"EFFECT OF FLOOD ON REINFORCED CONCRETE STRUCTURE"

A Thesis

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

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

With specialization in

STRUCTURAL ENGINEERING

Under the supervision of

MR. CHANDRA PAL GAUTAM
(Associate Professor)

By

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173 234

HIMACHAL PRADESH, INDIA

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CERTIFICATE

This is to certify that the work which is being presented in the project title **"EFFECT OF FLOOD ON REINFORCED CONCRETE STRUCTURE"** in partial fulfilment of the requirements for the award of the degree of Masters of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **PRABHAT SINGH (142654)** during a period from July 2015 to December 2015 under the supervision of **MR. CHANDRA PAL GAUTAM** Assistant Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

Date: -

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JUIT Waknaghat	JUIT Waknaghat	

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Prabhat singh
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M.tech (SE)

ABSTRACT

This paper presents an overview of flood characteristics with respect to their applicability for estimating and analyzing direct flood damage to buildings. The approach taken is to define ‘‘flood actions’’ as acts which a flood could directly do to a building, potentially causing damage or failure. This definition expands the traditional approach of analyzing flood damage to buildings which often focuses on damage from slow-rise flood depth**.**

Keywords: Flood design, Hydrostatic, Hydrodynamic, SAP2000.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ASSUMPTIONS AND NOTATIONS

Assumptions in design:

- Using partial safety factor for loads in accordance with clause 36.4 of IS-456-2000 as Υ_t=1.5
- Using partial safety factors in accordance with clause 36.4 of IS-456-2000 combination of load. D.L+L.L. - 1.5
- Slab is assumed to be continuous over interior support and partially fixed on edges, due to monolithic construction and due to construction of walls over it.
- Beams are assumed to be continuous over interior support and they frame in to the column at ends.

Symbols:

The following symbols has been used in our project and its meaning is clearly mentioned respective to it:

A -	Area
Ast -	Area of steel
b -	Breadth of beam or shorter dimension of rectangular column
D -	Overall depth of beam or slab
DL -	Dead load
d^1 -	Effective depth of slab or beam
$M_{u,max}$ -	Moment of resistance factor
F_{ck} -	Characters tic compressive strength
F_y -	Characteristic strength of steel

L_d - Development length

LL - Live load

L_x - Length of shorter side of slab

L_y - Length of longer side of slab

B.M. - Bending moment

M_u - Factored bending moment

M_d - Design moment

M_f - Modification factor

P_t - Percentage of steel

W - Total design load

W_d - Factored load

T_{cmax} - Maximum shear stress in concrete with shear

T_v - Shear stress in concrete

ϕ - Diameter of bar

P_u - Factored axial load

$M_{u,lim}$ - Limiting moment of resistance of a section.

M_{ux}, M_{uy} - Moment about X and Y axis due to design loads

A_c - Area of concrete

A_{sc} - Area of longitudinal reinforcement for column

CHAPTER 1

INTRODUCTION

1.1 General

Severe floods in the past as well as the recent floods in many States including Andhra Pradesh, Bihar, UP, Assam, West Bengal and Odisha which caused devastation and large submergence remind us of inadequacy of flood management measures. Therefore, concerted efforts are required to make a critical review of the existing flood management measures, capabilities of managers and related guidelines and policies together with state of the art technologies.

According to the estimates prepared by the Rashtriya Barh Ayog (National Commission on Floods),the area prone to floods in the country is of the order of 40 million hectares out of which about 80%can be provided with reasonable degree of protection through various measures. According to the data published by NDMA in National Disaster Management Guidelines-Management of Floods, from the year 1953 to 2005 inclusive, 6,45,49,660 houses had been damaged by floods averaging about 12,18,000 houses lost per year.

Burnt Brick and Stone houses are usually constructed using mud mortar in the rural areas. The mud mortar also becomes soft under continuous wetting under water by which the walls lose their bearing strength and tend to collapse under their own weight or the weight of the roof. Also, if the water is flowing, they collapse more easily under the dynamic pressure of water. The houses made from light weight materials like GI or other Metal sheets or Grass, Leaves, Reeds, Bamboo etc. easily float away as soon as their holding down ports are uprooted by the flowing water.

An Intensity Scale was first defined by the Expert Group appointed by the Ministry of Urban Development for producing the Vulnerability Atlas of India as given in table.

Table 1 Flood Intensity Scale for Damage to Houses

Depth of flood above plinth (mm)	Flood Intensity scale Period of flood in hours		
	≤24	>24 to 72	>72
< 0.9 m (3 ft)	I	II	III
900 ≤ 2000	II	III	IV
>2000	III	IV	V

Floods occurring in the alluvial plains of the rivers or the costal deltas give rise to the following types of problems during floods:

1) The bearing capacity of the soil gets reduced and buildings of heavy materials may sink and get damaged by differential settlements.
2) The soil can be eroded under the action of flowing water and scouring can take place around and under the foundations resulting in the uprooting of the lighter posts or sinking and tilting of the heavier foundations.
3) Siltation can take place around the buildings when the flood water recede away from the site.
4) The phenomena of soil liquefaction can take place during an earthquake of medium to high intensity if occurring during the flood seasons. It actually happened in large areas of north Bihar during August 1988 earthquake when the area was already under floods.

All the site effects can lead to severe damage to the housing units unless constructed using appropriate types of foundations, materials and technologies.

The main aim of my work is to study the impact action of a flood on rural mountain buildings with design and analysis of concrete and pre-stressed concrete buildings with their respective response under the flood load.

1.2 Flood design

In flood-prone regions, it is important to design structures to resist the forces encountered during a flood. The movement of water and debris can also result in several design considerations unique to floods. These are the following forces imposed on the structure during flood

1.2.1 **Hydrostatic force**: Lateral or vertical forces resulting from standing or slow-moving water in contact with a structure. Lateral loads can occur when a vertical wall has flood water on one side and is not flooded on the other side. Vertical *(buoyancy)* loads occur when elements of the structure displace flood waters.

1.2.2 **Hydrodynamic force:** Lateral forces typically resulting from water moving at a moderate to high speed in contact with a structure. Lateral loads are created when the structure is impacted by the moving water and drag forces are created as the water moves around the structure.

1.2.3 **Wave force:** Lateral or vertical forces resulting from breaking and non-breaking waves striking the structure. Vertical uplift loads occur when waves peak or run-up against a structure

1.2.4 **Impact force:** Lateral forces resulting from debris, ice and other objects carried by floodwaters impacting a structure.

1.2.5 **Scour:** The removal of soil, sand or fill material by moving water that can result in the loss of bearing capacity or anchoring capacity of the foundation.

1.3 Building design

The structural analysis and design aspects of a five story reinforced – concrete building, designed and built in India, is described herein. Nowadays the house building is major work of the social progress of the county. Daily new techniques are being developed for the construction of houses economically, quickly and fulfilling the requirements of the community engineers and architects do the design work, planning and layout, etc, of the buildings. Draughtsman are responsible for doing the drawing works of building as for the direction of engineers and architects.

A building frame consists of number of bays and storey. The three dimensional view of the building is shown in Fig.1 and the plan and elevation view is given in Fig.2. A multi-storey, multi-panelled frame is a complicated statically intermediate structure. A design of R.C building of G+4 storey frame work is taken up. The building in plan (16*12) consists of columns built monolithically forming a network. The size of building is 16x12m. The number of columns are 45. It is residential building.

The design is made using software on structural analysis design (SAAP2000). The building subjected to both the vertical loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc and live loads thus building is designed for dead load, live load. The building is designed as three dimensional vertical frame and analysed for the maximum and minimum bending moments and shear forces by the software and manually in excel spreadsheets as per **IS456-2000** and then compare the results.

1.4 Resource utilization

- The analysis of the models will be done on computer with the help of SAP-2000 software.
- Input and Output data is managed on Microsoft Excel Sheets.
- Code Of Practice - Plain and Reinforced Concrete (Fourth Revision) IS :456 2000
- Code of Practice – Design aids for reinforced concrete to IS : 456 1978
- Code of practice for design wind loads for structures IS : 875 (Part 3) 1987
- Code for Earthquake resistant design of structures IS : 1893 (Part 1) 2002

1.5 Data

1.5.1 Silent features:

- Utility of building: residential building.

- No of stories : G+4
- Shape of the building : 4 rooms in each floor
- No. of rooms: 16
- Type of construction: R.C.C framed structure
- Types of walls: brick wall

1.5.2 Geometric details:

- Ground floor : 3.2m
- Floor to floor height : 3.2m.
- Plan area : $(12*12)m^2$
- Single Floor Area - $144m^2$.
- Total Design Area - $864m^2$.

1.5.3 Loading Conditions and material properties for Static Analysis:

- Dead load : IS 875 (Part I)-1987
- Live load : IS 875 (Part I)-1987
- Load Combination : Dead load + live load : IS 875 (Part I)-1987
- Floor finish : $1.00kN/m^2$ IS 875 (Part I)-1987
- Density of concrete (wet) : 25 kN/m^2 : IS-456)
- Material used Concrete M-25 and Reinforcement Fe-415(HYSD Confirming to IS-786)
- $E_c = 5000\sqrt{f_{ck}}$ N/mm^2 (E_c is short term static modulus of elasticity in N/mm^2)
- $F_{ck} = 0.7\sqrt{fc}$ kN/mm^2 (F_{ck} is characteristic cube strength of concrete in N/mm^2

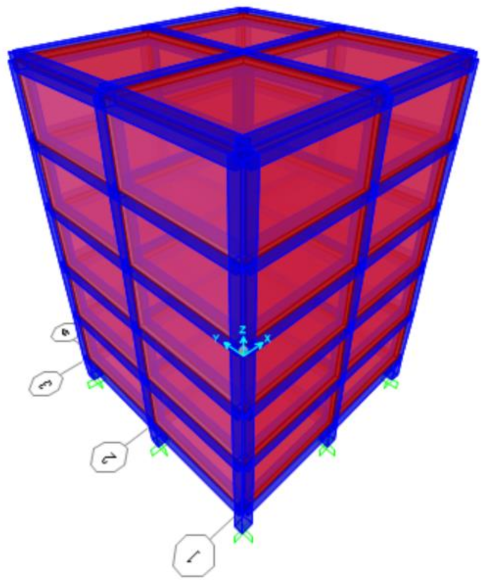

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Fig.1- 3D view of the buildings

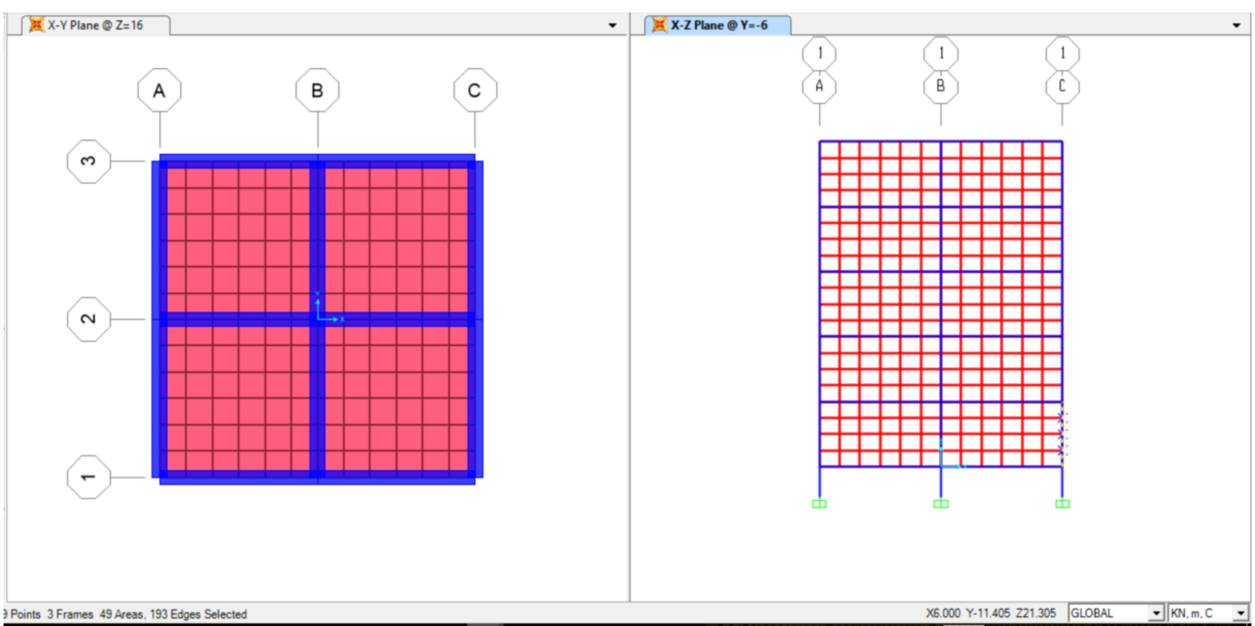


Fig.2 Plan and Elevation of the building.

CHAPTER 2

REVIEW OF LITERATURE

Ilan Kelman, Robin Spence "An overview of flood actions on buildings"

Inference:-

This paper provides an overview identifying and categorising flood actions in order to suggest their relative importance for direct flood damage assessment. These categories indicate the current capability available for introducing more flood actions to flood damage analysis.

Shiyun Xiao, Bin Yue, Xiaoqing Wang, Liujuan Yang "Study on impact loadings of flood on buildings "

Inference:-

1) The impact pressures of both the bottom and the top increase with the distance.
2) The impact pressure increases approximately linearly with the gradient.
3) The impact pressure decreases approximately linearly from the bottom to the top of model. In the horizontal direction, the impact pressure on both sides is less than that of middle at the same height of model because of the boundary effect.
4) The impact pressure increases with the increasing water heights both in the vertical direction and in the horizontal direction.

Shiyun Xiao and Hongnan Li "Impact of Flood on a Simple Masonry Building"

Inference:-

The numerical results are compared with the experimental results, and the distribution of impact loading is also studied. The impact pressures of both the bottom and the top increase with the distance and increase approximately linearly with the gradient. The impact pressure decreases approximately linearly from the bottom to the top of the model. In the horizontal direction, the impact pressure on both sides is less than that of the middle at the same height of the model because of the boundary effect. The impact pressure increases with increasing water height both in the vertical direction and in the horizontal direction.

The numerical results are compared with the experimental results, and the distribution of impact loading is also studied. The impact pressures of both the bottom and the top increase with the distance and increase approximately linearly with the gradient. The impact pressure decreases approximately linearly from the bottom to the top of the model. In the horizontal direction, the impact pressure on both sides is less than that of the middle at the same height of the model because of the boundary effect. The impact pressure increases with increasing water height both in the vertical direction and in the horizontal direction.

Norberto C. Nadal; Raúl E. Zapata; Ismael Pagán; Ricardo López; and Jairo Agudelo "Building Damage due to Riverine and Coastal Floods"

Inference:-

The flood damage results provide a basis to compare the risk of flood damage between different locations and flood hazards. The results also allow making an important distinction between the flood damages caused by hydrostatic actions _function of floodwater depth_ and those damages caused by hydrodynamic actions _function of floodwater velocity_. In the case of riverine events, floodwater velocity can increase the damage by an additional factor of over 100% when compared to flood inundations alone, where floodwater velocity is equal to zero. When considering storm surges, it was determined that floodwater velocity can increase flood damage by up to 140%, when compared to still floodwater. Similarly, in the case of tsunamis, floodwater velocity can increase the damage almost 190%. The results from this study demonstrate the need to consider floodwater hydrodynamics as part of the damage assessment of buildings located in flood prone areas.

Caspar J.W.P. Groot "Effect of water on mortar-brick bond"

Inference:-

1) With the help of the developed neutron transmission techniques it is possible to obtain precise quantitative information about water distributions and flow processes in masonry test specimens.

2) The supposed influence of flow effects on the mortar interface composition is confirmed by test results of neutron transmission monitoring technique and x-ray diffraction investigation

W. D. KEMPER AND R. C. ROSENAU "Soil Cohesion as Affected by Time and Water Content"

Inference:-

Cohesion of soils as measured by aggregate stabilities and moduli of rupture increases with time. Cohesional forces associated with water are in the range to be able to account for measured moduli of rupture in moist soils. However, high moduli of rupture of soils such as the Billings, when oven dry, indicate formation of solid phase bonds at particle-to-particle contacts. Increases of aggregate stabilities and moduli of rupture with time of storage or "curing" under air-dry conditions, indicate that migration of bonding components to strengthen these bonds continues even when there is as little as one molecular layer of water on the mineral surfaces.

These findings combined with those of other investigators suggest that soils will disintegrate and slump less if a few days are allowed for freshly cultivated soils to regain their solid phase cohesion before they are saturated by irrigation.

Ir W.Roos "Damage to buildings by flood"

Inference:-

1) There is no linear correlation between the water velocity and water depth for damage. A linear correlation was however given in the study by Clausen et al., 1990.

2) It is recommended to minimize the uncertainties . Especially the uncertainties in load case "debris" should be minimized since this load dictates the amount of damage calculated by the model.

Juan M. Alvarado "The Effects of Moisture Content on Soil Strength"

Inference:-

Any amount of water above the optimum moisture content makes the soils particles slide and prevents compaction. At this point, the water acts like a lubricant instead of like a glue. Therefore, 15% moisture content should be for building and structural foundations in order to make them more stiff and stable.

Gabriela M. Medero, Justin H. Kennedy, Peter K. Woodward and Meysam Banimahd "Flooding Effect on Earth Walls"

Inference:-

The following conclusions can be drawn from the study:

1. The addition of straw to the soil mixture changes the response of the earth material to the compaction effort. However, changes in the length of the straw (15–50 mm) as reinforcement do not produce significant variations in the density of the mixture. It is interesting to highlight that the process of building the earth walls causes a cut down in size of the straw length. Furthermore, the addition of straw increases the optimum water content of the mixture.

2. The unconfined compression tests carried out showed a significant increase in the peak of the simple compression strength when the compaction rate was increased from 40 to 80 blows per layer, but not such an increase when the rate was increased to between 60 to 80 blows per layer.

3. The flooding simulation tests in wall/sample without straw (un-reinforced) presented failure of the structure after six days of flooding, different to the response observed for the wall/sample with straw. The straw works as a reinforcement of the structure.

4. The wall/sample reinforced with straw showed hydraulic hysteresis when subjected to cycles of wetting/drying (repeated flooding events followed by dry periods). The material demonstrated expansible behaviour when wetted followed by shrinkage when dried. The authors believe that the walls could respond differently to flooding if under vertical stress (vertical load on the top of the

wall). The authors would like to highlight this behavioral feature has major importance to predict the hydro-mechanical response and long-term life of such structures.

5. Under flooding conditions, the wall/sample reinforced with straw showed formation of fungi at the surface and some rot growth from the sample was also observed. When wetted, the earth structures produce an environment where microorganisms easily can reproduce.

6. This work has shown that the structural integrity of earth materials has a certain capacity to resist failure during flooding conditions when a reinforcement material such as straw is used. It must be emphasized that this is influenced by many parameters, including: mixture composition, compaction rates and the nature of the reinforcement utilized.

Future work will be undertaken to investigate the effects of flooding on earth walls under vertical load as well as studying different compaction rates, suction profiles and building procedures.

Elisa Franzoni, Cristina Gentilini, Gabriela Graziani, Simone Bandini "Compressive behaviour of brick masonry triplets in wet and dry conditions"

Inference:-

In this paper, an experimental investigation performed on cement and lime based mortar prisms and masonry triplets with cement mortar layers is reported. The samples were subjected to compression test in dry, water saturated and moist conditions in order to investigate the changes in peak load value and static elastic modulus. Results showed that the cement based mortar is

the most affected by the presence of water within the pores due to its microstructural features, but such influence is mitigated in triplets due to the confinement exerted by the bricks. Highly dispersed results were obtained for the lime based mortar prisms, thus the experimental set-up should be revised. Bricks are scarcely affected by water saturation, probably owing to their coarse and cylindrical pores. The moist condition appeared to be the most harmful for masonry triplets. In fact, the lowest values of compression strength and elastic modulus were obtained for masonry samples with a percentage of water around 10% of the dry mass. This aspect deserves further investigations.

