**A REPORT ON STRUCTURAL ANALYSIS**

**AND DESIGN OF**

**{{Type\_of\_Building\_Bold\_UC}}**

{{Cover\_3D\_1}}

**Prepared by**

**{{Name\_of\_Consulting\_Institute}}**

**{{Locality\_C}}, {{District\_C}}, {{Country\_C}}**

**Submitted To**

{{Submitted\_To}}

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Chapter 1 : Introduction

* 1. **Introduction**

The structure of {{Type\_of\_Building}} building project located at {{District\_Cl}}, {{Country\_Cl}}, was carry out the design for the spatial requirements in accordance with purpose of the building considering the provision for various services and systems necessary for the operation of the building. In order to fulfill such requirements, the structural materials and the structural system have been determined taking into account the availability of materials, cost efficiency and structural integrity, i.e., stability, strength and serviceability; the three main factors to be incorporated in the design of all structures. The building is a {{Building\_System}} system consisting of {{Building\_Storey}} story {{Building\_Detail}}

The design has been carried out using IS 1893 (part 1): 2016, “*Criteria for Earthquake Resistant Design of Structures” and NBC 105:2020 “SEISMIC DESIGN OF BUILDINGS IN NEPAL”* using finite element software {{Software\_Version}}, developed by Research Engineers International, USA.

* 1. **Objectives and Scope of Work**

The main objectives of the work are to perform the structural design of the building in terms of suitability of the structural system, cost effectiveness, efficient use of materials and other resources, conformance to the acceptable building codes, standards and established engineering practices, with special emphasis on the effects due to earthquakes and other applicable demands.

###### Structural Components

The components of structural system used for this report are summarized in the following table.

*Table 1: Typical Structural Member and Components*

|  |  |  |
| --- | --- | --- |
| Structural  System | Element | Typical Component Types |
| **Special RC Moment - Resisting Frame (SMRF)** | Foundation | RC sections |
| Column | RC sections |
| Beam | RC sections |
| Lintels | RC beam |
| Walls | Non load bearing walls |
|

###### Codes, Standards and References

The design is based primarily on the {{Code\_1}} Part {{Part\_1}}: {{Year\_1}}, {{Title\_1}}which is adopted for the structural analysis and design of this building, while the relevant codes of British Standards, European Standards are referred to consider for the areas/provisions that are not addressed in the Indian Standards or as required for the purpose of design.

The basic building codes referred are listed below which are followed for structural design, also indicating their area of application.

*Table2: Codes and Standards*

|  |  |  |
| --- | --- | --- |
| S.No. | Codes and Standards | Description |
| 1 | IS 456: 2000 | Plain and Reinforced Concrete - Code of Practice |
| 2 | IS 875 (Part 1): 1987 | Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures: Part 1 Dead Loads – Unit Weights of Building Material and Stored Materials (Second Revision) |
| 3 | IS 875 (Part 2): 1987 | Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures: Part 2 Imposed Loads (Second Revision) |
| 4 | IS 875 (Part 2): 1987 | Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures: Part 2 Wind Loads (Second Revision) |
| 5 | SP 34: 1987 | Handbook on Concrete Reinforcement and Detailing |
| 6 | IS 13920: 2016 | Code of practice for Ductile detailing of reinforced concrete structures subjected to seismic forces |
| 7 | IS 1893: 2016 | Criteria for Earthquake Resistant Design of structures |
| 8 | IS 383: 1970 | Specification for coarse and fine aggregates from natural sources for Concrete |
| 9 | IS 1786: 1985 | Specification for high strength deformed steel bars and wires for concrete reinforcement (superseding IS:1139 -1966) |
| 10 | IS 1904: 1986 | Design and Construction of Foundation in soils: General Requirements. |
| 11 | IS 800: 2007 | Code of Practice for General Construction in Steel (Third Revision) |
| 12 | NBC: 201:1994 | Mandatory Rules of Thumbs - Reinforced Concrete Building with Masonry Infill |
| 13 | IS: 1905-1987 | Code of Practice for Structural Use of Un-reinforced Masonry. |
| 14 | NBC:109-1994 | Masonry: Unreinforced. |
| 15 | NBC:110-1994 | Plain and Reinforced Concrete. |
| 16 | IS:8009-1976 | Calculation of settlement of shallow foundations. |
| 17 | BS:8110-1985 | Structural Use of Concrete. |
| 18 | NBC:105-2020 | Seismic Design of Buildings in Nepal. |

