

# **SLAB DESIGN OF A SIX STORIED RESIDENTIAL BUILDING**

**Submitted by:**

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A Thesis Submitted to the Department of Civil Engineering, Daffodil International University in  
Partial Fulfillment of the Requirements for the Degree of

**Bachelor of Science in Civil Engineering**



**Daffodil**  
*International*  
**University**

**October-2021**

The thesis titled “**Slab Design of a Six Storied Residential Building**” submitted by **Md. Tasnimul Hasan Tasin** (171-47-357), **Raihanul Islam** (171-47-372), **Nur Mohammad Riad** (171-47-370), **Nur Mohammad** (181-47-659) in the Department of Civil Engineering, Daffodil International University, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of **Bachelor of Science in Civil Engineering** (Structural) and approved as in its style and contents presentation which has been held on \_\_\_\_\_2021

### **BOARD OF EXAMINERS**

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## APPROVAL

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This is to certify that the thesis entitled “**Slab Design of a Six Storied Residential Building**” submitted by **Md. Tasnimul Hasan Tasin** (171-47-357), **Raihanul Islam** (171-47-372), **Nur Mohammad Riad** (171-47-370), **Nur Mohammad** (181-47-659) in the Department of Civil Engineering, Daffodil International University, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of **Bachelor of Science in Civil Engineering** (Structural) and approved as in its style and contents presentation which has been held on .... 2021



**Ms. Arifa Akther** (Supervisor)  
Lecturer,  
Department of Civil Engineering  
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## DECLARATION

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This is to certify that the thesis entitled “**Slab Design of a Six Storied Residential Building**” submitted to the Department of Civil Engineering Daffodil International University (DIU) in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering is a record of original research work done by us under the supervision of **Arifa Akther**, Lecturer, Department of Civil Engineering, Daffodil International University, and the thesis has not been submitted elsewhere for any award/degree/diploma/fellowship or for any other purpose.



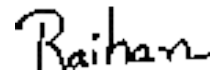
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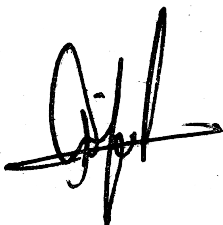
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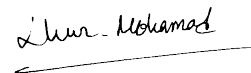
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## **ABSTRACT**

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The report has been written as “Slab Design of a Six Storied Residential Building”. The construction of a six storied building can be divided into several major steps. These stages involve the execution of all works in a professional standard, because a six storied building is a very difficult structure. One of the main tasks during construction is to ensure the safety of residents. The creation of comfortable conditions for people living in the house and providing the maximum convenience in the use of utilities in the house is also important.

The fundamental method followed right here is the sequential presentation of analysis & design of all forces of six storied constructing for earthquake and wind impact with the aid of using UBC 1994, BNBC, and ACI code proposed locations in Bangladesh. For this cause Dhaka metropolis has been selected. Data & Figure are supplied wherever felt vital in reader pleasant way. Analysis and layout has been completed with ETABS.

After analysis and design of the slab of a six-storied building in Dhaka we gained practical knowledge of design software ETABS and found out how the wind and earthquake loads affect the structure.

## **ACKNOWLEDGEMENT**

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At first, we wish to express all the praises sincerely to the Almighty ALLAH who has enabled us to complete the work with the sound condition. We like to express our sincere gratitude and profound indebtedness to our honorable supervisor Ms. Arifa Akther, Lecturar, Department of Civil Engineering, Daffodil International University (DIU), for her constant supervision, encouragement, and contribution of new ideas throughout this work. Without her invaluable supervision and cordial cooperation, it would have been impossible to complete this work under various constraints, including time constraints. Again, it was a great privilege to work under her supervision because her keen interest made it possible to accomplish the study. We are also grateful to Dr. Mohammad Hannan Mahmud Khan, Department Head of Civil Engineering, Daffodil International University, and Ms. Arifa Akther, Lecturer, Department of Civil Engineering, Daffodil International University Bangladesh, for the contribution of guidance throughout this study.

## **DEDICATION**

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We hereby declare that this is an original report written by us with our own findings and has not been published or presented in parts or as a whole for any other previous degree. Resources and materials by other researchers used as guidelines for our research.

## NOTATIONS

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LL	Live Load
DL	Dead Load
EQL	Earthquake Load
WL	Wind load
RCC	Reinforcement Cement Concrete
Psi	Pound per Square Inch
Psf	Pound per Square feet
BNBC	Bangladesh National Building Code
ASTM	American Standard for Testing Material
FF	Geographical Information System
PW	Partition Wall
AI	Artificial Intelligence
ACI	American Concrete Institute
UBC	Uniform Building Code
ETABS	Extended Three Dimensional Analysis of Building System
MS	Microsoft Office

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## **CHAPTER-I: INTRODUCTION**

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### **1. 1 Introduction:**

Shelter is one of important human survival needs which provides safety. In order to provide an economic & efficient shelter with provision of future, there are some basic procedures for an engineer to consider in a Structural Design. It is generally believed that only receiving training in a special design skill is not sufficient for successful professional practice. As new researches available and constantly introducing new design methods, the design programs are changing frequently. Understanding these rewarding developments, and in order to safely engage in innovative designs, engineers transparent grounding is required in terms of conversion and basic performance to build houses safely, economically and efficiently.

### **1. 2 Background of the Study:**

A new surge of activity within the construction of tall buildings has taken place within the previous couple of years. Although there are many advancements in building construction technology generally. One spectacular achievement are made in the design and construction of high-rise-buildings. The first development of high-rise buildings began with steel framing; ferroconcrete has since been economically and competitively utilized in variety of structures for both residential and commercial purposes. The newer high-rise buildings starting from 50 to 110 stories and now being built everywhere the US, are the results of very recent innovations and development of latest structural systems. Greater height entails increased column and beam sizes to form buildings more rigid in order that under wind load they're going to not sway beyond a suitable limit. Excessive lateral sway may cause serious recurring damage to partitions, ceilings and other architectural details. Additionally excessive sway may cause discomfort to the occupants of the building due to their perception of such motion.

New structural system of ferroconcrete, also as steel, take full advantage of the inherent potential stiffness of the entire building and thus don't require additional stiffening to limit the sway. In a steel structure, for example, the economy is often defined in terms of the entire average quantity of steel per square foot of floor area of the building. The typical unit weight of a standard frame with increasing numbers of stories. The gap between 2 the upper boundary and therefore the lower boundary represents the premium for height for the normal column and beam frame. Within the previous couple of years structural engineers have developed new structural systems with a view to eliminating this premium. Structural steel is widely utilized in buildings in developed countries. The development of improved construction techniques and constant improvements in methods of production and fabrication have rendered its use virtually limitless. Reinforced concrete frames are universally used for construction of medium to high-rise buildings. The event of improved construction techniques has made it possible to construct a high-rise building less costly both in time and money.

The development techniques being widely utilized in high-rise reinforced concrete buildings are:

- Lift Slab technique
- Slip-form construction technique
- Prefabricated construction
- Tilt-up construction
- Drop-slab construction
- Composite construction technique

In Bangladesh, reinforced embodied construction is semi mechanized.

Reinforcement slicing and catch are committed manually, concrete mixing is generally done by the usage of mixer machine; figured holding above in conformity with four storied heights are performed manually then upon it height figured is generally carried by hoist or pitcher and hoist.

Fabricated type scaffolding regarding metal tubes are extensively back whole upon the world. In Bangladesh bamboo and wood scaffolding are still being used. For shuttering wooden planks and steel sheets have observed large application. At present slip forms, current types etc. are being efficaciously used for concreting. Finishing about reinforced might also stand plastered finish. Formed finish is used into high-rise buildings then additionally within mean in imitation of medium upward push constructions. The present job is involved with the education regarding excessive upward shove constructing development practice in Bangladesh. It consists of the learning concerning construction method existence followed, the government on mechanization of development industry or strategies then methods of building of use. This type regarding discipline is useful for evaluating the state of excessive upward shove building industry together with its shortcomings then scope about development.

### **1. 3 Objective:**

- Doing overall analysis, modeling and design over the building for structural analysis.
- To achieve a practical knowledge on structural analysis, modeling, slab design and detailing of structural components using advanced software such as ETABS.

### **1. 4 Scope of Study:**

The main scope of this study was to gain knowledge about structure designing using advanced designing software such as ETABS and AutoCAD. The focus of this study was to concentrate on how to design two-way slab system in a structure considering lateral loads (i.e. wind load and earthquake load).

## **1. 5 Limitations**

- Analysis of the structure consists of multiple stages and factors. For concrete, no effects out of creep, contraction then temperature outcomes have been analyzed.
- The concrete hold also been viewed uncrack.
- Due to shortage of time no comparison amongst similar structures were done.
- Only the design of two-way slab was completed in this study

## CHAPTER-2: REVIEW OF LITERATURE

---

### 2. 1 RCC Frame Structure:

Reinforced cement concrete, or RCC, contains steel bars, called reinforcement bars or rebars. This combination works well since concrete is solid in compression, is easy to construct on-site, and is relatively inexpensive, and steel is quite strong in tension. The load is transported from a slab to the beams, the columns, the lower columns, and lastly to the foundation, which transfers it to the soil in an RCC-framed structure. The walls in such structures are built after the frame has been completed. The primary assignment of the structural engineer is the plan of structure. From the structure, the architect's essential goal of this proposition is to disperse data on the most recent ideas, strategies, and plan information to underlying specialists locked in the plan of wind and seismic-safe structure. Fundamental to the proposition are ongoing advances in seismic plans, especially those identified with structures in zones of low and moderate seismicity. Wind – and tremor Resistant incorporates the plan parts of steel, cement, and composite structure inside a solitary book. The taller is the structure, the more essential it is to pick a proper primary framework. A significant thought influencing the underlying framework is the capacity of the building. Current places of business call for enormous open spaces that can be partitioned with lightweight dividing to suit the individual occupant's requirements.

Subsequently, principle vertical parts are by and large organized, beyond what many would consider possible, around the edge of the arrangement and inside in-bunch around the lift, mix, and administration lifts. The floor regions between the outside and inside segments, leveling huge segment free region accessible for office arranging. The administrations are disseminated evenly in every story over the parceling and are usually covered in roof space. The additional profundity needed by this space causes commonplace story tallness in a place of business to be 3000 mm or more. A significant advance forward in fortified solid tallness rise underlying framework comes with the presentation of vertical dividers for opposing level burden. This is the first to progress critical improvements in the prior arrangement of tall solid buildings liberating them and level plate framework. The advancement and refinement of these new frameworks, along with the improvement of higher strength concrete, has permitted the stature of solid structure to reach inside development comes from the wide accessibility of strengthening bars and the constituents of solid, stones, sand, concrete.

## **2. 2 Dead Loads**

The weight of a building's structural parts, such as beams, walls, roof, and structural flooring components, are examples of dead loads, also known as permanent or static loads. Permanent non-structural dividers, immovable fixtures, and even built-in cupboards can all be considered dead loads. The term "dead load" refers to weights that do not fluctuate significantly over time, such as the weight of

- All permanent components of a building, such as walls, beams, columns, flooring material, etc.
- Fixed permanent equipment and fittings that are a structural component (Like plumbing, HVAC, etc.)
- The dead loads are determined based on the member sizes and material densities considered.

