COST EVALUATION OF EARTHQUAKE RESISTANT STRUCTURES

A Dissertation Submitted in Partial Fulfillment
For the Award of the Degree of

Master of Engineering
in
Civil Engineering
With specialization in

STRUCTURAL ENGINEERING

Submitted by
ANAND SINGH
(Roll No. 8801)

Under the guidance of

Mr.Alok Verma
Lecturer

Dr. (Mrs.) P.R.Bose
Professor & Head

Civil Engineering Department
Delhi College of Engineering, Delhi

Department of Civil & Environmental Engineering
Delhi College of Engineering
University of Delhi, Delhi

2004-2006

Department of Civil & Environmental Engineering
Delhi College of Engineering, Delhi-110042

CERTIFICATE

This is to certify that the project entitled "COST EVALUATION OF EARTHQUAKE RESISTANT STRUCTURES" is being submitted by me (Mr. Anand Singh), is a bonafide record of student's own work carried by him under our guidance and supervision in partial fulfillment of requirement for the award of the Degree of Master of Engineering in Structural Engineering, Department of Civil and Environmental Engineering, Delhi College of Engineering, Delhi, University of Delhi.

The matter embodied in this project has not been submitted for the award of any other degree.

Anand Singh
Enroll No: 03/Str/04
Roll No: 8801

This is to certify that the above statement made by the candidate is correct of the best of our knowledge.

Mr.Alok Verma
Lecturer

Dr. (Mrs.).P.R.Bose
Professor & Head

Department of Civil & Environmental Engineering

Delhi College of Engineering, Delhi-110042

Acknowledgement

I wish to express my deep sense of gratitude and indebtness to Prof.(Mrs.) P.R.BOSE (HOD, Dept. of Civil Engineering) and Mr. ALOK VERMA (Lecturer) for making me perceive the various intricacies met during the work through their meticulous guidance and valuable suggestions without which completion of this project would not have been possible.

I also express my sincere gratitude to the faculty of Civil Engineering Department, Computer Centre, Library (Delhi college of Engg.) and Library (IIT Delhi). I also express my indebtedness to many soures, including those specially mentioned in the references, at the end of the text for using their papers for the preparation of this report.

Last but not the Least, I am thankful to my parents and friends for their forbearance, patience, encouragement and guidance. At last but not least I also express sincere thanks to Swati Consultants for giving me help.

Anand Singh

03/Stru/04

Univ. roll no. 8804

Contents

List of Figures

Abstract

In this study an attempt has been made to examine the variation in the cost on structural frame component of the building structures for provision of earthquake resistant features. Various commercial / office buildings with different parameters such as number of stories, place of construction in terms of seismic zone have been considered in the study. These buildings were designed for different loading conditions - for gravity loads only and for the condition when seismic forces also are considered. The cost difference for the provision of ductile detailing as per IS: 13920-1993 has been examined vis-à-vis the application of IS: 456-2000. A set of five school buildings, already constructed, has also been considered. The results as for the variation of cost of these school buildings have been compared with the idealized buildings having the same number of stories in the study. The comparison gives an idea on the additional cost that would incure on the structural frame of buildings for provision of seismic resistance provisions as per Indian codes of practice. Wind load has not been considered in the study. Importance factor is taken 1.5 for design of office building and calculation of cost of building.

Chapter:1
Introduction

Earthquakes are one of the worst type of natural disasters. Millions of lives are lost and other unbearable economic losses take place due to them each year around the world. In a seismic activity most of the losses and casualties take place due to the failures in civil engineering structures, a majority of them are building structures.

In the past building structures have been designed without any consideration of the seismic effects. As the knowledge about the earthquake, their behaviour and their effects on structures grew with time; seismic resistant design procedures have been started being followed in the analysis and design of structures.

Even though it is understood by people that seismic resistant features, if provided in the structures, shall provide added safety against seismic fury; they are often reluctant to provide those features in their buildings. It may be due to their ignorance of the actual quantum of increase in the cost of buildings due to the provisions of earthquake resistant design features.

In the initial phase of the introduction of RC framed structures in the construction industry, the knowledge about earthquakes was inadequate. Their impacts on building structures were not clearly understood. With time as the knowledge about earthquakes grew; earthquake resistant features were applied to building structures to ensure added safety to them.

With time earthquake analysis and design related Indian standard guidelines also came in and various codes of practice are available for this purpose. Out of them the use of the Indian standard codes of practice IS 1893-2002 & IS 13920-1993 (ref. 3) have been made in this study.

In these codes, various guidelines are given to impart earthquake resistant measures to the building structures. Due to the introduction of these features; the cost of building structures may increase by a certain amount.

In this study; an effort has been made to consider a set of building structures to estimate the probable rise, if any, in the cost due to the introduction of earthquake resistant structures. The approach has been to apply the codal guidelines in the design of buildings for imparting earthquake safety. Amounts of concrete and steel reinforcement, calculated in these cases, have been compared with those found out when the buildings are designed for gravity loads only. The findings may provide some information about possible increase in the cost due to the provision of earthquake resistance. Wind load has not been considered in the study. Importance factor is taken 1.5 for design of office building and calculation of cost of building.

Chapter:2

Literature Review

During a seismic event intense lateral forces are applied on to the building structures. Due to these lateral forces all the elements in a RC building structure are subjected to increased amounts of forces. In a building structure which has been designed for gravity loads only, such increase of forces in building elements may not be sustainable. Consequently, various types of damages occur in such buildings.

To reduce damages in the buildings it is important to provide added capacity in the building elements to take on the possible increase of forces due to seismic effects. Various types of earthquake resistant measures have been devised and reported in research literature and standard codes.

The behavior of a building during earthquake depends critically on its overall shape, size, and geometry, in addition to how the earthquake forces are carried to the ground.

The various aspects of earthquake resistant designs are:-

1. Sound architectural & structural concept
2. Strengthening for seismic lateral forces
3. Ductile detailing

The structural system for a building block developed according to sound concept does not result in abnormal additional requirement of concrete/steel. Rather, it reduces the additional cost for the strengthening the structure against the seismic forces, particularly in the structural system, which do not have uniform and symmetrical distribution of stiffness in plan and elevation.

The strengthening for the seismic lateral forces and the provisions for ductile detailing lead to additional cost to the project.

Very little research literature is available about the possible increase in the cost of different types of buildings. In one such study conducted in the case of RC buildings, ***Mittal (2001)*** has reported the following observations and conclusion as quoted:

1. ***The maximum total additional steel in kg/sq.m. for beams and columns both is of the order of 12 kg/sq.m.***

2. ***The additional steel due to lateral forces in beams increases with the increase in number of stories as well as increase in seismic zone coefficient. The pattern of variation of additional steel due to lateral forces in beam follow the pattern of variation for seismic base shear. It is due to the fact that the increase in additional moments in the beams due to lateral force are proportional to the increase in seismic base shear.***

3. ***The additional steel due to lateral force in columns decrease with the increase in number of stories but increase with the increase in seismic zone coefficient. The total additional steel due to lateral force in beams and columns increase in no of stories as well as increase in seismic coefficient.***

4. ***The additional steel due to ductile detailing in beams decrease with the increase in number of stores as well as increase in seismic zone coefficient .It is due to the fact that as the base shear increases ,the additional moment in beams also increases proportionately. It leads to increase in positive and negative steel at joint face and simultaneously decrease in the difference of negative and positive steel.***

5. ***Additional steel due to ductile detailing in columns increases with the increase in no of stories. As per IS :13920,the additional steel in columns is provided in the forms of lateral stirrups in confinement zone as well in the middle height of***

column. The additional volume of confinement steel in the forms of lateral stirrups also increases with the size of columns.

6. ***The total additional steel required due to the ductile detailing in beams and columns increases marginally with the increase in no of stories.***

7. ***Additional steel requirements in beams and columns due to seismic lateral forces is almost 3 times that of the ductile detailing as per IS :13920.***

8. ***The total additional steel requirement in beams is about 3 times of the additional steel requirement in columns.***

9. ***The order of total additional steel for ductile detailing in beams and columns is about 2.5 kg,approximately for seismic zones III and IV amounts to RS 50 per sq m of total floor area approximately. It is very small sum. As per the principles of earthquake resistant design philosophy, the additional resistance provided by the ductile detailing is many fold that of provided by additional strengthening for seismic lateral forces. It shows the cost effectiveness of the provision for ductile detailing.***

10. ***The total additional steel requirement on an average works out to be about 9kg per sq m i.e., about Rs 180/- per sq m for seismic zone III & 11kg per sq m i.e., about Rs 220/- per sq m for seismic zone IV.Assuming total building cost for a building block with average specifications around Rs 7000/-per sq m, the additional cost due to earthquake resistant design provisions works out to be 2.65 % only for seismic zone III & about 3.2 % for seismic zone IV. By extrapolated the values of zone III & IV, the additional cost for zone V will be about 5.3%. The additional cost for ductile detailing alone is about 0.7 % only.***

To estimate such additional cost it is required that the building blocks are analyzed designed and detailed for the following conditions:-

1. For vertical loads only,
2. For vertical loads and lateral loads without ductile detailing and,
3. For vertical loads and lateral loads with ductile detailings.

2.1 Seismic Load Analysis

The effect of seismic forces on the building can be analyzed either by the static method or by the dynamic analysis. The fundamental difference between the two methods lies in their approach of calculation of the design seismic force and its distribution to different levels along the height of the structure.

The numerical problem in this report has been analyzed using the Response Spectrum Method. The design spectrum, as given by clause 6.4.2 of IS: 1893-2002, has been used to calculate the design horizontal acceleration spectrum value i.e. $A_{h.}$

The horizontal base shear V_B as per IS 1893-2002 is given by

$$V_B = A_h * W$$

where,

A_h = design horizontal seismic coefficient

W = effective weight of the structure

The forces and reactions obtained by the STAAD Pro 2004 analysis are used for designing the individual members, beams, columns etc.

2.2 Using STAAD Pro 2004

The analysis and design of building members has been carried out using the structural analysis and design software (STAAD Pro 2004). The methodology used by the software in analysis is discussed below.

2.3 Stiffness Analysis

The stiffness analysis implemented in STAAD Pro 2004 is based on the matrix displacement method. In the matrix analysis of structures by the displacement method, the structure is first idealized into an assembly of discrete structural components (frame members or finite elements).Each component has an assumed form of displacement in a manner which satisfies the force equilibrium and displacement compatibility at the joints.

2.4 Assumption of the Analysis

For a complete analysis of the structure, the necessary matrices are generated on the basis of the following assumptions:

1. The structure is idealized into an assembly of beam, plate and solid type elements joined together at their vertices (nodes). The assemblage is loaded and reacted by concentrated loads acting at the nodes. These loads may be both forces and moments which may act in any specified direction.
2. A beam member is a longitudinal structural member having a constant, doubly symmetric or near-doubly symmetric cross section along its length. Beam members always carry axial forces. They may also be subjected to shear and bending in two arbitrary perpendicular planes, and they may also be subjected to torsion.
3. Internal and external loads acting on each node are in equilibrium. If torsional or bending properties are defined for any member, six degrees of freedom are considered at each node (i.e. three translational and three rotational) in the generation of relevant matrices. If the member is defined as truss member (i.e. carrying only axial forces) then only the three degrees (translational) of freedom are considered at each node.
4. Two types of coordinate systems are used in the generation of the required matrices and are referred to as local and global systems.

2.5 Seismic Load Input in STAAD

The seismic load analysis of the structures can be done using STAAD by employing the response spectrum method of dynamic analysis. The following steps are involved in this process.

1. User provides the value for Z*I/2R as factors for input spectrum.
2. Program calculates time periods for first twelve modes.
3. Program calculates Sa/g for each mode utilizing time period and damping for each mode.
4. The program then calculates mode participation factor for different modes.
5. The peak lateral seismic force at each floor in each mode is calculated.
6. All response quantities for each mode are calculated.
7. The peak response quantities are then combined as per method(CQC or SRSS or ABS or TEN or CSM) as defined by the user to get the final results.

Chapter:3

Numerical Study

In this study an attempt has been made to examine the variation in the cost of a selected component of structural frame of the building structures. Various commercial / office buildings with different parameters such as number of stories, place of construction in terms of seismic zone have been considered in the study. These buildings were designed for different loading conditions - for gravity loads only & for the condition when seismic forces also are considered. The cost difference in view of the provision of ductile detailing as per IS: 13920-1993 also has been examined in addition to the application of IS: 456-2000. A set of five school buildings, already constructed, has also been considered. The results as for the variation of cost of these school buildings have been compared with the idealized buildings having the same number of stories in the study. The comparison gives some idea about the relative effect of provision of seismic resistant measures in buildings for different functions.

The building has been analysed for the following load combinations.

- **1.5*(Dead Load + Imposed Load).**
- **1.2*(Dead Load + Imposed Load ± Earthquake Load).**
- **1.5*(Dead Load ± Earthquake Load).**
- **0.9*Dead Load ± 1.5*Earthquake Load.**

The seismic analysis has been carried in accordance to the IS: 1893 (Part-1)-2002.

In the analysis response spectrum method has been used for seismic analysis of structures. In the response spectrum all buildings has been analysed for each zones. Importance factor has been taken 1.5 for building and soil type chosen is medium soil. For seismic analysis IS 1893:2002 has been used in addition to that help of IS 13920-1993 has also been taken for ductile detailing. For the calculation of dead load &live load

IS 875-1987has been used. The load combinations have been taken from different codes which were mentioned above.

3.1 FOR ONE STOREY:

Building Data:

Number of Storeys	**=**	**1**
Height of the storey	**=**	**3.3 m.**
Height of the building	**=**	**5.55m.**
Length of the building	**=**	**26.40m.**
Width of the building	**=**	**15.65m.**
Column size	**=**	**0.3m X 0.3 m**
Beam size	**=**	**0.25 m X 0.35 m**
Concrete Grade used	**=**	**M20**
Steel Grade used	**=**	**Fe 415**

Seismic Data:

Seismic Zone	**=**	**II,III,IV,V**
Soil type	**=**	**Medium Soil**

Load Data:

DL	**=**	**4.75 KN /m^2**
LL	**=**	**4 KN /m^2(For Commercial And Office Build.)**

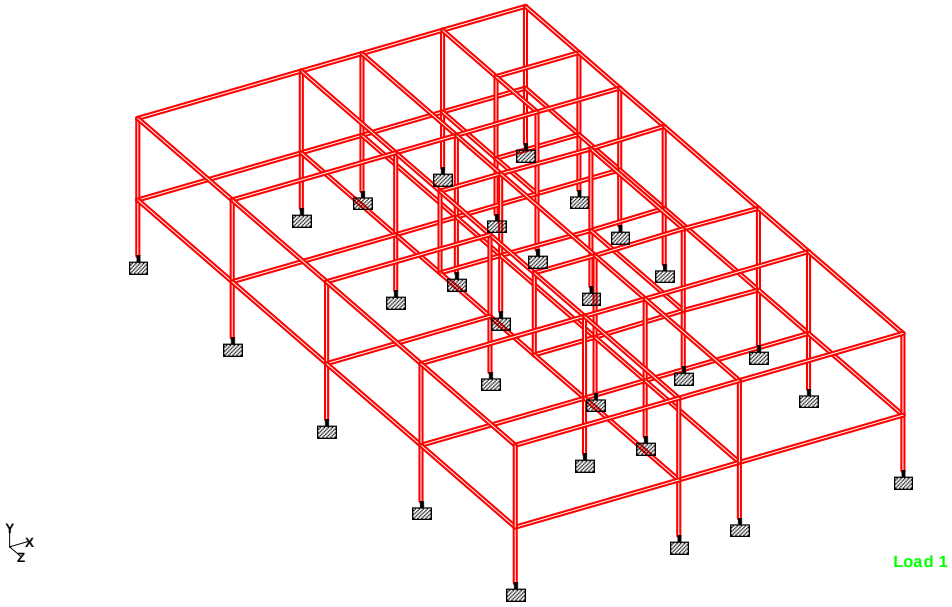

Fig 3.1: ONE STOREY

3.2 FOR THREE STOREY:

Building Data:

Number of Storeys	**=**	**3**
Height of the storey	**=**	**3.3 m.**
Height of the building	**=**	**12.15 m.**
Length of the building	**=**	**26.40m.**
Width of the building	**=**	**15.65m.**
Column size	**=**	**0.3m X 0.3 m**
Beam size	**=**	**0.25 m X 0.35 m**
Concrete Grade used	**=**	**M20**
Steel Grade used	**=**	**Fe 415**

Seismic Data:

Seismic Zone = II,III,IV,V

Soil type = Medium Soil

Load Data:

DL = 4.75 KN /m^2

LL = 4 KN /m^2 (For Commercial And Office Build.)