###### Structural Design Methodology

{{Software\_Version}} is used for linear static and dynamic analysis and design of three-dimensional structures, in which the spatial distribution of the mass and stiffness of the structure was adequate for the calculation of the significant features of structures. Frame sections are used in modeling of frame and thin shell element are used in modeling of slabs and shear walls. Dead load of masonry walls is calculated manually and applied on beams and slabs where necessary.

The structural elements of reinforced concrete were designed to Limit State Theory. The major structural elements were automatically designed in the inbuilt program to IS 456 for reinforced concrete structures elements.

The frame system is designed for gravity loads (Dead and Live/Imposed), seismic loads.

**Chapter 2 : Design Philosophy and Approach**

###### Introduction

This chapter presents the design philosophy and approach used in structural design of the afore said building.

###### Seismic Parameters

This section describes the seismic parameters taken for analysis of the building.

###### Seismic Coefficient Method / Response Spectrum Method:

* + 1. **Indian Standard: IS: 1893:2016**
       1. Horizontal Seismic Base Shear

According to Indian Standard IS: 1893:2016, the horizontal seismic shear force acting at the base of the structure, in the direction being considered, shall be:

**Vb = AhΣWi**

Where, Ah is basic seismic coefficient.

Ah=ZISa/2Rg

Horizontal Seismic Forces

The horizontal seismic force at each level (i) shall be taken as:

**Fi= Vb Wihi2/ ΣWihi2**

* + - 1. Fundamental Natural Period (IS 1893:20016):

The approximate fundamental natural period of vibration (T), in seconds, for the moment resisting frame structural system was estimated by the empirical expression:

T= 0.075H0.75 Where,

H = Height of building and

Response Reduction Factor(R):

It is the factor by which the actual base shear force, that would be generated if the structure were to remain elastic during its response to the Design Basis Earthquake (DBE) shaking, shall be reduced to obtain the design lateral force.

**R =** {{Response\_Reduction\_Factor}} as per IS 1893:2016

Site Type:

It is the type of soil considered for the site as per the data available from the geotechnical investigation report, which is of Type II medium soil. The combined effect of Time period and soil type defines the value of spectral acceleration Sa/g

Importance Factor (I):

It is a factor that depends on the importance of the structure being considered. The building is building its value is taken as {{Importance\_Factor}}.

Zone Factor (z):

It is a factor that depends on the local damage expected in the area under consideration. The location of the building states the value as {{Zone\_Factor}}.

###### 2.2.2 NBC 105:2020

1. Horizontal Seismic Base Shear
   1. **Ultimate Limit State**

For the ultimate limit state, the horizontal base shear coefficient (design coefficient), Cd (T1), shall be given by:

(𝑇1)

𝐶(𝑇1) = Rμ x Ωu

Where,

C (T1) = Elastic Site Spectra Rμ = Ductility Factor

𝛀u = Over strength Factor for ULS

* 1. **Serviceability Limit State**

For the serviceability limit state, the horizontal base shear coefficient (design coefficient), Cd (T1), shall be given by:

(𝑇1)

𝐶(𝑇1) = Ωs

Where,

Cs(T1) = Elastic Site Spectra determined for Serviceability Limit State

𝛀s = Over strength Factor for SLS

* + 1. **Elastic site spectra**

The Elastic site spectra for horizontal loading shall be as given by equation C (T) = Ch(T) Z I

Where,

Ch(T) = Spectral Shape factor Z = Seismic Zoning factor

I = Importance factor

* + 1. **Elastic Site Spectra for Serviceability Limit State**

The elastic site spectra for Serviceability Limit State shall be given by

Cs (T) = 0.20 C (T)

Where,

C (T)= The Elastic site spectra for horizontal loading

* + 1. **Ductility and Over-strength Factors**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S. No. | Structural System | Rμ | Ωu | Ωs |
| Moment Resisting Frame Systems | | | |  |
| 1 | Reinforced Concrete | {{Ductility\_Factor}} | {{Overstrength\_ULS}} | {{Overstrength\_SLS}} |

* + 1. **Site Subsoil Category**

Soil Type {{Soil\_Index}} – {{Soil\_Type}}

* + 1. **Time Period**

T1 = (0.05 H ¾) \*1.25 \*\*increase by 25% as per code

H = Height of building

###### Overall Design Procedure

Analysis and design of the residential apartment building is performed according to the following steps for each structural system.