### **2. 3 Live Load**

The downward force acting on the building is caused by the anticipated weight of the occupants and their belongings, including furniture, books, and so forth. These loads are typically stipulated in building codes, and structural engineers must design buildings to withstand these or higher loads. These loads will vary depending on the purpose of the space, such as residential, office, or industrial, to mention a few. Codes often demand residential live loads to be around 200 kg/m<sup>2</sup>, workplaces to be 250 kg/m<sup>2</sup>, and industrial to be 1000 kg/m<sup>2</sup>, which is the same as 1T/m<sup>2</sup>. These live loads are also known as forced loads.

### **2. 4 Floor Live Load**

Floor live loads are critical in building structural design. A good understanding of loading intensity is required for the economical and safe design of structures. In practice, the defined design load values in design codes are not necessarily the same. Such loads shall be taken as the minimum of live loads per square foot of pounds. Horizontal rejection to be included in the construction design for the specified occupancies, for uses not mentioned in this section but that is not listed in this section, and loads at least equivalent are considered to be it provides or accommodates comparable loadings

### **2. 5 Wind Loads**

This is a critical design consideration, particularly for tall buildings or structures with an enormous surface area. Buildings are constructed to withstand extreme wind conditions that may occur once every 100 years rather than everyday wind conditions. These are known as design wind speeds and are required by construction codes. A building is frequently required to withstand a wind force of 150 kg/m<sup>2</sup>, which can be a significant force when multiplied by the building's surface area.

## **2. 6 Earthquake Loads**

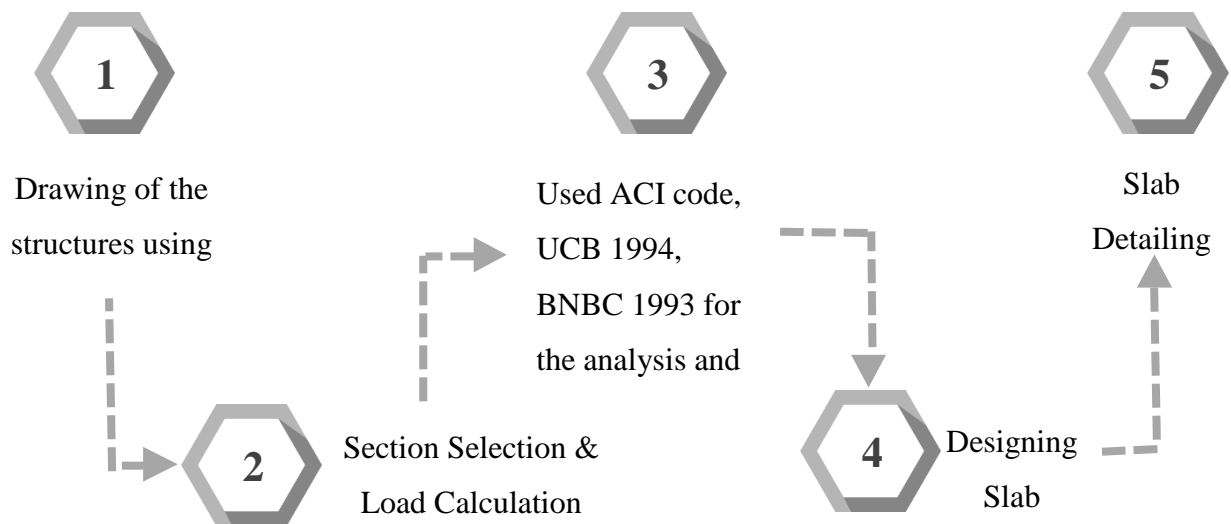
During an earthquake, the Earth violently shakes the building horizontally and vertically, much like a bucking horse shakes a rider in the rodeo sport. This has the potential to cause the structure to collapse. The higher the force on the building, the heavier it is. It is vital to note that wind and earthquakes apply horizontal forces to the building instead of vertical gravity forces.

## CHAPTER 3: METHODOLOGY

### 3.1 General

We have used ETABS as a Design & Analysis software. We maintained the design code as per ACI, BNBC and UBC code for calculation. Our required building was selected and its plan & elevation were drawn on ETABS software. All loads (including Wind and Earthquake) have been calculated on all beams & columns. As our proposed building locate in Dhaka we used the coefficients and all other variables as per the requirement for Dhaka zone. We have done several comparisons to check all the variations.

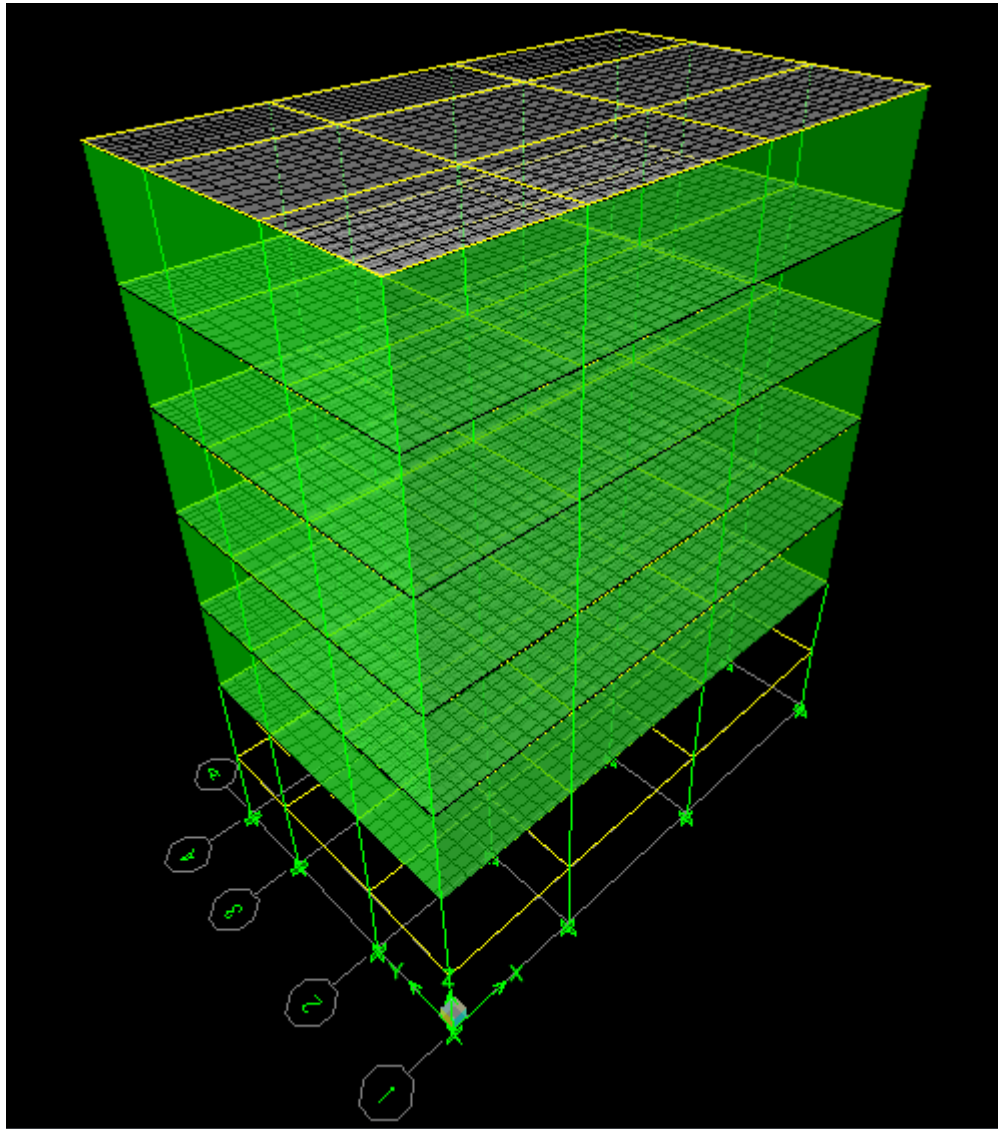
### 3.2 Work Follows Chart



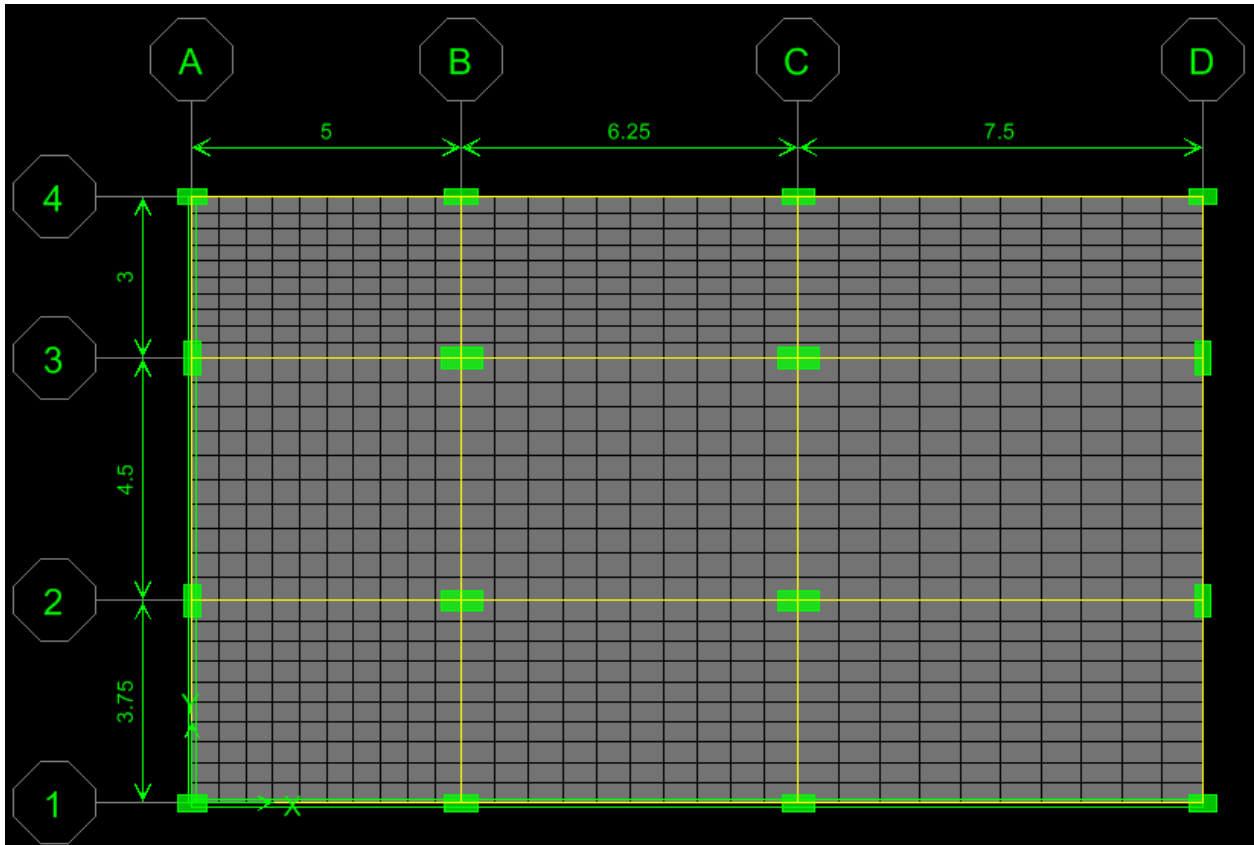
**Fig 3.2. 1:** Flow chart

## CHAPTER 4: ETABS MODELLING & LOAD CALCULATION

### 4. 1 ETABS Model:



**Fig 4.1. 1:** 3D View of the structure



**Fig 4.1. 2:** ETABS model Plan View

**X-Direction:**

A-B= 5m, B-C= 6.25m, C-D= 7.5m

**Y-Direction:**

1-2= 3.75m, 2-3= 4.5m, 3-4= 3m

## 4. 2 LOADS APPLIED ON THE MODEL:

### 4.2. 1 Gravity Loads:

Here are the loads due to gravity that were applied to the structure

Loads	
LL	3 KN/m <sup>2</sup>
PW	2.5 KN/m <sup>2</sup>
FF	1.5 KN/m <sup>2</sup>

### 4.2. 2 Wind Loads:

Here are the calculations for wind load at our 6 storied structure:

