COMPARITIVE STUDY OF FLAT SLAB STRUCTURE BASED ON IS-1893:2002 AND IS-1893:2016

Submitted in partial fulfillment of the requirements

for the degree of

Bachelor of Engineering

By

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CERTIFICATE

This is to certify that, **Aware Saad Aslam(15DCE60), Dhamaskar Hasib Zahoor (15DCE61), Savardekar Sultan Ismail (15DCE70)** and **Ansari Bilal Mohd. Azharuddin (13CE07)** has satisfactorily completed and delivered a Project report entitled, **"Comparative study of Flat slab structure based on IS 1893:2002 and IS 1893:2016"** in partial fulfillment for the completion of the **B.E.** in **Civil Engineering** Course conducted by the University of Mumbai in Anjuman-I-Islam's Kalsekar Technical Campus, New Panvel, Navi Mumbai, during the academic year 2017-18.

Prof. Firoz Nadaf

Guide

Dr. Rajendra B. Magar | **Dr. Abdul Razzak Honnutagi**

Head of Department | Director

Project Report Approval for B. E.

This B. E. Project entitled **"COMPARITIVE STUDY OF FLAT SLAB STRUCTURE BASED ON IS 1893:2002 AND IS 1893:2016"** by **Mr. Aware Saad Aslam, Mr. Dhamaskar Hasib Zahoor, Mr. Savardekar Sultan Ismail** and **Mr. Ansari Bilal Mohd Azharuddin** is approved for the degree of ***"Bachelor of Engineering"*** in ***"Department of Civil Engineering".***

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Supervisors

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DECLARATION

We declare that this written submission represents my ideas in our own words and where others ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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We take this opportunity to thank all our Professors and non-teaching staff who have directly or indirectly helped our project, we pay our respects and love to our parents and all other family members for their love and encouragement throughout our career. Last but not the least we express our thanks to our friends for their cooperation and support.

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ABSTRACT

sIn the present era, flat slab buildings are commonly used for construction as it has many advantages over conventional slab buildings in terms of architectural flexibility, use of space, easier formwork and shorter construction time. As due to this old traditional construction net height of room is reduced. Hence to improve aesthetical and structural aspect of multi storey, shopping mall ,offices, warehouses , public community hall, hospitals etc. are constructed in such a way were slab are directly on columns. This types of slab directly supported on column is termed as flat slab.

According to BIS Guidelines IS 1893-2002 says the storey drift in any storey due to minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times the storey height and the revised IS 1893-2016 recommends to put limitation prescribes (a) Punching shear failure should be avoided and (b) the lateral drift at the roof under design lateral force shall not excees 0.1 per cent.

The main objective of the present work is to compare the storey drift with previous IS 1893-2002 by the revised IS 1893-2016. Accordingly; we can state whether the structure can withstand without any failure or not.

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CHAPTER – 01

INTRODUCTION

1.1 GENERAL

Flat slab is a reinforced slab which does not have beams or girders and in which the slab directly rests on the column. Its load transfer mechanism includes transfer of load directly from slab to supporting columns. Flat slab provides more head room as there are no beams and hence provides more working area. The minimum overall thickness of flat slab is 125mm and maximum is 250mm.There are numerous elements which are modified to make work faster a economical like adoption of pre-cast technology which reduces construction time, adoption of alternative building materials and introduction of various types of flat slab construction which reduce dead weight and effective storey height makes beams invisible and enhances floor area.

Seismic performance of buildings should be assessed properly to safeguard a structure against devastating effects of earthquakes. We can't avoid earthquakes, but awareness and safe building construction practices can certainly reduce the extent of damage and failure.

The lateral loads are the premier ones because in contrast to vertical load that may be assumed to increase rapidly with height. The lateral loads are considerably higher in the top storey rather than the bottom storey due to which building tends to act as cantilever. In many of the seismic prone areas there are several instances of failure of buildings which have not been designed for seismic loads. All these reaction makes the study of the effect of lateral loads very important.

In this present study we shall compare the results as per the guidelines of both IS prescribed codes and will examine their behavior against seismic resistance.

1.2 RECENT EARTHQUAKES IN INDIA

The table 1.1 gives an overview of recent earthquakes in India along with magnitude and loss of life and property

Table 1. Recent Earthquakes in India

Date	Time	Location	Epicenter	Death	Magnitude
03 January, 2017	2:39 IST	India, Bangladesh	24.015°N, 92.018°E	8	5.7
4 January, 2016	04:35 IST	North East, India	24.8°N, 93.6°E	11 dead, 200 injured in Manipur & Assam	6.7
26 October, 2015	14:39 IST	Northern India, Pakistan, Afghanistan	36.524°"N, 70.368°"E	280 in Pakistan, 115 in Afghanistan and 4 in India	7.5
12 May, 2015	12:35 IST	Northern & North East India	27.794°N, 85.974°E	218	7.3
25 April, 2015	12:19 IST	Northern India	28.230°N, 84.731°E	8857	7.8
1 May, 2013	06:57 IST	Kashmir	33.1°N, 75.84°E	3 dead, 100 injured	5.7
5 March, 2012	13:10 IST	New Delhi	28.6°N, 77.4°E	1	5.2
18 September, 2011	18:10	Gangtok, Sikkim	27.723°N,	118	6.9

	IST		88.064°E		
10 August, 2009	01:21 IST	Andaman Islands	14.1°N, 92.8°E	26	7.5
6 February, 2008	11:39 IST	West Bengal	23.468°N, 87.116°E	50	4.3
6 November, 2007	05:58 IST	Gujrat	21.28°N, 70.7°E	5	5.1
8 October, 2005	08:50 IST	Kashmir	34.493°N, 73.629°E	130,000	7.6
26 December, 2004	09:28 IST	India Maldives	3.30°N, 95.87°E	283,106	9.1
26 January, 2001	08:50 IST	Gujarat	23.6°N, 69.8°E	20,000	7.7
29 March, 1999	00:35 IST	Chamoli district, Uttarakhand	30.408°N, 79.416°E	103 Approx.	6.8
22 May, 1997	13:41 IST	Jabalpur, Madhya Pradesh	23.18°N, 80.02°E	39	6.0
30 September, 1993	09:20 IST	Latur	18.08°N, 76.52°E	9,748	6.2
20 October, 1991	02:53 IST	Uttarkashi, Uttarakhand	30.73°N, 78.45°E	>2,000	7.0
21 August, 1988	04:40 IST	Udaipur, Nepal	26.755°N, 86.616°E	1,000	6.7
19 January, 1975	13:32 IST	Himachal Pradesh	32.46°N, 78.43°E	47	6.8

1.3 NEED OF THE PROJECT

In order to move towards safer side and enhancing the stability of structure consisting flat slab, Guidelines prescribed by revised IS code 1893-2016 and its recommendations given on storey drift should be followed rather than the previous recommendations of IS 1893-2002 which proves comparatively less safer.

1.4 ORGANIZATION OF REPORT

The introductory chapter i.e., **Chapter-1** gives brief introduction about flat Slab and Seismic behavior of the Flat Slab. The need, objectives and scope of the proposed work are identified along with the methodology that is followed to carry out the work.

Chapter-2 presents the review of literature on Analysis and Design of flat slab w.r.t parametric and comparative study between flat slab with drop and without drop also with grid slab etc. The report concludes with aim, objectives and scope of the work at the present stage.

CHAPTER – 02

LITERATURE REVIEW

2.1 GENERAL

Due to the recent earthquakes there was a tremendous loss of life and property. The present design codes are Forced-based which fails and caused misjudgment in the actual building response. The behavior of flat slab building during earthquake depends critically on 'Building Configuration'. This fact has resulted in to ensure safety against earthquake forces of tall structures. When the structure is subjected to the stated levels of seismic hazard. This Chapter presents review of literature pertaining to Seismic behavior of the structure consisting Flat Slab.

2.2 TECHNICAL PAPERS

2.2.1 DR .D K Paul Retd. Professor(Department of Earthquake Engg., IIT Roorkee)

It shows the up gradations in the newly Published revised code IS 1893-2016.

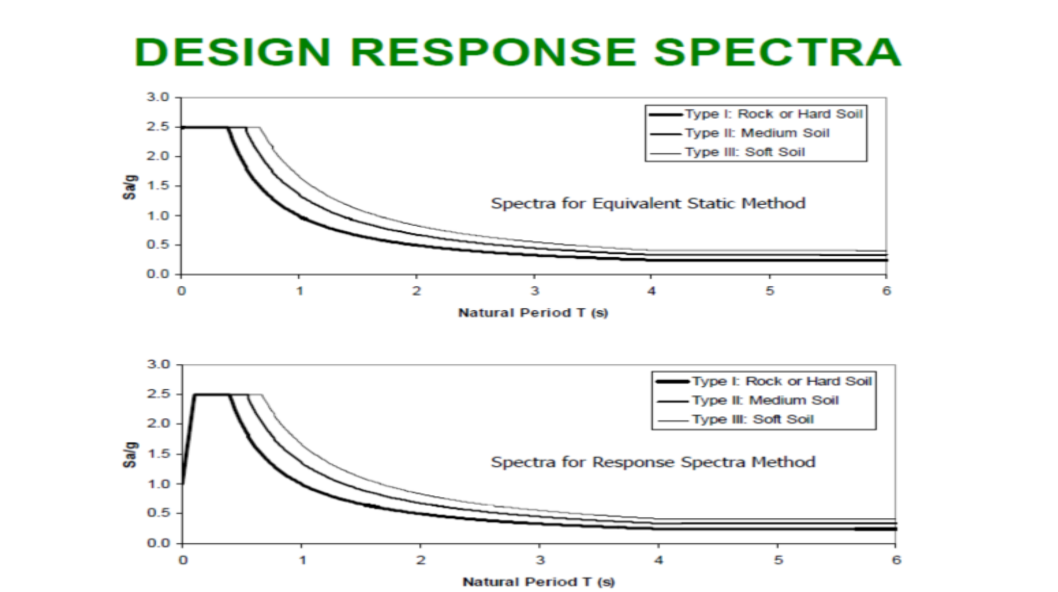


Fig.01. Design Response spectra [1]

2.2.2 Niharika .M. Keskar, Dr.S.P.Raut (April 2017) [2]

In this work, they focused on a G+9 multistoried commercial building having flat slab with and without shear wall and has been analyzed. Comparative study of these structures are analyzed on the parameters like base period, base shear, storey drift and storey displacements. As compared to the conventional frame structure model and flat slab with shear wall model behavior is better than flat slab without shear wall model.