1. Structural system/concept is developed for each structural system. Used the basic structural systems described in Table 1.1 as a guideline.
2. Created the finite element model with varying complexity and refinement suitable for developing and understanding the response. Carried out different types of analysis to determine the response of the building under gravity and lateral loadings.
3. Designed the structural components to remain elastic under gravity and earthquake loads under DBE level earthquake, as appropriate. Linear analysis is conducted for DBE level earthquake with response reduction factor to determine the response of the building. Design is carried out in accordance with the relevant provisions of the latest national building code and Indian standard provisions.
4. If the global building and local component responses meet the acceptance criteria, structural design drawings are prepared. The final construction drawings are to be verified by the third-party engineer as needed.

Step 1: Structural System development

Architectural Design Review

Step 2: Preparation of Modeling

Step 3: Structural Analysis

Step 6: Preparation of structural drawings

*Figure 1: Overall Design Procedure*

Step 4: RC Design using IS 456-2000

The structural elements of reinforced concrete are designed to Limit State Theory, while the structural steel elements are designed to the Permissible / Working Stress Theory if require. The major structural elements are automatically designed by the feature included in the program to IS 456 and IS 800 for reinforced concrete structures and structural steel elements respectively, while the certain design calculations for those not properly figured due to the limitation of program are manually carried out in accordance with the relevant latest standards.

#### Chapter 3 : Basic Materials

###### Introduction

This chapter presents the strength of materials used in the design of structural components.

###### Concrete

The minimum compressive, used in different types of structural components are shown in the following table.

*Table 3: Compressive Strength of concrete*

|  |  |  |  |
| --- | --- | --- | --- |
| Standard | Member | f'c (Nominal) | f'c (Expected) |
|  |  | (MPa) | (MPa) |
| IS 456:2000 | Beam | 20 | 20 |
| IS 456:2000 | Sill Band/Lintel Band | 20 | 20 |
| IS 456:2000 | Slab | 20 | 20 |
| IS 456:2000 | Column | 20 | 20 |
| IS 456:2000 | Foundation | 20 | 20 |

###### Reinforcing Steel

Minimum yield strength of reinforcing steel (Fe500) to be used in the design is shown in the following table.

*Table 4: Yield Strength of Reinforcing steel*

|  |  |  |
| --- | --- | --- |
| Diameter | f’y (Nominal) | f’y (Expected) |
|  | MPa | MPa |
| 10mm and below (for Stirrup) | 415 | 456.5 |
| 10 mm and above | 500 | 550 |

###### Soil Bearing Capacity

The geometrical size of footing was determined considering the allowable bearing capacity as {{Bearing\_Capacity}} {{Areal\_Load}}.

#### Chapter 4 : Modeling and Analysis

###### Introduction

This chapter presents the finite element modeling of the building, including modeling assumptions of materials, sections, and components properties. The structural system adopted in the building is the dual system consisting of Special moment resisting frame and ductile shear wall. The structural system is believed to perform best under seismic loading. To ensure the ductile response of the building during seismic event the overall structure has been detailed according to the latest code provision (e.g., IS 13920:2016). One of the fundamental attributes required for the proper seismic response of a building during earthquake motions is that its lateral load resisting members should be tied together to act as a single unit. This provision is intended to provide continuous lateral load system that ties all parts of the structures together. It also provides for proper connection between the members of the system to transmit additional seismic forces safely.