From BNBC 1993 we get,

Exposure condition	Basic wind speed, $V_b$	Velocity to pressure co-efficient, $C_e$	Structural importance co-efficient $C_i$	Sustained wind pressure $q_z$	Gust co-efficient $C_g$	Pressure, $P_{z-x}$	Pressure, $P_{z-y}$
A	210 km/h	$47.2 \times 10^{-6}$	1	$2.0815 C_z$ KN/m <sup>2</sup>	1.393	$3.5896 C_z$ KN/m <sup>2</sup>	$4.4160 C_z$ KN/m <sup>2</sup>
	130.52 mph						

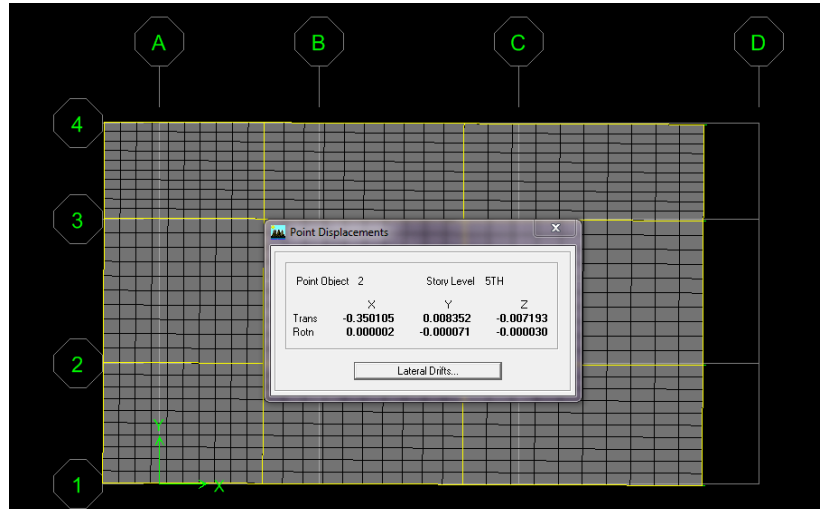
Wind direction-X	Wind direction-Y
B= 11.5m	B= 19m
L= 19m	L= 11.5m
h= 17.5m	h= 17.5m
L/B= 1.65	L/B= 0.61
h/B= 1.52	h/B= 0.92
$C_p= 1.238$	$C_p= 1.523$

**WL calculation for 6 storied structure:** the calculation was done using BNBC 1993 (Section 2.4)

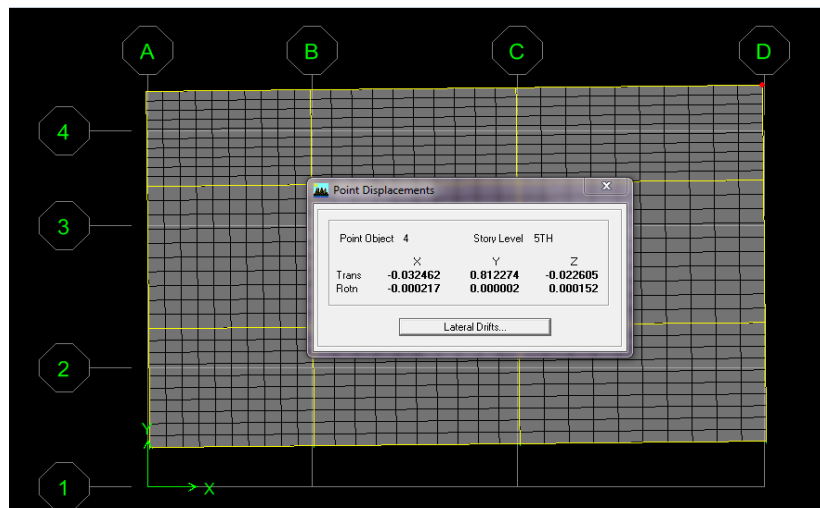
Table 4.2. 1 : WL calculation for 6 storied structure										
Wind pressure calculation			X-dir				Y-dir			
Floor	Height (m) from GL	Cz	P <sub>z-x</sub> (KN/m <sup>2</sup> )	Area (m <sup>2</sup> )	Floor level force (KN)	Floor level force (kip)	P <sub>z-y</sub> (KN/m <sup>2</sup> )	Area (m <sup>2</sup> )	Floor level force (KN)	Floor level force (kip)
1F	3.5	0.368	1.321	40.250	53.169	11.952	1.625	66.500	108.068	24.294
2F	7	0.442	1.587	40.250	63.861	14.356	1.952	66.500	129.799	29.179
3F	10.5	0.531	1.906	40.250	76.720	17.247	2.345	66.500	155.936	35.054
4F	14	0.604	2.168	40.250	87.267	19.618	2.667	66.500	177.373	39.873
Roof	17.5	0.668	2.398	20.125	48.257	10.848	2.950	33.250	98.084	22.049
			Total force along X direction			<b>74.021</b>	Total force along Y direction			<b>150.450</b>

Maximum allowable deflection for 6 floors:

<b>h/500</b>	<b>0.035 m</b>	<b>1.378 in</b>
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**Deflection of our structure due to WX load**



**Deflection of our structure due to WY load**

Deflection of our structure due both WX and WY load was less than maximum allowed deflection. So, our structure design is ok

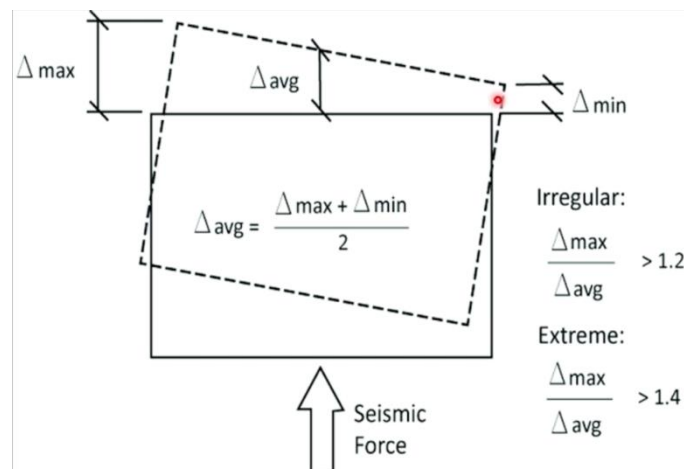
### 4.2. 3 EARTHQUAKE LOAD CALCULATIONS:

The structure was designed for Dhaka. So, according to BNBC 1993:

Earth quake load		
Soil type	S3	S=1.5
Zone	Zone 2	Z=0.15
Importance factor	1	

**EQL calculation:** No manual calculation was done. ETABS was used to apply the load on the structure. The application process was similar to BNBC 1993 (Section 2.5).

And we know,

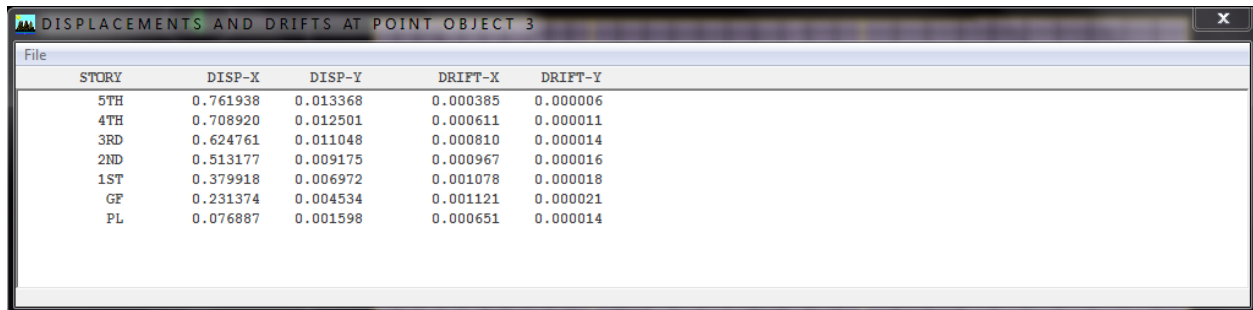


**Fig 4.2. 1:** Torsional Irregularity Check diagram

Now from ETABS we get,

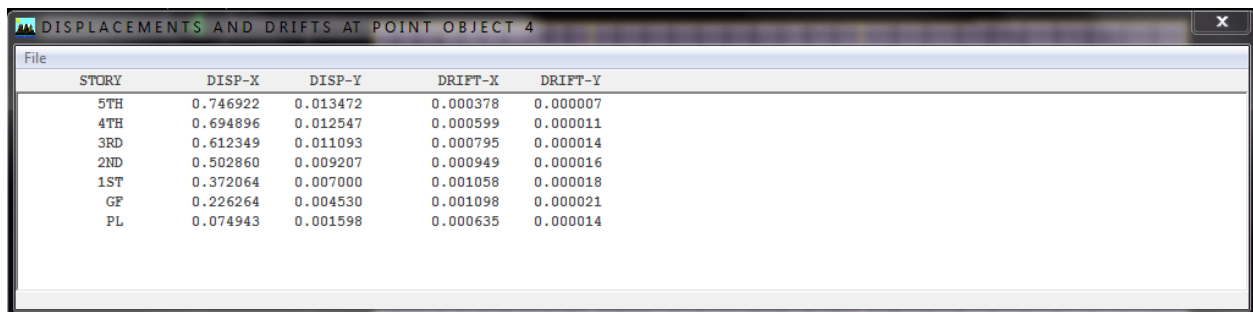
For Earthquake load X direction:

$$\Delta_{\text{Max}} =$$



STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
5TH	0.761938	0.013368	0.000385	0.000006
4TH	0.708920	0.012501	0.000611	0.000011
3RD	0.624761	0.011048	0.000810	0.000014
2ND	0.513177	0.009175	0.000967	0.000016
1ST	0.379918	0.006972	0.001078	0.000018
GF	0.231374	0.004534	0.001121	0.000021
PL	0.076887	0.001598	0.000651	0.000014

$$\Delta_{\text{Min}} =$$



STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
5TH	0.746922	0.013472	0.000378	0.000007
4TH	0.694896	0.012547	0.000599	0.000011
3RD	0.612349	0.011093	0.000795	0.000014
2ND	0.502860	0.009207	0.000949	0.000016
1ST	0.372064	0.007000	0.001058	0.000018
GF	0.226264	0.004530	0.001098	0.000021
PL	0.074943	0.001598	0.000635	0.000014

