and bottom layers to control tensile stresses from bending, placed in a perpendicular fashion, with additional bars in sensitive locations such as the rims and joints. These include; concrete and steel properties, load combinations and building code requirements and specifications, and the reinforcement detailing. There is always a guarantee of safety and affordability when construction work is well planned.

A comprehensive structural analysis and earthquake-resistant design for a commercial building was undertaken to develop a robust Reinforced Cement Concrete(RCC) frame structure. The project was initiated with a primary focus on designing a multi-level building accommodating complex architectural requirements in a seismically vulnerable zone. Advanced computational techniques were employed using SAP2000 software for structural modeling and analysis. Comprehensive structural components were systematically evaluated including slabs, beams, columns and foundations. Detailed load calculations were performed following IS codes. Structural modeling incorporated multiple levels featuring lower basement. upper basement. lower ground. and five floors with specialized design interventions. Preliminary design calculations were executed for structural elements. Lateral load distributions were analyzed. Load combinations were defined following standard specifications. Reinforcement designs were developed for each structural member. ensuring comprehensive structural safety and performance under various loading conditions.

12.2 Objectives

The prime intention of organizing project was to design a comprehensive RCC frame structure with earthquake-resistant characteristics for a commercial building in a seismically active zone. Other aims were:

To upgrade the structural design by incorporating advanced computational techniques and software modeling.

To boost the structural safety through systematic load analysis and se1sm1c load considerations.

12.3 Nature of Works

I guided the comprehensive structural design project for a commercial building with a strategic approach to seismic resilience. I supervised the structural analysis process by integrating

1

To develop a 3D structural model using SAP2000 and calculate imposed loads considering different material densities and seismic criteria.

To conduct preliminary structural evaluations for structural elements including slab, beams, and columns with precise dimensional specifications.

To transform discrete loads into systematic load distributions and evaluate seismic weight through comprehensive structural load calculations.

To determine fundamental natural vibration period and calculate seismic base shear for ensuring structural stability under different loading conditions.

13 Personal Engineering Activities (PEAs) 13.1

I developed knowledge on structural design from the analysis of behavior of reinforced concrete. I gained knowledge on critical parameters that affect structural member performance by doing intense theoretical analysis. I also gathered perception on load distribution patterns in different structural members by means of thorough assessment. I focused on the various structural members such as beams, columns, slabs & foundations to determine the best pattern for reinforcement. To improve the design interventions, I analyzed multiple incidents relating to structure failures. I made understandings about concrete mix and specification along with requirements of steel grades for structural purposes. I gathered information on a number of loading conditions, in terms of how it influenced the stability of the building. I understood such fundamental notfons of preliminary design as those which were required when performing member sizing calculations. I researched for foundation design concepts considering the type of soil to be assumed in the structural design. I analyzed several design codes in order to conform with the latest codes in this field. I researched SAP2000 software applications for the structural modeling point of view. I compared the detailed reinforcement requirements for various structural members. I comprehensively learnt computational techniques used in problem solving of structural systems using advanced software.

13.2

I opted to design an RCC frame structure with comprehensive safety measures. I picked mat foundation considering the soft soil conditions beneath the structure. I selected to incorporate

multiple levels including LowerBasement + UpperBasement + LowerGround + 5floors + roof configuration. I decided on a systematic grid layout featuring l0grids along XAxis. I preferred

I 3grids along Y-axis for optimal space utilization. I chose to maintain 27.43 Im building height above foundation level. I decided on varying floor heights. I selected 2.743m height for basement levels. I opted for 3.657m floor-to-floor height from Lower Ground to 4th Floor. I picked 3.657m height for the terrace level. I proposed installation of 4 lifts on each floor level. I decided to incorporate specialized design elements for soft soil conditions. I selected comprehensive structural components including slabs beams columns. I chose to integrate staircase design within the structural framework. I opted for mat foundation considering the underlying soil characteristics. I decided on SAP2000 software platform for structural analysis. I preferred detailed reinforcement design for each structural member. I selected appropriate load combinations following standard specifications. I proposed systematic detailing approaches for all structural elements.

13.3

I started the project by analyzing the structural plan and evaluating the effective areas for each load-bearing component(figure2). I devised 3D model of design in SAP2000(figure3). I calculated the imposed loads based on the specified areas: parking with 5kN/m2, store room with 5kN/m2, staircase and lobby with 4kN/m2, roof with l.5kN/m2, and retail shop with 4kN/m2. I incorporated dead loads by using densities of materials, including marble at 26kN/m2, screed at 24kN/m3, plaster at 20.4kN/m3, concrete at 25kN/m3, and masonry at 20.4kN/m3. I calculated the total gravity loads using IS 875 (Part I and Part 2). I applied lateral seismic loads per IS 1893:2002, considering Kathmandu's Zone V seismic criteria. I divided staircase loads equally to supporting beams and converted all loads to equivalent UDL. I adjusted the loads for two-way slabs using a trapezoidal and triangular load distribution, as per IS 456:2000. I performed the preliminary design for beams, slabs, and columns. I estimated beam depths for deflection control using IS 456:2000 Clause 23.2. I used factored axial loads for column dimensions following IS 456:2000 Clause 39.3. I finalized RC element design using the Limit State Method.