CHAPTER 3

OBJECTIVES

3.1 Objective

- Modeling and design of G+4 RCC framed structure.
- Analysis of the structure under flood load.
- To make the building safe from flood hazards.

3.2 Methodology

- Analysis of the structure for its responses when subjected to flood load.
- Comparison of their behaviors under both loads.
- Find the critical members.
- Redesign for the critical members.

CHAPTER 4

DESIGN OF MULTI STORIED RESIDENTIAL BUILDING

4.1 General

A structure can be defined as a body which can resist the applied loads without appreciable deformations.

Civil engineering structures are created to serve some specific functions like human habitation, transportation, bridges, storage etc. in a safe and economical way. A structure is an assemblage of individual elements like pinned elements (truss elements), beam element, column, shear wall slab cable or arch.

Structural engineering is concerned with the planning, designing and thee construction of structures. Structure analysis involves the determination of the forces and displacements of the structures or components of a structure. Design process involves the selection and detailing of the components that make up the structural system.

The main object of reinforced concrete design is to achieve a structure that will result in a safe economical solution.

The objective of the design is

1. Slab design
2. Beam design
3. Column design

These all are designed under limit state method.

Software Used

This project is mostly based on software and it is essential to know the details about these software's.

SAP2000

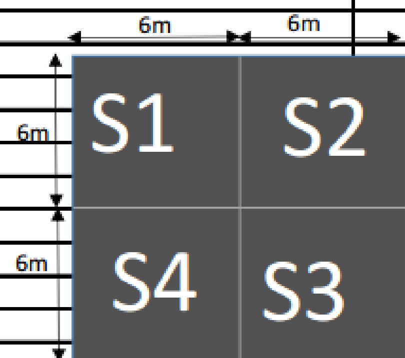
SAP2000 is a general purpose finite element program which performs the static or dynamic, linear or nonlinear analysis of structural systems. It is also a powerful design tool to design structures following AASHTO specifications, ACI and AISC building codes. These features, and many more make SAP2000 the state-of-the-art in structural analysis program.

The SAP2000 graphic user interface (GUI) is used to model, analyse, design, and display the structure geometry, properties and analysis results.

4.2 Slab design

4.2.1 Design spreadsheet (Top floor)

SLAB DESIGN (2 WAY)



Sr. No.			Units	Remarks
1	Concrete Grade (Fck)	25	Mpa	M25 grade
2	Renforcing Steel Grade (Fy)	415	Mpa	Fe415 grade
3	Shorter Span Lx	6	m	
4	Longer Span Ly	6	m	
5	(Ly\Lx)	1		two way slab
6	(L/d)basic	23		
7	% of steel assumed	0.3	%	range (.2 - .4)
8	modification factor	1.5		
9	nominal cover	25	mm	
10	Trial depth	174	mm	
11	Overall depth provided	220	mm	
12	effective depth	190	mm	
	LOADINGS			
13	dead load	5.5	KN/m^2	
14	Floor finish considered	1.5	KN/m^2	
15	Live load considered	1.5	KN/m^2	
16	Total load	8.5	KN/m^2	
17	Total factored load	12.75	KN/m^2	

DESIGN MOMENTS				
18	($\acute{\alpha}_x$)-ve (continious edge)	0.047		two adjaent edges are discontinious
19	($\acute{\alpha}_x$)+ve (mid span)	0.035		
20	($\acute{\alpha}_y$)-ve (continious edge)	0.047		
21	($\acute{\alpha}_y$)+ve (mid span)	0.035		
	For shorter span			
22	(Mx)-ve	21.57	KN-m	moment along X
23	(Mx)+ve	16.07	KN-m	moment along X
	For longer span			
24	(My)-ve	21.57	KN-m	moment along Y
25	(My)+ve	16.07	KN-m	moment along Y

REINFORCEMENT				
	Main reinforcement			
26	Ast for shorter span	323.58	mm^2	
27	Ast for longer span	239.26	mm^2	
28	Main reinforcement bars dia.	10	mm	
29	area of one bar	78.5	mm^2	
30	Spacing for shorter span	243	mm	
31	no. of bars for shorter span	5		
32	Ast (provided)	392.5		
33	Spacing for longer span	300	mm	
34	no. of bars for longer span	4		
	Torsional reinforcement at 4 corners			
35	Torsional bars dia	10	mm	
36	Ast in each of the 4 layes	242.685	mm^2	
37	distance frm the centre	1.2	m	
38	area of one bar	78.5	mm^2	
39	spacing	120	mm	
40	no. of bars	4		
	Reinforcement in edge strip			
41	Ast (.12% of crossectional area)	228	mm^2	
42	edge strip bars dia	10	mm	
43	area of one bar	78.5	mm^2	
44	spacing	243	mm	
45	no. of bars	3		
CHECKS				
	check for depth			
46	depth(min)	80	mm	**OK**
	check for shear			
47	Shear stress (Vus)	38.25	KN	
48	calculated shear strength (τ_u)	0.2	N/mm^2	
49	Pt% steel	0.21		
50	designed shear strenght (τ_c)	0.338	N/mm^2	**OK**
	check for deflection			
51	$(L/D)_{Allowable}$ for Pt%=.21	36.8		
52	$(L/D)_{provided}$	31.58		**OK**

Reinforcement details

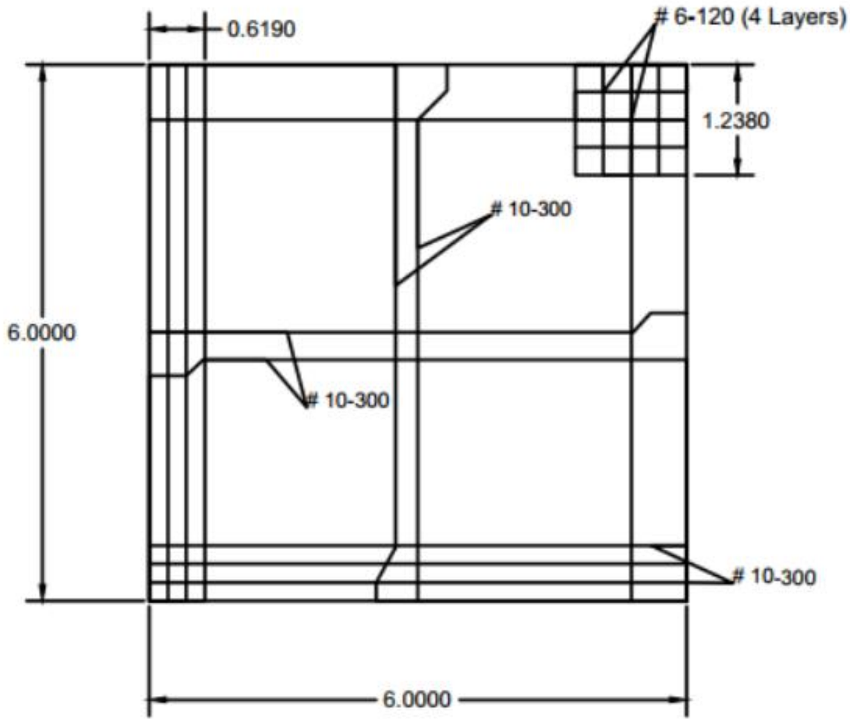


Fig.3 Reinforcement Details Of Slab

Main Reinforcement: 10mm—5 Bars @ 300mm c/c Along Lx.

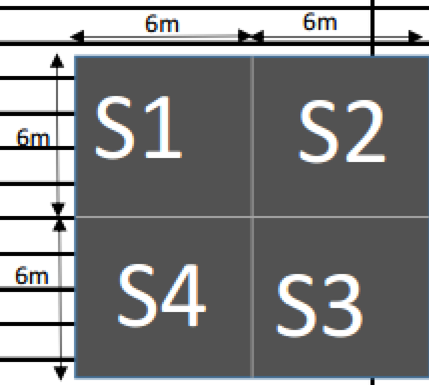
10mm—5 Bars @ 300mm c/c Along Ly.

Torsional Reinforcement: 6mm—4 Bars @ 120mm c/c In 4 Layers. Provided Till distance Of 1238mm from the Centre of Support.

Reinforcement In Edge Strips: 10mm—3 Bars @ 300mm c/c Up to 619 mm from edge Of the Slab.

4.2.2 Design spread sheet (Lower floors)

SLAB DESIGN (2 WAY)



Sr. No.			Units	Remarks
1	Concrete Grade (Fck)	25	Mpa	M25 grade
2	Renforcing Steel Grade (Fy)	415	Mpa	Fe415 grade
3	Shorter Span Lx	6	m	
4	Longer Span Ly	6	m	
5	(Ly\Lx)	1		two way slab
6	(L/d)basic	23		
7	% of steel assumed	0.3	%	range (.2 - .4)
8	modification factor	1.5		
9	nominal cover	25	mm	
10	Trial depth	174	mm	
11	Overall depth provided	220	mm	
12	effective depth	190	mm	
	LOADINGS			
13	dead load	5.5	KN/m^2	
14	Floor finish considered	1.5	KN/m^2	
15	Live load considered	3	KN/m^2	
16	Total load	10	KN/m^2	
17	Total factored load	15	KN/m^2	
	DESIGN MOMENTS			
18	($\acute{\alpha}_x$)-ve (continious edge)	0.047		two adjaent edges are discontinious
19	($\acute{\alpha}_x$)+ve (mid span)	0.035		
20	($\acute{\alpha}_y$)-ve (continious edge)	0.047		
21	($\acute{\alpha}_y$)+ve (mid span)	0.035		
	For shorter span			
22	(Mx)-ve	25.38	KN-m	moment along X
23	(Mx)+ve	18.9	KN-m	moment along X
	For longer span			
24	(My)-ve	25.38	KN-m	moment along Y
25	(My)+ve	18.9	KN-m	moment along Y

REINFORCEMENT				
	Main reinforcement			
26	Ast for shorter span	382.77	mm^2	
27	Ast for longer span	282.48	mm^2	
28	Main reinforcement bars dia.	10	mm	
29	area of one bar	78.5	mm^2	
30	Spacing for shorter span	206	mm	
31	no. of bars for shorter span	5		
32	Ast (provided)	392.5		
33	Spacing for longer span	278	mm	
34	no. of bars for longer span	4		
	Torsional reinforcement at 4 corners			
35	Torsional bars dia	10	mm	
36	Ast in each of the 4 layes	287.0775	mm^2	
37	distance frm the centre	1.2	m	
38	area of one bar	78.5	mm^2	
39	spacing	120	mm	
40	no. of bars	4		
	Reinforcement in edge strip			
41	Ast (.12% of crossectional area)	228	mm^2	
42	edge strip bars dia	10	mm	
43	area of one bar	78.5	mm^2	
44	spacing	205	mm	
45	no. of bars	3		
CHECKS				
	check for depth			
46	depth(min)	86	mm	**OK**
	check for shear			
47	Shear stress (Vus)	45	KN	
48	calculated shear strength (τ_u)	0.24	N/mm^2	
49	Pt% steel	0.21		
50	designed shear strenght (τ_c)	0.338	N/mm^2	**OK**
	check for deflection			
51	$(L/D)_{Allowable}$ for Pt%=.21	36.8		
52	$(L/D)_{provided}$	31.58		**OK**

Reinforcement details:

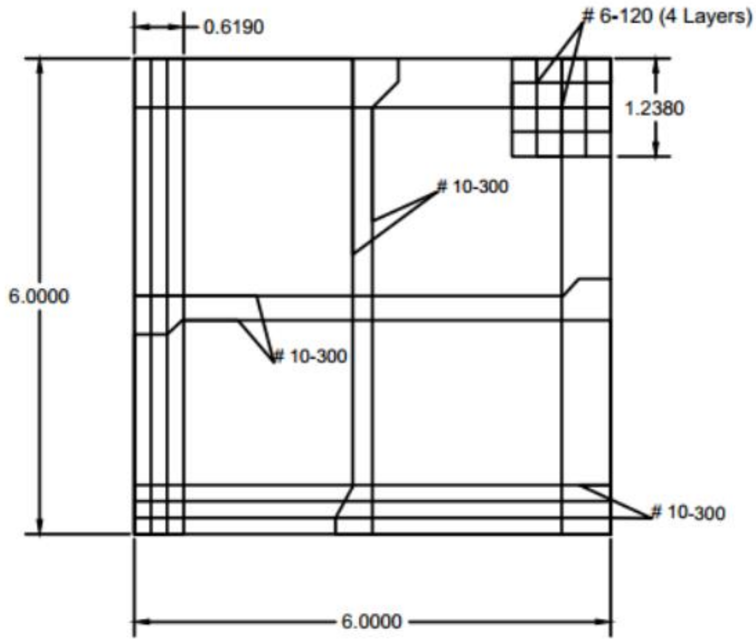


Fig.4 Reinforcement Details Of Slab

Main Reinforcement: 10mm—5 Bars @ 300mm c/c Along Lx.

10mm—4 Bars @ 300mm c/c Along Ly.

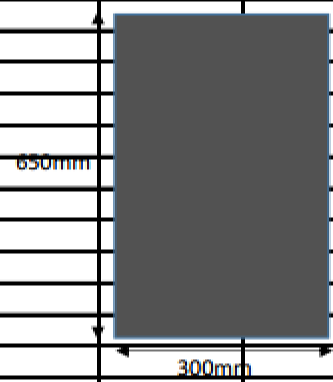
Torsional Reinforcement: 6mm—4 Bars @ 120mm c/c In 4 Layers. Provided till distance of 1238mm from the centre of support.

Reinforcement In Edge Strips: 10mm—3 Bars @ 300mm c/c Up to 619 mm from edge of the slab.

4.3 Beam design

4.3.1 Design spreadsheet (Top floor, Exterior)

BEAM DESIGN



Sr. no.			units	Remarks
1	Concrete grade (Fck)	25	Mpa	M25 grade
2	Steel grade (Fy)	415	Mpa	Fe415 grade
3	effective span	6	m	
4	$(L/D)_{basic}$ assumed	10		
5	clear cover	50	mm	
6	Effective depth	600	mm	
7	total depth	650	mm	About XX-Axis
8	Trail width	300	mm	
		LOADS		
9	self weight	4.875	KN/m^2	
10	wall load for 200 mm thick wall	1.91	KN/m^2	
11	total dead load	6.785	KN/m^2	
12	factored dead load (g)	10.1775	KN/m^2	
13	live load (q)	19.125	KN/m	
14	Live load from slab	12.75	KN/m^2	
		BEANDING MOMENT AND SHEAR FORCE		
15	Mu(-ve)	169.7085	KN-m	@ exterior supports
16	Mu(+ve)	149.07375	KN-m	@ centre of span
17	Vu	158.2335	KN	Max shear force at supports
18	$Mu_{(lim)}$ (limiting bending moments)	372.6	KN-m	UNDER REINFORCED
		REINFORCEMENT		
	Main reinforcement			
19	Ast(-ve)	850.0392916	mm^2	@ supports
20	Dia of bar used	25	mm	
21	Area of one bar	490.625	mm^2	
22	No. of bars	2		
23	Ast(+ve)	738.4369194	mm^2	@ centre of span
24	Dia of bar used	20	mm	
25	Area of one bar	314	mm^2	

26	No. of bars	3		
	Shear reinforcement			
27	τ_u	0.88		
28	Pt%	0.55		
29	τ_c	0.57		Design shear strength
30	Design for shear reinforcement			
31	Vus	55.6335	KN	
32	Dia of bar used	8	mm	2 leged barrs for stirups
33	Area of one bar	103.68	mm^2	
34	Spacing	300	mm	
35	hence provide ϕ8mm, 2 leged bars with calculated spacing in all over the beam			
	CHECK			
	Check for deflection			
36	Pt%	0.55	%	
37	K1 (modification factor)	1.2		
38	K_L	1		
39	K_T	1		
40	$(L/D)_{allowable}$	31.2		
41	$(L/D)_{actual}$	10		OK

Reinforcement details

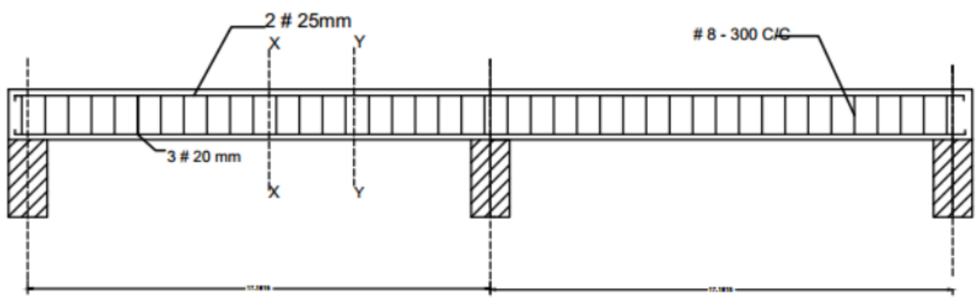


Fig.5 Reinforcement Details Of continuous beam

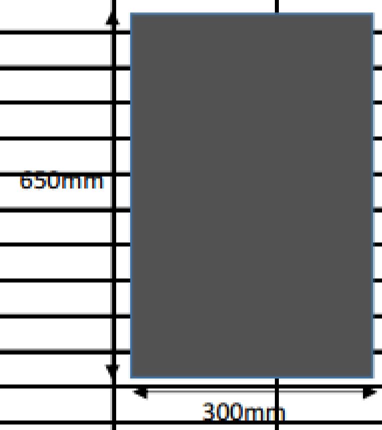
Reinforcements Near Support: 2—25mm Bars @ 50mm c/c.

Reinforcements At Mid Span: 3—20mm Bars @ 67mm c/c

Shear Reinforcements: 8mm 2 Legged Stirrups @ 153mm c/c Throughout Beam.

4.3.2 Design spreadsheet (Top floor, Interior)

BEAM DESIGN



Sr. no.			units	Remarks
1	Concrete grade (Fck)	25	Mpa	M25 grade
2	Steel grade (Fy)	415	Mpa	Fe415 grade
3	effective span	6	m	
4	$(L/D)_{basic}$ assumed	10		
5	clear cover	50	mm	
6	Effective depth	600	mm	
7	total depth	650	mm	About XX-Axis
8	Trail width	300	mm	
	LOADS			
9	self weight	4.875	KN/m^2	
10	wall load for 200 mm thick wall	1.91	KN/m^2	
11	total dead load	6.785	KN/m^2	
12	factored dead load (g)	10.1775	KN/m^2	
13	live load (q)	38.25	KN/m	
14	Live load from slab	25.5	KN/m^2	
	BEANDING MOMENT AND SHEAR FORCE			
15	Mu(-ve)	284.4585	KN-m	@ exterior supports
16	Mu(+ve)	252.34875	KN-m	@ centre of span
17	Vu	261.5085	KN	Max shear force at supports
18	$Mu_{(lim)}$ (limiting bending moments)	372.6	KN-m	UNDER REINFORCED
	REINFORCEMENT			
	Main reinforcement			
19	Ast(-ve)	1528.594017	mm^2	@ supports
20	Dia of bar used	25	mm	
21	Area of one bar	490.625	mm^2	
22	No. of bars	4		
23	Ast(+ve)	1327.371365	mm^2	@ centre of span
24	Dia of bar used	20	mm	
25	Area of one bar	314	mm^2	

26	No. of bars	5		
	Shear reinforcement			
27	τ_u	1.45		
28	Pt%	1.09		
29	τ_c	0.57		Design shear strength
30	Design for shear reinforcement			
31	Vus	158.9085	KN	
32	Dia of bar used	8	mm	2 leged barrs for stirups
33	Area of one bar	103.68	mm^2	
34	Spacing	141.3404469	mm	
35	hence provide ϕ8mm, 2 leged bars with calculated spacing in all over the beam			
	CHECK			
	Check for deflection			
36	Pt%	1.09	%	
37	K1 (modification factor)	1.2		
38	K_L	1		
39	K_T	1		
40	$(L/D)_{allowable}$	31.2		
41	$(L/D)_{actual}$	10		**OK**

Reinforcement details:

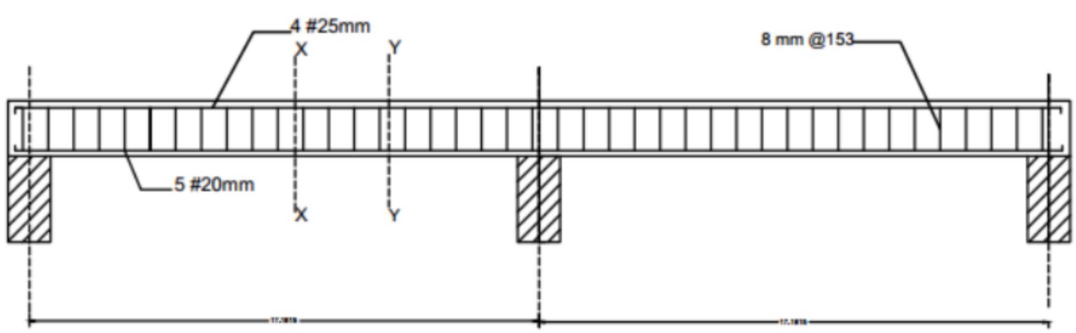


Fig.6 Reinforcement Details Of continuous beam

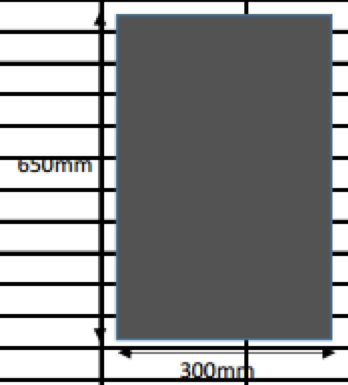
Reinforcements Near Support: 4—25mm Bars @ 50mm c/c.