We will select the deflection value for the top floor so,

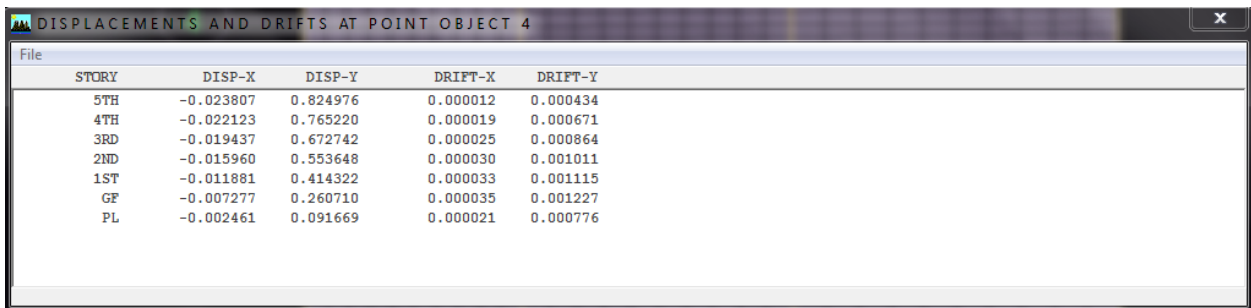
$$\Delta_{\text{Avg}} = (\Delta_{\text{Max}} + \Delta_{\text{Min}}) / 2 = (0.761938 + 0.746922) / 2 = 0.77$$

Now,  $\Delta_{\text{Max}} / \Delta_{\text{Avg}} = 1.03 < 1.2$  so our structure is ok

Now from ETABS we get,

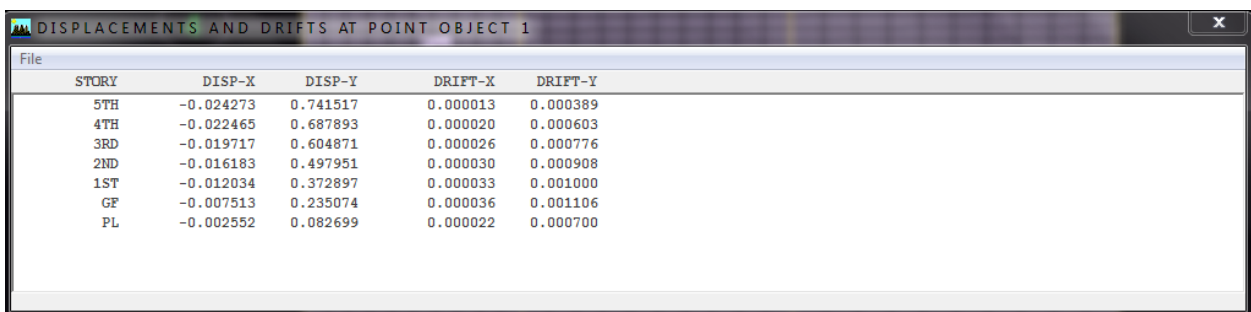
For Earthquake load Y direction:

$$\Delta_{\text{Max}} =$$



STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
5TH	-0.023807	0.824976	0.000012	0.000434
4TH	-0.022123	0.765220	0.000019	0.000671
3RD	-0.019437	0.672742	0.000025	0.000864
2ND	-0.015960	0.553648	0.000030	0.001011
1ST	-0.011881	0.414322	0.000033	0.001115
GF	-0.007277	0.260710	0.000035	0.001227
PL	-0.002461	0.091669	0.000021	0.000776

$$\Delta_{\text{Min}} =$$

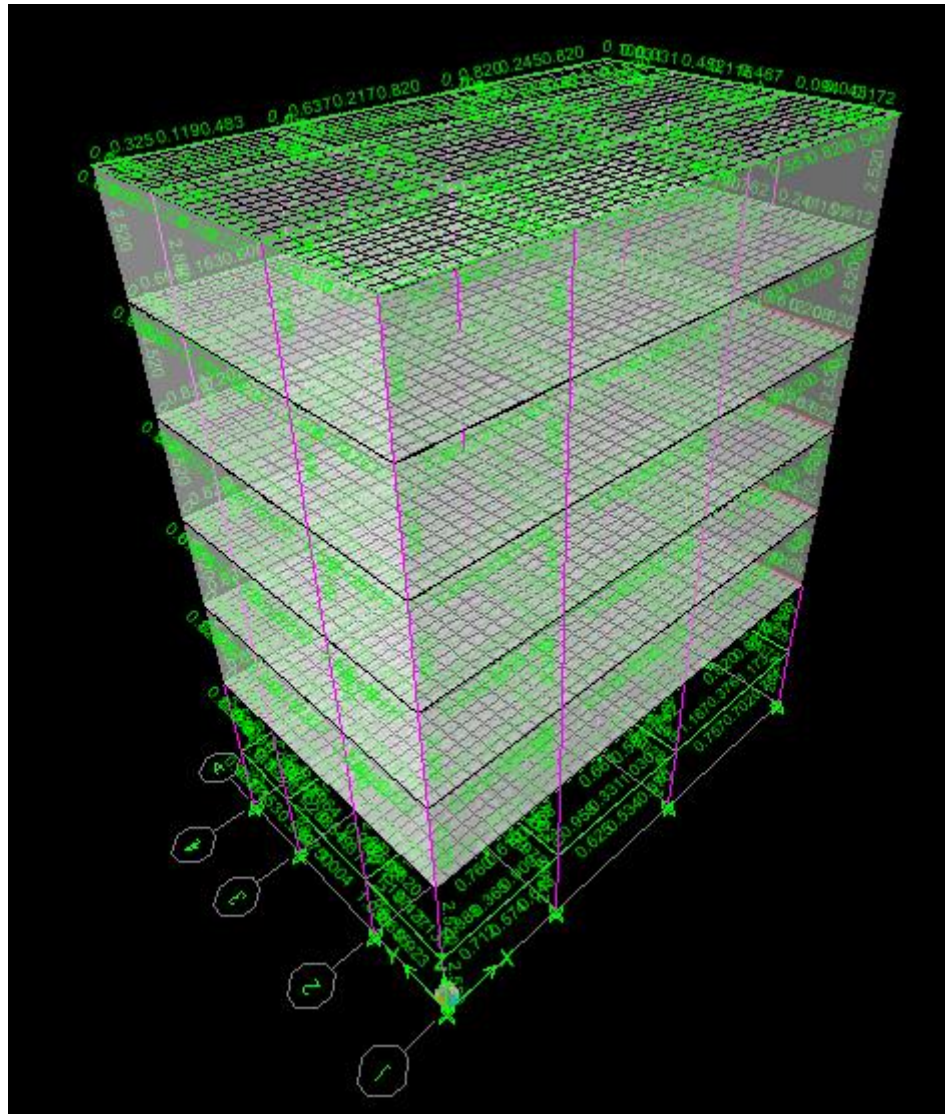


STORY	DISP-X	DISP-Y	DRIFT-X	DRIFT-Y
5TH	-0.024273	0.741517	0.000013	0.000389
4TH	-0.022465	0.687893	0.000020	0.000603
3RD	-0.019717	0.604871	0.000026	0.000776
2ND	-0.016183	0.497951	0.000030	0.000908
1ST	-0.012034	0.372897	0.000033	0.001000
GF	-0.007513	0.235074	0.000036	0.001106
PL	-0.002552	0.082699	0.000022	0.000700

We will select the deflection value for the top floor so,

$$\Delta_{\text{Avg}} = (\Delta_{\text{Max}} + \Delta_{\text{Min}})/2 = (0.824976 + 0.741517)/2 = 0.78$$

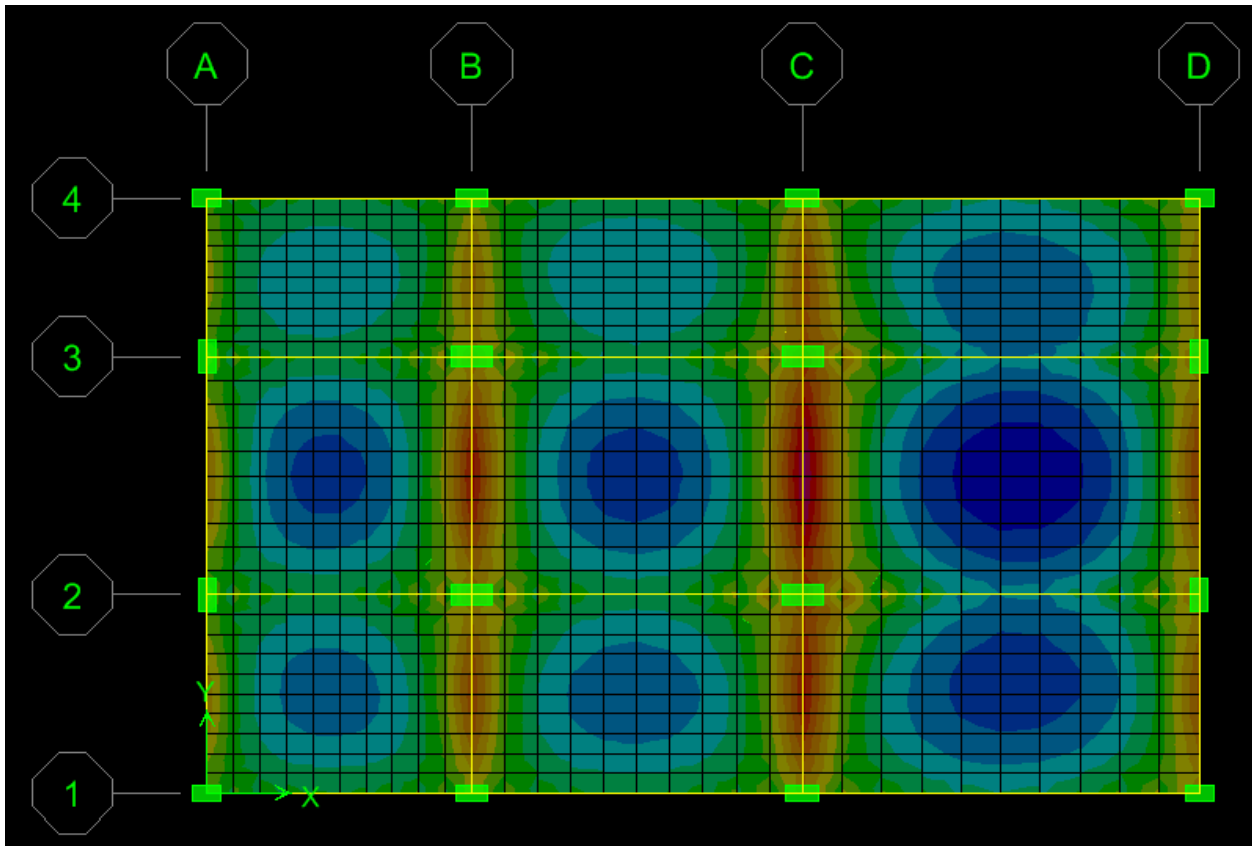
Now,  $\Delta_{\text{Max}}/\Delta_{\text{Avg}} = 1.05 < 1.2$  so our structure is ok