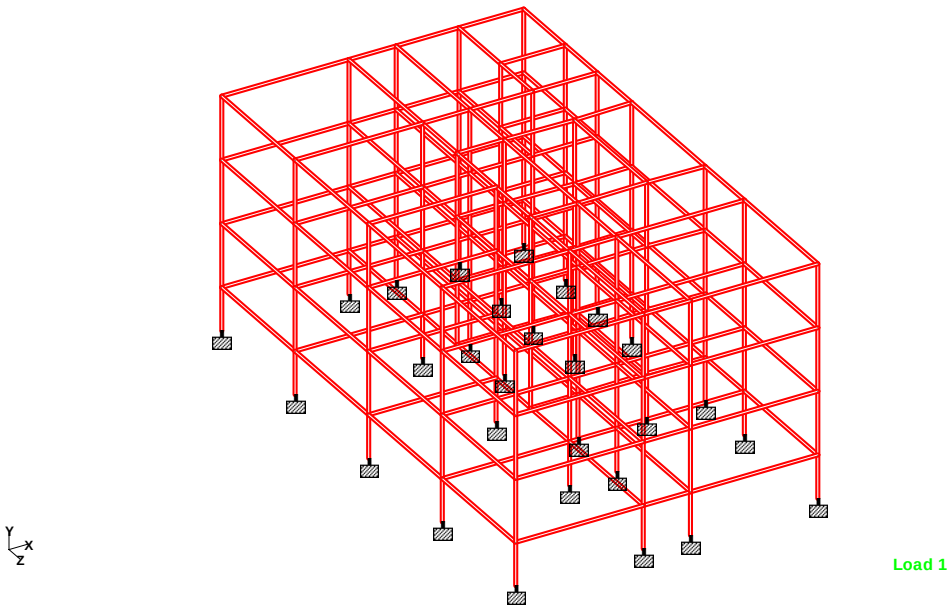

Fig 3.2: THREE STOREY

3.3 FOR FOUR STOREY:

Building Data:

Number of Storeys = 4

Height of the storey = 3.3 m.

Height of the building = 15.45m.

Length of the building	**=**	**26.40 m.**
Width of the building	**=**	**15.65 m.**
Column size	**=**	**0.35m X 0.35 m**
Beam size	**=**	**0.25 m X 0.35 m**
Concrete Grade used	**=**	**M20**
Steel Grade used	**=**	**Fe 415**

Seismic Data:

Seismic Zone	**=**	**II,III,IV,V**
Soil type	**=**	**Medium Soil**

Load Data:

DL	**=**	**4.75 KN /m^2**
LL	**=**	**4 KN /m^2 (For Commercial And Office Build.)**

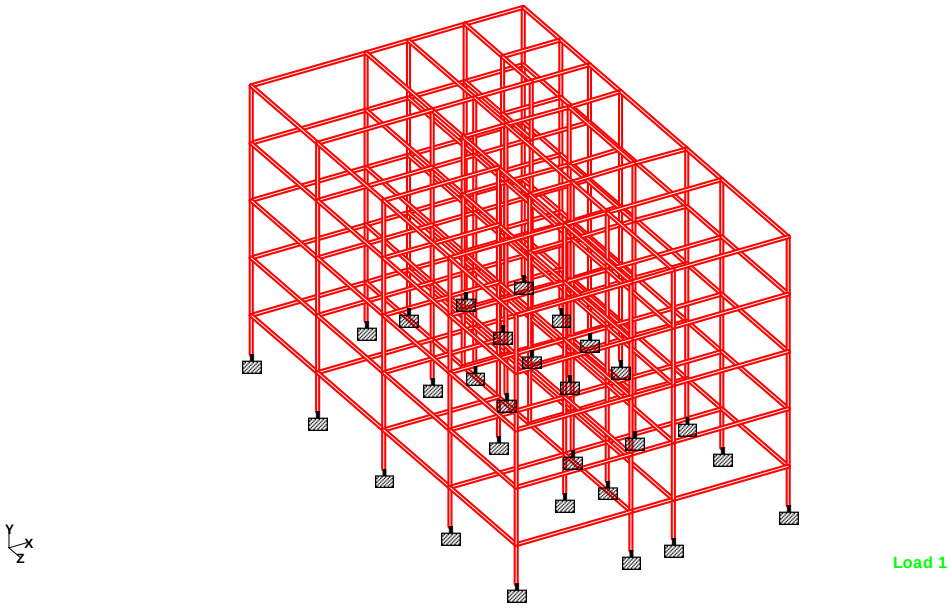

Fig 3.3: FOUR STOREY

3.4 FOR FIVE STOREY:

Building Data:

Number of Storeys	**=**	**5**
Height of the storey	**=**	**3.3 m.**
Height of the building	**=**	**18.75m.**
Length of the building	**=**	**26.40m.**
Width of the building	**=**	**15.65m.**
Column size	**=**	**0.35m X 0.35 m**
Beam size	**=**	**0.25 m X 0.35 m**
Concrete Grade used	**=**	**M20**
Steel Grade used	**=**	**Fe 415**

Seismic Data:

Seismic Zone	**=**	**II,III,IV,V**
Soil type	**=**	**Medium Soil**

Load Data:

DL	**=**	**4.75 KN /m^2**
LL	**=**	**4 KN /m^2 (For Commercial And Office Build.)**

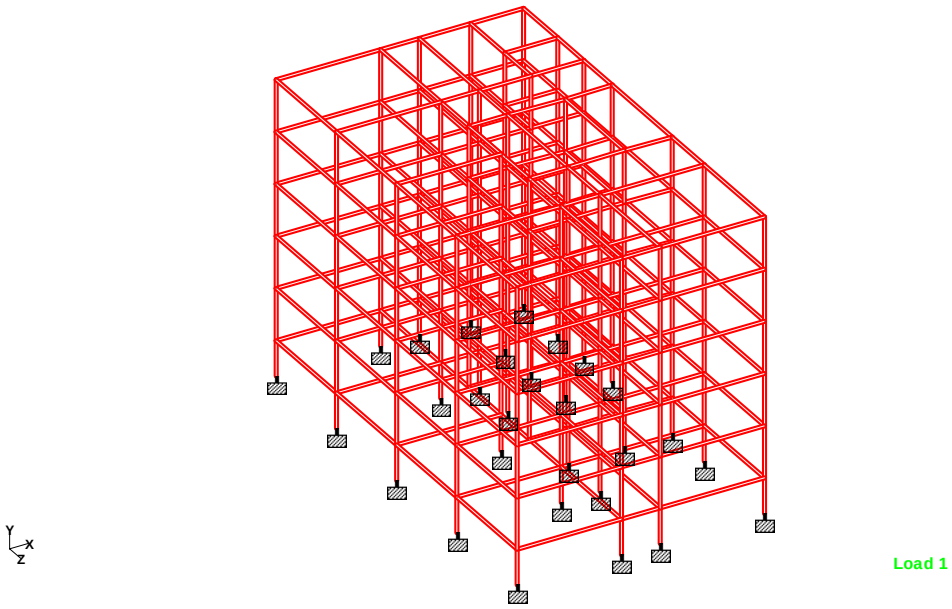

Fig 3.4: FIVE STOREY

3.5 FOR SEVEN STOREY:

Building Data:

Number of Storeys	**=**	**7**
Height of the storey	**=**	**3.3 m.**
Height of the building	**=**	**25.35m.**
Length of the building	**=**	**26.40m.**
Width of the building	**=**	**15.65m.**
Column size	**=**	**0.4m X 0.4 m**
Beam size	**=**	**0.25 m X 0. 35 m**
Concrete Grade used	**=**	**M20**
Steel Grade used	**=**	**Fe 415**

Seismic Data:

Seismic Zone	**=**	**II,III,IV,V**

Soil type = **Medium Soil**

Load Data:

DL = **4.75 KN /m^2**

LL = **4 KN /m^2 (For Commercial And Office Build.)**

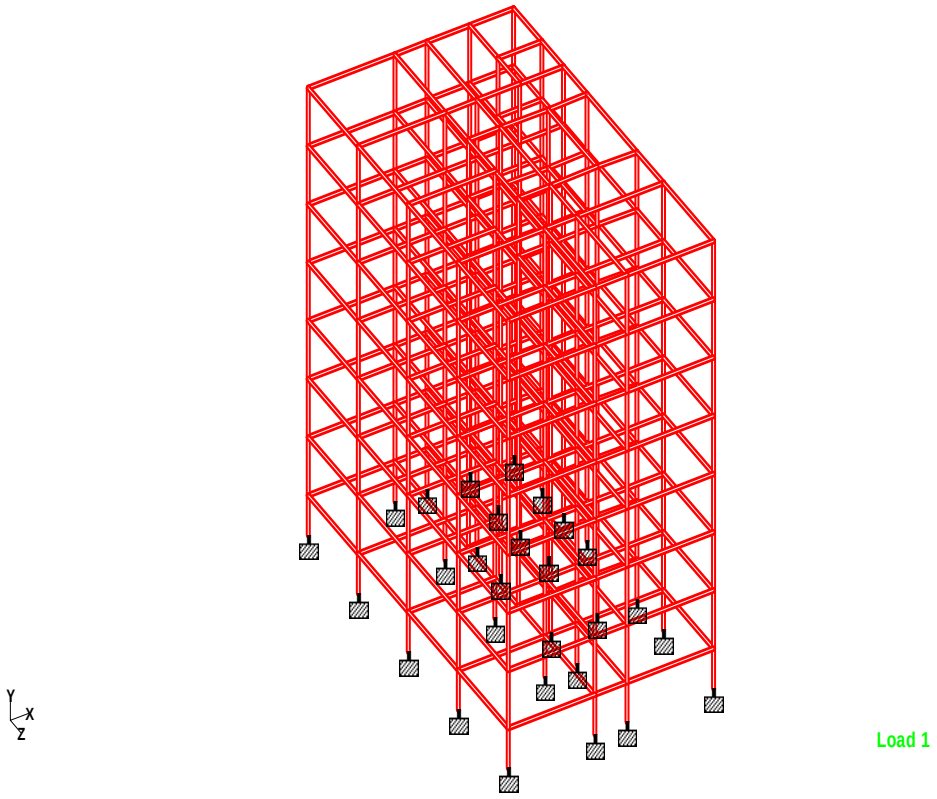

Fig 3.5: SEVEN STOREY

3.6 FOR NINE STOREY:

Building Data:

Number of Storeys = **9**

Height of the storey = **3.3 m.**

Height of the building = **31.95m.**

Length of the building	**=**	**26.40m.**
Width of the building	**=**	**15.65m.**
Column size	**=**	**0.45m X 0.45 m**
Beam size	**=**	**0.25 m X 0. 35 m**
Concrete Grade used	**=**	**M20**
Steel Grade used	**=**	**Fe 415**

Seismic Data:

Seismic Zone	**=**	**II,III,IV,V**
Soil type	**=**	**Medium Soil**

Load Data:

DL	**=**	**4.75 KN /m^2**
LL	**=**	**4 KN /m^2 (For Commercial And Office Build.)**

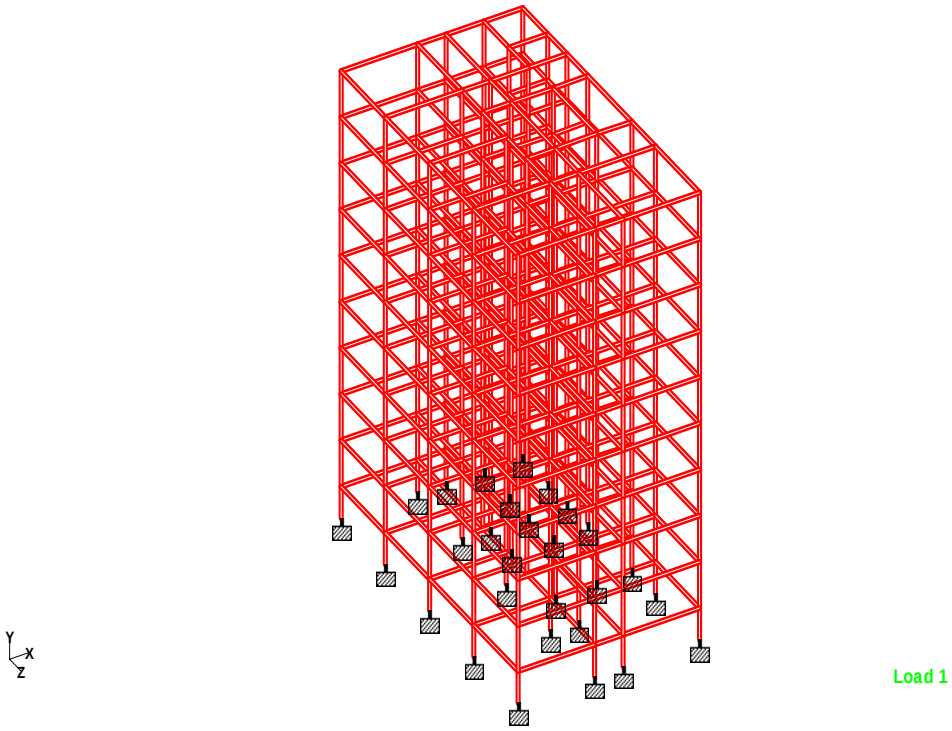

Fig 3.6 : NINE STOREY

3.7 FOR ELEVEN STOREY:

Building Data:

Number of Storeys	**=**	**11**
Height of the storey	**=**	**3.3 m.**
Height of the building	**=**	**38.55m.**
Length of the building	**=**	**26.40m.**
Width of the building	**=**	**15.65m.**
Column size	**=**	**0.5m X 0.5 m**
Beam size	**=**	**0.25 m X 0. 35 m**
Concrete Grade used	**=**	**M20**

Steel Grade used	**=**	**Fe 415**

Seismic Data:

Seismic Zone	**=**	**II,III,IV,V**
Soil type	**=**	**Medium Soil**

Load Data:

DL	**=**	**4.75 KN /m^2**
LL	**=**	**4 KN /m^2 (For Commercial And Office Build.)**

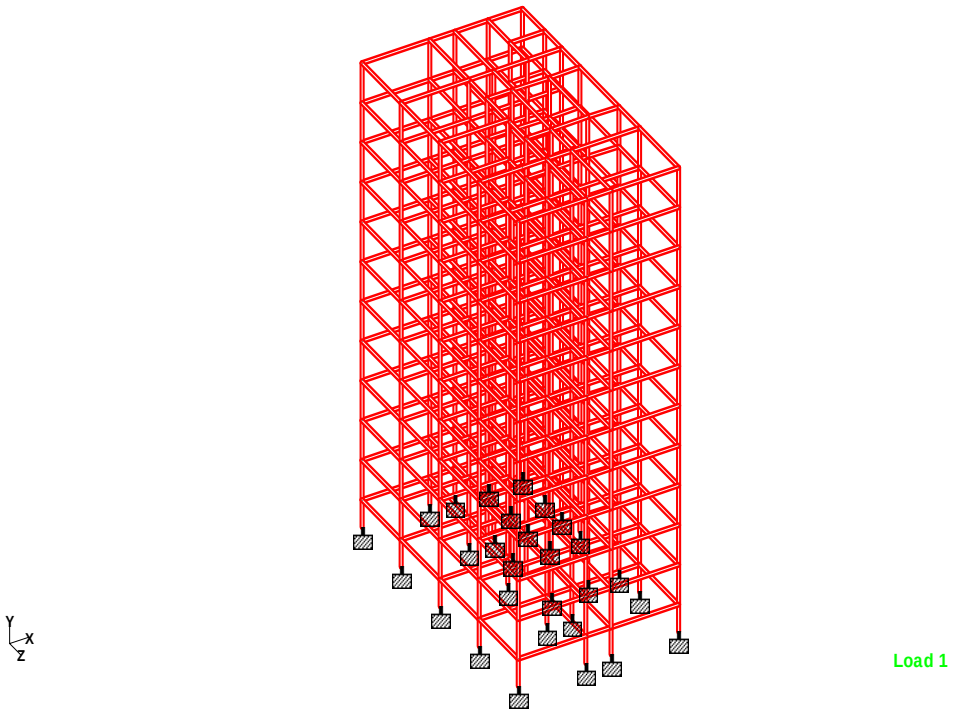

Fig 3.7: ELEVEN STOREY

3.8 FOR THIRTEEN STOREY:

Building Data:

Number of Storeys	**=**	**13**
Height of the storey	**=**	**3.3 m.**
Height of the building	**=**	**45.15m.**
Length of the building	**=**	**26.40m.**
Width of the building	**=**	**15.65m.**
Column size	**=**	**0.55m X 0.55 m**
Beam size	**=**	**0.25 m X 0. 35 m**
Concrete Grade used	**=**	**M20**
Steel Grade used	**=**	**Fe 415**

Seismic Data:

Seismic Zone	**=**	**II,III,IV,V**
Soil type	**=**	**Medium Soil**

Load Data:

DL	**=**	**4.75 KN /m^2**
LL	**=**	**4 KN /m^2 (For Commercial And Office Build.)**

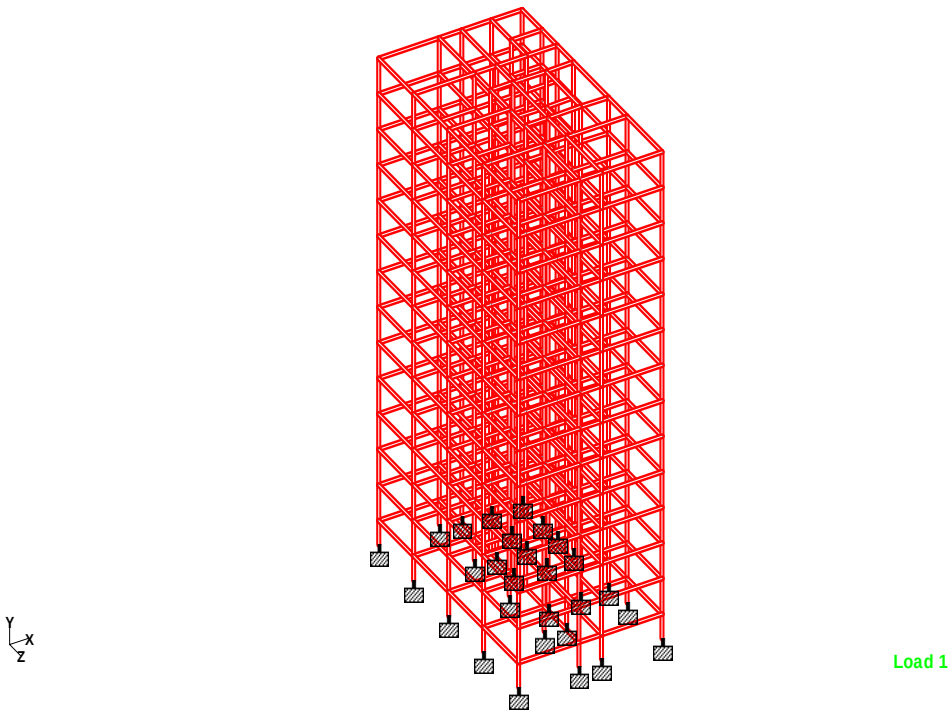

Fig 3.8: THIRTEEN STOREY

Chapter:4

Cost Calculation of Different Storey Heights

4.1 For One Storey:

For gravity load:

Total concrete	**= 51.18 m^3**
Total steel (By IS 456)	**= 4676.32 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 1,12,596=00**
COST OF STEEL (BY IS 456)	**= Rs. 1,07,556=00**
TOTAL COST	**= Rs. 2,20,152=00**

Fig 4.1: % Increase in cost for One storey building

For seismic load :

ZONE II

Total concrete	**= 51.18 m^3**
Total steel (By IS 456)	**= 4567.72 kg**
Total steel (By IS 13920)	**= 5750.94 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 1,12,596=00**
COST OF STEEL (BY IS 456)	**= Rs. 1,05,057=00**
COST OF STEEL (BY IS 13920)	**= Rs 1,32,271=00**
TOTAL COST (BY IS 456)	**= Rs. 2,17,653=00**
TOTAL COST (BY IS 13920)	**= Rs 2,38,308=00**

ZONE III

Total concrete	**= 51.18 m^3**
Total steel (By IS 456)	**= 4590.04 kg**
Total steel (By IS 13920)	**= 5891.74 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 1,12,596=00**
COST OF STEEL (BY IS 456)	**= Rs. 1,05,571=00**
COST OF STEEL (BY IS 13920)	**= Rs 1,35,510=00**
TOTAL COST (BY IS 456)	**= Rs. 2,17,653=00**
TOTAL COST (BY IS 13920)	**= Rs 2,48,106=00**

ZONE IV

Total concrete	**= 51.18 m^3**
Total steel (By IS 456)	**= 4833.93 kg**

Total steel (By IS 13920) **= 6012.94 kg**

Cost of Concrete Per m^3 **= Rs.2200/ m^3**

Cost of Steel Per Kg **= Rs.23/kg**

COST OF CONCRETE **= Rs. 1,12,596=00**

COST OF STEEL (BY IS 456) **= Rs. 1,11,180=00**

COST OF STEEL (BY IS 13920) **= Rs 1,38,298=00**

TOTAL COST (BY IS 456) **= Rs. 2,23,776=00**

TOTAL COST (BY IS 13920) **= Rs 2,50,893=00**

ZONE V

Total concrete **= 51.18 m^3**

Total steel (By IS 456) **= 5441.31 kg**

Total steel (By IS 13920) **= 6378.60 kg**

Cost of Concrete Per m^3 **= Rs.2200/ m^3**

Cost of Steel Per Kg **= Rs.23/kg**

COST OF CONCRETE **= Rs. 1,12,596=00**

COST OF STEEL (BY IS 456) **= Rs. 1,25,150=00**

COST OF STEEL (BY IS 13920) **= Rs 1,46,707=00**

TOTAL COST (BY IS 456) **= Rs. 2,37,746=00**

TOTAL COST (BY IS 13920) **= Rs 2,59,303=00**

4.2 For Three Storey

For gravity load :

Total concrete **= 105.59 m^3**

Total steel (By IS 456) **= 10137.85 kg**

Cost of Concrete Per m^3 **= Rs.2200/ m^3**

Cost of Steel Per Kg **= Rs.23/kg**

COST OF CONCRETE = Rs. 2,32,298=00

COST OF STEEL (BY IS 456) = Rs. 2,33,170=00

TOTAL COST = Rs. 4,65,468=00

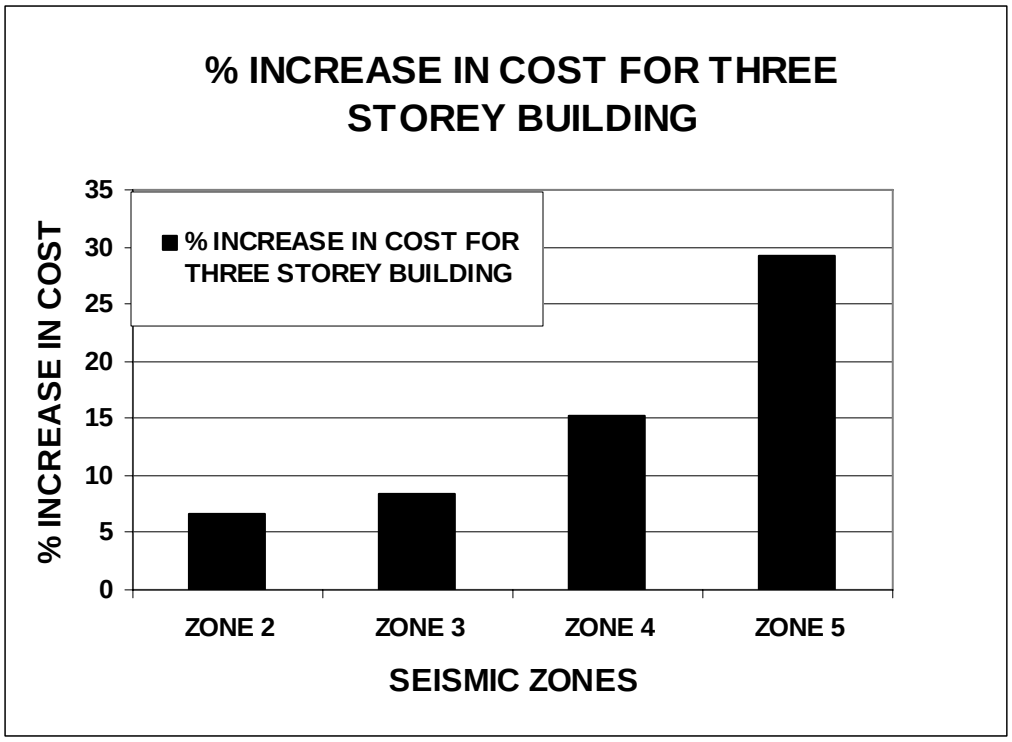

Fig 4.2: % Increase in cost for Three storey building

<u>For seismic load</u> :

<u>ZONE II</u>

Total concrete = 105.59 m^3

Total steel (By IS 456) = 9664.17 kg

Total steel (By IS 13920) = 11466.42 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 2,32,298=00

COST OF STEEL (BY IS 456) = Rs. 2,22,276=00

COST OF STEEL (BY IS 13920) = Rs 2,63,728=00

TOTAL COST (BY IS 456) = Rs. 4,54,574=00

TOTAL COST (BY IS 13920) = Rs 4,96,025=00

ZONE III

Total concrete = 105.59 m^3

Total steel (By IS 456) = 9984.03 kg

Total steel (By IS 13920) = 11831.21 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 2,32,298=00

COST OF STEEL (BY IS 456) = Rs. 2,29,633=00

COST OF STEEL (BY IS 13920) = Rs 2,72,118=00

TOTAL COST (BY IS 456) = Rs. 4,61,931=00

TOTAL COST (BY IS 13920) = Rs 5,04,416=00

ZONE IV

Total concrete = 105.59 m^3

Total steel (By IS 456) = 11328.02 kg

Total steel (By IS 13920) = 13206.38 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 2,32,298=00

COST OF STEEL (BY IS 456) = Rs. 2,60,5

COST OF STEEL (BY IS 13920) = Rs 3,03,746=00

TOTAL COST (BY IS 456) = Rs. 4,92,842=00

TOTAL COST (BY IS 13920) = Rs 5,36,044=00

ZONE V

Total concrete = 117.29 m^3

Total steel (By IS 456) = 13136.84 kg

Total steel (By IS 13920) = 14939.60 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 2,58,038=00

COST OF STEEL (BY IS 456) = Rs. 3,02,147=00

COST OF STEEL (BY IS 13920) = Rs 3,43,610=00

TOTAL COST (BY IS 456) = Rs. 5,60,185=00

TOTAL COST (BY IS 13920) = Rs 6,01,648=00

4.3 For Four Storey :

For gravity load

Total concrete = 147.71 m^3

Total steel (By IS 456) = 13151.44 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 3,24,962=00

COST OF STEEL (BY IS 456) = Rs. 3,02,483=00

TOTAL COST = Rs. 6,27,445

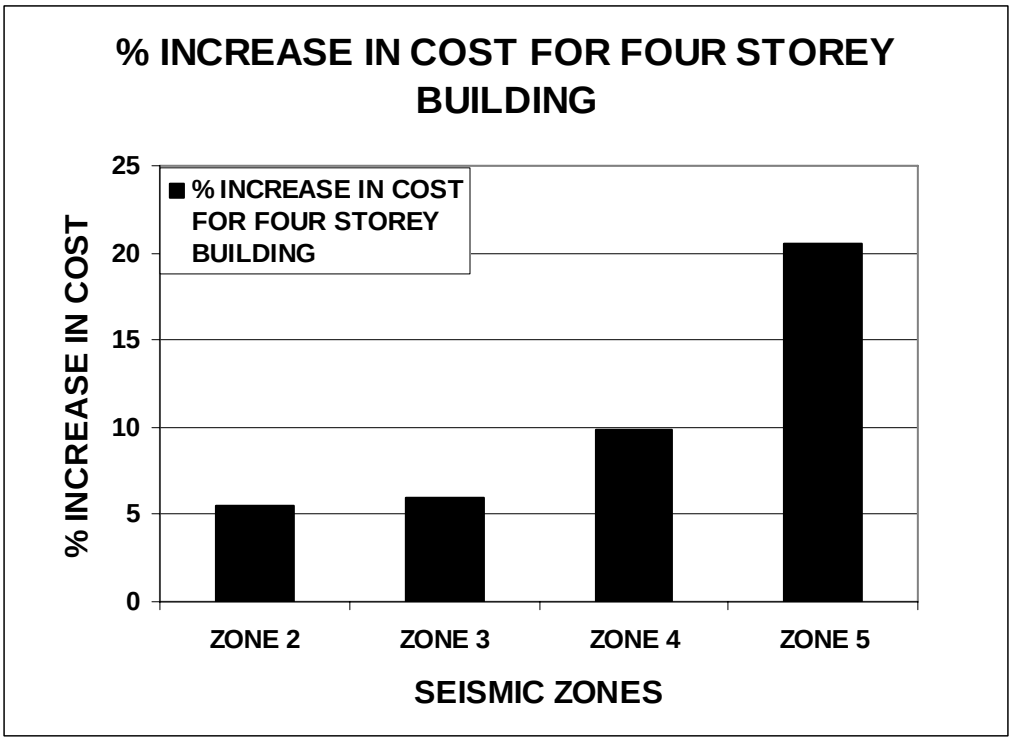

Fig 4.3: % Increase in cost for Four storey building

For seismic load :

ZONE II

Total concrete	**= 147.71 m^3**
Total steel (By IS 456)	**= 12496 kg**
Total steel (By IS 13920)	**= 14663.56 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**
COST OF CONCRETE	**= Rs. 3,24,962=00**
COST OF STEEL (BY IS 456)	**= Rs. 2,87,408=00**
COST OF STEEL (BY IS 13920)	**= Rs 3,37,262=00**
TOTAL COST (BY IS 456)	**= Rs. 6,12,370=00**
TOTAL COST (BY IS 13920)	**= Rs 6,62,224=00**

ZONE III

Total concrete = 147.71 m^3

Total steel (By IS 456) = 12591.84 kg

Total steel (By IS 13920) = 14783 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 3,24,962=00

COST OF STEEL (BY IS 456) = Rs. 2,89,612=00

COST OF STEEL (BY IS 13920) = Rs 3,40,009=00

TOTAL COST (BY IS 456) = Rs. 6,14,574=00

TOTAL COST (BY IS 13920) = Rs 6,64,971=00

ZONE IV

Total concrete = 147.71 m^3

Total steel (By IS 456) = 13594.43 kg

Total steel (By IS 13920) = 15845.47 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 3,24,962=00

COST OF STEEL (BY IS 456) = Rs. 3,12,672=00

COST OF STEEL (BY IS 13920) = Rs 3,64,446=00

TOTAL COST (BY IS 456) = Rs. 6,37,634=00

TOTAL COST (BY IS 13920) = Rs 6,89,408=00

ZONE V

Total concrete = 147.71 m^3

Total steel (By IS 456) = 16497.16 kg

Total steel (By IS 13920) = 18765.2 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 3,24,962=00
COST OF STEEL (BY IS 456) = Rs. 3,79,435=00
COST OF STEEL (BY IS 13920) = Rs 4,31,600=00
TOTAL COST (BY IS 456) = Rs. 7,04,397=00
TOTAL COST (BY IS 13920) = Rs 7,56,562=00

