 20 \times 300 \times 0.48 \times (412.5)^2 \{1-0.42 \times 0.48\} = 140.85$ kNm.

$M_{u2} = f_{sc} A_{sc} (d-d')$

$= 355 \times 1258 \times (412.5 - 25) = 173.05$ kN-m.

$M^{bL}_{ulim} = 140.85 + 173.05 = 313.9$ kNm

Similarly, $M^{bR}_{ulim} = 313.9$ kNm

Therefore, $V_u = 1.4[(313.9 + 313.9) / 3.15] = 279$ kN

Therefore V_u is greater of (a) and (b), i.e., Vu = 279 kN

(ii) Now $\tau_v = V_u/bd = 279 \times 1000/300 \times 412.5 = 2.25 \text{ N/mm}^2$

$p = 100 A_{st} / bd = (100 \times 1863)/300 \times 412.5 = 1.5$

$\tau'_c = 0.72 \text{ N/mm}^2$ from Table 19 of IS 456: 2000

$\delta = 1 + (3 Pu / A_g f_{ck})$ should not be greater than 1.5 as per IS 456.-2002 clause 40.2.2.

$\delta = 1 + (3 \times 796 \times 1000/300 \times 450 \times 20) = 1.88 > 1.5$

Therefore $\delta = 1.5$

Now $\tau_c = 0.72 \times 1.5 = 1.08 \text{ N/mm}^2$

Since $\tau_c < \tau_v$

Provide shear reinforcement

$V_{us} = V_u - \tau_c \; b \; d$

$= 279 \times 1000 - 1.08 \times 300 \times 412.5$

$= 145350$ N

Provide 8 mm ø 2 legged vertical stirrups.

Spacing is lesser of

a) $S_v <= (A_{sv} \; 0.87 \; fy) / (0.4 \; b) = 226.8$ mm

b) $0.75 \; d = 0.75 \times 400 = 300$ mm

c) 300 mm

Therefore, provide 8 mm ø 2 legged vertical stirrups.@225 mm c/c.

A.3 CALCULATIONS FOR THE DESIGN OF FOOTING FOR CASE 2

The results of analysis for the footing are as follows:

Axial Load carried by column = 605.9 kN

Design of foundation is done as per IS: 456-2000 [3]

Parameters

Bearing capacity of Soil	= 350 kN/m^2
Unit weight of Earth	= 20 kN/m^3
Grade of Concrete	M 20
Grade of Steel	Fe 415
Load factor	1.5

Calculation

(i) Soil Pressure

Approximate area of footing required	= 605.9 / 350 = 1.73 m^2
Weight of footing including earth	= 20 x 1.0 x 1.73 = 34.6 KN
Total weight on Soil	= 605.9 + 34.6 = 640.5 KN
Actual area of footing required.	= 640.5 / 350 = 1.83 m^2

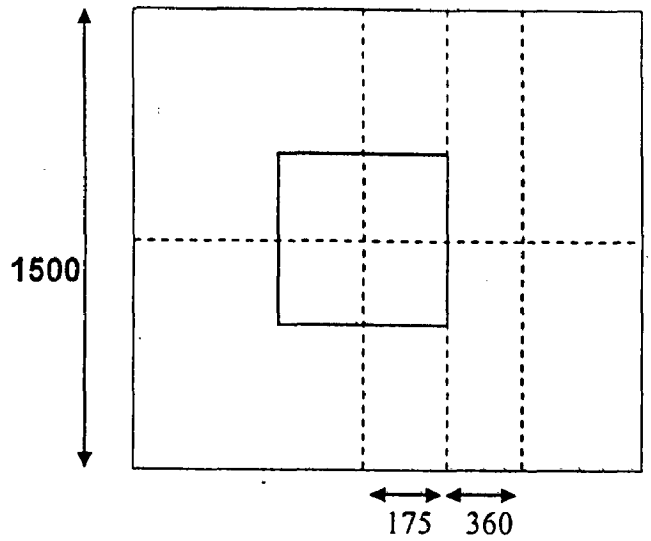
Hence, provide square footing of size 1.5 x 1.5 m.