**Fig 4.2. 2 :** ETABS model of 6 storied building with longitudinal reinforcement requirements

## CHAPTER 5: SLAB DESIGN

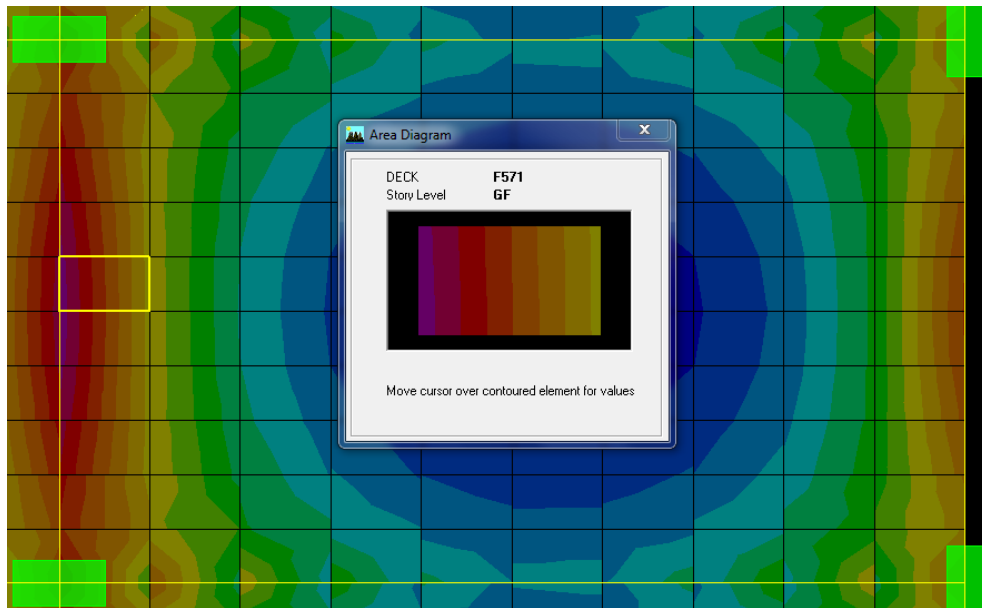
### 5.1 Slab Calculations:



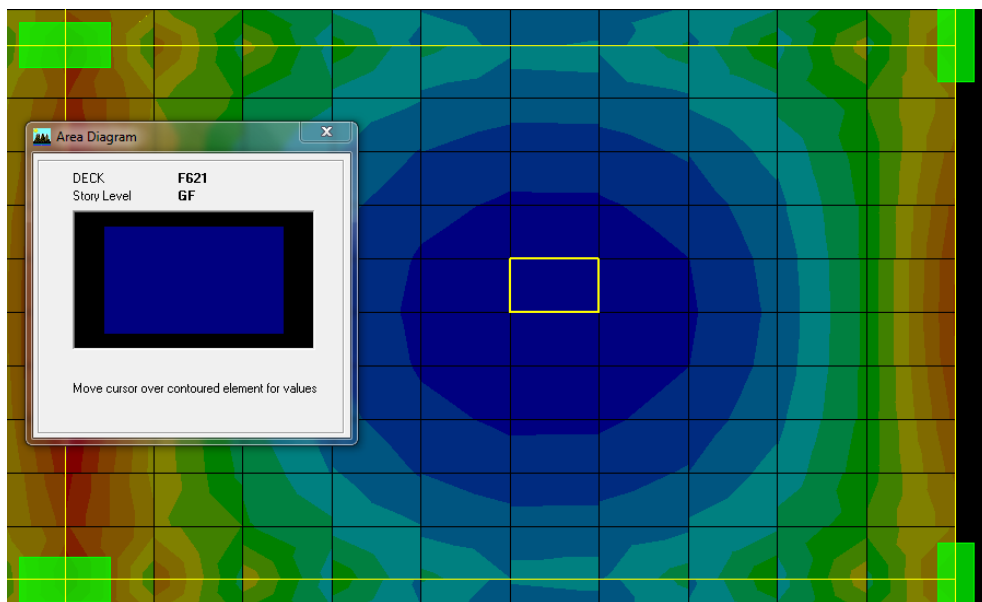
**Fig 5.1. 1: Stress Contour of Slab**

This is the stress contour of slab. The moment values of the slabs were taken from here. The middle blue portion indicates positive moment and the highest positive moment was taken as the design moment. The red portion at the sides are the negative moments and the highest negative moments at the sides were taken as design moments.

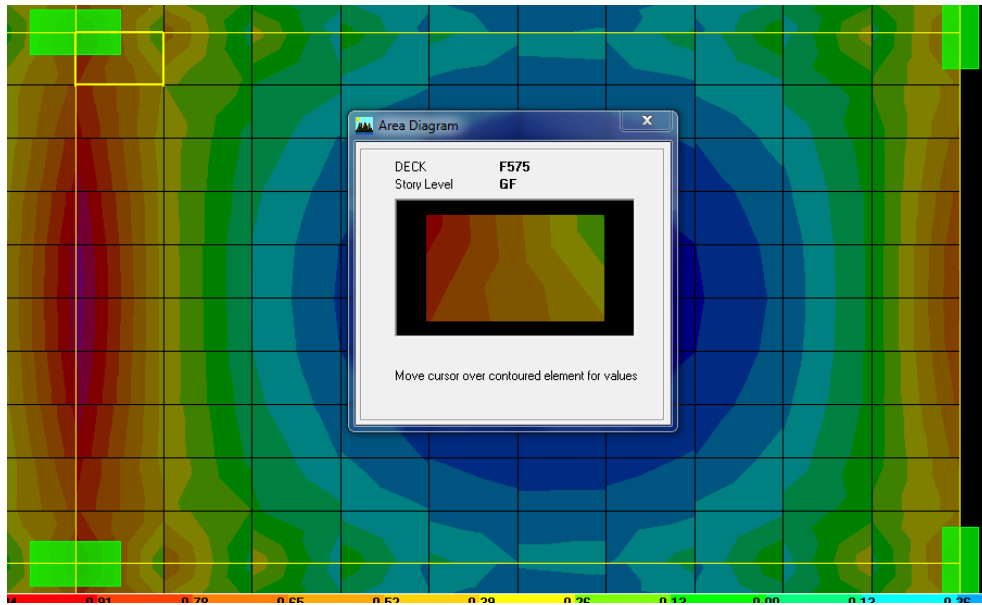
Below the stress figures indicate the process in which we selected the maximum moments for long and short directions of slab 6:



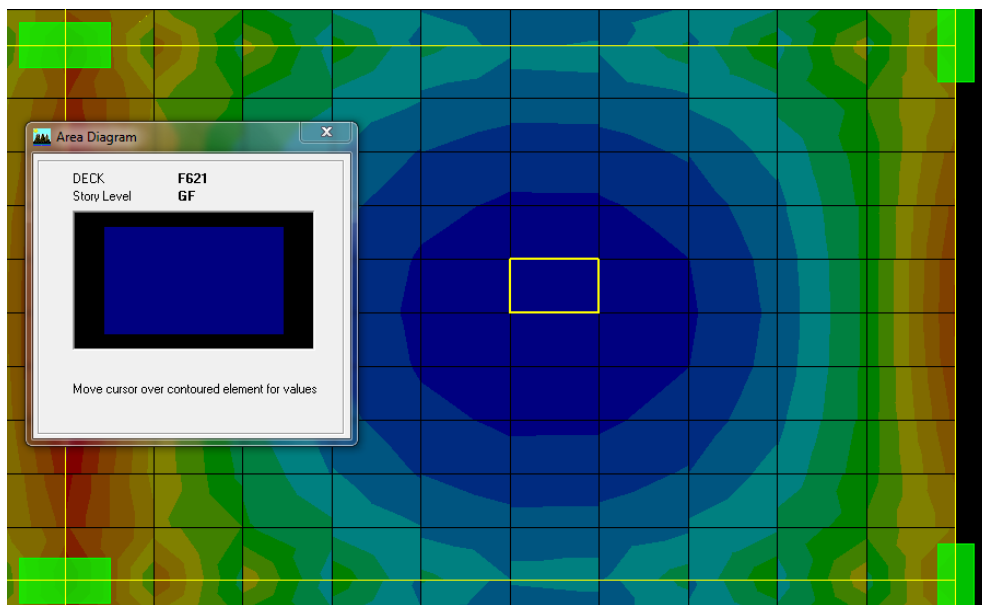
According to ETABS our highest negative moment on slab 6 was found on the Left Support and the value of the moment was 1.1110 kft/ft. So we selected this as design moment.



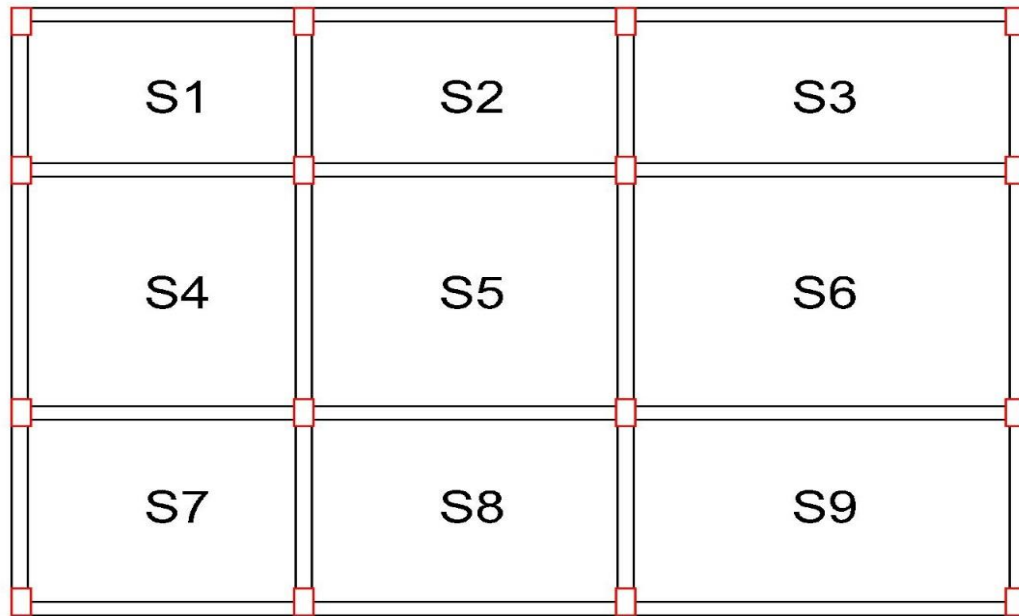
According to ETABS our highest positive moment on slab 6 was found on the middle and the value of the moment was 0.6074 kft/ft. So we selected this as design moment.



According to ETABS our highest negative moment on slab 6 was found on the Left Support and the value of the moment was 0.8602 kft/ft. So we selected this as design moment



According to ETABS our highest positive moment on slab 6 was found on the middle and the value of the moment was 0.6074 kft/ft. So we selected this as design moment.