4.4 For Five Storey

For gravity load :

Total concrete = 183.59 m^3
Total steel (By IS 456) = 16579.52 kg
Cost of Concrete Per m^3 = Rs.2200/ m^3
Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 4,03,898=00
COST OF STEEL (BY IS 456) = Rs. 3,81,329=00
TOTAL COST = Rs. 7,85,227=00

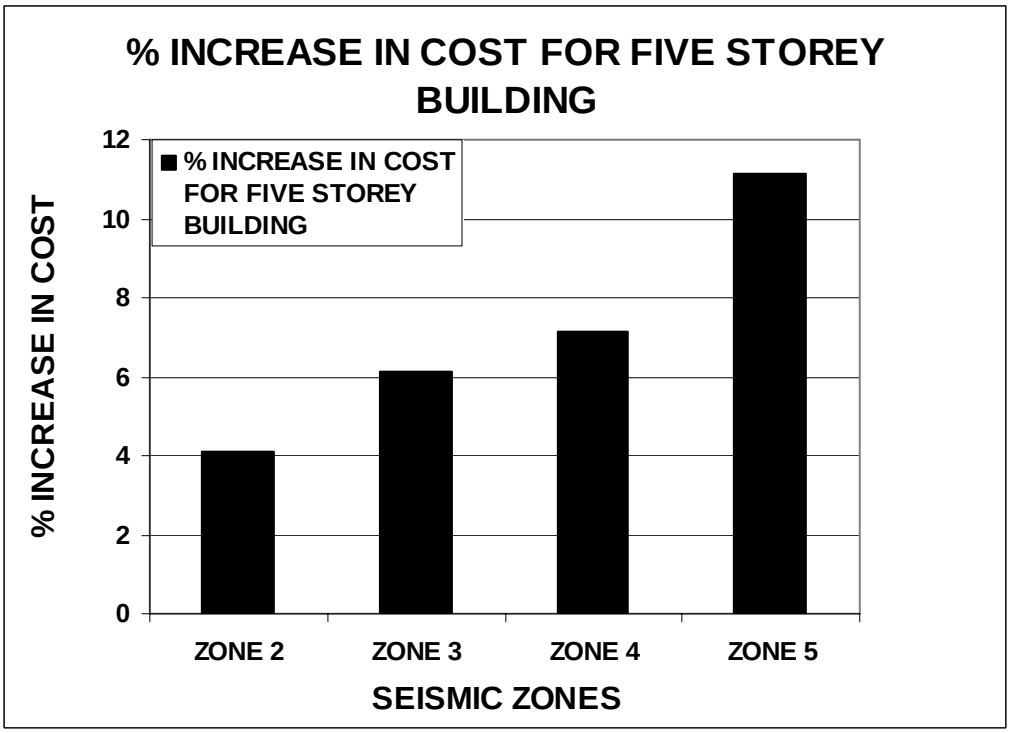

Fig 4.4: % Increase in cost for Five storey building

<u>For seismic load</u> :

<u>ZONE II</u>

Total concrete	**= 183.59 m^3**
Total steel (By IS 456)	**= 19000.00 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 4,03,898=00**
COST OF STEEL (BY IS 456)	**= Rs. 3,77,923=00**
COST OF STEEL (BY IS 13920)	**= Rs 4,37,006=00**
TOTAL COST (BY IS 456)	**= Rs. 7,81,821=00**
TOTAL COST (BY IS 13920)	**= Rs 8,40,904=00**

ZONE III

Total concrete = 183.59 m^3

Total steel (By IS 456) = 18482 kg

Total steel (By IS 13920) = 21061 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 4,03,898=00

COST OF STEEL (BY IS 456) = Rs. 4,25,085=00

COST OF STEEL (BY IS 13920) = Rs 4,84,400=00

TOTAL COST (BY IS 456) = Rs. 8,28,983=00

TOTAL COST (BY IS 13920) = Rs 8,88,298=00

ZONE IV

Total concrete = 183.59 m^3

Total steel (By IS 456) = 15796.39 kg

Total steel (By IS 13920) = 18325.65 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 4,03,898=00

COST OF STEEL (BY IS 456) = Rs. 3,63,317=00

COST OF STEEL (BY IS 13920) = Rs 4,21,490=00

TOTAL COST (BY IS 456) = Rs. 7,67,215=00

TOTAL COST (BY IS 13920) = Rs 8,25,388=00

ZONE V

Total concrete = 183.59 m^3

Total steel (By IS 456) = 16801.74 kg

Total steel (By IS 13920) = 19354.7 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 4,03,898=00

COST OF STEEL (BY IS 456) = Rs. 3,86,440=00

COST OF STEEL (BY IS 13920) = Rs 4,45,158=00

TOTAL COST (BY IS 456) = Rs. 7,90,338=00

TOTAL COST (BY IS 13920) = Rs 8,49,056=00

4.5 For Seven Storey:

For gravity load

Total concrete = 267.31 m^3

Total steel (By IS 456) = 24578.4 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 5,88,082=00

COST OF STEEL (BY IS 456) = Rs. 5,65,303=00

TOTAL COST = Rs. 11,53,385=00

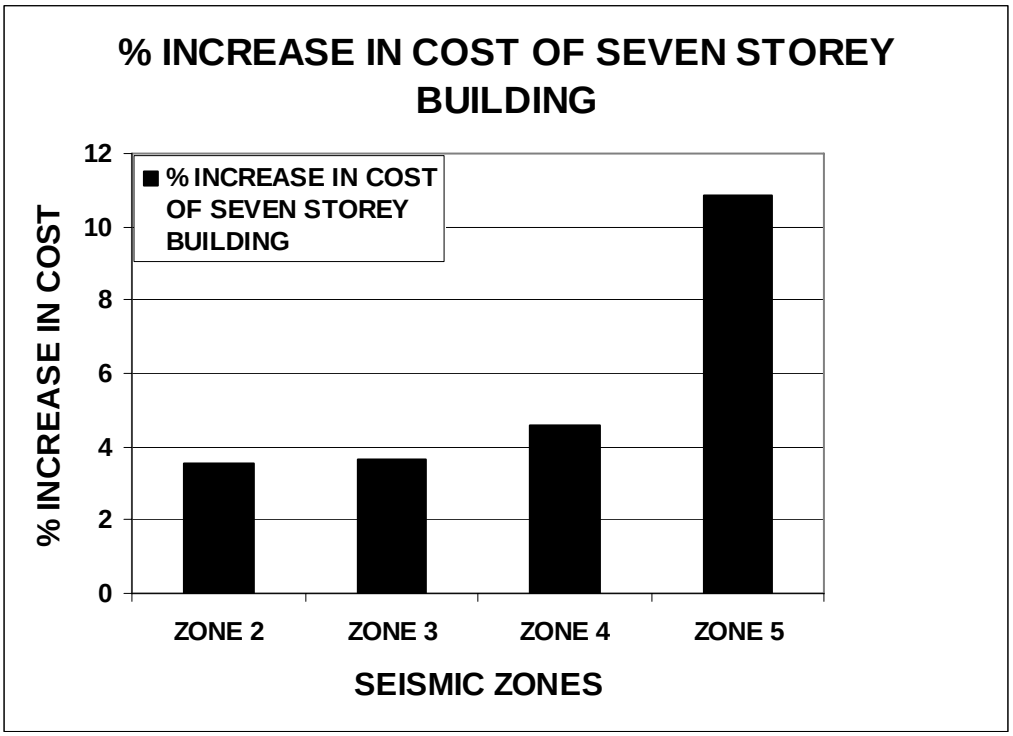

Fig 4.5: % Increase in cost for Seven storey building

For seismic load :

ZONE II

Total concrete	**= 267.31 m^3**
Total steel (By IS 456)	**= 23051.13 kg**
Total steel (By IS 13920)	**= 26361.43 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 5,88,082=00**
COST OF STEEL (BY IS 456)	**= Rs. 5,30,176=00**
COST OF STEEL (BY IS 13920)	**= Rs 6,06,313=00**
TOTAL COST (BY IS 456)	**= Rs. 11,36,489=00**
TOTAL COST (BY IS 13920)	**= Rs 11,94,395=00**

ZONE III

Total concrete	**= 267.31 m^3**
Total steel (By IS 456)	**= 23113.15 kg**
Total steel (By IS 13920)	**= 26417.40 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 5,88,082=00**
COST OF STEEL (BY IS 456)	**= Rs. 5,31,602=00**
COST OF STEEL (BY IS 13920)	**= Rs 6,07,600=00**
TOTAL COST (BY IS 456)	**= Rs. 11,19,684=00**
TOTAL COST (BY IS 13920)	**= Rs 11,95,682=00**

ZONE IV

Total concrete = 267.31 m^3

Total steel (By IS 456) = 23497.4 kg

Total steel (By IS 13920) = 26870.6 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 5,88,082=00

COST OF STEEL (BY IS 456) = Rs. 5,40,440=00

COST OF STEEL (BY IS 13920) = Rs 6,18,023=00

TOTAL COST (BY IS 456) = Rs. 11,28,522=00

TOTAL COST (BY IS 13920) = Rs 12,06,105=00

ZONE V

Total concrete = 267.31 m^3

Total steel (By IS 456) = 26625.72 kg

Total steel (By IS 13920) = 30022 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 5,88,082=00

COST OF STEEL (BY IS 456) = Rs. 6,12,392=00

COST OF STEEL (BY IS 13920) = Rs 6,90,506=00

TOTAL COST (BY IS 456) = Rs. 12,00,474=00

TOTAL COST (BY IS 13920) = Rs 12,78,588=00

4.6 For Nine Storey:

For gravity load

Total concrete = 376.10 m^3

Total steel (By IS 456) = 32988.1 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 8,27,420=00

COST OF STEEL (BY IS 456) = Rs. 7,58,726=00

TOTAL COST = Rs. 15,86,146=00

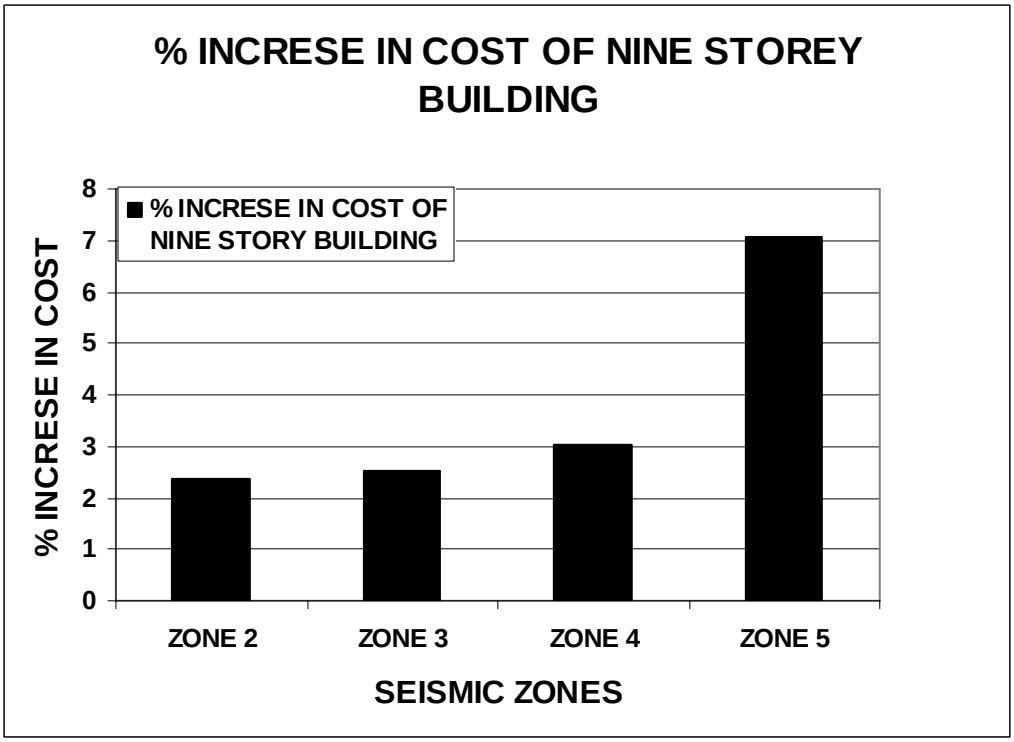

Fig 4.6: % Increase in cost for Nine storey building

For seismic load :

ZONE II

Total concrete = 376.10 m^3

Total steel (By IS 456) = 30573.2 kg

Total steel (By IS 13920) = 34612.2 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 8,27,420=00

COST OF STEEL (BY IS 456) = Rs. 7,03,184=00

COST OF STEEL (BY IS 13920) = Rs 7,96,081=00

TOTAL COST (BY IS 456) = Rs. 15,30,604=00

TOTAL COST (BY IS 13920) = Rs 16,23,501=00

ZONE III

Total concrete = 376.10 m^3

Total steel (By IS 456) = 30680.8 kg

Total steel (By IS 13920) = 34725.9 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 8,27,420=00

COST OF STEEL (BY IS 456) = Rs. 7,05,658=00

COST OF STEEL (BY IS 13920) = Rs 7,98,696=00

TOTAL COST (BY IS 456) = Rs. 15,33,078=00

TOTAL COST (BY IS 13920) = Rs 16,26,116=00

ZONE IV

Total concrete = 376.10 m^3

Total steel (By IS 456) = 31041.73 kg

Total steel (By IS 13920) = 35085.2 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 8,27,420=00

COST OF STEEL (BY IS 456) = Rs. 7,13,960=00

COST OF STEEL (BY IS 13920) = Rs 8,06,960=00

TOTAL COST (BY IS 456) = Rs. 15,41,380=00

TOTAL COST (BY IS 13920) = Rs 16,34,380=00

ZONE V

Total concrete = 376.10 m^3

Total steel (By IS 456) = 33761.24 kg

Total steel (By IS 13920) = 37867.65 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 8,27,420=00

COST OF STEEL (BY IS 456) = Rs. 7,76,508=00

COST OF STEEL (BY IS 13920) = Rs 8,70,956=00

TOTAL COST (BY IS 456) = Rs. 16,03,929=00

TOTAL COST (BY IS 13920) = Rs 16,98,376=00

4.7 For Eleven Storey

For gravity load :

Total concrete = 507.47 m^3

Total steel (By IS 456) = 42180.2 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 11,16,434=00

COST OF STEEL (BY IS 456) = Rs. 9,70,145=00

TOTAL COST = Rs. 20,86,579=00

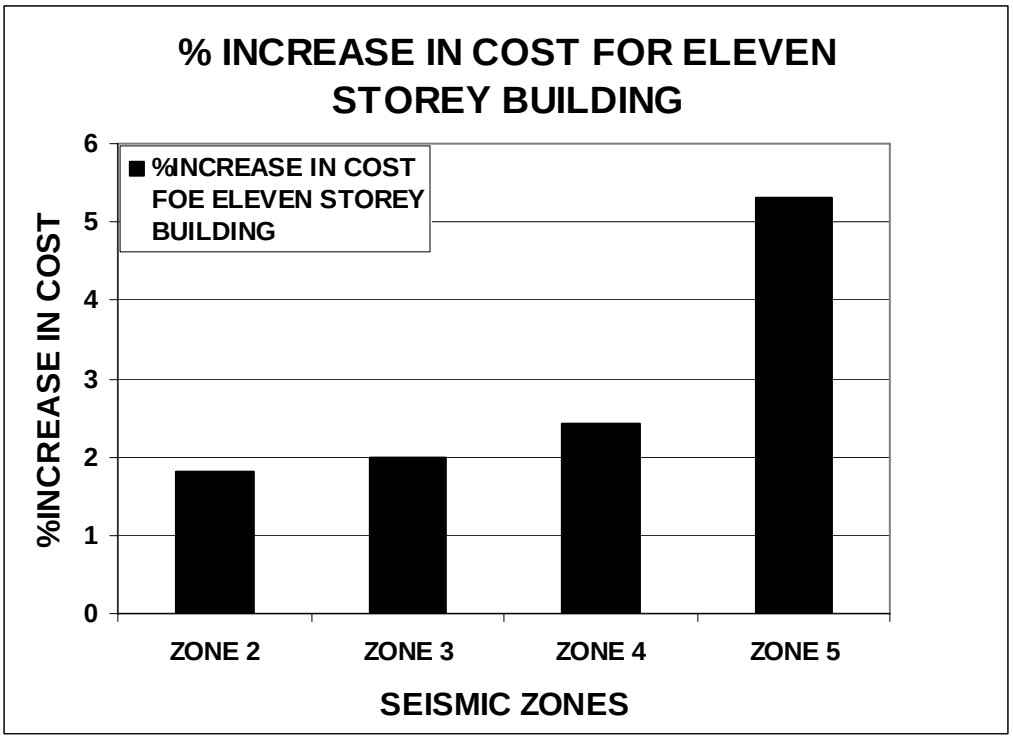

Fig 4.7: % Increase in cost for Eleven storey building

For seismic load :