21

30' 24 24' 24' 24 24 18' 18'

HATCH UNHATCH

JO" 24" 24' 24' 24" 24' 18' 18"

Figure 2: Analysis area

Figure 3: Depiction of 3D model

13.4

I started the calculations with initial design of slab(figure4). I determined the effective depth of the slab to be 100mm based on the deflection control criteria using IS 456:2000. I provided an eff. cover of 30mm, resulting in overall depth of 130mm(figure5). I used Fe415 HYSD bars and assumed tensile reinforcement of 0.3%. For the beams along the X-direction, I evaluated the

effective depth as 525mm, providing an effective cover of 40mm that resulted in overall depth of 565mm. I determined the beam width to be 230mm. For beams in the Y-direction, I calculated the effective depth to be 605mm with eff. cover of 40mm, depicting in an overall depth of 645mm. I provided a beam width of 260mm. For secondary beams, I adjusted the width to 200mm and the depth to 500mm based on load requirements. I moved to the design of columns. For Column l(figure6), I calculated the total load as 659 .7bd+ I 507.876KN and determined the

dimensions to be b and d as 365mm. For Column II (figure7), I calculated the total load as

659.7bd+3193.87kN and provided dimensions with b & d as 570mm. For Column IIl(figure8), I evaluated the total load as 659 .7bd+4429.248kN and provided dimensions of as b & d with 625mm. I also did vertical load evaluations.

Preliminary design of slab

Criteria for deflection was:

(1/d) < (1/d)hasie \* ajly

For continuous slab, take (1/d)basic =26 as per IS 456 cl.23.2.l (a). For modification factor p=1 for singly reinforced.

And for rectangular section y =1. For a:

fs = 0.58 \* fy \* (Astreq / Astprovided) = 240.7 N/mrn2

Providing fy =415 for Fe415 steel HYSD bars and assuming Asueq=Asrprovided Then on assuming 0.3% tensile reinforcement and

/y=240.7 In graph from fig.4 ofIS 456 .a=1.42

( )<26\*1.42

3657.6 >99.06

Or, d > 26 1.42

So,providing d =l00mrn and effective cover= 30mm Overall depth= 130mm

Column I (A-1): Load from:

Slab= 8.4\*6.248.\*2.591

= 135.98 kN Beam:

X- direction:

=

(0.565\*0.23\* 1.981 +0.5\*0.5\*0.2\*2.591)\*25 = 9.674kN

Y-direction:

=5.638\* .645\*0.26\*25 =23.67 kN

Shear wall:

= 5.638\*.2286\*(2.743-.645)\*25+(2.5910.2286)\*.2286\*2.743\*25

=104.528kN Self-weight:

=25\*bd\*(2.743-0.13)

= 65.325bd kN

Upper basement:

= 65.325bd+ I 04.528+ 135.98+9.674+23.67

= (65.325bd+273.852) kN

Lower ground floor:

= 25\*bd\*(3.657-0.l 3)+135.98+9.674+23.67

= (88.175bd+l69.324) kN

Upper ground floor:

=20.4\*(6.248+2.59 l)\*0.2286\*(3.657-0.13)\*0.3 + (88. I 75bd+169.324)

= (88.175bd+212.94) kN

I stto 4th:

= 4\* (88.175bd + 212.94)

=352.7bd +851.76 KN

:. Total load= L All loads

= 659.7bd + 1507.876 kN

Considering 20% seismic load, Then design load

= (659.7bd\*1.5\* 1.2 + 1507.876\* 1.5)

= 1187.46bd+2714.17 kN

Considering 3.5% steel.

Pu=0.46fck (Ag-x% of Ag) + 0.75\* fy\* Ase

:. Ag =bd =131994.156

:. b =d =363.31mm Providing b =d = 365mm

Vertical Load Analysis Self -weight of slab Slab thickness = 130mm

Cone. unit weight= 25 kN/m3

Own-Slab wt.= 25\*0.13= 3.25 kN/m2

Wt. of slab due to floor finishing = 1.157 kN/m2 Total self-weight= 4.407 kN/m2

Self -weight of Primary beam

Along X-axis, Self-weight of beam= 0.23\*0.565\*25 = 3.248 kN/m Along Y-axis, Beam Own-load= 0.26\*0.645\*25 = 4.193 kN/m

Self -weight of Secondary beam

Along X, Beam own load = 0.2\*0.5\*25 = 2.5kN/m

Along Y-axis, Self-weight of beam= 0.2\*0.5\*25 = 2.5kN/m

Self -weight of column

For column-I type, Own load= 25\*0.365\*0.365 = 3.331kN/m For column-II type, Own load= 25\*0.57\*0.57 = 8.122kN/m For column-illtype, Own load= 25\*0.625\*0.625 = 9.765kN/m

7.3l'oZ

.407<

3.6576 3,6576

Figure 4: Slab design

Screed (25mm) Marble (15mm)

130mm

Slab (M25) Plaster (12mm)