**Fig 5.1. 2:** Slab location

### **5. 2 Slab Size (Clear Span):**

No of Slab - S1 = 16.5'X 10', S2 = 20.5'X10', S3 = 15' X 10', S4 = 16.5'X15', S5 = 20.5'X15', S6 = 15'X15', S7 = 16.5'X12.5', S8=20.5'X12.5', S9=15'X12.5'

Maximum Slab Size (S5) = 20.5'X15'

### **5. 3 Load Calculation**

Given,

$$\text{Partition Wall} = 2.5 \text{ KN/m}^2 = 53 \text{ psf}$$

$$\text{Floor Finish} = 1.5 \text{ KN/m}^2 = 32 \text{ psf}$$

$$\text{Self-Weight} = 63 \text{ psf}$$

$$\text{Total dead load} = (\text{Partition Wall} + \text{Floor Finish} + \text{Self Weight})$$

$$= (53+32+63) \text{ psf}$$

$$= 148 \text{ psf}$$

$$\text{Live Load} = 3 \text{ KN/m}^2 = 63 \text{ psf}$$

### **Factored Load**

$$1.4 \text{ D.L} = 1.4 \times 148 = 207 \text{ psf}$$

$$1.7 \text{ L.L} = 1.7 \times 63 = 107 \text{ psf}$$

$$\text{Total W} = 314 \text{ psf}$$

**Minimum Effective Depth:**

$$\rho = 0.85\beta_1\left(\frac{f'_c}{f_y}\right)\frac{\epsilon_u}{\epsilon_u + \epsilon_t}$$

$$= 0.85 \times 0.85 \times \left(\frac{3.5}{60}\right) \times \frac{0.003}{0.003 + 0.005}$$

$$0.0158$$

Taking  $b = 1\text{ft} = 12\text{in}$ ,

$$\text{Now } d_{\text{eff}} = \sqrt{\frac{M_{\text{max}}}{\phi \rho f_y b \left(\frac{0.59 \rho f_y}{f'_c}\right)}} = \sqrt{\frac{1.0637 \times 12}{0.9 \times 0.0158 \times 60 \times 12 \left(\frac{0.59 \times 0.0158 \times 60}{3.5}\right)}} = 1.22 \text{ in}$$

**Checking availability of thickness:**

As “d” is less than effective depth of  $(t-1) = (5-1) = 4$ ”

So,  $t = 5$ ” is ok

## 5. 4 Steel Area Calculation

### 5.4. 1 Long Direction:

Table 5.4.1. 1: Moment data collection Long Direction					
Slab No.	Length(ft)	Width(ft)	Left Support Moment (-M)	Midspan Support Moment (M)	Right Support Moment (-M)
1	16.5	10	0.3740	0.2299	0.4963
2	20.5	10	0.5688	0.2497	0.6477
3	15	10	0.7350	0.3650	0.5238
4	16.5	15	0.584	0.452	0.8658
5	20.5	15	0.9404	0.4740	1.0637
6	15	15	1.1110	0.6074	0.8292
7	16.5	12.5	0.5021	0.3348	0.6868
8	20.5	12.5	0.7693	0.3530	0.8354
9	15	12.5	0.9243	0.4160	0.6908

For Slab 1,

<b>Table 5.4.1. 2: Slab 1 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.3740	0.01	0.13	0.13	1-#3 ext top	0.11	-----
Midspan Support	0.2299	0.01	0.13	0.13	1-#3 @10in c/c alt ckd	0.11	10 in c/c
Right Support	0.4963	0.01	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 2,

<b>Table 5.4.1. 3: Slab 2 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.5688	0.01	0.13	0.13	1#3 ext top	0.11	-----
Mid Span Support	0.2497	0.01	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.6477	0.01	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 3,

<b>Table 5.4.1. 4: Slab 3 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min (in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.7350	0.02	0.13	0.13	1#3 ext top	0.11	-----
Mid Span Support	0.3650	0.01	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.5238	0.02	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 4,

<b>Table 5.4.1. 5: Slab 4 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.584	0.02	0.13	0.13	1#3 ext top	0.11	-----
Mid Span Support	0.452	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.8658	0.03	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 5,

<b>Table 5.4.1. 6: Slab 5 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.9404	0.04	0.13	0.13	1#3 ext top	0.11	-----
Mid Span Support	0.4740	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	1.0637	0.04	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 6,

<b>Table 5.4.1. 7: Slab 6 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	1.1110	0.05	0.13	0.13	1#3 ext top	0.11	-----
Mid Span Support	0.6074	0.03	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.8292	0.05	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 7,

<b>Table 5.4.1. 8: Slab 7 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.5021	0.02	0.13	0.13	1#3 ext top	0.11	-----
Mid Span Support	0.3348	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.6868	0.03	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 8,

<b>Table 5.4.1. 9: Slab 8 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.7693	0.03	0.13	0.13	1#3 ext top	0.11	-----
Mid Span Support	0.3530	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.8354	0.03	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 9,

<b>Table 5.4.1. 10: Slab 9 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.9243	0.04	0.13	0.13	1#3 ext top	0.11	-----
Mid Span Support	0.4160	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.6908	0.03	0.13	0.13	1-#3 ext top	0.11	-----

#### 5.4. 2 Short Direction

<b>Table 5.4.2. 1: Moment data collection Short Direction</b>					
<b>Slab No.</b>	<b>Length(ft)</b>	<b>Width(ft)</b>	<b>Left Support Moment (-M)</b>	<b>MidSpan Support Moment (M)</b>	<b>Right Support Moment (-M)</b>
1	16.5	10	0.4977	0.3998	0.6367
2	20.5	10	0.4786	0.4895	0.7415
3	15	10	0.5290	0.5647	0.6938
4	16.5	15	0.7625	0.4664	0.7246
5	20.5	15	0.8658	0.5708	0.8010
6	15	15	0.8602	0.6074	0.8002
7	16.5	12.5	0.4798	0.3057	0.5789
8	20.5	12.5	0.5507	0.3282	0.3283
9	15	12.5	0.4749	0.3682	0.3890

For Slab 1,

<b>Table 5.4.2. 2: Slab 1 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.4977	0.02	0.13	0.13	1#3 ext top	0.11	----- -
Mid Span Support	0.3998	0.01	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.6367	0.02	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 2,

<b>Table 5.4.2. 3: Slab 2 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.4786	0.02	0.13	0.13	1#3 ext top	0.11	-----
Mid Span Support	0.4895	0.01	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.7415	0.02	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 3,

<b>Table 5.4.2. 4: Slab 3 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.5290	0.02	0.13	0.13	1#3 ext top	0.11	-----
Mid span Support	0.5647	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.6938	0.03	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 4,

<b>Table 5.4.2. 5: Slab 4 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.7625	0.03	0.13	0.13	1#3 ext top	0.11	-----
Mid span Support	0.4664	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.7246	0.03	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 5,

<b>Table 5.4.2. 6: Slab 5 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.8658	0.04	0.13	0.13	1#3 ext top	0.11	-----
Mid span Support	0.5708	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.8010	0.04	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 6,

<b>Table 5.4.2. 7: Slab 6 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.8602	0.04	0.13	0.13	1#3 ext top	0.11	-----
Mid span Support	0.6074	0.03	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.8002	0.05	0.13	0.13	1-#3 ext top	0.11	-----

For Slab 7,

<b>Table 5.4.2. 8: Slab 7 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.5507	0.02	0.13	0.13	1#3 ext top	0.11	-----
Midspan Support	0.3057	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.5789	0.03	0.13	0.13	1-#3 ext top	0.11	-----

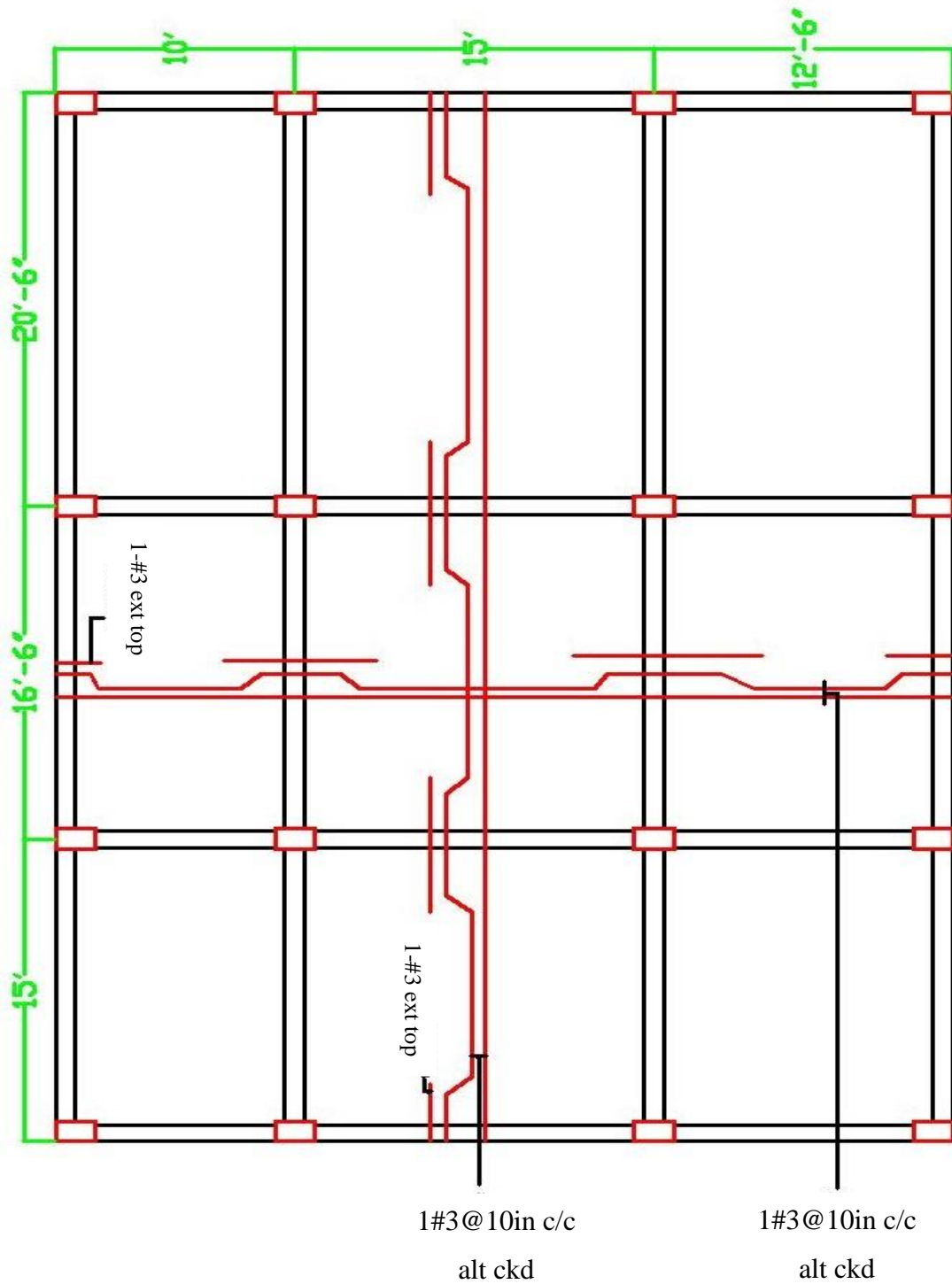
For Slab 8,

<b>Table 5.4.2. 9: Slab 8 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.5507	0.02	0.13	0.13	1#3 ext top	0.11	-----
Midspan Support	0.3282	0.02	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.3283	0.03	0.13	0.13	1-#3 ext top	0.11	-----

