

# **THREE STORY OFFICE BUILDING ANALYSIS, DESIGN AND COST ESTIMATION**



پوهنتون کاردان  
KARDAN UNIVERSITY

A project report submitted in the  
partial fulfillment for the degree of  
Bachelor in Civil Engineering

**Najeem Ullah Nasiry**

**Muhammad Nasim Akbari**

**Abdullah Azizi**

FACULTY OF ENGINEERING AND TECHNOLOGY  
DEPARTMENT OF CIVIL ENGINEERING  
KARDAN UNIVERSITY

February , 2020

# **VERTICAL STRUCTURE**

A project report submitted in the  
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Najeem Ullah Nasiry

Mohammad Nasim Akbari

Abdullah Azizi

**Supervisor**

Engineer Abdul Tawfiq “Pouya”

**FACULTY OF ENGINEERING AND TECHNOLOGY**

**DEPARTMENT OF CIVIL ENGINEERING**

**KARDAN UNIVERSITY**

February, 2020

## PROJECT APPROVAL

The undersigned certified that they have read the following project report title “name of project”, Design and Estimation” and are satisfied from the overall performance and recommend the report to the department of Civil Engineering for acceptance.

Engineer Abdul Tawfiq “Pouya”

Supervisor

Signature: \_\_\_\_\_

Engineer Sayed Dawod “Karimi”

Member

Signature: \_\_\_\_\_

Engineer Fazal U Rahman “Mehrabi”

Member

Signature: \_\_\_\_\_

Engineer Gul Rahman “Abdulrahimzai”

Academic Administrator-BCE

Signature: \_\_\_\_\_

Faculty of Engineering and Technology  
Department of Civil Engineering  
Kardan University

## DECLARATION

We declare that this project entitled “project title, Design and Estimation” is the result of our own work except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

**Name:** Najeemullah “Nasiry”  
**REG. #:** **602-1604028**

**Signature:** \_\_\_\_\_

**Name:** Mohammad Nasim “Akbari”  
**REG. #:** **404-1304012**

**Signature:** \_\_\_\_\_

**Name:** Abdullah “Azizi”  
**REG. #:** **601-1504020**

**Signature:** \_\_\_\_\_

## **DEDICATION**

The sponsor of our family and the support of our instructors brought this book to presentation scene. We must be grateful to all those lecturers who delivered their lectures in a professional manner and with the entire honesty.

Hence, we dedicate it to our beloved parents. May Allah grant them the rewards of their devotion and sincerity.

## **ACKNOWLEDGEMENT**

Hereby, we are grateful to all our instructors who have taught us to struggle for learning and put our knowledge and experience into action. Now that we are being able to commence writing and compiling this book is the result of their guidelines and encouragement.

The availability of reading materials and learning tools, along in an academic environment have given me the opportunity to devote on my lessons and get the most benefit from them. It is an obvious fact the we would have not been in the current position and the level of education, if the existent facilities were missing.

During the educational term, we have obtained the sufficient knowledge and been trained in the required manner to analyze and design any type of construction structures by breaking down the difficult problems into different parts to be solved.

It is our obligation to always consider the dedication and sponsor of our family as well, because it's them supporting us to grow up and reach out to our desired position and fulfill our hopes.

This book be approved by instructors, and the readers exempt us from any errors in its composition. we hope this copy will open a new window for us towards further success and become a key to our development.

Group Member

## **ABSTRACT**

This final project report describe the concrete mix design as well as the analysis and design of three story office building.

The main purpose are having experience in the field of concrete mix design and construction engineering, we thought to work on a project practical as a part of completing our academic career. However, we started to work on a project by name of “three story office building analysis, design and cost estimation”

This project has 465m<sup>2</sup> building area and it is a three-story office building which is located in Lugar-Afghanistan. the project contains with three typical office building which ground floor has four working office, one conference room, one meeting room, one kitchen, one dining room, one server room, four toilet and one hall. On the other hand first floor has seven working office, one library, one teahouse, one storage, and two toilet, also there is eight working office, one teahouse, and one storage at the second floor.

Therefor we started this project by research about concrete mix design to select the better and proper mark of concrete. Then design of project starts by calculation of loads (vertical and horizontal) on building and continues by using Gasper Kane’s method to analyzing the critical frame, then designed each member of building including Slabs, Beams, Stairs and Footing. After all this design ends with calculating of required materials, their costs and amount of the materials with the total cost of this project.

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# **CHAPTER ONE**

## **INTRODUCTION**

The project will be going to consider for our project report is a three story office building located in Pol-e-Alam, Lugar province. We will be designing a moment resisting frame which consisted of slab, beam, column and footing. This type of structure is ordinarily used to resist gravity and lateral loads.

The intended will be used by court of appeal, which has a significant role in governmental offices. The structures' physics occupy 465m<sup>2</sup> area which has a length of 24.7m and width of 18.8m. moreover, every story has about 7 offices and 2 wash rooms and space for storage.

### **1.1 Problem Statement**

One of the most important considerations in a construction project is the concrete mix design and its related provisions. Due to unorthodox methods applied by private contractors nowadays. Concrete mix design does not meet the required criteria as stated in many project documents. It will be striving to focus on concrete mix design provisions based on internationally certified codes such as American Concrete Institute, ACI 211.1, [1]. In order to achieve the most suitable concrete mix for our project in terms of workability, economy, strength and durability. That will compare the properties of various concrete mixes and select the most appropriate one for our project.

## **1.2 Scope of Project**

The intended project is designed for an area of 465 square meter area, 24.7 meter length, 18.8meter width, it is located in Lugar province, Afghanistan. It has three stories. It is a tipic three story building.

Additionally, it will analyze the project using Kane's method and design slabs, beams, columns and footing. We will use our pre-determined concrete mix during the construction phase of the project. Thus, a detailed report of tests will be presented from different marks of concrete done in laboratory. We will compare the properties of various concrete mixes and select the most appropriate one for our project.

## **1.3 Objectives**

- To make high quality concrete.
- Find the reason why the concrete quality is less in Afghanistan.
- Find solutions for our research problem.
- To know and improve the team work.
- Design of structures with engineering codes and requirement.
- Estimate the project.
- Compare the manual calculations with software.
- How to construct the project.

## 1.4 Methodology

To make clear how the project work out, a proper trail or method ought to be chosen. It further helps to get the specified consequence and puts ease to go through the overall process. Accordingly, an appropriate flow-chart is necessary to better illustrate the entire process, as shown in chart 1.1.

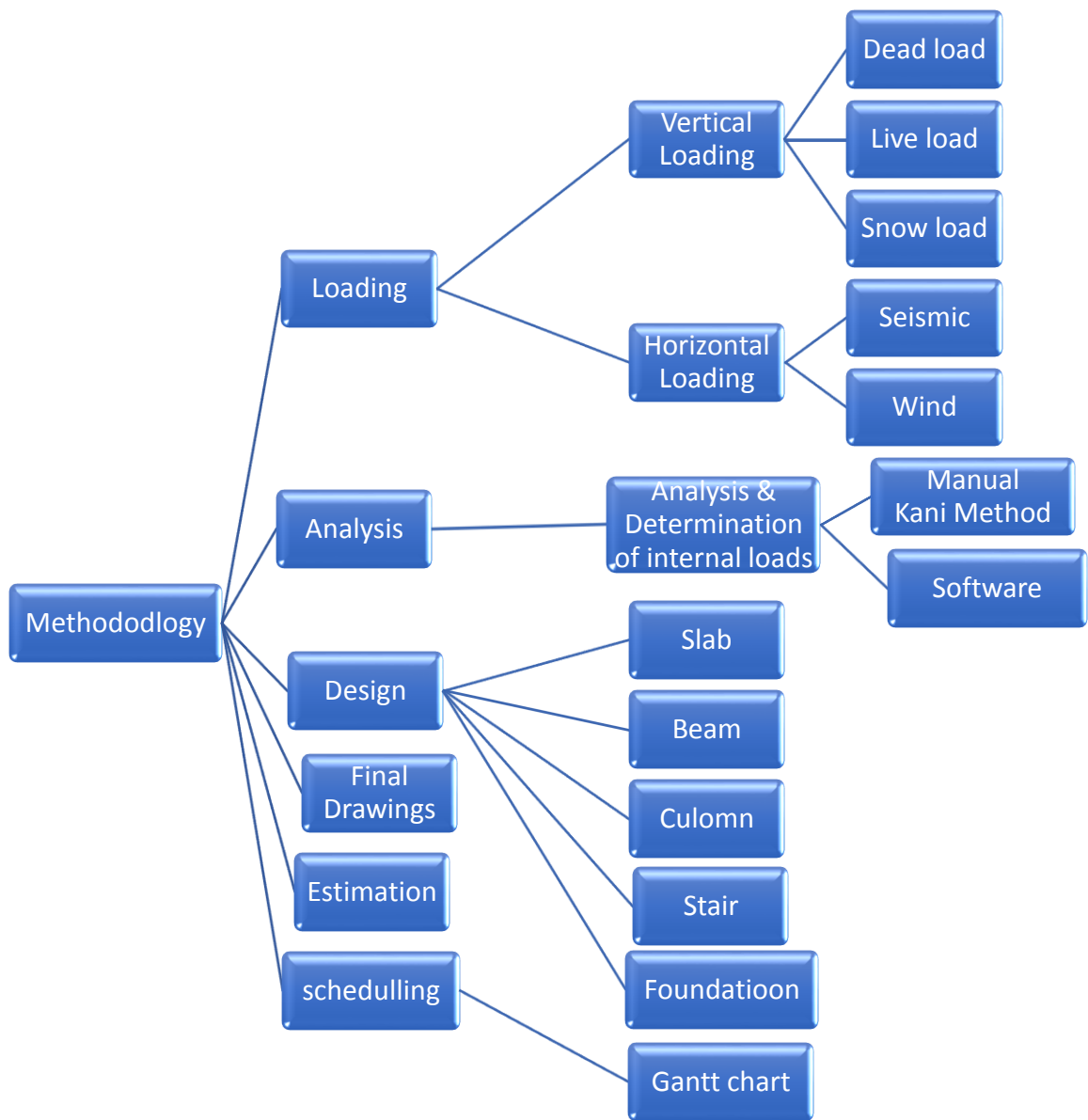


Chart 1.1: flow chart of methodology

The software to design and analysis which are based in static and linear is, (AutoCAD, ETAB, SAFE), are used in this project.

## **1.5 Load Calculations**

Since buildings are affected by both gravity and lateral loads, they both should be taken into account. According to “IBC, UBC and ASCE” codes.

## **1.6 Analysis and Design Process**

Building is analyzed using Kani and coefficient methods with taking into account applied loads on each member. That are slabs, Beams, Columns, Stairs, Foundation

## **1.7 Final Drawings**

The calculated members, plan view, side view, section view, cross sections and steel bars percentage will be shown in figures.

## **1.8 Cost estimation**

This part is the process of predicating the cost and price of the resources required by the scope of a project. Since cost estimation is about the prediction of costs rather than counting the actual cost of Material estimation and Cost estimation.

## **1.9 Potential contributions of the proposed project**

We should consider the needs of the client throughout the design process. This project can stand out as thoroughly designed buildings. Factors for example seismic effects, economy and engineering standards will be better calculated. Because it can be stand as a building of complete design.

# **CHAPTER TWO**

## **LITURATURE REVIEW**

### **2.1 Introduction**

A literature review is the comprehensive study of scholarly articles on a research questions so that the researcher and the reader could a deep understanding of the existing information on the matter. Additionally, it is used to confirm the validity of the research question and to draw attention to the gap existed in the knowledge.

One of the most important considerations in a construction project is the concrete mix design and its related provisions. Due to unorthodox methods applied by private contractors nowadays. Concrete mix design does not meet the criteria required for the projects. In order to achieve the most suitable concrete mix for a project in terms of workability, economy, strength and durability. It is vital to compare the properties of various concrete mixes and select the most appropriate one for the intended project. The provisions for the concrete mix design are mainly provided in the internationally certified codes.

The purpose from this literature review is the provide insight on the concrete mix design, investigate factors that affect concrete mix design, and finally select the most appropriate concrete mix design for our project in terms of workability, economy, strength and durability.

It will focus on the provisions of internationally certified codes, and the different requirements they propose for the concrete mix design. However, in the beginning of this literature review we will introduce concrete mix design and its key terms. Moreover, we will shortly have a glance at the workability, economy, strength and durability of concrete.

In addition to defining key terms we will describe 5 Methods for concrete mix design which is consisted of American Method of Mix Design, Graphic Method of Mix Design, Mix Design by Indian Standard Method, American Concrete Institute Method of Mix Design, and Rapid Method of Mix Design.

## **2.2 Concrete Mix Design**

Concrete mix design is the process of selecting the ingredients for a concrete mixture and deciding on their proportions. When designing a concrete mix, you should always consider the desired strength, durability, and workability of the concrete for the project in question, [1].

Cement mix design is often mistakenly referred to "concrete mix design." However, cement is simply one of the ingredients of concrete. It is a binding substance that allows concrete to set, harden, and adhere to other materials. Therefore, it cannot and should not be used interchangeably with concrete mix design. In general, concrete mixes are designed to follow the guidelines provided by ACI Committee 211, [2]. Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete. A concrete mix can be designed using the tables and calculations provided in the standard.

### **2.2.1 Methods of Concrete Mix Design**

The following points highlight the five methods of concrete mix design. The methods are: First, American Method of Mix Design, Second, Graphic Method of Mix Design, Third, Mix Design by Indian Standard Method, Fourth, American Concrete Institute Method of Mix Design, Fifth, Rapid Method of Mix Design.

### **2.2.1.1 American Method of Mix Design**

The American Concrete Institute ACI, [3]. method is based on the fact that for a given maximum size of aggregate the water content in kilogram per cubic meter of concrete determines the workability of concrete mix, usually independent of the mix proportions. The relative water contents for various work-abilities are given in Table 20.2.

Table 20.24 gives the actual content of water for a reference (plastic) consistency of table 20.23. It is thus possible to start the mix design by selecting the water content from these tables.

Further it is also assumed that the optimum ratio of bulk volume of coarse aggregate to the total volume of concrete depends only on the maximum size of aggregate and on the grading of fine aggregate. Table 20.25 gives the maximum bulk volume of coarse aggregate per unit volume of concrete. For other consistency the values of Table 20.23 should be multiplied by a factor given in Table 20.26,[3].

#### **2.2.1.1.1 Procedure**

After fixing the maximum size and type of aggregate, the workability is determined with the help of water content obtained from given Tables 20.23 and 20.24, and bulk volume of coarse aggregate from Table 20.25. From given specific gravity of coarse aggregate, its absolute volume is determined.

Now the water/cement ratio is chosen from strength as well as durability requirements and the quantity of cement is computed dividing water content by water/cement ratio. Thus the absolute volumes of water, coarse aggregate, are known. The absolute volume of fine aggregate can be determined by subtracting the above weights from the weight of concrete.

### **2.2.1.2 Graphic Method of Mix Design**

This method has been developed by Road Research Laboratory, London, [4]. and its detailed procedure has been explained in Road Note No. 4. Here this method is explained with the help of Fig. 20.5 and 20.6. The aggregates to be mixed together are served and their percentage passing through standard serves for fine aggregate serve 4.75 mm, 2.36 mm, 1.18 mm. 600 micron, 300 micron and 150 micron are used. For coarse aggregate maximum size allowed, say 38 mm, 19 mm, 9.5 mm 4.75 mm, 2.36 mm serve used.

#### **2.2.1.2.1 Procedure**

The percentage passing through each serve of the coarse and fine aggregate or two fractions of coarse aggregate which are to be mixed to obtain the desired grading curve are noted along the two opposite vertical sides of a square from top to bottom as shown in Fig. 20.5. The points corresponding to the same serve size are joined by the straight lines. If the serve size does not exist on any of the vertical axis, then the line should be joined to the 100% point on the left hand axis and 0% point on the right hand axis.

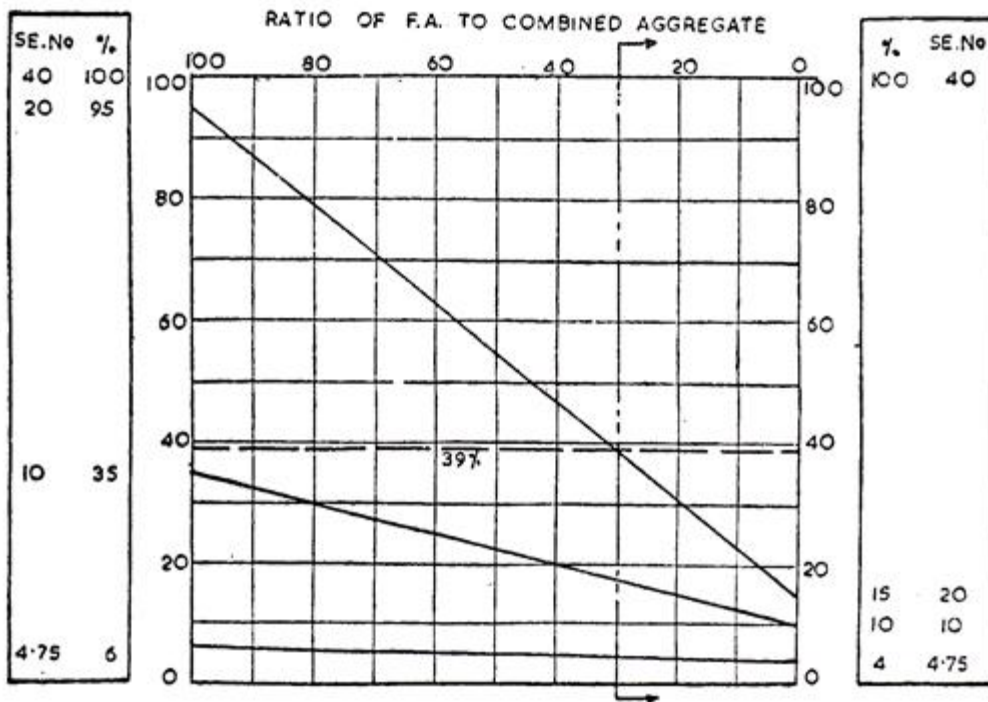
Now a vertical line is drawn through the point of intersection of the line joining the same serve size point and the horizontal line representing the correct percentage of aggregate smaller than the desired serve or the vertical line drawn from the appropriate point along the scale at the top of the diagram (this scale represents the ratio of fine to total aggregate) and the combined grading is given by the inter section of this line and the serve size lines joining the pairs of points. If two coarse aggregate are to be combined with sand then the two C.A sizes to be combined using the % passing 20 mm sieve as a criterion. Its two sands are to be combined then 600 micron sieve should be taken as criterion.

Now draw a horizontal line through 41% line parallel to x-axis. Draw a vertical line through the point of inter-section of line joining the percentages of 4.75 mm line and horizontal line of 41% intersecting all lines as shown.

Measure the corresponding percentages indicated by these points of inter-section as shown in the Fig. 20.5. These will be the percentages of each fraction. These percentages are shown on the lines.

Now let us combine two fractions of coarse aggregate. In this case the percentage passing through 19:0 or (20) mm sieve size is taken as the criterion. The percentages passing each sieve are marked along the two opposite sides of the square as shown in chart-1 and the points corresponding to same sieve size are joined by straight lines Fig.1.1.

Fig.1.1. Fraction of coarse aggregate,[3].



source:(ACI Committee 435).

### **2.2.1.3 Mix Design by Indian Standard Method**

The bureau of Indian standards has recommended a procedure for mix design of concrete based on the experimental work carried out in the national laboratories. The mix design procedure is given in IS-10262- 2000, [5]. After that no revision has been done in this procedure, whereas IS 456- 2000, [6]. Hence IS2000 needs revision as the strength of cement available in the country has improved significantly.

Thus following changes need to be effected:

- The 28 day strength of A, B, C, D, E & F category of cements needs to be revised.
- The relation between the different strengths of cement and w/c ratio should be re-established.
- The relation between 28 days compressive strength and w/c ratio should be extended up to a compressive strength of 80 MPa (800 kg/cm<sup>2</sup>), if the graph is to be used for high strength concrete.
- As per the revised IS 456-2000 the degree of workability is expressed in terms of slump in place of compacting factor. This change needs new values of sand and water content to be used for normal concrete upto 35 MPa and higher strength Concrete above 35 MPa.

However in the absence of any revision in IS 10262-1982, the existing procedure of IS 10262 is described below step wise,[5].

The IS recommendations for mix design include the design for nominal concrete mixes (non-air entrained) for both medium and high strength concrete.

The method of mix design consists of determining the followings:

- Water content
- Percentage of fine aggregate corresponding to the maximum nominal size of aggregate for the reference value of workability
- Water-cement ratio, and
- Grading of fine aggregate.

The water content and percentage of fine aggregate is then adjusted for any difference in workability. Finally the mass of ingredients per unit volume of concrete is calculated by absolute volume method. This method is applicable to both ordinary port-land and port-land pozzolana cements. The final mix proportions selected after trial mixes, may need minor adjustment. In case of fly ash cement concrete, water content may be reduced by about 3 to 5% and proportion of fine aggregate may be reduced by 2 to 4%.

#### **2.2.1.4 American Concrete Institute Method of Mix Design**

ACI method of concrete mix design is based on the estimated weight of the concrete per unit volume. This method takes into consideration the requirements for consistency, workability, strength and durability. This article presents ACI method of concrete mix design.

Though ACI committee, [7].Studied its method of mix design in 1944 and almost all Indian multipurpose concrete dams have been designed using then prevalent ACI committee method of mix design. Since then many improvements have been incorporated in the original method. Here the latest method of concrete mix design based on ACI 211-1, manual of concrete practice part-I recommendations is discussed , [8].

The ACI committee has assumed the following basic assumptions,[8]:

- Fresh concrete of a given slump and containing a reasonably well graded aggregate of given maximum size will have practically a constant water content, regardless of variation in w/c ratio and cement content which are inter related over a considerable range of practical proportions.
- The optimum dry rodded volume of coarse aggregate per unit volume of concrete depends on its maximum size and the fineness modulus of the fine aggregate as shown in table 20.39 regard less of shape of particles. The effect of angularity is reflected in the void contents. Thus angular coarse aggregates require more mortar than rounded aggregates.
- Irrespective of methods of compaction, even after complete compaction is done, a definite percentage of air remains in the concrete and is inversely proportional to the maximum size of the aggregate.

## 2.2.1.4.1 Procedure for ACI Method of Concrete Mix Design

### 2.2.1.4.1.1 Choice of slump

If slump is not specified, a value appropriate for the work can be selected from Table 1. The values provided in table can be used only when vibration is used to consolidate concrete, “as sited by”, [9].

Table 2.1. Slump value base on type of construction,[10].

Construction Type	Slump value, mm	
	Minimum	Maximum*
Reinforced foundation walls and footings	25	75
Plain footings, caissons, and substructure walls	25	75
Beams and reinforced walls	25	100
Building columns	25	100
Pavements and slabs	25	75
Mass concrete	25	50

Source (ACI 211-1-91)

#### **2.2.1.4.1.2 Choice of maximum size of aggregate**

Commonly, maximum aggregate size should be the largest that is economically available and consistent with dimensions of structural element. ACI 211.1-91, [10]. Showing that, maximum aggregate size shall not surpass:

- One-fifth of the narrowest dimension between sides of forms.
- one-third the depth of slabs
- 3/4-ths of the minimum clear spacing between individual reinforcing bars, bundles of bars, or pre-tensioning strands.

These limitations may be ignored provided that workability and methods of consolidation are such that the concrete can be placed without honeycomb or void.

#### **2.2.1.4.1.3 Estimation of mixing water and air content**

The quantity of water per unit volume of concrete required to produce a given slump is dependent on,[10]:

- nominal maximum size
- particle shape
- grading of the aggregates
- concrete temperature
- amount of entrained air
- use of chemical admixtures.

Table 2.2 and Table 2.3 provide estimates of required mixing water for concrete made with various maximum sizes of aggregate, for non-air and air-entrainment concrete, respectively. based on “Proportioning concrete mix”, [11].

Table 2.2. Approximate mixing water (Kg/m<sup>3</sup>) and air content for different slumps and nominal maximum sizes of aggregates for non-air content concrete,[11].

Slump, mm	Water, Kg/m <sup>3</sup> of concrete for indicated nominal maximum sizes of aggregate							
	9.5 mm	12.5 mm	19 mm	25 mm	37.5 mm	50 mm	75 mm	150 mm
25-50	207	199	190	179	166	154	130	113
75-100	228	216	205	193	181	169	145	124
150-175	243	228	216	202	190	178	160	—
Approximate Air content quantity, %	3	2.5	2	1.5	1	0.5	0.3	0.2

Source (ACI 211-1-91)

Table 2.3. Approximate mixing water (Kg/m<sup>3</sup>) and air content for different slumps and nominal maximum sizes of aggregates for air content concrete,[10].

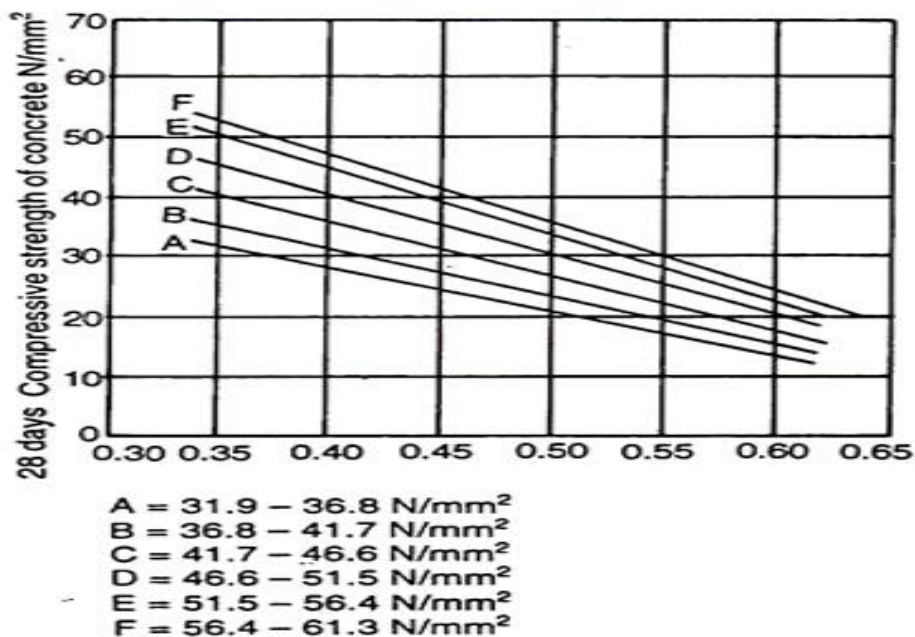
Slump, mm	Water, Kg/m <sup>3</sup> of concrete for indicated nominal maximum sizes of aggregate							
	9.5 mm	12.5 mm	19 mm	25 mm	37.5 mm	50 mm	75 mm	150 mm
25-50	181	175	168	160	150	142	122	107
75-100	202	193	184	175	165	157	133	119
150-175	216	205	197	184	174	166	154	—
Recommended average total air content (%) for different level of exposure								
Mild exposure	4.5	4	3.5	3	2.5	2	1.5	1
Moderate exposure	6	5.5	5	4.5	4.5	4	3.5	3
Severe exposure	7.5	7	6	6	5.5	5	4.5	4

Source (ACI 211-1-91)

### 2.2.1.5 Rapid Method of Mix Design

To estimate the preliminary water-cement ratio corresponding to the target mean strength a more realistic approach will be to correlate it with the 28 days compressive strength of cement. The characteristic strength is found to be better related to characteristic 28 days strength of cement rather than at earlier ages. Thus this approach will need 28 days for determining the characteristic strength of cement and next 28 days for trial mixes strength of concrete. The 28 day strength of cement can be taken as that given by curves of chart.2.2, [12].

Chart.2.2. Relation between free w/c ratio and concrete strength for different cement strength,[12].



Source (ACI 211-1)

The 28 days or 56 days is too long a period for a contractor to wait for the results of the trial mix. There is a tendency to use mix directly without trying trial mixes. To reduce the time required for trial mixes, the cement Research Institute of India (CRI) has developed a method called rapid method, by which the compressive strengths of cement and concrete are obtained by using accelerated curing method as discussed in IS 9013-1978, and This method reduces the period for finding the strength of trial mixes from 28 days to 3 days only, [13].

The 28 days compressive strength of concrete is found to be statistically significantly related to its accelerated strength. Thus the trial mixes are correlated to the target mean accelerated strength rather than to the target mean 28 days strength, with the help of correlation between the two, [14].

This correlation is found to be independent of type or characteristics of cement used i.e. the correlation is not affected by the type of cement used, presumably due to the fact that they affect both the accelerated and normal 28 days strength of concrete in a proportionate manner, so that the effect is neutralized when their ratios are compared. More over for individual application such correlations can be established for the type of the materials and mix proportions to be used, [15].

### **2.3 Workability of Concrete**

Workability of concrete is the property of freshly mixed concrete which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished' as defined by ACI Standard, [16].

ASTM defines it as "that property determining the effort required to manipulate a freshly mixed quantity of concrete with minimum loss of homogeneity, [17].

The workability of concrete depends on many factors which are explained in factors affecting workability of concrete. Water cement ratio has much effect in the workability.

Workability is directly proportional to water cement ratio. An increase in water-cement ratio increases the workability of concrete, [18].

Workability of concrete can be divided into following three types:

- a. Unworkable Concrete
- b. Medium Workable
- c. Highly Workable Concrete

## **2.4 Strength and Durability**

In general, the minimum compressive strength and a range of W/C ratios are specified for a given concrete mix. However, possible requirements for resistance to freeze thaw and chemical attack must be considered. Therefore, a balance must be made between strength and workability, [19].

## **2.5 Relation between target strength and specified characteristic strength**

As stated in book (Advanced Concrete Technology, [20]). Compressive strength is normally specified in terms of a characteristic value,  $f_{ck}$ , below which a stated maximum proportion of results, usually 5 percent in Europe, is permitted to occur. For mix design purposes, relationships between strength and water/cement ratio or cement content are usually based on average strength, so that information is required on how to estimate the average strength to be targeted for any given specified strength. Statistical theory and concreting practice have combined to confirm that the proportion of results expected to be below the characteristic strength is related to the margin when expressed as a multiple,  $k$ , of the standard deviation, as shown in Table 2.4, at the bellow.

Table 2.4. Statistical margin factors for strength,[20].

<b>Maximum percentage of results below the characteristic strength level</b>	<b>Minimum value of k</b>
10	1.28
5	1.64
2.5	2.00
1	2.33
0.5	2.58
0.1	3.00

Source: (ACI).

Thus, the minimum margin is  $1.64 \times$  standard deviation when the specified maximum percentage is 5 per cent. However, taking into account the need for safety to cover time delay in obtaining strength results and other aspects introducing uncertainty, it would be very unwise to operate at this margin. Indeed, compliance requirements for strength are usually set at a level to discourage the use of low values for k. In UK practice values of k of less than 2 would not normally be adopted.

## **2.6 Adjustments to allow for moisture content of aggregates**

For production purposes it is necessary to increase the batch weights of the fine and coarse aggregates by their respective free moisture contents, to ensure the correct SSD weights. The amount of water to be added is reduced correspondingly. Assuming 6 per cent free moisture in the fine aggregate and 2 per cent in the coarse aggregate the adjustments to the batch figures would be as shown in Table 1.5. It will usually be necessary to round the final figures to 5 or 10 kg, depending on the weigh scale divisions of the batching equipment and the batch size,[21].

# CHAPTER THREE

## METHODOLOGY

One type of research design will be applied which is experimental. The methodology is a way to advance a project, whether it is at the stage of analysis, design or implementation of the project in the area, using the best effective method to solve problems.

In this chapter, it attempts to solve the building problems and problems of the project, which it was, discussed the ways to be solve. The problems encountered in this methodology are the problems that we have addressed in the second chapter, the literature review, in this chapter; efforts are be made to consider the standards and engineering code in the process of loading, analyzing, designing. Design of concrete to eventually build a structure with eventually to build a structure with more efficiency better workability and more durable.

Whatever we name from the concrete, we have to take a few basic points, at first, which is to consider best concrete mix design, the second is the adoption of the code, and the third one is Economy in building, which will be discusses in summary form in the above.

Benefits of adopting engineering codes. In concrete mix, design can make construction phase more effective and more durable, it also by enforces and adopting engineering codes in the structure caused serviceability in buildings, which increases building confidence and functionality.

### 3.1 Overall Methodology

Every Project realization needs a methodology to better organize analysis and design processes. Engineering processes require high level of accuracy so that there may remain no indeterminacy. Therefore, a flow chart is use to explain every step accordingly.

Methodology is a procedure of doing any work step-by-step based on rules. The design and analysis of structures follow the rules that are specifies for this purpose.

A proper flow-chart is needed to transmit the overall process clearly, as shown in chart.3.1.