Figure 5: Sections for slab

12.59t0

3,5050

6,2480

2,7430

Figure 6: Depiction of type I column

62480

.,.\_-----7.3140-------4 1

lJ O:SO

- l i

! 2,7i30

1----3. 570---+---3.6570--l

Figure 7: Depiction of type II column

7.3140

l3.4375

6. B750

3.4375

3,6570

3.6570

Figure 8: Display of type III column

13.5

I ensure accurate transfer of slab self-weight and live load for comprehensive structural analysis by transforming discrete loads into systematic load distributions(table I to table 6). I determined the slab load for beam I (A-B) as 6.200kN/m. I evaluated the total uniformly distributed load (UDL) due to the slab on this beam as 6.200kN/m. I noted total load for this beam to be 28.346kN. I calculated similar values for beam 1(B-C), confirming the slab load and UDL to be 6.200kN/m each. I obtained the total load on this beam as 28.346kN. I assessed beam l(C-C'), where I determined a slab load of 5.350kN/m. I verified the UDL contribution to be 5.350kN/m. I recorded the total load as I 9.569kN. I performed the calculations for beam I (C'-D) and validated identical results, with the total load also being I 9.569kN. I proceeded with beam I '(A B), where I calculated the slab load to be 6.200kN/m. I found the total UDL to be I 2.40 I kN/m. I confirmed the total load on this beam as 56.692kN. I repeated these calculations for beam I '(B C), obtaining consistent results. I convert vertical load calculations into uniformly distributed loads (UDL) on beams(table7 to 10). I determined the seismic weight of the structure considering the contributions from various elements(tablel I). I evaluated the slab self-weight as per its thickness and density, resulting in a distributed load contribution of 4.4kN/m2. I found that beam and column self-weights were included based on their cross-sectional dimensions and

material properties. I calculated the total floor seismic weight by summing up these loads and adding imposed live loads as specified by the design code.

Slab load converted to UDL to transfer into the beam

Table I: Lower & upper basement along x

Beam ID

Beam

Length

Slab

ID

Intensity DL

k.'l/m2

Lx

Ly

Lx/Ly

Slab Load

total

Total Load(kN)

UDL

due to slab

triilllgular

trapezoidal

one

way

l(A-B)

4.572

S2

4.4

3.505

4.572

0.767

6.200

6-200

28.346

l(B-C)

4.572

S2

4.4

3.505

4.572

0.767

6.200

6200

28.346

l(C-C')

3.657

S4

4.4

3.505

3.657

0.958

5.350

S.350

19.569

l(C'-D)

3.657

S5

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l(D-D')

3.657

S6

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l(D'-E)

3.657

S7

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l(E-E')

3.657

S8

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l(E'-F)

3.657

S9

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l'(A-B)

4.572

S2

4.4

3.505

4.572

0.767

6.200

12.401

56.692

S2

4.4

3.505

4.572

0.767

6.200

l'(B-C)

4.572

S2

4.4

3.505

4.572

0.767

6.200

12.401

56.692

S2

4.4

3.505

4.572

0.767

6.200

l'(C-C')

3.657

S4

4.4

3.505

3.657

0.958

5.350

10.701

39.138

S4

4.4

3.505

3.657

0.95&

5350

l'(C'-D)

3.657

S4

4.4

3.505

3.657

0.958

5.350

10.701

39.138

S4

4.4

3.505

3.657

0.95&

5350

l'(D-D')

3.657

S4

4.4

3.505

3.657

0.958

5.350

10.701

39.138

S4

4.4

3.505

3657

0.95&

5350

l'(D'-E)

3.657

S4

4.4

3.505

3.657

0.958

5.350

10.701

39.138

S4

4.4

3.505

3.657

0.958

5.350

Table 2: Lower & upper basement along y

Beam ID

Beam Length

Slab ID

Intensity DL

Lx

Ly

Lx.JLy

Slab Load

total udl due to slab

Total Load(k..'<)

triangulaJ"

trapezoidal

one

way

A(0-1)

2.743

S20

4.4

2.743

4.572

0.6

10.058

10.058

27.590

A(l-1')

3.505

SI

4.4

3.505

4.572

0.767

5.141

5.141

18.018

A(l'-2)

3.505

Sl

4.4

3.505

4.572

0.767

5.141

5.141

18.018

A(2-3)

6.758

R2

4.4

4.572

6.758

0.676

8.524

8.524

57.602

A.(3-4)

8.473

R4

4.4

4.572

8.473

0.540

9.082

9.082

76.951

A(4-5)

6.758

R2

4.4

4.572

6.758

0.676

8.524

8.524

57.602

A(S-5?

3.505

SI

4.4

3.505

4.572

0.767

5.141

5.141

18.018

A(5'-6)

3.505

Sl

4.4

3.505

4.572

0.767

5.141

5.141

18.018

A(6-7)

S20

4.4

2.743

4.572

0.6

10.058

10.058

0.000

B(0-1)

2.743

S20

4.4

2.743

4.572

0.6

10.058

20.116

55.179

S20

4.4

2.743

4.572

0.6

10.058

B(l-1')

3.505

SI

4.4

3.505

4.572

0.767

5.141

10.281

36.037

Sl

4.4

3.505

4.572

0.767

5.141

B(l'-2)

3.505

SI

4.4

3.505

4.572

0.767

5.141

10.281

36.037

Sl

4.4

3.505

4.572

0.767

5.141

B(2-3)L

6.758

R3

4.4

4.572

6.758

0.676

8.524

8.524

57.602

B(2-3)R

6.758

R3

4.4

4.572

6.758

0.676

8.524

8.524

57.602

B(3-4)L

8.473

R4

4.4

4.572

8.473

0.540

9.082

9.082

76.951

B(3-4)R

8.473

R4

4.4

4.572

8.473

0.540

9.082

9.082

76.951

B(4-5)L

6.758

R3

4.4

4.572

6.758

0.576

8.524

8.524

57.602

Table 3: LGF along x

Beam ID

Beam length

Slab ID

Intensity DL

k.1'1/m2

Lx

Ly

Lx/Ly

Slab Load

total udl

Total

triangu!aJ"

trapezoidal

one

way

due to

slab

Load(K..N)

l(A-B)

4.572

S2

4.'11

3.505

4.572

0.767

6.200

6.200

28.346

l(B-C)

4.572

S2

4.4

3.505

4.572

0.767

6.200

6.200

28346

l(C-C')

3.657

S4

H

3.505

3.657

0.958

5.350

13.702

50.116

parabolic

4.4

8.352

l(C'-D)

3.657

S4

H

3.505

3.657

0.958

5.350

5.350

19.569

i(D-0')

3.657

S4

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l(D'-E)

3.657

S4

4.4

3.505

3.657

0.958

5350

5.350

19.569

l(E-E?