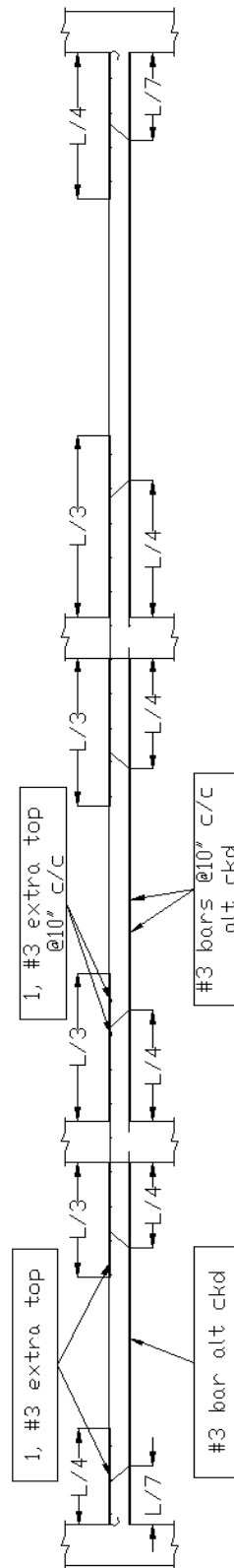
For Slab 9,

<b>Table 5.4.2. 10: Slab 9 calculation</b>							
Position	M (k-ft/ft)	As (in <sup>2</sup> )	As min(in <sup>2</sup> )	As Provided (In <sup>2</sup> )	Reinforcement	Bar Area	Spacing
Left Support	0.4749	0.04	0.13	0.13	1#3 ext top	0.11	-----
Midspan Support	0.3682	0.03	0.13	0.13	1#3@10in c/c alt ckd	0.11	10 in c/c
Right Support	0.3890	0.04	0.13	0.13	1-#3 ext top	0.11	-----

## 5.5 Slab Detailing



**Fig 5.5. 1: Slab Detailing**



**Fig 5.5. 2: Slab cross section**

## **CHAPTER 6: CONCLUSIONS & RECOMMENDATIONS**

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### **6. 1 Conclusions:**

- In the case of two way slab it has been found in practice that a huge moments develops at the support and the negative moment is huge. In this case steel reinforcements must be provided to withstand this moment. In most of the cases extra top bars are provided.
- We were successful in attaining the knowledge of realistic skills concerning structural analysis, diagram and detailing about structural components using concepts concerning Earthquake and Wind design.
- Modeling over the building for structural analysis was achieved.

### **6. 2 Recommendations**

- Only two way slabs design of a residential building was done in this study. For further study we would recommend to compare between one way and two way slab design and to compare between the slab design of other structure types of get better understanding of how slab designing works
- As we worked with only slab detailing the design of columns, beams, stairs and footings were skipped in this study. In future studies we recommend the full design be done.
- For further study real life data should be used for better understanding.
- Should try to use newer version of BNBC codes for analysis and design for further studies

## REFERENCES

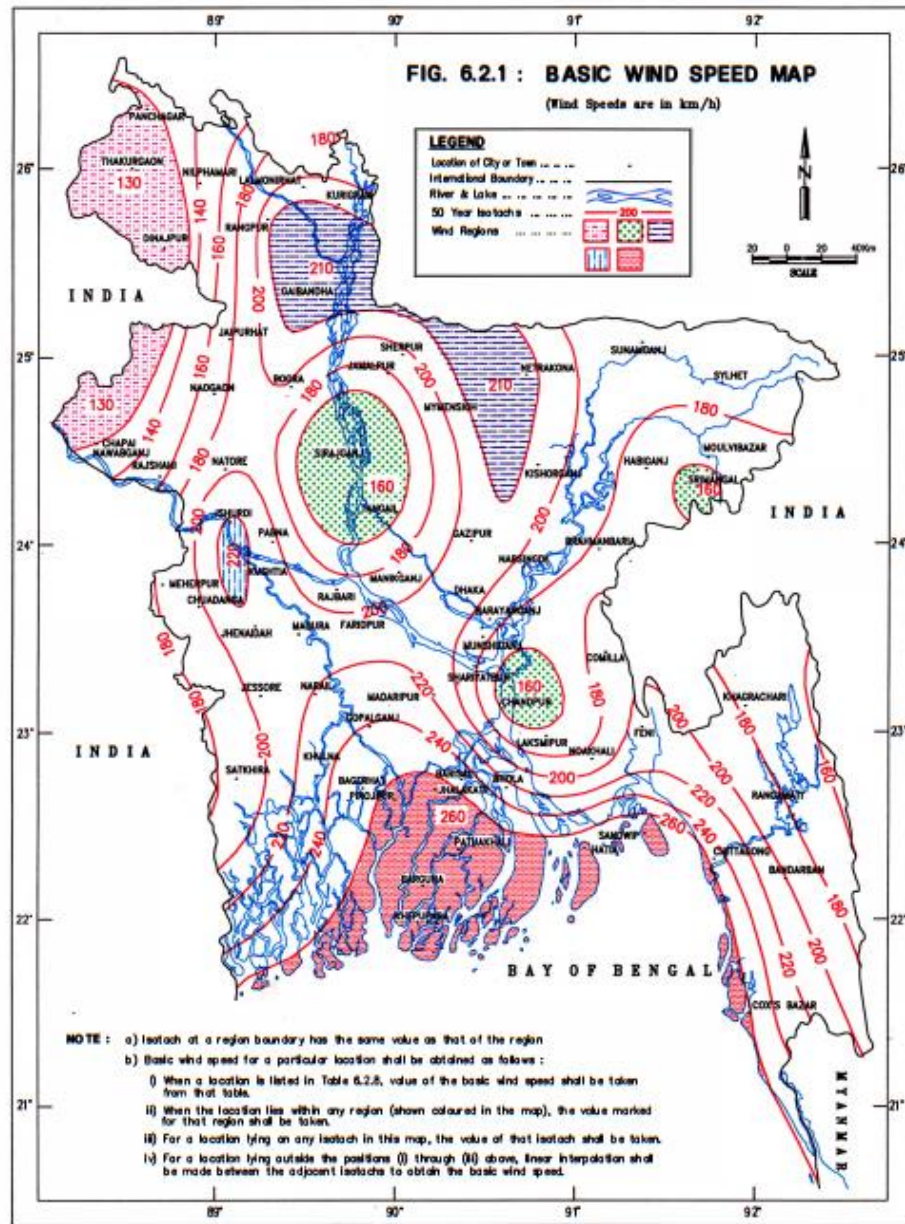
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- ETABS (Version 9.6.0)
- MS Office

## APPENDIXES

### APPENDIX 1:

#### Basic Wind speed map of Bangladesh



### Basic Wind speed for selected locations in Bangladesh

Location	Basic Wind Speed (km/h)	Location	Basic Wind Speed (km/h)
Angarpota	150	Lalmonirhat	204
Bagerhat	252	Madaripur	220
Bandarban	200	Magura	208
Barguna	260	Manikganj	185
Barisal	256	Meherpur	185
Bhola	225	Moheshkhali	260
Bogra	198	Moulvibazar	168
Brahmanbaria	180	Munshiganj	184
Chandpur	160	Mymensingh	217
Chapai Nawabganj	130	Naogaon	175
Chittagong	260	Narail	222
Chuadanga	198	Narayanganj	195
Comilla	196	Narsinghdi	190
Cox's Bazar	260	Natore	198
Dahagram	150	Netrokona	210
Dhaka	210	Nilphamari	140
Dinajpur	130	Noakhali	184
Faridpur	202	Pabna	202
Feni	205	Panchagarh	130
Gaibandha	210	Patuakhali	260
Gazipur	215	Pirojpur	260
Gopalganj	242	Rajbari	188
Habiganj	172	Rajshahi	155
Hatiya	260	Rangamati	180
Ishurdi	225	Rangpur	209
Joypurhat	180	Satkhira	183
Jamalpur	180	Shariatpur	198
Jessore	205	Sherpur	200
Jhalakati	260	Sirajganj	160
Jhenaidah	208	Srimangal	160
Khagrachhari	180	St. Martin's Island	260
Khulna	238	Sunamganj	195
Kutubdia	260	Sylhet	195
Kishoreganj	207	Sandwip	260
Kurigram	210	Tangail	160
Kushtia	215	Teknaf	260
Lakshmipur	162	Thakurgaon	130

**2.4.6.2 Sustained Wind Pressure :** The sustained wind pressure,  $q_z$  on a building surface at any height  $z$  above ground shall be calculated from the following relation :

$$q_z = C_c C_i C_z V_b^2 \quad (2.4.1)$$

where,  $q_z$  = sustained wind pressure at height  $z$ , kN/m<sup>2</sup>  
 $C_i$  = structure importance coefficient as given in Table 6.2.9

$C_c$  = velocity-to-pressure conversion coefficient =  $47.2 \times 10^{-6}$   
 $C_z$  = combined height and exposure coefficient as given in Table 6.2.10  
 $V_b$  = basic wind speed in km/h obtained from Sec 2.4.5

### Structure importance Coefficient, $C_I$

Structure Importance Category (see Table 6.1.1 for Occupancy)	Structure Importance Coefficient, $C_I$
I Essential facilities	1.25
II Hazardous facilities	1.25
III Special occupancy structures	1.00
IV Standard occupancy structures	1.00
V Low-risk structures	0.80

### Combined height and Exposure co-efficient, $C_z$

Height above ground level, $z$ (metres)	Coefficient, $C_z$ <sup>(1)</sup>		
	Exposure A	Exposure B	Exposure C
0-4.5	0.368	0.801	1.196
6.0	0.415	0.866	1.263
9.0	0.497	0.972	1.370
12.0	0.565	1.055	1.451
15.0	0.624	1.125	1.517
18.0	0.677	1.185	1.573
21.0	0.725	1.238	1.623
24.0	0.769	1.286	1.667
27.0	0.810	1.330	1.706
30.0	0.849	1.371	1.743
35.0	0.909	1.433	1.797
40.0	0.965	1.488	1.846
45.0	1.017	1.539	1.890
50.0	1.065	1.586	1.930
60.0	1.155	1.671	2.002
70.0	1.237	1.746	2.065
80.0	1.313	1.814	2.120
90.0	1.383	1.876	2.171
100.0	1.450	1.934	2.217
110.0	1.513	1.987	2.260
120.0	1.572	2.037	2.299
130.0	1.629	2.084	2.337
140.0	1.684	2.129	2.371
150.0	1.736	2.171	2.404
160.0	1.787	2.212	2.436
170.0	1.835	2.250	2.465
180.0	1.883	2.287	2.494
190.0	1.928	2.323	2.521
200.0	1.973	2.357	2.547
220.0	2.058	2.422	2.596
240.0	2.139	2.483	2.641
260.0	2.217	2.541	2.684
280.0	2.910	2.595	2.724
300.0	2.362	2.647	2.762
Note : (1) Linear interpolation is acceptable for intermediate values of $z$ .			