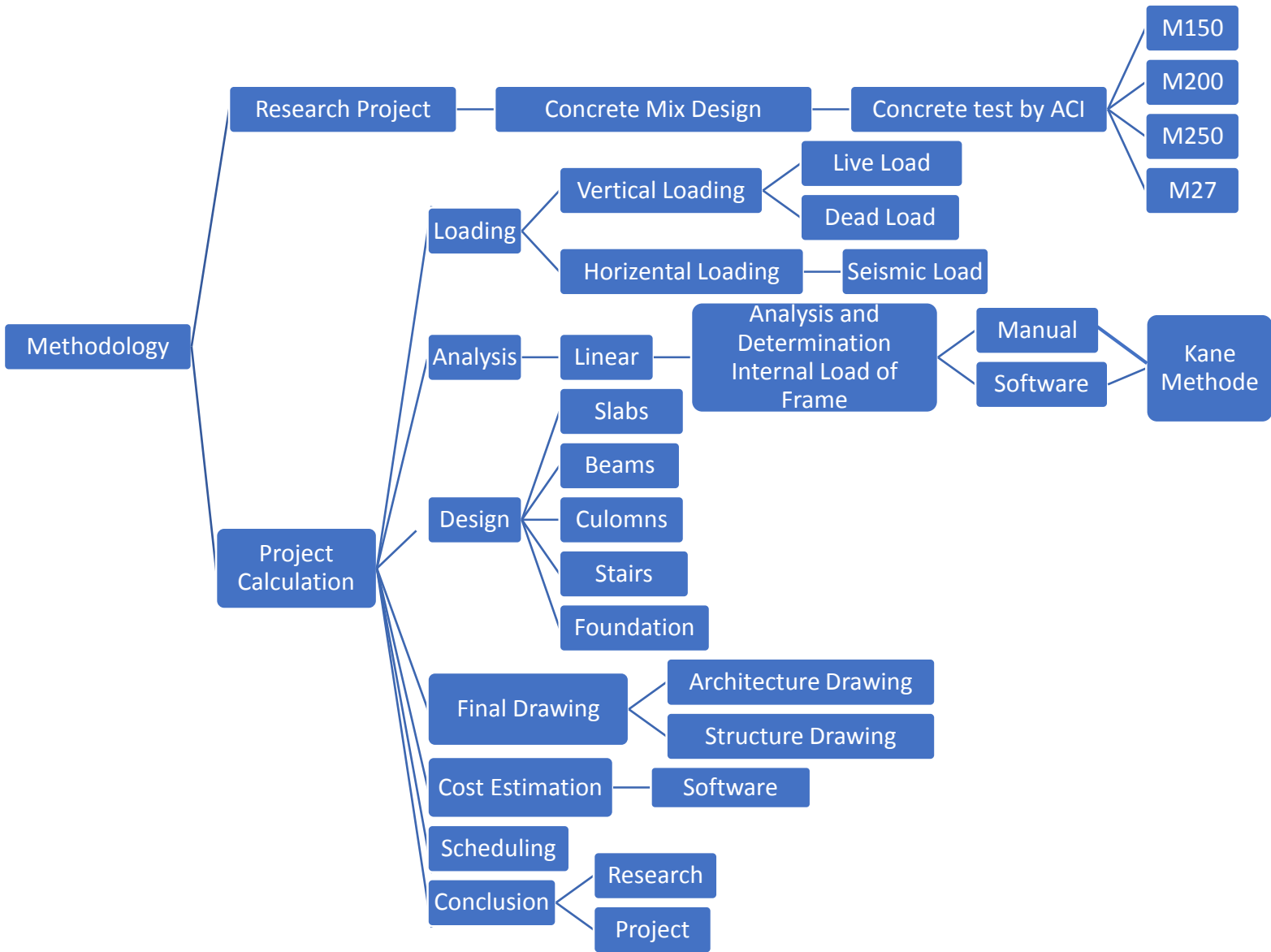


Chart.3.1: Flow Chart, Methodology

## **3.2 Concrete Mix Design**

Concrete mix design is the process of selecting the ingredients for a concrete mixture and deciding on their proportions. When designing a concrete mix, you should always consider the desired strength, durability, and workability of the concrete for the project in question,[1].

Cement mix design is often mistakenly referred to "concrete mix design." However, cement is simply one of the ingredients of concrete. It is a binding substance that allows concrete to set, harden, and adhere to other materials. Therefore, it cannot and should not be used interchangeably with concrete mix design. In general, concrete mixes are designed to follow the guidelines provided by ACI Committee 211, [2]. And suggested Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete. A concrete mix can be designed using the tables and calculations provided in the standard.

### **3.2.1 Methods of Concrete Mix Design**

The following points highlight the five methods of concrete mix design. The methods are:

- American Method of Mix Design (ACI)
- Graphic Method of Mix Design
- Mix Design by Indian Standard Method (ISM)
- American Concrete Institute Method of Mix Design
- Rapid Method of Mix Design

### **3.2.2 ACI Method of Concrete Mix Design:**

The American Concrete Institute ACI,[3]. method is based on the fact that for a given maximum size of aggregate the water content in kilogram per cubic meter of concrete determines the workability of concrete mix, usually independent of the mix proportions. The relative water contents for various work-abilities are given in Table 20.2.

Table 20.24 gives the actual content of water for a reference (plastic) consistency of table 20.23. It is thus possible to start the mix design by selecting the water content from these Tables.

Further it is also assumed that the optimum ratio of bulk volume of coarse aggregate to the total volume of concrete depends only on the maximum size of aggregate and on the grading of fine aggregate. Table 20.25 gives the maximum bulk volume of coarse aggregate per unit volume of concrete. For other consistency the values of Table 20.23 should be multiplied by a factor given in Table 20.26

#### **3.2.2.1 Procedure For ACI Method of Concrete mix Design**

- Choice of Slump
- Choice of Maximum size of aggregate
- Estimation of mixing water and air content
- Selection of water-cement or water-cementations material ratio
- Calculation of cement content
- Estimation of coarse aggregate content
- Estimation of fine aggregate content
- Adjustments for aggregate moisture
- Trail Batch Adjustments

### **3.3 Loading**

Loading is an important factor in the building to be consider in the early stage of calculations. There are different types of loadings to be considered such as, vertical loading (dead loads , live loads , snow loads and self-Wight loads), horizontal loadings (seismic load, wind load). Some of the loads are already assigned by codes for each country we have used “IBC4, UBC5 and ASCE5” [12] codes partially in our calculations. There are two types of loading that calculated for the building.

- Vertical loading
- Horizontal Loading

#### **3.3.1 Vertical Loads or Gravity Loads**

Vertical loading is consisting of all loads, which are effective on building on vertical positions such as slabs, beams, dead load, live load, gravity load, snow load, and roof loading. The dead loads must have calculated by architecture design of the building or details sections. The live loads must have designed by national and international codes.

##### **3.3.1.1 Types of Vertical Loads**

- Dead loads
- Live Load

###### **3.3.1.1.1 Dead Load(DL)**

The first vertical load that is considered is dead load. Dead loads are permanent or stationary loads. These loads are principally due to self-weight of structural members, permanent partition walls, fixed permanent equipment’s, and weight of different materials. It majorly consists of the weight of roofs, beams, walls, column, etc. that are otherwise the permanent parts of the building.

### **3.3.1.1.2 Live Loads (LL)**

The second vertical load that is considered in design of a structure is live loads. Live loads are either movable or moving loads without any acceleration or impact. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc. Live loads keep on changing from time to time. These loads are to be suitably assumed by the designer. It is one of the major loads in the design. The minimum values of live loads to be assumed are given in IS 875 (part 2)–1987. It depends upon the intended use of the building.

#### **3.3.1.1.2.1 The code gives the values of live loads for the following occupancy classification:**

- Residential buildings—dwelling houses, hotels, hostels, boiler rooms and plant rooms, garages
- Educational buildings
- Institutional buildings
- Assembly buildings
- Business and office buildings
- Industrial buildings
- Storage rooms

Source: (IBC-Chapter.16-Tables.1607.2),[24].

The code gives uniformly distributed load as well as concentrated loads. The floor slabs have to be designed to carry uniformly distributed either loads or concentrated loads whichever produce greater stresses in the part under consideration. Since it is unlikely that any one time all floor will not be simultaneously carrying maximum loading, the code permits some reduction in imposed loads in designing columns, load bearing walls, piers supports and foundations.

The calculation of dead loads of each structures are calculated by the volume of each section and multiplies with unit of weight.

$$W_u = 1.2D + 1.6L \quad \text{Eq (3.1)}$$

### 3.3.1.2 Ultimate load

The ultimate load is related to the limit load using the concept of safety factor.

Limit load the maximum loads to be expected in service

For structure analysis and design, we must calculate ultimate load that the process mean loading. In structure, we have Slab, Beam, Column and Foundation.

### 3.3.2 Slab

Slabs are also considering as main element of the buildings, when calculation the loads slabs are also considered in the calculations and types of slabs must be properly assigned on each floor of the building. The slabs could be one way and two way containing continue edge, discontinue edge. In the designing process, we must consider the critical slab and applies the results on all other slabs for each floor.

$$\frac{LL}{LS} \geq 2 \quad \text{One Way Slab} \quad \text{Eq (3.2)}$$

$$\frac{LL}{LS} < 2 \quad \text{Two Way Slab} \quad \text{Eq (3.3)}$$

$$W_s = \frac{w_u * l_s}{2} \text{ (Rectangular)} \quad \text{Eq (3.4)}$$

If the slab is two ways, then the loads are distributed is

$$W_s = \frac{W_u * l_s}{2} * \left\{ \frac{3-m^2}{2} \right\} \quad \text{Eq (3.5)}$$

$$m = \frac{LS}{LL} \text{ (Trapezoidal sides)} \quad \text{Eq (3.6)}$$

### 3.3.2.1 Formulas for Design Process

- Slab Load

$$W_s = \text{Triangular sides} + \text{Trapezoidal sides} \quad \text{Eq (3.6)}$$

$$W_s = \frac{W_u \cdot L_s}{3} (\text{Triangular sides}) \quad \text{Eq (3.7)}$$

### 3.3.3 Beam

As the main purpose or function of beams is to take the loads from slab, wall and its self-weight and transfer it to columns, to calculate beams loadings, it is necessary to have slab load, wall load and beam self-weight load.

For facilitating the loading and design process, the critical frame or section has to be select and the process applied on the other parts are taken from the same as the critical once. While selecting the frame to be design, the critical frame is that frame which its tributary area is more.

#### 3.3.3.1 Ultimate loads on beam

- **Wall Load**

$$W_w = \gamma_{brick} \cdot V_w \quad \text{Eq (3.8)}$$

- **Self-Weight**

$$W_{se} = \gamma_{concrete} \cdot b \cdot h \quad \text{Eq (3.9)}$$

- **Total beam Load**

$$W_{uB} = W_s + 1.2W_w + 1.2W_{self} \quad \text{Eq (3.10)}$$

### 3.3.4 Horizontal Loads

Horizontal loads are other than loads, which applied by the weight of building itself. Horizontal loadings are mainly secondary effect of natural hazards or nature itself, That include Seismic load and Wind load.

#### 3.3.4.1 Seismic loads effects

Seismic Calculation

$$F_i = C_{vx} \cdot V \quad \text{Eq (3.11)}$$

Where:

$F_i$ : Seismic force on (i) story

$C_{vx}$ : Vertical distribution factor

$V$ : Base Shear

$$C_{vx} = \frac{w_x \cdot h_x^k}{\sum_{i=1}^n w_i \cdot h_i^k} \quad \text{Eq (3.12)}$$

Where:

$w_x$  and  $w_i$ : Weight of each story

$h_x$  and  $h_i$ : Height of each story from the base of the building

$K$ : An exponential related to the structure or building time period

$K$  value can be considered with respect to  $T$  value:

- $T = C_u \cdot T_a \quad \text{Eq (3.13)}$

Where:

$T$ : Fundamental period of the structure

$C_u$ : Exact coefficient (table 12.8-1 ASCE with respect to SD1)

$T_a$ : Approximate structure time-period

$$SD1 = \frac{2}{3} * SM1 \quad \text{Eq (3.14)}$$

$$Sm1 = Fv \cdot S1 \quad \text{Eq (3.15)}$$

Where:

*SD1*: Spectral response accelerations at short period  $t = 0.1$  sec (ABC)

*Sm1*: The maximum considered earthquake spectral response accelerations for long Period (IBC1613.3.3)

*Fv*: Site coefficient defined in IBC Table 1613.3.3(2)

*S1*: Spectral response accelerations for long period (1.0 sec) (ABC)

#### 3.3.4.1.1 For determining $T_a$ there are two methods:

- Method 1:

$T_a = \frac{n}{10}$ ; this method can be used for building up to 12 stories and each story height should not be less than 3m.

- Method 2:

$$T_a = C_t * h_n^x \quad \text{Eq (3.16)}$$

Where  $C_t$  (building period coefficient) and  $x$  (constant) values are given in, table 12.8-2 ASCE with respect to structure type.

- If  $T \leq 0.5$  then,  $k = 1$
- If  $T \geq 2.5$  then,  $k = 2$
- If  $0.5 < T < 2.5$  the  $k$  value is calculated by linear interpolation formula.

$$y = y_1(x - x_1) * \frac{y_2 - y_1}{x_2 - x_1} \quad \text{Eq (3.17)}$$

$$V = C_s \cdot W_{\text{effective}} \quad \text{Eq (3,18)}$$

Where:

V: Base shear

Cs: Seismic response coefficient

$$C_s = \frac{SD_s * I}{R}; C_s \text{ min} = 0.044SD_s * I \geq 0.01 \text{ and } C_s \text{ max} = \frac{SD_1}{T\left(\frac{R}{I}\right)} \quad \text{Eq (3.19)}$$

Where:

SDs: Spectral design response acceleration of seismic at short period (t = 0.2 sec)

I: Importance factor

I=1 Ordinary Structures (e.g. Storages...)

I=1.25 Intermediate Structures (e.g. residential buildings...)

I=1.5 Important Structures

R: response modification factor, given in ASCE 7-10 Table 12.2-1

$$SD_s = \frac{2}{3} * S_{ms} = F_a * S_s \quad \text{Eq (3.20)}$$

Where:

*S<sub>ms</sub>*: The maximum considered earthquake spectral response accelerations for short period as determined in section (IBC1613.3.3)

*F<sub>a</sub>*: Site coefficient defined in IBC Table 1613.3.3

*S<sub>s</sub>*: spectral response accelerations for short period (t = 0.2 sec) defined in ABC.

## **3.4 Analysis**

Analysis is the key of structure designing in engineering.

Analysis is the second process of our project structure, which is performed precedent to the design of structural members and the determination of the reinforcement, or any other material required. In order to analyze a structure, there are many methods each with specific properties in calculation and analysis. After we have analyzed a structure either by any method, the design process can proceed based on the effects of the internal forces such as, moment, shear, axial and torsion forces.

### **3.4.1 Linear Static Analysis**

A linear static analysis is an analysis where a linear relation holds between applied forces and displacements. In practice, this is suitable to structural problems where stresses remain in the linear elastic extent of the used material. In a linear static analysis, the model's stiffness matrix is constant, and the solving process is relatively short compared to a nonlinear analysis on the same model. Therefore, for a first estimate, the linear static analysis is often used prior to performing a full nonlinear analysis "Structural Dynamic".

There are many different methods for linear static analysis such as:

- Force method
- Approximate method
- Three moment equation method
- Slope deflection equation method
- Moment distribution method
- Kane method

In this project, the Kane method will be use.

### **3.4.2 Non-Linear static Analysis**

A nonlinear analysis is an analysis where a nonlinear relation holds between applied forces and displacements. Nonlinear effects can originate from geometrical nonlinearity's (i.e. large deformations), material nonlinearity's (i.e. elastic-plastic material), and contact. These effects result in a stiffness matrix, which is not constant during the load application. This is opposed to the linear static analysis, where the stiffness matrix remained constant. As a result, a different solving strategy is required for the nonlinear analysis and therefore a different solver “dynamic analysis”.

Modern analysis software makes it possible to obtain solutions to nonlinear problems. However, experienced skill is required to determine their validity and these analyses can easily be inappropriate. Care should be taken to specify appropriate model and solution parameters.

### **3.4.3 Kane Method**

Professor Gasper Kane has investigated on substitute frames for the analysis of indeterminate structures in Germany (1852-1857) “Structural guide\_55” this method offered an iterative scheme for applying slope deflection method.

This method is applicable for:

- (1) beams with no translation of joints,
- (2) rotation factor of multistoried frames,
- (3) analyzing of frames with no translation of joints etc. This method is an indirect extension of slope deflection method and is efficient due to simplicity of moment distribution. In Kane's method, all the components are carried out in a single line diagram of the structure. His method is convenient for multistoried building frames in vertical and lateral loading conditions as it is self-correcting. It is the only easy and approximate method by which a whole frame can be analyzed in 2D.

### **3.5 Design process of the building**

Structural design is the science of studying the Mechanics of a structure. Designing the skeleton of a building determines the real strength of the structure.

#### **3.5.1 Methods of Structural Design**

- 1- Working stress method (WSM)
- 2- Ultimate load method (ULM)
- 3- Limit state method (LSM)

##### **3.5.1.1 Limit state method (LSM)**

- The philosophy of the limit state method of design represents a definite advancement over the traditional design philosophies.
- Unlike WSM, which based calculations on service load conditions alone, and unlike ULM, which based calculations on ultimate load conditions alone, LSM aims for a comprehensive and rational solution to the design problem, by considering safety at ultimate loads and serviceability at working loads.
- The LSM philosophy uses a multiple safety factor format which attempts to provide adequate safety at ultimate loads as well as adequate serviceability at service loads, by considering all possible limit state “Linear & Nonlinear principle”

There are two types of limit states:

- Ultimate limit states (limit states of collapse): - which deal with strength, overturning, sliding, buckling, fatigue fracture etc.
- Serviceability limit states: – which deals with discomfort to occupancy and/ or malfunction, caused by excessive deflection, crack width, vibration leakage etc., and loss of durability etc.

### 3.6 Slab Design

Reinforced concrete slabs are large flat plates that are supported by reinforced concrete beams, walls, or columns, by masonry walls, by structural steel beams or columns, or by the ground. If they are supported on two opposite sides only, they are referred to as one-way slabs because the bending is in one direction only—that is, perpendicular to the supported edges. Should beams on all four edges support the slab, it is referred to as a two-way slab because the bending is in both directions. Actually, if a rectangular slab is supported on all four sides, but the long side is two or more times, as long as the short side, the slab will, for all practical purposes, act as a one-way slab, with bending primarily occurring in the short direction. Such slabs are designed as one-way slabs.

#### 3.5.1 One way slab design steps and formulas

Step 1) Slab minimum thickness (hs):

Table 3.4: Minimum thickness of non-pre-stressed one-way slabs unless deflections are computed

Minimum thickness h				
	Simply supported	One ended Continuous	Both ends continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be large deflections			
<b>Solid One-way slabs</b>	<b>L/20</b>	<b>L/24</b>	<b>L/28</b>	<b>L/10</b>

Source: (Table 9.5a ACI 318-2002)

Step 2) Moment (Mu):

$$\begin{aligned}
 M_u &= \frac{W_u * L_n^2}{24}, & M_u &= \frac{W_u * L_n^2}{14}, & M_u &= \frac{W_u * L_n^2}{16} \\
 M_u &= \frac{W_u * L_n^2}{10}, & M_u &= \frac{W_u * L_n^2}{11} & & \text{Eq (3.30)}
 \end{aligned}$$

Step 3) Amount of steel bars ( $A_s$ ,  $AT/s$ )

$$A_s = \frac{as*b}{s} \quad \text{Eq (3.31)}$$

$s$  for  $A_s$ : spacing between bars in short direction.

$s$  for  $AT/s$ : spacing between bars in long direction.

Step 4) Actual strain  $\epsilon_s$ :

$$\epsilon_s = \epsilon_c * \left[ \frac{d-c}{c} \right];$$

$$c = \frac{a}{\beta_1};$$

$$a = \frac{A_s * f_s}{0.85 * f'_c * b} \quad \text{Eq (3.32)}$$

$\epsilon_s \geq 0.005$  Tension control  $\phi = 0.9$

$\epsilon_s < 0.005$  Compression control  $\phi = 0.65$

Step 5) Nominal Moment ( $\phi M_n$ ):  $M_u \leq \phi M_n$

$$\phi M_n = A_s * f_s * \left( d - \frac{a}{2} \right) \quad \text{Eq (3.33)}$$

Step 6) Actual Shear ( $V_u$ ):

$$V_u = \frac{W_u * L_n}{2} \quad \text{Eq (3.34)}$$

Step 7) Ultimate Shear ( $\phi V_n$ ):  $V_u \leq \phi V_n$

$$\phi V_n = \phi * (0.17 \sqrt{f'_c} \cdot b \cdot d); \phi = 0.75 \quad \text{Eq (3.35)}$$

### 3.5.2 Two-way slab design steps and formulas

According to ACI, there are three methods for design of two-way slabs:

- Direct Design method
- Coefficient Method (about 70% accuracy)
- Equivalent Frame Design Method (Software based)

In this project, the Coefficient Method is used. Followings are the design processes and formulas:

Step 1) Slab thickness:

If  $h > h_{min}$ ;                      Ok

If  $h < h_{min}$ ;                      Use  $h_{min}$

There are three conditions for computing minimum thickness ( $h_{min}$ ):

Condition#1)

If  $\alpha m \leq 0.2$  then,                       $h_{min} = \frac{Ln}{33}$ ,                      Eq (3.36)

For  $F_y = 60000 \text{ PSI}$                        $\alpha m = \frac{ECB \cdot IB}{ECS \cdot IS}$                       Eq (3.37)

Condition#2)

If  $0.2 < \alpha m \leq 2$ ;

$$h_{min} = \frac{\text{Ln}(0.8 + \frac{f_y}{200000})}{36 + 5\beta(\alpha m - 0.2)} \dots \text{PSI} \quad h_{min} = \frac{\text{Ln}(0.8 + \frac{f_y}{14060})}{36 + 5\beta(\alpha m - 0.2)} \dots \text{KG/Cm}^2 \quad \text{Eq (3.38)}$$

$$\beta = \frac{\text{Ln}L}{\text{Ln}S}$$

Condition# 3)

If  $\alpha m > 2$  then,

$$h_{min} = \frac{\text{Ln}(0.8 + \frac{f_y}{200000})}{36 + 9\beta} \dots \text{PSI} \quad h_{min} = \frac{\text{Ln}(0.8 + \frac{f_y}{14060})}{36 + 9\beta} \dots \text{KG/Cm}^2 \quad \text{Eq (3.39)}$$

Step 2) Moments Calculation:

$$Mu^+ = C^+ \cdot Wu \cdot Ln^2 \quad , \quad Mu^- = C^- \cdot Wu \cdot Ln^2 \quad \text{Eq (3.40)}$$

Table 3.5: Moment Coefficients for slab design by Coefficient Method.

Moments	Short Span						Long span, all value of m
	Value of m						
	1.0	0.9	0.8	0.7	0.6	0.5 and less	
Case-1 Interior panels Negative moment at Continuous edge Positive moment at midspan	.033	.040	.048	.055	.063	.083	.033
	0.025	.030	0.36	.040	.047	.062	.025
Case-2-One edge discontinuous Negative moment at continuous edge Positive moment at midspan	.041	.048	.055	.062	.069	.085	.041
	.021	.024	.027	.031	.035	.042	.021
Case-3-Two edge discontinuous Negative moment at continuous edge Positive moment at midspan	.049	.057	.064	.071	.078	.090	.049
	.025	.028	.032	.036	.039	.045	.025
case-4- Three edge discontinuous Negative moment at continuous edge Discontinuous edge Positive midspan	.058	.066	.074	.082	.090	.098	.058
	.029	.033	.037	.041	.045	.049	.029
Case-5- Four edge discontinuous Negative moment at Continuous edge discontinuous edge positive moment at midspan	.033	.038	.043	.053	.055	.055	.033
	.050	.057	.064	.080	.080	.083	.050

Source: (Table 3 ACI 1947).

Step 3) Reinforcements:

$$A_s^{\pm} = \frac{M_u^{\pm}}{\phi * f_y * j * d}; \quad j=0.87 \quad \text{Eq (3.41)}$$

$$N. O. B^{\pm} = \frac{A_s^{\pm}}{a_s} \quad \text{Eq (3.42)}$$

$$\text{Spacing} = \frac{L}{N.O.B} \quad \text{Eq (3.43)}$$

Checking: As with  $A_{smin}$

$$A_{smin} = \rho_{min} * b * h$$

$$S_{min} < S < S_{max} \qquad S_{min} = 3in = 8cm \qquad \text{Eq (3.44)}$$

$$S_{max} = M_{min} \left\{ \begin{array}{l} 300mm \\ 3h \end{array} \right. \text{ (Should not be greater than 18in)}$$

### 3.7 Beam Design

Beams are important part of the buildings; the function of the beams are to carry loads from the slabs to the columns. We have used some simple math to calculate the beams. In order to design beams, we must consider some steps.

1. Check sections size for moment
2. Check beam depth for deflections
3. Design of longitudinal bars
4. Design of stirrups; Section sizes d, h and b: Effective depth (d):

Table 3.6: Minimum thickness of non-pre-stressed beams or one-way slabs unless deflections are computed “Table 9.5a ACI 318-2002”

Minimum thickness h				
	Simply supported	One ended Continuous	Both ends continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be large deflections			
<b>Solid One-way slabs</b>	<b>L/20</b>	<b>L/24</b>	<b>L/28</b>	<b>L/10</b>
<b>Beams or ribbed one-way slabs</b>	<b>L/16</b>	<b>L/18.5</b>	<b>L/21</b>	<b>L/58</b>

Thickness (h):

$$h = d + 65 \text{ (For one layer reinforcement)}$$

$$h = d + 90 \text{ (For double layers' reinforcement)} \qquad \text{Eq (3.45)}$$

Width (b):

$$0.4 \leq \frac{b}{d} \leq 0.8 \qquad \text{Eq (3.46)}$$

Check Section strength for moment:

If  $\phi Mn \geq Mu$  ... OK

If  $\phi Mn < Mu$  ... NOT OK, change section size or material properties.

$$\phi Mn = \phi * \rho * b * d^2 * f_y * \left( \frac{\rho * f_y}{1.7 * f_c} \right) \quad \text{Eq (3.47)}$$

$$\rho = 0.4 \rho_{balance}; \quad \text{Eq (3.48)}$$

$$\rho_{balance} = 0.85 * \beta_d * \frac{f_c}{f_y} \left( \frac{600 \text{Mpa}}{600 \text{Mpa} + f_y} \right) \quad \text{Eq (3.49)}$$

Reinforcements:

$$As^{\pm} = \rho^{\pm} * b * d \quad \text{Eq (3.50)}$$

$$\rho^{\pm} = \frac{0.85 * f_c}{f_y} \left( 1 - \sqrt{1 - \frac{2Rn^{\pm}}{0.85 * f_c}} \right) \quad \text{Eq (3.51)}$$

$$Rn^{\pm} = \frac{Mu^{\pm}}{\phi * b * d^2} \quad \text{Eq (3.52)}$$

$$As_{max} = \rho_{max};$$

$$As_{min_{min}}$$

$$\rho_{min} = \max \left\{ \begin{array}{l} \frac{1.4}{f_y} * b * d \\ \frac{0.25 * \sqrt{f_c}}{f_y} * b * d \end{array} \right\}; \quad \text{Eq (3.53)}$$

$$\rho_{max} = 0.75 \rho_{balance} \quad \text{Eq (3.54)}$$

Spacing and clear spacing:

$$S = Sc + db; \quad \text{Eq (3.55)}$$

$$S_{max} = \min \left\{ \begin{array}{l} 380 \frac{280}{f_s} 2.5 * Cc \\ 300 \frac{280}{f_s} \end{array} \right\}; \quad \text{Eq (3.56)}$$

$$f_s = \frac{2}{3} * f_y \quad \text{Eq (3.57)}$$

$$Sc = \frac{b - (2c + 2ds + ndb)}{n - 1}; \quad \text{Eq (3.58)}$$

$$Sc_{min} = \max \left\{ \begin{array}{l} db \\ 25 \\ \frac{4}{3} MSA \end{array} \right\} \quad \text{Eq (3.59)}$$

Check section ductility:

$$\epsilon_t = \epsilon_{cu} * \left(\frac{d-c}{c}\right); \quad \text{Eq (3.55)}$$

$$c = \frac{a}{\beta}; \quad \text{Eq (3.56)}$$

$$a = \frac{A_{suse} * f_s}{0.85 * f'_c * d} \quad \text{Eq (3.57)}$$

### 3.8 Column Design

Columns are mainly designed for moments (from analyze) and axial (from loading) we must use max moment in our design. The moments are analyze in Kani methods and the results are designed here.

Calculation of ultimate axial load (Tributary Area Method) “Hibbler, R.C”

$$AT = x * y \quad \text{Eq (3.58)}$$

Load transfer from slab and beam to column:

- Dead Load;

$$PD_s = DL_s * AT \quad \text{Eq (3.59)}$$

- Live Load;

$$LL = LL_s * AT \quad \text{Eq (3.60)}$$

- Beams load;

$$PB = \gamma_{con} * VB, \quad VB = L * B * h_w \quad \text{Eq (3.61)}$$

- Self-weight of column;

$$P_{self} = \gamma_{con} * V_{col}, \quad V_{col} = Lu * b * h \quad \text{Eq (3.62)}$$

### 3.7.1 For short columns:

Section Sizes:

$$A_g = \frac{A_{st}}{\rho_g}, \quad \text{Eq (3.63)}$$

$\rho = 0.0018$ , for 60000PSI,  $\rho = 0.0022$ , for other than 60000PSI

$$A_g = b * h \quad \text{Eq (3.64)}$$

Longitudinal Reinforcements:

$$\phi P_n = \phi \cdot 0.8 * [0.85(A_g - A_{st}) + f_y \cdot A_{st}] \quad \text{Eq (3.65)}$$

- $\phi = 0.65$  For rectangular column
- $\phi = 0.7$  For circular column

### 3.7.2 For long column:

$$\text{Step 1) } \frac{K * L_u}{r} \leq 34 - 12 \frac{M^1}{M^2} \quad \text{Eq (3.66)}$$

$$\text{Step 2) } A_g = \frac{P_u}{0.6 f_c} \quad \text{Eq (3.67)}$$

$$\text{Step 3) } \quad \text{Eq (3.68)}$$

- $e = \frac{M_u}{P_u}$ , e: eccentricity Eq (3.69)

- $P_n = \frac{P_u}{\phi}$ ,  $P_n$ : Nominal load capacity Eq (3.70)

- $K_n = \frac{P_n}{f_c * C * A_g}$ ,  $K_n$ : Load effect Eq (3.71)

- $R_n = \frac{P_n}{f_c * C * A_g} * \frac{e}{h} = K_n \frac{e}{h}$   $R_n$ : Moment effect Eq (3.72)

- $\gamma = \frac{h - (2 * 2.5 \text{in})}{h}$  Eq (3.73)

Stirrups:

$$S = \min \begin{cases} 16\phi_b \\ 48\phi_T \\ B \end{cases} \quad \text{Eq (3.74)}$$

### 3.7.3 ACI code requirements for column:

1. The clear spacing between longitudinal bars must be greater than 1 in.
2. The minimum steel percentage 1% and maximum 8%.
3. Minimum number of bars:
  - a. For square or rectangular columns: 4
  - b. For triangular columns: 3
  - c. For circular columns: 6
4. Use up to #10 for main (longitudinal) bars and #3 for ties (stirrups). For greater than #10 use #4 for ties.

### 3.9 Design of stirrups

$$S_0 = \min \{b/2 \ 8\phi_l \ 24\phi_t \ 150\text{mm}\}$$

$$S_{\max} = \min \{16\phi_l \ 48\phi_t \ b = 350\text{mm}\} \text{ the } S_{\max} \text{ should not be greater than } 250\text{mm}$$

$$L_0 = \max \{500\text{mm} \ Ln/6 \ H\}$$

### 3.10 Foundation Design

Four types of footing are most common such as:

1. Wall footing
2. Square footing
3. Rectangular footing
4. Combined footing
5. Mat footing

In this project, only rectangular footing is used. A rectangular is used to support the load of a single column. These are the most commonly used footings, particularly where the loads are relatively light, and the columns are not closely spaced. The key design formulas are as follow:

- Required thickness

$$h_f = 1 - 2 h_{\text{column}} \quad \text{Eq (3.68)}$$

- Net pressure of soil

$$q_n = q_a - [W_f + W_s + W_{pcc} + LL] \quad \text{Eq (3.69)}$$

- Size of footing

$$A = \frac{PD+PL}{q_n}; \quad \text{Eq (3.70)}$$

$$S = \sqrt{A} \text{ (short side)} \quad \text{Eq (3.71)}$$

For finding long side length use:  $q_n = \frac{P_a}{S \cdot L} + \frac{6M_a}{S \cdot L^2}$  Eq (3.72)

Check soil pressure:

$$q_n \geq q_{\text{max}};$$

$$q_{A_f \frac{p}{S \cdot L^2} \frac{6M}{\text{max}}}; \quad \text{Eq (3.73)}$$

$$M = \frac{M_u}{1.3}; \quad \text{Eq (3.74)}$$

$$P = P_D + P_L \quad \text{Eq (3.75)}$$

- Maximum and minimum soil pressures

$$q_{\text{max, min}} = \frac{P_u}{S \cdot L} \pm \frac{6M_u}{S \cdot L^2} \quad \text{Eq (3.76)}$$

Check one-way shear

$$\phi V_c \geq V_u \Rightarrow \phi \frac{1}{6} \sqrt{f_c'} \cdot b \cdot d_{req} \geq V_u ; \quad \phi = 0.75$$

$$\phi \frac{1}{6} \sqrt{f_c'} \cdot b \cdot d_{req} \geq V_u$$

$$d_{req} \geq \frac{6V_u}{\phi \sqrt{f_c'} \cdot b} ;$$

$$V_u = q_u \left( \frac{L}{2} - \frac{a}{2} - d \right) \cdot b \quad \text{Eq (3.77)}$$

$$d = h - \text{cover} - \frac{\phi_b}{2} \quad \text{Eq (3.78)}$$

If  $d_{req} < d$  ..... OK

If  $d_{req} > d$  ..... NOT OK

Check for sliding and rotation

$e < \frac{L}{6}$  ..... No sliding and rotation

$e = \frac{L}{6}$  ..... Sliding and rotation may or may not occur

$e > \frac{L}{6}$  ..... Sliding and rotation occurs

$$e = \frac{M_u}{P_u} \quad \text{Eq (3.79)}$$

➤ Check two-way shear

$$\phi V_c \geq V_u \Rightarrow \phi \frac{1}{3} \sqrt{f_c'} \cdot b_0 \cdot d_{req} \geq V_u$$

$$d_{req} \geq \frac{3V_u}{\phi \sqrt{f_c'} \cdot b_0} ; \quad V_u = q_u [A_f - (a - d)^2] \quad \text{Eq (3.78)}$$

➤ Check combined shear

$$V_u = \frac{V_{u_{net}}}{b_0 \cdot d} + \gamma_v \frac{M_u}{j \cdot c} \quad ; \quad \frac{J}{c} = \frac{1}{3} [b_1 \cdot d(b_1 + 3b_2) + d^3] \quad \text{Eq (3.79)}$$

$$\gamma_f = \frac{1}{1 + \frac{2}{3} \sqrt{\frac{b_1}{b_2}}} \quad ; \quad \gamma_f + \gamma_v = 1 \quad \text{Eq (3.80)}$$

Where:

$\gamma_v$ : Amount of pressure, which acts as shear

j: Polar moment of inertia

Area of steel bar

$$A_s = \frac{M_u}{\phi f_s \cdot j \cdot d} \quad ; \quad j = 0.95 \quad ; \quad \phi = 0.9 \quad \text{Eq (3.81)}$$

Number of critical bars

$$(N \cdot O \cdot B)_{\text{critical}} = \frac{2}{1 + \beta} \cdot \text{Total number of bars}; \quad \beta = \frac{L}{S} \quad \text{Eq (3.82)}$$

Dowel bars and Development length

$$(A_d)_{\text{min}} = 0.005A_g$$

$d_L$  is taken from table A-6 appendices of (Mc. Gregor) book.