3.657

S4

H

3.505

3.657

0.958

5.350

5.350

19.569

l(E'-F)

3.657

S4

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l'(A-B)

4.572

S2

H

3.505

4.572

0.767

6.200

12.401

56.692

S2

4.4

3.505

4.572

0.767

6.200

l'(B-C)

4.572

S2

4.4

3.505

4.572

0.767

6.200

12.401

56.692

S2

H

3.505

4.572

0.767

6.200

Table 4: LGF along y

Beam JD

Beam length

Slab

ID

Intensity DL

kN/m2

Lx

Ly

Lx/Ly

Slab Load

total udl due to slab

Total Load(KN)

triangular

trapezoidal

one

way

A(l-1')

3.505

SI

4-4

3.505

4.572

0.767

5.141

5.141

18.018

A(l'-2)

3.505

SI

4-4

3.505

4.572

0.767

5.141

5.141

18.018

A(5-5')

3.505

SI

4A

3.505

4.572

0.767

5.141

5.141

18.018

A(S'-6)

3.505

Sl

4-4

3.505

4.572

0.767

5.141

5.141

18.018

B(l-1')

3.505

SI

4-4

3.505

4.572

0.767

5.141

10.281

36.037

SI

4-4

3.505

4.572

0.767

5.141

B(l'-2)

3.505

SI

4.4

3.505

4.572

0.767

5.141

10.281

36.037

Sl

4-4

3.505

4.572

0.767

5.141

B(5-5')

3.505

SI

4.4

3.505

4.572

0.767

5.141

10.281

36.037

Sl

4-4

3.505

4.572

0.767

5.141

B(5'-6)

3.505

SI

4.4

3.505

4.572

0.767

5.141

10.281

36.037

Sl

4-4

3.505

4.572

0.767

5.141

B(6-7)

2.743

S20

4.4

2.743

4.572

0.6

10.058

20.116

55.179

S20

4-4

2.743

4.572

0.6

10.058

C(l-1')

3.505

SI

4.4

3.505

4.572

0.767

5.141

10.281

36.037

S3

4-4

3.505

3.657

0.958

5.141

C(l'-2)

3.505

SI

4.4

3.505

4.572

0.767

5.141

10.281

36.037

S3

4.4

3.505

3.657

0.958

5.141

C(2-2')

3.353

S5

4..4

3.353

3.657

0.917

4.917

4.917

16.486

C(2'-3)

3.353

ss

4-4

3.353

3.657

0.917

4.917

4.917

16.486

C(3-3')

4.204

S8

4..4

3.657

4,204

0.870

6.016

6.016

25.288

C(3'-4)

4-204

S8

4-4

3.657

4.204

0.870

6.016

6.016

25.288

C(4-4')

3.353

S5

4.,4

3.353

3.657

0.917

4.917

4.917

16.486

C(4'-5)

3.353

S6

4.4

3.353

3.962

0.846

4.917

4.917

16.486

Table 5: UGF-Roof along x

Beam ID

Beam

Slab

In eosity

Lx

Ly

L y

Slab Load

total udl

Total

length

ID

DL

kN/m2

triangular

trapazoidal

one

way

due to slab

Load(KK)

!(a-A)

2.743

Sl9

4.4

2.743

2.743

8.046

29.198

80.093

S23

4.4

2.743

3.505

0.783

21.152

l(A-B)

4.572

S2

4.4

3.505

4.572

0.767

6.200

6.200

28.346

l(B-C)

4.572

S2

4.4

3.505

4.572

0.767

6-200

6-200

28.346

l(C-C)

3.657

S4

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l(C'-D)

3.657

S5

4.4

3.505

3.657

0.958

5.350

5350

19.569

l(D-D')

3.657

S6

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l(D'-E)

3.657

S7

4.4

3.505

3.657

0.958

5350

5350

19.569

l(E-E')

3.657

ss

4.4

3.505

3.657

0.958

5.350

5.350

19.569

l(E'-F)

3.657

S9

4.4

3.505

3.657

0.958

5.350

5350

19\_569

l'(a-A)

2.743

S23

4.4

2.743

3.505

0.783

21.152

42.304

116.042

S23

4.4

2.743

3.505

0.783

21.152

l'(A-B)

4.572

S2

4.4

3.505

4.572

0.767

6.200

12.401

56.692

S2

4.4

3.505

4.572

0.767

6.200

l'(B-C)

4.572

S2

4.4

3.505

4.572

0.767

6.200

12.401

56.692

S2

4.4

3.505

4.572

0.767

6.200

l'(C-C)