A vertical lateral force-resisting system shall be continuous and should run from the foundation to the top of the building. The flow of seismic forces in the structure should be such that these forces are delivered through structural connections to horizontal diaphragms; the diaphragms then distribute these forces to the vertical lateral force resisting elements such as ordinary shear walls or frames; these vertical elements transfer the forces into foundation; and foundation transfers the forces into the soil. The presence of discontinuity in a load path makes a building inadequate of carrying seismic forces. Therefore, the design professional should identify any gaps in the load paths and then take necessary mitigation measures to complete the load path. A continuous load path has been maintained in this building. The provision of redundancy is recommended because of the uncertainties involved in the magnitude of both seismic loads and member capacities. If any member of a lateral force resisting system fails, the redundancy of the structure will help ensure that there is another member present in the lateral force resisting system that will contribute lateral resistance to the structure. Redundancy also provides multiple locations for potential yielding, possibly distributing inelastic activity within the structure and improving the ductility and energy dissipation.

Typical characteristics of redundancy include multiple lines of resistance to distribute the lateral forces uniformly throughout a structure, and multiple bays in each line of resistance to reduce the shear and axial demands on any one element. If enough redundancy is not present in the structure, an analysis is required to demonstrate the adequacy of the lateral force elements. A distinction should be made between redundancy and adequacy. Simple meaning of redundancy is “more than one”. One line of moment frame can be adequate to carry the entire design lateral load, but is not redundant.

The structural elements of reinforced concrete are designed to Limit State Theory, while the structural steel elements are designed to the Permissible / Working Stress Theory if require. The major structural elements are automatically designed by the feature included in the program to IS 456 and IS 800 for reinforced concrete structures and structural steel elements respectively, while the certain design calculations for those not properly figured due to the limitation of program are manually carried out in accordance with the relevant latest standards.

###### Modeling of Structural System

Complete, three-dimensional elastic models are created, representing the structure’s spatial distribution of the mass and stiffness to an extent that is adequate for the calculation of the significant features of the building’s elastic response. ETABS is used as analysis tool. Nominal material properties are used in modeling of structural components. The models include columns, shear walls, beams and slabs.

* + 1. **Beams**

Frame elements are used in modeling of beams, which includes the effects of bending, torsion, axial deformation, and shear deformations. Insertion point and end offsets are applied to account for the finite size of beam and column intersections, if required.

* + 1. **Columns**

Frame elements are used in modeling of columns, which includes the effects of biaxial bending, torsion, axial deformation, and biaxial shear deformations.

* + 1. **Shear Walls**

Shell elements are used in modeling of shear walls, which includes the effects of biaxial bending, torsion, axial deformation, and biaxial shear deformations.

* + 1. **Damping**

Constant modal damping of 5% was used for IS code and 10% is used for NBC 105:2020.

#### Chapter 5 : Loads

###### Introduction

This chapter presents the design loads considered in the structural design, including gravity loads and seismic loads.

###### Gravity Load

Self-weight of the structure is considered as dead load and finishes, and partitions are considered as superimposed dead load. Live load is determined in accordance with occupancy or use. The following loads are in addition to the self-weight of the structure. The minimum loading requirements are taken from IS 875 (Part 2)-1987.

*Table 5 : Live Load, Superimposed Dead Load*

|  |  |  |
| --- | --- | --- |
| Occupancy or Use | Load Amplitude | Load Type |
| In-accessible Roof | 0.75KN/m² | Live Load |
| Accessible Roof | 1.5 KN/m² | Live Load |
| Live Load | 2.0, 3.0 KN/m² | Live Load |
| Wall Load |  |  |
| Wall Load 9” thick without opening | {{Nine\_inch\_without\_opening}} {{Linear\_Load}} | Superimposed Load |
| Wall Load 9” thick with opening | {{Nine\_inch\_with\_opening}} {{Linear\_Load}} | Superimposed Load |
| Wall Load 5” thick | {{Five\_inch}} {{Linear\_Load}} | Superimposed Load |
| Floor Finish | {{Floor\_Finish}} {{Areal\_Load}} | Superimposed Load |