ZONE II

Total concrete	**= 507.47 m^3**
Total steel (By IS 456)	**= 38742.84 kg**
Total steel (By IS 13920)	**= 43816.42 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 11,16,434=00**
COST OF STEEL (BY IS 456)	**= Rs. 8,91,085=00**
COST OF STEEL (BY IS 13920)	**= Rs 10,07,778=00**
TOTAL COST (BY IS 456)	**= Rs. 18,98,863=00**
TOTAL COST (BY IS 13920)	**= Rs 21,24,212=00**

ZONE III

Total concrete = 507.47 m^3

Total steel (By IS 456) = 38902.43 kg

Total steel (By IS 13920) = 43993.01 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 11,16,434=00

COST OF STEEL (BY IS 456) = Rs. 8,94,756=00

COST OF STEEL (BY IS 13920) = Rs 10,11,839=00

TOTAL COST (BY IS 456) = Rs. 20,11,190=00

TOTAL COST (BY IS 13920) = Rs 21,28,273=00

ZONE IV

Total concrete = 507.47 m^3

Total steel (By IS 456) = 39306.41 kg

Total steel (By IS 13920) = 44388.63 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 11,16,434=00

COST OF STEEL (BY IS 456) = Rs. 9,04,047=00

COST OF STEEL (BY IS 13920) = Rs 10,20,938=00

TOTAL COST (BY IS 456) = Rs. 20,20,481=00

TOTAL COST (BY IS 13920) = Rs 21,37,372=00

ZONE V

Total concrete = 507.47 m^3

Total steel (By IS 456) = 41842.76 kg

Total steel (By IS 13920) = 47001.25 kg

Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**
COST OF CONCRETE	**= Rs. 11,16,434=00**
COST OF STEEL (BY IS 456)	**= Rs. 9,62,383=00**
COST OF STEEL (BY IS 13920)	**= Rs 10,81,029=00**
TOTAL COST (BY IS 456)	**= Rs. 20,78,817=00**
TOTAL COST (BY IS 13920)	**= Rs 21,97,463=00**

4.8 For Thirteen Storey :

For gravity load:

Total concrete	**= 664.38 m^3**
Total steel (By IS 456)	**= 52383.5 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**
COST OF CONCRETE	**= Rs. 14,61,636=00**
COST OF STEEL (BY IS 456)	**= Rs. 12,04,820=00**
TOTAL COST	**= Rs. 26,66,456=00**

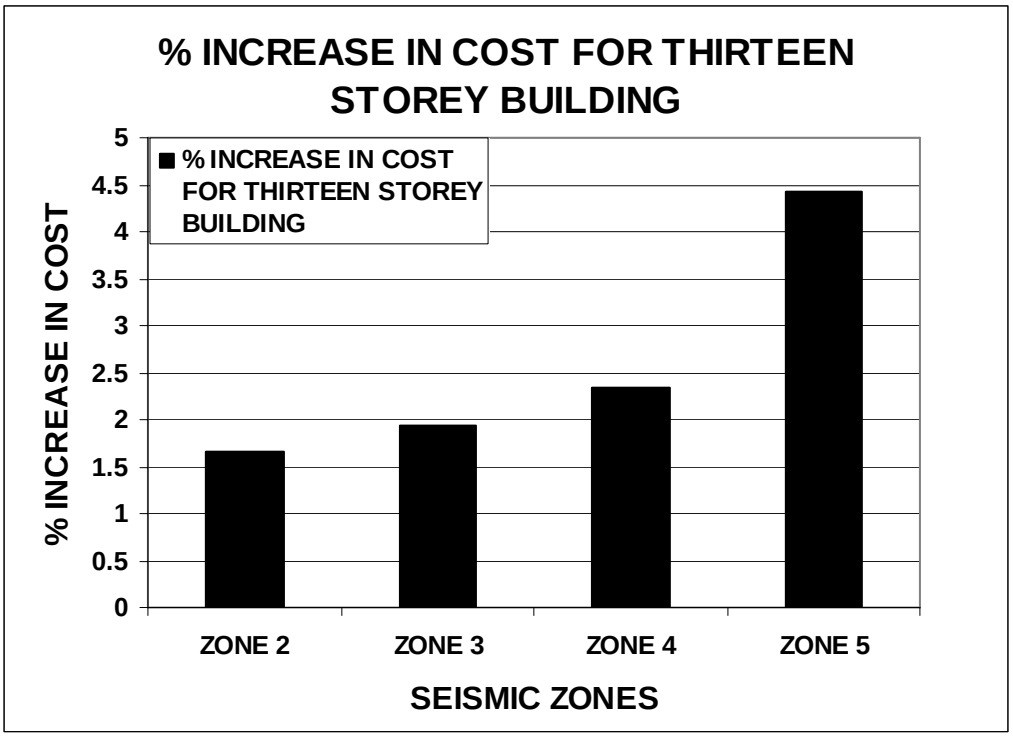

Fig 4.8: % Increase in cost for Thirteen storey building

For seismic load:

ZONE II

Total concrete	**= 664.38 m^3**
Total steel (By IS 456)	**= 47557.7 kg**
Total steel (By IS 13920)	**= 54312.3 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 14,61,636=00**
COST OF STEEL (BY IS 456)	**= Rs. 10,93,827=00**
COST OF STEEL (BY IS 13920)	**= Rs 12,49,183=00**
TOTAL COST (BY IS 456)	**= Rs. 25,55,463=00**
TOTAL COST (BY IS 13920)	**= Rs 27,10,819=00**

ZONE III

Total concrete = 664.38 m^3

Total steel (By IS 456) = 47851.42 kg

Total steel (By IS 13920) = 54627.2 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 14,61,636=00

COST OF STEEL (BY IS 456) = Rs. 11,00,583=00

COST OF STEEL (BY IS 13920) = Rs 12,56,426=00

TOTAL COST (BY IS 456) = Rs. 25,62,219=00

TOTAL COST (BY IS 13920) = Rs 27,18,062=00

ZONE IV

Total concrete = 664.38 m^3

Total steel (By IS 456) = 48288.81 kg

Total steel (By IS 13920) = 55096.06 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 14,61,636=00