3.657

S4

4.4

3.505

3.657

0.958

5.350

10.701

39.138

Table 6: UGF-Roof along y

Beam ID

Beam length

Slab ID

Intensity

Lx

Ly

Lx/Ly

Slab Load

total udl

Total Load(KN)

DL

kN/m2

triangulM

trapazoidal

one

way

due to slab

A(0-1)

2.743

S19

4.4

2.743

2.743

8.046

18.104

49.661

S20

4.4

2.743

4.572

0.6

10.058

A(l-1')

3.505

SI

4.4

3\_505

4.572

0.767

5.141

5.141

18.018

A(l'-2)

3.505

SI

4.4

3.505

4.572

0.767

5.141

5.141

18.018

A(2-2')

3.353

S15

4.4

3.353

4.572

0.733

4.917

4.917

16.486

A(2'-3)

3.353

SlS

4.4

3353

4.572

0.733

4.917

4.917

16.486

A(3-3')

4.203

S17

4.4

4.204

4.572

0.919

6.165

6.165

25.916

A(3'-4)

4.204

S17

4.4

4.204

4.572

0.919

6.165

6.165

25.916

A(4-4)

3.353

SlS

4.4

3.353

4.572

0.733

4.917

4.917

16.486

A(4'-5)

3.353

S15

4.4

3.353

4.572

0.733

4.917

4,917

16.486

A(S-5')

3.505

SI

4.4

3-505

4.572

0.767

5.141

5.141

18.018

A(S'-6)

3.505

SI

4.4

3.505

4.572

0.767

5.141

5.141

18.018

A(6-7)

2.743

S19

4.4

2.743

2.743

8.046

18.104

49.661

Live load converted to UDL to transfer into the beam

Table 7: Upper and Lower Basement laong x

Be.im

ID

Beam

Slab

Intensity

LL

LK

Ly

LKILy

Slab Load

one

total udl

Total

Lump sum

length

ID

kK/m2

triangular

trapazoidal

way

due to slab

Load(KN)

load(kN)

l(A-B)

4.572

S2

5

3.505

4.572

0.767

7.046

7.046

32.212

16.106

l(B-C)

4.572

S2

5

3.505

4.572

0.767

7.046

7.046

32.212

16.106

l(C-C')

3.657

S4

5

3.505

3.657

0.958

6.080

6.080

22.237

11.119

l(C'-D)

3.657

ss

5

3.505

3-657

0.958

6.080

6.080

22-237

11-119

l(D-D')

3.657

S6

5

3.505

3.657

0.958

6.080

6.080

22.237

11.119

l(D'-E)

3.657

S7

5

3.505

3.657

0.958

6.080

6.080

22.237

11.119

l(E-E')

3.657

S8

5

3.505

3.657

0.958

6.080

6.080

22.237

11.119

l(E'-F)

3.657

S9

5

3.505

3.657

0.958

6.080

6.080

22.237

11.119

l'(A-B)

4.572

S2

5

3.505

4.572

0.767

7.046

14.092

64.423

32.212

S2

5

3.505

4.572

0.767

7.046

l'(B-C)

4.572

S2

5

3.505

4.572

0.767

7.046

14.092

64.423

32..212

S2

5

3.505

4.572

0.767

7.046

l'(C-C')

3.657

S4

5

3.505

3.657

0.958

6.080

12.160

44.475

22.237

S4

5

3.505

3.657

0.958

6.080

l'(C'- D)

3.657

S4

5

3.505

3.657

0.958

6.080

12.160

44.475

22.237

S4

5

3.505

3.657

0.958

6.080

l'(D- D')

3.657

S4

5

3.505

3.657

0.958

6.080

12.160

44.475

22.237

S4

5

3.505

3.657

0.958

6.080

l'(D'-E)

3.657

S4

5

3.505

3.657

0.958

6.080

12.160

44.475

22..237

S4

5

3.505

3.657

0.958

6.080

Table 8: Upper and Lower Basement laong y

Beam

ID

Beam

Slab

Intensity

LL

Lx

Ly

LK/Ly

Slab Load

one

total udl

Total

Lump

swn

length

ID

kN/m2

triangular

trapazoidal

way

due to slab

Load(KN)

load(kN)

A(0-1)

2.743

S20

5

2.743

4.572

0.6

11.429

11.429

31.352

15.676

A(l-1')

3.505

SI

5

3.505

4.572

0.767

5.842

5.842

20.475

10.238

A(l'-2)

3.505

SI

5

3.505

4.572

0.767

5.842

5.842

20.475

10.238

A(2-3)

6.758

R2

5

4.572

6.758

0.676

9.686

9.686

65.457

32.729

A(3-4)

8.473

R4

5

4.572

8.473

0.540

10.320

10.320

87.444

43.722

A(4-5)

6.758

R2

5

4.572

6.758

0.676

9.686

9.686

65.457

32.729

A(5-5')

3.505

SI

5

3.505

4.572

0.767

5.842

5.842

20.475

10.238

A(S'-6)

3.505

SI

5

3.505

4.572

0.767

5.842

5.842

20.475

10.238

Table 9: Wall load evaluation

External wall

s

Beam

1D.