### 3.11 Software

There are several engineering software programs which are used in engineering projects especially in vertical structures (analyze and design process). In this project we use two software that are most useable for drawing, analyze and design of vertical structure, as follow.

- Auto CAD
- ETABS
- SAFE
- Primavera

### **3.12 Cost Estimation**

Cost estimation is the art of assigning value. It is also a science making use of a wide range of techniques to predict the costs of activities and assets. There exist a wide range of methods, applications and names for estimates. It might seem like a forest full of definitions out there. We will explain the principles of cost estimating for you in four easy steps: “James K. Wight J.M. Reinforced Concrete”

Cost estimation is part of the cost engineering profession. It is used to predict the quantity, cost and price of the resources required by the scope of a project. A project might be any process that is started to perform work activities and/or create assets. The accuracy of the estimate depends heavily on the level of project scope definition: as the design and conditions of the project become better defined, so do the estimated values.

Cost estimation is needed to provide decision makers with the means to make investment decisions, choose between alternatives and to set up the budget during the front end of projects. For this, estimates made by vendors and contractors need to be validated by clients as well. In later phases of the project, the budget estimate is used as a baseline to assess the performance of a project.

Estimating is done by breaking down the total scope of a project in manageable parts, to which resources can be assigned and priced. There are standardized ways of breaking down a project, like the Work Breakdown Structure (WBS) and the Cost Breakdown Structure (CBS), but depending on the needs of the project team and external parties’ multiple structures are often implemented to align reporting and sharing of cost data.

A cost estimate is more than a list of costs. It also includes a detailed Basis of Estimate (BOQ) report that describes the assumptions, inclusions, exclusions, accuracy and other aspects that are needed to interpret the total project cost. Otherwise, it would be a meaningless number.

# CHAPTER FOUR

## ANALYSIS AND DESIGN RESULTS

### 4.1 Concrete Mix Design

Concrete mix design is the process of selecting the ingredients for a concrete mixture and deciding on their proportions. When designing a concrete mix, you should always consider the desired strength, durability, and workability of the concrete for the project in question.

Cement mix design is often mistakenly referred to "concrete mix design." However, cement is simply one of the ingredients of concrete. It is a binding substance that allows concrete to set, harden, and adhere to other materials. Therefore, it cannot and should not be used interchangeably with concrete mix design. In general, concrete mixes are designed to follow the guidelines provided by ACI Committee 211., Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete. A concrete mix can be designed using the tables and calculations provided in the standard.

#### 4.1.1 Test calculations

20-Mpa Compressive strength of concrete Mix Design with Ordinary Portland Cement According to ACI 211.1 and ACI 318-05

Project name:	Lugar-Afghanistan
Client :	Kardan University student
Contractor :	Team group

Sieve analysis of coarse aggregates and reducing sample

According to ASTM C 136 and ASTM C 702

Sample No.	Sieve sizes		Sieve analysis of coarse aggregate according to ASTM C136-01			
	inch	mm	Coarse Agg#1 (Size, 12.5mm to 25 mm)			
			Weight of retained materials on sieve	Percentage of retained materials on each sieve.	Percentage of cumulative retained materials on all above sieves	Percentage of passing from sieve
Coarse aggregate No. 1	3 1/2	90.0	0.0	0.0	0.0	100.00
	3	75.0	0.0	0.0	0.0	100.00
	2.5	63.0	0.0	0.0	0.0	100.00
	2	50.0	0.0	0.0	0.0	100.00
	1.5	37.5	0	0.0	0.0	100.00
	1	25.0	0	0.0	0.0	100.00
	3/4	19.0	1017.45	10.0	10.0	89.98
	1/2	12.5	7402.5	72.9	82.9	17.12
	3/8	9.5	1644.3	16.2	99.1	0.93
	No.4	4.8	22.05	0.2	99.3	0.71
	No.8	2.4	0	0.0	99.3	0.71
	No.200	0.075	0.0	0.0	99.3	0.71
Pan	---	72.5	0.7	100.0	0.00	
Total	$w_{t1}$		10159	100.0		

7 days target is 20 Mpa.

Compressive strength test method ASTM C 39

Water Cement Ratio and Trial Mix Summary									
Trial Mix	Strength (Mpa) Cylinder			Slump (mm)	Max load N	W/C ratio	Air content%	Max size Agg	Volume of Agg/unit Vol of concrete
	7 days	14 days	28 days						
Design Compressive			28.3	75		0.520	1.5	25	0.66
Actual Compressive	<b>22.47</b>			75	400N		1.5		
Condition	Ok			Ok					

### Mark 250 MPA

Proportioning use by Volume Mix Ratio

Cement : Sand : aggregate 22 mm : aggregate 12 mm

(1 : 1.46 : 1.40 : 1.0)

Cyl.No	Age	Load(kN)	Area (cm <sup>2</sup> )	Strength (MPA)	Kg /cm <sup>2</sup>	PSI	Type of fracture
1	7 days	427.5	176.6	24.21	246.84	3510.1	1
2	7 days	402.5	176.6	22.79	232.41	3304.8	2
3	7 days	430.2	176.6	24.36	248.40	3532.3	1
		<b>Average</b>		<b>23.79</b>	<b>242.55</b>	<b>3449.1</b>	

<b>4000 psi (27.6Mpa) TRIAL MIX DATA</b>		REPORT OF CONCRETE CYLINDER TEST(ASTM C 39)	
Slump (ASTM C 143)	50m m	7 days(Mpa)	28 days(Mpa)
Temperature °C	15.8	22.6	35.6
Air %	-	22.4	35.3
Specimens 6 No Cylinder Casted	6.0	24.8	35.0
Average strength		23	35.3

### Mix design M15

Project name	Lugar-Afghanistan							
Client	Team group			DATE OF CASTING			21-Nov-2019	
contractor	Kardan University student			SPECIFIED STRENGTH			15N/mm <sup>2</sup>	
Part of structure	15 MPA TRAIL MIX			REQUIRED AVERAGE STRENGTH			22N/mm <sup>2</sup>	
Cylinder No	Testing Date	Age days	Length(m)	Diameter (mm)	Area (mm <sup>2</sup> )	Type of fracture	Load (KN)	Compressive strength Kg/cm <sup>2</sup>
1	28-Nov-2.19	7	300	150	17671.5	2	295.3	170.4
2	28-Nov-2.19	7	300	150	17671.5	3	280.6	162

3	28- Nov- 2.19	7	300	150	17671.5	2	310	178.9
Average Compressive Strength								
days	Mpa	Kg/c m <sup>2</sup>	Psi					
7	16.7	170. 4	2423.7					

### 4.1.2 Comparing and Result

Comparison of all four marks which we did their tests in laboratory (mark 150, Mark200 Mark250 and mark276) we did different tests to understand the strength of them and select each of the marks for the right place.

As we talk about mark 150 or M15 it means that M stands for design mix and 15 stands for compressive strength of concrete after 7,14 and 28 days curing.

M15 use for building floors and mostly for leveling course and bedding footings, it is use for small work where more strength not required.

Mark 200 or M20 it is applicable for RCC works for slabs, beams, columns and water retaining walls, mostly use for RCC structure, also well for workshops floor, garages and drive ways.

Mark 2500 or M25 is use for heavy load structures use in all construction areas, where more strength required, usually in foundation and high ways.

27.6 MPA is a strength that we need it on the places their more strength required; it actually depends on the design requirement but day-to-day life it is use in paver and parking due to heavy loads.

As you know we did compressive test on them all so we got the following results.

Design strength	Age	Mpa
Mark: 150	7 Day	16.7
Mark: 200	7 Day	18
Mark: 250	7 Day	23.79
Mark: 276	7 Day	23

Therefore, after the test was complete we were able to choose the best one for our project, as we said that economy is very important for our project.

Selection of Mark200 and Mark250 are got place after checking their strength and the by respect the economy.

Mark200 for beams, slabs, columns and Mark250 for foundations and driveways that required more strength.

Modulus of elasticity of the Mark200 is 22360 MPA and

Mark250 concrete is 2500 MPA; the behavior of Mark250 concrete is stiffer than Mark200, because it can take more loads and the deflection is less as compared to Mark200 concrete.

#### **4.1.2.1 Result**

The result that we got from tests which done are okay for our project therefore Mark200 and Mark250 are better because Mark 276 is not suitable for the project it is not economically fit.

Higher marks should applied for the place where the load is more, us much mark is higher that much it will be expensive, so Mark 150 has not the strength that we need in beams,

slabs, columns, and foundations. Because of the strength and economy, we select mark 200 for beams, slabs, columns, and mark 250 is for foundations and driveways.

Mark 200 compressive strength was in seven days 18Mpa and Mark 250 compressive strength was in seven days 23.79 Mpa it is okay for this project.

## 4.2 Analysis and design

We have attempt to calculate and design the structure of the three Story office building both with traditional method, which is not very popular and accurate measurement. The traditional methods are mostly done by hand calculation and the structures are only 2D analyzed. The traditional methods consume a lot of time and the accuracy of the results are not very trustable.

We have also calculated the same structure using ETABS and SAFE software. The software can calculate the structure 2D and 3D. The calculations are based on the input methods and the software uses different combination to design the structure.

### 4.2.1 Overall Design Criteria

Assumed Material Density For This Project ( $\rho$ )	
Materials	Unite Weight
Plaster Cement Concrete (PCC)	1800 kg/m <sup>3</sup>
Reinforcement Cement Concrete (RCC)	2400 kg/m <sup>3</sup>
Terrazzo	2000 kg/m <sup>3</sup>
Brick	1800 kg/m <sup>3</sup>
(Wooden Truss)	50 kg/m <sup>3</sup>

### 4.3 Loading

#### 4.3.1 Roof Loading

##### Dead Load of Roof:

$$DL = \sum \gamma_i * t_i \quad \text{Eq (4.1)}$$

$$DL = \gamma_{\text{plaster}} * t_p + \gamma_{\text{Rcc}} * t_{\text{Rcc}} + \gamma_{\text{Mortar}} * t_M + \gamma_{\text{stone}} * t_s \quad \text{Eq (4.2)}$$

$$\begin{aligned} DL &= 1800 \frac{\text{Kg}}{\text{m}^3} * 0.02\text{m} + 2500 \frac{\text{Kg}}{\text{m}^3} * 0.15\text{m} + 2000 \frac{\text{Kg}}{\text{m}^3} * 0.03\text{m} + 2200 \frac{\text{Kg}}{\text{m}^3} * 0.015\text{m} \\ &= 504 \frac{\text{Kg}}{\text{m}^2} \end{aligned}$$

##### Live Load of Roof:

$$LL = 75 \text{ to } 100 = 100 \frac{\text{Kg}}{\text{m}^2}$$

#### 4.3.1.1 Ultimate Load of Roof:

$$W_{UR} = 1.2 * DL_R + 1.6 * LL_R = 1.2 * 504 \frac{\text{Kg}}{\text{m}^2} + 1.6 * 100 \frac{\text{Kg}}{\text{m}^2} = 764.8 \frac{\text{Kg}}{\text{m}^2} \dots \text{Com\#1}$$

$$W_{UR} = 1.4 * DL_R = 1.4 * 504 = 705.6 \frac{\text{Kg}}{\text{m}^2} \dots \text{com\#2}$$

We select the maximum weight =  $764.8 \frac{\text{Kg}}{\text{m}^2}$

#### 4.3.2 Floor Loading

##### Dead Load of Floor:

$$DL_{\text{floor}} = \sum (\gamma * t) = DL_{\text{plaster}} + DL_{\text{Rcc}} + DL_{\text{Mort}} + DL_{\text{stone}} \quad \text{Eq (4.3)}$$

$$\begin{aligned} &1800 \frac{\text{Kg}}{\text{m}^3} * 0.02\text{m} + 2500 \frac{\text{Kg}}{\text{m}^3} * 0.15\text{m} + 2000 \frac{\text{Kg}}{\text{m}^3} * 0.03\text{m} + 2200 \frac{\text{Kg}}{\text{m}^3} * 0.015\text{m} = \\ &504 \frac{\text{Kg}}{\text{m}^2} \end{aligned}$$

##### Live Load of Floor:

LL=80PSF, for commercial buildings

$$LL = \frac{80 * \left(\frac{1}{2.2} \text{Kg}\right)}{\left(\frac{1}{3.28}\right)^2} = 392 \frac{\text{Kg}}{\text{m}^2}$$

#### 4.3.2.1 Ultimate Load of Floor:

$$W_{uF} = 1.2DL_f + 1.6LL_f = 1.2 \times 504 \frac{\text{Kg}}{\text{m}^2} + 1.6 \times 392 \frac{\text{Kg}}{\text{m}^2} = 1232 \frac{\text{Kg}}{\text{m}^2}$$

#### 4.3.3 Load transfer from slabs to beams

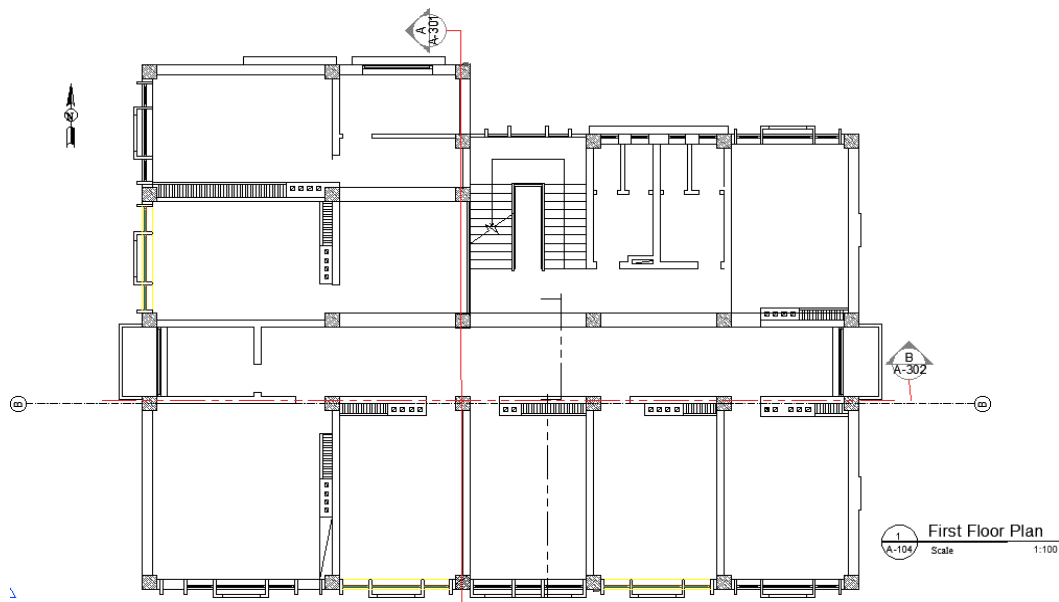


Figure 4.1 plan view

#### 4.3.3.1 Beam Loading Calculation for Frame B:

##### 4.3.3.1.1 Beam#1, Story#1:

##### 4.3.3.1.1.1 Slab Load:

$$W_{Slab} = \frac{W_u L_1}{3} + \frac{W_u L_2}{3} * \left[ \frac{3 - m^2}{2} \right] = \frac{1232 * 6.55}{3} + \frac{1232 * 3}{3} * \left[ \frac{3 - \frac{3}{6.55}}{2} \right] \quad \text{Eq (4.4)}$$

$$W_{Slab} = 4255.7 \frac{\text{Kg}}{\text{m}} = 4.26 \frac{\text{T}}{\text{m}}$$

#### 4.3.3.1.1.2 Wall Load:

$$W_{Wall} = \gamma_{Brick} \times AC = \gamma_{Brick} \times t \times y = 1800 \frac{\text{Kg}}{\text{m}^3} \times 2.6\text{m} \times 0.25\text{m} \times 0.75\text{m} = 878 \frac{\text{Kg}}{\text{m}}$$

$$W_{Wall} = 0.88 \frac{\text{T}}{\text{m}} \quad \text{Eq (4.5)}$$

#### 4.3.3.1.1.3 Self-Load:

$$W_{Self} = \gamma_{Con} \times Ac = 2.4 \frac{\text{T}}{\text{m}^3} \times 0.35\text{m} \times 0.4\text{m} = 0.288 \frac{\text{T}}{\text{m}} \quad \text{Eq (4.6)}$$

#### 4.3.3.1.1.4 Total Load on Beam#1:

$$W_{B1} = W_{Slab} + W_{Wall} + W_{Self} \quad \text{Eq (4.7)}$$

$$W_{uB1} = W_{Slab} + 1.2 * W_{Wall} + 1.2 * W_{Self} \quad \text{Eq (4.8)}$$

$$W_{uB1} = 4.26 + 1.2 * 0.88 + 1.2 * 0.288 = 5.67 \frac{\text{T}}{\text{m}}$$

The beam#1 is the same with beam#6 =  $5.67 \frac{\text{T}}{\text{m}}$

#### 4.3.3.1.2 Beam#2 Storey#1:

##### 4.3.3.1.2.1 Slab Load:

$$W_{Slab} = \frac{W_{uLs}}{3} + \frac{W_{uLs}}{3} * \left[ \frac{3 - m^2}{2} \right] = \frac{1232 * 4.5}{3} + \frac{1232 * 3}{3} * \left[ \frac{3 - \frac{3}{4.5}}{2} \right] \quad \text{Eq (4.4)}$$

$$W_{Slab} = 3422 \frac{\text{Kg}}{\text{m}} = 3.42 \frac{\text{T}}{\text{m}}$$

##### 4.3.3.1.2.2 Wall Load:

$$W_{Wall} = 0.88 \frac{\text{T}}{\text{m}} \quad \text{Eq (4.5)}$$

#### 4.3.3.1.2.3 Self-Load:

$$W_{Self} = 0.288 \frac{T}{m} \quad \text{Eq (4.6)}$$

#### 4.3.3.1.2.4 Total Load on Beam#2:

$$W_{uB2} = W_{Slab} + W_{Wall} + W_{Self} \quad \text{Eq (4.7)}$$

$$W_{uB2} = 3.42 + 1.2 * 0.88 + 1.2 * 0.288 = 4.8 \frac{T}{m}$$

The beam#2 is the same with beam#3, beam#4, beam# 7, beam# 8 beam# 9 =  $4.8 \frac{T}{m}$

#### 4.3.3.1.3 Beam#5 Storey#1:

##### 4.3.3.1.3.1 Slab load:

$$W_{Slab} = \frac{W_{uLs}}{3} + \frac{W_{uLs}}{3} * \left[ \frac{3-m^2}{2} \right] = \frac{1232*4.65}{3} + \frac{1232*3}{3} * \left[ \frac{3-\frac{3^2}{4.5}}{2} \right] \quad \text{Eq (4.8)}$$

$$W_{Slab} = 3.5 \frac{T}{m}$$

##### 4.3.3.1.3.2 Wall Load:

$$W_{Wall} = 0.88 \frac{T}{m}$$

##### 4.3.3.1.3.3 Self-Load:

$$W_{Self} = 0.288 \frac{T}{m}$$

#### 4.3.3.1.3.4 Total Load on Beam#5:

$$W_{uB5} = W_{Slab} + W_{Wall} + W_{Self}$$

$$W_{uB5} = 3.5 + 1.2 * 0.88 + 1.2 * 0.288 = 4.9 \frac{T}{m}$$

The beam#5 is the same with beam#10 =  $4.9 \frac{T}{m}$

#### 4.3.3.1.4 Beam#11 Storey#3:

##### 4.3.3.1.4.1 Slab load

$$W_{Slab} = \frac{W_u L_s}{3} + \frac{W_u L_s}{3} * \left[ \frac{3-m^2}{2} \right] = \frac{764.8*6.55}{3} + \frac{764.8*3}{3} * \left[ \frac{3-\frac{3}{6.55^2}}{2} \right]$$

$$W_{Slab} = 2.73 \frac{T}{m} \quad \text{Eq (4.4)}$$

##### 4.3.3.1.4.2 Wall Load:

$$W_{Wall} = 0 \quad \text{Eq (4.5)}$$

##### 4.3.3.1.4.3 Self-Load:

$$W_{Self} = 0.288 \frac{T}{m} \quad \text{Eq (4.6)}$$

##### 4.3.3.1.4.4 Total Load on Beam#11:

$$W_{uB11} = W_{Sl} + W_{Self} \quad \text{Eq (4.7)}$$

$$W_{uB11} = 2.73 + 1.2 * 0.288 = 3 \frac{T}{m}$$

#### 4.3.3.1.5 Beam#12 Storey#3:

##### 4.3.3.1.5.1 Slab load

$$W_{Slab} = \frac{W_u L_s}{3} + \frac{W_u L_s}{3} * \left[ \frac{3-m^2}{2} \right] = \frac{764.8*4.55}{3} + \frac{764.8*3}{3} * \left[ \frac{3-\frac{3}{4.55^2}}{2} \right]$$

$$W_{Slab} = 2.14 \frac{T}{m} \quad \text{Eq (4.4)}$$

##### 4.3.3.1.5.2 Wall Load:

$$W_{Wall} = 0.88 \frac{T}{m} \quad \text{Eq (4.5)}$$

##### 4.3.3.1.5.3 Self-Load:

$$W_{Self} = 0 \quad \text{Eq (4.6)}$$

#### 4.3.3.1.5.4 Total Load on Beam#12:

$$W_{uB12} = 2.14 + 1.2 * 0.288 = 2.48 \frac{T}{m}$$

The beam#12 is the same with beam#13, beam#14=  $2.88 \frac{T}{m}$

#### 4.3.3.1.6 Beam#15 Storey#3:

##### 4.3.3.1.6.1 Slab load

$$W_{Slab} = \frac{W_{uLs}}{3} + \frac{W_{uLs}}{3} * \left[ \frac{3-m^2}{2} \right] = \frac{764.8*4.65}{3} + \frac{764.8*3}{3} * \left[ \frac{3-\frac{3}{4.65^2}}{2} \right]$$

$$W_{Slab} = 2.17 \frac{T}{m} \quad \text{Eq (4.4)}$$

##### 4.3.3.1.6.2 Wall Load:

$$W_{Wall} = 0 \quad \text{Eq (4.5)}$$

$$4.3.3.1.6.3 \text{ Self-Load: } \quad W_{Self} = 0.288 \frac{T}{m} \quad \text{Eq (4.6)}$$

##### 4.3.3.1.6.4 Total Load on Beam#15:

$$W_{uB15} = 2.7 + 1.2 * 0.288 = 2.5 \frac{T}{m}$$

#### 4.3.3.2 All Loads on Beams:

$$W_{uB1} = 5.67 \frac{T}{m}$$

$$W_{uB2} = 4.8 \frac{T}{m}$$

$$W_{uB3} = 4.8 \frac{T}{m}$$

$$W_{uB4} = 4.8 \frac{T}{m}$$

$$W_{uB5} = 4.9 \frac{T}{m}$$

$$W_{uB6} = 5.67 \frac{T}{m}$$

$$W_{uB7} = 4.8 \frac{T}{m}$$

$$W_{uB8} = 4.8 \frac{T}{m}$$

$$W_{uB9} = 4.8 \frac{T}{m}$$

$$W_{uB10} = 4.9 \frac{T}{m}$$

$$W_{uB11} = 3 \frac{T}{m}$$

$$W_{uB12} = 2.48 \frac{T}{m}$$

$$W_{uB13} = 2.48 \frac{T}{m}$$

$$W_{uB14} = 2.48 \frac{T}{m}$$

$$W_{uB15} = 2.5 \frac{T}{m}$$

### 4.3.4 Cantilever Loads:

#### 4.3.4.1 Loading:

##### 4.3.4.1.1 Roof ultimate load

$$W_{u_{\text{Roof}}} = 764.8 \frac{\text{Kg}}{\text{m}^2} = 0.7648 \frac{\text{T}}{\text{m}^2} \quad \text{Eq (4.9)}$$

- Roof ultimate Moment:

$$M_{u_{\text{Roof}}} = \frac{W_u * L^2}{2} = \frac{764.8 \text{Kg} * 1.525 \text{m}^2}{2} = 889 \text{Kg} * \text{m} \quad \text{Eq (4.10)}$$

##### 4.3.4.1.2 Floor ultimate load

$$W_{u_{\text{Floor}}} = 1232 \frac{\text{Kg}}{\text{m}^2} = 1.232 \frac{\text{T}}{\text{m}^2}$$

- Floor ultimate Moment:

$$M_{u_{\text{Floor}}} = \frac{W_u * L^2}{2} = \frac{1232 \text{Kg} * 1.525^2}{2} = 1432 \text{Kg} * \text{m}$$

## 4.4 Seismic calculations

### 4.4.1 Effective weight

Table 4.1: Effective weights

Effect weight for story one			
Function	Formula		Result
Tributary Area ( $A_T$ )	$A_T = 2 (0.5 \times L_s) \times$ $L.T.s$	$A_T = 2 (0.5 \times 4.825)$ $\times 24.7$	119.1 m <sup>2</sup>
Weight of slab	$W_s = DL \times AT$	$W_s = 504 \times 119.1$	60 T
Weight of beam	$W_b = \gamma \times (L \times h \times$ $b)$	$W_b = 2.4 \times (0.3 \times$ $0.4 \times 24.7)$	7.11 T
Weight of column	$W_c = \gamma \times (L \times h \times$ $b \times \text{No.}c)$	$W_c = 2.4 \times (3.14 \times$ $0.5 \times 0.5 \times 6)$	11.3T

Weight of Wall	$W_w = \gamma \times (L \times b \times h) \times 0.75$	$W_w = 1.8 \times (2.7 \times 0.25 \times 22.2 \times 0.75)$	20.2 T
Total Dead Loads (DL <sub>T</sub> )	$DLT = \Sigma DL$	60 T + 7.11 T + 11.3 T + 20.2 T	98.61 T
Total Live Loads (LL <sub>T</sub> )	$LLT = \% LL \times AT$	0.4 * 0.1 * 119.1	4.764 T
Total Weight	$W1 = DL + LL$	98.61 + 4.764	103.374 T

Effective weight for the story#2 is similar to story#1 as the architectural drawing and division for these stories is the same.

Table 4.2: Effective weights

Effect weight Roof			
Function	Formula		Result
Tributary Area (A <sub>T</sub> )	$At = 2 (0.5 \times L_s) \times L_{T.s}$	$At = 2 (0.5 \times 4.825) \times 24.7$	119.1 m <sup>2</sup>
Weight of slab	$W_s = DL \times AT$	$W_s = 504 \times 119.1$	60 T
Weight of beam	$W_b = \gamma \times (L \times h \times b)$	$W_b = 2.4 \times (0.3 \times 0.4 \times 24.7)$	7.11 T
Weight of column	$W_c = \gamma \times (L \times h \times b \times No.c)$	$W_c = 2.4 \times (3.14 \times 0.5 \times 0.5 \times 6)$	11.3 T
Weight of Wall	$W_w = \gamma \times (L \times b \times h) \times 0.75$	0	0
Total Dead Loads (DL <sub>T</sub> )	$DLT = \Sigma DL$	60 T + 7.11 T + 11.3 T	78.41 T
Total Live Loads (LL <sub>T</sub> )	$LLT = \% LL \times AT$	0.4 * 0.1 * 119.1	4.764 T
Total Weight	$W1 = DL + LL$	78.41 + 4.764	83.2 T

#### 4.4.1.1 Total effective weight

$$W_{\text{effective}} = (2 * 103.374 + 83.2) T = 289.9 T$$

#### 4.4.2 Vertical Distribution Factor

$$F_i = C_{vx} \cdot V \quad \text{Eq (4.11)}$$

$$C_{vx} = \frac{W_x \cdot h_x^k}{\sum_{i=1}^n W_i \cdot h_i^k} \quad \text{Eq (4.12)}$$

$$S_{ms} = f_a \cdot S_s \quad \text{Eq (4.13)}$$

$f_a$ - from table ABC

$S_s$ - for Kabul=1.28

$$S_{ms} = 1 \cdot 1.28 = 1.288$$

$$SD_s = \frac{2}{3} S_{ms} = \frac{2}{3} f_a \cdot S_s = \frac{2}{3} \cdot 1 \cdot 1.28 = 0.853 \quad \text{Eq (4.14)}$$

$$C_s = \frac{SD_s}{R} = \frac{0.868}{8} = 0.106 \quad \text{Eq (4.15)}$$

$$C_{s_{\min}} = 0.044 \cdot SD_1 \cdot I = 0.044 \cdot 0.853 \cdot 1 = 0.0375 \quad \text{Eq (4.16)}$$

$$C_{s_{\max}} = \frac{SD_1}{T \left(\frac{R}{I}\right)} \dots \text{if } \dots T < TL, \quad C_{s_{\max}} = \frac{SD_{1+TL}}{T \left(\frac{R}{I}\right)} \dots \text{if } \dots T > TL \quad \text{Eq (4.17)}$$

T- Fundamental time period of building

$$C_s < C_{s_{\max}}$$

$$T = C_u \cdot T_a \quad \text{Eq (4.18)}$$

$$T_a = \frac{N}{10} = 0.1N = 0.1 \cdot 3 = 0.3 \quad \text{Eq (4.19)}$$


$$S_{m1} = f_v \cdot S_1 = 1.5 \cdot 0.51 = 0.765 \quad \text{Eq (4.20)}$$

$$SD_1 = \frac{2}{3} S_{m1} = \frac{2}{3} \cdot 0.765 = 0.51; \quad C_u = 1.4 \quad \text{Eq (4.21)}$$

$$T = C_u \cdot T_a = 1.4 \cdot 0.3 = 0.42 \quad \text{Eq (4.22)}$$

$$C_{s_{\max}} = \frac{0.51}{0.42 \left(\frac{8}{1}\right)} = 0.151$$

0.0375 < 0.106 < 0.151 ... .. ok

In this case our  $K=1$    $[T=0.42 < 0.5\text{sec}]$  Eq (4.23)

$$C_{vX} = \frac{W_x \cdot h_x^k}{\sum_{i=1}^n W_i \cdot h_i^k} \quad \text{Eq (4.24)}$$

Story#1

$$C_{v1} = \frac{(103.374) \cdot (3.14)^1}{103.374 \cdot 3.14^1 + 103.374 \cdot 6.28^1 + 83.2 \cdot 9.42^1}$$

$$C_{v1} = 0.184$$

Story#2

$$C_{v2} = \frac{103.374 \cdot 6.28^1}{103.374 \cdot 3.14^1 + 103.374 \cdot 6.28^1 + 83.2 \cdot 9.42^1} = 0.369$$

Story#3

$$C_{v3} = \frac{83.2 \cdot 9.42^1}{103.374 \cdot 3.14^1 + 103.374 \cdot 6.28^1 + 83.2 \cdot 9.42^1} = 0.44$$