Reinforcements At Mid Span: 5—20mm Bars @ 67mm c/c

Shear Reinforcements: 8mm 2 Legged Stirrups @ 153mm c/c Throughout Beam.

4.3.3 Design spreadsheet (Lower floors, Exterior)

BEAM DESIGN



Sr. no.			units	Remarks
1	Concrete grade (Fck)	25	Mpa	M25 grade
2	Steel grade (Fy)	415	Mpa	Fe415 grade
3	effective span	6	m	
4	$(L/D)_{basic}$ assumed	10		
5	clear cover	50	mm	
6	Effective depth	600	mm	
7	total depth	650	mm	About XX-Axis
8	Trail width	300	mm	
		LOADS		
9	self weight	4.875	KN/m^2	
10	wall load for 200 mm thick wall	3.8	KN/m^2	
11	total dead load	8.675	KN/m^2	
12	factored dead load (g)	13.0125	KN/m^2	
13	live load (q)	22.5	KN/m	
14	Live load from slab	15	KN/m^2	
		BEANDING MOMENT AND SHEAR FORCE		
15	Mu(-ve)	205.2675	KN-m	@ exterior supports
16	Mu(+ve)	180.05625	KN-m	@ centre of span
17	Vu	191.7675	KN	Max shear force at supports
18	$Mu_{(lim)}$ (limiting bending moments)	372.6	KN-m	UNDER REINFORCED
		REINFORCEMENT		
	Main reinforcement			
19	Ast(-ve)	1049.037497	mm^2	@ supports
20	Dia of bar used	25	mm	
21	Area of one bar	490.625	mm^2	
22	No. of bars	3		
23	Ast(+ve)	907.043262	mm^2	@ centre of span
24	Dia of bar used	20	mm	
25	Area of one bar	314	mm^2	

26	No. of bars	3		
	Shear reinforcement			
27	τ_u	1.07		
28	Pt%	0.82		
29	τ_c	0.57		Design shear strength
30	Design for shear reinforcement			
31	Vus	89.1675	KN	
32	Dia of bar used	8	mm	2 leged barrs for stirups
33	Area of one bar	103.68	mm^2	
34	Spacing	251.8877214	mm	
35	hence provide ϕ8mm, 2 leged bars with calculated spacing in all over the beam			
	CHECK			
	Check for deflection			
36	Pt%	0.82	%	
37	K1 (modification factor)	1.2		
38	K_L	1		
39	K_T	1		
40	$(L/D)_{allowable}$	31.2		
41	$(L/D)_{actual}$	10		**OK**

Reinforcement details:

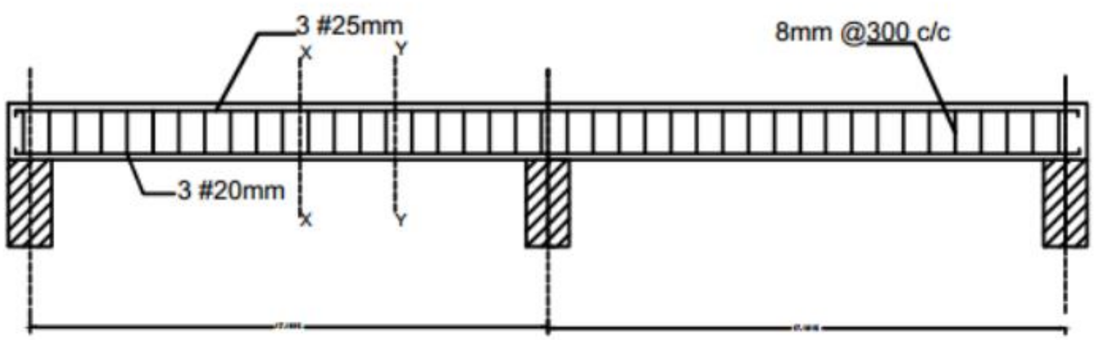


Fig.7 Reinforcement Details Of continuous beam

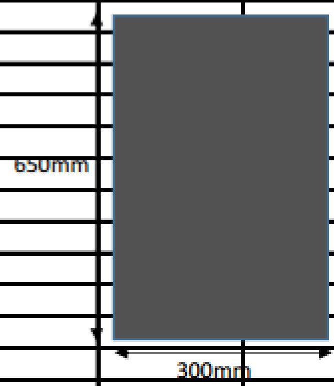
Reinforcements Near Support: 3—25mm Bars @ 50mm c/c.

Reinforcements At Mid Span: 3—20mm Bars @ 67mm c/c

Shear Reinforcements: 8mm 2 Legged Stirrups @ 153mm c/c Throughout Beam.

4.3.4 Design spreadsheet (Lower floors, Interior)

BEAM DESIGN



Sr. no.			units	Remarks
1	Concrete grade (Fck)	25	Mpa	M25 grade
2	Steel grade (Fy)	415	Mpa	Fe415 grade
3	effective span	6	m	
4	$(L/D)_{basic}$ assumed	10		
5	clear cover	50	mm	
6	Effective depth	600	mm	
7	total depth	650	mm	About XX-Axis
8	Trail width	300	mm	
	LOADS			
9	self weight	4.875	KN/m^2	
10	wall load for 200 mm thick wall	1.91	KN/m^2	
11	total dead load	6.785	KN/m^2	
12	factored dead load (g)	10.1775	KN/m^2	
13	live load (q)	45	KN/m	
14	Live load from slab	30	KN/m^2	
	BEANDING MOMENT AND SHEAR FORCE			
15	Mu(-ve)	324.9585	KN-m	@ exterior supports
16	Mu(+ve)	288.79875	KN-m	@ centre of span
17	Vu	297.9585	KN	Max shear force at supports
18	$Mu_{(lim)}$ (limiting bending moments)	372.6	KN-m	UNDER REINFORCED
	REINFORCEMENT			
	Main reinforcement			
19	Ast(-ve)	1798.297284	mm^2	@ supports
20	Dia of bar used	25	mm	
21	Area of one bar	490.625	mm^2	
22	No. of bars	4		
23	Ast(+ve)	1556.596759	mm^2	@ centre of span
24	Dia of bar used	20	mm	
25	Area of one bar	314	mm^2	

26	No. of bars	5		
	Shear reinforcement			
27	τ_u	1.66		
28	Pt%	1.09		
29	τ_c	0.57		Design shear strength
30	Design for shear reinforcement			
31	Vus	195.3585	KN	
32	Dia of bar used	8	mm	2 leged barrs for stirups
33	Area of one bar	103.68	mm^2	
34	Spacing	114.9691383	mm	
35	hence provide ϕ8mm, 2 leged bars with calculated spacing in all over the beam			
		CHECK		
	Check for deflection			
36	Pt%	1.09	%	
37	K1 (modification factor)	1.2		
38	K_L	1		
39	K_T	1		
40	$(L/D)_{allowable}$	31.2		
41	$(L/D)_{actual}$	10		OK

Reinforcement details:

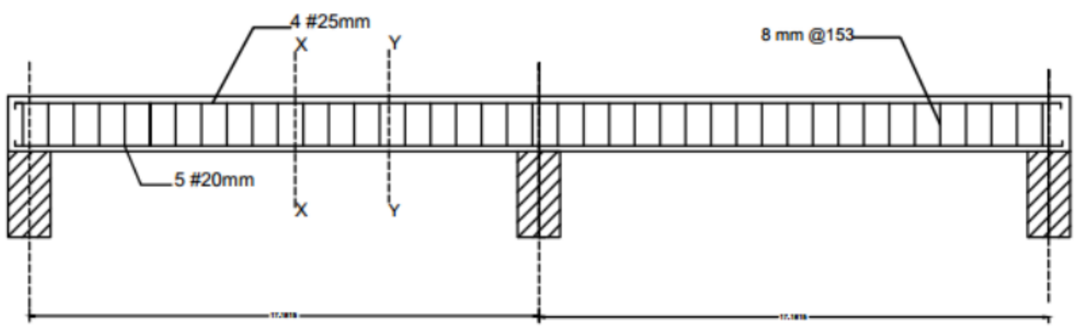


Fig.8 Reinforcement Details Of continuous beam

Reinforcements Near Support: 4—25mm Bars @ 50mm c/c.

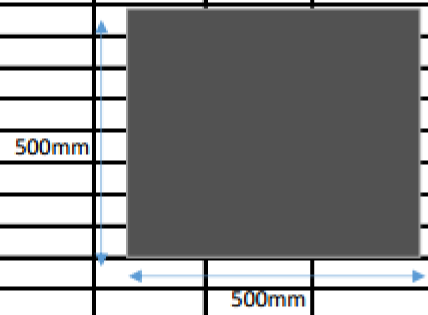
Reinforcements At Mid Span: 5—20mm Bars @ 67mm c/c

Shear Reinforcements: 8mm 2 Legged Stirrups @ 153mm c/c Throughout Beam.

4.4 Column design

4.4.1 Design spreadsheet (First floor)

COLUMN DESIGN OF FIRST FLOOR



Sr. no.			Units	Remarks
1	Fy (steel grade)	415	Mpa	Fe415
2	Fck (concrete grade)	25	Mpa	M25
3	trial depth (D)	500	mm	
4	trail width (b)	500	mm	
5	Ultimate axial load (P_u)	3173	KN	
6	Ultimate moment (M_{ux})	81	KN-m	About XX-Axis
7	Ultimate moment (M_{uy})	41.5	KN-m	About YY-Axis
8	clear cover (d')	50	mm	
9	d'/D	0.1		
	REINFORCEMENT			
10	Assumed P% of reinforcement	1	%	
11	A_{st}	2500	mm^2	Area of steel
12	dia of bar used	20	mm	
13	area of one bar	314	mm^2	
14	no. of bars used	8		
15	A_{st} (provided)	2512	mm^2	
	check			
16	A_c	250000	mm^2	Area of concrete
17	P% (actual)	1.005	%	
18	$P/(F_{ck})$	0.04		ratio
19	$P_u/(F_{ck}*b*D)$	0.508		ratio
20	$M_{ux1}/(F_{ck}*b*D^2)$ ratio	0.03		ratio
21	M_{ux1}	93.75	KN-m	Along XX-Axis
22	M_{uy1}	93.75	KN-m	Along YY-Axis
23	P_{uz}	3566.1	KN	
24	P_u/P_{uz}	0.89		
25	α_n	2		
26	$(M_{ux}/M_{ux1})^2+(M_{uy}/M_{uy1})^2$	0.942		OK
	Latral ties			
27	tie bar dia	8	mm	
28	spacing	300	mm	through out the column

Reinforcement design

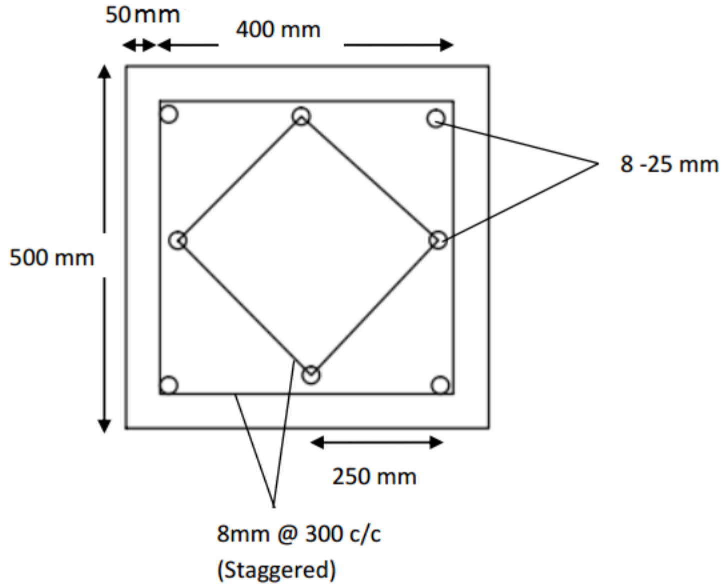


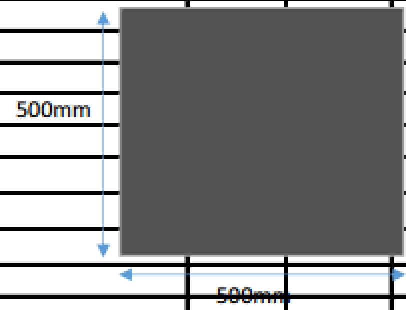
Fig.9 Reinforcement Details Of Column

Longitudinal Reinforcement: 8—20mm (Three on Each Face).

Shear Reinforcement: 8mm Stirrups @ c/c mm throughout the Column.

4.4.2 Design spreadsheet (Second floor)

COLUMN DESIGN OF SECOND FLOOR



Sr. no.			Units	Remarks
1	Fy (steel grade)	415	Mpa	Fe415
2	Fck (concrete grade)	25	Mpa	M25
3	trial depth (D)	500	mm	
4	trail width (b)	500	mm	
5	Ultimate axial load (P_u)	2343	KN	
6	Ultimate moment (M_{ux})	110.68	KN-m	About XX-Axis
7	Ultimate moment (M_{uy})	107.5	KN-m	About YY-Axis
8	clear cover (d')	50	mm	
9	d'/D	0.1		
	REINFORCEMENT			
10	Assumed P% of reinforcement	1	%	
11	A_{st}	2500	mm^2	Area of steel
12	dia of bar used	20	mm	
13	area of one bar	314	mm^2	
14	no. of bars used	8		
15	A_{st} (provided)	2512	mm^2	
	check			
16	A_c	250000	mm^2	Area of concrete
17	P% (actual)	1.005	%	
18	P/(F_{ck})	0.04		ratio
19	P_u/(F_{ck}*b*D)	0.375		ratio
20	M_{ux1}/(F_{ck}*b*D^2) ratio	0.07		ratio
21	M_{ux1}	218.75	KN-m	Along XX-Axis
22	M_{uy1}	218.75	KN-m	Along YY-Axis
23	P_{uz}	3566.1	KN	
24	P_u/P_{uz}	0.657		
25	α_n	1.6		
26	(M_{ux}/M_{ux1})^2+(M_{uy}/M_{uy1})^2	0.657		OK
	Latral ties			
27	tie bar dia	8	mm	
28	spacing	300	mm	through out the column

Reinforced details:

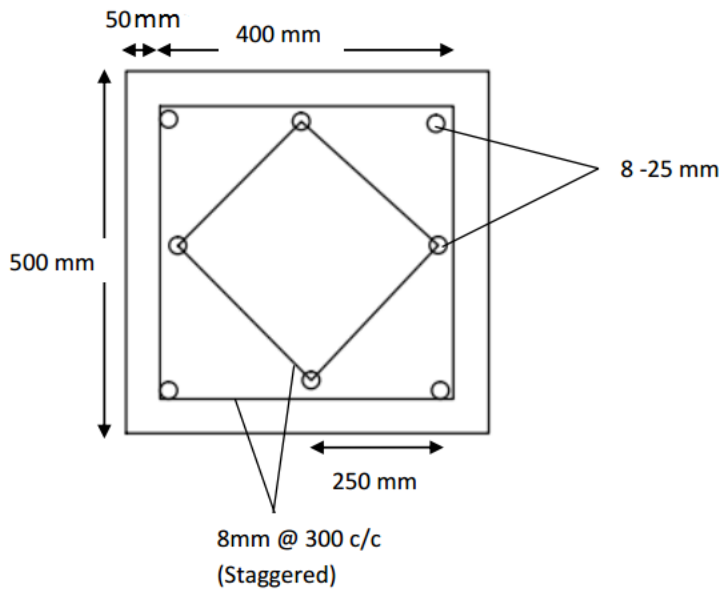
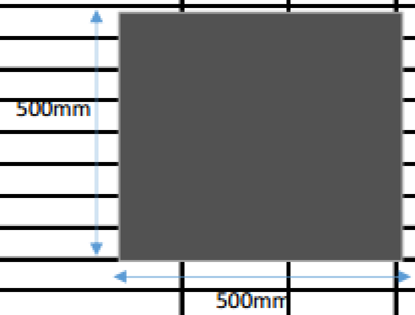


Fig.10 Reinforcement Details Of Column

Longitudinal Reinforcement: 8—20mm (Three on Each Face).
Shear Reinforcement: 8mm Stirrups @ c/c mm throughout the Column.

4.4.3 Design spreadsheet (Third floor)

COLUMN DESIGN OF THIRD FLOOR



Sr. no.			Units	Remarks
1	Fy (steel grade)	415	Mpa	Fe415
2	Fck (concrete grade)	25	Mpa	M25
3	trial depth (D)	500	mm	
4	trail width (b)	500	mm	
5	Ultimate axial load (P_u)	1537	KN	
6	Ultimate moment (M_{ux})	101.66	KN-m	About XX-Axis
7	Ultimate moment (M_{uy})	97.5	KN-m	About YY-Axis
8	clear cover (d')	50	mm	
9	d'/D	0.1		
		REINFORCEMENT		
10	Assumed P% of reinforcement	1	%	
11	A_{st}	2500	mm^2	Area of steel
12	dia of bar used	20	mm	
13	area of one bar	314	mm^2	
14	no. of bars used	8		
15	A_{st} (provided)	2512	mm^2	
	check			
16	A_c	250000	mm^2	Area of concrete
17	P% (actual)	1.005	%	
18	$P/(F_{ck})$	0.04		ratio
19	$P_u/(F_{ck}*b*D)$	0.246		ratio
20	$M_{ux1}/(F_{ck}*b*D^2)$ ratio	0.09		ratio
21	M_{ux1}	281.25	KN-m	Along XX-Axis
22	M_{uy1}	281.25	KN-m	Along YY-Axis
23	P_{uz}	3566.1	KN	
24	P_u/P_{uz}	0.431		
25	α_n	1.3		
26	$(M_{ux}/M_{ux1})^2+(M_{uy}/M_{uy1})^2$	0.519		OK
	Latral ties			
27	tie bar dia	8	mm	
28	spacing	300	mm	through out the column

Reinforcement details:

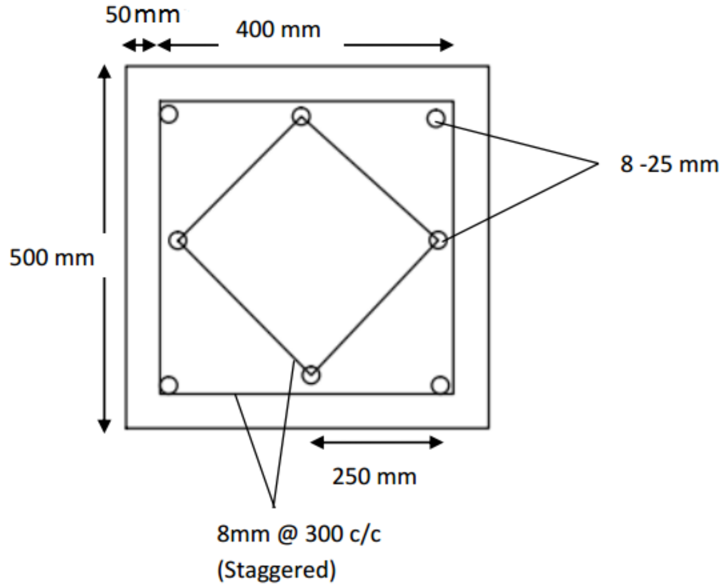
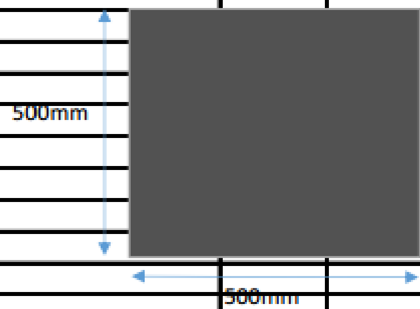


Fig.11 Reinforcement Details Of Column

Longitudinal Reinforcement: 8—20mm (Three on Each Face).
Shear Reinforcement: 8mm Stirrups @ c/c mm throughout the Column.