Results with shear wall are more reliable than with drop column.

2.2.3 Sandeep. G. S. and Gururaj Patil (July 2017) [3]

Dynamic analysis for conventional slab buildings, flat slab with and without drop panel buildings is performed using response spectrum analysis for seismic zones II, III, IV and V as per Indian standard code.

The effect of height of the building on these buildings is evaluated. Significant variation in seismic parameters like storey displacement and storey drift with respect to zones and height of buildings is noticed and discussed below.

The following are the major conclusions drawn from the analysis of seismic behavior of three types of buildings (i.e. Conventional slab buildings, flat slab with and without drop panels buildings) for all seismic zones as per IS code.

1) From top storey lateral displacement for 5 storey building, we can conclude that buildings with flat slab without drop panel building are not suitable for zone IV and zone V. Also conventional slab buildings and buildings with flat slab with drop panel building are not suitable for zone V with respect to lateral displacement. 10 storey and 15 storey buildings with flat slab with drop and without drop panel buildings are not suitable for zone IV and zone V with respect to lateral displacement. So to control lateral displacement of the storey, introduction of shear walls, bracings or retrofitting of buildings are suggested.
2) Storey drift follows a parabolic path along the storey height with maximum value lying somewhere near storey three. From the storey drift plots it is clear that 5, 10 and 15 storey buildings with flat slab with and without drop panel are as suitable as conventional slab buildings with respect to storey drift in all the seismic zones. And so flat slab can be adopted wherever required instead of conventional slab in any seismic zone.
3) Conventional slab building has highest lateral stiffness compared to flat slab with or without drop panel where as flat with drop panel has more lateral stiffness than flat slab without drop panel.

2.2.4 Renuka Ramteke (May-Jun 2017) [4]

The main objective of this project is to perform parametric study on behavior of multi storey R.C.C using same plan area but different plan aspect ratio (L/B) and slenderness ratio (H/B) under seismic condition , and to perform analysis response Spectrum analysis by considering zone 3

1) Limiting plan aspect ratio is L/B =5 and slenderness ratio is 3.32
2) In earthquake prone areas narrow and tall structure are not recommended , having aspect ratio more than L/B=4 and slenderness ratio is 2.88without infill elements.
3) Structure with aspect ratio more than 3 has higher magnitude of design base shear along X and Y direction through their seismic weight is lesser than structure with aspect ratio 3.
4) Building having square plan i.e aspect ratio equals 1 is safest.

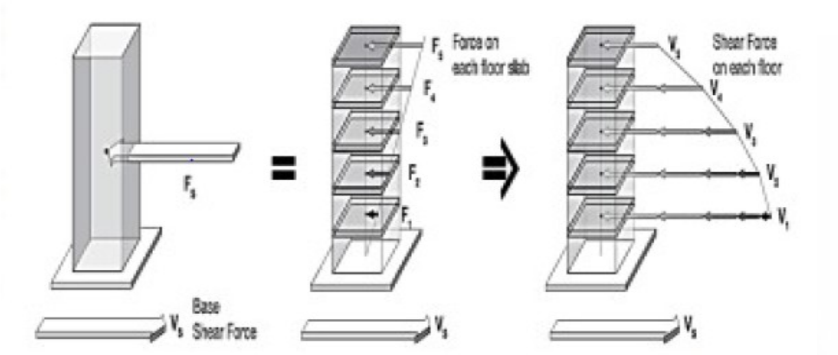


Fig.02. Shows variation in lateral force , base shear and storey shear due to ground motion [4]

2.2.5 Dr.M Rame Gowda , Techi Tata (Sept 2016) [6]

Response spectrum analysis is carried out for two different models consisting of flat slab with and without drop for all seismic zones of India for both G+9 storey buildings. The results obtained from the analysis are described below through charts and description :-

1) The Storey Displacement is less for the flat slab with drop as compared to the flat slab without drop with an average 2 mm displacement variation in each zone
2) The storey drift is 8% more in case of flat slab without drop as compared to flat slab with drop for all seismic zones.
3) The storey acceleration will be 0.5% more for the flat slab without drop as compared to the flat slab with drop at all seismic zones. And the storey acceleration will be maximum at the top and minimum at the base.

4) The storey shear for flat slab without drop is 14% more than as compared to flat slab with drop for all seismic zones .
5) The overturning moment for flat slab without drop is 15% more as compared to the flat slab with drop for all seismic zones.

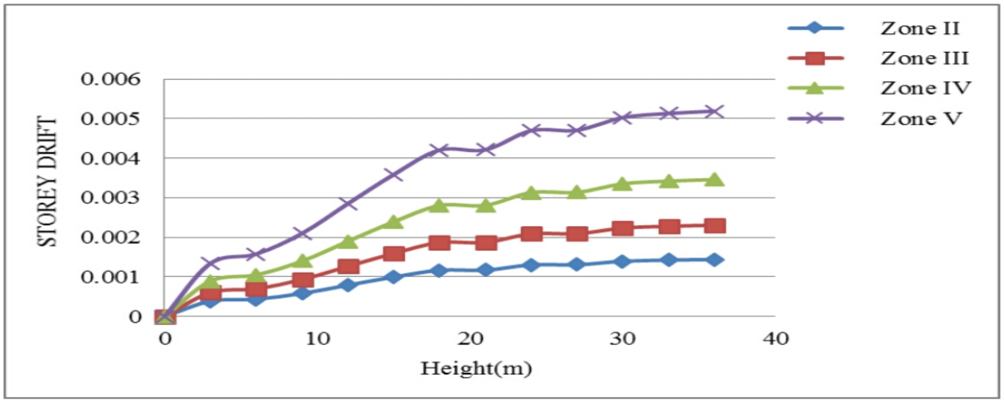


Fig .03. Storey Drift versus Height with drop [6]

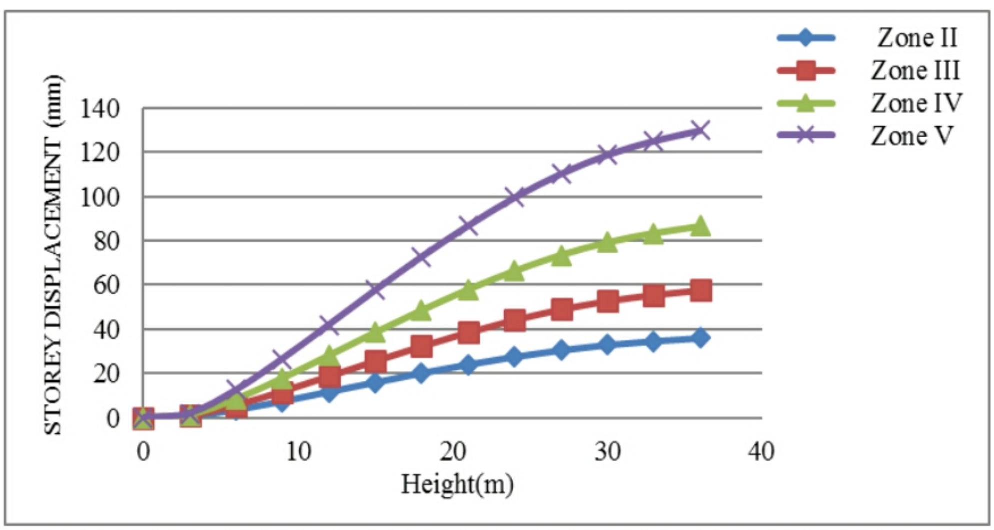


Fig .04. Storey Displacement versus Height with drop [6]

2.2.6 Dr . S.N. Tande (May 2016) [7]

The main moto of this paper is to compute the results by designing with two different methods and there by concluduing the better one.

1) The design of flat slab has direct design method has some restrictions that (a) It should have minimum 3 span in each directions and (b) It should haveb staggered column orientation. Hence equivalent Frame Method is adopted.
2) Both Direct Design method and equivalent frame method are approximate methods but results obtained from Equivalent Frame method are more accurate
3) The equivalent frame method is not satisfactorily for hand calculations. Therefore use of computers softwares which based on finite element analysism is adopted.

2.2.7 P. Srinavasulu and A. Dattatreya Kumar (July 2015) [8]

The objective of this paper is to investigate the behaviour of flat slab in 4 different cases as I).flat slab structure without drop, II). Flat slab structure with column drop, III). Flat slab structure with shear wall, IV). Flat slab structure with column drop and shear wall together, through response spectrum method, by using ETABS software.