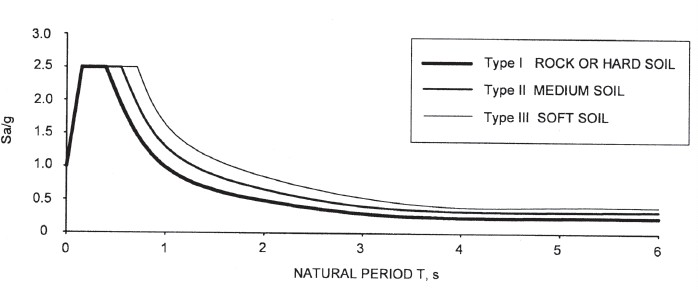
###### Seismic Load

**5.3.1 IS 1893 (Part 1):2016**

The basic seismic input may be determined from IS 1893 (part 1): 2016, “*Criteria for Earthquake Resistant Design of Structures”*

*Table 6: Parameters for Seismic Loading*

|  |  |
| --- | --- |
| Parameter | Value |
|  | As per IS 1893 |
| Zone factor, Z | {{Zone\_Factor}} |
| Importance factor, I | {{Importance\_Factor}} |
| Response reduction factor, R | {{Response\_Reduction\_Factor}} |



*Figure 2: Response Spectra for Earthquakes with Different Return Periods for Soil Type*

**5.3.2 NBC 105:2020**

|  |  |
| --- | --- |
| **Parameter (For soil type {{Soil\_Index}})** | |
| **The lower periods of the flat part of the spectrum Ta** | {{Ta}} |
| **The upper periods of the flat part of the spectrum Tc** | {{Tc}} |
| **peak spectral acceleration normalized by PGA α** | {{Alpha}} |
| **Coefficient that controls the descending branch of the spectrum, K** | {{K}} |
| **Seismic zoning factor as per cl.4.1.4 (Z) for {{Seismic\_Region}}** | {{Zone\_Factor}} |
| **Importance factor as per cl.4.1.5 (I)** | {{Importance\_Factor}} |
| **Over strength Factor for SLS as per Table 13 (𝛀s )** | {{Overstrength\_SLS}} |
| **Over strength Factor for ULS as per Table 13 (𝛀u )** | {{Overstrength\_ULS}} |
| **Ductility Factor as per Table 13 (Rμ)** | {{Ductility\_Factor}} |

###### Load Combinations

* + 1. **Code-based Design**
       1. Combinations for Limit State Method (IS 1893:2016)

Limit State Method design load combinations used in code-based design are shown in the following table. (Ref: IS 1893:2016)

*Table 7: Limit State Load Combinations used in Code-based Design (IS)*

|  |  |
| --- | --- |
| No. | Load Combination |
| 1.1 | 1.2 [DL + IL ± ELX] |
| 1.2 | 1.2 [DL + IL ± ELY] |
| 2.1 | 1.5 [ DL ± ELX] |
| 2.2 | 1.5 [ DL ± ELY] |
| 3.1 | 0.9 DL± 1.5 ELX |
| 3.2 | 0.9 DL± 1.5 ELY |

|  |  |
| --- | --- |
| Where, |  |
|  | DL = Dead load |
|  | LL = Live load |
|  | EQ= Earthquake load |

Live load at roof level is not included in the seismic weight calculations.

* + - 1. Combinations for Limit State Method (NBC 105:2019, Draft V1.3)

*Table 8: Limit State Load Combinations used in Code-based Design (NBC 105:2019, Draft V1.3)*

|  |  |
| --- | --- |
| No. | Load Combination |
| 1 | 1.2 DL + 1.5IL |
| 2 | DL + λ IL ± ELX |
| 3 | DL + λ IL ± ELY |

Where, λ = 0.6 for storage facilities

= 0.3 for other usage

###### Analysis Procedures

* + 1. **Code Based Design**

Analysis procedure of the code based design was shown in the table below.

*Table 9: Analysis Procedures for Code Base Design*

|  |  |
| --- | --- |
| Load Case | Analysis Procedures |
| Gravity load | Linear Static |
| Earthquake load | Linear Static |
| Live Load | Linear Static |

* + - 1. Seismic Weight
         1. IS Code

The seismic weight at each level, Wi, were taken as the sum of the dead loads and the seismic live loads between the mid-heights of adjacent story. 100% of dead load, superimposed dead load and 25% of live load up to 3 kN/m2 and 50% of live load above 3 KN/m2 were considered as mass source.