Beam length(m)

wall load(UDL)

/m

\ all Load after

WallLoad{KN)

deduction (KN/m)

External Wall

lower & upper basement(Deduction 0%)

I

A(l'-1)

3.05

15.784

15.784

48.141

2

A(l-2)

7.01

15.784

15. 84

110.645

3

A(2-3)

6.705

15.784

15. &4

105.831

4

A(3-4)

8.406

15.784

15.784

132.680

5

A(4-5)

6.705

15.784

15.784

105.831

6

A(5-6)

7.01

15.784

15.784

110.645

7

A(6-6')

3.05

15.784

15. 84

48.141

8

l'(A-B)

4.572

15.784

15.784

72.164

9

l'(B-C)

4.572

15.784

15. 84

2.164

10

l'(C-D)

7.315

15.784

15.784

115.459

II

l'(D-E)

7.315

15.784

15.784

115.459

12

l'(E-F)

7.315

15.784

15. 84

115.459

13

'(A-B)

4.5 2

15.784

15. 84

72.164

14

6'(8-C)

4.572

15.784

15.784

72.164

15 '(

C-D)

7.315

15.784

15.784

115.459

16

6'(D-E)

7.315

15.784

15. 84

115.459

17

6'(E-F)

7.315

15.784

15.784

115.458

Sill!

1643.335

Table 10: Internal wall ealuvation

Internal v.r-all

S.

Beam

ID.

Length

wall load(UDL) KN/m

\'Vall Load after

deduction (XN/m)

Wallload(KN)

Lower basement (Deduction 40%)

1

D{2-3)

6.096

12.185

7.311

44.566

2

D{4-5)

6.096

12.185

7.311

44.566

3

E(2-3)

6.096

12.185

7.311

44.566

4

E(4-5)

6.096

12.185

7.311

44.566

5

2(D-E)

6.705

12.185

7.311

49.022

6

3(0-E)

6.705

12.185

7.311

49.022

7

4(D-E)

6.705

12.185

7.311

49.022

8

5(D-E)

6.705

12.185

7.311

49.022

s

374.352

Lm-..er Ground Floor (Deduction 40%)

9

D{1-2)

6.400

16.449

9.869

63.169

10

D( -3)

3-200

16.449

9.869

31.584

11

D(4-5)

3.505

16.449

9.869

34.593

12

D(5-6)

6.400

16.449

9.869

63.169

13

E(l-2)

6.400

16.449

9.869

63.169

Table 11: Seismic weight analysis

floor

DL

LL

TL

roof

9145.740

664.804

9810.544

4th

10898.873

3545.63

14444.504

3rd

10898.873

3545.63

14444.504

2nd

10898.873

3545.63

14444.504

1st

10898.873

3545.63

14444.504

UpperGF

10578.322

3545.63

14123.953

Lower GF

10964.882

2478.541

13443.424

UpperB

11395.219

3983.48

15378.699

Total

110534.634

13.6

I examined fundamental natural period of vibration (Ta)( Ta = (0.09h)/ d) for the structure using the specified height and base dimensions. I found Ta for the x as 0.3835s and for the y-direction as 0.4225s. I evaluated these values based on the building's height of 27.43 Im and base dimensions of 41.423m in the x-direction and 34.135m in the y-direction. I ensured these parameters adhered to IS1893:2000 standards. I calculated the seismic base shear (Vb) for both directions. I found Vb in the x-direction to be 9948.l 17kN with Z as 0.36, I as I, Ras 5, Ta as 0.384s, and (Sa/g) as 2.5. I got the same value in the y-direction with Ta as 0.423s and identical factors. I computed lateral load distribution along the building height(tablel 2). I found Qi for the roof as 25 l 9.495kN and for the fourth floor as 2786.296kN. I evaluated the lateral forces for all other floors, confirming total equilibrium with the base shear(figure9). I located mass center focusing on the building's geometric mass distribution for structural members(table I 3, 14 & I 5). I then created detailed reinforcement design for slab(figure 11, 12 & 13). I concluded the project by ensuring structural stability, meeting seismic requirements, & verifying load distribution.

Table 12: Lateral load distribution

S..

Floor

"' i

Hi

Wi 2

Qi

S.F

Roof

9810.544

27.431

7381857

2519.495

2519.495

4th

14444.504

23.773

8163556

2786.296

5305.791

3rd

14444.504

20.116

5844913

1994.922

7300.713

2nd

14444.504

16.458

3912710

1335.444

8636.157

1st

14444.504

12.801

2366948

807.861

9444.018

pper GF

14123.953

9.144

1180827

403.027

9847.045

LowerGF

13443.424

5.486

404615.4

138.098

9985.144

UpperB

15378.699

2.743

115715.7

39.494

10024.64

Total

29371143.1

2786.2961\N

5305.791kN

7300.713kN

86>6.157kN

9444.018\iN

9847.045\iN

9985.144\iN

10024.639\iN

Lateral Force Diagram ShearForce Diagram

Figure 9: LF & SF diagrams

Table 13: Center of mass evaluation for lower and upper basement for column

Beam Designation

Height

(m)

Intensity

(kN/m)

Total Load (kN)

X

(m)

y

(m)

\VX

(b."\l"-m)

\VY

( -m)