1) Base Shear values increases from model1 to model 4. As weight of structure increases from model 1 tomodel 4 Flat slab attracts more shear value, when flat slab provided with shear wall rather than flat slab having column drops.

Height of building (m)	Story	MODEL1 (KN)	MODEL2 (KN)	MODEL3 (KN)	MODEL4 (KN)
2.1	Plinth	1164.53	1412.03	2194.68	2405.98
5.6	STORY1	1163.58	1410.9	2193.15	2404.32
8.8	STORY2	1133.17	1374.32	2135.56	2341.74
12	STORY3	1058.17	1284.14	1993.87	2187.75
15.2	STORY4	918.77	1116.53	1730.55	1901.58
18.4	STORY5	695.25	847.75	1308.3	1442.68
21.6	STORY6	367.7	453.88	689.55	770.21

Fig.05. Comparison of design storey shear in all 4 models [8]

2) Providing column drops to flat slab, storey displacements reduces slightly, as stiffness increases slightly. But when flat slabs combine with shear walls, these displacements reduces tremendously as stiffness of shear walls increases overall lateral stiffness of structure.

Story	MODEL1 (mm)	MODEL2 (mm)	MODEL3 (mm)	MODEL4 (mm)
STORY1	3.1	3	1.1	1.1
STORY2	5.7	5.2	2.2	2.1
STORY3	8.1	7.1	3.5	3.3
STORY4	10.2	8.7	4.8	4.5
STORY5	11.8	9.9	6	5.6
STORY6	13.1	10.7	7.2	6.6

Fig.06. Comparison of storey displacements in x-direction in 4 models [8]

2.2.8 Mohana H.S, Kavan M.R (June 2015) [9]

The main objective of this paper is :-

- To study the performance of flat slab and conventional slab structure subjected to various loads and conditions.
- To the study the behavior of both structure for the parameters like storey shear, storey displacement Drift ratio, axial forces.
- Comparisons of flat and conventional building for the above parameters

Hence they came to the conclusion that :-

1) Storey shear of flat slab is 6% more compared to conventional slab structure, and storey shear is Maximum at base and least at top storey.
2) The design axial forces on flat slab are more compared to conventional structure the difference of forces is nearly 5.5%.

3) Storey displacement is Maximum at roof level than at base, and storey displacement of flat slab structure is greater than conventional structure, there will be an average 4mm displacement variation in each seismic zone for both structures.

4) As the seismic level increases all parameters like axial force, displacement, storey shear intensities are increases.

2.2.9 Salman I. Khan†* and Ashok R. Mundhada† (June 2015) [11]

The main moto behind the journal was :-

- To perform dynamic analysis of multistoried RCC buildings with Flat slab & Grid slab (12, 15, 18 Storey) using Response Spectrum Analysis, considering different earthquake Zones as per the Indian Standard code of practice IS 1893-2002 part-I: Criteria for Earthquake resistant structure (Zone II, III, IV, V).
- To compare seismic behavior of multistoried RCC building with Flat slab & Grid slab for different earthquake intensities in terms of various responses such as, base shear, Story displacements, Story Drift, Axial Force, Time Period.
- To find the relationship between earthquake intensities and responses.

The following conclusions were obtained :-

1. The base shear will increase drastically as the height increases. Base shear of flat slab building is more than that of the grid slab building. The difference between the two varies from 3-4(%).
2. The lateral displacement (both Ux and Uy) is maximum at terrace level for all types of columns. Lateral displacement of Grid slab building is less than that of the flat slab building. The difference between the two is less if the building width is more.
3. For improving Drift conditions of flat slab in higher seismic zones, lateral load resisting system should be coupled with slab column frame or stiffness of column should be increased.
4. The natural time period increases as the height increases. Comparitively flat slab building possess more Time period. The difference between the two is about 23(%).

2.2.10 Salman I Khan and Ashok R Mundhada (Feb 2015) [12]

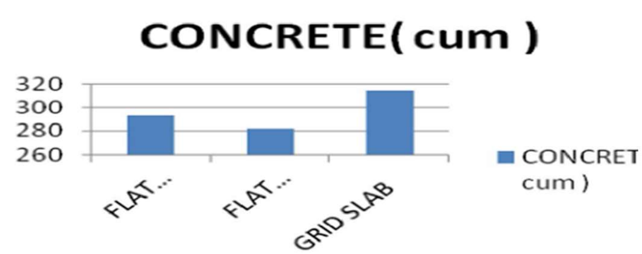
This paper presents a review of the seismic performance of multi-storied buildings for different floor heights and having different floor systems like Flat slabs, Grid slabs and conventional solid slab-beam systems. It seems that the seismic performance of buildings having grid slab and flat slab is comparable but the differences exist. For e.g. the base shear of a multi-storey structure with flat slab is less as compared to Grid slab, whereas the axial force in the intermediate columns are more in case of flat slabs than grid slabs. Buildings having the flat slab system are weaker in shear as compared to those with conventional or even grid slab systems. The storey drift in building with flat slab construction was significantly more as compared to conventional RCC building. As a result, additional moments wer developed. Therefore, the columns of such buildings should be designed by considering additional moments caused by the drift. Base shear of flat slab building would be less than the base shear in grid slab building.

2.2.11 Amit A. Sathawane , R.S. Deotale [13]

The aim was to determine the most economical slab between flat slab with drop. Flat slab without drop and grid slab. Analysis was done both by manually by IS 456-2000 and by using software too. Flat slab and Grid slab has been analysed by STAAD PRO.

1) It is observed that the FLAT slab with drop is more economical than Flat slab without drop and Grid slabs.
2) Enhance resistance to punching shear failure at the junction of column and slab by incorporating heads in slab rigidity of slab can be increased
3) Concrete required in grid slab is more as compared to flat slab with Drop and flat slab without drop.
4) Steel required in grid slab is more as compared to flat slab with Drop and flat slab without drop.

Fig.07. Concrete in cu m for various slabs



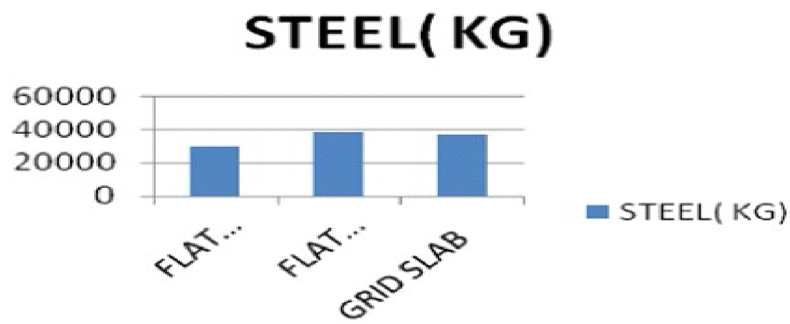


Fig.08. Steel in kg for various slabs [13]

5) Rate /sq ft of flat slab with Drop (327) was found to be more economical than flat slab without drop (358) and grid slab (372).

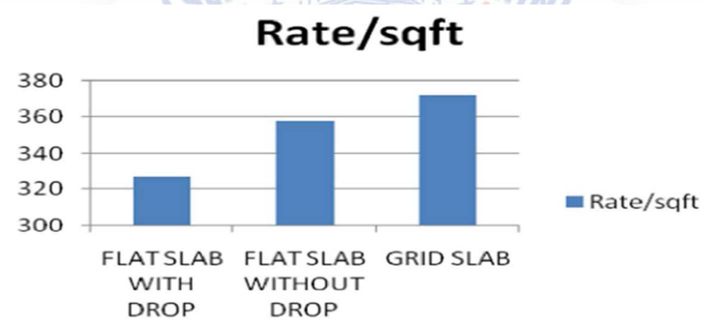


Fig.09. Rate per sq ft for various slab [13]

❖ Storey Drift

- Storey Drift can be defined as ratio of displacement of two consecutive floor to height of that floor.

  Or
- As per IS 1893-2016 It can be defined as the relative displacement between the floors above and or below the storey under consideration

Fig .10. Failure Caused due to excessive Drift [1]

2.3 PROBLEM DEFINATION

It is proposed to analyze R.C.C Structure consisting flat Slab which meets the recommendations of revised IS CODE 1893-2016 and to compare the results with previous IS 1893-2002.

2.4 OBJECTIVES

- To analyze.a flat slab using revised IS CODE 1893-2016 .
- To Compare the examined results with previous code IS 1893-2002.
- To check whether the drift should not exceed its described limitation.

2.5 METHODOLOGY

The methodology followed out to achieve the above-mentioned objectives as follows

- Review of the existing literatures by different researchers and relevant Indian design code provision for designing the seismic resisting structures consisting Flat Slab.
- Understanding the basic concept of earthquake resistant design of structure.
- Selecting the seismic Zone and setting performance objective.
- Using Equivalent static analysis method.
- IS 1893-2016 (PART 1).
- IS 1893-2002.
- Use of E-TABS.
- To check whether the drift should not exceed the limiting value.
- To compare the results between both IS CODES mentioned as above.

2.6 AIM

To analyze a flat slab structure using revised IS CODE 1893-2016 and to compare the results with previous code IS 1893-2002.

2.7 SCOPE OF WORK

The study is confined to design a regular flat slab without any consideration of prestressing and post-tensioning. Also the flat slab structure can be further examined for different irregularities. It is described briefly in future scope of the project.