4.4.4 Design spreadsheet (Fourth floor)

COLUMN DESIGN OF FOURTH FLOOR



Sr. no.			Units	Remarks
1	Fy (steel grade)	415	Mpa	Fe415
2	Fck (concrete grade)	25	Mpa	M25
3	trial depth (D)	500	mm	
4	trail width (b)	500	mm	
5	Ultimate axial load (P_u)	745	KN	
6	Design moment (M_{ux})	166.2	KN-m	About XX-Axis
7	Design moment (M_{uy})	127	KN-m	About YY-Axis
8	clear cover (d')	50	mm	
9	d'/D	0.1		
		REINFORCEMENT		
10	Assumed P% of reinforcement	1	%	
11	A_{st}	2500	mm^2	Area of steel
12	dia of bar used	20	mm	
13	area of one bar	314	mm^2	
14	no. of bars used	8		
15	A_{st} (provided)	2512	mm^2	
	check			
16	A_c	250000	mm^2	Area of concrete
17	P% (actual)	1.005	%	
18	P/(F_{ck})	0.04		ratio
19	$P_u/(F_{ck}*b*D)$	0.119		ratio
20	$M_{ux1}/(F_{ck}*b*D^2)$ ratio	0.087		ratio
21	Max. bending moment (M_{ux1})	271.875	KN-m	Along XX-Axis
22	Max. bending moment (M_{uy1})	271.875	KN-m	Along YY-Axis
23	P_{uz}	3566.1	KN	
24	P_u/P_{uz}	0.209		
25	α_n	1.13		
26	$(M_{ux}/M_{ux1})^2+(M_{uy}/M_{uy1})^2$	0.997		OK
	Latral ties			
27	tie bar dia	8	mm	
28	spacing	300	mm	through out the column

Reinforcement details:

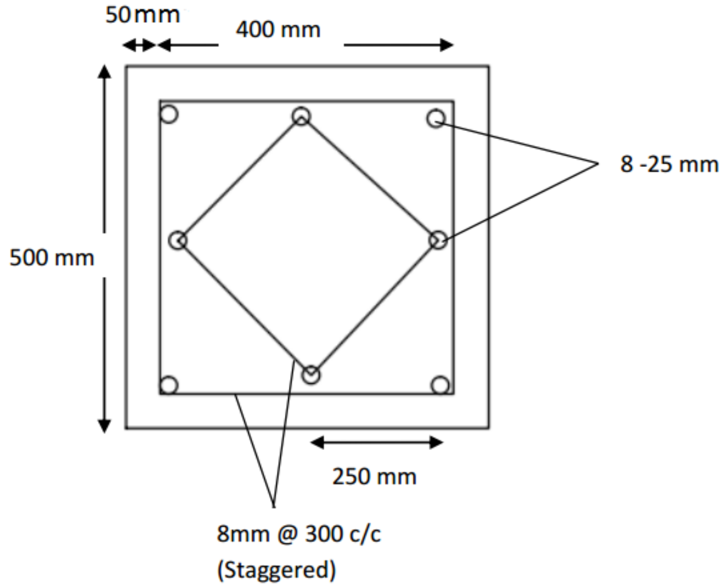


Fig.12 Reinforcement Details Of Column

Longitudinal Reinforcement: 8—20mm (Three on Each Face).
Shear Reinforcement: 8mm Stirrups @ c/c mm throughout the Column.

4.5 Design loads for building

4.5.1 Dead loads:

Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including, finishes and fixed equipment. Dead load is the total load of all of the components of the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc.

Self-weight of beam = 25*.65*.3 = 4.875kN/m^2

Factored dead load on beams = 1.5 * 4.875 = 7.3125kN/m^2

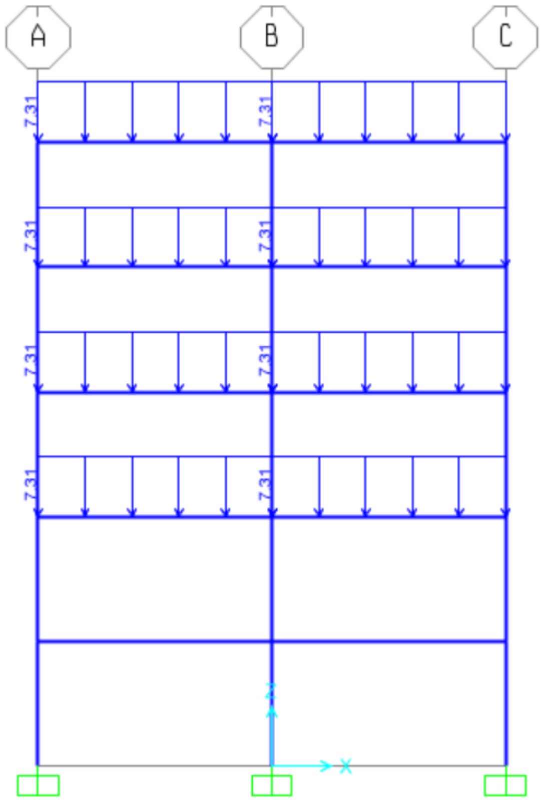


Fig.13 Dead load on structure

4.5.2 Live loads

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities.

Dead load of slab on exterior beams = Self-weight of slab = 5.5 kN/m^2

Floor finishing = 1.5 kN/m^2

Live load considered for external beams of top floor = 1.5 kN/m^2

Live load considered for internal beams of top floor = 1.5 kN/m^2

Live load considered for external beams of lower floors = 1.5 kN/m^2

Live load considered for internal beams of lower floors = 3 kN/m^2

Total live load on external beams of top floor = 8.5 kN/m^2 = 12.75 kN/m^2 (Factored)

Total live load on internal beams of top floor = 8.5 * 2 = 17 kN/m^2 = 25.5 kN/m^2 (Factored)

Total live load on external beams of lower floors = 10 kN/m^2 = 15 kN/m^2 (Factored)

Total live load on internal beams of lower floors = 20 kN/m^2 = 30 kN/m^2 (Factored load)

Now the live load act as a triangular loading on **external beams of top floor** i.e. = 1.5 *12.75 = **19.125 kN/m^2**

Total live load on **internal beams of top floor** = 1.5*25.5 = **38.25 kN/m^2.**

Total live load on **external beams of lower floor** = 1.5*15 = **22.5 kN/m^2**

Total live load on **internal beams of lower floor** = 1.5*30 = **45 kN/m^2**

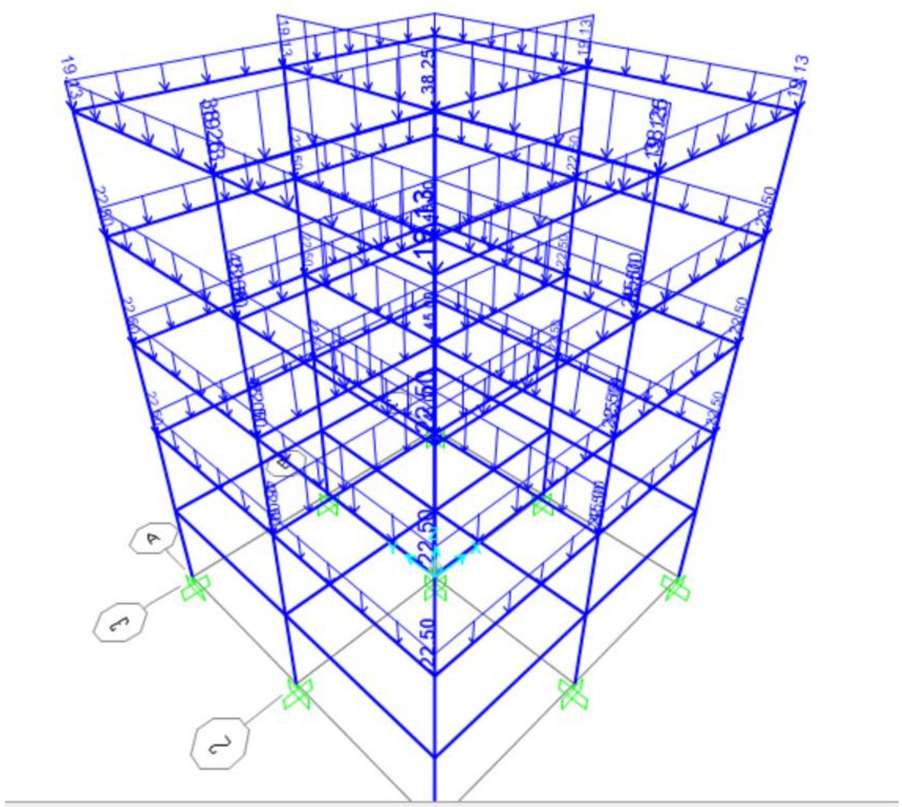


Fig.14 Showing live load acting on structure

4.4.3 Wall loads

Brick wall of 200mm is considered in the building. Hence extra wall load will be applied on the beams of the buildings.

Wall load on exterior beam of top floor = 1.91 kN/m^2 = 2.865 kN/m^2 (Factored)

Wall load on interior beam of top floor = 1.91 kN/m^2 = 2.865 kN/m^2 (Factored)

Wall load on exterior beam of lower floor = 3.83 kN/m^2 = 5.73 kN/m^2 (Factored)

Wall load on exterior beam of top floor = 1.91 kN/m^2 = 2.865 kN/m^2 (Factored)

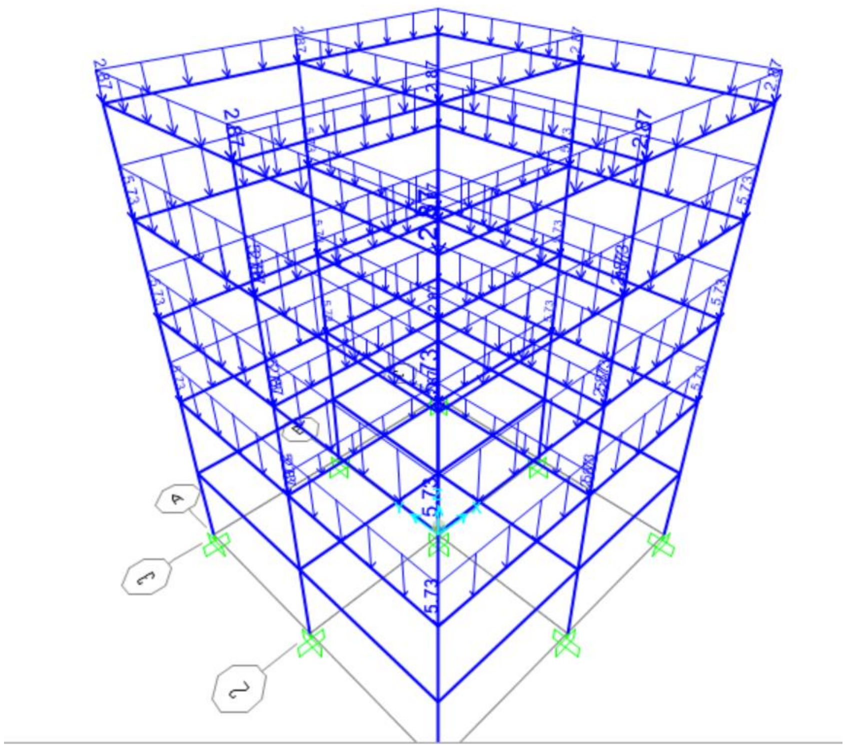


Fig.15 Wall load acting on structure

4.4.4 Wind load

Wind Load as per IS (Part-3) 1987

Vz = Vb x k1 x k2 x k3

Where, Vb = 39 m/s (for Shimla) in Appendix A of IS 875 (Part-3) k1 = factor for maximum design life

Since, the building is a residential building, clause 5.3.1 and Table 1 of IS 875 (Part-3), k1= 1 (for all general buildings, having return period of 50 years)

K2= factor of terrain, height and structure clause 5.3.2

Category 3 is adopted as per the note which says this category includes well wooded areas and shrubs, towns and industrial areas full or partially developed.

Clause 5.3.2.2 states variation of wind speed with height for different sizes of structures in different terrains is k2 dependent. Assuming Class A structures and/or their components such as cladding, glazing, roofing etc, having maximum dimension (greatest horizontal or vertical dimension) less than 20 m. Also, the wind speed till 10 m height of the building is constant and varies after that.

Clause 5.3.3.1 states that the value is taken to be 1 for factor k3 when slope is less then 3 degree.

$Pz = 0.6(Vz)^2$ Where, Pz is the wind pressure.

4.5.5 Flood load

The flood load applied to the building is according to the ASCE and USACE.

Assumptions:

Floodwater velocities in the area of the house average = 2.25 m/s (Maximum according to the Chennai flood survey 2015)

Floodwater flows parallel to front elevation and impact side elevation

Floodwater debris hazard exists and is characterized as normal

W = weight of debris = 5kN
CB = blockage coefficient = 1
Cstr = building structure coefficient = 0.8

4.5.5.1 Lateral Hydrostatic load

During any point of floodwater contact with a structure, hydrostatic pressures are equal in all directions and always act perpendicular to the surface on which they are applied. Pressures increase linearly with depth or "head" of water above the point under consideration. For structural analysis, hydrostatic forces, as shown in Figures

$$f_{sta} = 1/2\ P_h\ H = 1/2\ \gamma_w H^2$$

where:

f_{sta} = hydrostatic force from standing water (kN/m) acting at a distance $H/3$ above ground
P_h= hydrostatic pressure due to standing water at a depth of H (kN/m^2), ($Ph = \gamma_w H$)
γ_w = specific weight of water (9.8 kN/m^3 for seawater)
H = floodproofing design depth (m)

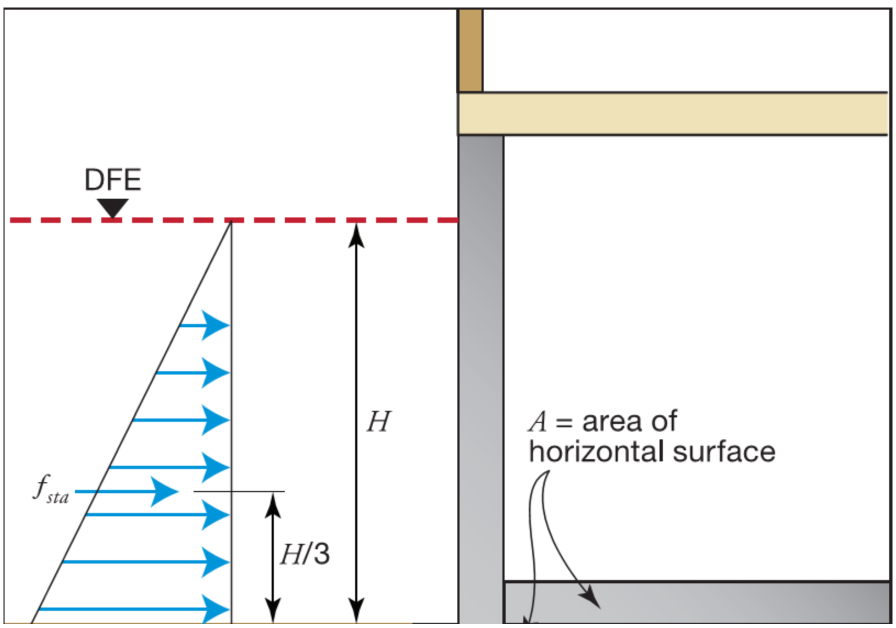


Fig.16 Hydrostatic load on building

f_{sta} = 1/2 * 9.8 * 3.2^2 = 50.176 kN/m, acting 1.07m above the grond level

For design purposes, this lateral pressure is generally assumed to act on the receiving structure at a point one-third of the water depth above the base of the structure or two-thirds of the altitude from the water surface, which correlates to the centre of gravity for a triangular pressure distribution.

4.4.5.2 Hydrodynamic Loading

These loads are a function of flow velocity and structural geometry. Low velocity hydrodynamic forces are defined as situations where floodwater velocities do not exceed 10 ft/sec, while high velocity hydrodynamic forces involve floodwater velocities in excess of 10 ft/sec.

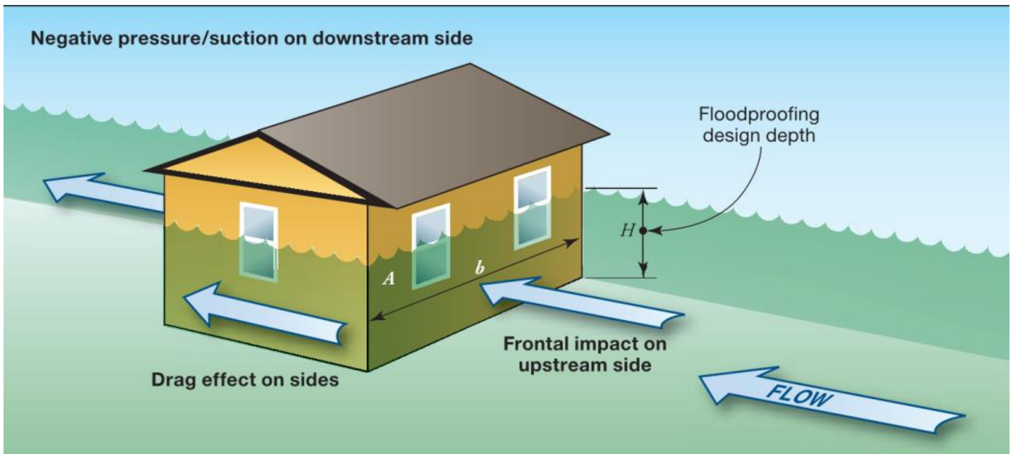


Fig17 Hydrodynamic and impact forces

In cases where velocities do not exceed 10 ft/sec, the hydrodynamic effects of moving water can be converted to an equivalent hydrostatic force by increasing the depth of the water (head) above the flood level by an amount *dh*.

$$dh = \frac{C_d V^2}{2g}$$

where:

dh = equivalent head due to low velocity flood flows (m)

C_d = drag coefficient (from Table)

V = velocity of floodwater (m/sec)

g = acceleration of gravity (equal to 9.8 m/sec^2)

Determine drag coefficient *Cd* by calculating b/H and using Table 4

b/H = 12/3.2 =3.75, C_d = 1.25

Now, dh = (1.25 * 2.25^2) / (2 * 9.8) = .323 m

Table 2: Drag Coefficients for Ratios of Width to Height (w/h)

Width to Height Ratio *(b/H)*	Drag Coefficient (C_d)
1–12	1.25
13–20	1.3
21–32	1.4
33–40	1.5
41–80	1.75
81–120	1.8
>120	2.0

The value *dh* is then converted to an equivalent hydrostatic pressure through use of the basic equation for lateral hydrostatic forces introduced earlier.

$$f_{dh} = \gamma_w(dh)H = P_{dh}H$$
$$f_{dh} = 9.8(.323)3.2 = 10.129kN/m$$

where:

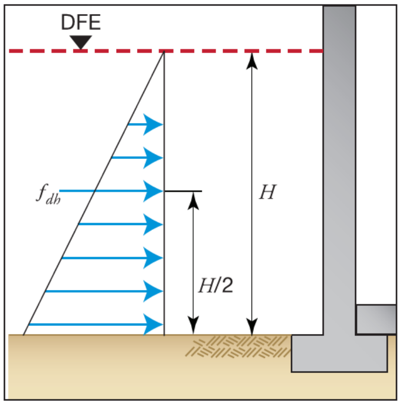
f_{dh} = equivalent hydrostatic force due to low velocity flood flows (kN/m)

γ_w = specific weight of water (9.8 kN/m^3 for saltwater)

dh = equivalent head due to low velocity flood flows (fm)

H = floodproofing design depth (m)

P_{dh} = hydrostatic pressure due to low velocity flood flows (kN/m^2) ($P_{dh} = \gamma_w(dh)$)



Although f_{dh} is considered a hydrostatic force for velocities under 10 ft/sec, it acts at a point *H*/2, similarly to lateral hydrodynamic forces.