COST OF STEEL (BY IS 456) = Rs. 11,10,643=00

COST OF STEEL (BY IS 13920) = Rs 12,67,209=00

TOTAL COST (BY IS 456) = Rs. 25,72,279=00

TOTAL COST (BY IS 13920) = Rs 27,28,845=00

ZONE V

Total concrete = 664.38 m^3

Total steel (By IS 456) = 50656.12 kg

Total steel (By IS 13920) = 57504.86 kg

Cost of Concrete Per m^3 = Rs.2200/ m^3

Cost of Steel Per Kg = Rs.23/kg

COST OF CONCRETE = Rs. 14,61,636=00

COST OF STEEL (BY IS 456) = Rs. 11,65,091=00

COST OF STEEL (BY IS 13920) = Rs 13,22,612=00

TOTAL COST (BY IS 456) = Rs. 26,26,727=00

TOTAL COST (BY IS 13920) = Rs 27,84,248=00

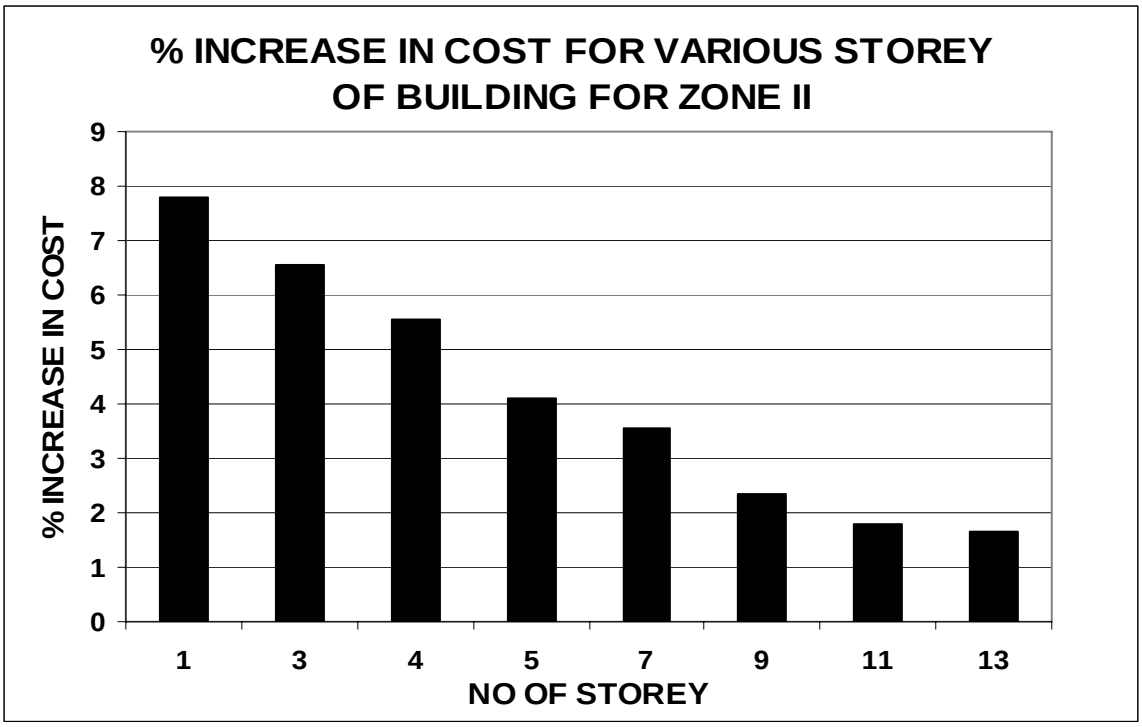

Fig 4.9: % Increase in cost for various storey of building for Zone II

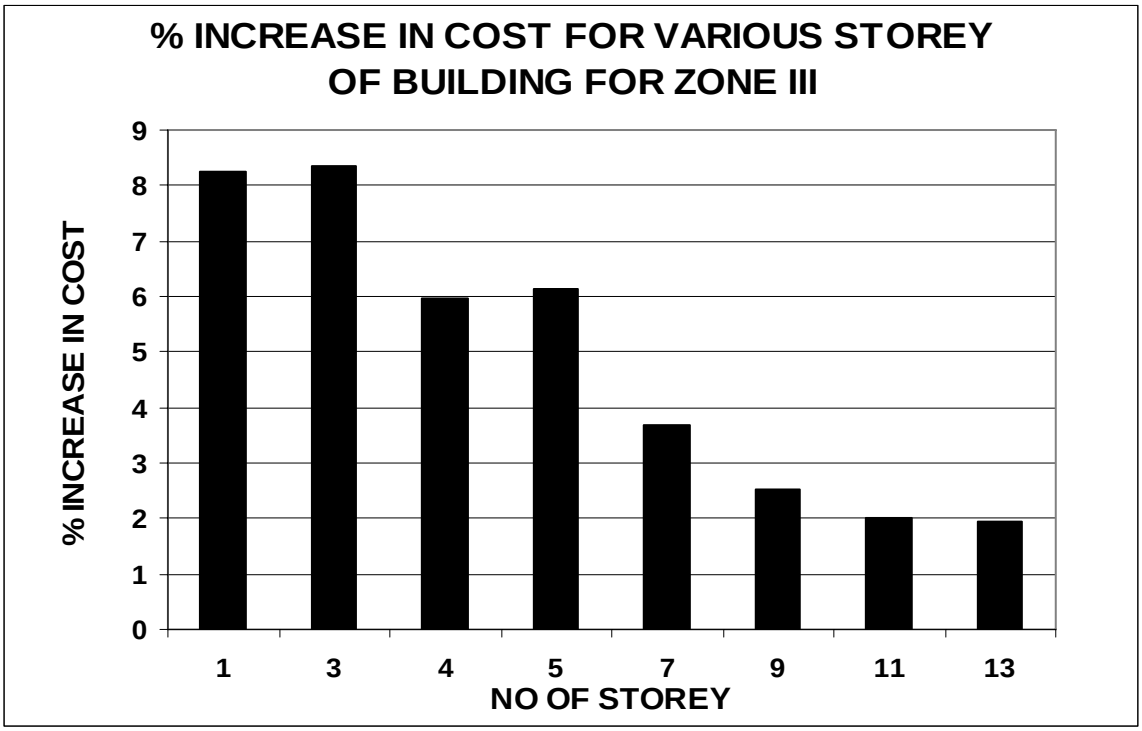

Fig 4.10: % Increase in cost for various storey of building for Zone III

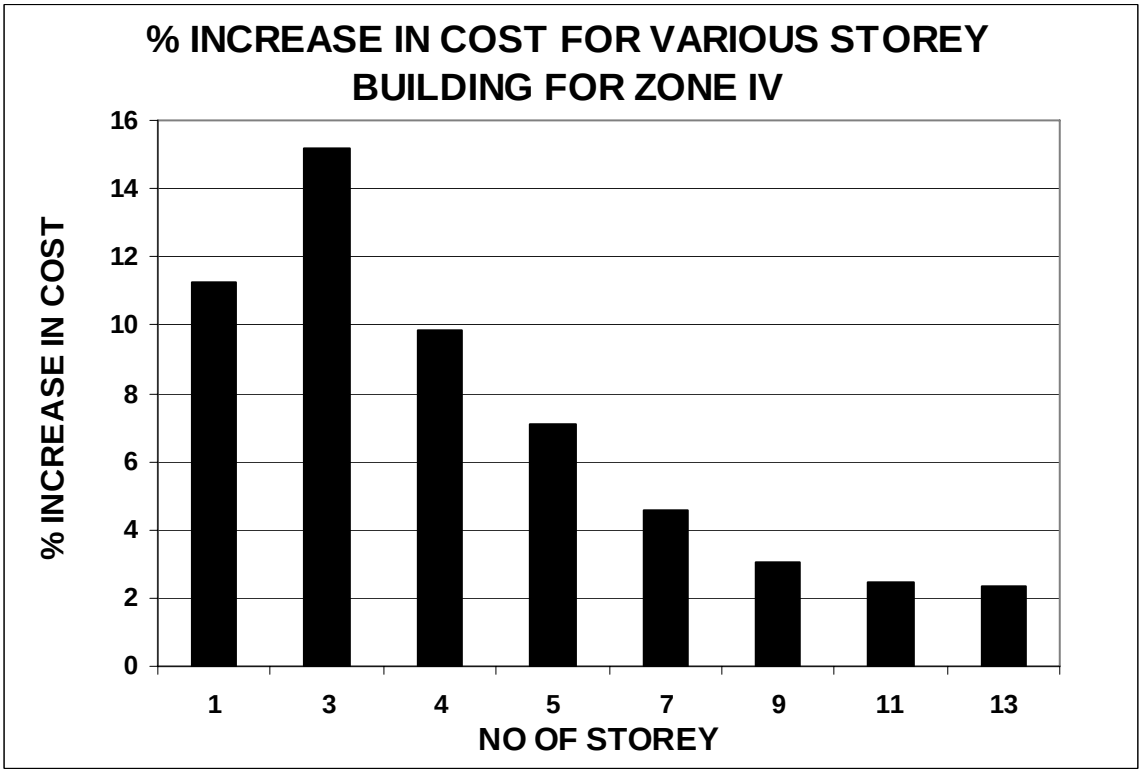

Fig 4.11: % Increase in cost for various storey of building for Zone IV

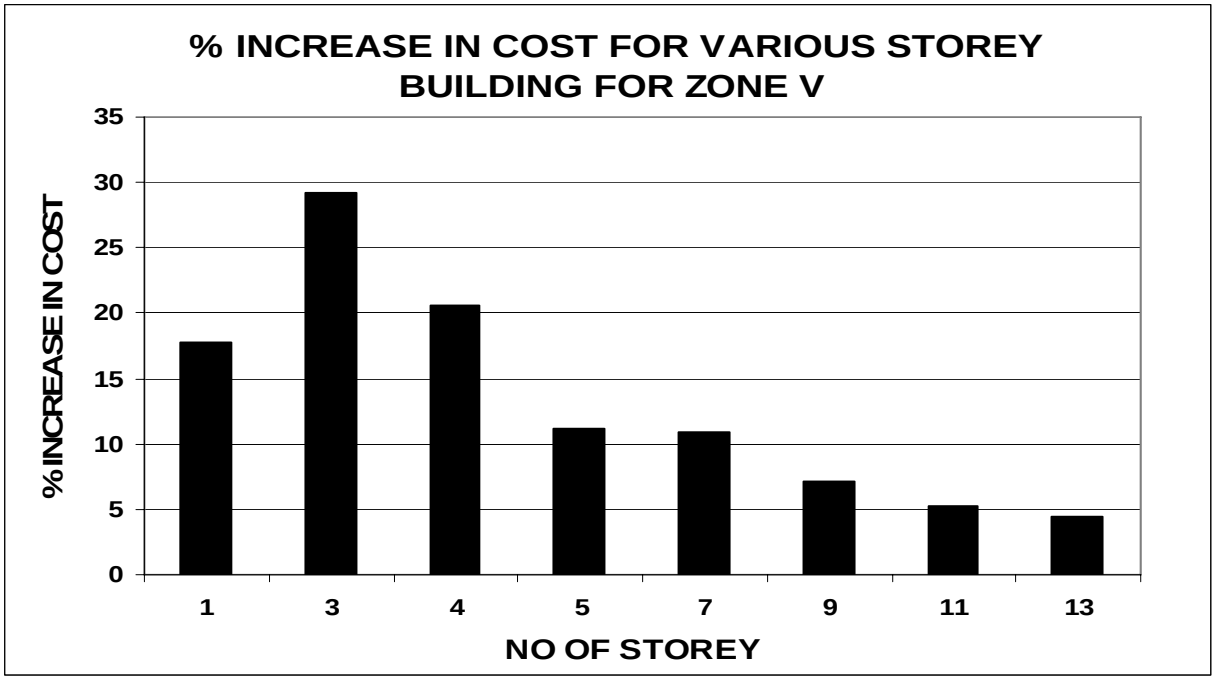

Fig 4.12: % Increase in cost for various storey of building for Zone V

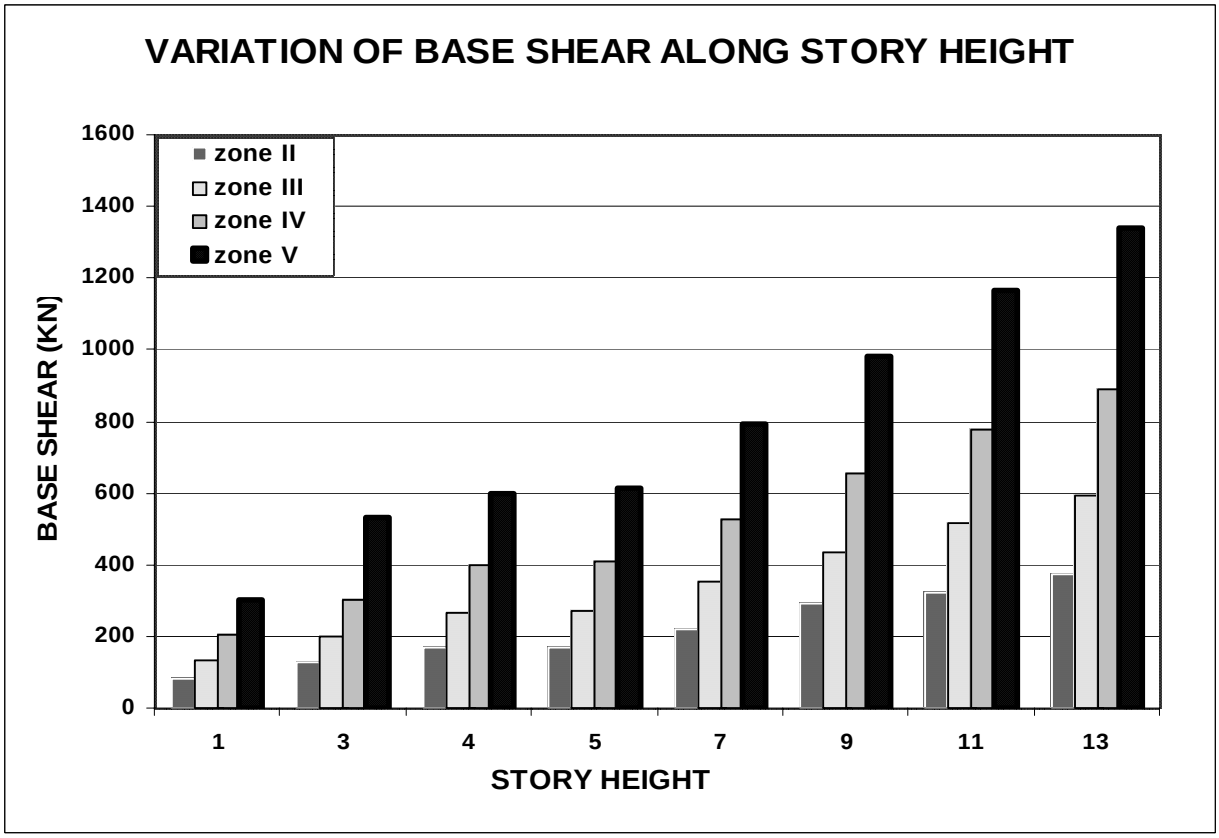

Fig 4.13: Increase in Base Shear for different storey height of buildings.

Chapter:5

Typical Field Example of School Building(Ref. 7)

5.1 Building-1 :

For gravity load :

Total concrete	=	**379.38 m^3**
Total steel (By IS 456)	=	**18786.7 kg**
Cost of Concrete Per m^3	=	**Rs.2200/ m^3**
Cost of Steel Per Kg	=	**Rs.23/kg**

COST OF CONCRETE	=	**Rs. 8,34,636=00**
COST OF STEEL (BY IS 456)	=	**Rs. 4,32,094=00**
TOTAL COST	=	**Rs. 12,66,730=00**

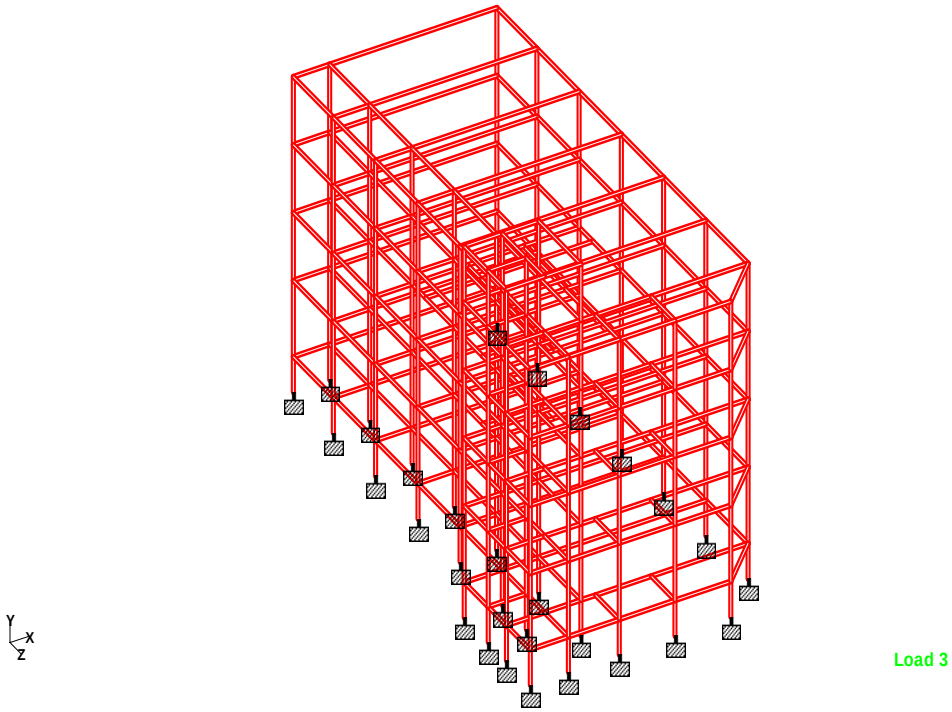

Fig 5.1: BUILDING-1

For seismic load :

ZONE IV

Total concrete	**= 379.38 m^3**
Total steel (By IS 456)	**= 29788.62 kg**
Total steel (By IS 13920)	**= 34113.62 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 8,34,636=00**
COST OF STEEL (BY IS 456)	**= Rs. 6,85,138=00**
COST OF STEEL (BY IS 13920)	**= Rs 7,84,603=00**
TOTAL COST (BY IS 456)	**= Rs. 15,19,774=00**
TOTAL COST (BY IS 13920)	**= Rs 16,19,239=00**

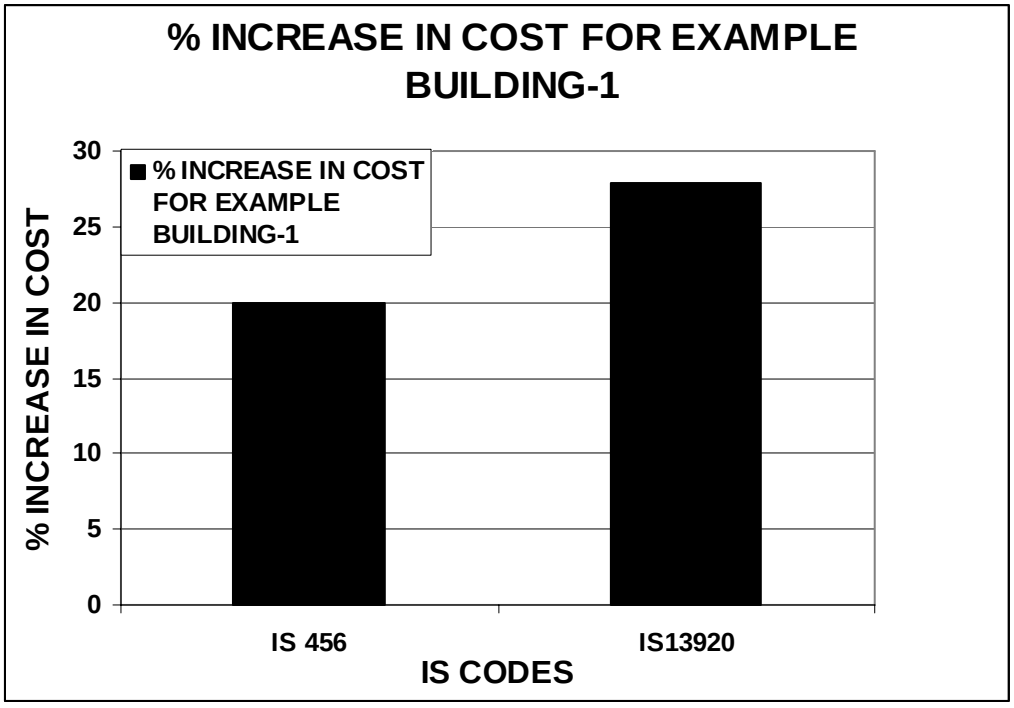

Fig 5.2: % Increase in cost for example building-1

5.2 Building-2 :

For gravity load :

Total concrete	=	**402.23 m^3**
Total steel (By IS 456)	=	**20992.35 kg**
Cost of Concrete Per m^3	=	**Rs.2200/ m^3**
Cost of Steel Per Kg	=	**Rs.23/kg**

COST OF CONCRETE	=	**Rs. 8,84,906=00**
COST OF STEEL (BY IS 456)	=	**Rs. 4,82,824=00**
TOTAL COST	=	**Rs. 13,67,730=00**

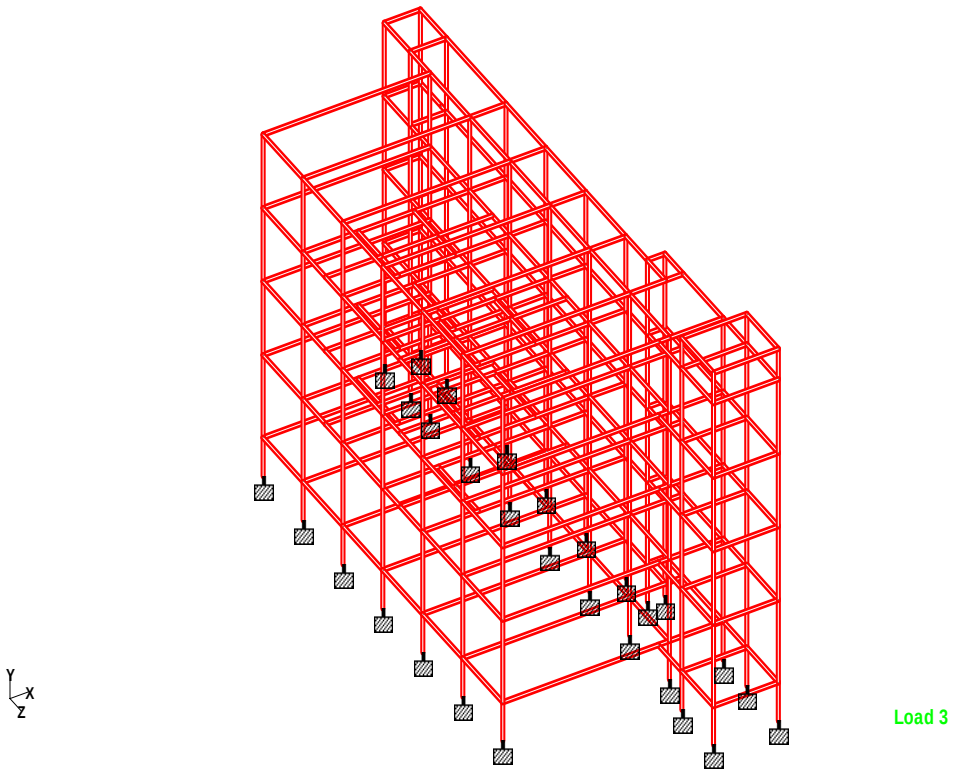

Fig 5.3: BUILDING-2

For seismic load :

ZONE IV

Total concrete	**= 402.23 m^3**
Total steel (By IS 456)	**= 30301.9 kg**
Total steel (By IS 13920)	**= 35286.3 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 8,84,906=00**
COST OF STEEL (BY IS 456)	**= Rs. 6,96,944=00**
COST OF STEEL (BY IS 13920)	**= Rs 8,11,585=00**
TOTAL COST (BY IS 456)	**= Rs. 15,81,850=00**
TOTAL COST (BY IS 13920)	**= Rs 16,96,491=00**