CHAPTER – 03

MODELLING AND

COMPARITIVE STUDY

3.1 Guidelines to Flat slab structure

Clause 9.8.1.1 :-

a) **Column Strip:-** Column strip means a design strip having a width of 0.25 l_2, but not greater than 0.25 l_1 on each side of the column centre line, where l_1 is the span in the direction moments are being determined, measure centre to centre supports and l_2 is the span transverse to l_1 , measure centre to centre of supports.

b) **Middle Strip:-** Middle strip means design strip bounded on each of its opposite sides by the column strip.

c) Panel :- Panel means that part of the slab bounded on each of its four sides by centre line of the column or centre line of adjacent spans.

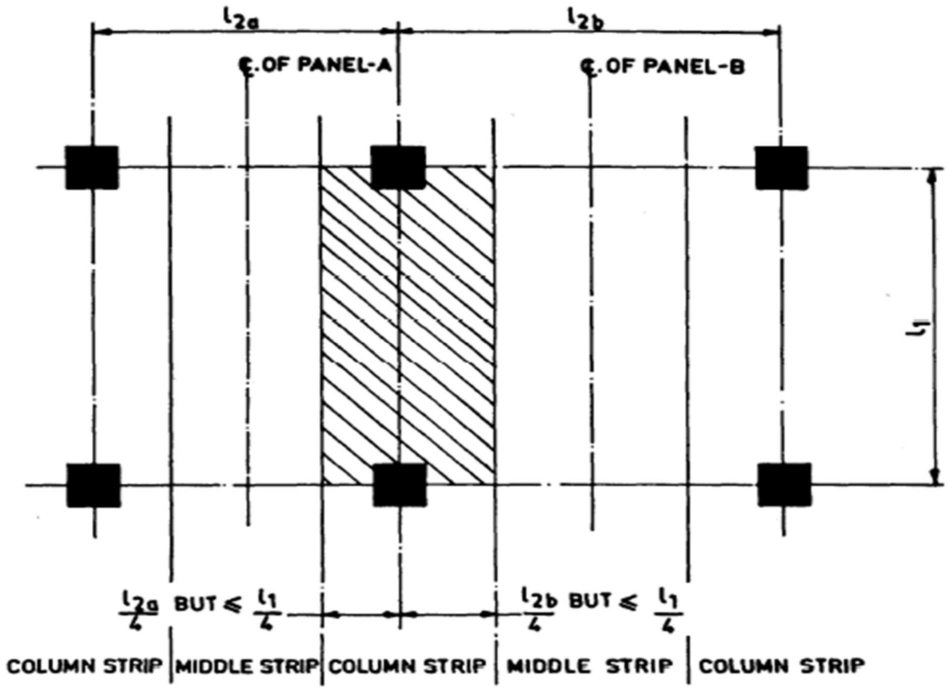


Fig .11. Panels, column strips, and middle strips [17]

Clause 9.8.2 Proportioning :-

i. The minimum thickness of slab shall be 125 mm.

ii. **Drops** :- The drops when provided, shall be rectangular in plan and have a length in each direction not less than one-third of the panel length in that direction, For exterior panels the width of drops at right angle to the non-continuous edge and measured from the centre line of the column shall be equal to one-half the width of drop for interior panels.

iii. **Column heads** :- Where Column heads are provided, that portion of a column head which lies within the largest right circular cone or pyramid that has a vertex angle of 90^0 and can be included entirely within the outlines of the column and the column head, shall be considered for design purpose

Clause 9.8.2 Openings in Flat Slab :-

Openings of any size may be provided in the flat slab if it is shown by analysis that the requirements of strength and serviceability are met. However, for openings conforming to the following, no special analysis is required.

a) Openings are of any size may be placed within the middle half of the span in each direction, provided the total amount of reinforcement required for the panel without the opening is maintained.

b) In the area common to two column strips, not more than one - eight of the width of strip in either span shall be interrupted by the openings. The equivalent of reinforcement interrupted shall be added on all sides of the openings.

In the area common to one column strip and one middle strip, not more than one-quarter of the reinforcement in either strip shall be interrupted by the openings. The equivalent of reinforcement interrupted shall be added on all sides of the openings.

3.2 MODELLING AND ANALYSIS

MODEL - 1 (G+6)

Material Properties

Grade of concrete = M30

Grade of steel = Fe 500

Unit weight of concrete = 25 KN/m^3

Structural Elements

Slab thickness = 200 mm

Drop thickness = 300 mm

Number of stories = (7) G+6

Number of bays along X-direction = 5

Number of bays along Y-direction = 5

Storey height = 3.5

Bay width along X-direction = 6 m

Bay width along Y-direction = 6 m

Column size (interior) = 400 mm x 400 mm

Column size (exterior) = 900 mm x 1200mm

Edge Beam = 350 X 900 mm

Drop size = 2m x 2m

Loading Specifications

Wall load = 16 KN/m

Live load of slab = 5 KN/m

Floor Finish = 1.5 KN/m^2

Earthquake load for the building has been calculated as per IS-1893:2002

Zone (Z) = III

Soil type = Medium

Response Reduction Factor (RF) = 3

Importance Factor (I) = 1.5

Fundamental Natural Period (T) = $0.075h^{0.75}$ = 0.813.

<u>NOTE</u> :- The above factors remains same when analyse and design as per **IS- 1893:2016**

Architectural aspects

Aspect ratio = 1.0

Slenderness ratio = 0.7

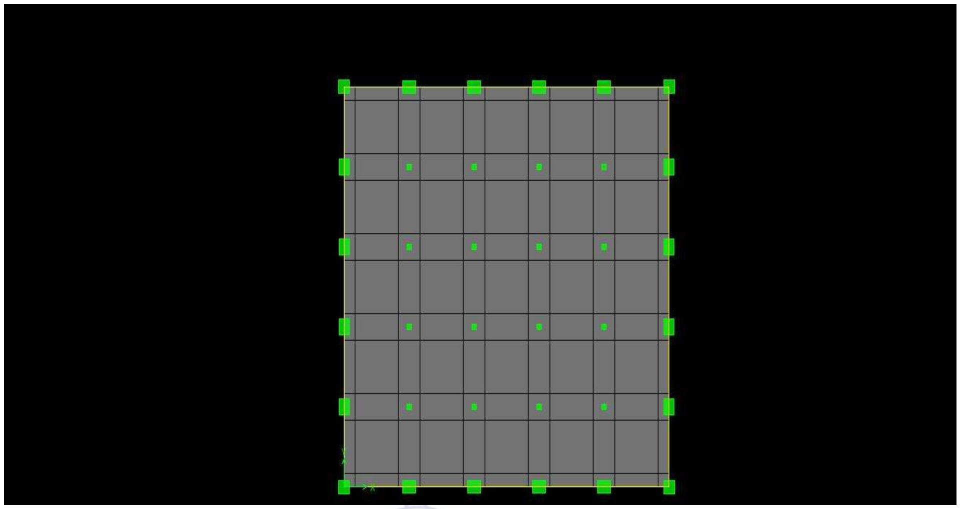


Fig .12.1.1 PLAN (G+6)

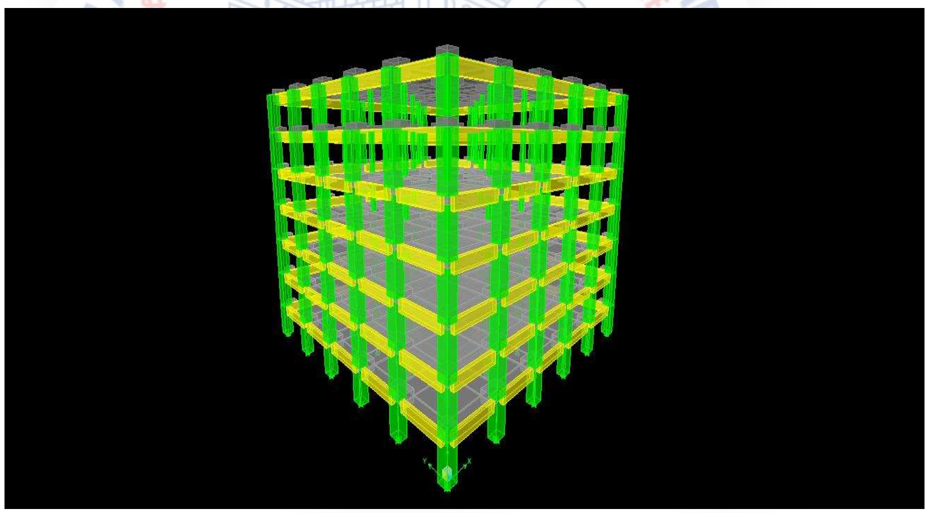


Fig .12.1.2 3d view (Extrusion)

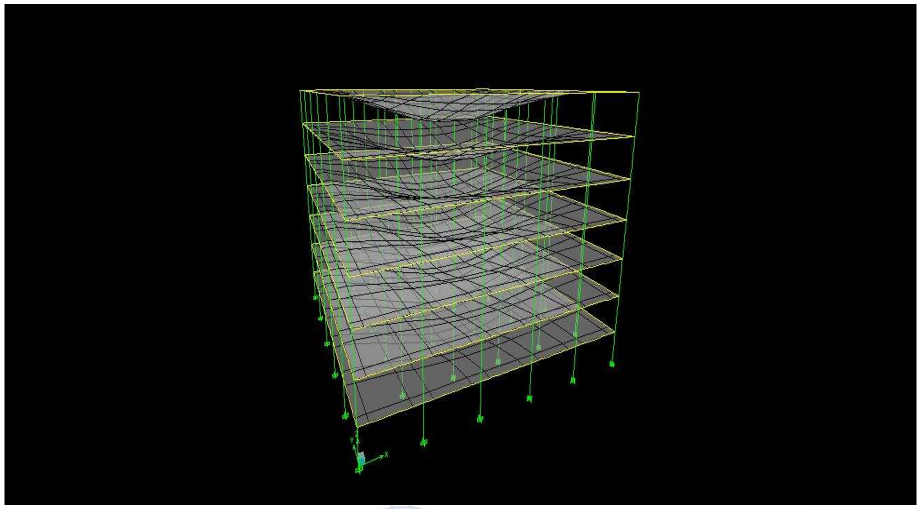


Fig .12.1.3 Deflected Shape.