Fig18 Hydrodynamic force n building

Now total force due to flow velocity on the building face (upstream)

$$f_d = f_{dh} W$$

$$f_d = 10.129 * 12 = 121.458\ kN$$

Where:

W = width of the submerged wall (m)

4.4.5.3 Debris Impact Load

For design purposes, this can be considered a concentrated load acting horizontally at the flood elevation, or any point below it, equal to the impact force created by a typical object traveling at the velocity of the floodwater acting on a 1-square-foot surface of the submerged structure area perpendicular to the flow.

The equation for calculating debris loads is given

$$F_i = WVC_B C_D C_{Str}$$

$$F_i = 5 * 2.25 * 1 * 1.25 * .8 = 11.25\ kN$$

where:

Fi = impact force (kN)

W = weight of the object (kN)

V = velocity of water (m/sec)

C_D = depth coefficient (see Table 4)

C_B = blockage coefficient (taken as 1.0 for no upstream screening, flow path greater than 30 ft; see Table 4 for more information)

C_{Str} = building structure coefficient

= 0.2 for timber pile and masonry column supported structures 3 stories or less in height above grade

= 0.4 for concrete pile or concrete or steel moment resisting frames 3 stories or less in height above grade

= 0.8 for reinforced concrete (including insulated concrete) and reinforced masonry foundation walls

Table 3: Depth Coefficient (C_D) by Flood Hazard Zone and Water Depth

Flood Hazard Zone and Water Depth	C_D
Floodway[1] or Zone V	1.0
Zone A, stillwater flood depth > 5 ft	1.0
Zone A, stillwater flood depth = 4 ft	0.75
Zone A, stillwater flood depth = 3 ft	0.5
Zone A, stillwater flood depth = 2 ft	0.25
Zone A, stillwater flood depth < 1 ft	0.0

1 Per ASCE 24, a "floodway" is a "channel and that portion of the floodplain reserved to convey the base flood without cumulatively increasing the water surface elevation more than a designated height."

Table 4: Values of Blockage Coefficient (C_B)

Degree of Screening or Sheltering within 100 ft Upstream	C_B
No upstream screening, flow path wider than 30 ft	1.0
Limited upstream screening, flow path 20 ft wide	0.6
Moderate upstream screening, flow path 10 ft wide	0.2
Dense upstream screening, flow path less than 5 ft wide	0.0

CHAPTER 5

RESULT AND DISCUSSION

5.1 Displacements of joints

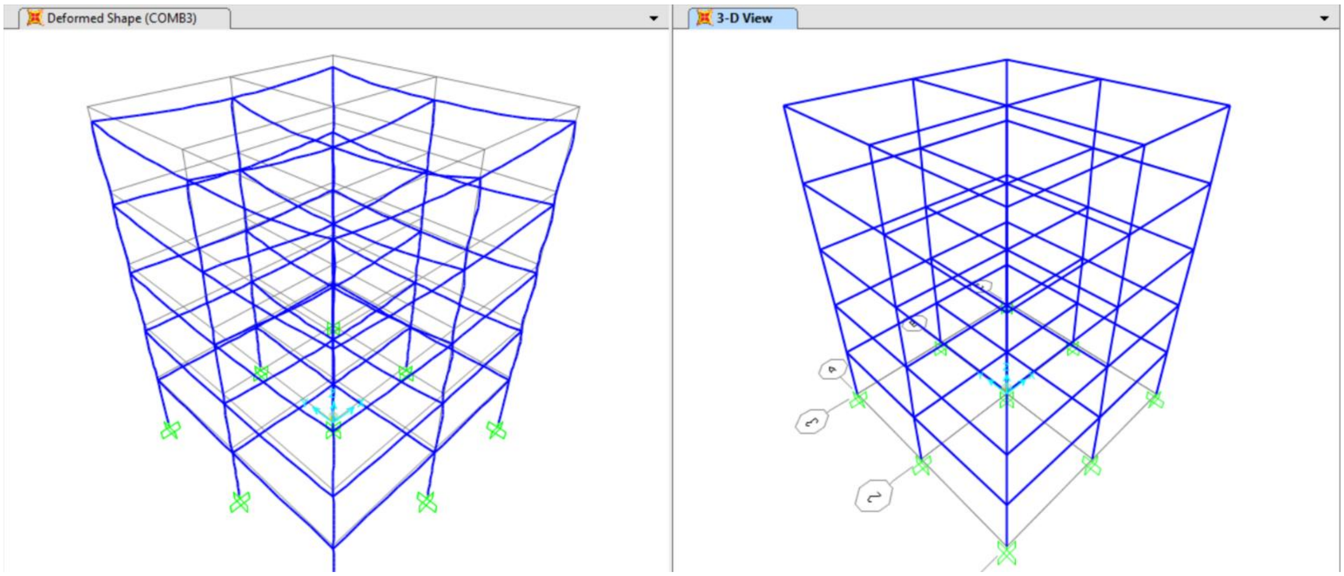


Fig.19 Displacements of the joints

Table 5 Joint displacements of the structure

TABLE: Joint Displacements						
Joint	U1	U2	U3	R1	R2	R3
Text	m	m	m	Radians	Radians	Radians
1	0	0	0	0	0	0
2	2.694E-18	2.274E-18	-0.000813	-0.000144	0.000036	0
3	1.411E-17	1.402E-17	-0.001565	-0.000747	0.00027	1.552E-20
4	3.237E-17	3.369E-17	-0.002123	-0.000738	0.000252	2.154E-20
5	5.163E-17	5.379E-17	-0.002484	-0.000748	0.000224	2.55E-20
6	6.958E-17	7.172E-17	-0.002643	-0.001014	0.000463	5.053E-20
7	0	0	0	0	0	0
8	2.662E-18	2.274E-18	-0.001398	-1.31E-18	0.000029	0
9	1.402E-17	1.402E-17	-0.002715	-5.526E-18	0.000393	1.552E-20
10	3.224E-17	3.369E-17	-0.00369	-5.774E-18	0.000366	2.154E-20
11	5.148E-17	5.379E-17	-0.004325	-5.731E-18	0.000326	2.55E-20
12	6.928E-17	7.172E-17	-0.00462	-4.417E-18	0.000693	5.053E-20
13	0	0	0	0	0	0
14	2.629E-18	2.274E-18	-0.000813	0.000144	0.000036	0
15	1.392E-17	1.402E-17	-0.001565	0.000747	0.00027	1.552E-20
16	3.211E-17	3.369E-17	-0.002123	0.000738	0.000252	2.154E-20
17	5.133E-17	5.379E-17	-0.002484	0.000748	0.000224	2.55E-20
18	6.897E-17	7.172E-17	-0.002643	0.001014	0.000463	5.053E-20
19	0	0	0	0	0	0
20	2.694E-18	2.307E-18	-0.00129	-0.000149	1.615E-18	0
21	1.411E-17	1.411E-17	-0.002504	-0.001053	5.306E-18	1.552E-20
22	3.237E-17	3.382E-17	-0.003402	-0.001039	5.818E-18	2.154E-20
23	5.163E-17	5.394E-17	-0.003984	-0.001054	5.827E-18	2.55E-20
24	6.958E-17	7.203E-17	-0.004251	-0.001454	4.848E-18	5.053E-20
25	0	0	0	0	0	0
26	2.662E-18	2.307E-18	-0.002156	-1.263E-18	1.456E-18	0
27	1.402E-17	1.411E-17	-0.004229	-7.604E-18	6.294E-18	1.552E-20
28	3.224E-17	3.382E-17	-0.005756	-7.549E-18	6.668E-18	2.154E-20
29	5.148E-17	5.394E-17	-0.006754	-7.583E-18	6.669E-18	2.55E-20
30	6.928E-17	7.203E-17	-0.007232	-6.066E-18	5.724E-18	5.053E-20
31	0	0	0	0	0	0
32	2.629E-18	2.307E-18	-0.00129	0.000149	1.559E-18	0
33	1.392E-17	1.411E-17	-0.002504	0.001053	5.244E-18	1.552E-20
34	3.211E-17	3.382E-17	-0.003402	0.001039	5.672E-18	2.154E-20
35	5.133E-17	5.394E-17	-0.003984	0.001054	5.715E-18	2.55E-20
36	6.897E-17	7.203E-17	-0.004251	0.001454	4.538E-18	5.053E-20
37	0	0	0	0	0	0
38	2.694E-18	2.34E-18	-0.000813	-0.000144	-0.000036	0
39	1.411E-17	1.42E-17	-0.001565	-0.000747	-0.00027	1.552E-20
40	3.237E-17	3.395E-17	-0.002123	-0.000738	-0.000252	2.154E-20
41	5.163E-17	5.41E-17	-0.002484	-0.000748	-0.000224	2.55E-20
42	6.958E-17	7.233E-17	-0.002643	-0.001014	-0.000463	5.053E-20
43	0	0	0	0	0	0
44	2.662E-18	2.34E-18	-0.001398	-1.257E-18	-0.000029	0

45	1.402E-17	1.42E-17	-0.002715	-5.304E-18	-0.000393	1.552E-20
46	3.224E-17	3.395E-17	-0.00369	-5.68E-18	-0.000366	2.154E-20
47	5.148E-17	5.41E-17	-0.004325	-5.525E-18	-0.000326	2.55E-20
48	6.928E-17	7.233E-17	-0.00462	-3.959E-18	-0.000693	5.053E-20
49	0	0	0	0	0	0
50	2.629E-18	2.34E-18	-0.000813	0.000144	-0.000036	0
51	1.392E-17	1.42E-17	-0.001565	0.000747	-0.00027	1.552E-20
52	3.211E-17	3.395E-17	-0.002123	0.000738	-0.000252	2.154E-20
53	5.133E-17	5.41E-17	-0.002484	0.000748	-0.000224	2.55E-20
54	6.897E-17	7.233E-17	-0.002643	0.001014	-0.000463	5.053E-20

5.2 Axial loads on structure

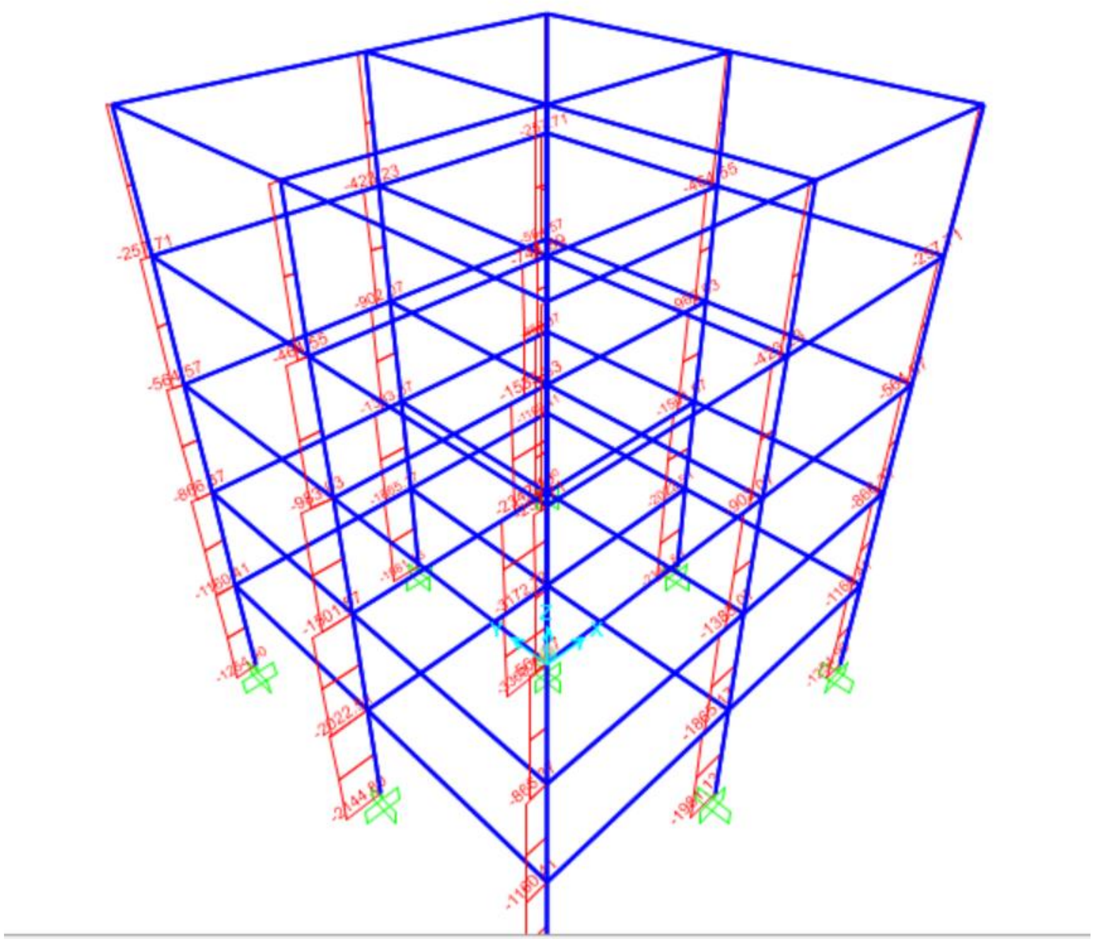


Fig.20 Axial load on structure

5.3 Bending moment diagrams

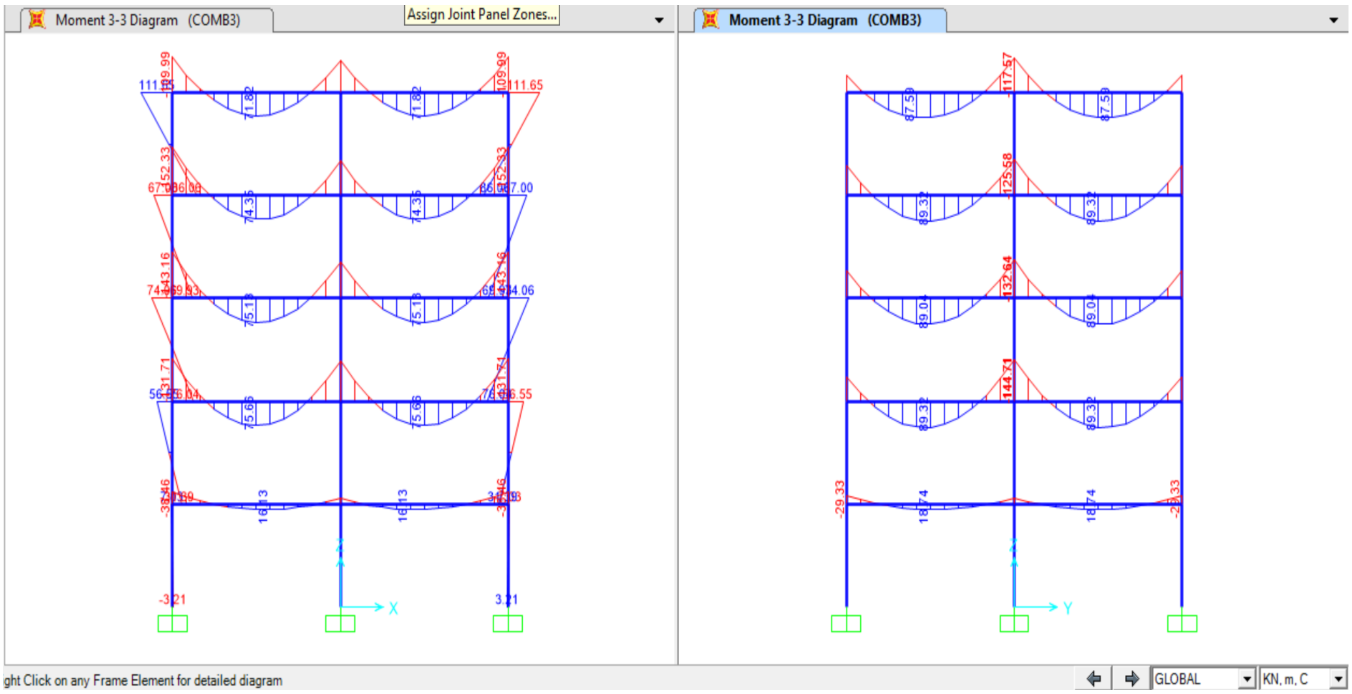


Fig.21 (i) Bending moment (XZ plane) (ii)Bending moment (YZ plane)