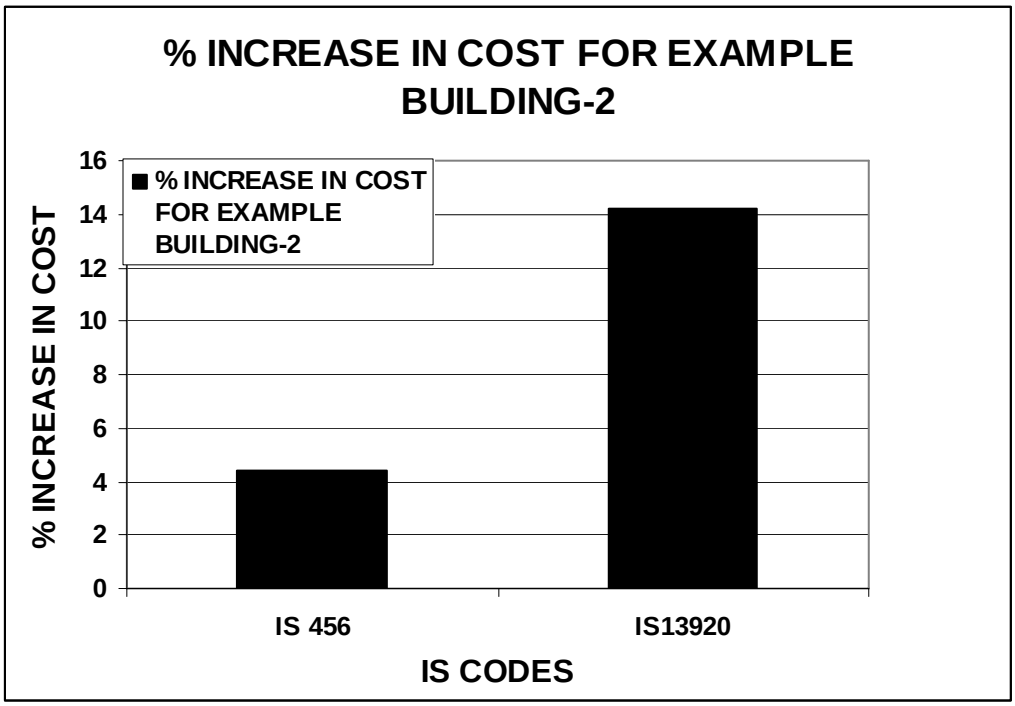

Fig 5.4: % Increase in cost for example building-2

5.3 Building-3:

For gravity load :-

Total concrete	=	**355.03 m^3**
Total steel (By IS 456)	=	**16539.75 kg**
Cost of Concrete Per m^3	=	**Rs.2200/ m^3**
Cost of Steel Per Kg	=	**Rs.23/kg**

COST OF CONCRETE	=	**Rs. 7,81,066=00**
COST OF STEEL (BY IS 456)	=	**Rs. 3,80,415=00**
TOTAL COST	=	**Rs. 11,61,481=00**

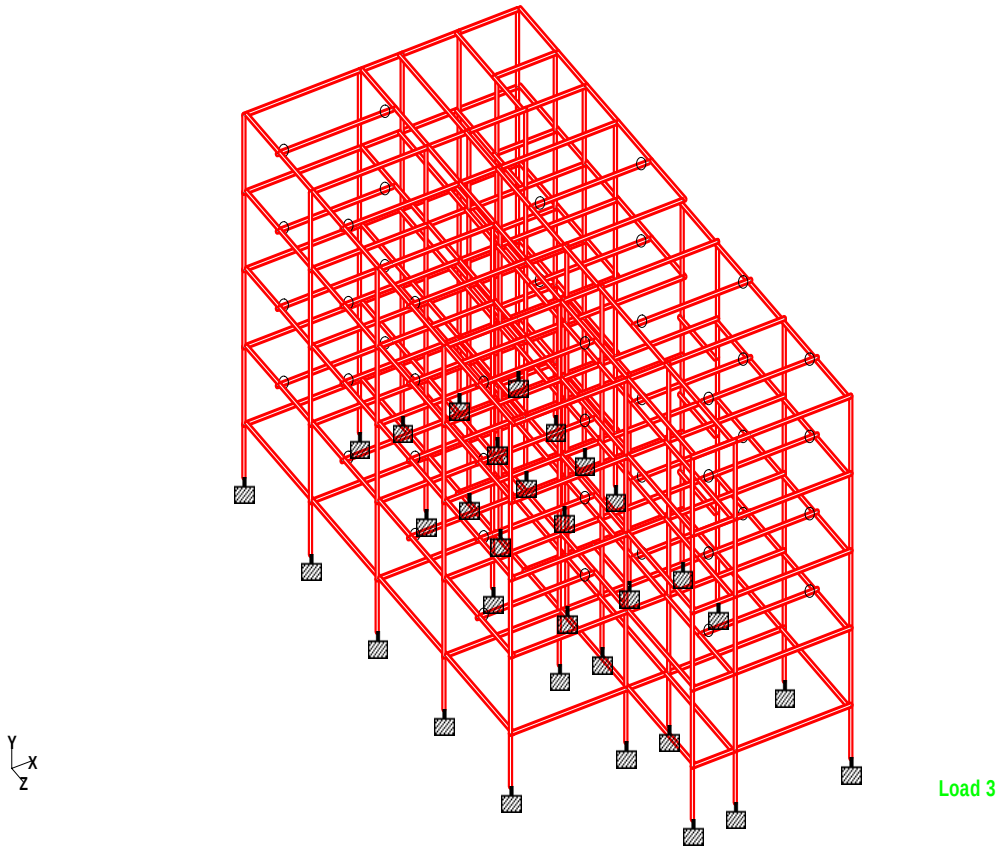

Fig 5.5: BUILDING-3

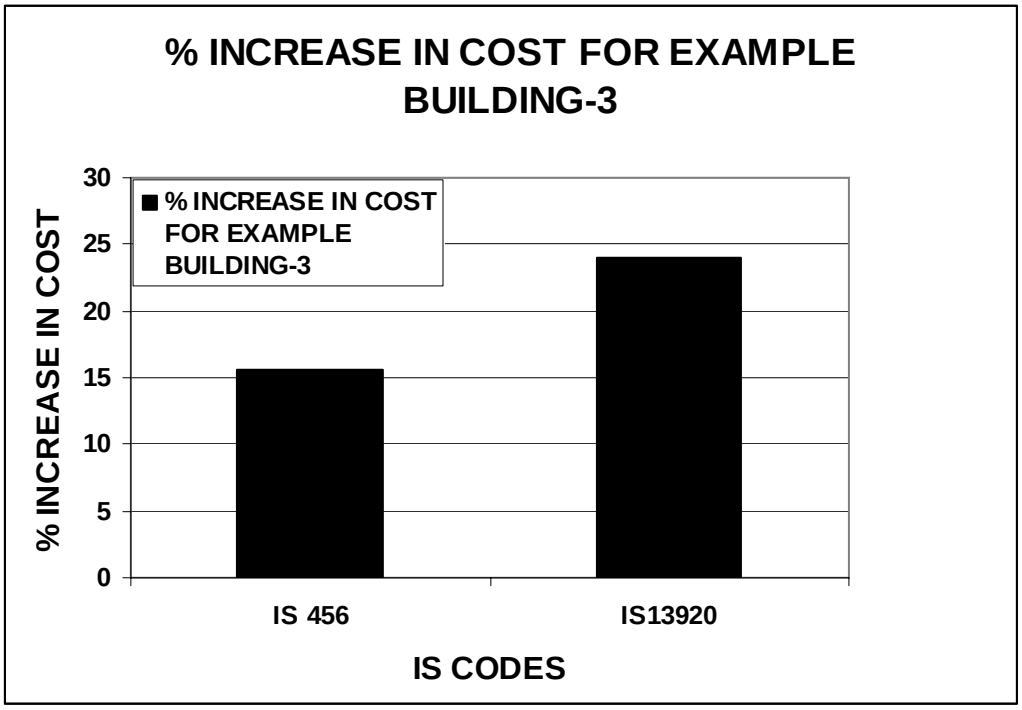

Fig 5.6: % Increase in cost for example building-3

<u>For seismic load</u> :

<u>ZONE IV</u> :

Total concrete	**= 355.03 m^3**
Total steel (By IS 456)	**= 18773 kg**
Total steel (By IS 13920)	**= 23704 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 7,81,066=00**
COST OF STEEL (BY IS 456)	**= Rs. 4,31,779=00**
COST OF STEEL (BY IS 13920)	**= Rs 5,45,192=00**
TOTAL COST (BY IS 456)	**= Rs. 12,12,845=00**
TOTAL COST (BY IS 13920)	**= Rs 13,26,258=00**

5.4 Building-4:

For gravity load :

Total concrete	**=**	**359.97 m^3**
Total steel (By IS 456)	**=**	**19514.1 kg**
Cost of Concrete Per m^3	**=**	**Rs.2200/ m^3**
Cost of Steel Per Kg	**=**	**Rs.23/kg**
COST OF CONCRETE	**=**	**Rs. 7,91,934=00**
COST OF STEEL (BY IS 456)	**=**	**Rs. 4,48,825=00**
TOTAL COST	**=**	**Rs. 12,40,759=00**

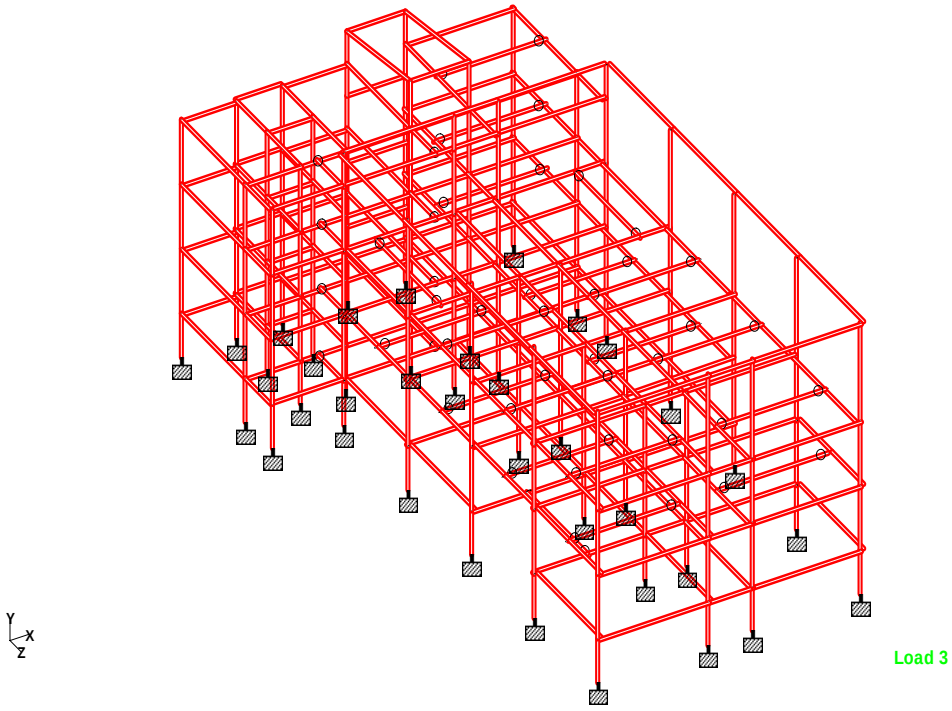

Fig 5.7: BUILDING-4

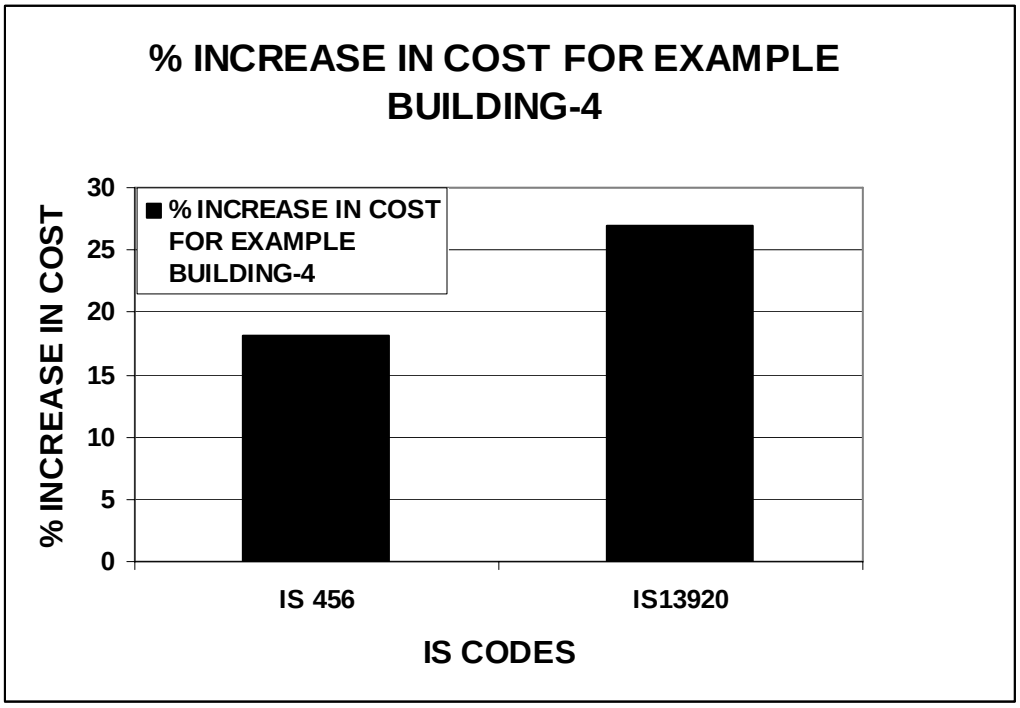

Fig 5.8: % Increase in cost for example building-4

<u>For seismic load</u> :

<u>ZONE IV</u>

Total concrete	**= 359.97 m^3**
Total steel (By IS 456)	**= 29317.54 kg**
Total steel (By IS 13920)	**= 34067.36 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 7,91,934=00**
COST OF STEEL (BY IS 456)	**= Rs. 6,74,304=00**
COST OF STEEL (BY IS 13920)	**= Rs 7,83,550=00**
TOTAL COST (BY IS 456)	**= Rs. 14,66,238=00**
TOTAL COST (BY IS 13920)	**= Rs 15,75,484=00**

5.5 Building-5:

For gravity load :

Total concrete	**= 148.31 m^3**
Total steel (By IS 456)	**= 8130.65 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**

COST OF CONCRETE	**= Rs. 3,26,282=00**
COST OF STEEL (BY IS 456)	**= Rs. 1,87,005=00**
TOTAL COST	**= Rs. 5,13,287=00**

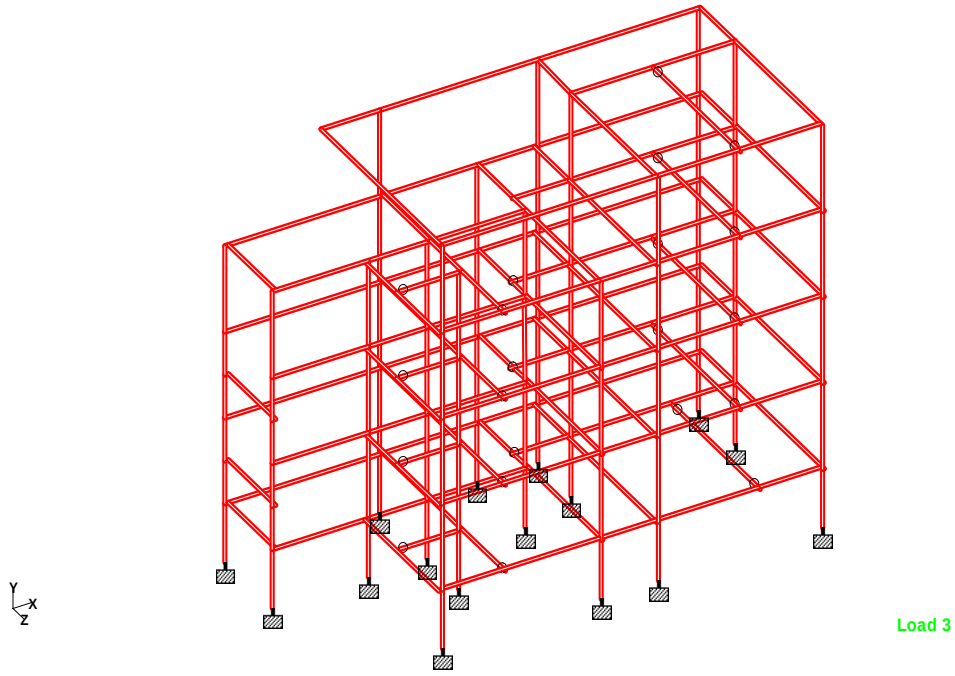

Fig 5.9: BUILDING-5

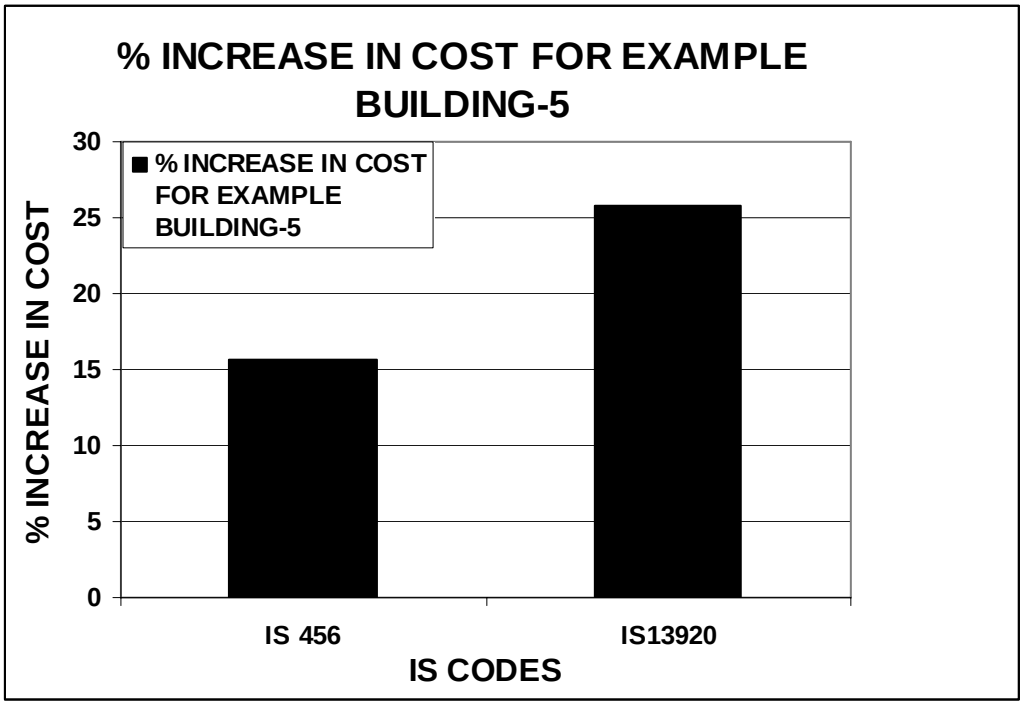

Fig 5.10: % Increase in cost for example building-5

<u>For seismic load</u> :