MODEL - 1 (G+8)

NOTE :-

1. Material properties, structural elements, loading specification and seismic data remains same.
2. Fundamental Natural Period (T) = $0.075h^{0.75}$ = 0.985

Architectural aspects

Aspect ratio = 1.0

Slenderness ratio = 0.93

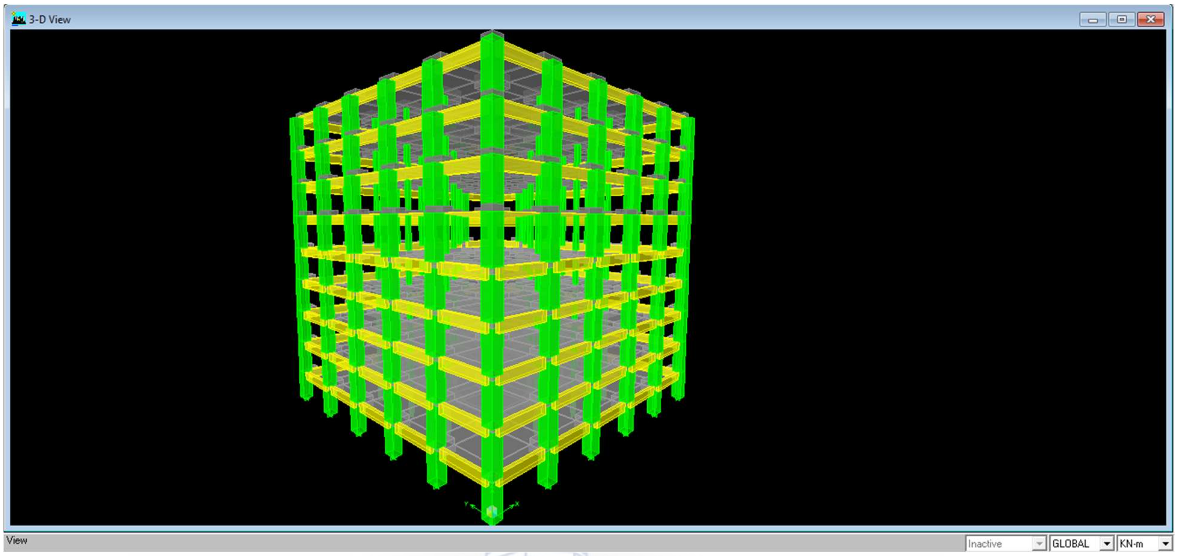


Fig .12.1.4 3d view (Extrusion)

MODEL - 2 (G+6)

Material Properties

Grade of concrete = M30

Grade of steel = Fe 500

Unit weight of concrete = 25 KN/m^3

Structural Elements

Slab thickness = 200 mm

Drop thickness = 300 mm

Number of stories = (7) G+6

Number of bays along X-direction = 7

Number of bays along Y-direction = 4

Storey height = 3.5

Bay width along X-direction = 6 m

Bay width along Y-direction = 6 m

Column size (interior) = 450 mm x 450 mm

Column size (exterior) = 500 mm x 800mm

Edge Beam = 350 mm x 900 mm

Drop size = 2m x 2m

Loading Specifications

Wall load = 14.56 KN/m

Live load of slab = 5 KN/m

Floor Finish = 1.5

Earthquake load for the building has been calculated as per IS-1893:2002

Zone (Z) = III

Soil type = Medium

Response Reduction Factor (RF) = 3

Importance Factor (I) = 1.5

Fundamental Natural Period (T) = $0.075h^{0.75}$ =0.813

Architectural aspects

Aspect ratio = 1.75

Slenderness ratio = 0.5

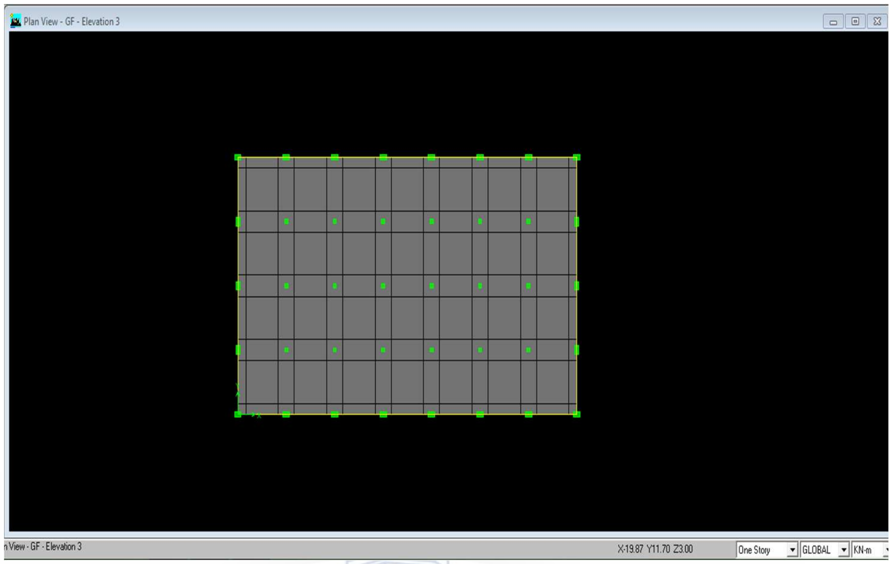


Fig .12.2.1 Plan (G+6)

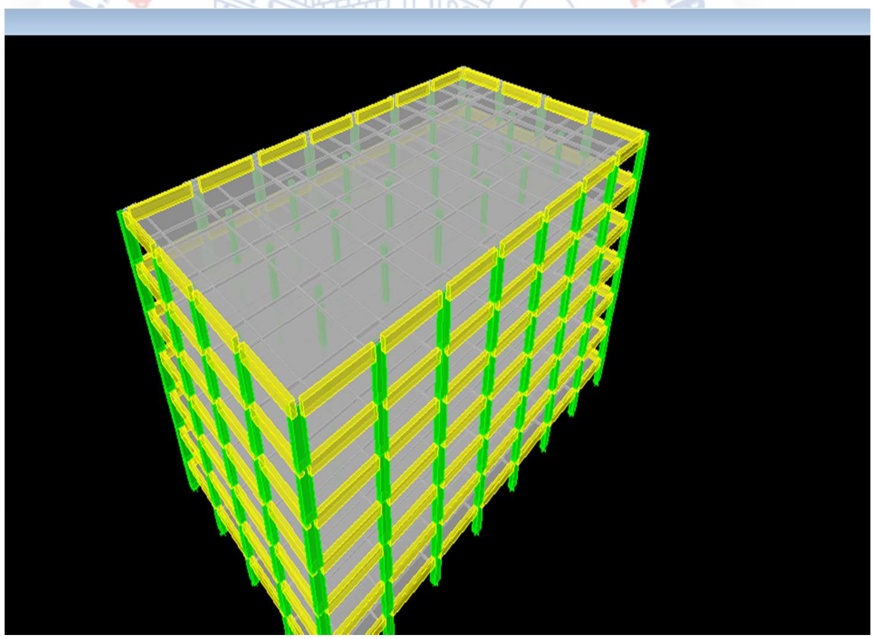


Fig .12.2.2 3d view (Extrusion)

MODEL - 2 (G+8)

Structural Elements

Slab thickness = 200 mm

Drop thickness = 300 mm

Number of stories = (9) G+8

Number of bays along X-direction = 7

Number of bays along Y-direction = 4

Storey height = 3.5

Bay width along X-direction = 6 m

Bay width along Y-direction = 6 m

Column size (interior) = 500 mm x 500 mm

Column size (exterior) = 500 mm x 800mm

Edge Beam = 350 mm x 900 mm

Drop size = 2m x 2m

NOTE :-

1. Material properties, loading specification and seismic data remains same.
2. Fundamental Natural Period (T) $= 0.075h^{0.75} = 0.985$

Architectural aspects

Aspect ratio = 1.75

Slenderness ratio = 0.67

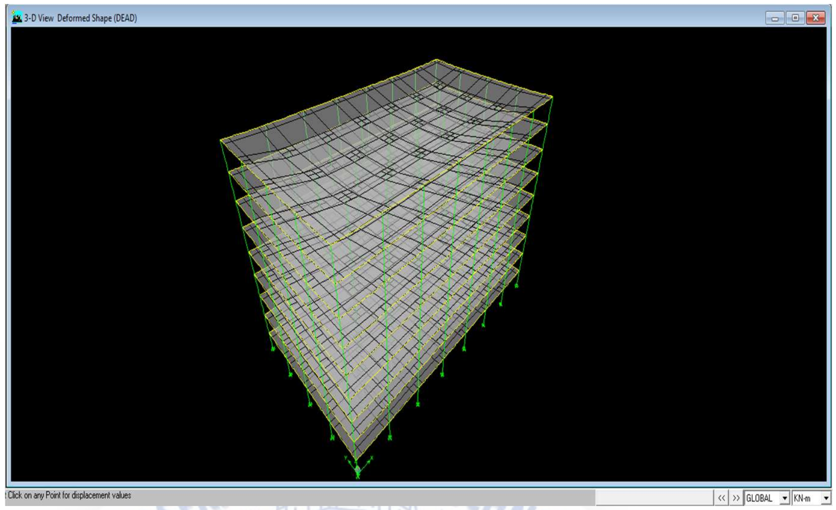


Fig .12.2.3 Deflected shape (G+8)

MODEL - 3 (G+6)

Material Properties

Grade of concrete = M30

Grade of steel = Fe 500

Unit weight of concrete = 25 KN/m^3

Structural Elements

Slab thickness = 200 mm

Drop thickness = 300 mm

Number of stories = (7) G+6

Number of bays along X-direction = 3

Number of bays along Y-direction = 7

Storey height = 3.5

Bay width along X-direction = 6 m

Bay width along Y-direction = 6 m

Column size (interior) = 500 mm x 500 mm

Column size (exterior) = 900 mm x 1200 mm

Edge Beam = 350 mm x 900 mm

Drop size = 2m x 2m.