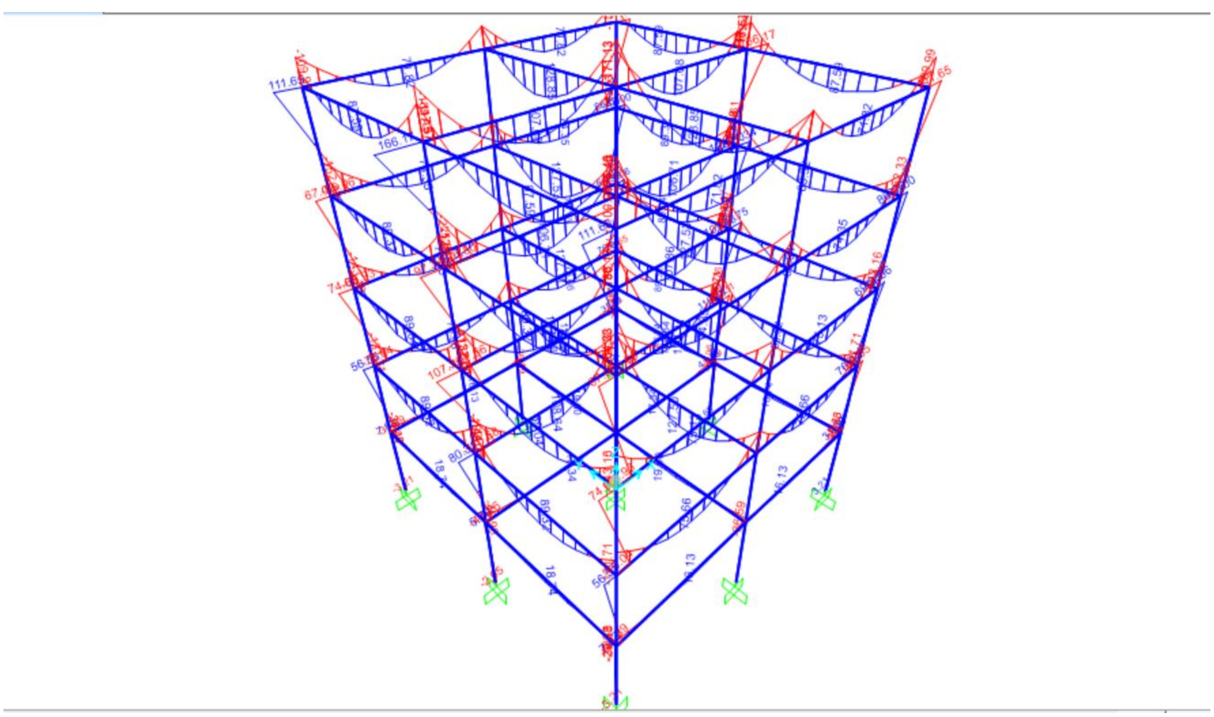


Fig.22 Bending moment diagram of whole structure

5.4 Shear force diagrams

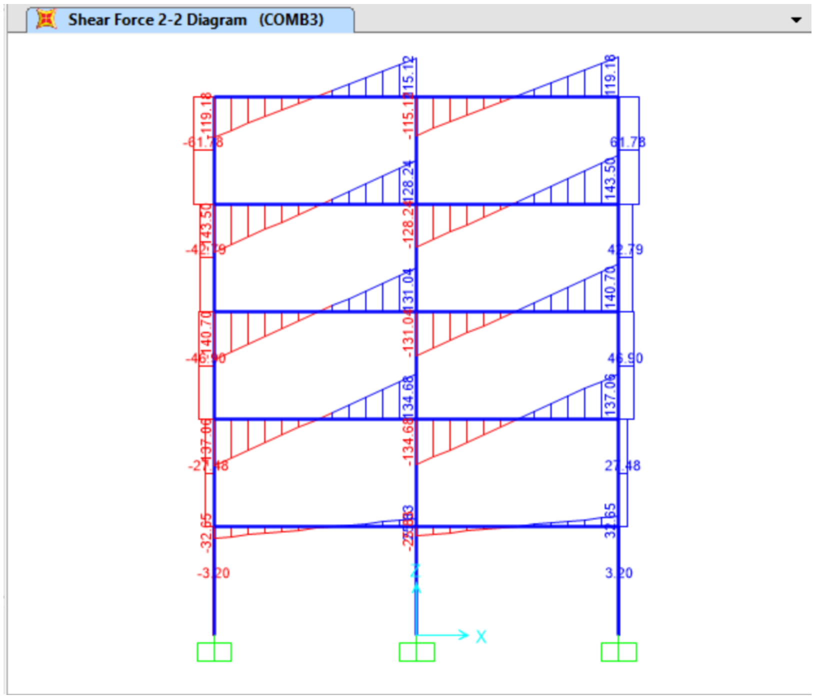


Fig.23 Shear force (XZ plane)

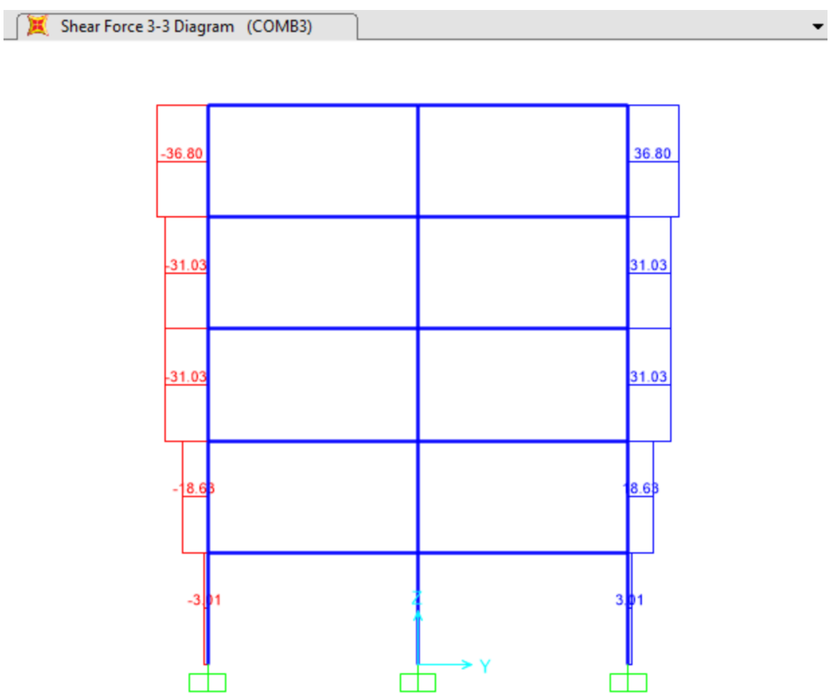


Fig.24 Shear force diagram (YZ plane)

5.5 Joints reactions and moments

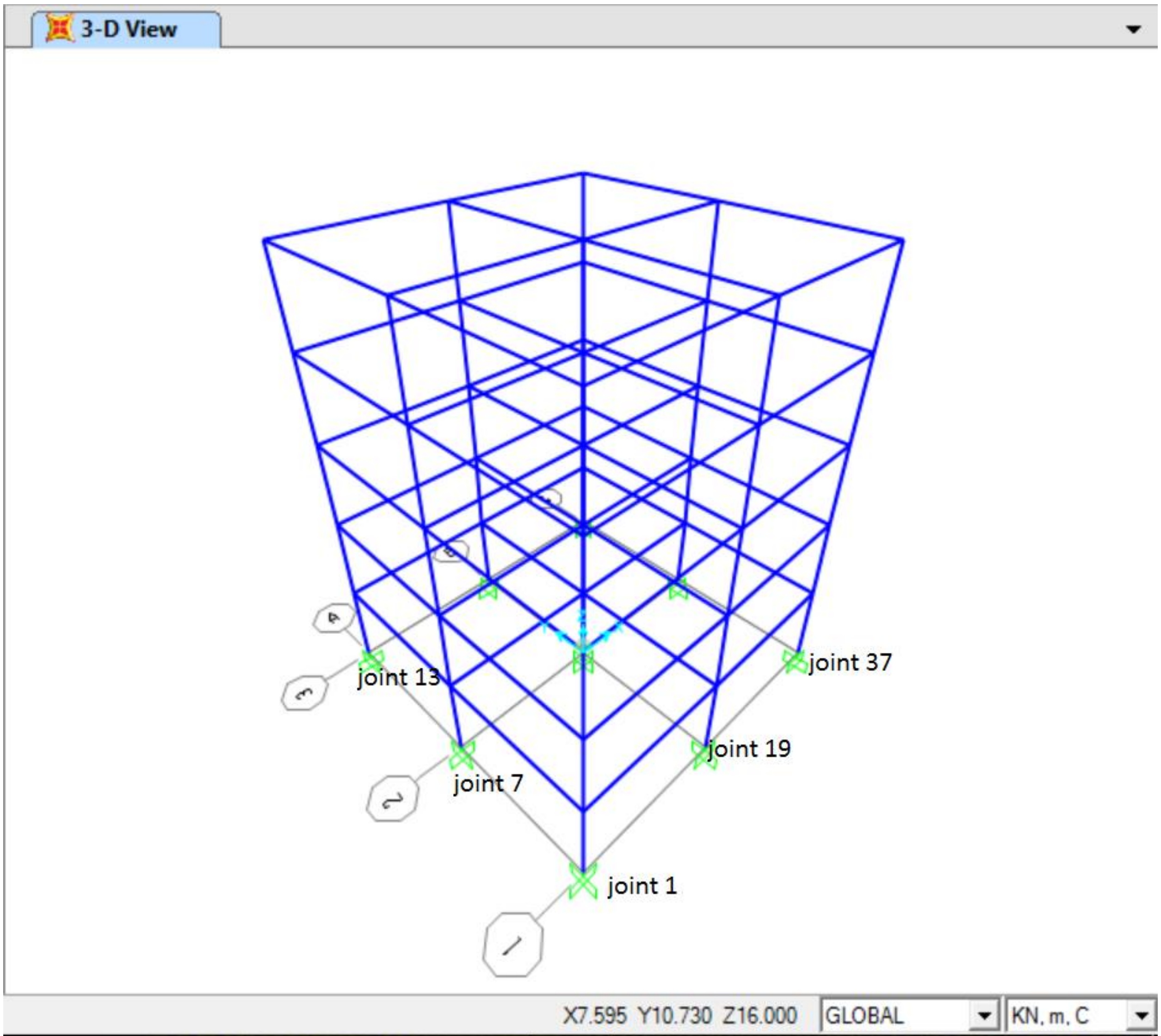


Fig.25 Showing joints with reference to the table.

Table 6 (i)Joint reactions and moments (ii)Base reactions

TABLE: Joint Reactions						
Joint	F1	F2	F3	M1	M2	M3
Text	KN	KN	KN	KN-m	KN-m	KN-m
1	3.198	3.009	1254.898	-3.1688	3.2089	-7.43E-17
7	2.637	-2.32E-15	2144.802	1.868E-14	2.6453	-7.43E-17
13	3.198	-3.009	1254.898	3.1688	3.2089	-7.43E-17
19	-6.168E-15	3.111	1981.133	-3.2762	-9.652E-14	-7.43E-17
25	-1.864E-14	-3.732E-15	3300.766	2.04E-14	-1.079E-13	-7.43E-17
31	-7.52E-15	-3.111	1981.133	3.2762	-9.566E-14	-7.43E-17
37	-3.198	3.009	1254.898	-3.1688	-3.2089	-7.43E-17
43	-2.637	-4.296E-15	2144.802	2.123E-14	-2.6453	-7.43E-17
49	-3.198	-3.009	1254.898	3.1688	-3.2089	-7.43E-17

TABLE: Base Reactions						
OutputCase	GlobalFX	GlobalFY	GlobalFZ	GlobalMX	GlobalMY	GlobalMZ
Text	KN	KN	KN	KN-m	KN-m	KN-m
COMB3	1.51E-14	-9.659E-15	16572.229	5.002E-12	-1.819E-12	-4.352E-14

5.6 Displacement of joints (Including flood load)

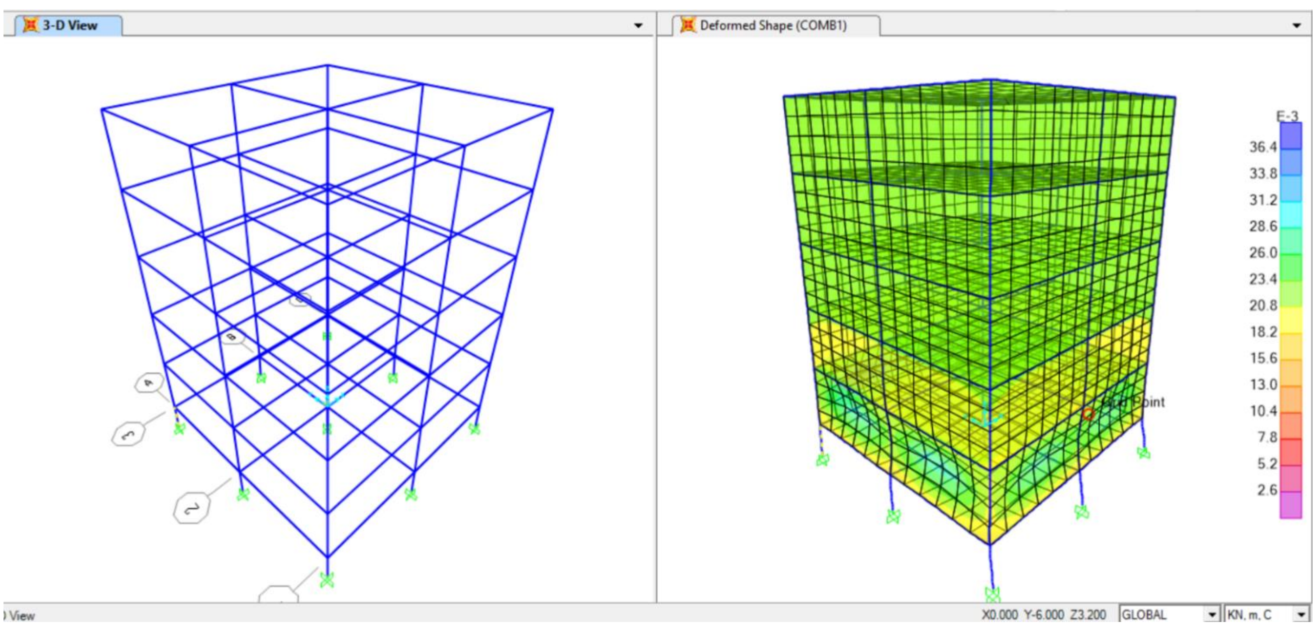


Fig 26 Displacement of the joints after flood load

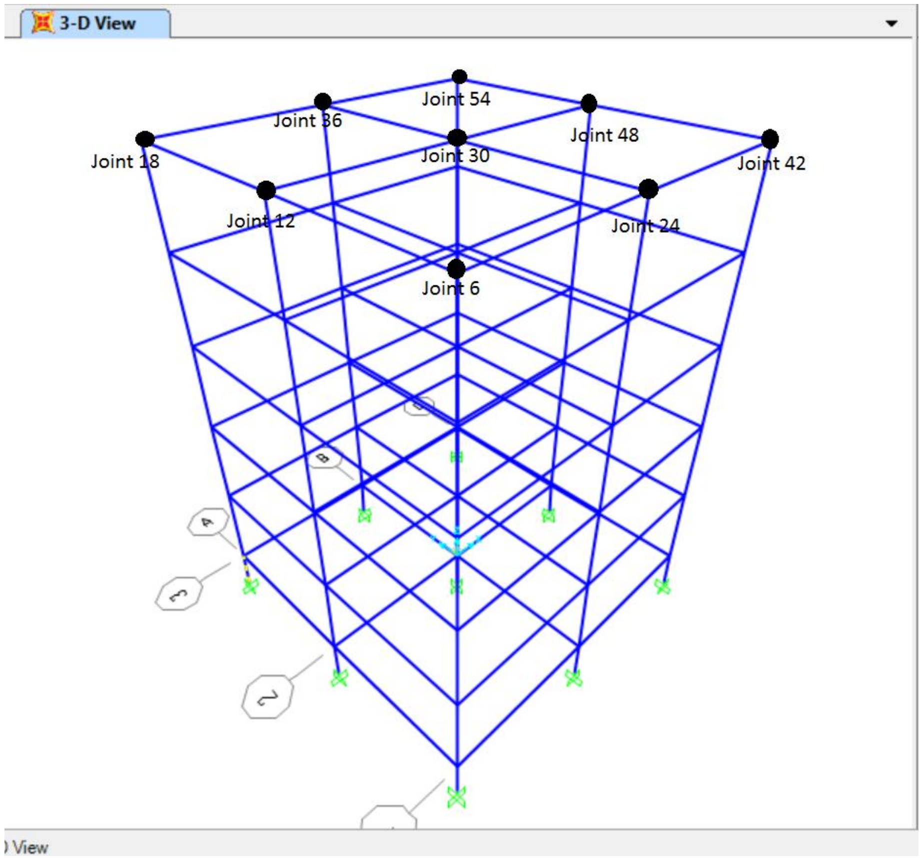


Fig 27 Joints having maximum deflection

Table 7 Joint displacements of the structure

TABLE: Joint Displacements						
Joint	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	m	m	m	Radians	Radians	Radians
2	0.011971	0.016932	0.000286	0.000028	-0.000177	-0.000237
3	0.01211	0.01705	0.000063	-0.00012	0.00012	-1.92E-07
4	0.012396	0.017335	-0.000068	-0.0001	0.000098	-2.36E-07
5	0.01266	0.017596	-0.000144	-0.0001	0.000099	-6.47E-07
6	0.012924	0.017859	-0.000167	-0.00013	0.00012	-3.78E-07
8	0.011971	0.016932	-0.000457	-0.0002	-0.002729	-0.000031
9	0.01211	0.01705	-0.000572	-7.8E-05	0.00086	2.59E-07
10	0.012396	0.017335	-0.000659	-8.5E-05	0.000244	1E-07
11	0.01266	0.017596	-0.00072	-8.3E-05	0.00033	6.86E-08
12	0.012924	0.017859	-0.000752	-8.3E-05	0.000573	8.49E-08
14	0.011971	0.016932	-0.000781	0.000311	-0.000106	0.000843
15	0.01211	0.01705	-0.000956	-8.2E-05	0.000106	-0.000013
16	0.012396	0.017335	-0.001065	-5.8E-05	0.000096	5.79E-07
17	0.01266	0.017596	-0.001131	-6.2E-05	0.000097	-3.7E-08
18	0.012924	0.017859	-0.001151	-3.6E-05	0.000118	-6.56E-07
20	0.011971	0.016932	-0.000431	0.002251	0.000193	0.00003
21	0.01211	0.01705	-0.000545	-0.00081	0.000079	-6.78E-07
22	0.012396	0.017335	-0.000639	-0.00032	0.000085	-7.68E-08
23	0.01266	0.017596	-0.000704	-0.00038	0.000083	-5.65E-08
24	0.012924	0.017859	-0.000737	-0.00065	0.000083	-7.04E-08
26	0.011971	0.016932	-0.001678	-0.00106	0.00072	3.81E-07
27	0.01211	0.01705	-0.002496	0.000185	-0.000114	2.22E-08
28	0.012396	0.017335	-0.003097	-0.00013	0.000121	2.22E-09
29	0.01266	0.017596	-0.003494	-7.2E-05	0.000072	2.23E-10
30	0.012924	0.017859	-0.003701	-8.2E-05	0.000084	8.09E-11
32	0.011971	0.016932	-0.001213	0.004589	0.000193	-0.00003
33	0.01211	0.01705	-0.001434	-0.00058	0.000079	5.09E-07
34	0.012396	0.017335	-0.001569	0.000351	0.000085	7.29E-08
35	0.01266	0.017596	-0.001653	0.000185	0.000083	5.49E-08
36	0.012924	0.017859	-0.00169	0.000499	0.000083	6.93E-08
38	0.011971	0.016932	-0.000796	0.000039	-0.000037	-0.000399
39	0.01211	0.01705	-0.000957	-0.00011	0.000073	8.6E-06
40	0.012396	0.017335	-0.001064	-9.8E-05	0.000064	4.1E-07
41	0.01266	0.017596	-0.001129	-9.8E-05	0.000066	6.71E-07
42	0.012924	0.017859	-0.001149	-0.00012	0.000042	8.99E-07
44	0.011971	0.016932	-0.00122	-0.0002	-0.002227	0.000031
45	0.01211	0.01705	-0.001443	-7.8E-05	0.000249	-4.39E-07
46	0.012396	0.017335	-0.001577	-8.5E-05	-0.000242	-1.05E-07
47	0.01266	0.017596	-0.001659	-8.3E-05	-0.000133	-6.98E-08
48	0.012924	0.017859	-0.001696	-8.3E-05	-0.000428	-8.47E-08
50	0.011971	0.016932	-0.001863	0.000331	-0.000076	-0.000263
51	0.01211	0.01705	-0.001976	-9.8E-05	0.000088	3.62E-06
52	0.012396	0.017335	-0.002061	-6.2E-05	0.000067	-8.19E-07
53	0.01266	0.017596	-0.002116	-6.5E-05	0.000068	1.2E-08

54	0.012924	0.017859	-0.002133	-3.9E-05	0.000044	1.36E-07
78	0.009879	0.014717	0.000695	-0.00416	0.003398	-0.000068
79	0.009879	0.014717	-0.000229	-0.0025	0.006218	0.000161
80	0.009879	0.014717	-0.000504	-0.0042	0.003266	0.00124
81	0.009879	0.014717	-0.0004	-0.00415	0.002994	-0.000945
82	0.009879	0.014717	-0.000733	-0.0025	0.005476	-0.000162
83	0.009879	0.014717	-0.0016	-0.00425	0.003087	-0.000284
84	0.009879	0.014717	-0.000208	-0.00744	0.002023	-0.000139
85	0.009879	0.014717	-0.000585	-0.00245	0.002121	4.5E-07
86	0.009879	0.014717	-0.000747	-0.00889	0.002022	0.000138