Al

2.613

3.331

8.703

0

2.743

0.000

23.872

A2

2.61

8.123

21.225

0

9.753

0.000

207.004

A3

2.613

8.123

21.224

0

16.458

0.000

349.306

A4

2.613

8.123

21.224

0

24.863

0.000

527.695

A5

2.613

8.123

21.224

0

31.569

0.000

670.023

A6

2.613

3.331

8.703

0

38.571

0.000

335.680

Bl

2.613

8.123

21.224

4.572

2.743

97.037

58.218

B2

2.613

9.766

25.518

4.572

9.753

116.666

248.873

BJ

2.613

9.766

25.518

4.572

16.458

116.666

419.968

B4

2.613

9.766

25.518

4.572

24.863

116.666

634.444

BS

2.613

9.766

25.518

4.572

31.569

116.666

805.564

B6

2.613

8.123

21.224

4.572

38.571

97.037

818.634

Cl

2.613

8.123

21.224

9.144

2.743

194.073

58.218

C2

2.613

9.766

25.518

9.144

9.753

33.333

48.873

C3

2.613

9.766

25.518

9.144

16.458

233.333

419.968

C4

2.613

9.766

25.518

9.144

24.863

233.333

634.444

cs

2.613

9.766

25.518

9.144

31.569

233.333

805.564

C6

2.613

8.123

21.224

9.144

38.571

194.073

818.634

D1

2.613

8.123

21.224

16.458

2.743

349.306

58.218

D2

2.613

9.766

25.518

16.458

9.753

419.968

248.873

D3

2.613

9.766

25.518

16.458

16.458

419.968

419.968

D4

2.613

9.766

25.518

16.458

2.4.863

419.968

634.444

D5

2.613

9.766

25.518

16.458

31.569

419.968

805.564

D6

2.613

8.123

1.224

16.458

38.571

349.306

818.634

El

2.613

8.123

21.224

23.773

2.743

504.560

58.218

E2

2.613

9.766

25.518

23.773

9.753

606.629

248.873

E3

2.613

9.766

25.518

23.773

16.458

606.629

419.968

E4

2.613

9.766

25.518

23.773

24.863

606.629

634.444

ES

2.613

9.766

25.518

23.773

31.569

606.629

805.564

E6

2.613

8.123

21.224

23.773

38.571

504.560

818.634

Fl

2.613

3.331

8.703

31.088

2.743

270.556

23.872

Table 14: Center of mass evaluation for lower and upper basement for slabs

Slab Design ation

DL

(kN/ mA2)

LL

J

mA2)

Total Intensit y

( /mA

2)

LY

LX

Total Load (kN)

y (m)

X

(m)

\VX

( -m)

WY

(kN-m)

GSl

4.4

5

6.9

.743

4.571

86.51

1.37

2.29

197.77

118.78

GS

4.4

5

6.9

.743

4.571

86.51

1.37

6.86

593.14

118.78

GS3

4.4

5

6.9

2.743

7.314

138.43

1.37

12.80

1771.90

190.06

GS4

4.4

5

6.9

2.743

7.314

138.43

1.37

20.11

2784.38

190.06

GS5

4.4

5

6.9

2.743

7.314

138.43

1.37

27.43

3796.85

190.06

GS6

4.4

s

6.9

4.572

7.01

221.14

6.24

2.29

505.53

1379.93

GS?

4.4

s

6.9

4.572

7.01

221.14

6.24

6.86

1516.16

1379.93

GS8

4.4

5

6.9

7.01

7.314

353.77

6.24

12.80

4528.27

2207.53

GS9

4.4

s

6.9

7.01

7.314

353.77

6.24

20.11

7115.75

2207.53

GS10

4.4

5

6.9

7.01

7.314

353.77

6.24

27.43

9703.23

2207.53

GSll

4.4

s

6.9

4.572

6.705

211.52

13.11

2.29

483.54

2771.99

GS12

4.4

s

6.9

4.572

6.705

211.52

13.11

6.86

1450.19

2771.99

GS13

4.4

5

6.9

6.705

7.314

338.38

13.11

12.80

4331.25

4434.45

GSl4

4.4

5

6.9

6.705

7.314

338.38

13.11

20.11

6806.15

4434.45

GS15

4.4

5

6.9

6.705

7.314

338.38

13.11

27.43

9281.05

4434.45

GS16

4.4

s

6.9

8.406

4.572

265.18

20.66

2.29

606.21

5478.93

GS17

4.4

s

6.9

8.406

4.572

265.18

20.66

6.86

1818.09

5478.93

GS18

4.4

s

6.9

8.406

7.314

424.22

20.66

12.80

5430.04

8764.86

GS19

4.4

s

6.9

8.406

7.314

424.22

20.66

20.11

8532.81

8764.86

GS20

4.4

5

6.9

8.406

7.314

424.22

20.66

27.43

11635.5

7

8764.86

GS21

4.4

s

6.9

4.572

6.705

211.52

28.22

2.29

483.54

5968.50

GS22

4.4

5

6.9

4.572

6.705

211.52

28.22

6.86

1450.19

5968.50

GS23

4.4

5

6.9

6.705

7.314

338.38

28.22

12.80

4331.25

9548.03

GS24

4.4

5

6.9

6.705

7.314

338.38

28.22

20.11

6806.15

9548.03

GS25

4.4

s

6.9

6.705

7.314

338.38

28.22

27.43

9281.05

9548.03

GS26

4.4

s

6.9

4.572

7.01

221.14

35.08

2.29

505.53

7756.59

GS27

4.4

5

6.9

4.572

7.01

221.14

35.08

6.86

1516.16

7756.59

GS28

4.4

5

6.9

7.01

7.314

353.77

35.08

12.80

4528.27

12408.51

Table 15: Evaluation of beam center of mass

Beam designation

Length (m)

Total load

(kN)