* + - * 1. NBC 105:2019, Draft V1.3 Code

|  |  |
| --- | --- |
| Live Load Category | Factor (λ) |
| Storage | 0.60 |
| For Other Purpose | 0.30 |
| Roof | Nil |

* + - 1. Linear Static Procedure (LSP)

Linear static analysis is carried out for gravity and earthquake loadings.

###### Component and Member Design

The structural components are designed to satisfy the strength and ductility requirements. Strength capacities for different types of actions considered in the design are summarized in the table below.

*Table 10: Component and Member Design*

|  |  |  |  |
| --- | --- | --- | --- |
| Structural  System | Component | Design Approach/Consideration | Code Reference |
| **Special RC Moment - Resisting Frame (SMRF)** | RC beams | Flexural response Shear | RC beams |
| RC columns | Compression Flexure Shear | RC columns |
| Footings | Bearing capacity of soil Flexural, shear | Footings |
| RC connections | Moment connections | RC connections |
| Shear connections |  | Shear connections |
| IS 456:2000 |  | IS 456:2000 |

#### Chapter 6 : Structural Design Results

###### Introduction

This chapter presents the analysis and design results of the building. The structural components were designed to resist the elastic demand forces considering R factor using seismic coefficient analysis and response spectrum method.

###### Analysis Results

The analysis results for the building are tabulated in relevant section.

* + 1. Base Shear

The base shear was compared in the footing level. Total weight of building above footing level and base shear is shown as in Table 10 below.

* + 1. Story Drift

Maximum drift was calculated based on the dual system of SMRF structure. The deflections from ETABS are used to obtain the maximum drift for center of diaphragm for individual floor.

* + 1. Deformation

Maximum deformation of the building for static earthquake load condition for X and Y direction is read form ETABS model. Deformed value of the structure is tabulated in Table 10.

###### Concrete Column Design

The design of Columns and Beams will be done directly using {{Software\_Version}} version design software output using {{Code\_1}}-{{Year\_1}}. The critical output will be used for design of the said building among the results from {{Code\_1}}-{{Year\_1}}.

The concrete column was designed using various sections with reference to {{Code\_2}}-{{Year\_2}}. The minimum size of reinforcement bars of column was designed considering the ductile detailing with reference to {{Code\_8}}.

###### Slab and Staircase Design

The design of slab and staircase was done by Excel worksheets developed by the consultant.

The concrete column was designed using various sections with reference to {{Code\_2}}-{{Year\_2}}. The minimum size of reinforcement bars of column was designed considering the ductile detailing with reference {{Code\_8}}.

###### Concrete cover

Concrete cover of RC structural elements is provided based on {{Code\_2}}-{{Year\_2}}.

###### Serviceability Requirements

The structural design shall satisfy the following requirements of limit state of serviceability:

{{Code\_2}}-{{Year\_2}} limits the inter-story drift to 0.004 times the story height with partial load factor of 1.

###### Ductile Detailing

Detailing provisions of {{Code\_8}} is followed to provide appropriate ductile properties to the structure and improve Seismic Response of the structure.

Salient features are as follows:

Special confinement zone adjacent to each beam column joint is defined, for beams the length is equal to twice the beam effective depth and for columns it is largest of:

Largest sectional dimension of column One sixth of clear height

450 mm

For columns within the special confinement zone:

Length of laterally unsupported tie shall not exceed 300 mm.

Minimum sectional area (Ash) of ties is related to unsupported length (s), grade of materials (fck and fy) and ratio of core area (Ac) to actual gross sectional area (Ag) of column, as Ash=0.18sxhxfck/fy[(Ag/Ac)-1]

Spacing of ties shall not exceed 100 mm, shall not exceed one fourth of smallest column sectional dimension and need not be less than 75.

Laps in columns shall be permitted only within a specific zone near mid story height. Tie spacing in the lap splice zones shall not be less than 150 mm

For beams, within the confinement zone:

Stirrup spacing shall not exceed one fourth the effective depth.

Shear strength shall be at least the gravity load shear plus 1.4 times ratio of sum of moments of resistance (top tension for one end and bottom tension for the other end) to the span of beam.