Check  $\sum C_{v_x} = 1 = 0.184 + 0.369 + 0.44 = 0.993 \cong 1$  ok Condition

#### 4.4.2.1 Base Shear

$$V = C_s \cdot W_{\text{effective}} \quad \text{Eq (4.25)}$$

$$V = 0.091 \cdot 289.9T = 30.72T$$

#### 4.4.2.2 Seismic Forces on each story level:

$$F_1 = C_{v1} \cdot V = 0.184 \cdot 30.72T = 5.65T \quad \text{Eq (4.26)}$$

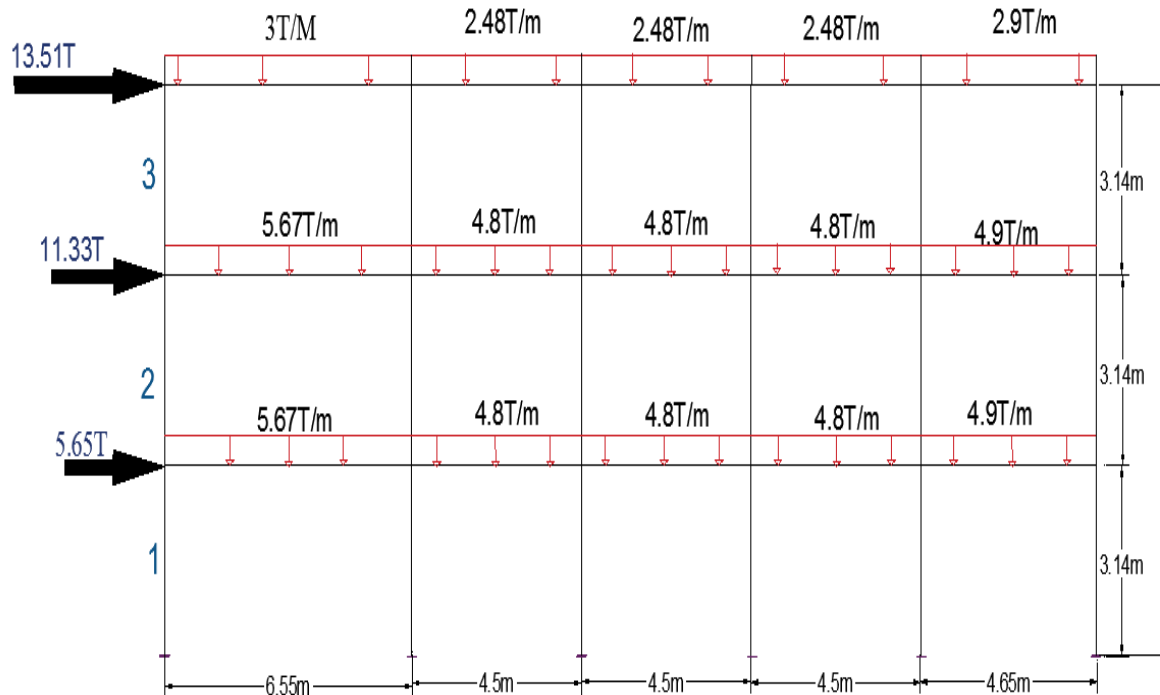
$$F_2 = C_{v2} \cdot V = 0.369 \cdot 30.72T = 11.33T$$

$$F_3 = C_{v3} \cdot V = 0.44 \cdot 30.72T = 13.51T$$

$$\sum F_i = F_1 + F_2 + F_3 = 30.49T$$

## 4.5 Frame Analysis by Kani Method

### 4.5.1 Frame



### 4.5.2 Stiffness

$$K_{ik} = \frac{4EI}{L} = \frac{I}{L} = \frac{\frac{1}{12}bh^3}{L} \quad \text{Eq (4.27)}$$

Beam # 1:  $b = 35\text{cm}$ ,  $h = 40\text{cm}$ ,  $L = 655\text{cm}$

$$K_{B1} = K_{B6} = K_{B11}$$

$$K_{B1} = \frac{\frac{1}{12} \cdot 35\text{cm} \cdot (40\text{cm})^3}{655\text{cm}} = 244.2$$

Beam # 2:  $b = 35\text{cm}$ ,  $h = 40\text{cm}$ ,  $L = 450\text{cm}$

$$K_{B2} = K_{B3} = K_{B4} = K_{B7} = K_{B8} = K_{B9} = K_{B12} = K_{B13} = K_{B14}$$

$$K_{B2} = \frac{\frac{1}{12} \cdot 35\text{cm} \cdot (40\text{cm})^3}{450\text{cm}} = 355.5$$

Beam # 5 = Beam # 10 = Beam # 15

$$K_{B5} = \frac{\frac{1}{12} \cdot 35\text{cm} \cdot (40\text{cm})^3}{465\text{cm}} = 344$$

Column #1: b = 50cm, h = 50cm, L = 314cm

$$K_{C1} = \frac{\frac{1}{12} \cdot 50\text{cm} \cdot (50\text{cm})^3}{314\text{cm}} = 1658$$

The columns have the same size and length therefore, the value of (K) is the same for all columns, Kc=1658

### 4.5.3 Rotation Coefficient

- Rotation Factor ( $\mu$ )

$$\mu_{ik} = -\frac{1}{2} \frac{K_{ik}}{\sum K_{ik}} \quad \mu_A = \mu_B = \mu_C = \mu_D = 0 \quad \text{Eq (4.28)}$$

Joint#7		Joint#8		Joint#9		Joint#10		Joint#11		Joint#12	
7-1	-0.232	8-2	-0.211	9-3	-0.205	10-4	-0.205	11-5	-	12-6	-0.226
									0.206		
7-8	-0.034	8-7	-0.031	9-8	-0.044	10-9	-0.044	11-10	-	12-11	-0.046
									0.044		
7-13	-0.232	8-9	-0.045	9-10	-0.044	10-11	-0.044	11-12	-	12-18	-0.226
									0.042		
		8-14	-0.211	9-15	-0.205	10-16	-0.205	11-17	-		
									0.206		

Joint#13		Joint#14		Joint#15		Joint#16		Joint#17		Joint#18	
13-7	-0.232	14-8	-0.211	15-9	-0.205	16-10	-0.205	17-11	-0.206	18-12	-0.226
13-14	-0.034	14-13	-0.031	15-14	-0.044	16-15	-0.044	17-16	0.044	18-17	-0.046
13-19	-0.232	14-15	-0.045	15-16	-0.044	16-17	-0.044	17-18	0.042	18-24	-0.226
		14-20	-0.211	15-21	-0.205	16-22	-0.205	17-23	0.206		
Joint#19		Joint#20		Joint#21		Joint#22		Joint#23		Joint#24	
19-13	-0.435	20-14	-0.367	21-15	-0.349	22-16	-0.349	23-17	0.351	24-18	-0.414
19-20	-0.064	20-19	-0.054	21-20	-0.075	22-21	-0.075	23-22	0.075	24-23	-0.085
		20-21	-0.079	21-22	-0.075	22-23	-0.075	23-24	0.072		

#### 4.5.4 Fix End Moment

$$(\bar{M}_{ik} = \pm \frac{W_u \cdot L^2}{12}) \quad \text{Eq (4.29)}$$

$$\bar{M}_{7-8} = \mp \frac{5.67 \cdot 6.55^2}{12} = \mp 20.2$$

$$\bar{M}_{7-8} = \bar{M}_{23-14} = \mp 20.2$$

$$\bar{M}_{8-9} = \mp \frac{4.8 \cdot 4.5^2}{12} = \mp 8.1$$

$$\bar{M}_{8-9} = \bar{M}_{9-10} = \bar{M}_{10-11} = \bar{M}_{14-15} = \bar{M}_{15-16} = \bar{M}_{16-17} = \mp 8.1$$

$$\bar{M}_{11-12} = \mp \frac{4.9 \cdot 4.65^2}{12} = \mp 8.8$$

$$\bar{M}_{11-12} = \bar{M}_{17-18} = \mp 8.8$$

$$\bar{M}_{19-20} = \mp \frac{3 \cdot 6.55^2}{12} = \mp 10.7$$

$$\bar{M}_{20-21} = \mp \frac{2.48 \cdot 4.5^2}{12} = \mp 4.2$$

$$\bar{M}_{20-21} = \bar{M}_{21-22} = \bar{M}_{22-23} = \mp 4.2$$

$$\bar{M}_{23-24} = \mp \frac{2.5 * 4.65^2}{12} = \mp 4.21$$

#### 4.5.5 Resistant Moments:

$$\bar{M}_i = \sum_k \bar{M}_{ik} \quad \text{Eq (4.30)}$$

$$\bar{M}_7 = -20.2$$

$$\bar{M}_9 = 20.2 - 8.1 = 12.1$$

$$\bar{M}_9 = 0$$

$$\bar{M}_{10} = 0$$

$$\bar{M}_{11} = 8.1 - 8.8 = -0.7$$

$$\bar{M}_{12} = 8.8$$

$$\bar{M}_{13} = -20.2$$

$$\bar{M}_{14} = \bar{M}_8 = 12.1$$

$$\bar{M}_{15} = 0$$

$$\bar{M}_{16} = 0$$

$$\bar{M}_{17} = 8.1 - 8.8 = -0.7$$

$$\bar{M}_{18} = 8.8$$

$$\bar{M}_{19} = -10.7$$

$$\bar{M}_{20} = 6.5$$

$$\bar{M}_{21} = 0$$

$$\bar{M}_{22} = 0$$

$$\bar{M}_{23} = -1$$

$$\bar{M}_{24} = 4.21$$

#### 4.5.6 Story Moments:

$$\bar{M}_R = \frac{\sum F \cdot h}{3} \quad \text{Eq (4.31)}$$

$$\bar{M}_{R1} = \frac{30.46 * 3.14}{3} = 31.88$$

$$\bar{M}_{R2} = \frac{24.81 * 3.14}{3} = 25.96$$

$$\bar{M}_{R3} = \frac{13.15 * 3.14}{3} = 14.14$$



**4.5.10 Final Moments:  $(Mik): Mik = \bar{M}ik + 2M'ik + M'ki + M''ik$**

Final Moments												
	Joint#7		Joint#8		Joint#9		Joint#10		Joint#11		Joint#12	
	7-1	5.956	8-2	-9.046	9-3	-4.784	10-4	-4.973	11-5	-4.65	12-6	-4.62
	7-8	-15.41	8-7	23.89	9-8	12.8	10-9	13.22	11-10	13.25	12-11	10.51
	7-13	7.559	8-9	-3.868	9-10	-2.957	10-11	-2.972	11-12	-10.4	12-18	-7.72
			8-14	-12.79	9-15	-6.926	10-16	-7.147	11-17	-6.62		
<b>Results</b>		-1.89		-1.807		-1.869		-1.869		-8.44		-1.83
	Joint#13		Joint#14		Joint#15		Joint#16		Joint#17		Joint#18	
	13-7	4.5	14-8	-13.69	15-9	-8.359	16-10	-8.517	17-11	-7.95	18-12	-10.2
	13-14	-16.44	14-13	23.18	15-14	11.99	16-15	12.33	17-16	12.39	18-17	12.51
	13-19	9.018	14-15	-4.559	15-16	-3.867	16-17	-3.845	17-18	-4.88	18-24	-5.21
			14-20	-7.842	15-21	-2.728	16-22	-2.924	17-23	-2.51		
<b>Results</b>		-2.922		-2.908		-2.963		-2.96		-2.96		-2.91
	Joint#19		Joint#20		Joint#21		Joint#22		Joint#23		Joint#24	
	19-13	6.497	20-14	-11.2	21-15	-5.762	22-16	-6.059	23-17	-5.83	24-18	-7.85
	19-20	-8.162	20-19	12.33	21-20	6.078	22-21	6.432	23-22	6.401	24-23	6.141
			20-21	-2.734	21-22	-1.939	22-23	-1.998	23-24	-2.18		
<b>Results</b>		-1.666		-1.603		-1.623		-1.624		-1.62		-1.71

## 4.6 Design

### 4.6.1 Design of Slabs

#### 4.6.1.1 Layout

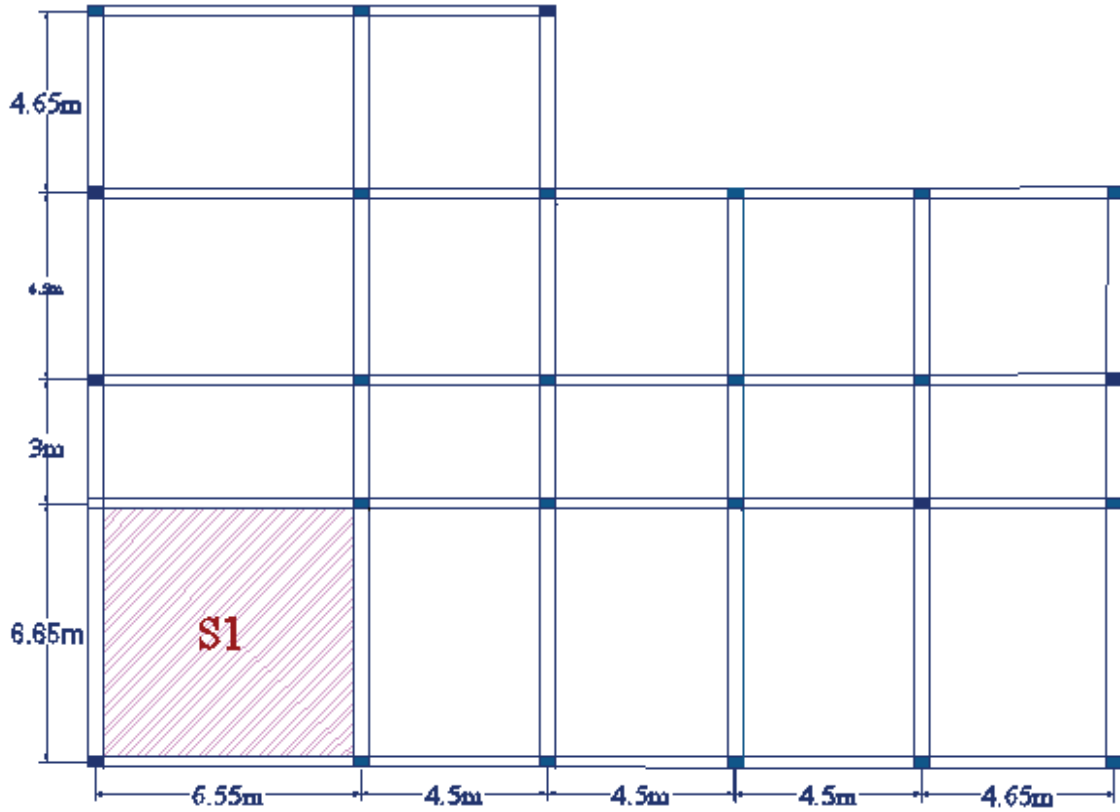
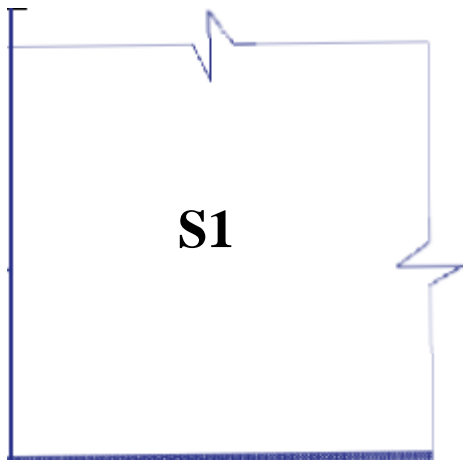


Figure 4.2 Project or Critical Slab

#### 4.6.1.2 Two-Way Slabs Design



### 4.6.1.3 Minimum thickness requirement ACI Provision

#### 4.6.1.4 T- Beam Inertia

$$A1 = 12 * 100 = 1200\text{cm}^2$$

$$A2 = 28 * 30 = 840\text{cm}^2$$

$$Y1 = \frac{12}{2} + 28 = 34\text{cm}^2$$

$$Y2 = \frac{28}{2} = 14\text{cm}^2$$

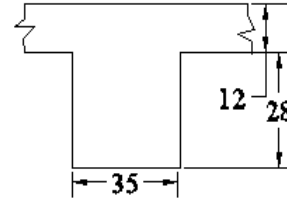
$$Y = \frac{A1*Y1 + A2*Y2}{A1 + A2}$$

$$= \frac{1200*34 + 840*14}{1200 + 840} = 25.7\text{cm}$$

$$I_b = \sum \frac{1}{3} b y^{-3}$$

$$I_b = \frac{1}{3} b1 h1^3 + \frac{1}{3} b2 h2^3 + \frac{1}{3} b3 h3^3 - \frac{1}{3} b4 h4^3$$

$$I_b = \frac{1}{3} (30) (25.7)^3 + \frac{1}{3} (100) (16)^3 - \frac{1}{3} * 30 * 2^3 * 2 = 306119$$



#### 4.6.1.5 L Beam Inertia

$$A1 = 12 * 65 = 780\text{cm}^2$$

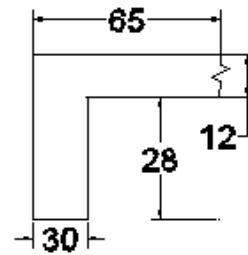
$$A2 = 28 * 30 = 840\text{cm}^2$$

$$Y1 = \frac{12}{2} + 28 = 34\text{cm}^2$$

$$Y2 = \frac{28}{2} = 14\text{cm}^2$$

$$Y = \frac{780*34 + 840*14}{780 + 840} = 23.6$$

$$I_b = \frac{1}{3} (30) (23.6)^3 + \frac{1}{3} (65) (10)^3 - \frac{1}{3} * 25 * 5^3 = 152067$$



$\alpha_m$  For T-Beam

$$\alpha m = \frac{\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4}{4}$$

$$\alpha_1 = \frac{Ib}{I_s}$$

$$\alpha_1 = \frac{306119}{\frac{1}{12}(552)(16)^3} = 1.62$$

$$\alpha_2 = \frac{152067}{\frac{1}{12}(327.5)(16)^3} = 1.36$$

$$\alpha_3 = \frac{152067}{\frac{1}{12}(275)(16)^3} = 1.62$$

$$\alpha_4 = \frac{306119}{\frac{1}{12}(455)(16)^3} = 1.97$$

$$\alpha_m = \frac{1.62 + 1.63 + 1.62 + 1.97}{4} = 6.42 \geq 2 \text{ Condition 3}$$

Use third Condition

$$\alpha_m \geq 2$$

$$h_{min} = \frac{Ln(0.8 + \frac{fy}{14060})}{36 + 9\beta}$$

$$Ln = 625\text{cm}$$

$$\beta = \frac{Ln \text{ long}}{Ln \text{ short}} = \frac{665}{655} = 1.01$$

$$F_y = 4200$$

$$h_{min} = \frac{625(0.8 + \frac{4200}{14060})}{36 + 9(1.01)} = 15.22\text{cm}$$

$$h_{min} = 15.22\text{cm} < 16\text{cm} \dots\dots\dots \text{Use (16cm) Ok}$$

#### 4.6.1.6 Check slab thickness for shear

$$\phi V_c > V_u$$

$$\phi V_c = \phi 0.53 * \lambda * \sqrt{F_c'} b_0 * d$$

$$\phi V_c = 0.75 * 0.53 * 1 * \sqrt{250'} * 100 * 13.5$$

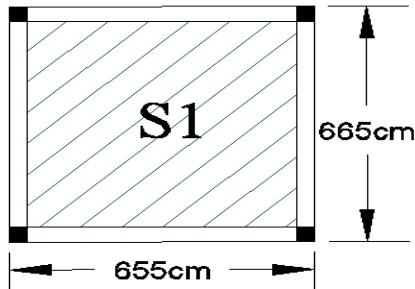
$$\phi V_c = 8484 \text{ kg}$$

$$V_u = W_u * \left[ \frac{L_s}{2} - \frac{a}{2} - d \right] * b$$

$$V_u = 1232 * \left[ \frac{6.65}{2} - \frac{0.35}{2} - 0.135 \right] * 1\text{m} = 3714.48$$

$$\phi V_c > V_u = \dots \text{ok}$$

#### 4.6.1.7 Slab: S1



##### 4.6.1.7.1 Long direction

$$W_u = 1.2DL + 1.6LL = 1232 \text{ kg/m}^2$$

$$M_o = \frac{W_u \times L^2 \times L_n^2}{8} = \frac{1232 \times 6.55^2 \times (5.25)^2}{8}$$

$$= 39402 \text{ kg} \cdot \text{m} = 40 \text{ T} \cdot \text{m}$$

$$M_{ud}^- = -0.16 M_o = -0.16 * 40 = -6.4$$

$$M_{uc}^- = -0.7 M_o = -0.7 * 40 = -28$$

$$M_{u+} = -0.57 M_o = -0.57 * 40 = -22.8$$

$$C.S = M_{uc}^-(d) = 0.75(-28) = -21$$

$$M.S = M_{ms}^-(d) = 0.25(-28) = -7$$

$$C.S = M_{uc}^+ = 0.6(22.8) = 13.68$$

$$M.S = M_{ms}^+ = 0.4(22.98) = 9.2$$

$$C.S = M_{cs}^-(C) = 0.75(-28) = -21$$

$$M.S = M_{ms}^-(C) = 0.25(-28) = -7$$

$$A_{s+} = \frac{M_{u+}}{\phi \times f_y \times j \times d} = \frac{7 \times 1000 \times 100}{0.9 \times 4200 \times 0.87 \times 13.5} = 15.76 \text{ cm}^2$$

$$A_{s-} = \frac{M_{u-}}{\phi \times f_y \times j \times d} = \frac{9.2 \times 10^5}{0.9 \times 4200 \times 0.87 \times 13.5} = 20.7 \text{ cm}^2$$

$$A_{s_{\min}} = 0.0018 \times 655 \times 16 = 18.8$$

$$A_{s-} > A_{s_{\min}} > A_{s+}$$

$A_{s-}$  ..... Ok

Assume  $A_{s+}$  .....  $A_{s_{\min}}$

$$\text{Assume } 10\text{mm} = a_s = 0.785 \text{ cm}^2$$

$$\text{N.B.O}^- = \frac{20.7 \text{ cm}^2}{0.785} = 26 \emptyset 10\text{mm} @ 26 \text{ cm } \frac{C}{C}$$

$$\text{N.B.O}^+ = \frac{18.8 \text{ cm}^2}{0.785} = 25 \emptyset 10\text{mm} @ 21 \text{ cm } \frac{C}{C}$$

#### 4.6.1.7.2 Check Spacing:

$S_{\text{range}}$  (20cm – 25cm)

$$S_{\text{max}} = 25 \leq 26 \text{ ..... ok}$$

Note: According to ACI 314-14 if  $\alpha \frac{mLl}{L_s} \geq 1$  then 80% of column strip moments will be restricted to beams.

#### 4.6.1.7.3 For Short Direction:

$$W_u = 1232 \text{ kg/m}^2$$

$$M_o = \frac{1232 \times 6.05 \times (6.65)^2}{8} = 41202 \text{ kg} \cdot \text{m} = 41 \text{ T} \cdot \text{m}$$

$$M_{u-} = -0.65 \times 41 = -24.6$$

$$M_{u+} = +0.35 \times 41 = 14.35$$

$$M_{cs-} = 4.94 \times 24.6 = 18.45$$

$$M_{ms-} = 4.94 \times 24.6 = 6.15$$

$$M_{cs}^+ = 0.6 * 14.35 = 8.61$$

$$M_{ms}^+ = 0.4 * 14.35 = 5.74$$

$$A_{s-} = \frac{M_{u-}}{\phi * f_y * j * d} = \frac{6.15 * 10^5}{0.9 * 4200 * 0.87 * 13.5} = 13.85 \text{ cm}^2$$

$$A_{s+} = \frac{M_{u+}}{\phi * f_y * j * d} = \frac{5.74 * 10^5}{0.9 * 4200 * 0.87 * 13.5} = 12.9 \text{ cm}^2$$

$$A_{smin} = 0.0018 * 665 * 16 = 18 > A_{s-} \quad A_{s+} \quad \text{Use } A_{smin}$$

$$\text{Assume } \#10\text{mm} = a_s = 0.785 \text{ cm}^2$$

$$\text{N.B.O} = \frac{18.8}{0.785} = 24 \phi 10\text{mm} @ 27 \text{ cm } \frac{c}{c}$$

## 4.6.2 Design of Beams

The critical beam to be designed should have positive moment and the maximum span.

Beam #1: is selected

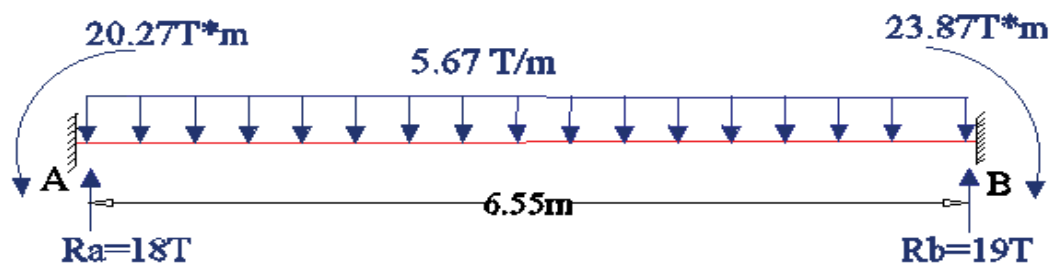
$$\text{➤ Not less than} = \frac{-Wul^2}{12} = \frac{-5.67 * (6.55)^2}{12} = -20.27 \text{ T} * \text{m}$$

Design Moments

$$M_{u+} = 23.87 \text{ T} * \text{m}$$

$$M_{u-} = -20.27 \text{ T} * \text{m}$$

### 4.6.2.1 Layout



$$\sum M_A = 0$$

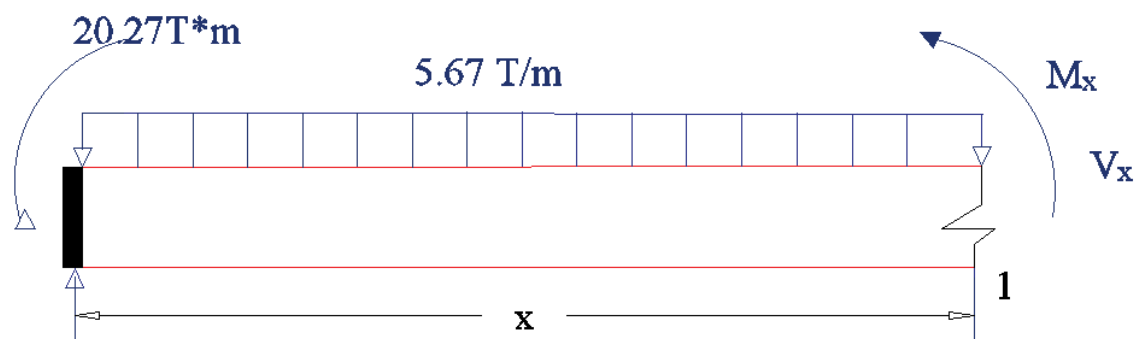
$$-23.87 + 20.27 + 5.67 * 6.55 * \frac{6.55}{2} - Ra * 6.55 = 0$$

$$Ra = 18 \text{ T}$$

$$+\uparrow Fy = 0$$

$$Rb - 5.67 * 6.55 + 18 = 0$$

$$Rb = 19 \text{ T}$$



$$\sum A = 0$$

$$M = -2.835 + 18x - 20.27$$

$$V = -5.67x + 18$$

Where:  $V = 0$ ,  $M = M_{\max}$

$$V = -5.67x + 18$$

$$X = \frac{18}{5.67} = 3.17 \text{ mm}$$

$$M_{\max} = -2.835 (3.17)^2 + 18 (3.17) - 20.27 = 8.3$$

$$M_{\max} = 8.3 < 20.27 < 23.89$$

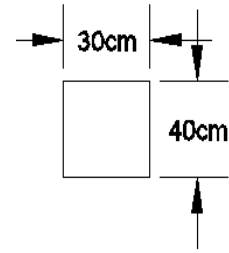
➤ So it can not be used for design

#### 4.6.2.2 Checking beam height for deflection according to ACI 318 – 14

$h_{min}$  = One end continuous  $L/18.5$

$$h_{min} = \frac{Ln}{18.5} = \frac{(6.55-0.3)*1000}{18.5} = 337.8mm$$

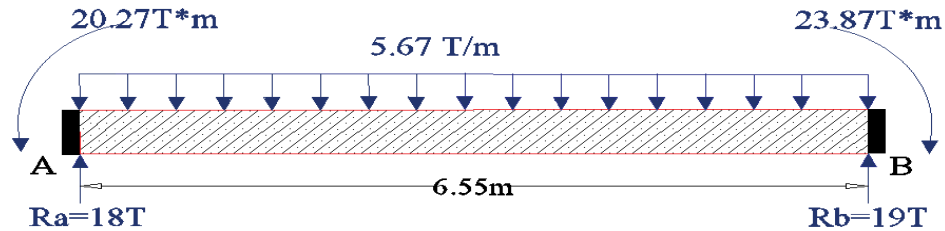
$$h_{min} = 337.8 < 400 \dots ok$$



#### 4.6.2.3 Checking beam section for strenght

$F_y = 420 \text{ Mpa}$

$F_c = 25 \text{ mm}$



$$[\phi Mn \geq Mu \dots ok]$$

$$[\phi Mn < Mu \dots not ok]$$

$$d = h - 65mm \longrightarrow d = 400 - 65 = 335$$

$$\rho = 0.4 * \rho_{balance}$$

$$\phi Mn = \phi * \rho * b * d^2 * fy \left[ 1 - \frac{\rho * fy}{1.7 fc} \right]$$

$$\rho_{balance} = 0.9 * Bd * \frac{Fc}{Fy} \left[ \frac{600mpa}{600 + Fy} \right] = 0.9 * 0.85 * \frac{25}{420} \left[ \frac{600}{600 + 420} \right] = 0.026$$

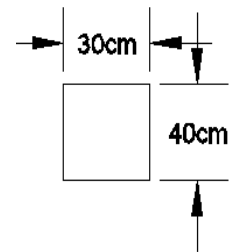
$$\rho = 0.4 * 0.026 = 0.0107$$

$$\phi Mn = \phi * \rho * b * d^2 * fy \left[ \frac{\rho * fy}{1.7 fc} \right]$$

$$\phi Mn = 0.9 * 0.0107 * 300 * 335^2 * 420 \left[ 1 - \frac{0.0107 * 420}{1.7 * 25} \right]$$

$$\phi Mn = 102824492.8 \text{ N.mm} = 12.17 \text{ T.m}$$

$$12.17 \text{ T.m} < 23.87 \text{ T.m} \dots Not ok$$

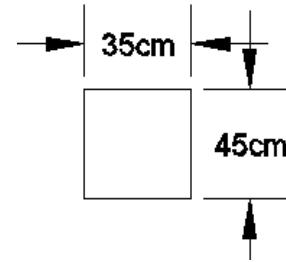


#### 4.6.2.4 Change Section of Beam

$$h = 45/ \quad b = 35/ \quad d = 435$$

$$0.9 * 0.0107 * 350 * 435^2 * 420 \left[ 1 - \frac{0.0107 * 420}{1.7 * 25} \right]$$

$$\phi M_n = 239544040 N.mm = 23.95 T.m \dots ok$$



#### 4.6.2.5 Reinforcement Calculation

$$A_s^+ = \rho \times b \times d \longrightarrow \rho^+ = \frac{0.85 F_c}{F_y} \left[ 1 - \frac{2 R_n}{0.85 F_c} \right]$$

$$R_n^+ = \frac{M_u^+}{\phi \times b \times d^2} = \frac{23.87 * 10^4 * 10^3 N.m}{0.9 * 350 * (435^2)} = 4m$$

$$\rho^+ = \frac{0.85 * 25}{420} \left[ 1 - \frac{2 * 4}{0.85 * 25} \right] = 0.0106$$

$$A_s^+ = 0.0106 * 350 * 435 = 1613.85 mm^2$$

$$R_n^- = \frac{M_u^-}{\phi \times b \times d^2} = \frac{20.27 * 10^4 * 10^3 N.m}{0.9 * 350 * (435^2)} = 3.4m$$

$$\rho^- = \frac{0.85 * 25}{420} \left[ 1 - \frac{2 * 3.4}{0.85 * 25} \right] = 0.0088$$

$$A_s^- = 0.0088 * 350 * 435 = 1339.8 mm^2$$

#### 4.6.2.6 Check $A_s^+ A_s^-$ with $A_{smin}$

$$A_{smin} = \rho_{min} \times b \times d$$

$$= 0.003 * 350 * 435 = 502 mm^2$$

$$\rho_{min} = \text{Max} \left\{ \begin{array}{l} \frac{1.4}{f_y} = \frac{1.4}{420} = 0.0033 \\ \frac{0.25 \sqrt{f_c'}}{f_y} = \frac{0.22 * \sqrt{25}}{420} = 0.0026 \end{array} \right.$$

$$A_s^- < A_{smin} < A_s^+ \longrightarrow [A_s^+ = 1442 mm^2] [A_s^- = 387 mm^2] Use$$