**2.4.6.3 Design Wind Pressure :** The design wind pressure,  $p_z$  for a structure or an element of a structure at any height,  $z$  above mean ground level shall be determined from the relation :

$$p_z = C_G C_p q_z \quad (2.4.2)$$

where,  $p_z$  = design wind pressure at height  $z$ , kN/m<sup>2</sup>

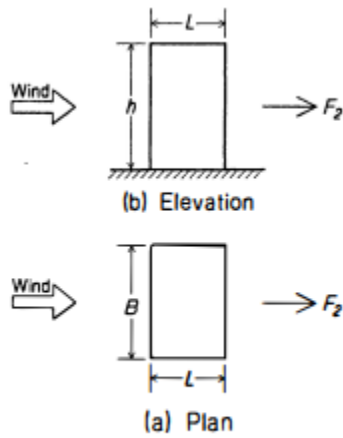
$C_G$  = gust coefficient which shall be  $G_z$ ,  $G_h$ , or  $\bar{G}$  as set forth in Sec 2.4.6.6

$C_p$  = pressure coefficient for structures or components as set forth Sec 2.4.6.7

$q_z$  = sustained wind pressure obtain from Eq (2.4.1).

### Gust responses factor, $G_h$ and $G_z$

Height above ground level (metres)	$G_h^{(2)}$ and $G_z$		
	Exposure A	Exposure B	Exposure C
0-4.5	1.654	1.321	1.154
6.0	1.592	1.294	1.140
9.0	1.511	1.258	1.121
12.0	1.457	1.233	1.107
15.0	1.418	1.215	1.097
18.0	1.388	1.201	1.089
21.0	1.363	1.189	1.082
24.0	1.342	1.178	1.077
27.0	1.324	1.170	1.072
30.0	1.309	1.162	1.067
35.0	1.287	1.151	1.061
40.0	1.268	1.141	1.055
45.0	1.252	1.133	1.051
50.0	1.238	1.126	1.046
60.0	1.215	1.114	1.039
70.0	1.196	1.103	1.033
80.0	1.180	1.095	1.028
90.0	1.166	1.087	1.024
100.0	1.154	1.081	1.020
110.0	1.114	1.075	1.016
120.0	1.134	1.070	1.013
130.0	1.126	1.065	1.010
140.0	1.118	1.061	1.008
150.0	1.111	1.057	1.005
160.0	1.104	1.053	1.003
170.0	1.098	1.049	1.001
180.0	1.092	1.046	1.000
190.0	1.087	1.043	1.000
200.0	1.082	1.040	1.000
220.0	1.073	1.035	1.000
240.0	1.065	1.030	1.000
260.0	1.058	1.026	1.000
280.0	1.051	1.022	1.000
300.0	1.045	1.018	1.000
Note : (1) For main wind-force resisting systems, use building or structure height $h$ for $z$ .			
(2) Linear interpolation is acceptable for intermediate values of $z$ .			



Rectangular Building

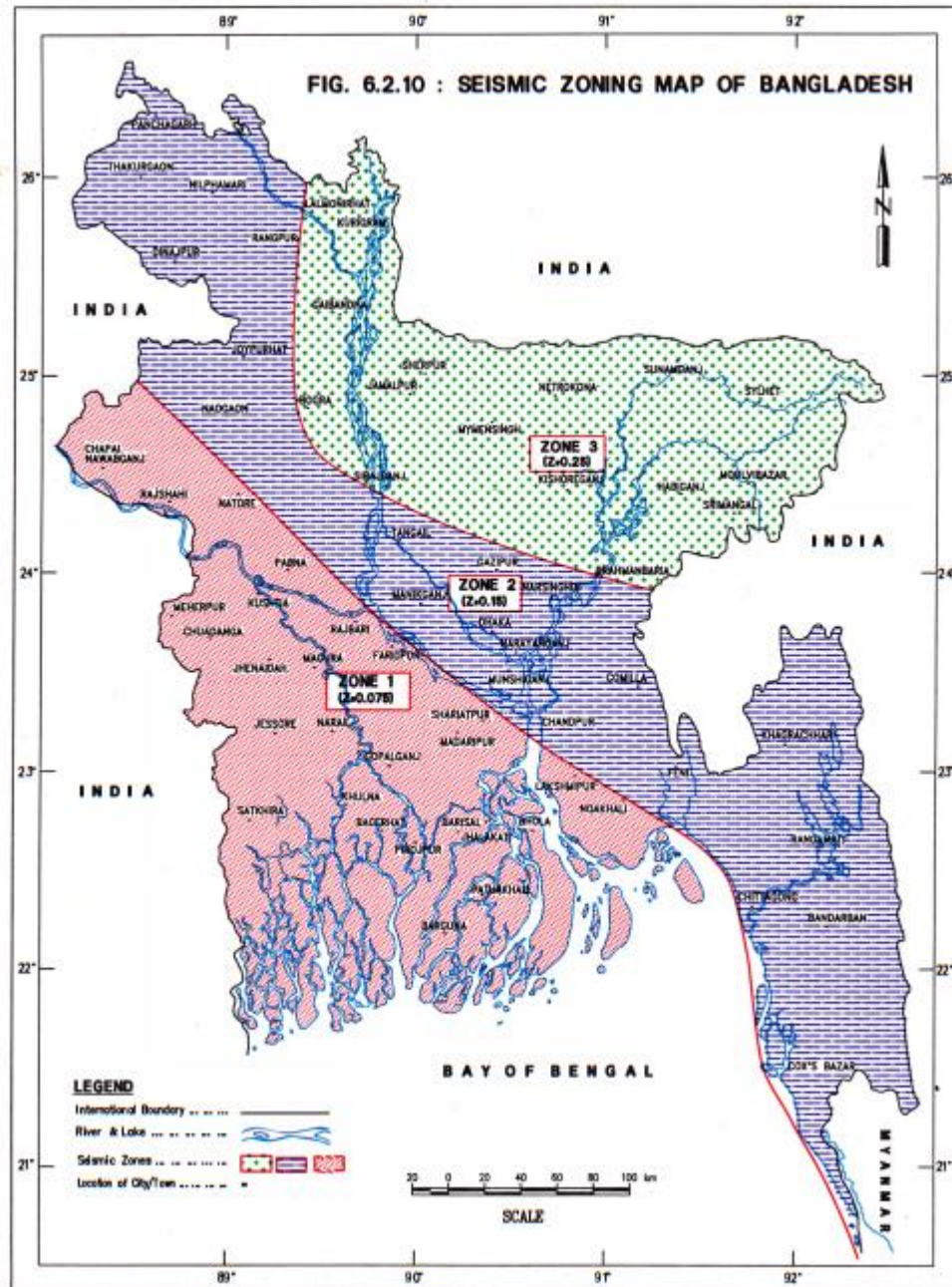
Table 6.2.15 <sup>(1)</sup>  
Overall Pressure Coefficients,  $\bar{C}_p$  <sup>(2)</sup> for Rectangular Buildings with Flat Roofs

$h/B$	$L/B$					
	0.1	0.5	0.65	1.0	2.0	$\geq 3.0$
$\leq 5$	1.40	1.45	1.55	1.40	1.15	1.10
10.0	1.55	1.85	2.00	1.70	1.30	1.15
20.0	1.80	2.25	2.55	2.00	1.40	1.20
$\geq 40.0$	1.95	2.50	2.80	2.20	1.60	1.25

Note: (1) These coefficients are to be used with Method-2 given in Sec 2.4.6.6a(ii). Use  $\bar{C}_p = \pm 0.7$  for roof in all cases.  
(2) Linear interpolation may be made for intermediate values of  $h/B$  and  $L/B$ .

## APPENDIX 2:

### Seismic zoning map of Bangladesh



**2.5.5.2 Seismic Dead Load :** Seismic dead load,  $W$ , is the total dead load of a building or a structure, including permanent partitions, and applicable portions of other loads listed below :

- In storage and warehouse occupancies, a minimum of 25 per cent of the floor live load shall be applicable.
- Where an allowance for partition load is included in the floor design in accordance with Sec 2.3.3.3, all such loads but not less than  $0.6 \text{ kN/m}^2$  shall be applicable.
- Total weight of permanent equipment shall be included.

**2.5.6.1 Design Base Shear :** The total design base shear in a given direction shall be determined from the following relation :

$$V = \frac{ZIC}{R} W \quad (2.5.1)$$

where,  $Z$  = Seismic zone coefficient given in Table 6.2.22  
 $I$  = Structure importance coefficient given in Table 6.2.23  
 $R$  = Response modification coefficient for structural systems given in Table 6.2.24  
 $W$  = The total seismic dead load defined in Sec 2.5.5.2  
 $C$  = Numerical coefficient given by the relation :

**Table 6.2.22**  
Seismic Zone Coefficients,  $Z$

Seismic Zone (see Fig 6.2.10)	Zone Coefficient
1	0.075
2	0.15
3	0.25

**Table 6.2.23**  
Structure Importance Coefficients  $I, I'$

Structure Importance Category (see Table 6.1.1 for occupancy)	Structure Importance Coefficient	
	$I$	$I'$
I Essential facilities	1.25	1.50
II Hazardous facilities	1.25	1.50
III Special occupancy structures	1.00	1.00
IV Standard occupancy structures	1.00	1.00
V Low-risk Structures	1.00	1.00

**2.5.6.2 Structure Period :** The value of the fundamental period,  $T$  of the structure shall be determined from one of the following methods :

- Method A :** For all buildings the value of  $T$  may be approximated by the following formula :

$$T = C_t (h_n)^{3/4} \quad (2.5.3)$$

where,  $C_t$  = 0.083 for steel moment resisting frames  
= 0.073 for reinforced concrete moment resisting frames, and eccentric braced steel frames  
= 0.049 for all other structural systems  
 $h_n$  = Height in metres above the base to level  $n$ .

**Table 6.2.24**  
**Response Modification Coefficient for Structural Systems,  $R$**

c. Moment Resisting Frame System	1. Special moment resisting frames (SMRF)	
	i) Steel	12
	ii) Concrete	12
	2. Intermediate moment resisting frames (IMRF), concrete <sup>(4)</sup>	8
	3. Ordinary moment resisting frames (OMRF)	
	i) Steel	6
	ii) Concrete <sup>(5)</sup>	5

**Table 6.2.25**  
**Site Coefficient,  $S$  for Seismic Lateral Forces <sup>(1)</sup>**

Site Soil Characteristics		Coefficient, $S$
Type	Description	
$S_1$	A soil profile with either : a) A rock-like material characterized by a shear-wave velocity greater than 762 m/s or by other suitable means of classification, or b) Stiff or dense soil condition where the soil depth is less than 61 metres	1.0
$S_2$	A soil profile with dense or stiff soil conditions, where the soil depth exceeds 61 metres	1.2
$S_3$	A soil profile 21 metres or more in depth and containing more than 6 metres of soft to medium stiff clay but not more than 12 metres of soft clay	1.5
$S_4$	A soil profile containing more than 12 metres of soft clay characterized by a shear wave velocity less than 152 m/s	2.0
<b>Note : (1)</b> The site coefficient shall be established from properly substantiated geotechnical data. In locations where the soil properties are not known in sufficient detail to determine the soil profile type, soil profile $S_3$ shall be used. Soil profile $S_4$ need not be assumed unless the building official determines that soil profile $S_4$ may be present at the site, or in the event that soil profile $S_4$ is established by geotechnical data.		