Maximum deflection

Joints having maximum deflection

5.7 Axial force (Including flood load)

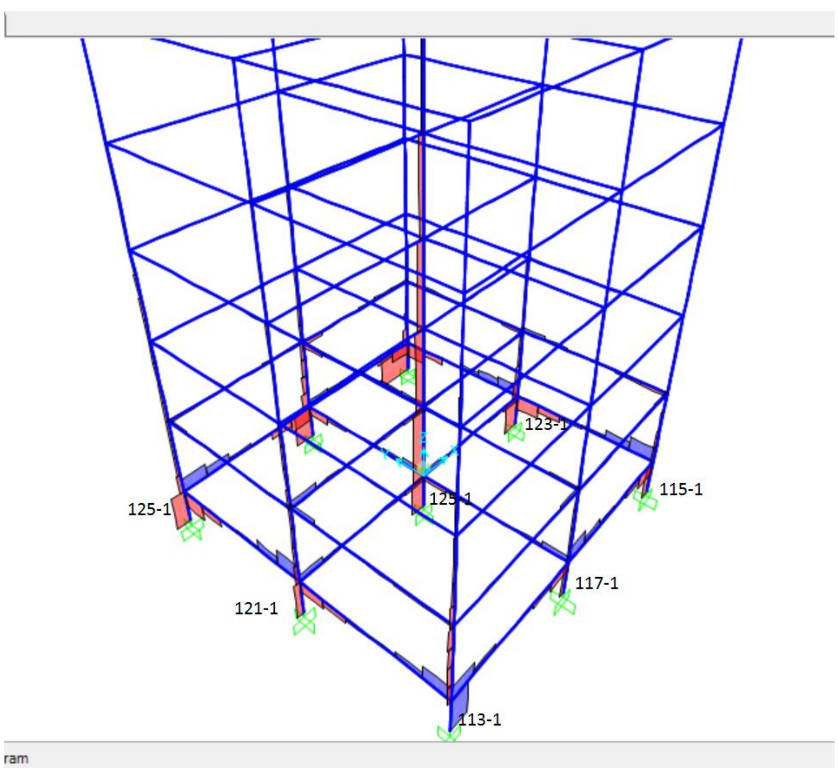


Fig 28 Axial force on building after flood load

Table 8 Axial force on the building

TABLE: Element Forces - Frames						
Frame	Station	OutputCase	CaseType	P	FrameElem	ElemStation
Text	m	Text	Text	KN	Text	m
113	0	COMB1	Combination	3799.74	113-1	0
113	0.75	COMB1	Combination	3808.175	113-1	0.75
113	1.5	COMB1	Combination	3816.61	113-1	1.5
115	0	COMB1	Combination	-1264.879	115-1	0
115	0.75	COMB1	Combination	-1256.444	115-1	0.75
115	1.5	COMB1	Combination	-1248.009	115-1	1.5
117	0	COMB1	Combination	-2767.916	117-1	0
117	0.75	COMB1	Combination	-2759.481	117-1	0.75
117	1.5	COMB1	Combination	-2751.046	117-1	1.5
119	0	COMB1	Combination	-2201.099	119-1	0
119	0.75	COMB1	Combination	-2192.664	119-1	0.75
119	1.5	COMB1	Combination	-2184.229	119-1	1.5
121	0	COMB1	Combination	-4020.843	121-1	0
121	0.75	COMB1	Combination	-4012.408	121-1	0.75
121	1.5	COMB1	Combination	-4003.973	121-1	1.5
123	0	COMB1	Combination	-8769.369	123-1	0
123	0.75	COMB1	Combination	-8760.934	123-1	0.75
123	1.5	COMB1	Combination	-8752.499	123-1	1.5
125	0	COMB1	Combination	-1150.187	125-1	0
125	0.75	COMB1	Combination	-1141.752	125-1	0.75
125	1.5	COMB1	Combination	-1133.317	125-1	1.5
127	0	COMB1	Combination	-3213.239	127-1	0
127	0.75	COMB1	Combination	-3204.804	127-1	0.75
127	1.5	COMB1	Combination	-3196.369	127-1	1.5
129	0	COMB1	Combination	-4097.545	129-1	0
129	0.75	COMB1	Combination	-4089.11	129-1	0.75
129	1.5	COMB1	Combination	-4080.675	129-1	1.5

5.8 Bending moment diagram (including flood load)

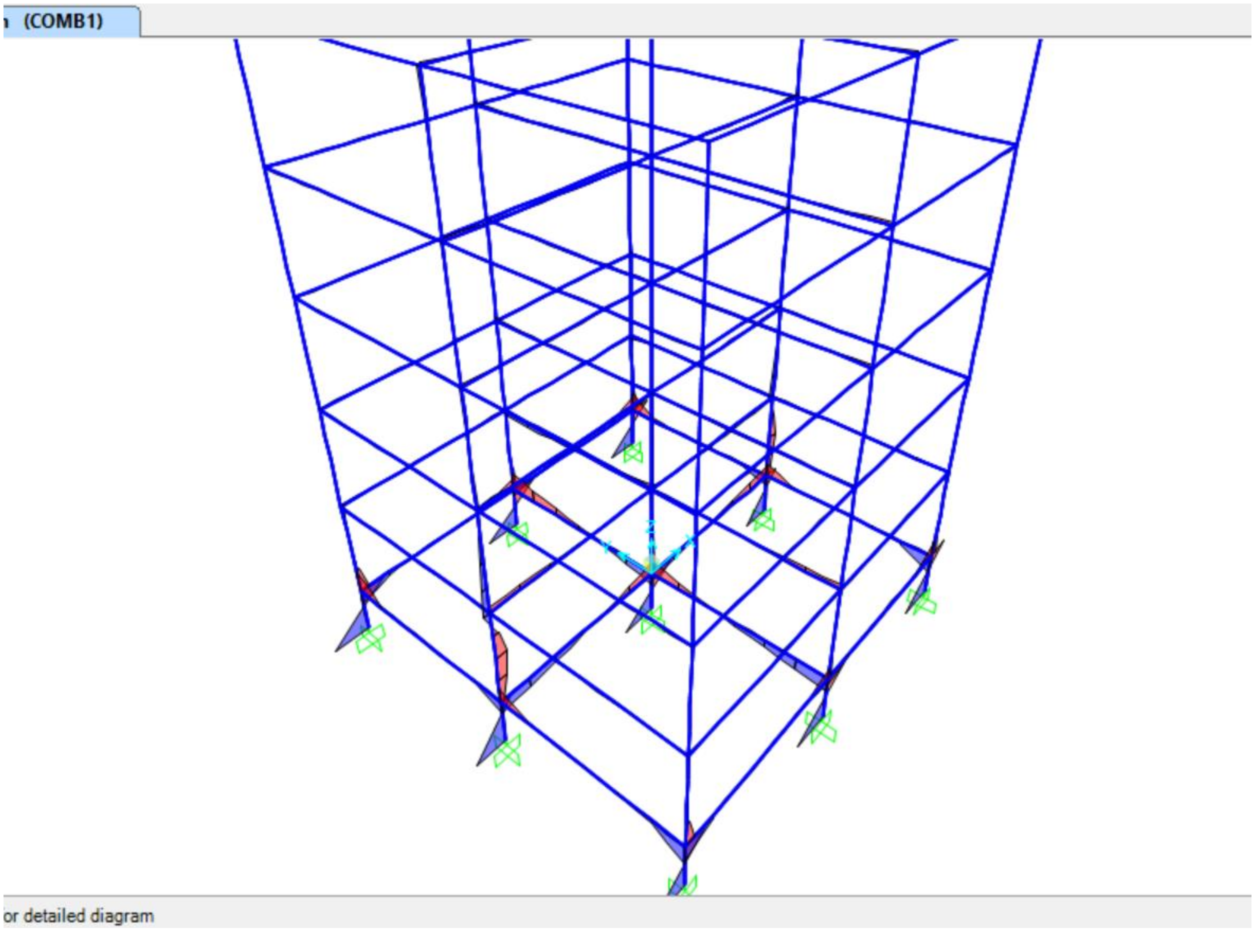


Fig 29 Bending moment diagram after flood load

Table 9 Bending moment (Max)

TABLE: Element Forces - Frames						
Frame	Station	OutputCase	CaseType	M3	FrameElem	ElemStation
Text	m	Text	Text	KN-m	Text	m
113	0	COMB1	Combination	3856.6096	113-1	0
113	0.75	COMB1	Combination	558.4145	113-1	0.75
113	1.5	COMB1	Combination	-2739.7806	113-1	1.5
115	0	COMB1	Combination	3368.3654	115-1	0
115	0.75	COMB1	Combination	1021.7898	115-1	0.75
115	1.5	COMB1	Combination	-1324.7858	115-1	1.5
117	0	COMB1	Combination	3879.4911	117-1	0
117	0.75	COMB1	Combination	536.6985	117-1	0.75
117	1.5	COMB1	Combination	-2806.0941	117-1	1.5
119	0	COMB1	Combination	3926.6129	119-1	0
119	0.75	COMB1	Combination	491.9769	119-1	0.75
119	1.5	COMB1	Combination	-2942.6591	119-1	1.5
121	0	COMB1	Combination	3496.9101	121-1	0
121	0.75	COMB1	Combination	899.7926	121-1	0.75
121	1.5	COMB1	Combination	-1697.3249	121-1	1.5
123	0	COMB1	Combination	3910.5713	123-1	0
123	0.75	COMB1	Combination	507.2015	123-1	0.75
123	1.5	COMB1	Combination	-2896.1683	123-1	1.5
125	0	COMB1	Combination	4094.797	125-1	0
125	0.75	COMB1	Combination	332.3594	125-1	0.75
125	1.5	COMB1	Combination	-3430.0782	125-1	1.5
127	0	COMB1	Combination	4077.7769	127-1	0
127	0.75	COMB1	Combination	348.5125	127-1	0.75
127	1.5	COMB1	Combination	-3380.752	127-1	1.5
129	0	COMB1	Combination	4094.9986	129-1	0
129	0.75	COMB1	Combination	332.168	129-1	0.75
129	1.5	COMB1	Combination	-3430.6626	129-1	1.5

5.9 Shear stress (including flood load)

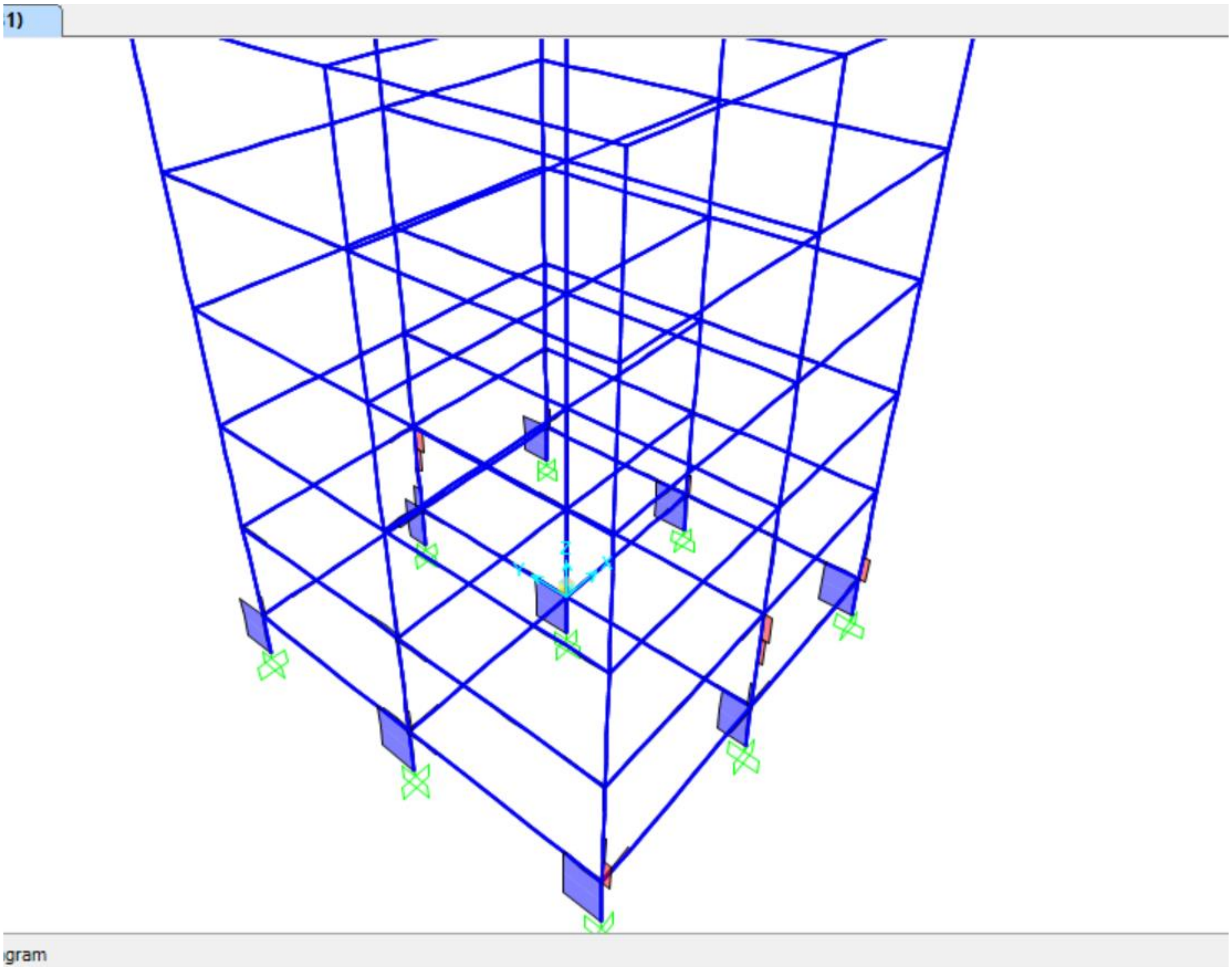


Fig 30 Shear force diagram after flood load

Table 10 Shear force (Max)

TABLE: Element Forces - Frames						
Frame	Station	OutputCase	CaseType	V3	FrameElem	ElemStation
Text	m	Text	Text	KN	Text	m
113	0	COMB1	Combination	5346.493	113-1	0
113	0.75	COMB1	Combination	5346.493	113-1	0.75
113	1.5	COMB1	Combination	5346.493	113-1	1.5
115	0	COMB1	Combination	5922.696	115-1	0
115	0.75	COMB1	Combination	5922.696	115-1	0.75
115	1.5	COMB1	Combination	5922.696	115-1	1.5
117	0	COMB1	Combination	5333.094	117-1	0
117	0.75	COMB1	Combination	5333.094	117-1	0.75
117	1.5	COMB1	Combination	5333.094	117-1	1.5
119	0	COMB1	Combination	5349.982	119-1	0
119	0.75	COMB1	Combination	5349.982	119-1	0.75
119	1.5	COMB1	Combination	5349.982	119-1	1.5
121	0	COMB1	Combination	5922.305	121-1	0
121	0.75	COMB1	Combination	5922.305	121-1	0.75
121	1.5	COMB1	Combination	5922.305	121-1	1.5
123	0	COMB1	Combination	5315.175	123-1	0
123	0.75	COMB1	Combination	5315.175	123-1	0.75
123	1.5	COMB1	Combination	5315.175	123-1	1.5
125	0	COMB1	Combination	4211.577	125-1	0
125	0.75	COMB1	Combination	4211.577	125-1	0.75
125	1.5	COMB1	Combination	4211.577	125-1	1.5
127	0	COMB1	Combination	5937.804	127-1	0
127	0.75	COMB1	Combination	5937.804	127-1	0.75
127	1.5	COMB1	Combination	5937.804	127-1	1.5
129	0	COMB1	Combination	3712.379	129-1	0
129	0.75	COMB1	Combination	3712.379	129-1	0.75
129	1.5	COMB1	Combination	3712.379	129-1	1.5

5.10 Base reaction (including flood load)

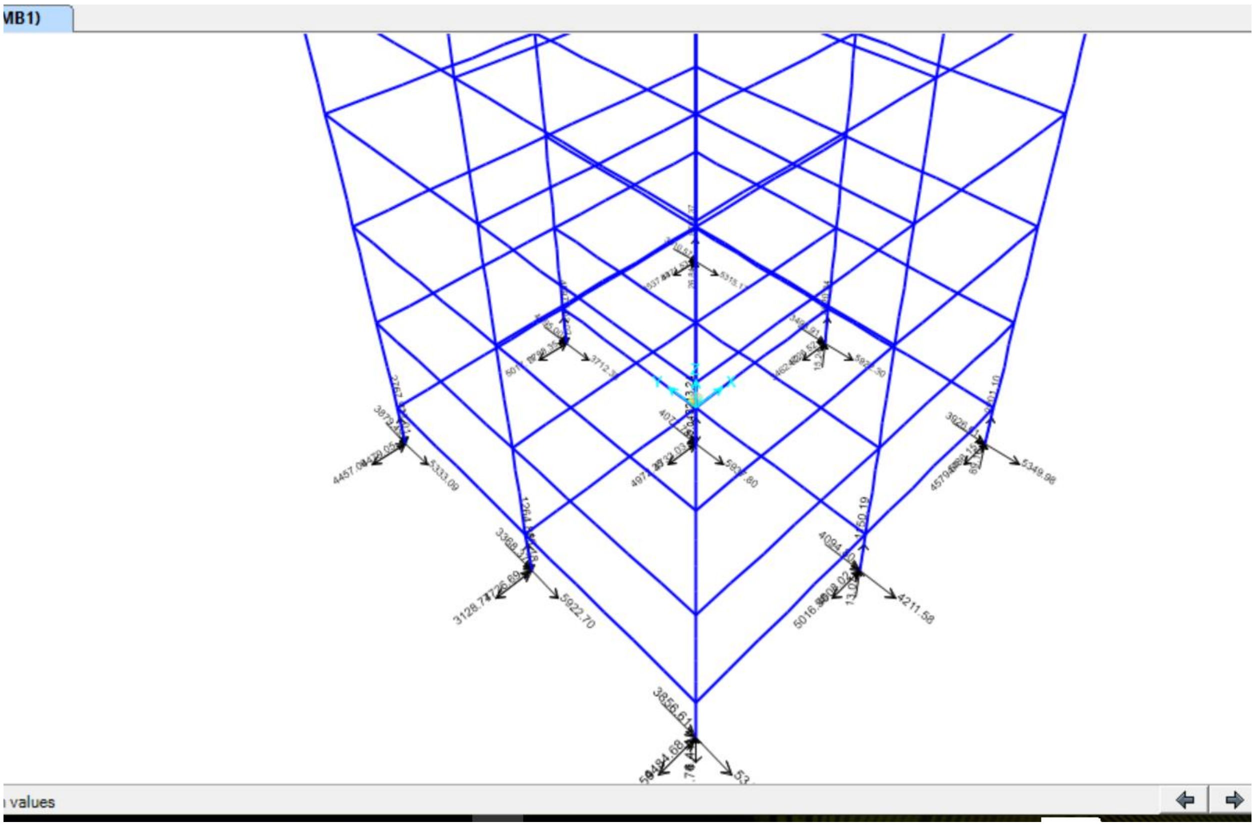


Fig 31 Base reaction after flood load

Table 11 Base reaction

TABLE: Joint Reactions				
Joint	**OutputCase**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN
1	COMB1	-4397.593	-5346.493	-3799.74
7	COMB1	-3128.767	-5922.696	1264.879
13	COMB1	-4457.057	-5333.094	2767.916
19	COMB1	-5016.583	-4211.577	1150.187
25	COMB1	-4972.353	-5937.804	3213.239
31	COMB1	-5017.108	-3712.379	4097.545
37	COMB1	-4579.515	-5349.982	2201.099
43	COMB1	-3462.823	-5922.305	4020.843
49	COMB1	-4537.826	-5315.175	8769.369