#### 4.6.2.6.1 Check $A_s^+ A_s^-$ with $A_{smax}$

$$A_{smax} = \rho_b \times b \times d = 0.016$$

$$A_{smax} = 0.75 * 0.016 * 350 * 435 = 2968 \geq A_s^+ .. ok$$

#### 4.6.2.7 Number of bars: ( $\emptyset 14 - \emptyset 25$ )

$$\text{Use } \emptyset 25 \quad a_s = 490 \text{mm}^2$$

$$\text{N.O. } B^+ = \frac{A_s}{a_s} = \frac{1613.85}{490} = 3.2 \cong 4 \emptyset 20 \text{mm at bottom}$$

$$A_s^+ \text{ use} = 1960 \text{mm}^2$$

$$\text{Use } \emptyset 14 \quad a_s = 314 \text{mm}^2$$

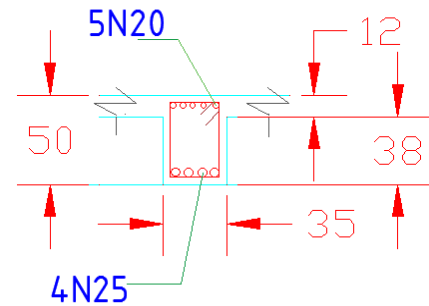
$$\text{N.O. } B^- = \frac{A_s}{a_s} = \frac{1339}{314} = 4.2 \cong 5 \emptyset 20 \text{mm at Top}$$

$$A_s^- \text{ use} = 1570 \text{mm}^2$$

#### 4.6.2.8 Clear Spacing

$$S_c = \frac{B - (2 * cov - 2 * \emptyset s + n \emptyset * b)}{n - 1} =$$

$$\frac{350 - 2 * 40 - 2 * 9 - 4 * 20}{9 - 1} = 19 \text{mm}$$



#### 4.6.2.9 Check ductility of Beam

$$a = \frac{A_s * f_s}{0.85 * f_c * b} = \frac{1339.8 \text{mm}^2 * 420 \text{mpa}}{0.85 * 25 \text{mpa} * 350} = 75.6 \text{mm}$$

$$C = \frac{a}{\beta} = \frac{75.6}{0.85} = 88.9$$

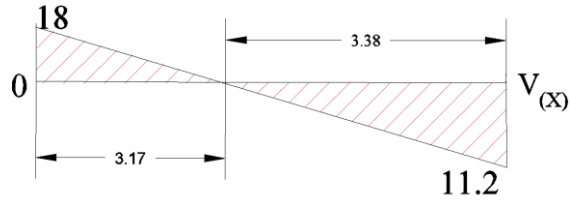
$$\epsilon_s = \epsilon_c \left[ d - \frac{c}{c} \right] = 0.003 \left[ \frac{435 - 88.9}{88.9} \right] = 0.011 > 0.005 \text{ Tension Control } \emptyset$$

$$= 0.9 ... ok$$

#### 4.6.2.10 Shear Calculation

$$V = -5.67x + 18$$

X	Y
0	18
3.17	0.0261
0	-19.13



$$\phi V_n \geq V_u: \phi V_n = \phi(V_s + V_c)$$

$$\phi(V_s + V_c) \geq V_u = V_s + V_c \geq \frac{V_u}{\phi} = V_s \geq \frac{V_u}{\phi} - V_c$$

$$V_c = \frac{1}{6} * \sqrt{f_c} * b_w * d$$

$$V_c = \frac{1}{6} * \sqrt{26} * 350 * 435 = 126875 \text{ N}$$

$$abc^{\Delta} = ade^{\Delta} = \frac{V_u d}{x_1 - d} = \frac{19.13}{x_1}$$

$$V_u d = \frac{19.13}{x_1} * x_1 - d = \frac{19.13}{3.38} (3.38 - 0.435) = 16.66T = 166600N$$

$$V_c \geq \frac{V_u}{\phi} = -V_c = V_s \geq \frac{166600}{0.75} - 126875 = V_s = 95258N$$

$$V_s = \frac{A_v * f_y * d}{S} = \left( \frac{A_v}{S} \right) = \frac{V_s}{f_y * d}$$

$$\left( \frac{A_v}{S} \right)_{req} = \frac{95258}{420 * 435} = 0.52$$

Check  $\left( \frac{A_v}{A_s} \right)_{req}$  With  $\left( \frac{A_v}{A_s} \right)_{min, max}$

$$1) \frac{A_v}{S} \quad \left| \quad \begin{aligned} \frac{1}{3} * \frac{b_w}{f_y} &= 0.277 \\ \frac{1}{6} * \sqrt{f_c} * \frac{b_w}{f_y} &= 0.26 \end{aligned} \right.$$

$$2) \frac{A_v}{S} \quad \left| \quad \frac{2}{3} * \sqrt{f_c} * \frac{b_w}{f_y} = 2.77$$

$$\left(\frac{Av}{S}\right)_{min} < \left(\frac{Av}{S}\right)_{req}$$

$$Av = 2As: \quad \frac{2As}{S} = 0.52$$

#### 4.6.2.11 Size of Stirrups

Use  $\emptyset 8mm$ :  $as = 50mm^2$

$$\frac{2As}{S} = 0.52 = S = 2 * \frac{50}{0.52} = S = 192.3$$

##### 4.6.2.11.1 Check with $S_{min,max}$

$$S_{min} = 3in = 80mm$$

$$S_{max} = \min \left\{ \begin{array}{l} 600 \\ \frac{d}{2} = \frac{435}{2} = 217.5 \dots Vs \leq 2Vc \\ \frac{16*Av*fy}{b*\sqrt{fc}} \\ \frac{3*Av*fy}{b} \end{array} \right.$$

$$S_{max} = \min \left\{ \begin{array}{l} 300 \\ \frac{d}{4} = 108.75 \dots Vs > 2Vc \end{array} \right.$$

$$Vs < 2Vc = 95258 < 2 * 126875N = 253750$$

$$S_{min} \left\{ \begin{array}{l} 600 = 600mm \\ \frac{d}{2} = \frac{435}{2} = 217.5mm \end{array} \right.$$

Use  $\emptyset 8mm @ 190mm \frac{c}{c}$  for all over the Beam Length

## 4.6.3 Column Design

### 4.6.3.1 Layout Frame

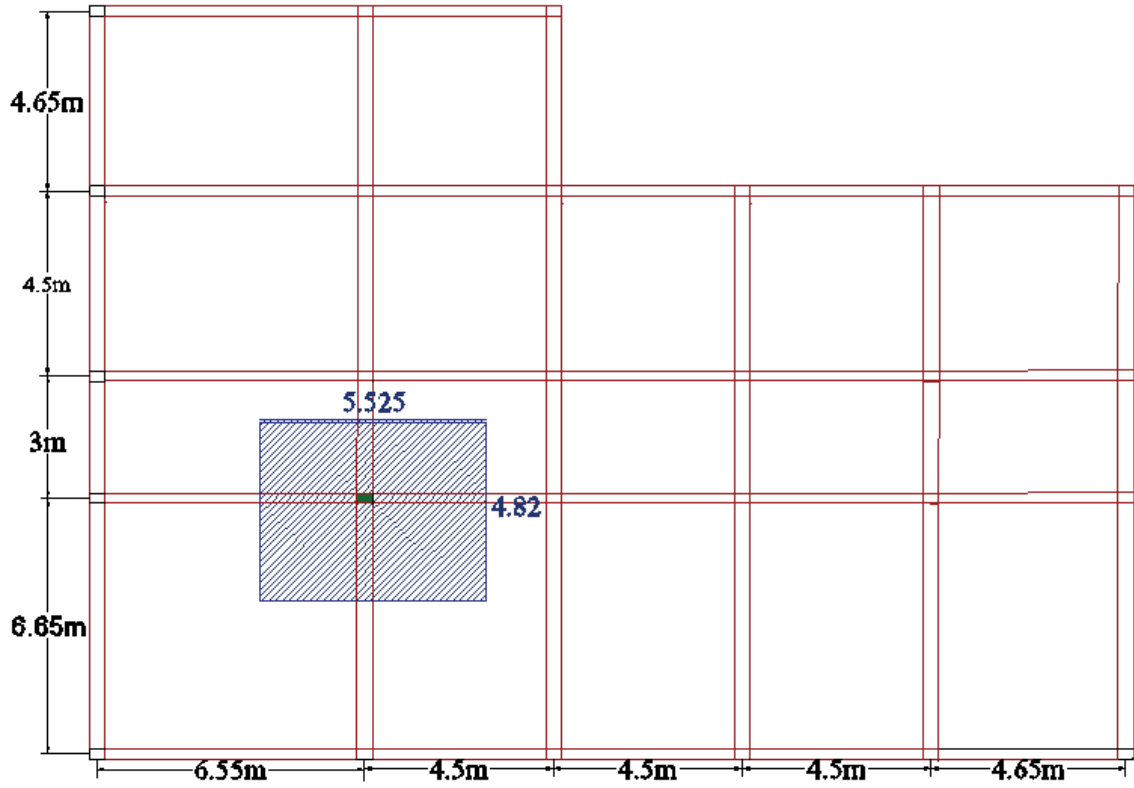


Figure 4.3

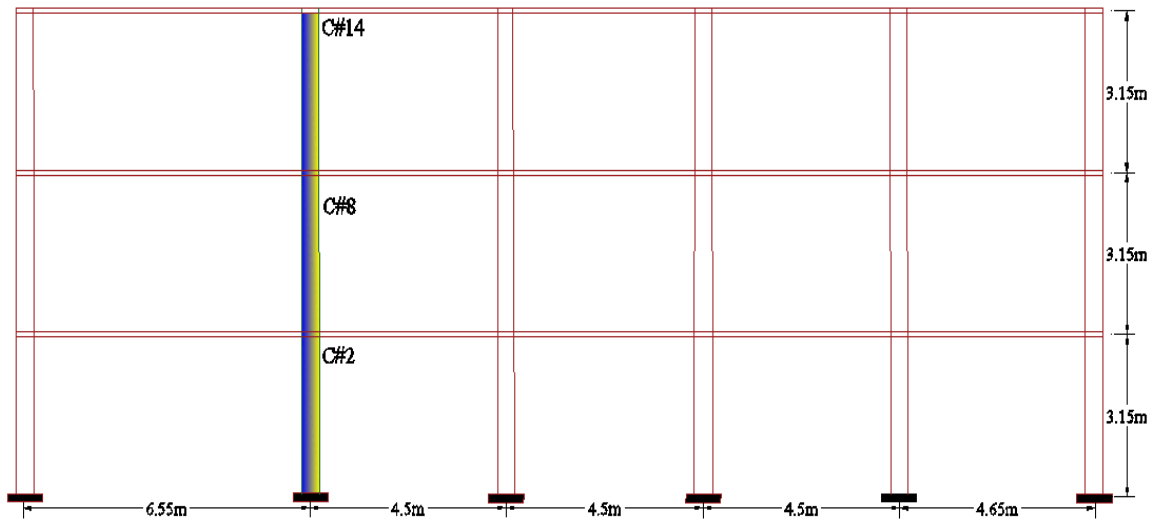


Figure 4.4

$$A_t = 5.525 * 4.825 = 26.65 \text{m}^2$$

### 4.6.3.2 Loading of Column

#### 4.6.3.2.1 Loading of Column #14

$$P_{u14} = 1.2PD_8 + 1.6PL_8$$

$$PD_{14} = P_{\text{slab}} + P_{\text{Beam}} + P_{\text{wall}} + P_{\text{self}}$$

$$P_{\text{slabs}} = DL_S * AT$$

$$= 504 * 26.65 \text{ m}^2 = 13431 \text{ kg} = 13.4T$$

$$P_{\text{Beam}} = \gamma_{\text{con}} * V = 2.4 \frac{T}{m} [27.6 * 0.50 * 0.35] = 11599 \text{ kg} = 11.5T$$

$PD_{\text{Wall}} =$  There is no wall on the Roof.

$$PD_{\text{Wall}} = 0$$

$$PD_{\text{Self}} = \gamma_{\text{con}} * V_{\text{col}} = 2.4 \frac{T}{m} (3.14 * 0.5 * 0.5) = 1.8T$$

$$PL_{14} = 100 \frac{\text{kg}}{\text{m}^2} * 26.65 = 2665 \text{ kg} = 2.6T$$

$$P_{u14} = 1.2 * 26.7 + 1.6 * 2.6 = 36.2T$$

#### 4.6.3.2.2 Loading of Column #8

$$P_{u10} = 1.2PD_{10} + 1.6PL_{10} + P_{u14}$$

$$P_{\text{slabs}} = DL_S * AT$$

$$= 504 * 26.65 \text{m}^2 = 13.4T$$

$$P_{\text{Beam}} = 11.6T$$

$$P_{\text{Wall}} = \gamma * V = 1800 \text{ kg/m}^3 (22.2 * 0.25 * 2.7) * 0.75$$

$$P_{\text{Wall}} = 20.2T$$

$$P_{\text{Self}} = 1.8T$$

$$PL_{10} = 13.4 + 11.6 + 20.2 + 1.8 = 47T$$

$$P_{u10} = 1.2 * 47 + 1.6 * 2.6 = 96.76T$$

#### 4.6.3.2.3 Loading of Column #2

$$P_{u2} = 1.2 * 47 + 1.6 * 2.6 = 96.76$$

$$W_S = 13.4T$$

$$W_B = 11.6$$

$$W_w = 20.2$$

$$W_S = 1.8$$

$$P_L = 2.6$$

$$W_{u2} = 157.32T$$

### 4.6.3.3 Design of Column #2

Section Sizes

$$A_g = 50 * 50 = 2500 \text{ cm}^2$$

$$A_g > A_{g_{req}}$$

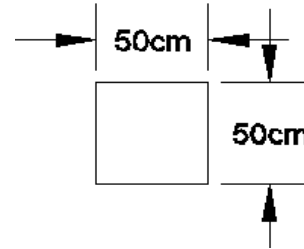
$$A_g > A_{g_{min}}$$

$$A_{g_{req}} = \frac{P_u}{0.6F_c} = \frac{15732 * 1000 \frac{\text{kg}}{\text{T}}}{0.6 * 250 \frac{\text{kg}}{\text{cm}^2}} = 1048.8 \text{ cm}^2$$

$$A_{g_{min}} = b_{min} * h_{min} \longrightarrow \text{According to ACI: } b_{min} = 25 \text{ cm} / h_{min} = 25$$

$$= 25 \text{ cm} * 25 \text{ cm} = 625 \text{ cm}^2$$

$$A_{g_{req}}: A_{g_{min}} < A_g = 2500 \text{ cm}^2$$



#### 4.6.3.3.1 Change Column Size:

$$A_g = 40 * 40 = 1600 \text{ cm}^2$$

$$A_{g_{req}}: A_{g_{min}} < A_g = 1600 \text{ cm}^2$$

#### 4.6.3.3.2 Vertical Reinforcement

#### 4.6.3.3.3 Eccentricity (e)

$$e = \frac{P_u}{M_u} = \frac{13.69 \text{ T} * \text{m}}{157.32 \text{ T} * \text{m}} = 0.087 \text{ cm}$$

#### 4.6.3.3.4 Kn, Rn:

$$K_n = \frac{P_u}{\phi * F_c' * A_g} = \frac{15732 * 1000 \frac{\text{kg}}{\text{T}}}{0.65 * 250 \frac{\text{kg}}{\text{cm}^2} * 1600 \text{ cm}^2} = 0.6$$

$$R_n = K_n * \frac{e}{h} = 0.6 * \frac{0.087 \text{ cm}}{40 \text{ cm}} = 0.0013 \text{ kg}$$

$$\gamma = \frac{h'}{h} = \frac{30 \text{ cm}}{40 \text{ cm}} = 0.75$$

$$\frac{e}{h} = \frac{0.087}{40} = 0.002175 > 0.2$$

X1

X

X2

$$\gamma = 0.7$$

$$\gamma = 0.75$$

$$\gamma = 0.8$$

Kn | Rn

|

Kn | Rn

Y1

Y

Y2

$$\rho_{g1} = 0.022$$

$$\rho_{g2} = 0.0202$$

$$\rho_{g3} = 0.0185$$

#### 4.6.3.3.5 Area of Steel bars (Stirrups)

$$A_s = \rho_g * b * h = 0.0202 * 40 * 40 = 32.32 \text{ cm}^2$$

$$\text{Use } \emptyset 24 \text{ mm: } a_s = 4.52 \text{ cm}^2$$

$$\text{N.O.B} = \frac{A_s}{a_s} = \frac{32.32 \text{ cm}^2}{4.52 \text{ cm}^2} = 7.15 \cong 8 \emptyset 24 \text{ mm}$$

#### 4.6.3.3.6 Design of horizontal bars (Stirrups)

Intermediate seismic zone

$$\text{Use } \emptyset 10 \text{ mm for stirrups : } a_s = 0.78 \text{ cm}^2$$

$$L_0 = \max \left\{ \begin{array}{l} 500 \text{ mm} = 500 \text{ mm} \\ \frac{L_n}{6} = 456.6 \text{ mm} \end{array} \right.$$

$$L_0 = 500 \text{ mm}$$

$$S_{\min} = \left\{ \begin{array}{l} 8\emptyset L = 192 \quad \longrightarrow \text{But not less than } 100 \text{ mm} \\ 24\emptyset T = 240 \\ 150 \text{ mm} = 150 \text{ mm} \end{array} \right.$$

$$S_{\min} = 456 \text{ mm}$$

$$S_{\max} = \left\{ \begin{array}{l} 16\emptyset L = 16 * 24 = 384 > 250 \text{ mm} \quad \text{But not more than } 250 \text{ mm} \\ 48\emptyset T = 480 \\ b = 400 \text{ mm} \end{array} \right.$$

$$S_{\max} = 250 \text{ mm}$$

Use:

$$\emptyset 10 \text{ mm} @ 250 \text{ mm} \frac{c}{c}$$

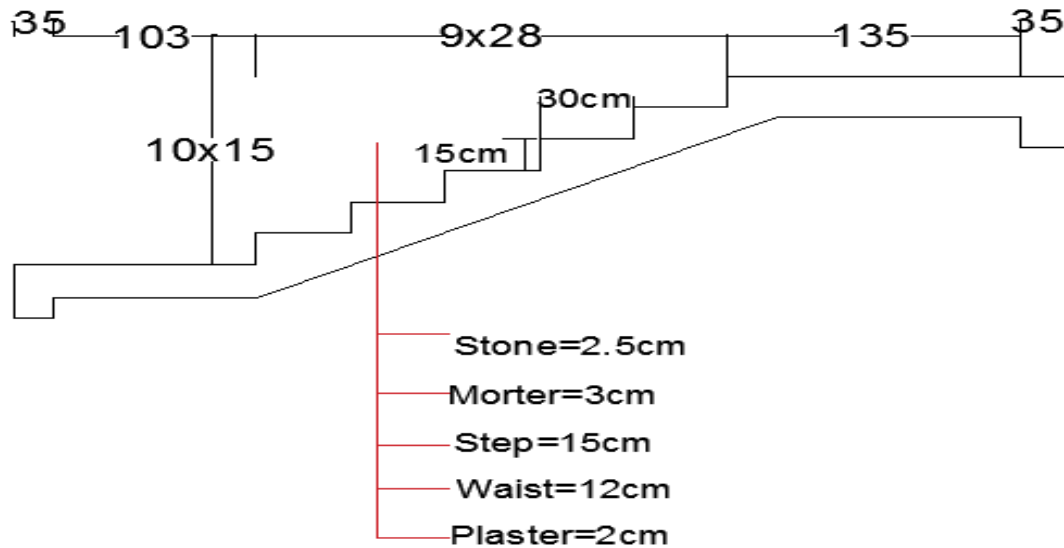
$$\emptyset 10 \text{ mm} @ 150 \text{ mm} \frac{c}{c} : \text{ in } L_0$$

#### 4.6.3.3.7 Check Design with code requirement

1.  $1\% \leq \rho_g \leq 8\% = 1\% \leq 2.02\% \leq 8\% \dots ok$
2. N.O.B = 8... ok
3. Minimum column diameter = 25 cm.  $25 \text{ cm} < 40 \text{ cm} \dots ok$
4. Use  $\emptyset 10 \text{ mm}$  Ties for up to  $\emptyset 32 \text{ mm}$  of vertical bars  
 $20 \text{ mm} < 32 \text{ mm}$  use  $\emptyset 10 \text{ mm} \dots ok$

## 4.6.4 Design of Stairs

### 4.6.4.1 Layout



### 4.6.4.2 Load transfer from Stairs

$$P = \frac{S1 \cdot W1 + S2 \cdot W2}{2}$$

$$W1 = 1.2DL + 1.6LL$$

$$DL = \sum \gamma_i \cdot T_i$$

$$= DL_p + DL_w + DL_s + DL_m + DL_{st}$$

$$= \gamma_p \cdot T_p \left( \frac{\sqrt{Run^2 - Rise^2}}{Run} \right) + \gamma_w \cdot T_w \left( \frac{\sqrt{Run^2 - Rise^2}}{Run} \right) + \frac{1}{2} \cdot \gamma_s \cdot T_s + \gamma_m \cdot T_m + \gamma_{st} \cdot T_{st}$$

$$= 1800 \frac{kg}{m^3} \cdot 0.02m \left( \frac{\sqrt{(30)^2 - (15)^2}}{30} \right) + 2400 \frac{kg}{m^3} \cdot 0.12m \left( \frac{\sqrt{(30)^2 - (15)^2}}{30} \right) + \frac{1}{2} \cdot 2400 \cdot 0.15 + 2000 \cdot 0.03$$

$$+ 2200 \cdot 0.025 = 657 \frac{kg}{m^2}$$

$$LL = 500 \quad \text{for commercial building}$$

$$W_u = 1.2 \cdot 657 + 1.6 \cdot 500 = 1588.4 \frac{kg}{m^2}$$

### 4.6.4.3 Moments Calculation

$$L = 4.65$$

$$Mu^- = C^+ \times Wu \times Ln^2 \times b = - \frac{1}{14} * 1588.4 \text{ kg/m}^2 (4.65)^2 * 1 = -2453 \text{ kg*m}$$

$$Mu^+ = C^- \times Wu \times Ln^2 \times b = + \frac{1}{10} * 1588.4 \text{ kg/m}^2 (4.65)^2 * 1 = +3434 \text{ kg*m}$$

### 4.6.4.4 As, N.O.B and Spacing

$$As_{min} = 0.0018bd = 0.002 * 100\text{cm} * 15 = 3\text{cm}^2$$

$$d = h - 2.5 = 16 - 2.5 = 13.5\text{cm}$$

$$As^+ = \frac{Mu^+}{\phi \times fy \times j \times d} = \frac{3434 \text{ kg*m} * 100 \text{ cm/m}}{0.9 * 4200 \frac{\text{kg}}{\text{cm}^2} * 0.87 * 13.5\text{cm}} = 7.7\text{cm}^2$$

$$As^- = \frac{Mu^-}{\phi \times fy \times j \times d} = \frac{2453 \text{ kg*m} * 100 \text{ cm/m}}{0.9 * 4200 \frac{\text{kg}}{\text{cm}^2} * 0.87 * 13.5\text{cm}} = 5.52\text{cm}^2$$

$$\text{Use } \emptyset 12\text{mm}: as = \frac{\pi}{4} (1\text{cm})^2 = 1.13\text{cm}^2$$

$$N.O.B = \frac{As^+}{as} = \frac{7.7\text{cm}^2}{1.13\text{cm}^2} = 6.8 \cong 7$$

$$S^+ = \frac{100\text{cm}}{N.O.B} = \frac{120\text{cm}}{7} = 17.1\text{cm} \cong 17$$

$$N.O.B = \frac{As^-}{as} = \frac{5.52\text{cm}^2}{1.13\text{cm}^2} = 4.88 \cong 5$$

$$S^- = \frac{120\text{cm}}{N.O.B} = \frac{120\text{cm}}{5} = 24\text{cm}$$

## 4.6.5 Design of Footing

### 4.6.5.1 Layout

$$q_a = 20 \frac{\text{T}}{\text{m}^2}$$

$$F_c' = 250 \frac{\text{kg}}{\text{m}^2}$$

$$F_y = 4200 \frac{\text{kg}}{\text{m}^2}$$

### 4.6.5.2 Thickness of Footing

$$h = 1.7 * h_{\text{col}} = 1.7 * 40 = 68 \text{cm}$$

### 4.6.5.3 Area of steel bar

$$PD = PD1 + PD2 + PD3 = 26.7 + 47 + 47 = 120.7 \text{T}$$

$$PL = PL1 + PL2 + PL3 = 2.6 + 2.6 + 2.6 = 7.8 \text{T}$$

$$q_n = q_a - (\gamma_{\text{con}} * t + \gamma_{\text{soil}}) = 20 \frac{\text{T}}{\text{m}^2} - \left( 2.4 \frac{\text{T}}{\text{m}^3} * 0.68 + 1.8 * 0.26 \right) = 17.9 \frac{\text{T}}{\text{m}^2}$$

$$A_f = \frac{PD+PL}{q_n} = \frac{120.7+7.8}{17.9} = 7.178 \text{m}^2$$

$$B = \sqrt{A_f} = \sqrt{7.178 \text{m}^2} = 2.679 \text{m}$$

$$L = \frac{A_f}{B} = \frac{7.178 \text{m}^2}{2.679} = 2.679$$

### 4.6.5.4 Check Soil Pressure

$$C = \frac{L}{2} = \frac{2.679 \text{m}}{2} = 1.3395 \text{m}$$

$$I = \frac{1}{12} * B * L^3 = \frac{1}{12} * 2.679 * 2.679^3 = 4.29 \cong 4.3$$

$$P = PD + PL = 120.7 + 7.8 = 128.5 \text{T}$$

$$M_u = MD + ML + ME = -13.69 \text{T} * \text{m}$$

$$M = \frac{M_u}{1.3} = \frac{-13.69}{1.3} = -10.5 \text{T} * \text{m}$$

$$q_n \geq q_{\text{max}} \dots \text{ok}$$

$$q_{\text{max}} = \frac{P}{A} + \frac{m * c}{I} = \frac{128.5}{7.178} + \frac{10.5 * 1.3395}{4.3} = 21.17 \dots \dots \dots q_n < q_{\text{max}} \dots \text{ok}$$

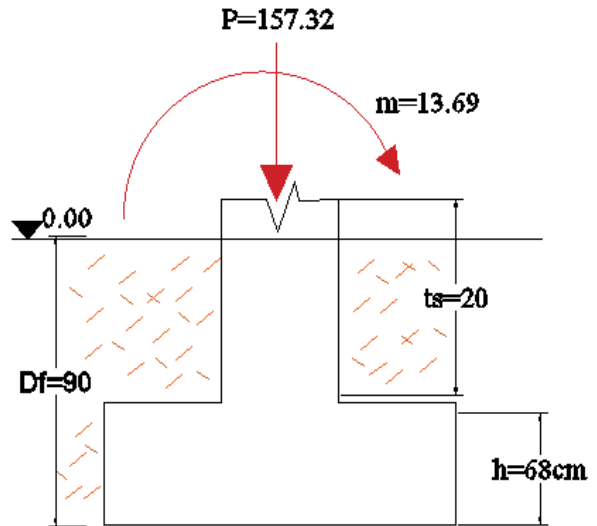


Figure 4.6

#### 4.6.5.5 Change type of footing :

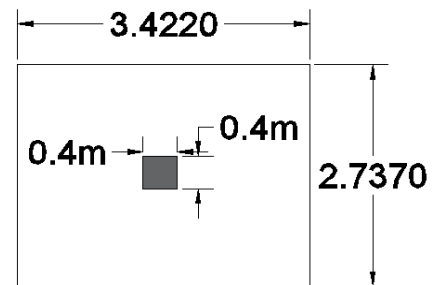
Use rectangular footing

$$q_{\max} = \frac{P}{B*L} + \frac{6*M}{B*L*L}$$

$$21.17 = \frac{128.5}{B*(1.25*B)} + \frac{6*10.5}{B*(1.25*B)^2} = 17.64 * \frac{102.8}{B^2} + \frac{50.4}{B^3}$$

$$B = 2.737\text{m} ,$$

$$L = 2.737*1.25 = 3.422\text{m} , A = 8.12\text{m}^2$$



#### 4.6.5.6 Check One Way Shear

$$d = h - \text{Cover} = 680 - 75 = 605\text{mm}$$

$$q_{u_{\max, \min}} = \frac{P}{S*L} \pm \frac{6M}{S*L*L} = \frac{128.5}{8.12} \pm \frac{6*10.5}{2.737*(3.422)^2}$$

$$q_{u_{\max}} = 0.1809\text{Mpa} , q_{u_{\min}} = 0.1355\text{Mpa}$$

$$V_u = q_u \left( \frac{L}{2} - \frac{a}{2} - d \right) * b$$

$$V_u = 18.9 \frac{\text{T}}{\text{m}^2} * \left[ \frac{3.422}{2} - \frac{0.4}{2} - 0.605 \right] = 44.858\text{T}$$

$$V_u = 448582\text{N}$$

$$d_{\text{req}} = 262.23 < d = 605 \dots \text{ok}$$

#### 4.6.5.6.1 Check sliding and rotation

$$e * \frac{L}{6} < 0.5$$

$$e = \frac{M_u}{P_u} = \frac{13.69 \text{ T*M}}{157.32 \text{ T*m}} = 0.087$$

$$\frac{L}{6} = \frac{3.422}{6} = 0.5703$$

$$e * \frac{L}{6} = 0.087 * 0.5703 = 0.049 < 0.5 \dots \text{ok} \quad \text{No sliding or rotation occurs}$$

#### 4.6.5.7 Check Two Way Shear

$$\phi V_c \geq \phi \frac{1}{3} \sqrt{F_c'} * b_0 * d_{req} \geq V_{u2} = d_{req} \geq \frac{3 * V_{u2}}{\phi * \sqrt{F_c'} * b_0}$$

$$b_0 = 4[a + d] = 4[0.4 + 0.605] = 4.02\text{m} = 4020\text{mm}$$

$$V_{u2} = q_u [A_f - (a + d)^2] = 18.09 \frac{\text{T}}{\text{m}^2} [8.12 - (0.4 + 0.605)^2] = 128.6\text{T}$$

$$V_{u2} = 1286194\text{N}$$

$$d_{req} \geq \frac{3 * V_{u2}}{\phi * \sqrt{F_c'} * b_0} = 262.2 \geq \frac{3 * 1286194\text{N}}{0.75 * \sqrt{25} * 4020} = 255.9$$

$$262.2 > 255.9 \dots \text{ok}$$

#### 4.6.5.8 Check Combined Shear

$$\phi V_c > V_u$$

$$V_u = \frac{V_u}{A_c} + \frac{\gamma * M_u}{\frac{J}{c}}$$

$$V_u = 44.858\text{T} = 448582\text{N}$$

$$b_1 = b_2 = a + d = 0.4 + 0.605 = 1.005\text{m}$$

$$A_c = 2[b_1 + b_2]d = 2[1.005\text{m} + 1.005] * 0.605$$

$$A_c = 2.613\text{m}^2$$

$$\gamma = 0.35 \text{ to } 0.4 \rightarrow \text{We use } 0.4$$

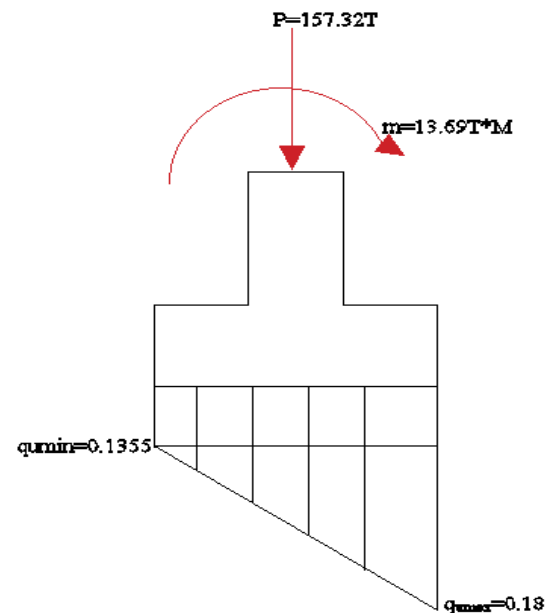
$$\frac{J}{c} = \frac{1}{3} [b_1 * d(b_1 + 3b_2) + d^3]$$

$$\frac{J}{c} = \frac{1}{3} [1.005 * 0.605(1.005 + 3 * 1.005) + 0.605^3] = 0.888\text{m}^3$$

$$V_u = \frac{44.858}{2.613} + \frac{0.4 * 13.69}{0.888} = 23.3 \frac{\text{T}}{\text{m}^2}$$

$$\phi V_u = 0.75 [0.85 \sqrt{F_c'}] = 0.75 [0.85 * \sqrt{25}] = 3.187 \text{ MPa} = 325 \frac{\text{T}}{\text{m}^2}$$

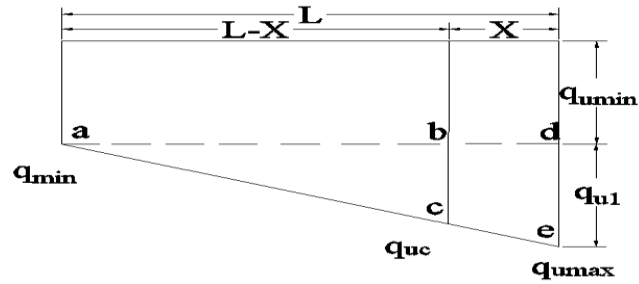
$$\phi V_u = 325 \frac{\text{T}}{\text{m}^2} > 23.3 \frac{\text{T}}{\text{m}^2} = V_u \dots \text{ok}$$