Loading Specifications

Wall load = 16 KN/m

Live load of slab = 5 KN/m

Floor Finish = 1.5

Earthquake load for the building has been calculated as per IS-1893:2002

Zone (Z) = III

Soil type = Medium

Response Reduction Factor (RF) = 3

Importance Factor (I) = 1.5

Fundamental Natural Period (T) = $0.075h^{0.75}$ =0.813

Architectural aspects

Aspect ratio = 0.428

Slenderness ratio = 1.17

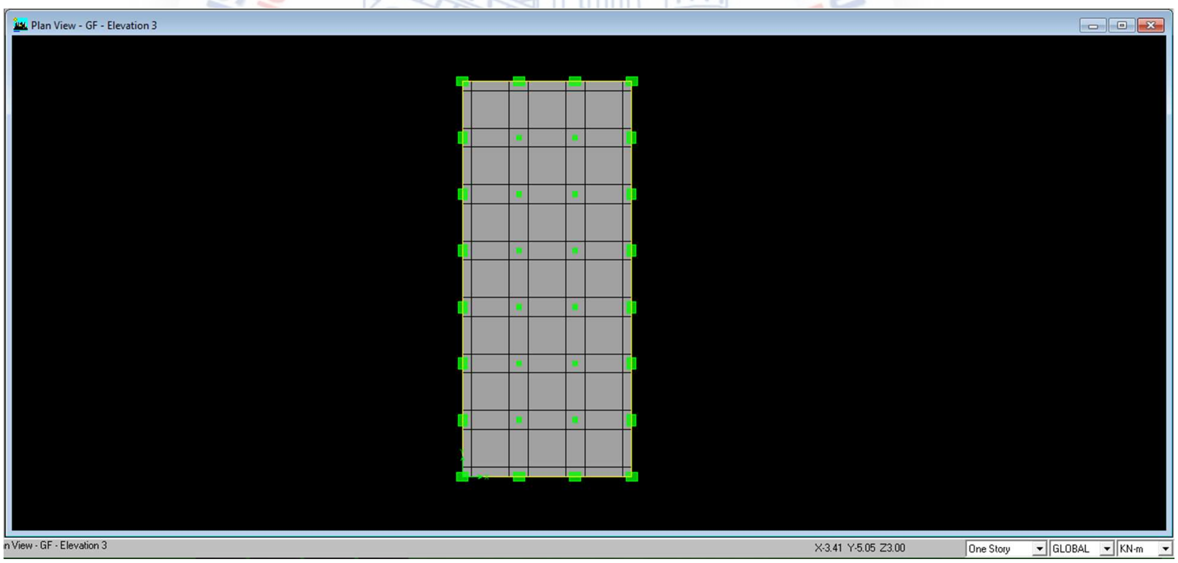


Fig .12.3.1 Plan (G+6)

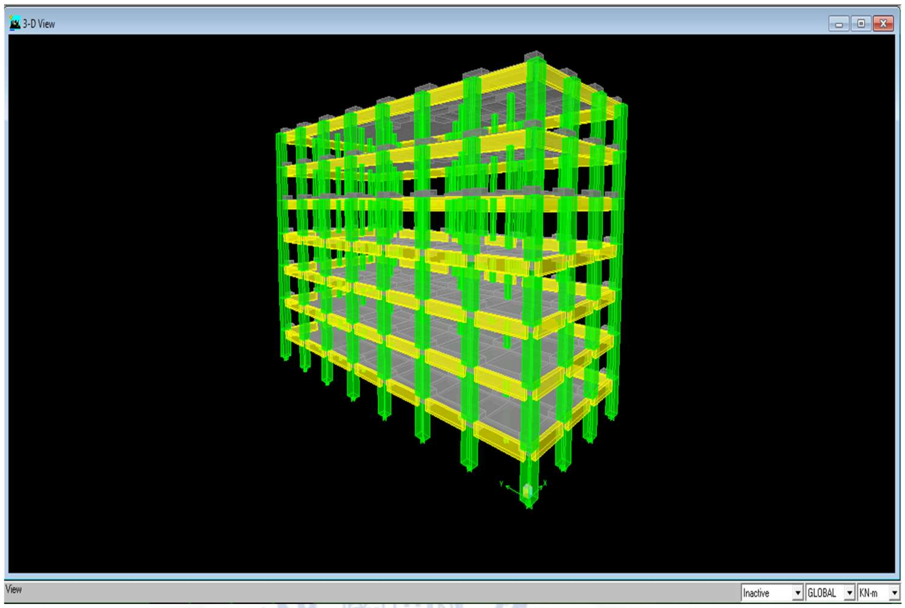


Fig .12.3.2 3d View (Extrusion)

MODEL - 3 (G+8)

Structural Elements

Slab thickness = 200 mm

Drop thickness = 300 mm

Number of stories = (7) G+6

Number of bays along X-direction = 3

Number of bays along Y-direction = 7

Storey height = 3.5

Bay width along X-direction = 6 m

Bay width along Y-direction = 6 m

Column size (interior) = 550 mm x 550 mm

Column size (exterior) = 900 mm x 1200 mm

Edge Beam = 350 mm x 900 mm

Drop size = 2m x 2m.

NOTE :-

3. Material properties, loading specification and seismic data remains same.

4. Fundamental Natural Period (T) $= 0.075h^{0.75} = 0.985$

Architectural aspects

Aspect ratio = 0.428

Slenderness ratio = 1.55

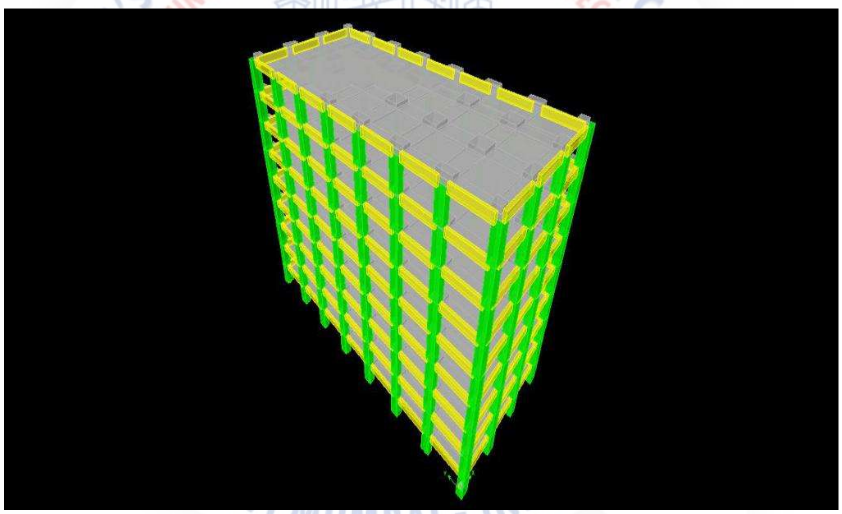


Fig .12.3.3 3d View (Extrusion)