Lap splices shall not be provided within:

1. a joint
2. the special confinement zones
3. 25% of span length adjacent to joint, where flexural yielding may occur under seismic forces. Stirrup spacing over the lap splices shall not be less than 150 mm

###### Foundation Design

Foundation was designed as isolated & combined footing manually. The dimension of the foundation was calculated based on {{Bearing\_Capacity}} {{Areal\_Load}} soil bearing capacity.

#### Chapter 7 : Results and Output

###### 7.1Analysis of Building

* + 1. Introduction:

This chapter presents the finite element modeling of the building as mentioned in section chapter 2, including modeling assumptions of materials, sections, components properties and design and result of the building.

The area of proposed three story structure for Residential building. Thickness of wall is as per drawing and positions of structural member are taken as per architectural drawing for analysis.

*Figure 5: Ground Floor of Building*

{{Groundfloor\_Plan\_1}}

* + 1. Analysis using NBC 105:2020

{{Seismic\_NBC\_1}}

* + 1. Foundation Design:

Foundation was designed as a isolated & combined foundation based on {{Bearing\_Capacity}} {{Areal\_Load}} bearing capacity.

* + 1. **Modal Participating Mass Ratio:**

Structure is analyzed for 6 mode. 90% of modal mass is exceeded at mode 6 in both x and y direction..

*Table 12: Modal Participation mass ratios*

{{Modal\_Participating\_Mass\_1}}

{{Modal\_Periods\_And\_Frequencies\_1}}

#### Chapter 8 : Summary

###### 8.1 Summary

Design was carried out for the building for which reinforce concrete structural system of frame was adopted. The seismic horizontal coefficient, base shear is greater in NBC 105:2020 than IS 1893 (Part 1):2016 but due the weightage of load combination is greater in IS code rather than NBC code so the building is critical in IS code than NBC. The drift and deflection of building is greater in NBC code than IS code which is in the permissible limit. The footings were checked for isolated & combined footing. The high values of reactions demand bigger size of footing areas with overlapping problem and hence designed as a combined foundation in some cases. Foundation design is carried out considering soil bearing capacity of {{Bearing\_Capacity}} {{Areal\_Load}}. This building was designed on the basis of IS 1893 (part 1): 2016.The proposed design satisfies the key requirement of the building codes.

The detail structural drawings of all elements are in separate volume of drawing.

# Annex 1

## (Architectural Drawing)

{{Architectural\_Sectional\_1}}

Annex 2

(Internal Stresses and Forces Diagram)

### Axial Force Diagram

{{Axial\_Elevation\_1}}

**Shear Force Diagram**

{{Shear\_Elevation\_1}}

**Bending Moment Diagram**

{{Moment\_Elevation\_1}}**Loads on Footing**

{{Footing\_Load\_Plan}}

Annex 3

(Story Response Plots and Tables)

### Storey Drift (X – Direction)

{{ Drift\_Elevation\_X }}

{{ Drift\_Elevation\_SS\_X }}

### Storey Drift (Y – Direction)

{{ Drift\_Elevation\_Y }}

{{ Drift\_Elevation\_SS\_Y }}

### Storey Displacement (X – Direction)

{{Displacement\_Elevation\_X}}

{{Displacement\_Elevation\_SS\_X}}

### Storey Displacement (Y – Direction)

{{Displacement\_Elevation\_Y}}

{{Displacement\_Elevation\_SS\_Y}}

{{Story\_Drifts\_1}}

# Annex 4

## (Concrete Frame Design Diagrams)

### Demand Longitudinal Reinforcement

{{LR\_Elevation\_1}}

{{LR\_Plan\_1}}

### Column Beam Capacity Ratios

{{CB\_3D\_1}}

ANNEX-5

(Sample Calculations and Summary)

{{Column\_Design\_1}}

{{Beam\_Design\_1}}

{{Column\_Design\_Excel\_1}}

{{Beam\_Design\_Excel\_1}}

{{Shearwall\_Design\_1}}

{{Slab\_Design\_1}}

{{Staircase\_Design\_1}}

{{Isolatedfooting\_Design\_1}}

{{Eccentric\_Footing\_Excel\_1}}

{{Design\_Summary\_1}}