### 4.6.5.9 Moments

$$\Delta abc : \Delta ade$$

$$\Delta abc : \Delta ade$$



$$\frac{q_u}{L-x} = \frac{q_{u\max} - q_{u\min}}{L}$$

$$q_u = \frac{q_{u\max} - q_{u\min}}{L} (L-x) = \frac{18.9 - 13.55}{3.422} (3.422 - 1.511)$$

$$x = \frac{L}{2} - \frac{a}{2} = \frac{3.422}{2} - \frac{0.4}{2} = 1.511$$

$$q_{uf} = 13.55 + 2.535 = 16 \frac{T}{m^2}$$

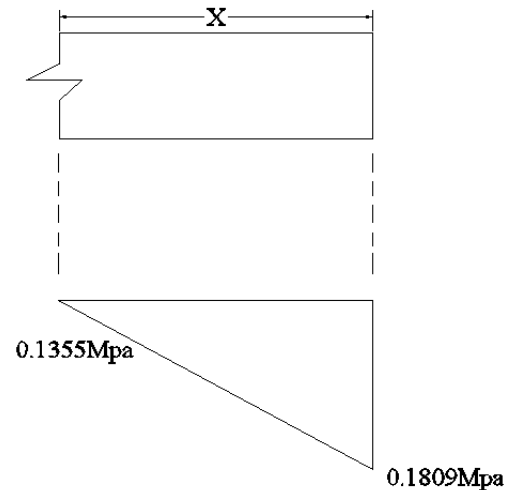
$$MD = M + MD$$

$$MD = (q_{uf} x * b) \frac{\alpha}{2} + \frac{1}{2} (q_{ul} * x * b) \frac{2}{3} \alpha (x)$$

$$MD = (16 \frac{T}{m^2} * 1.511m * 2.737) * \frac{1.511}{2} +$$

$$\frac{1}{2} (2.5335 \frac{T}{m^2} * 1.511 * 2.737) \frac{2}{3} * 1.511$$

$$MD = 38.6T * m$$



### 4.6.5.10 Reinforcements

#### 4.6.5.10.1 Long Direction

$$A_s = \rho * b * d$$

$$\rho = \frac{0.85 * F_c'}{\rho * b * d} \left[ 1 - \sqrt{1 - \frac{2 * R_n}{0.85 * F_c'}} \right]$$

$$R_n = \frac{M_n}{\rho * b * d} = \frac{38.6 * 10^4 \frac{N}{T} * 10^3 \frac{mm}{m}}{0.9 * 2737 * (605mm)^2} = 0.428 Mpa$$

$$\rho = \frac{0.85 \cdot 25 \text{Mpa}}{420 \text{Mpa}} \left[ 1 - \sqrt{1 - \frac{2 \cdot 0.428 \text{Mpa}}{0.85 \cdot 25 \text{Mpa}}} \right] = 0.001$$

$$\rho_{\min} = 0.0018 > \rho = 0.001$$

$$A_s = 0.0018 \cdot 2737 \cdot 605 = 2981 \text{mm}^2$$

#### 4.6.5.10.1.1 NOB

$$\text{Use } \emptyset 20 \text{mm} \quad a_s = 314 \text{mm}^2$$

$$\text{NOB} = \frac{A_s}{a_s} = \frac{2981 \text{mm}^2}{314 \text{mm}^2} = 9.49 \cong 10 \emptyset 20 \text{mm} \quad A_s \text{ use} = 3140 \text{mm}^2$$

$$S = \frac{B - 2 \text{Cover}}{N_o B} = \frac{2737 - 2 \cdot 75}{10} = 258.7 \cong 260 \text{mm}$$

$$\text{Use } 10 \emptyset 20 \text{mm} @ 260 \text{mm} \frac{c}{c}$$

#### 4.6.5.10.2 Short Direction

$$M_{D_s} = q_{\text{ave}} \cdot \frac{x^2}{2} \cdot L$$

$$q_{\text{ave}} = \frac{q_{\max} + q_{\min}}{2} = \frac{18.09 + 13.55}{2} = 15.82 \frac{\text{T}}{\text{m}}$$

$$x = \frac{B}{2} - \frac{a}{2} = \frac{2.737}{2} - \frac{0.4}{2} = 1.1685 \text{m}$$

$$M_{D_s} = 15.88 \frac{\text{T}}{\text{m}} \cdot \left( \frac{1.1685^2}{2} \right) \cdot 3.422 \text{m} = 36.95 \text{T} \cdot \text{m}$$

$$A_s = \rho \cdot b \cdot d$$

$$R_u = \frac{M_{D_s}}{\emptyset \cdot b \cdot d} = \frac{36.95 \text{T} \cdot \text{m} \cdot 10^4 \frac{\text{N}}{\text{m}} \cdot 10^3 \frac{\text{mm}}{\text{m}}}{0.9 \cdot 3422 \cdot 607^2} = 0.327 \text{MPa}$$

$$\rho = \frac{1}{m} \left[ 1 - \sqrt{1 - \frac{2 \cdot m \cdot R_u}{f_y}} \right] = \frac{1}{\frac{420}{0.85 \cdot 420}} \cdot \left[ 1 - \sqrt{1 - \frac{2 \cdot \frac{420}{0.85 \cdot 420} \cdot 0.327}{420}} \right] = 0.0007789$$

$$\rho = 0.0007789 < \rho_{\min} = 0.0018$$

$$\text{Use } \rho_{\min} = 0.0018$$

$$A_s = 0.0018 \cdot 3422 \cdot 605 = 3726.56$$

#### 4.6.5.10.2.1 Number of Bars

Use  $\emptyset 20mm$

$$A_s = \frac{\pi}{4} (20)^2 = 314mm$$

$$NOB = \frac{A_s}{a_s} = \frac{3726.56}{314} = 11.8 \cong 12\emptyset 20mm$$

$$A_{s_{use}} = 3768mm^2$$

#### 4.6.5.11 Dowel Bars (Ad)

$$A_{d_{min}} = 0.005$$

$$A_{g_{col}} = 0.005(400mm)^2 = 800mm^2$$

Use  $\emptyset 14mm$

$$a_s = 154mm^2$$

$$NOB = \frac{800}{154} = 5.19 \cong 6\emptyset 14mm$$

$$A_{s_{use}} = 924$$

#### 4.6.5.12 Development Length

From table A-6 m, Appendix A, Mc, Gregor 6<sup>th</sup> edition

For  $F_c' = 25MPa$

$$d_l = 36.5 * d_b$$

$$d_l = 40 * 14mm = 560mm$$

The structure drawing of foundation in Appendix-G.

## **4.7 work breakdown Structure (WBS)**

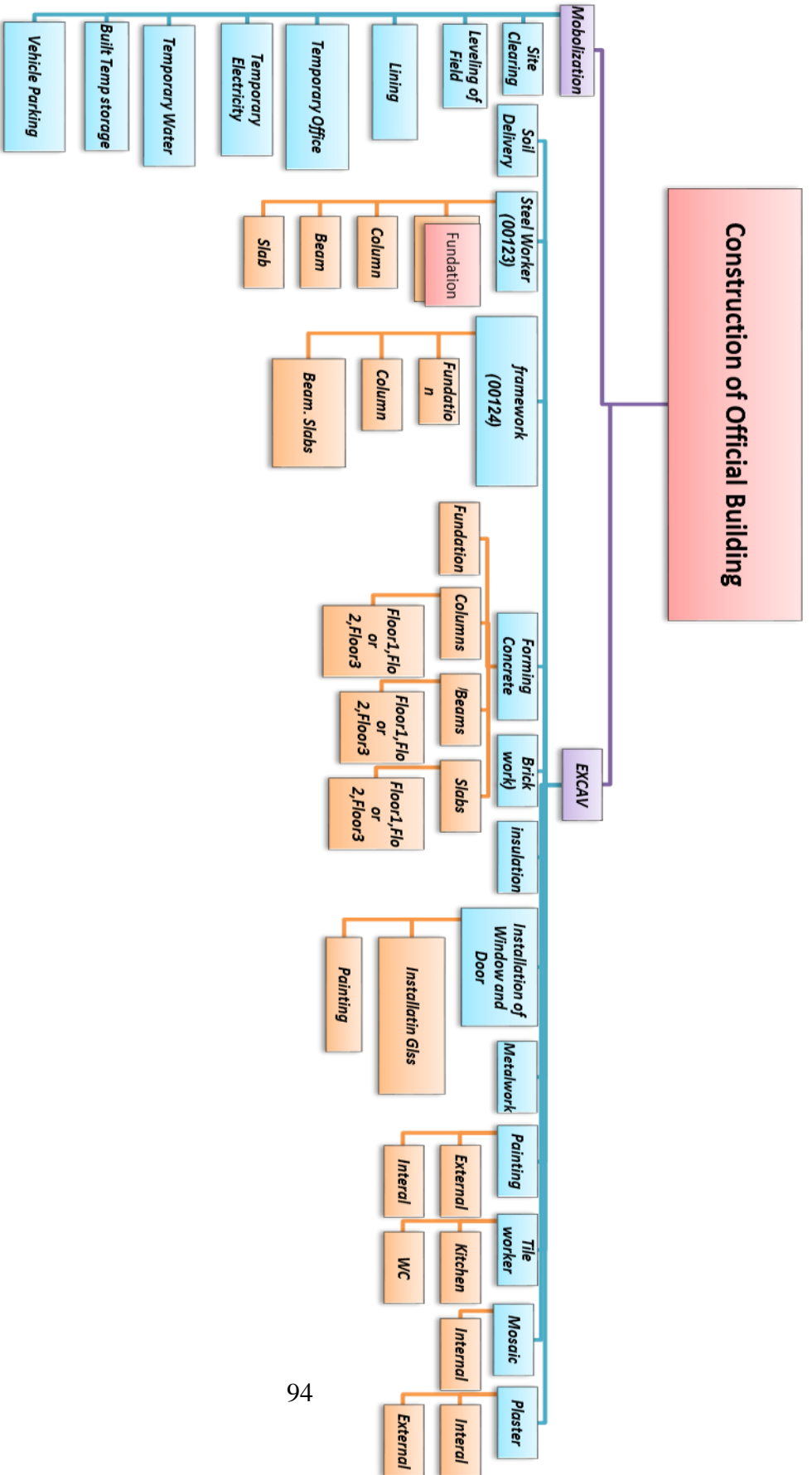
Actually WBS is the first stage of project management creating the work breakdown structure, a step that then enables subsequent planning of the work processes and schedule for accomplishing the project. When the work breakdown structure is in place, thoroughly reviewed and finalized, the structure can then be evaluated to determine the processes needed and the scheduled time and costs for achieving each of the goals.

The WBS is a hierarchical reflection of all the work in the project in terms of deliverables. In order to produce these deliverables, work must be performed.

A typical approach in developing a WBS is to start at the highest level, with the product of the project. For example, you are assigned as the project manager of a New Product Development project. The new product you are developing is a new toy for children age's five through nine. The objective of this product development project is to increase the revenue of the organization by ten percent.

The most important consideration in making a work breakdown structure is to avoid mirroring either an organizational structure or a functional structure, since these structures are not outcome-oriented. The defined objectives at all levels must not be measurable outcomes and deliverables, the parts and the entirety of what the customer will receive at project completion.

# Work Breakdown Structure



## **4.8 Cost Estimation**

A cost estimate is the approximation of the cost of a program, project, or operation. The cost estimate is the product of the cost estimating process. The cost estimate has a single total value and may have identifiable component values. A cost estimator is the professional who prepares cost estimates. Cost estimating is used to predict the quantity, cost and price of the resources required by the scope of a project. A project might be any process that is started to perform work activities and create assets. To use parametric estimating, first divide a project into units of work. Then, you must determine the cost per unit, and then multiply the number of units by the cost per unit to estimate the total cost.

A bill of quantities is a document by which it is possible to estimate the cost of a construction project (or part of it) or for its maintenance. A very important document prepared by the quantity surveyor on the basis of a project and used by all parties involved in the building's development.

## Cost Estimation

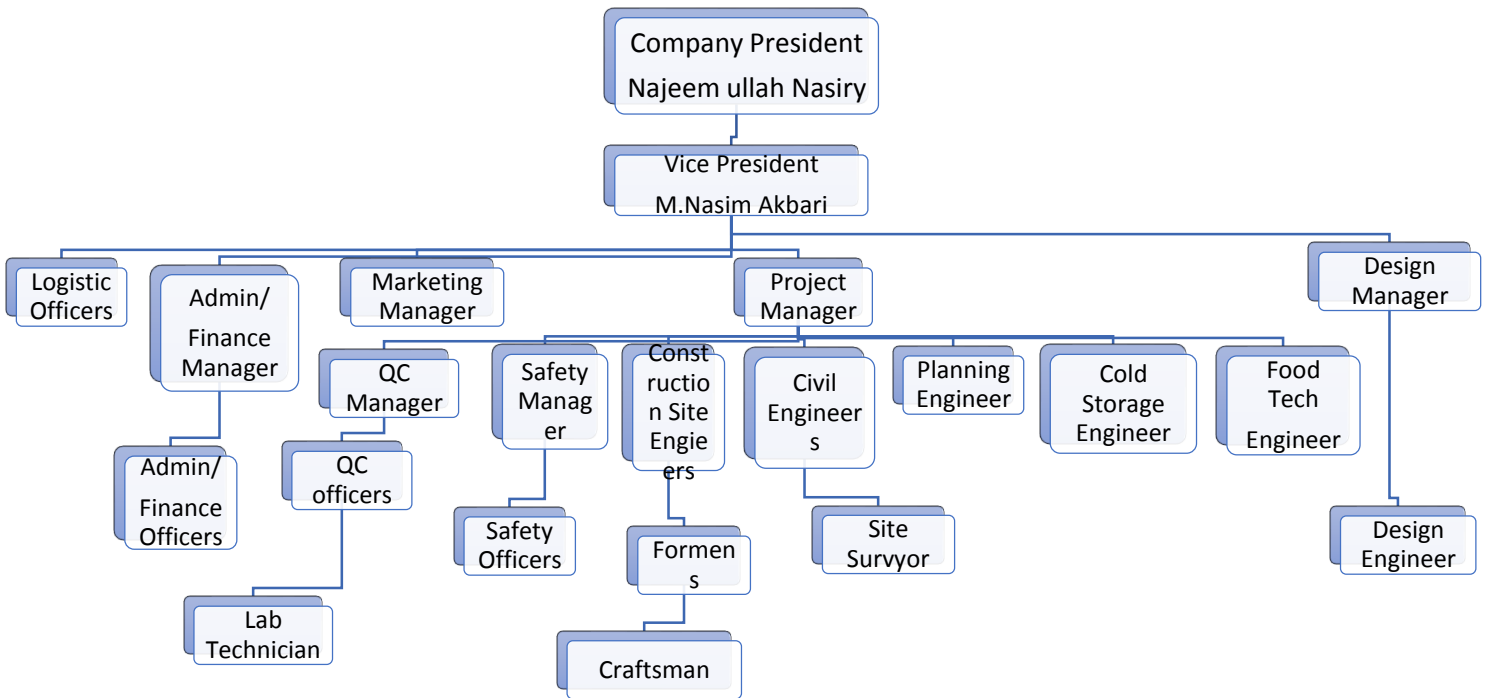
NO	Activity Name	IPA	Duration		SI		USL		UNIT	QUANTITY	UNIT PRICE	TOTAL COST	Total Labor		Labor Cost		Total Labor_cost (Af)
			Optional		Optional		Optional						SI	USL	SI (Af)/TON	USL (Af)	
1	Site clearing	-	1		1		3		LS	1	2000	2000	1.00	3	850	450	2200.00
2	Leveling of Field	-	1		1		1		LS	1	3500	3500	1.00	1	850	450	1300.00
3	Liming	-	1		1		1		LS	1	200	200	1.00	1	850	450	1300.00
4	Building Temporary utility	1&2	2		3		6		LS	3	5000	15000	9.00	18	850	450	15750.00
5	Building Sewage System	2	5		1		1		LS	12	0	0	12.00	12	850	450	15600.00
6	Building Perimeter Walls	3	10		2		3		LS	2	0	0	4.00	6	850	450	6100.00
7	Excavation (Footing)	2&3	5		1		5		LS	27	0	0	27.00	135	850	450	83700.00
8	Soil Filling	7	1		0		0		LS	27	0	0	0.00	0	850	450	0.00
9	Compaction	7&8	1		0		4		LS	27	0	0	0.00	108	850	450	48600.00
10	Gravel Filling	9	1				9		LS	432	6000	2592000	0.00	3888	850	450	1749600.00
11	Sand Filling	10	1		1		3		LS	432	0	0	432.00	1296	850	450	950400.00
12	Damp proof Insulation	9&10	1		1		2		LS	4	0	0	4.00	8	850	450	7000.00
13	Placing First Floor (Slab) Concrete	12	1		1		4		M3	21	180	3780	21.00	84	850	450	55650.00
14	Curing	13	28		0		2		LS	1	500	500	0.00	2	850	450	900.00
15	Reinforcement Work (Column)	13&14	5		2		3		T	20	7000	140000	40.00	60	850	450	61000.00
16	Forming	13&14	2		2		3		M2	206	0	0	412.00	618	850	450	628300.00
17	Placing Concrete (Column)	15&16	1		2		15		M2	21	0	0	42.00	315	850	450	177450.00
18	Reinforcement (Beam & Slab)	17	9		2		4		T	30	0	0	60.00	120	850	450	105000.00
19	Forming (Beam & Slab), Shoring	17	5		2		4		M2	206	0	0	412.00	824	850	450	721000.00
20	Placing Concrete (Beam & Slab)	17, 18&19	1		1		15		M2	206	0	0	206.00	3090	850	450	1565600.00
21	Curing	20		28			2		M2	1	0	0	0.00	2	850	450	900.00
22	Scarfolding	21	30				3		LS	5	0	0	0.00	15	850	450	6750.00
23	First Floor Brick Work	14&22	20		4		5		M3	131360	656800	525440.00	656800	850	450	742184000.00	
24	Setting First Floor Doors & Windows	13	2		1		1		LS	10	0	0	10.00	10	850	450	13000.00
25	Setup water pipes	23&24	2		1		2		LS	34	0	0	34.00	68	850	450	59500.00
26	water proofing for bath	23,24&25	4		1		2		LS	34	0	0	34.00	68	850	450	59500.00
27	Water proofing for bathroom	24	5		1		2		LS	3	0	0	3.00	6	850	450	5250.00
28	first floor filling	26&27	1		1		2		LS	4	0	0	4.00	8	850	450	7000.00
29	Fixing bathroom and kitchen fittings	26,27&28	3		1		2		LS	2	0	0	2.00	4	850	450	3500.00
30	first floor wiring	23	1						LS	2	0	0	0.00	0	850	450	1300.00

31	External wiring	29&30	3	1	2	LS	2	0	2.00	4	850	450	3500.00
32	Internal plaster	30&31	10	2	5	LS	2	0	4.00	10	850	450	7900.00
33	exterior plaster	31	12	2	5	M2	180	0	360.00	900	850	450	713000.00
34	painting coat 01 (exterior)	32&33	2	2	1	M3	161	0	322.00	161	850	450	346150.00
35	painting coat 02 (exterior)	32&33	3	2	1	M4	161	0	322.00	161	850	450	346150.00
36	painting coat 01 (interior)	32&33	4	2	2	M5	161	0	322.00	322	850	450	418600.00
37	painting coat 02 (interior)	32&33	4	2	2	M6	161	0	322.00	322	850	450	418600.00
38	Damp proof Insulation	32&33		1	2	LS	4	0	4.00	8	850	450	7000.00
39	Pitch roof	31	1	1	2	LS	3	0	3.00	6	850	450	5250.00
40	first floor lighting	34&35	5	1	1	LS	20	0	20.00	20	850	450	26000.00

41	Setting HVAC	36&37	2	1	1	LS	3	0	3.00	3	850	450	3900.00
42	Setting exhaust fans	40&41	1	1	1	LS	12	0	12.00	12	850	450	15600.00
43	setting water heater	42	1	1	1	LS	4	0	4.00	4	850	450	5200.00
44	Car park	40, 41, 42, & 43	2	1	1	LS	3	0	3.00	3	850	450	3900.00
45	Yard Pavement	40, 41, 42, & 43	5	1	1	LS	3	0	3.00	3	850	450	3900.00
46	Garden	44&45	10	2	4	LS	2	0	4.00	8	850	450	7000.00
47	irrigation piping	46	1	2	2	LS	2	0	4.00	4	850	450	5200.00
48	Clean up and demobilize site	47	5	0	3	LS	10	50000	0.00	30	850	450	13500.00
49	As built survey	46,47,&48	1	0	0	LS	21	5000	0.00	0	850	450	6300.00
50	project hand over	49	1	0	0	LS	1	0	0.00	0	850	450	1300.00
<b>Total</b>													<b>750893100.00</b>

## 4.11 Organization Chart

An organization chart is a diagram that normally carry a company's internal structure by detailing the roles, responsibilities, and relationships between individuals within a .



## 4.12 Gantt chart

A Gantt chart is a type of bar chart that indicates a project schedule. This chart lists that tasks to be act on the vertical axis, and time intervals on the horizontal axis. The width of the horizontal bar in the graph display the duration of each activity that when it starts and when it ends.

## **4.15 Quality Management**

Quality management ensures that an organization, product or service is consistent. Quality management is focused not only on product and service quality, but also on the means to achieve it. Quality management, therefore, uses quality assurance and control of processes as well as products to achieve more consistent quality.

### **Tests**

Here are several kinds of tests that you should expect. Generally, here are the quality tests that we have done and you also might conduct these on your building projects.

Slump test, Compressive strength test, Water permeability test, Rapid Chloride Ion Penetration test, Water Absorption, Initial surface absorption test, Soil investigation test, Plate load test, Soil analysis (Sampling), Proctor test, Compaction test, Compression test of concrete, Durability test, Mechanical and Chemical test, Compression test for CPU, Non-destructive test. And There are many more tests to be done in the construction project, what we wrote here are actually the important tests and others shall be done during the project is in progress and in sometimes by consultant or client's willingness to do so.

## **4.16 Safety**

Safety is the state of being safe; freedom from danger, risk or injury. The safety tools are Safety Shoes, Gum Boot, Safety Vest, Emergency lights, Rain Coat, Head lump, Safety Ladder, Safety Mask, Safety Gloves, any kind of safety sign, Safety Helmet, Safety Fire extinguisher, Safety belt, Safety Cabinet, Safety Hand Tools, Safety Harnesses, Safety High-visible clothing, Safety eye protection, Safety earplugs, Safety hard hats, Safety respirator and extra are the equipment of the safety to be save from injury.

# CHAPTER FIVE

## CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Conclusions

Our purpose from this project was to provide insight on the concrete mix design, investigate factors that affect concrete mix design, and finally select the most appropriate concrete mix design for our project in terms of workability, economy, strength and durability.

Concrete mix design is one of the most important considerations in a construction project and its related provisions. The procedures for concrete mix design involves mix design, sieve analysis, slump test, air content test, temperature test, cylinder filling, cylinder curing, and cylinder crushing; however, the Indian Standard (IS) 456-2000 for concrete has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In our project we selected four different grades of concrete to be test, and we tested the design strength 4000psi (27.6Mpa) (M25, M20, and M15). To maintain the strength of concrete for different elements, various types of concrete grades are required. The strength needed for foundation, beam, slab etc... Will be different. the procedure that we follow on these tests are, first of all we found the mix ratio to understand the quantity of cement, sand and aggregate that how much they should be add in mixer. For M15 is (1:2:4) 1 cement, 2 sand, 4 aggregate and for M20 mix ratio are (1:1.5:3) 1cement 1.5 sand and 3 is aggregate in M25 (1:1:2) respectively as we talk about (1:1:2) it means 1 represent proportion of cement other, 1 shows sand, and 2 represents aggregate. And for M27.6(1:0.5:1) it is also same the others 1shows cement proportion 0.5represent fine aggregate or sand and 1 means coarse aggregate by the way did all tests in different laboratory, we did M20 compressive strength test in Kardan University laboratory we proceed the mixing procedure step by step starting from calculation till crushing cylinder and achieving the target. In this procedure, the things that we did are selecting grades of concrete with proportions of them, adding the proportions calculating on  $1\text{cm}^3$  dry concrete, and applied the equations on them, after calculation we were ready to mix

concrete there was six cylinder ready to filling concrete and we did it. After passing seven days three-cylinder sample was, got ready to crush, so we crushed them and the average compressive strength in seven days was 18Mpa, and M25 procedure was same the M20 but the only different in this grades are the quantity of cement, sand and aggregate. We got help from GSMTL (Geo Scientific Material Testing Laboratories) to do M25 and M15 compressive strength test. For each of these tests there was three samples only. For M25 the average compressive strength in seven days was 23.79Mpa. For M15 the average compressive strength in seven days was 16.7Mpa, and we did design strength 4000 Psi (27.6 Mpa) as well by having help from VICC (Venco-Intiaz Construction Company) the average compressive strength in seven days was 23Mpa and the average compressive strength in twenty eight days was 35.3Mpa. It is very high strength without chemical admixtures but I have to say that we toke the proportion of this mix from grade M35 because there is no any standard grade by name of M27.6 our main aim was just to have 27Mpa or 28 Mpa so we got our target in this proportion. All the procedures that we did are only to select better and economical standards concrete marks to our project, so chased M15 for PCC concrete area and M20,M25 for foundations, beams, slabs, we recommend from tests M20 is better because it is economically and timeless.

## 5.2 Recommendations

To begin with, there must be all the required soil and concrete tests results available before the selection of the most suitable concrete mix. Sieve analysis should be done properly and all the materials should be of good quality.

The quality of materials affect the strength of the mix. For example, uncrushed gravel reduced the compressive strength significantly, compared with crush gravel, given that the water content ratio remains constant.

Next, a M10 mix is used where heavy load is not applied. Mainly for PCC. M15 can resist a load of up to 15 kilo newton and be used for one story buildings. However, due to limitations it is used for PCC.

Moreover, M20, M25, M30 are respectively used for conditions where a greater resistance is anticipated. However, certain factors can affect the required mix design for a project.

Additionally, the use of admixtures is not suggested unless it is a necessity.

The table below will provide some points as what should be done and what not.

DO	DONT
<p data-bbox="347 1293 849 1434">Order a quality concrete mix with the appropriate slump for proper placement required.</p> <p data-bbox="347 1493 849 1633">Place concrete on a well-drained sub-grade that has adequate and uniform load-bearing characteristics.</p>	<p data-bbox="915 1293 1417 1377">Don't use calcium chloride accelerators to achieve fast concrete set time.</p> <p data-bbox="915 1440 1417 1581">Don't order concrete in less than 3 yd<sup>3</sup> (2,m<sup>3</sup>) increments. Full color consistency is not guaranteed.</p> <p data-bbox="915 1644 1417 1785">Don't place concrete on a sub-grade that is not thoroughly compacted and dampened.</p>

<p>Grade the sub-grade so that the concrete is of uniform thickness and properly sloped for drainage.</p> <p>Vibrate or tamp and screed the concrete, then float it to the specified grade, flatness, and levelness.</p> <p>Texture all surfaces adequately and uniformly for slip resistance.</p> <p>Finish all surfaces within reasonably the same time after placement.</p> <p>Finish the edges first and do all hand-finishing in the same direction.</p> <p>Protect the concrete surface from rapid evaporation of bleed water.</p> <p>Use an approved curing compound for proper curing of concrete.</p> <p>Protect the freshly placed concrete from freezing for the first 72 hours.</p>	<p>Don't place concrete over freestanding water or muddy, frozen or soft spots.</p> <p>Don't add water after a portion of the load has been discharged, or retemper concrete that has started to set.</p> <p>Don't sprinkle water, or otherwise add water to the surface during finishing operations.</p> <p>Don't use inconsistent finishing practices.</p> <p>Don't over-trowel (burn or burnish) the concrete surface.</p> <p>Don't use plastic sheeting to cure color concrete.</p> <p>Don't allow items to stand on concrete during the curing process.</p>
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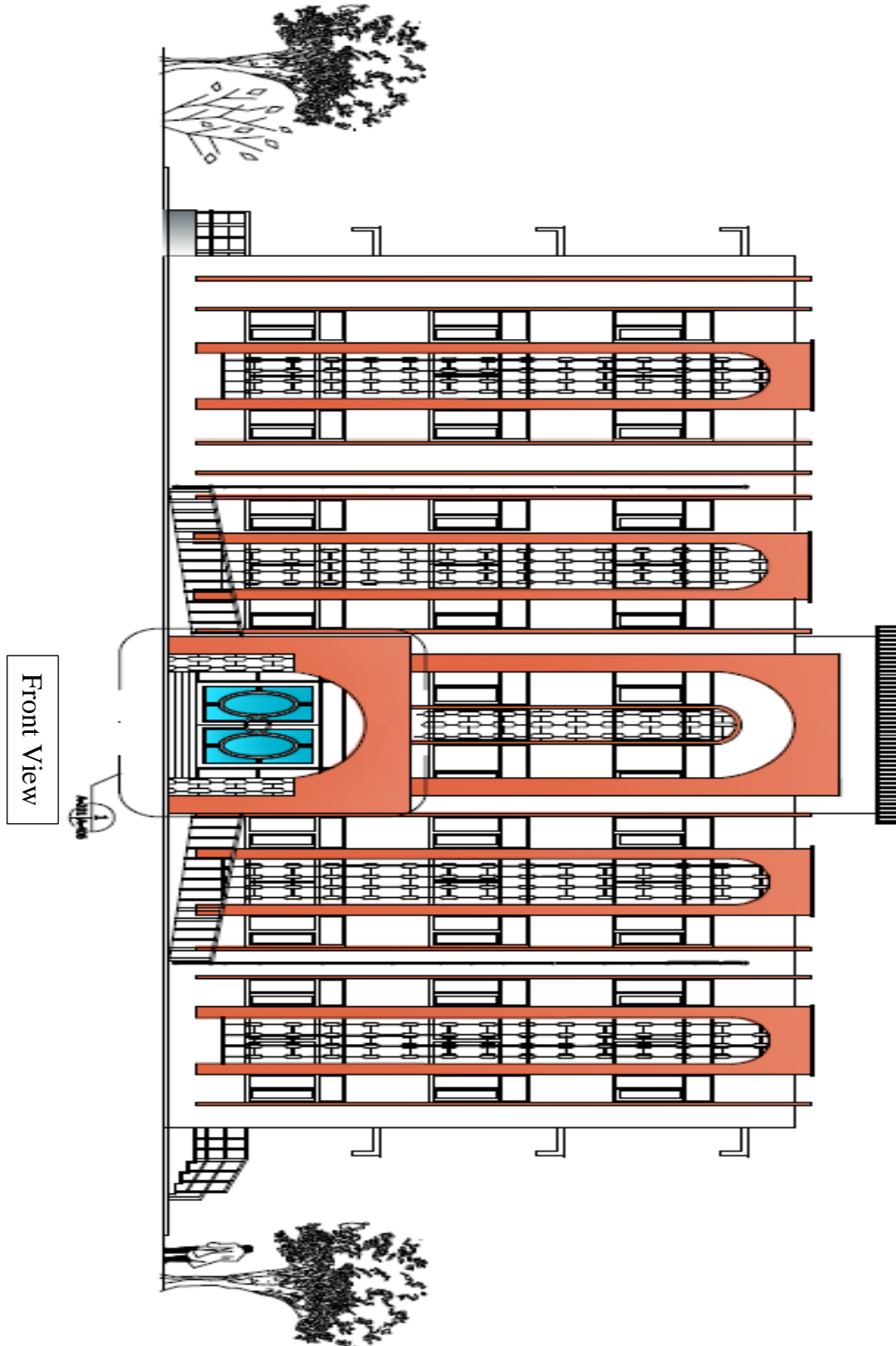
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# APPENDICES