CHAPTER – 04

RESULTS AND DISCUSSION

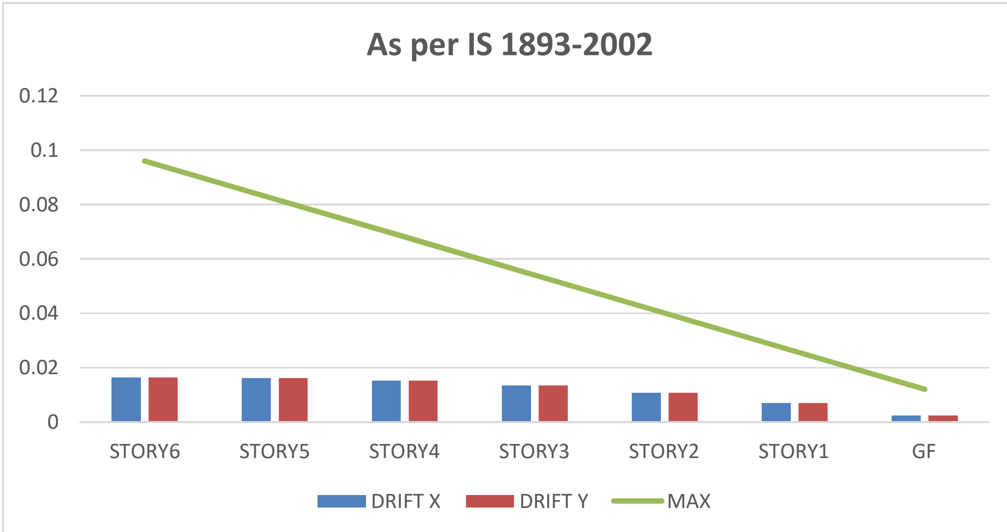
4.1 General

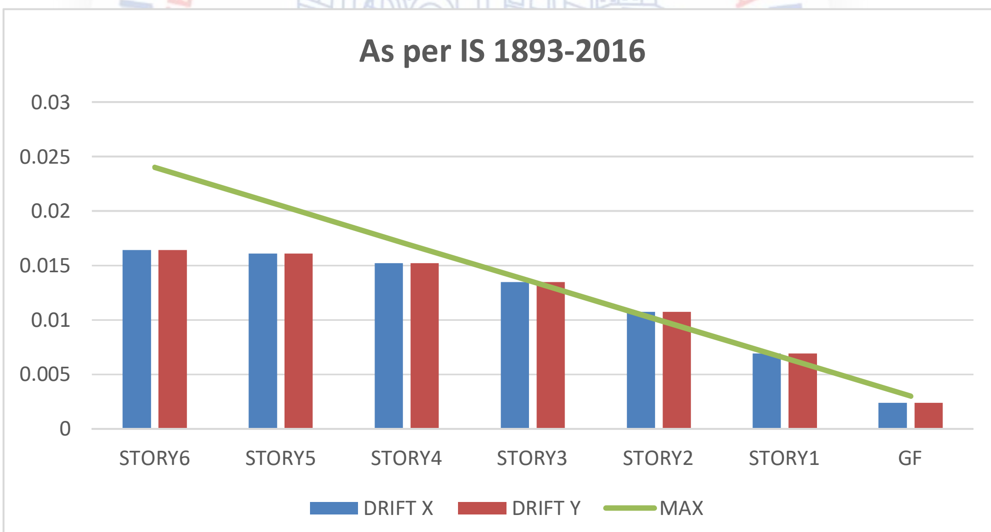
Results obtained through the mathematical modelling are presented and discussed in the following sub-topics.

4.2 Results

MODEL - 1 (G+6)

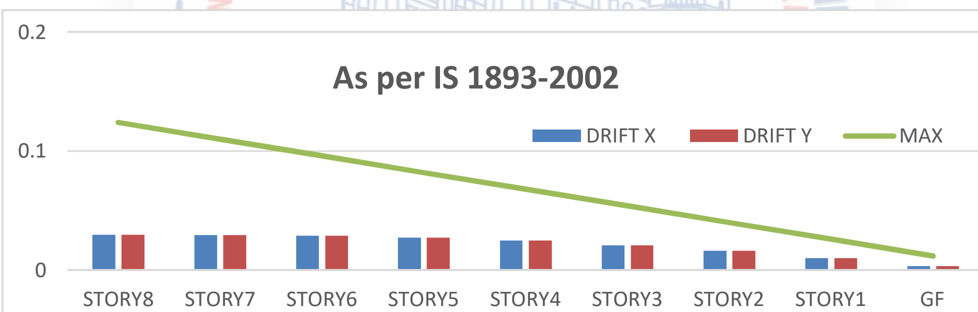
STORY	HEIGHT	DriftX	DriftY	LIMITATIONS	
				IS 1893-2002	IS 1893-2016
STORY6	24	0.016405	0.016405	0.096	0.024
STORY5	20.5	0.0161	0.0161	0.082	0.0205
STORY4	17	0.015208	0.015208	0.068	0.017
STORY3	13.5	0.013477	0.013477	0.054	0.0135
STORY2	10	0.010749	0.010749	0.04	0.01
STORY1	6.5	0.006935	0.006935	0.026	0.0065
GF	3	0.002399	0.002399	0.012	0.003

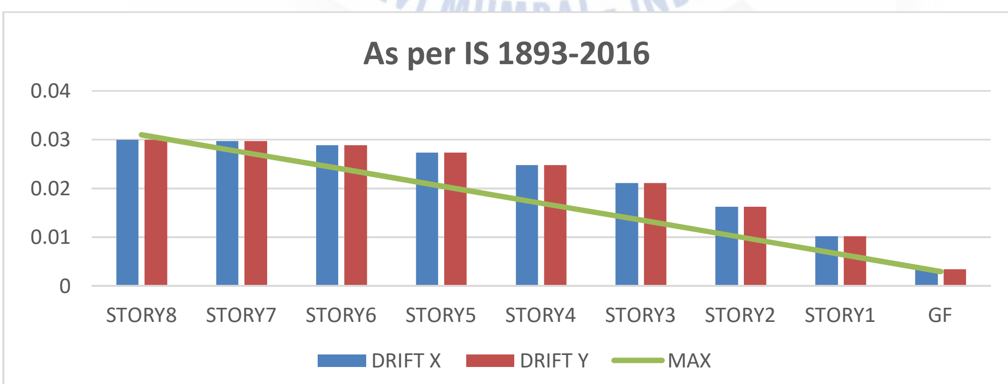

As per IS 1893-2002
0.12
0.1
0.08
0.06
0.04
0.02
0
STORY6
STORY5
STORY4
STORY3
STORY2
STORY1
GF
DRIFT X
DRIFT Y
MAX


As per IS 1893-2016
0.03
0.025
0.02
0.015
0.01
0.005
0
STORY6
STORY5
STORY4
STORY3
STORY2
STORY1
GF
DRIFT X
DRIFT Y
MAX

MODEL - 1 (G+8)

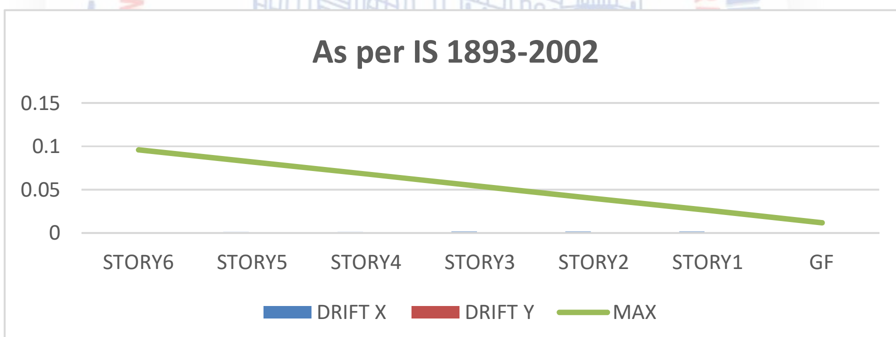
STORY	HEIGHT	DriftX	DriftY	LIMITATIONS	
				IS 1893-2002	IS 1893-2016
STORY8	31	0.029979	0.029979	0.124	0.031
STORY7	27.5	0.029713	0.029713	0.11	0.0275
STORY6	24	0.028916	0.028916	0.096	0.024
STORY5	20.5	0.027332	0.027332	0.082	0.0205
STORY4	17	0.024775	0.024775	0.068	0.017
STORY3	13.5	0.021115	0.021115	0.054	0.0135
STORY2	10	0.016271	0.016271	0.04	0.01
STORY1	6.5	0.010197	0.010197	0.026	0.0065
GF	3	0.003451	0.003451	0.012	0.003

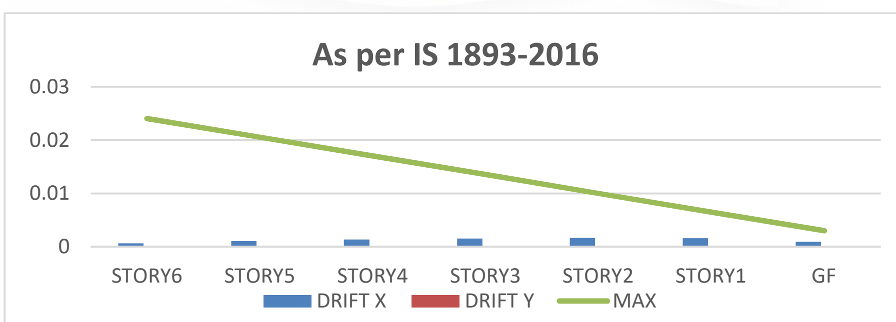




MODEL - 2 (G+6)

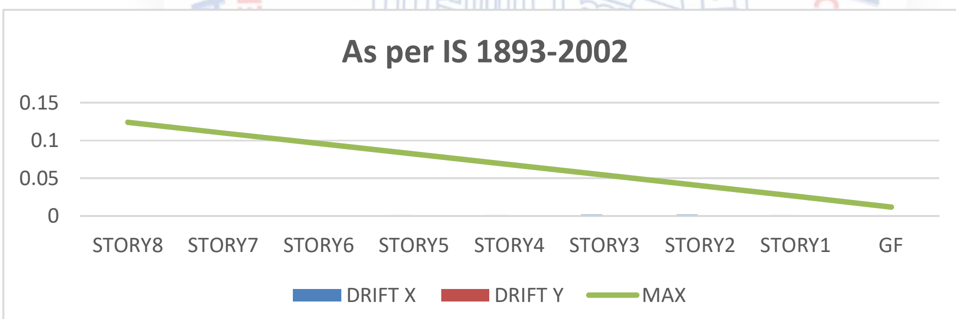
STORY	HEIGHT	DriftX	DriftY	LIMITATIONS	
				IS 1893-2002	IS 1893-2016
STORY6	24	0.000635	0	0.096	0.024
STORY5	20.5	0.001044	0	0.082	0.0205
STORY4	17	0.001352	0	0.068	0.017
STORY3	13.5	0.001545	0	0.054	0.0135
STORY2	10	0.001637	0	0.04	0.01
STORY1	6.5	0.001565	0	0.026	0.0065
GF	3	0.000888	0	0.012	0.003