X

(m)

y

(m)

wx

CkN-m)

WY

(ld-1-m)

Lower-Basement

Grid 1-1

31.088

100.997

15.544

2.743

1569.897

277.034

Grid 2-2

31.088

100.997

15.544

9.753

1569.897

985.023

Grid 3-3

31.088

100.997

15.544

16.458

1569.897

1662.209

Grid 4-4

31.088

100.997

15.544

24.863

1569.897

2511.088

Grid 5-5

31.088

100.997

15.544

31.569

1569.897

3188.374

Grid 6-6

31.088

100.997

15.544

38.571

1569.897

3895.555

A-A

41.496

173.972

0

20.748

0

3609.571

B-B

41.496

173.972

4.572

20.748

795.400

3609.571

C-C

41.496

173.972

9.144

20.748

1590.800

3609.571

D-D

41.324

173.972

16.458

20.662

2863.231

3594.609

E-E

41.324

173.972

23.773

20.662

4135.836

3594.609

F-F

41.324

173.972

31.088

20.662

5408.442

3594.609

SUM

1649.814

24213.090

34131.830

c ::)- .----,----,------r--..----.----.-----.------, ,

( 1-----<---+----+----+-------+----+----+----+ <

( 1 + +

+ + t

+ + + i

0-l----+---+---+----+----+-----+--1----+ <

(}- 1 +

t t t + +

t t i

0-1----+----+--+---+--+---+---+---t j

0- >--+--+--+--+---t--t--t--+--<

c::)-- l----+---+---+----+----+-----+--1----+ <

\_,,,}- 1

0- t

+ t t t +

+ + + + +

+ t t i

+ + + <

)-r-+---+----+-+----+----+---+----+ 1

(=)-- 1---+--+-----+----+-----+----+---+-1 j

0-c ic:b cb J, 0 cb (r) rb G:J

Figure 10: Depiction of grid structure

I,

-----,5'---

11'-6 11'-6'

2'

Figure 11: Depiction of Slab ID

I'

.. ---15

13'-9 '

Figure 12: Illustrating slab ID

212'

30' 24' 24' 24' 24' 24' 24' 18' ,e

....

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I I

0 - - /

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.., ,....

.... F-

' -...,. F-

- / -

/

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30' 24' 24' 24' 24' 24' 24' 18' 18'

Figure I 3: Depiction of slab reinforcement

1.4 Problem and Solution

One of the problems I encountered was related to the lateral load distribution. At first, I had a problem in assessing the correct load of seismic forces with respect to height of the building. We as a team deliberated on this issue. I asked my concern where I have noticed that there were different values indicated for lateral load for each of the floor. I deduced that the problem was linked to the confusion on the distribution of base shear formula. I went to seek counsel from my supervisor. I narrated my steps and asked the supervisor how one can properly apply the seismic weight and height factors. I went back to the Wi and hi2 terms & my supervisor advised me to check the results more rigorously. I took the supervisor's advice and reevaluated of distribution. I re-computed the lateral forces in the design (Qi) for each floor of the building. By improving these values, I realized that all the computations were accurate. I assured that it was done to the specifications set out in the project regarding the solution.

1.5 Creative Works

I went through the Wi and hi2 terms in more detail for lateral load analysis. I re-estimated the lateral forces (Qi) in the design for each floor of the building. I created 3D structural design

featuring SAP2000 for evaluating model. I created reinforcement plans and evaluated behavioral metrics of the structural members for stability.

1.6 Project Management

I was able to manage the team and set up meetings at least once a week to go over with the project. In order to come up with more creative ideas I engaged the team in group brainstorming sessions. I made it a point that every member of the team had a clear understanding of each other's roles and duties and that we could set realistic time frames for accomplishes. I managed time & ensured project was always on track and I always checked progress regularly. I encouraged the members and offered my assistance to them to keep up their morale in the group. I had meetings with the guide to endeavor for change on the issues affecting that project and acquire knowledge on the next step to take. I reported the status on the checkpoints and challenges encountered on the job to the supervisor. I encouraged people to cooperate within the team as well as help the members tack.le issues that may hinder efficient performance.

1.7 Codes

I studied IS 456-2000 for modelling & analyzing RC structure &referred IS 1893-2002 for creating seismic resistant design.

1.8 Summary

1.8.1

The structural evaluation & earthquake resistant design project was successfully completed through comprehensive design implementations. The project objectives were achieved through systematic structural member designs. Proper load distributions were established across all structural components. A multi-storied commercial building incorporating basement levels was effectively designed. The structural system utilized RCC frame design with mat foundation. Detailed analysis was performed using SAP2000 software platform. Load calculations encompassed dead loads, live loads, & seismic considerations. Member designs were optimized for structural efficiency. Foundation design addressed soft soil conditions appropriately. Seismic resistance features were incorporated following zone specifications. Structural member dimensions were finalized through iterative analyses. Load distribution patterns were verified

across all floor levels. Base shear calculations confirmed structural stability requirements. Center of mass evaluations ensured balanced load distributions. The final design achieved optimal structural performance parameters. The advanced computational techniques were implemented by SAP2000 software modeling, and structural safety was enhanced through detailed load calculations, seismic weight analysis, and adherence to IS 1893.

1.8.2

I enhanced the effectiveness of delegating tasks. I gained more experience in the way on how to manage my time effectively. I improved my interpersonal skills. I honed abilities to lead, guide and manage project activities.