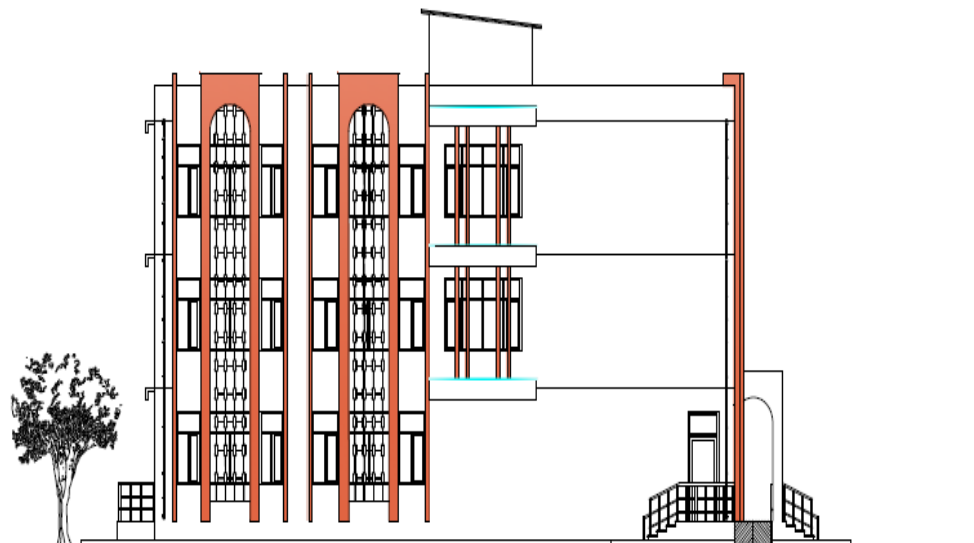
## Appendix –A



## Site Views

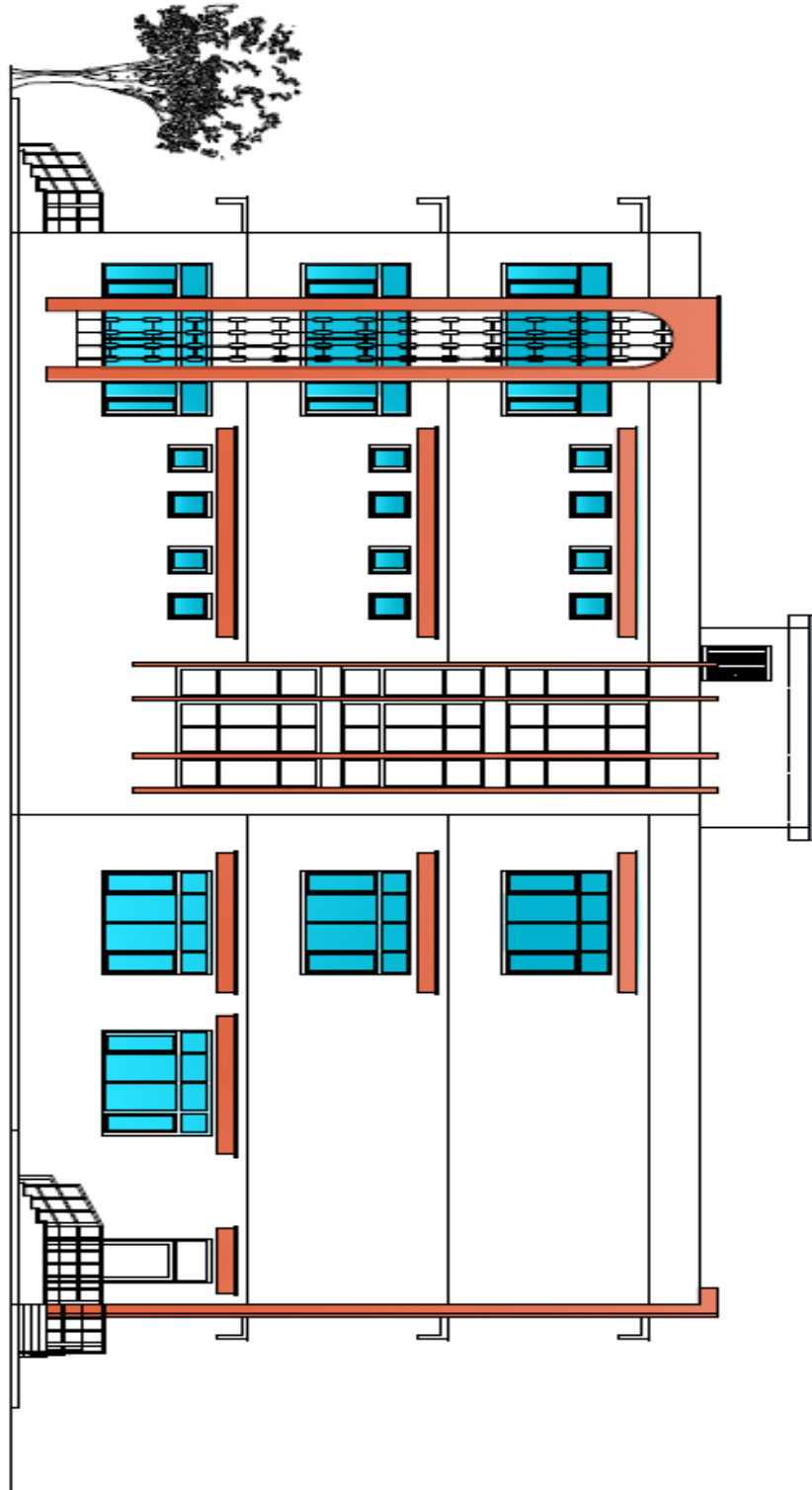


Right View

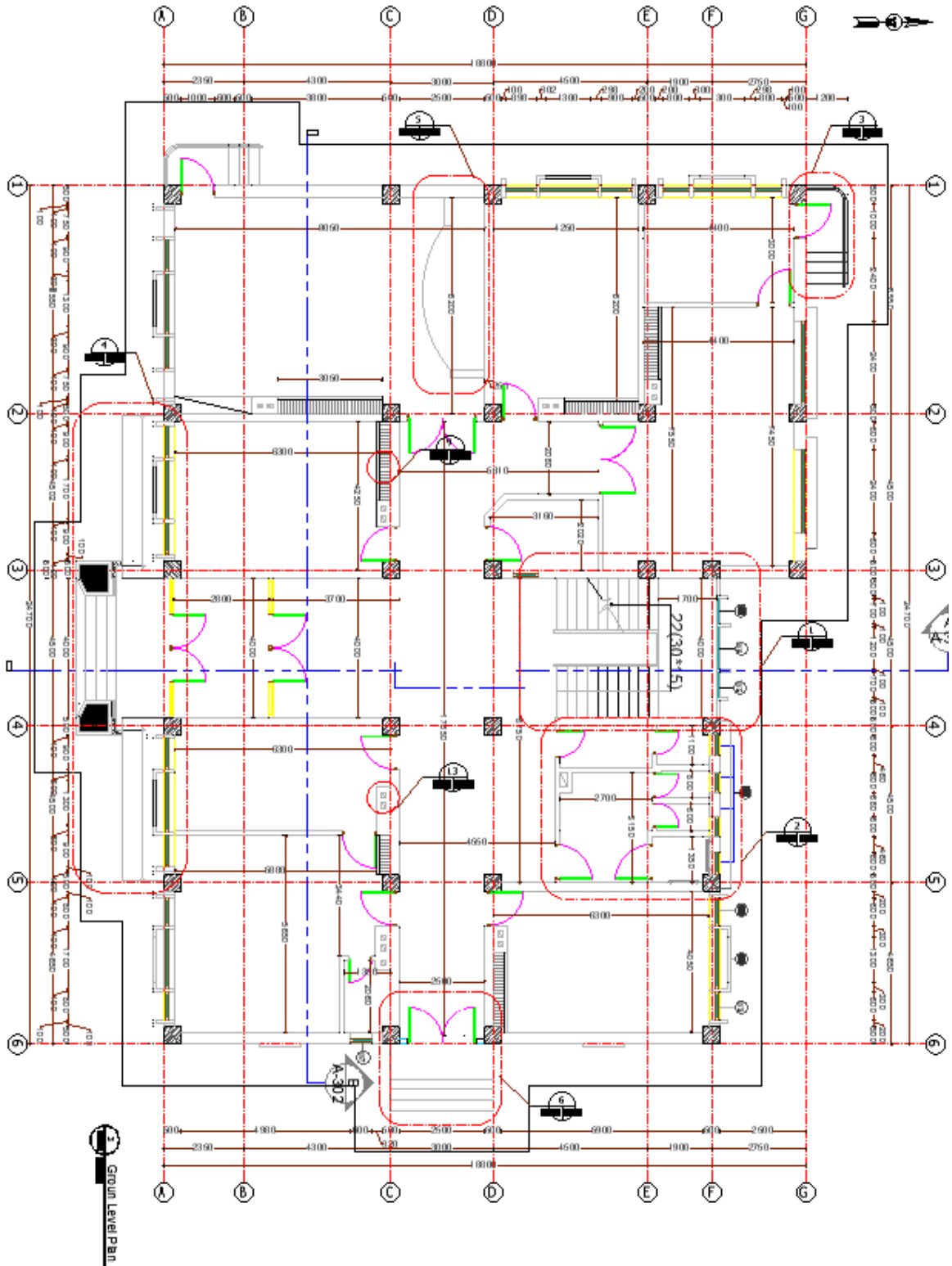


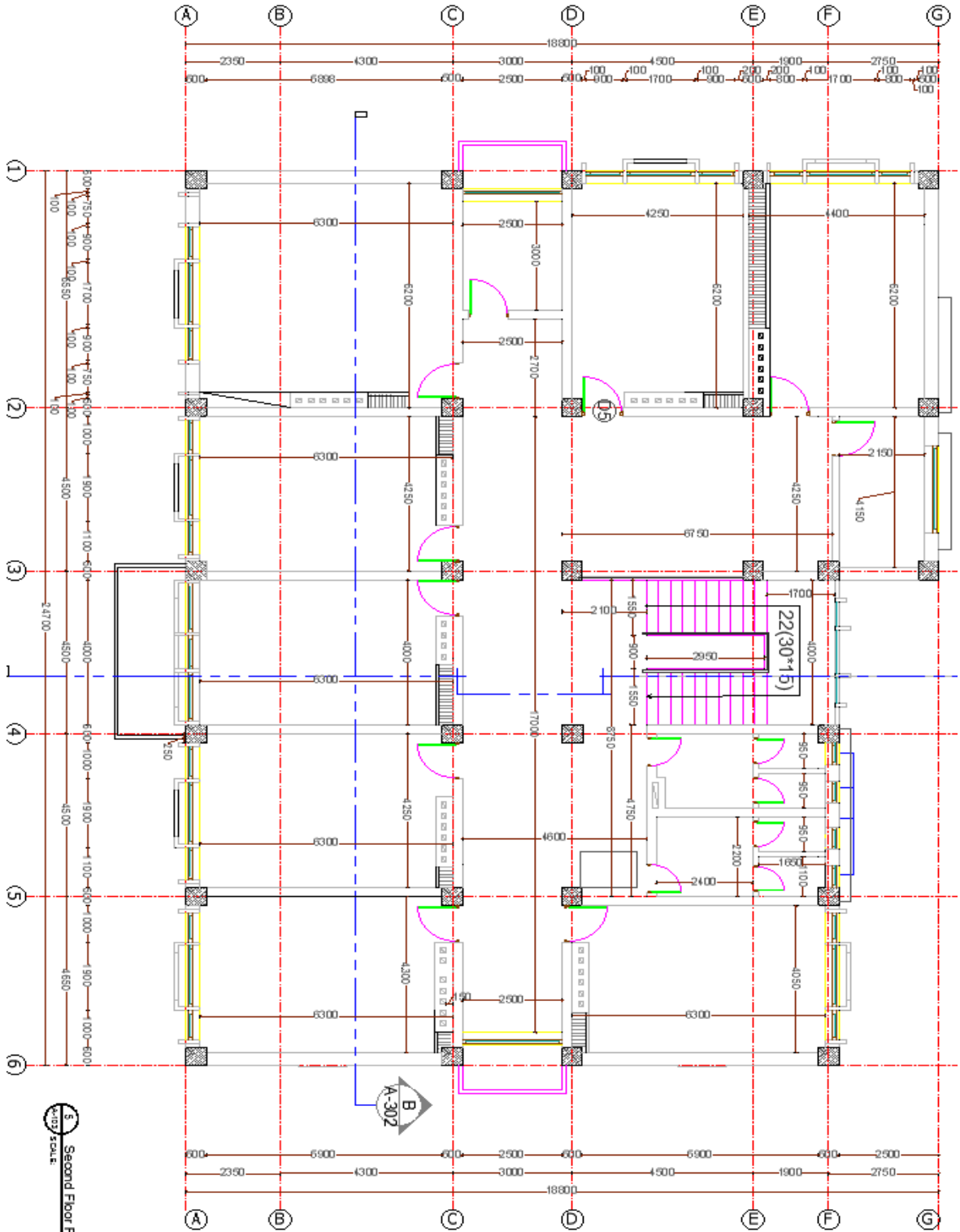
Left View

Back View



# Appendix -B

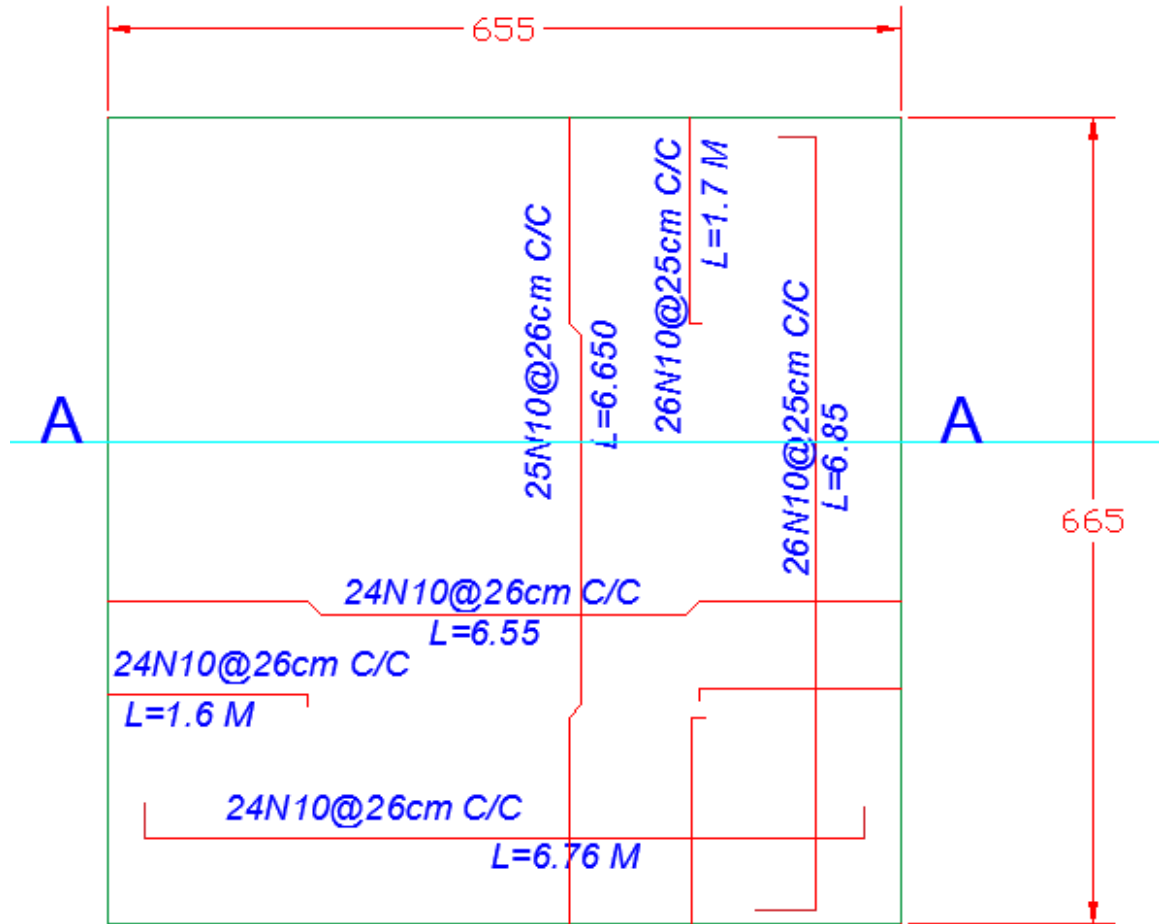




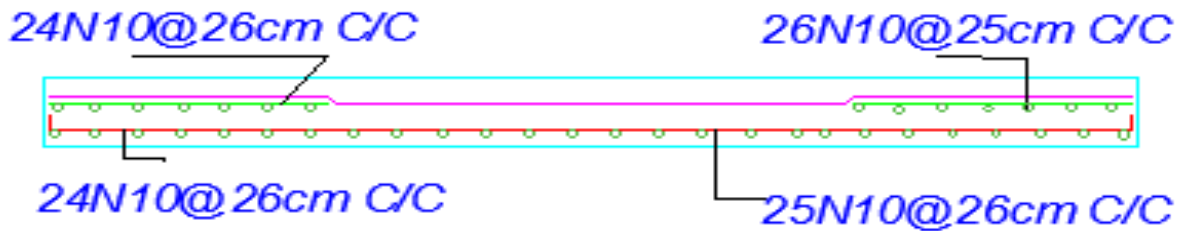
Second Floor Plan  
1/25

# APPENDIX-C

## Slab Reinforcement Plan

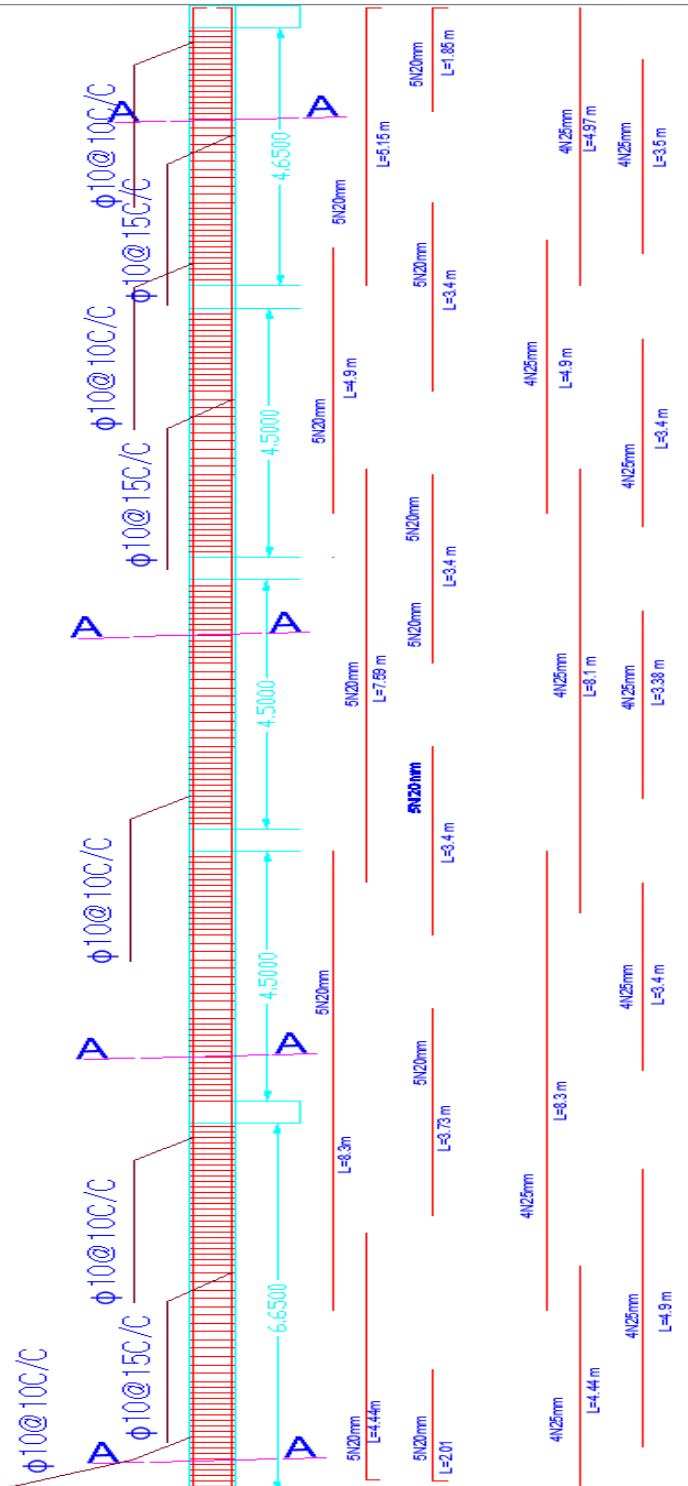


### Sec A-A

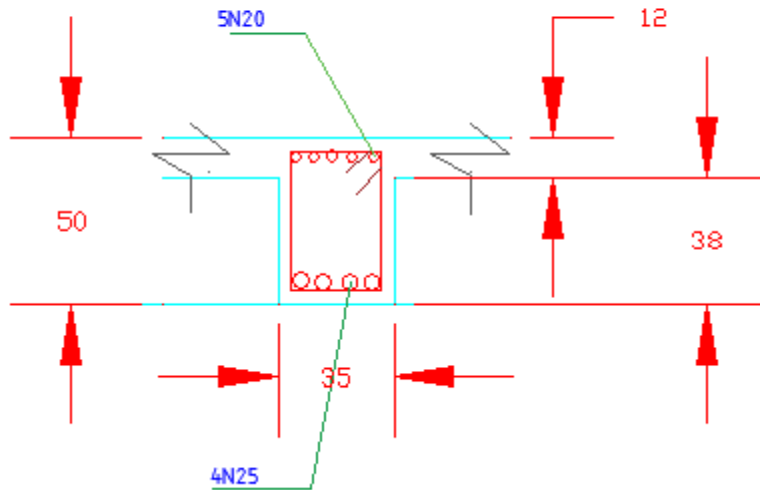


# Appendix-D

## Beams' Reinforcement Plans

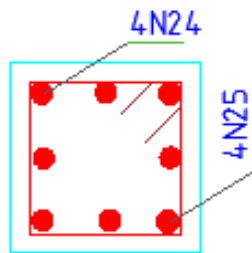


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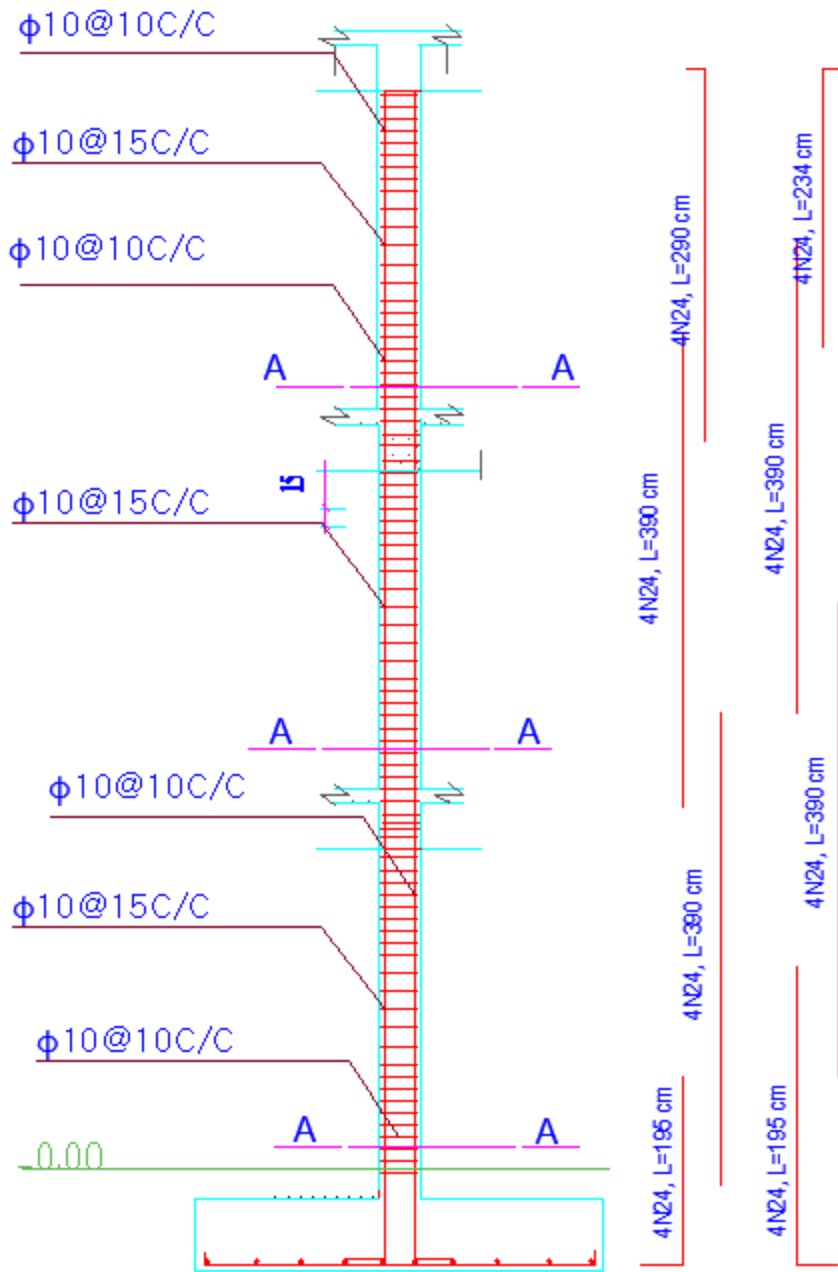


## Appendix-E

### Columns Reinforcement Plan

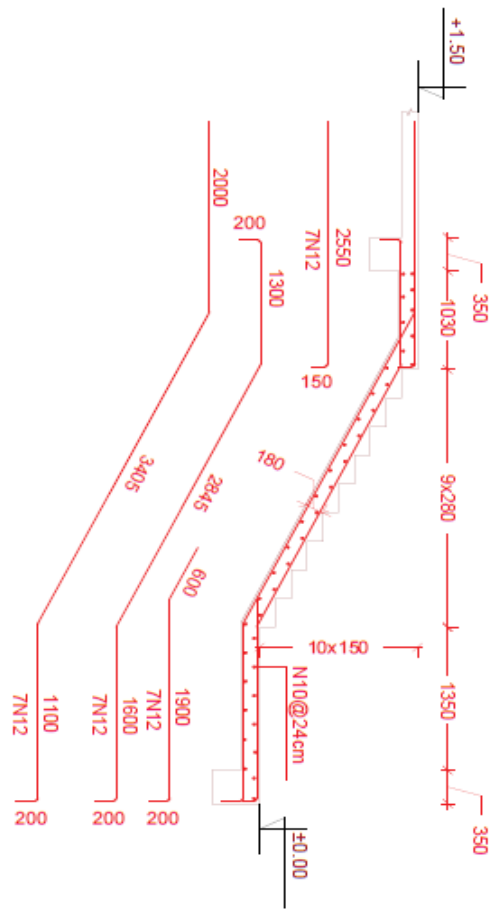
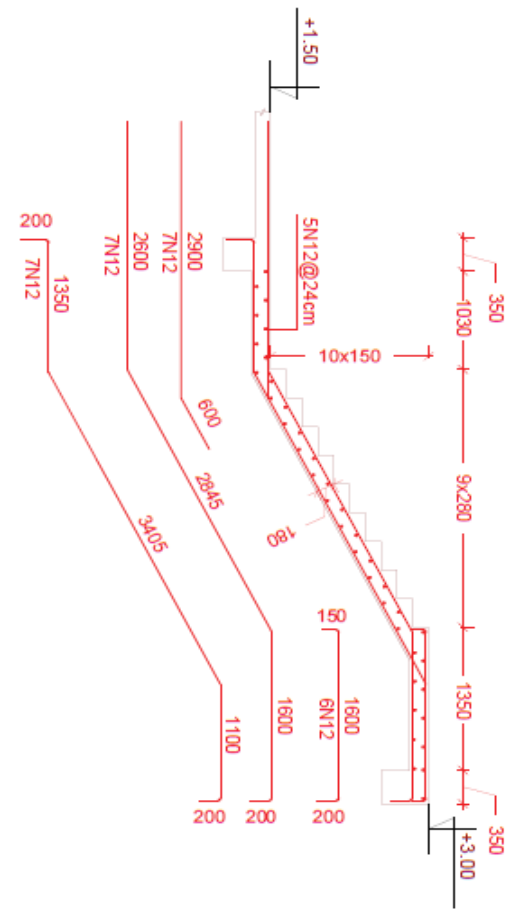
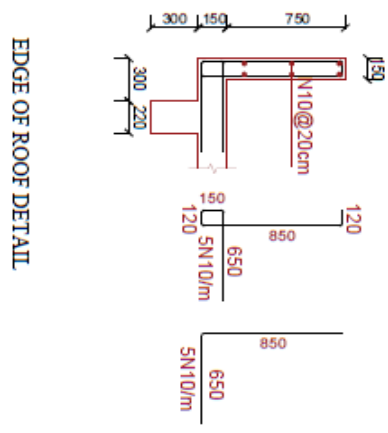
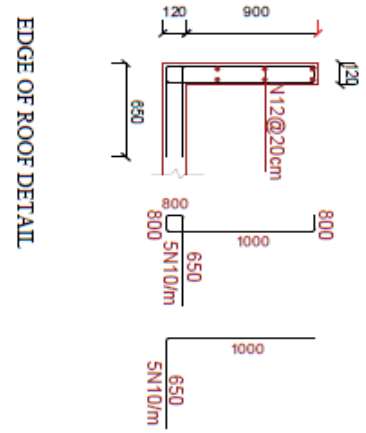


sec A-A (40X40)