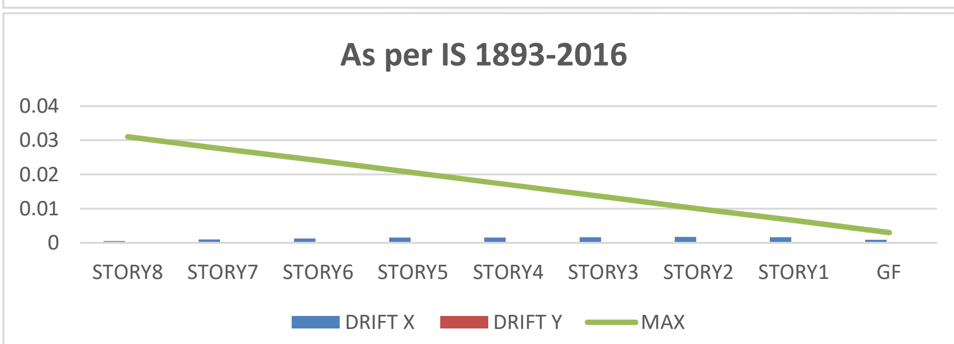




MODEL - 2 (G+8)

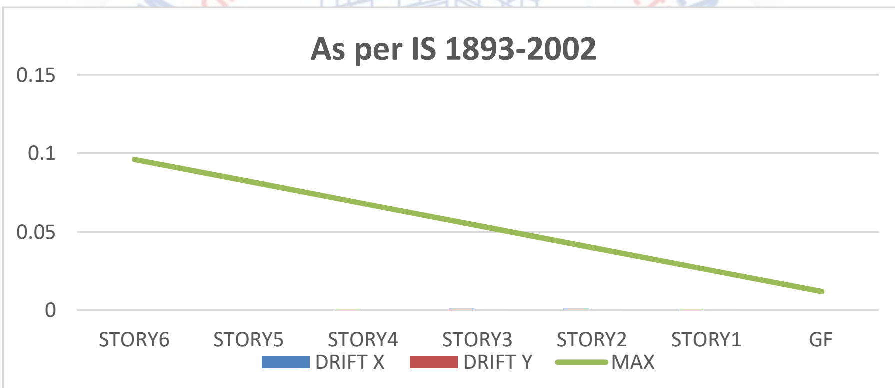
STORY	HEIGHT	DriftX	DriftY	LIMITATIONS	
				IS 1893-2002	IS 1893-2016
STORY8	31	0.000575	0	0.124	0.031
STORY7	27.5	0.000947	0	0.11	0.0275
STORY6	24	0.001255	0	0.096	0.024
STORY5	20.5	0.001481	0	0.082	0.0205
STORY4	17	0.001635	0	0.068	0.017
STORY3	13.5	0.001727	0	0.054	0.0135
STORY2	10	0.001756	0	0.04	0.01
STORY1	6.5	0.001643	0	0.026	0.0065
GF	3	0.000916	0	0.012	0.003

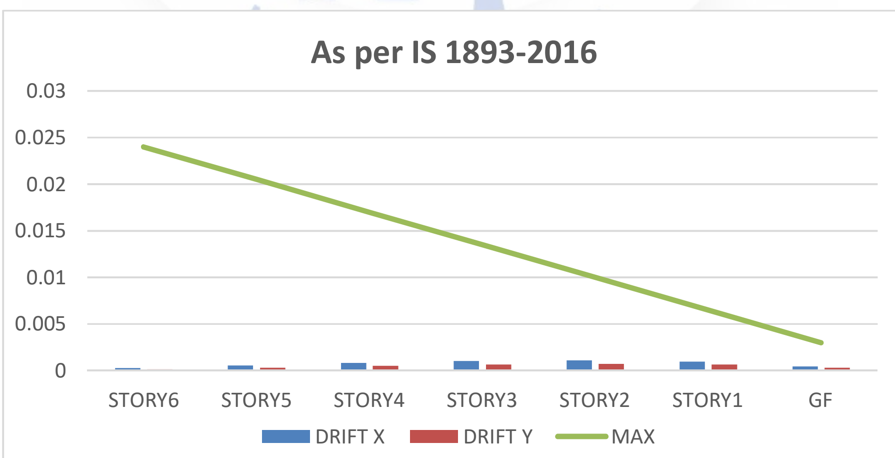




MODEL - 3 (G+6)

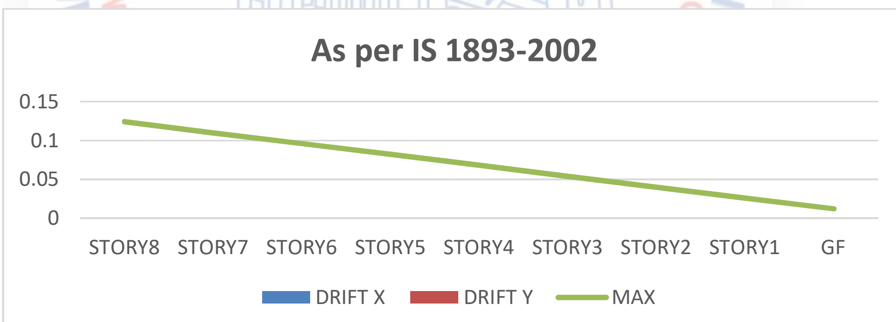
STORY	HEIGHT	DriftX	DriftY	LIMITATIONS	
				IS 1893-2002	IS 1893-2016
STORY6	24	0.000282	0.000128	0.096	0.024
STORY5	20.5	0.000564	0.000328	0.082	0.0205
STORY4	17	0.000856	0.000525	0.068	0.017
STORY3	13.5	0.001054	0.00066	0.054	0.0135
STORY2	10	0.001119	0.000717	0.04	0.01
STORY1	6.5	0.000974	0.000651	0.026	0.0065

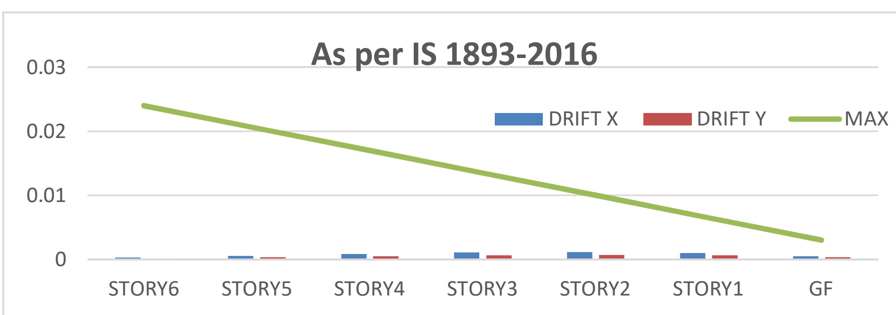




MODEL - 3 (G+8)

STORY	HEIGHT	DriftX	DriftY	LIMITATIONS	
				IS 1893-2002	IS 1893-2016
STORY8	31	0.000063	0.000019	0.124	0.031
STORY7	27.5	0.000103	0.000039	0.11	0.0275
STORY6	24	0.000229	0.000114	0.096	0.024
STORY5	20.5	0.000521	0.000316	0.082	0.0205
STORY4	17	0.000808	0.000511	0.068	0.017
STORY3	13.5	0.001002	0.000643	0.054	0.0135
STORY2	10	0.001067	0.000699	0.04	0.01
STORY1	6.5	0.000933	0.000636	0.026	0.0065
GF	3	0.000444	0.000323	0.012	0.003





4.3 Discussion

We have obtained the results from all 3 models in both the directions X and Y depending upon their aspect ratio and slenderness ratio which encloses that which type of structure is to be executed depending upon the limitations of storey drift described in revised code of Earthquake resisting Structure IS 1893:2016. Accordingly, we have assessed the results.

CHAPTER – 05

CONCLUSION

5.1 General

Inferences from the current study are listed in the following sub-topics. During the journey of the project, few question have arisen which were beyond the scope of present study. All these questions are opportunities for the future research. They are summarised in the future scope sub-topic.

5.2 Conclusions

1) When aspect ratio is 1 and simultaneously slenderness ratio is increased it is proved to be unsafe from both the direction X and Y as per the revised code of earthquake resisting structure. (IS:1893-2016)

2) But when aspect ratio is increased as the structure becomes more flatter its stability improves but the results are compatible for both 6 stories as well as 8 stories building and the structure lies in safer zone.

3) When aspect ratio is less than 1 the graph of storey drift in X and Y direction lies much below in the limitation prescribed by both the codes for both the stories G+6 and G+8 stories. Hence this type of structure are more reliable.

5.3 Future Scope

Current study gives a variation of storey drift under various architectural aspects. Any flat slab structure to be constructed may be in any seismic zone gives the rough idea regarding its limitation which is quite lesser than previously prescribed in the code of "Earthquake resisting structure" (IS 1893:2002). Accordingly, by keeping such parameters in mind the structure should be approved for future performance.

Also punching shear failure can be investigated as stated by IS 1893:2016 that punching shear failure should be avoided. There can be also future scope for irregularities of structure.

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