Total area provided = 2.25 m^2 > 1.83 m^2, O.K.

(ii) Bending Moment

The net earth pressure acting upward due to factored load,

P = 605.9 x 1.5 /2.25 = 404 kN/m^2



Bending moment about an axis- X passing through the face of column

BM = 404 x 1.5 x $(1.5-0.35)^2/4$ x 0.5= 100.02 kNm

The effective depth required from BM = $0.138\sigma_{ck}bd^2$, we get, d= 155.5 mm

Adopt 360 mm effective depth and 430 mm overall depth. Increased depth is taken due to shear consideration.

Area of tension reinforcement

BM = $0.87\sigma_y A_t (d- \sigma_y A_t / \sigma_{ck} b)$ A_t= 796 mm^2

Percentage of steel, p = 796 x 100/1500 x 360 = 0.143%

Provide 16 mm bars@ 330c/c.

(iii) Shear-One way action

The critical section is taken at distance 'd 'away from the face of column

Shear force, V_u = 404 x 1.5 [(1.5 -0.35)/2-0.36] = 130.30 kN

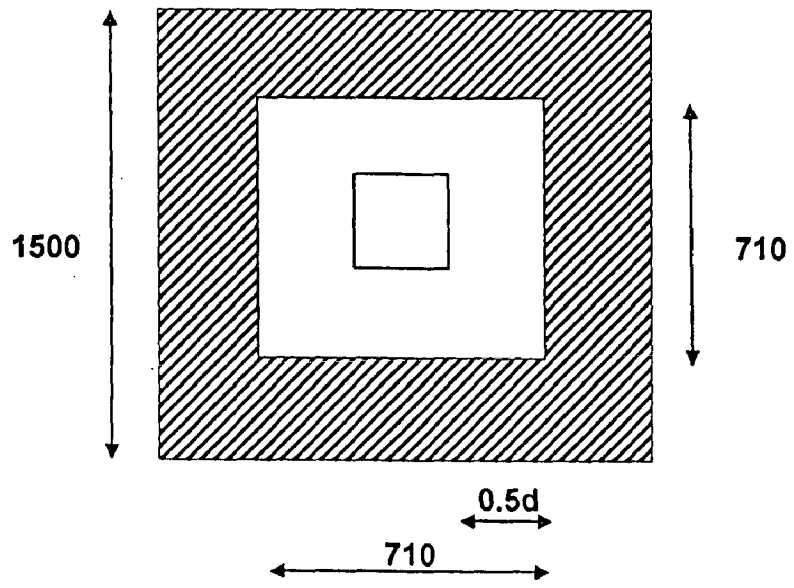
Nominal shear stress, $\tau_v = V_u / bd$ = 0.24 N/mm^2

Shear strength of M20 concrete with 0.143% steel, τ_c= 0.36 N/mm^2

$\tau_c > \tau_v$, therefore O.K.

(iv) Shear - Two way action

The critical section is taken at a distance '0.5d' away from the face of the column as shown in figure.



Plan

Shear force, V_u = 705.34 kN

Nominal shear stress, $\tau_v = V_u / bd = 0.68$ N/mm^2

Shear strength of M20 concrete

$\tau_c' = K_s \tau_c$

Where, $\tau_c = 1.118$ N/mm^2 for M 20 concrete

$K_s = (0.5 + \beta_C)$

β_C = Length of shorter side of column / Length of longer side of column = 1

Therefore, $K_s = (0.5+1.0) = 1.5$, this should not greater than 1

$\tau_C' = 1.0 \times 1.118 = 1.118 > \tau_v$ O.K.

(v) Development length

Development length of 16 mm diameter bar,

$L_d = (\sigma_s \times \Phi)/(4 \times \tau_{bd}) = 752$ mm

Actual embedment provided from face of the column

= (1500 - 350) /2 – 50 x cover

= 515 mm < L_d not O.K.

Provide hooks of 228 mm

$\sigma_{br} = P_u / A_c = 7.42$ N/mm^2

Allowable bearing capacity = $0.45 \times \sigma_{ck} = 9$ N/mm^2 O.K.