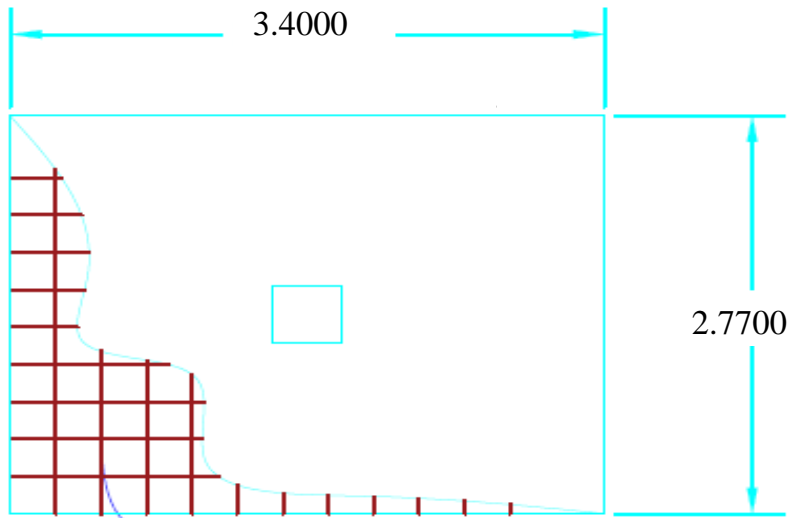
# Appendix-F

## Stairs Reinforcement Plan



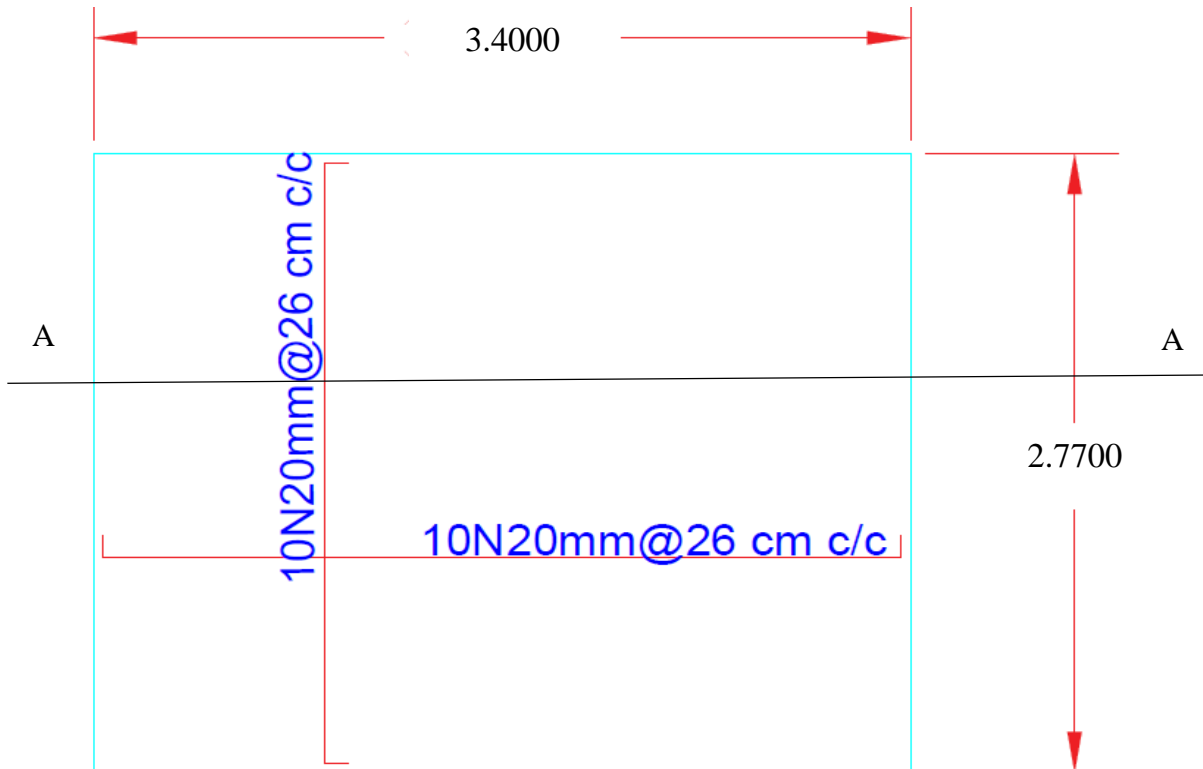
# Appendix-G

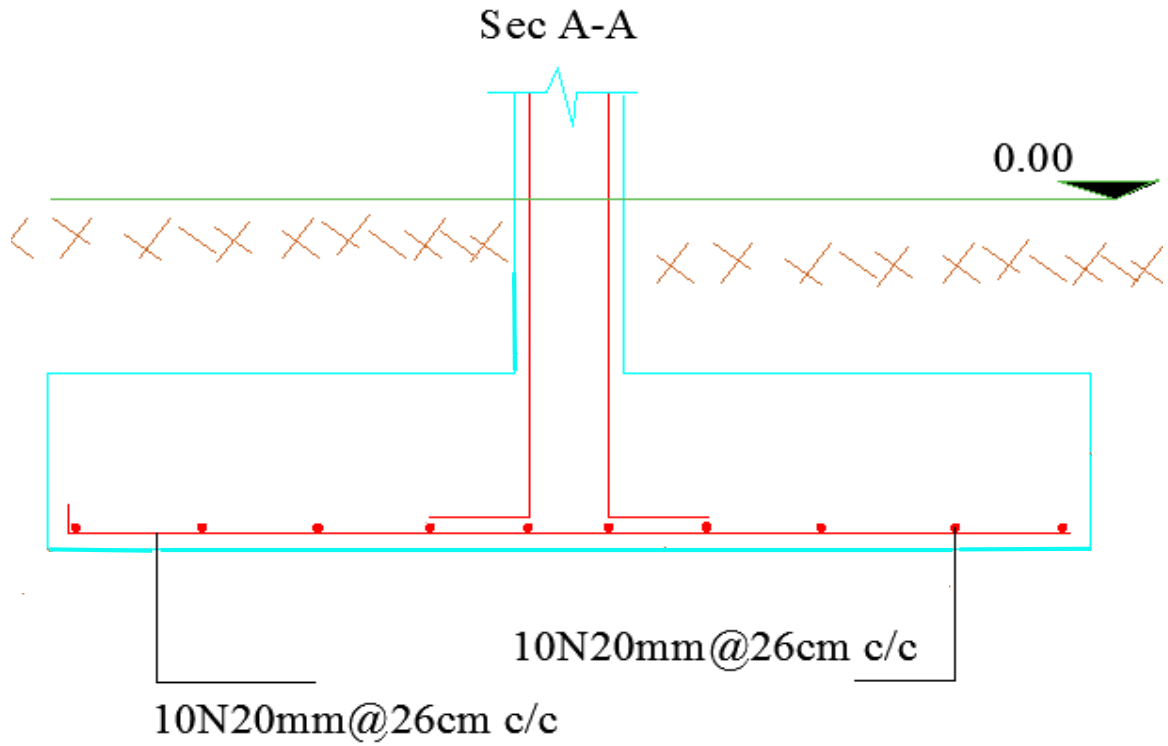
## Footings Reinforcement Plans



Foundation Plan

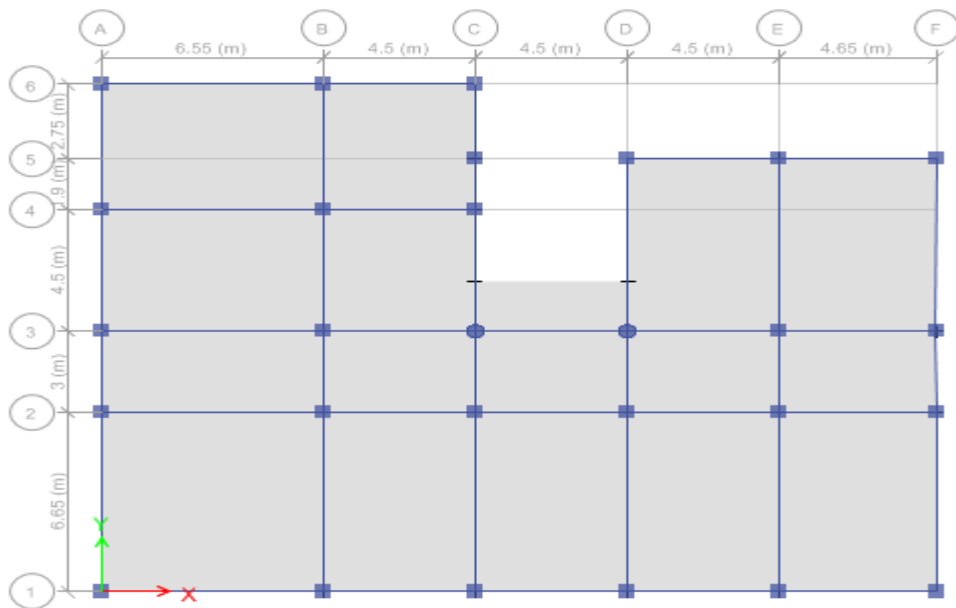
10N20mm@26 cm c/c

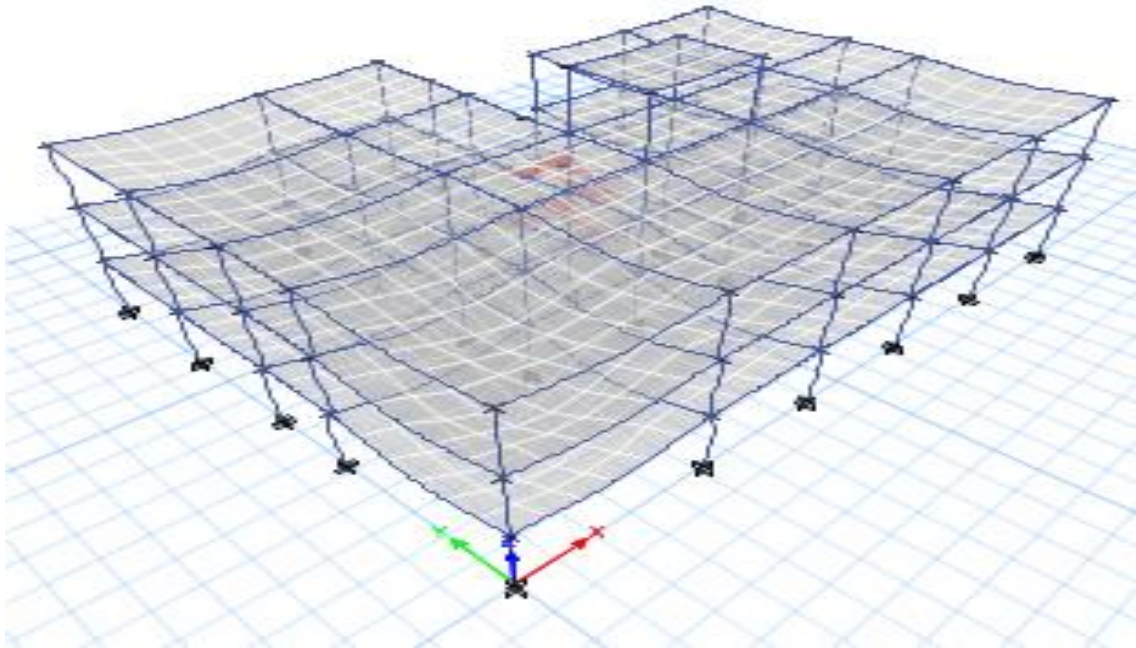




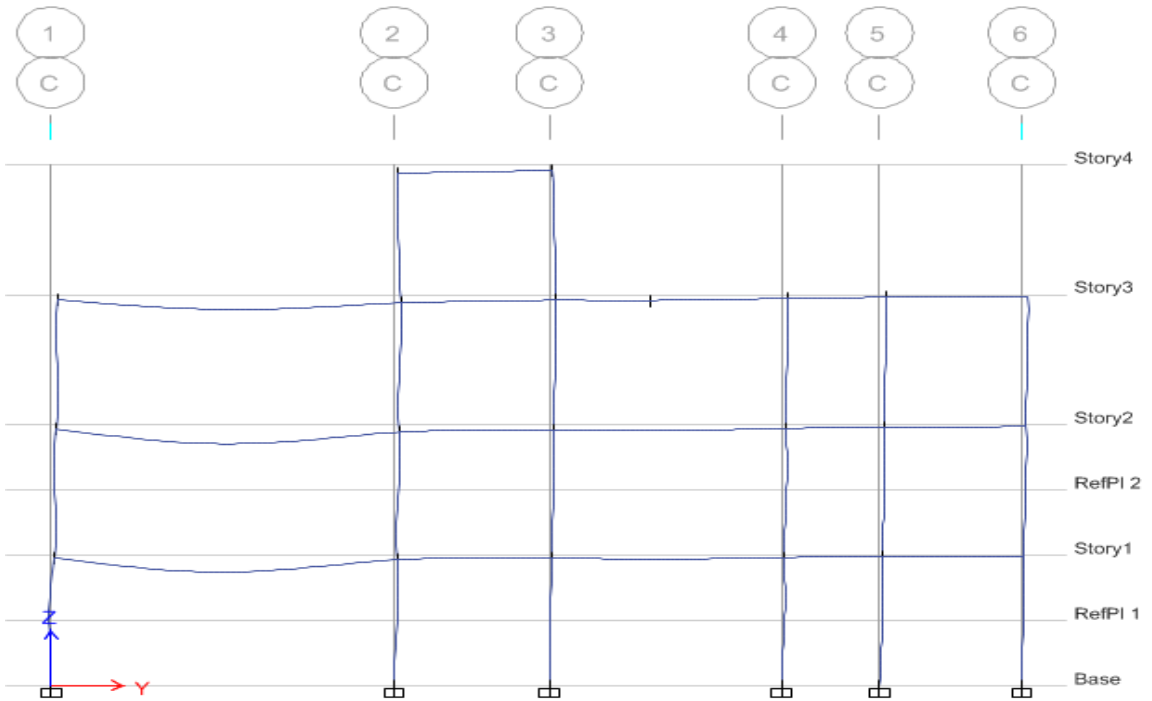
**Appendix-H**  
**Analysis and Design Results by Software**

**Frame 3D Elevation**

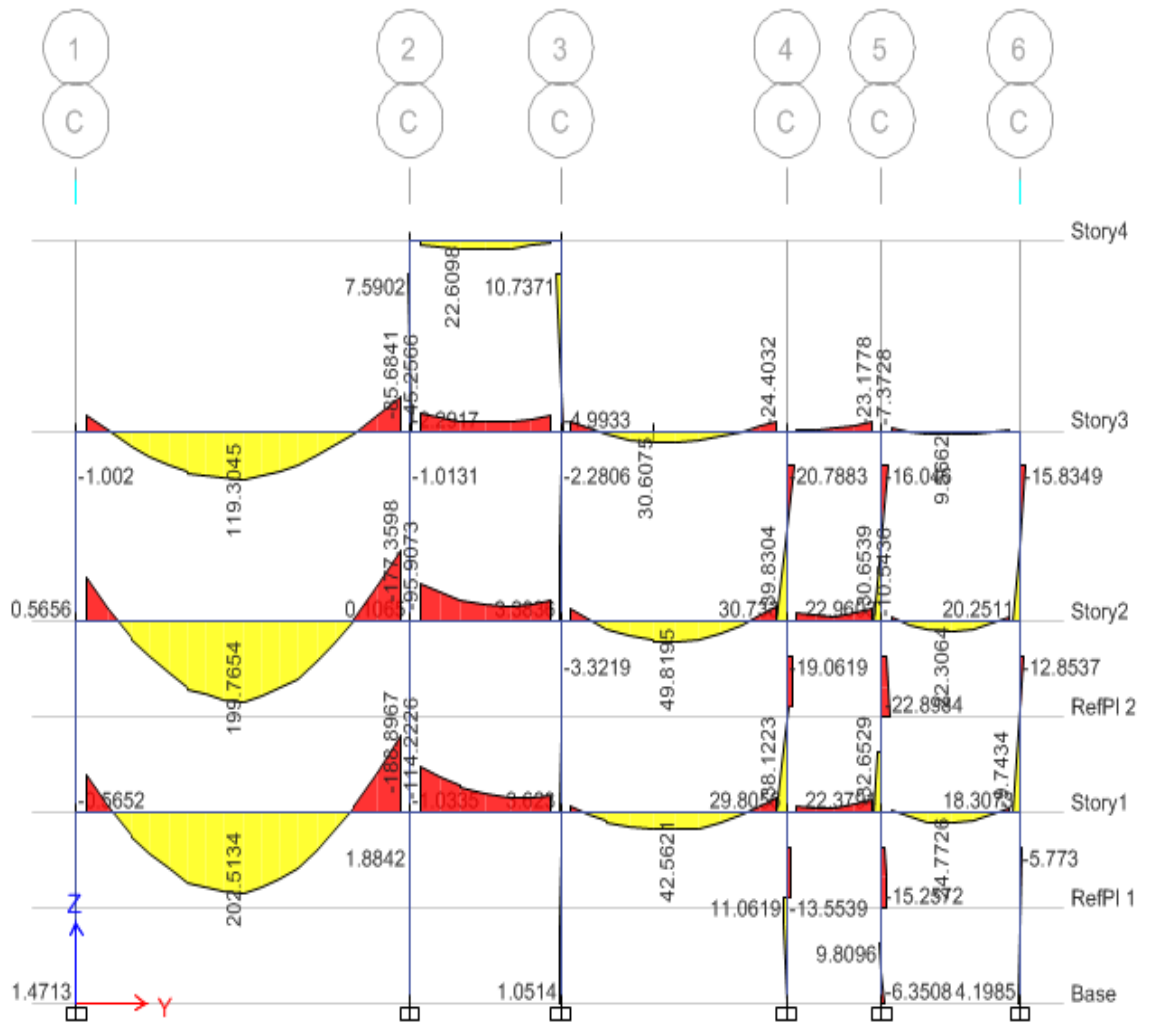




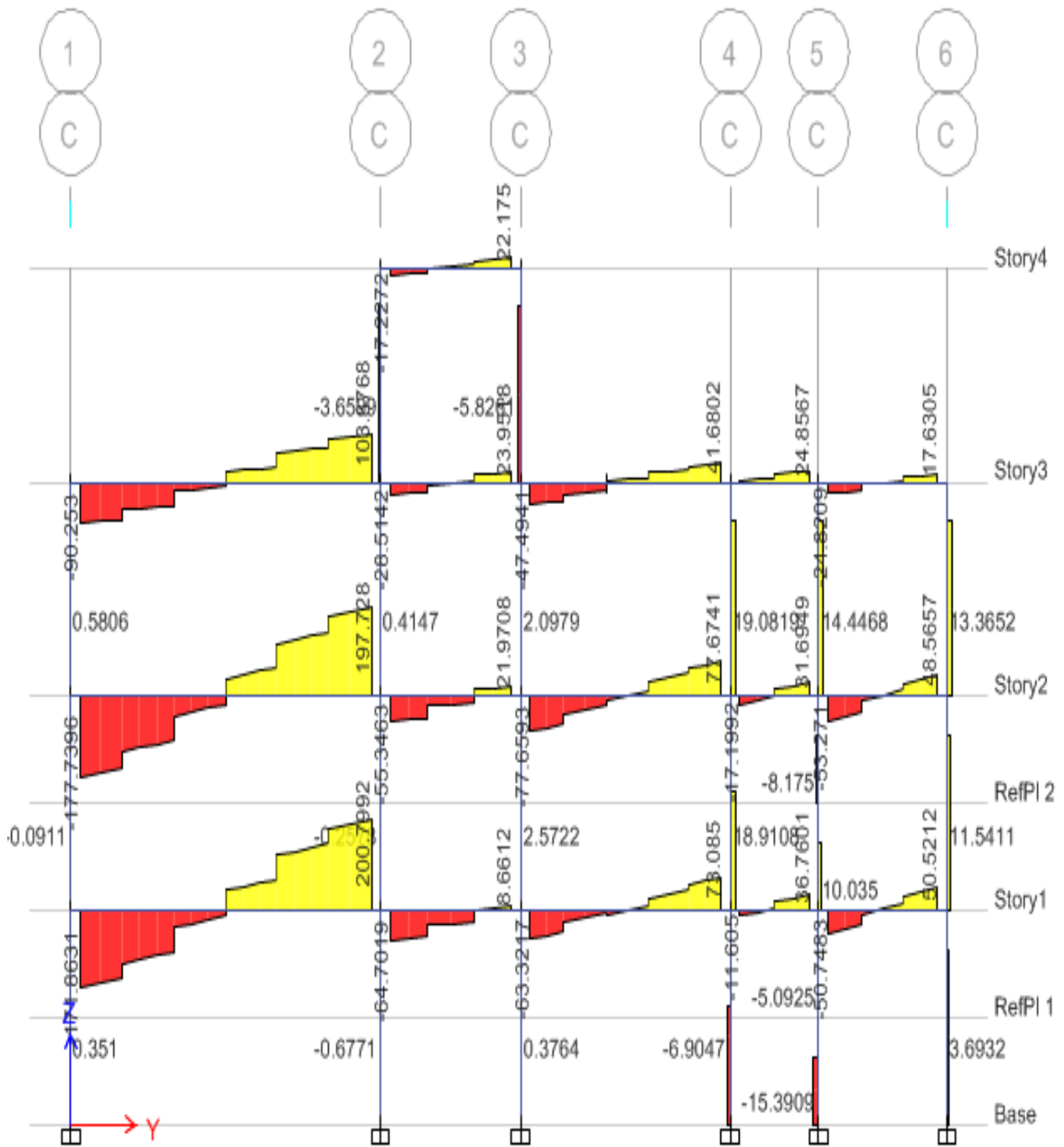
Displacements (Y-Y)



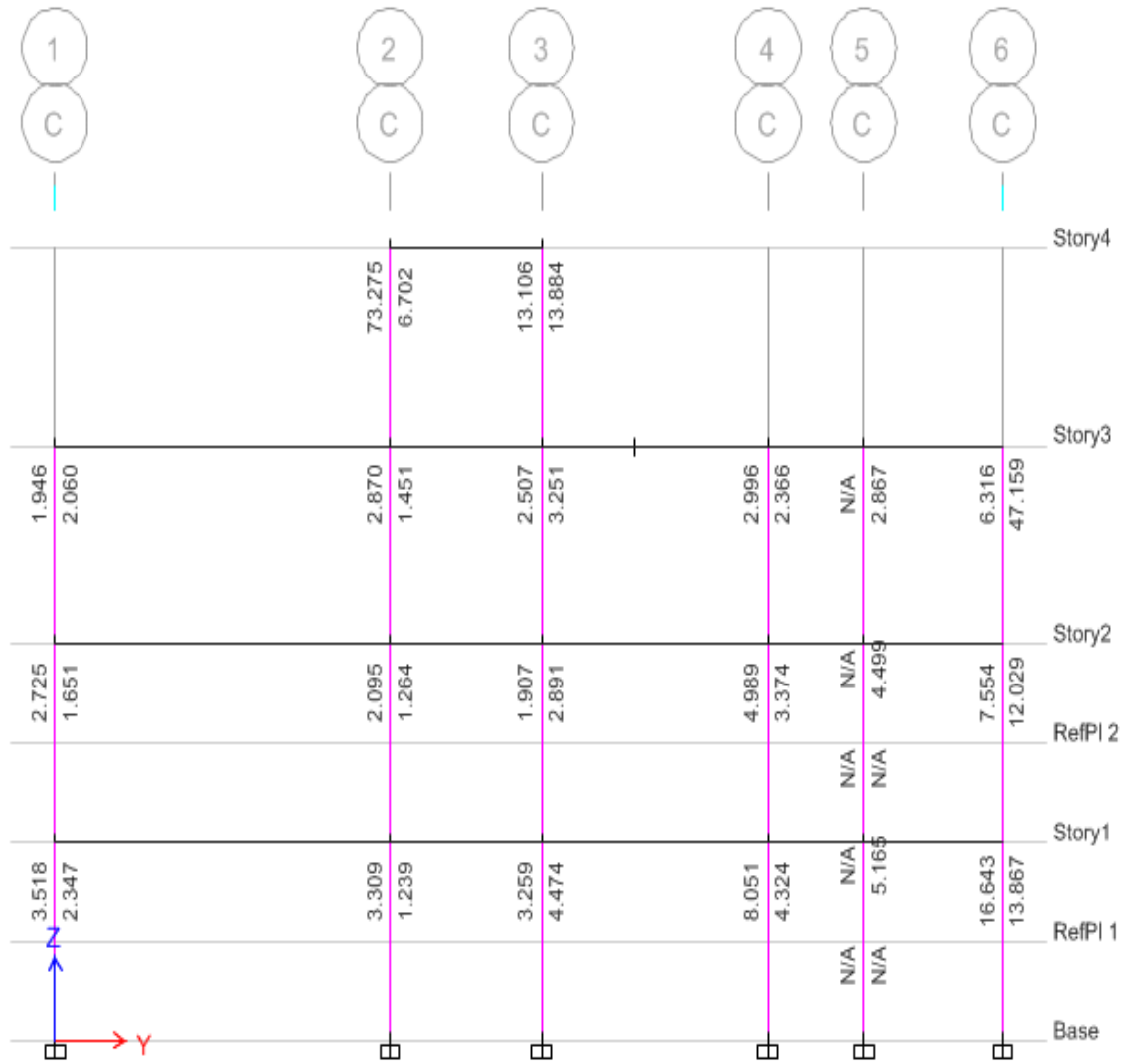
Elevation Displacements (Y-Y)



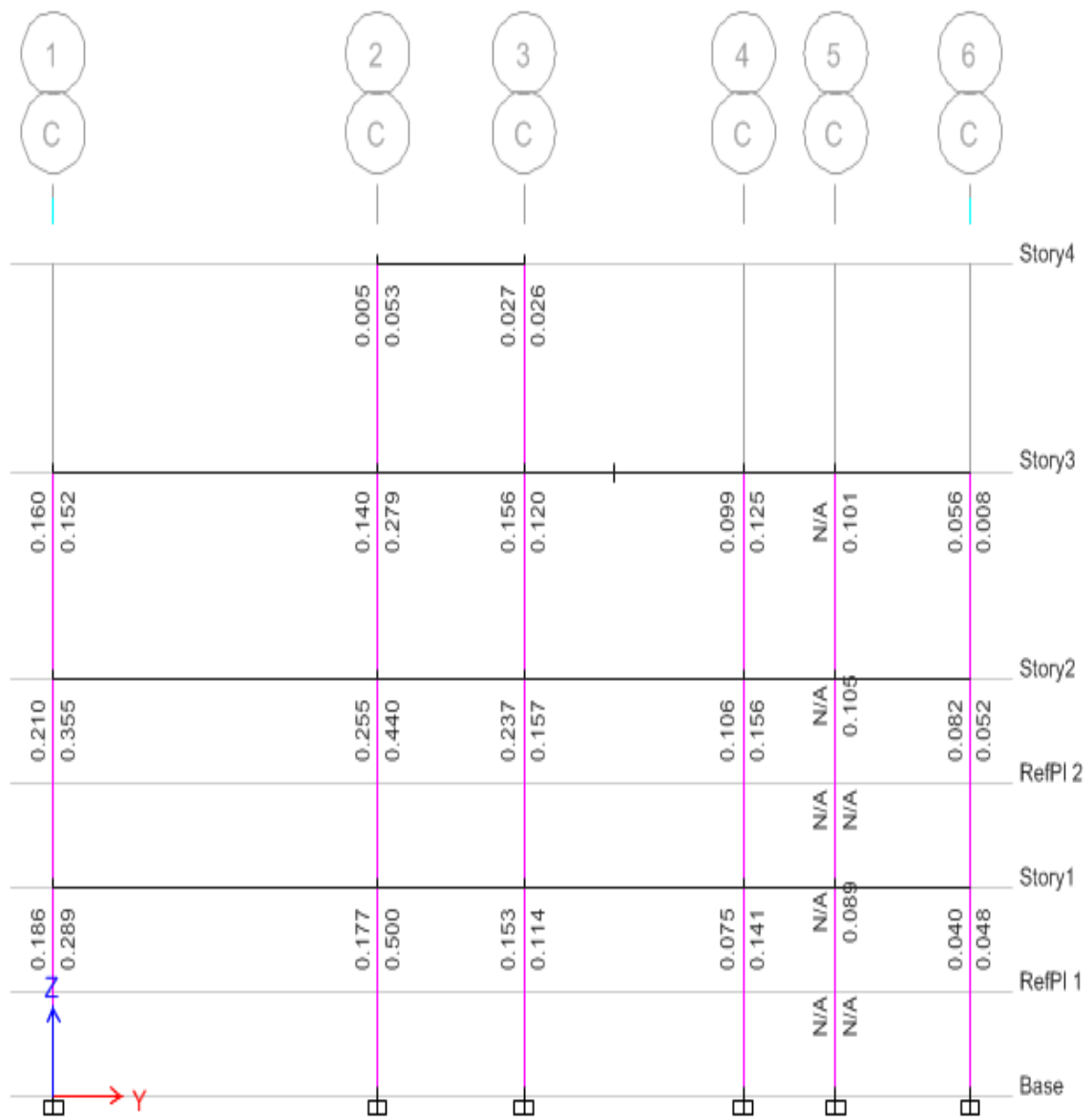
**Moment Diagram**



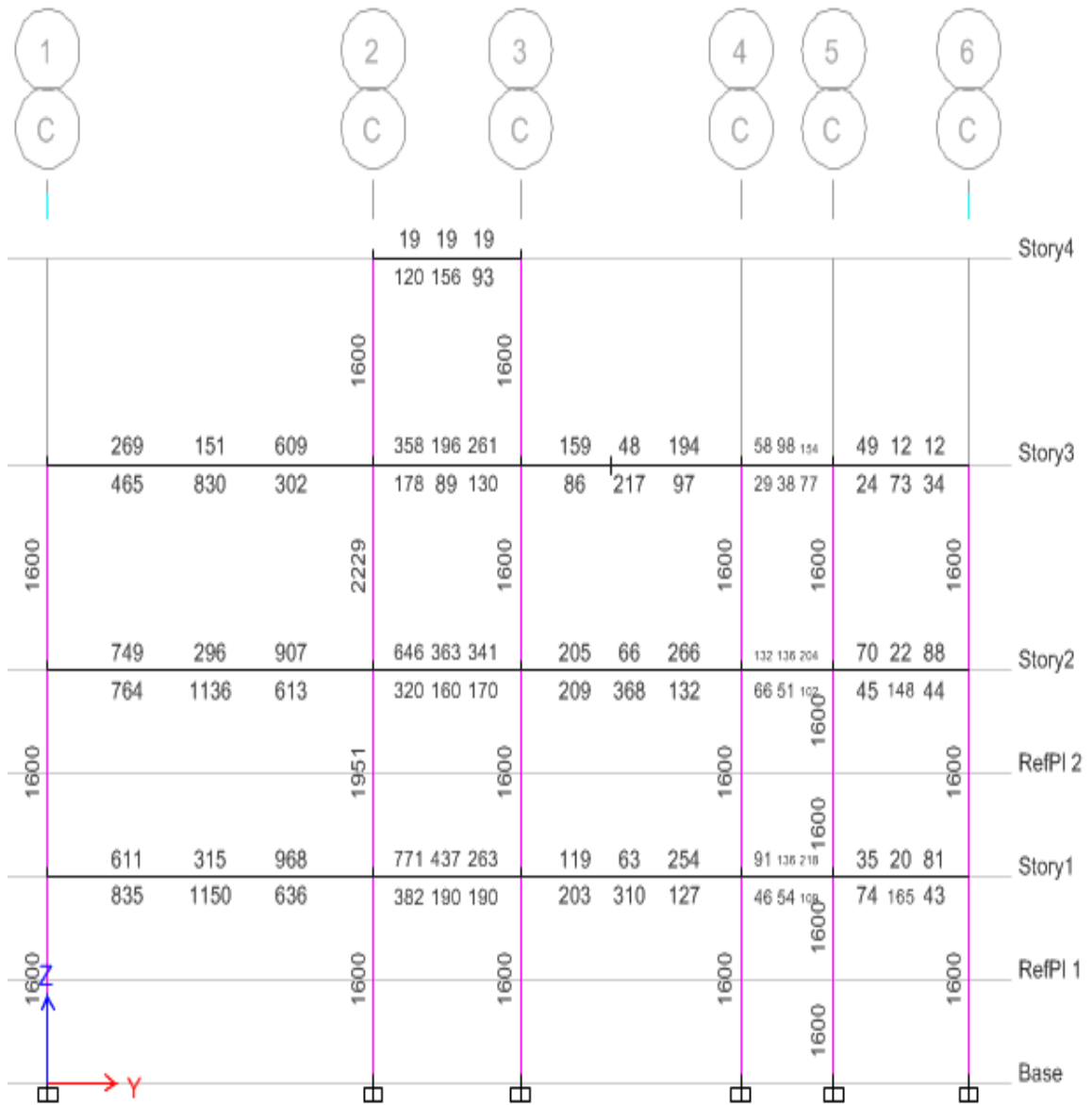
**Shear Diagram**



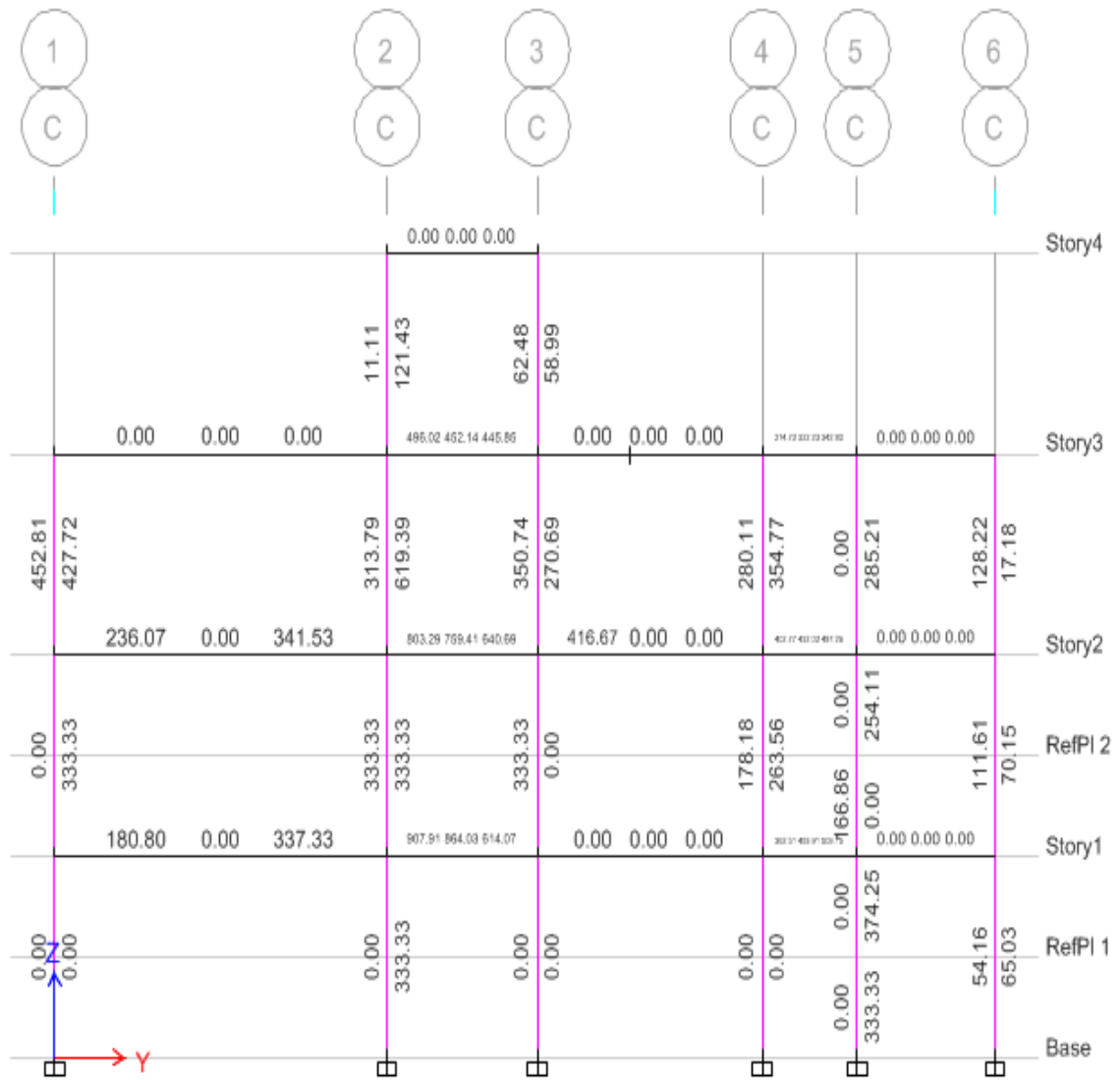
Column/Beam Capacity ratios



**Joint Shear capacity ratios**

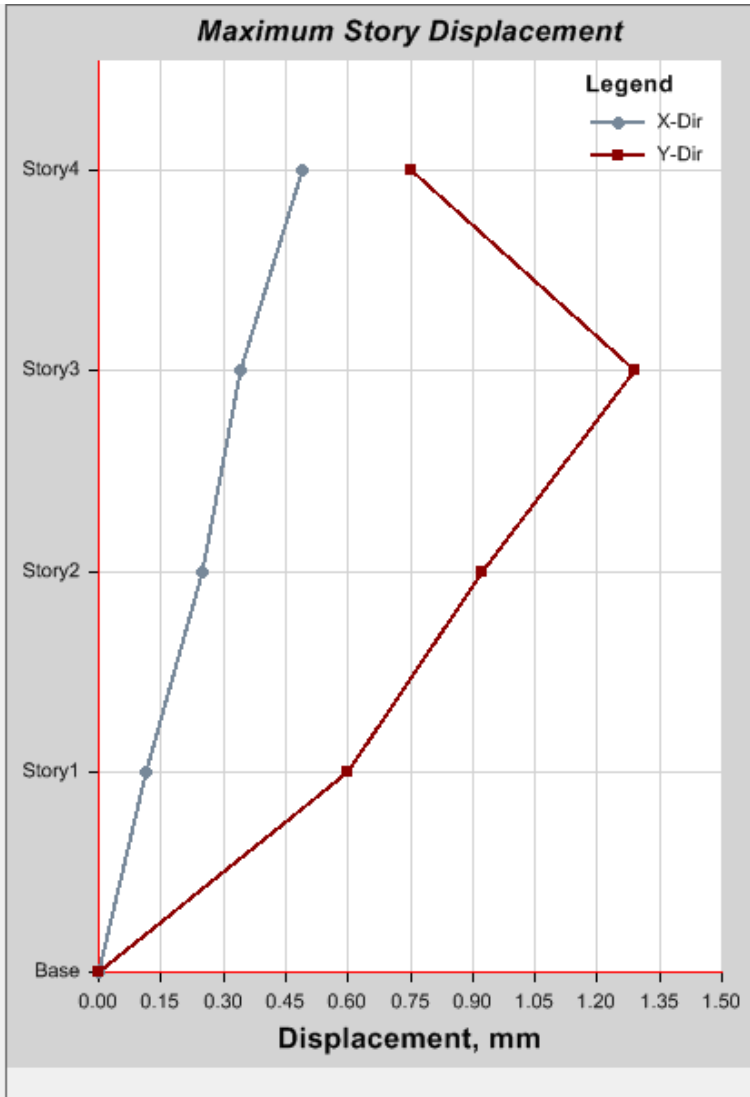


**Elevation View-Longitudinal Reinforcing**



**Elevation View-Shear Reinforcing**

<b>Name</b>	
Name	StoryResp 1
<b>Show</b>	
Display Type	Max story displ
Case/Combo	Comb 1
Load Type	Load Combination
<b>Display For</b>	
Story Range	All Stories
Top Story	Story4
Bottom Story	Base
<b>Display Colors</b>	
Global X	LightSlateGr
Global Y	DarkRed
<b>Legend</b>	
Legend Type	Integrated



**Global X**  
The plot display color for response in the global X direction.

Maximum Story Displacement (X and Y) direction