5.11 Members failed after applying flood load

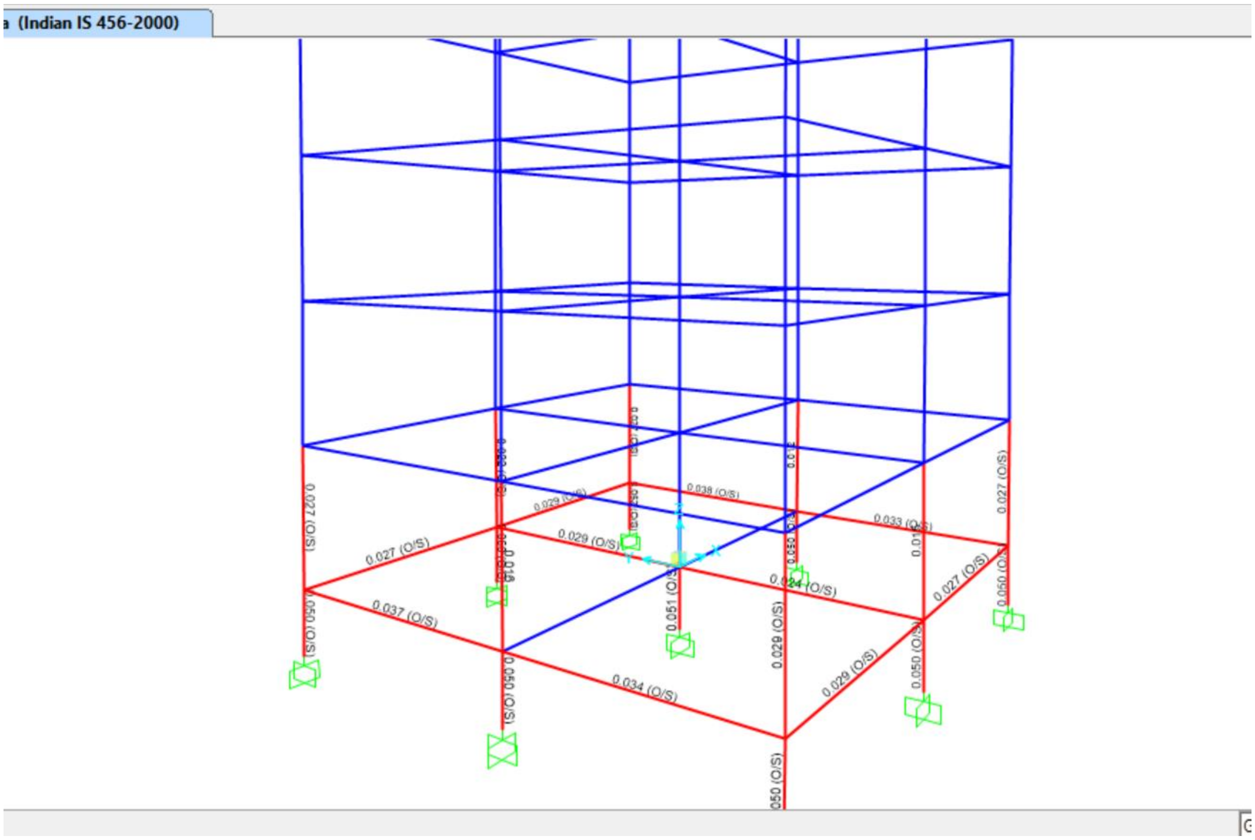


Fig 32 Showing failed members

After the application of Flood load some members failed due insufficient strength to resist the forces generated due to flood load failed members are coloured red in the above figure.

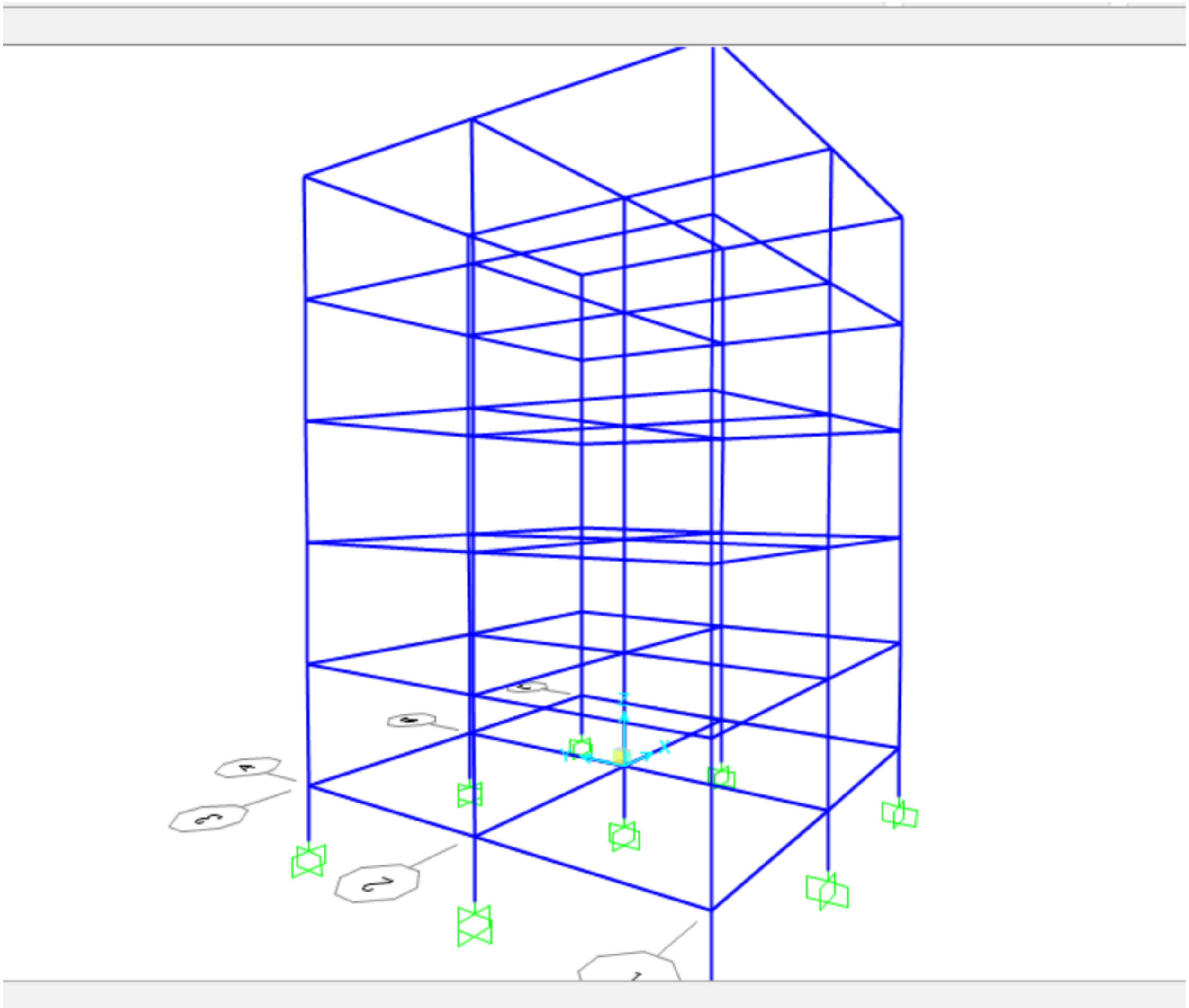


Fig 33 Showing all members after redesign

After revising the design of the members of the ground floor the structure is safe to resist forces due to flood load. Following are the amendments made to the structure to make it safe due flood loads.

- Column dimensions of the ground floor are revised as 650*650 mm.
- Grade of concrete is modified and increased from M25to M30.
- Percentage of steel reinforcement in lower floor is increased in the members respectively to increase inherent ductility of the structure.
- Provision for Bracing in Lower frame of the structure can be provided.

CHAPTER 6

CONCLUSION

- Sufficient Study of literature on Flood design has been done to understand behaviour of the RCC structure due to flood load.(Refer **Chapter 2**)
- Design loads and Exposure Conditions are taken as prescribed by IS Codes(Refer **Chapter 4**)
- A G+4 RCC structure of plan dimensions 12mx12m has been analysed, designed under flood load..
- For analysis, SAP2000 software has been used.
- Manual design has been carried out for R.C.C. structure(Refer **Chapter 4,Sec 4.2, 4.3, 4.4, 4.5**)
- Bending moment in RCC Member increases due to flood load (Refer **Chapter 5**)
- Stresses generated in RCC members of the structure also increases.(Refer **Chapter 6**)
- Overall RCC Structure has safer response when subjected to Wind and Flood.
- Immense confidence has been gained in the analysis and design of a multi-storeyed structure using SAAP2000 software which will benefit us as we step out of the portals of the college.

CHAPTER 7

SIGNIFICANCE OF PROJECT

- Protecting buildings that are constructed in special flood hazard areas (SFHAs) from damage caused by flood forces.
- It is required that materials and equipment located below the base flood level (and outside of dry flood proofed areas) be resistant to flood damage. This may apply to foundations, floor beams, joists, enclosures, and equipment servicing the building.

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ANNEXURE – A

IS 456 : 2000 References For The Design Of Way Slabs

Table 26 Bending Moment Coefficients for Rectangular Panels Supported on Four Sides with Provision for Torsion at Corners

(*Clauses* D-1.1 *and* 24.4.1)

Case No.	Type of Panel and Moments Considered	Short Span Coefficients α_x (Values of l_y/l_x)								Long Span Coefficients α_y for All Values of l_y/l_x
		1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	*Interior Panels*:									
	Negative moment at continuous edge	0.032	0.037	0.043	0.047	0.051	0.053	0.060	0.065	0.032
	Positive moment at mid-span	0.024	0.028	0.032	0.036	0.039	0.041	0.045	0.049	0.024
2	*One Short Edge Continuous*:									
	Negative moment at continuous edge	0.037	0.043	0.048	0.051	0.055	0.057	0.064	0.068	0.037
	Positive moment at mid-span	0.028	0.032	0.036	0.039	0.041	0.044	0.048	0.052	0.028
3	*One Long Edge Discontinuous*:									
	Negative moment at continuous edge	0.037	0.044	0.052	0.057	0.063	0.067	0.077	0.085	0.037
	Positive moment at mid-span	0.028	0.033	0.039	0.044	0.047	0.051	0.059	0.065	0.028
4	*Two Adjacent Edges Discontinuous*:									
	Negative moment at continuous edge	0.047	0.053	0.060	0.065	0.071	0.075	0.084	0.091	0.047
	Positive moment at mid-span	0.035	0.040	0.045	0.049	0.053	0.056	0.063	0.069	0.035
5	*Two Short Edges Discontinuous*:									
	Negative moment at continuous edge	0.045	0.049	0.052	0.056	0.059	0.060	0.065	0.069	—
	Positive moment at mid-span	0.035	0.037	0.040	0.043	0.044	0.045	0.049	0.052	0.035
6	*Two Long Edges Discontinuous*:									
	Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.045
	Positive moment at mid-span	0.035	0.043	0.051	0.057	0.063	0.068	0.080	0.088	0.035
7	*Three Edges Discontinuous (One Long Edge Continuous)*:									
	Negative moment at continuous edge	0.057	0.064	0.071	0.076	0.080	0.084	0.091	0.097	—
	Positive moment at mid-span	0.043	0.048	0.053	0.057	0.060	0.064	0.069	0.073	0.043
8	*Three Edges Discontinuous (One Short Edge Continuous)* :									
	Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.057
	Positive moment at mid-span	0.043	0.051	0.059	0.065	0.071	0.076	0.087	0.096	0.043
9	*Four Edges Discontinuous*:									
	Positive moment at mid-span	0.056	0.064	0.072	0.079	0.085	0.089	0.100	0.107	0.056

Table 12 Bending Moment Coefficients For Rectangular Panels With Provision For Torsion at Corners

ANNEXURE – B

IS 456 : 2000 References For Design Of Continuous Beam

IS 456 : 2000

Table 12 Bending Moment Coefficients

(Clause 22.5.1)

Type of Load	Span Moments		Support Moments	
	Near Middle of End Span	At Middle of Interior Span	At Support Next to the End Support	At Other Interior Supports
(1)	(2)	(3)	(4)	(5)
Dead load and imposed load (fixed)	$+\frac{1}{12}$	$+\frac{1}{16}$	$-\frac{1}{10}$	$-\frac{1}{12}$
Imposed load (not fixed)	$+\frac{1}{10}$	$+\frac{1}{12}$	$-\frac{1}{9}$	$-\frac{1}{9}$

NOTE — For obtaining the bending moment, the coefficient shall be multiplied by the total design load and effective span.

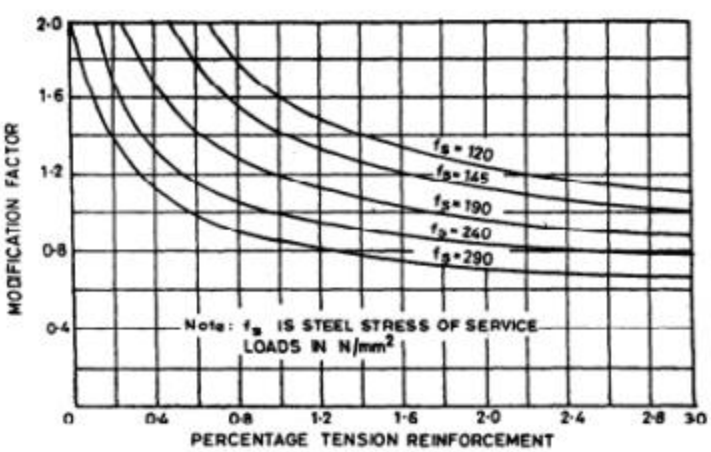
Table 13 Shear for Coefficients

(Clauses 22.5.1 and 22.5.2)

Type of Load	At End Support	At Support Next to the End Support		At All Other Interior Supports
		Outer Side	Inner Side	
(1)	(2)	(3)	(4)	(5)
Dead load and imposed load (fixed)	0.4	0.6	0.55	0.5
Imposed load (not fixed)	0.45	0.6	0.6	0.6

NOTE — For obtaining the shear force, the coefficient shall be multiplied by the total design load.

Table 5 Bending Moment And Shear Coefficients



$$f_s = 0.58\, f_y \frac{\text{Area of cross-section of steel required}}{\text{Area of cross-section of steel provided}}$$

Fig.34 Modification factor

Table 19 Design Shear Strength of Concrete, τ_c, N/mm^2

(*Clauses* 40.2.1, 40.2.2, 40.3, 40.4, 40.5.3, 41.3.2, 41.3.3 *and* 41.4.3)

$100 \frac{A_s}{bd}$	Concrete Grade					
	M 15	M 20	M 25	M 30	M 35	M 40 and above
(1)	(2)	(3)	(4)	(5)	(6)	(7)
≤ 0.15	0.28	0.28	0.29	0.29	0.29	0.30
0.25	0.35	0.36	0.36	0.37	0.37	0.38
0.50	0.46	0.48	0.49	0.50	0.50	0.51
0.75	0.54	0.56	0.57	0.59	0.59	0.60
1.00	0.60	0.62	0.64	0.66	0.67	0.68
1.25	0.64	0.67	0.70	0.71	0.73	0.74
1.50	0.68	0.72	0.74	0.76	0.78	0.79
1.75	0.71	0.75	0.78	0.80	0.82	0.84
2.00	0.71	0.79	0.82	0.84	0.86	0.88
2.25	0.71	0.81	0.85	0.88	0.90	0.92
2.50	0.71	0.82	0.88	0.91	0.93	0.95
2.75	0.71	0.82	0.90	0.94	0.96	0.98
3.00 and above	0.71	0.82	0.92	0.96	0.99	1.01

NOTE — The term A_s is the area of longitudinal tension reinforcement which continues at least one effective depth beyond the section being considered except at support where the full area of tension reinforcement may be used provided the detailing conforms to **26.2.2** and **26.2.3**

Table 6 Design Shear Strength Of Concrete Ʈc N/mm^2

ANNEXURE – C

IS 456 : 2000 References For The Design Of Short Columns Under Compression And Bi-Axial Loading

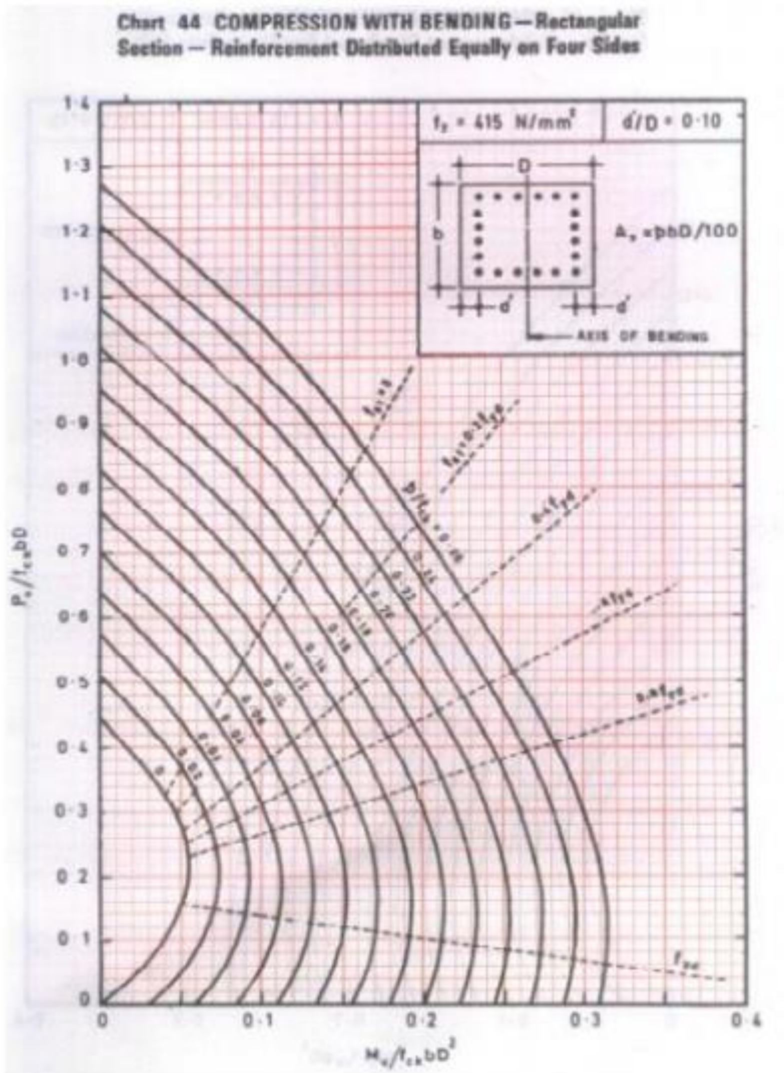


Fig.34 Non-Dimensional Parameter "Mux1/(Fck*b*D2)" Corresponding to the Ratio Pu/(Fck*b*d) and d'/D and p/Fck

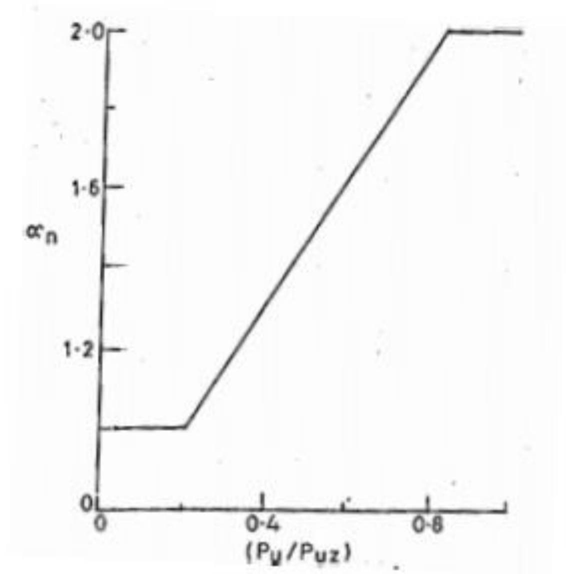


Fig.35 Coefficient For Biaxial Bending OF Columns