<u>ZONE IV</u>

Total concrete	**= 148.31 m^3**
Total steel (By IS 456)	**= 11636.8 kg**
Total steel (By IS 13920)	**= 13896.42 kg**
Cost of Concrete Per m^3	**= Rs.2200/ m^3**
Cost of Steel Per Kg	**= Rs.23/kg**
COST OF CONCRETE	**= Rs. 3,26,282=00**
COST OF STEEL (BY IS 456)	**= Rs. 6,74,304=00**
COST OF STEEL (BY IS 13920)	**= Rs 2,67,646=00**
TOTAL COST (BY IS 456)	**= Rs. 5,93,928=00**
TOTAL COST (BY IS 13920)	**= Rs 6,45,900=00**

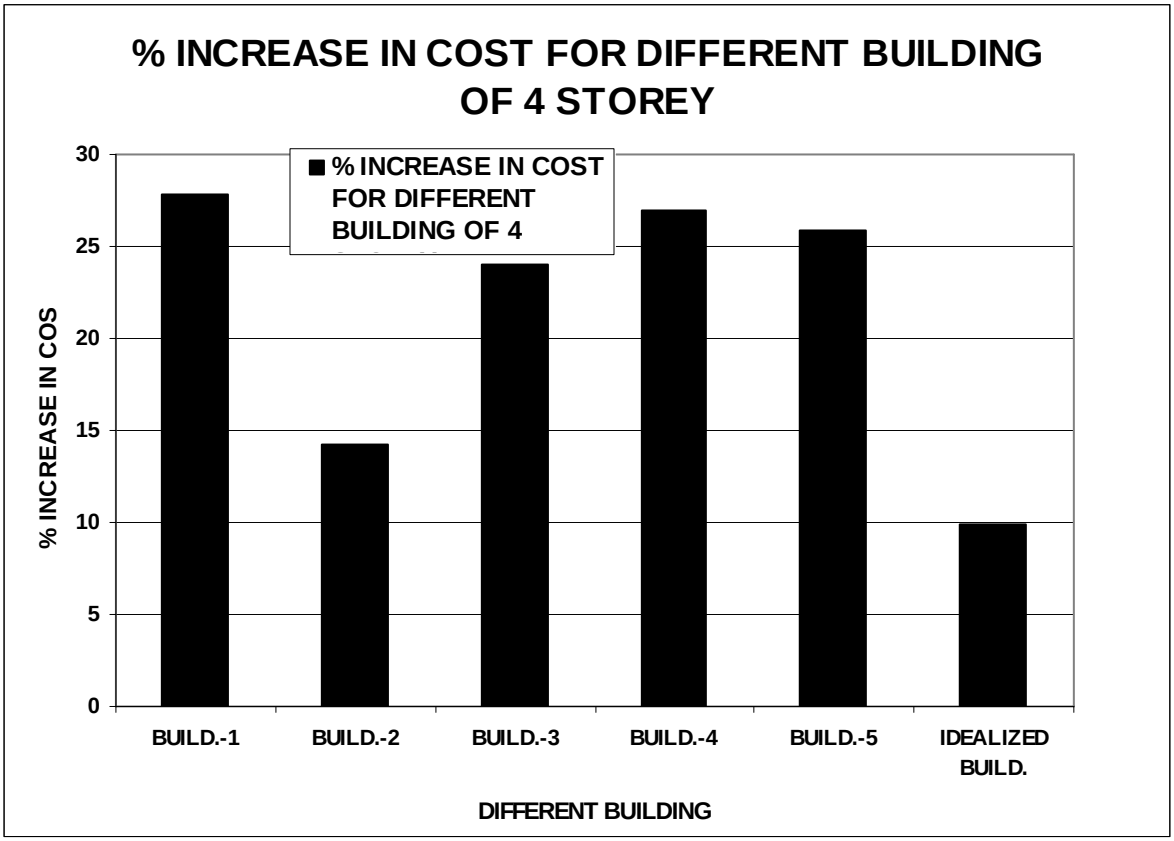

Fig 5.11: % Increase in cost for different building of 4 storey

Chapter:6
Results &Discussion

From fig 4.1 it is clear that as the seismic zone increases the value of % increase in cost increases. Fig 4.1 also shows that as value of seismic zone changes from zone II to zone IV, % increase in cost is gradual from zone II to zone IV while it becomes steep from zone IV to zone V. For one storey building the value of percentage increase in cost from zone II to zone V is varies between 7 to 17%. The three storey building also shows similar trend as that of one storey and variation in percentage increase in cost from zone II to zone V is approximately in between 6 to 30%.Four storey is similar one as one and three storey and variation in percentage increase in cost from zone II to zone V is in the range of 5 to 20%.Percentage increase in cost for five storey building is less in comparison to the building mentioned above and it ranges between 4 to 11% from zone II to zone V respectively.

From three storey it can be said that as the number of zone increases the percentage increase in cost increases gradually. Therefore similarly for seven storey building percentage increase in cost ranges between 3 to 10% as zone changes from II to V respectively. For nine storey the value of percentage increase in cost is further reduced and it ranges between 2 to 7%.Similarly for eleven storey and thirteen storey the value of percentage increase in cost 1 to 5% and 1 to 4% respectively. Finally it can be said that as the no of storey increases the percentage increase in cost is reduced gradually.

The value of maximum % increase in cost for zone II comes for one storey building, and it is approximately 8%. Similarly the value of maximum % increase in cost for zone III falls under three storey building, and it is around 8.4%. It is clear from fig 4.2 that value of maximum % increase in cost for zone IV comes for three storey building and it comes approximately 15%. Similarly for zone V it also comes for three storey building and it is approximately 30%.

From fig 4.9 to 4.12 it is clear that as the no of storey increases the percentage increase in cost decreases significantly. From fig 4.9 & 4.10 it is clear that as the no of storey increases the % increase in cost decreases almost gradually, while in fig 4.11 & 4.12 it is found that decreasing trend of % increase in cost is not similar as that of like fig 4.9 & 4.10. In fig 4.11 & 4.12 first of all upto three storey building there is increase in % increase of cost while afterwards there is gradual decrease in % increase in cost. Therefore it may be said that some critical point is there in terms of no of storey below which there is gradual decrease and beyond which there is first increase and then decrease.

In vertical variation, i.e. storey wise for a particular zone it can be said that for zone II percentage increase in cost varies between 7.8% to 1.67% for one storey building to thirteen storey building respectively. Similar pattern has also be seen for zone III except that for one storey building and three storey building percentage increase in cost is same around afterwards it is gradually reduced to 1.9 % for thirteen storey building. Therefore it can be said that as the storey height increases the value of percentage increase in cost reduces gradually. Now somewhat different pattern has been shown in fig 4.11& 4.12. In these figures, it has been observed that percentage increase in cost first increases upto three storey building and then afterwards decreases to thirteen storey building. The percentage increase in cost for zone IV from one storey building to three storey building is about 11 to 15 % respectively and then afterwards it decreases to around 2% for thirteen storey building.

From fig 5.2 it is clear that % increase in cost with IS 456 for example building-1 is around 20%. Similarly from fig 5.4, 5.6, 5.8, 5.10 it is clear that % increase in cost with IS 456 for example building-2,3,4,5 5%,16%,18% &16% respectively. Therefore it can be said that except example building-2 all others buildings have % increase in cost to be around 15 to 20%. This difference in cost even under uniform conditions shows that some other parameters like irregularity etc., also plays an important role which was not considered here.

In the study percentage increase in cost coming is more than A.K.Mittal`s paper. It may be due to two reasons one is the importance factor chosen in the study is 1.5 and other one is wind load is not consider in the study.

Chapter :7
Conclusion

1. Percentage increase in cost for one storey building with ductile detailing in zone II, III, IV and zone V are 7.8%, 8.25%, 11.23%, 17.8% respectively.
2. Percentage increase in cost for three storey building with ductile detailing in zone II, III, IV and zone V are 6.57%, 8.37%, 15.16%, 24.26% respectively.
3. Percentage increase in cost for four storey building with ductile detailing in zone II, III, IV and zone V are 5.54%, 5.98%, 9.87%, 20.57% respectively.
4. Percentage increase in cost for five storey building with ductile detailing in zone II, III, IV and zone V are 4.1%, 6.13%, 7.11%, 11.13% respectively.
5. Percentage increase in cost for seven storey building with ductile detailing in zone II, III, IV and zone V are 3.55%, 3.67%, 4.57%, 10.86% respectively.
6. Percentage increase in cost for nine storey building with ductile detailing in zone II, III, IV and zone V are 2.36%, 2.52%, 3.04%, 7.07% respectively.
7. Percentage increase in cost for eleven storey building with ductile detailing in zone II, III, IV and zone V are 1.80%, 2.00%, 2.43%, 5.31% respectively.
8. Percentage increase in cost for thirteen storey building with ductile detailing in zone II, III, IV and zone V are 1.66%, 1.93%, 2.33%, 4.42% respectively.
9. In vertical height wise variation for different storey height in zone II percentage increase in cost ranges between 1.66% to 7.8%.
10. In vertical height wise variation for different storey height in zone III percentage increase in cost ranges between 1.93% to 8.37%.
11. In vertical height wise variation for different storey height in zone IV percentage increase in cost ranges between 2.33% to 15.16%.
12. In vertical height wise variation for different storey height in zone V percentage increase in cost ranges between 4.42% to 24.26%.
13. In example building-1 of four storey percentage increase in cost in zone IV for earthquake and ductile detailing are 19.87% and 27.83% respectively.
14. In example building-2 of four storey percentage increase in cost in zone IV for earthquake and ductile detailing are 4.42% and 14.19% respectively.

15. In example building-3 of four storey percentage increase in cost in zone IV for earthquake and ductile detailing are 18.20% and 27.00% respectively.
16. In example building-4 of four storey percentage increase in cost in zone IV for earthquake and ductile detailing are 15.65% and 24.04% respectively.
17. In example building-5 of four storey percentage increase in cost in zone IV for earthquake and ductile detailing are 15.71% and 25.84% respectively.
18. From above conclusions it can be said that variation of percentage increase in cost for non ductile detailing in zone IV varies between 4.42% to19.97%.
19. From above conclusions it can be said that variation of percentage increase in cost for ductile detailing in zone IV varies between 14.19% to27.83%.
20. It was observed that as the number of seismic zone increases the cost of concrete and steel in a building increases.
21. It has been seen that for same zone and height of building, cost is more with IS: 13920 as compared to that with IS: 456 and it is mainly contributed by an increase in quantity of steel.
22. For different heights of building, change in total cost of concrete and steel from one zone to other is different, and the variation is not similar for all the zones. It seems that some other particulars also effect the cost variations. Identification of those factors may be in the scope of future work.
23. Increase in cost of concrete and steel in example buildings has been found to be different. Some other factors, such as regularity of building ,distribution and magnitude of imposed loads etc., may be responsible for it. The trend may be further explored in a future study.
24. For same storey in school buildings and commercial buildings; increase in cost is different. So it can be concluded that occupancy, type of building (commercial, educational as taken in this study) also affect the cost.

Chapter :8
Scope Of Future Work

1. Increase in cost of concrete and steel in example buildings has been found to be different. Some other factors, such as regularity of building ,distribution and magnitude of imposed loads etc, may be responsible for it. The trend may be further explored in a future study.

2. For different heights of building, change in total cost of concrete and steel from one zone to other is different, and the variation is not similar for all the zones. It seems that some other particulars also effect the cost variations. Identification of those factors may be in the scope of future work.

3. In the study wind load has not been consider it can be consider in future work.

References

1. Estimating and costing in civil engineering, Theory and practice Including specification and valuation, Twenty fifth revised edition by Prof B.N.Dutta.
2. Delhi Schedule Rates.2002.
3. I.S. Codes
   (a) IS :1893 2002 Criteria for Earthquake Resistant design of Structures (Fourth Revision).
   (b) IS :13920 – 1993 Ductile Detailing of Reinforced concrete structure subjected to seismic forces- Code of Practice.
   (c) IS :456-2002 Plane and reinforced concrete- Code of Practice (Fourth Revision).
4. Dr.A.K.Mittal, K.K.Pardhan " Additional Cost For Earthquake Resistant Design " Journal of Indian Building Congress ,Volume VIII,No 1 ,2001.
5. Paramjit Singh Dang ,Dr.V.Thiruvengadam. "Elemental Costing : A Rationalized Cost Estimation Approach For Buildings" Journal of Indian Building Congress ,Volume XIII, No 1, 2006.
6. Achal Kr..Mittal, "Seismic Damage Scenario of a Vulnerable City Engineering Approach" Journal of Indian Building Congress ,Volume VIII ,No 1 ,2001.
7. STAAD INPUT FILE OF FIVE SCHOOL BUILDINGS taken from SWATI CONSULTANT Rohini Delhi.
8. STAAD Pro 2004 Manual
9. Some websites
   (i) www. pubs.asce.org
   (ii) www.sciencedirect.com
   (iii)www.google.com
   (iv) www.yahoo.com

ANNEXURE- STADD Pro 2004 Input File of Three storey

STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 21-Apr-05
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 6.6 0 0; 3 9.05 0 0; 4 15.65 0 0; 5 0 0 6.6; 6 6.6 0 6.6;
7 9.05 0 6.6; 8 15.65 0 6.6; 9 9.05 0 9.7; 10 15.65 0 9.7; 11 0 0 13.2;
12 6.6 0 13.2; 13 9.05 0 16.3; 14 15.65 0 16.3; 15 9.05 0 19.8;
16 15.65 0 19.8; 17 0 0 19.8; 18 6.6 0 19.8; 19 9.05 0 26.4; 20 15.65 0 26.4;
21 0 0 26.4; 22 6.6 0 26.4; 26 0 2.25 0; 27 6.6 2.25 0; 28 9.05 2.25 0;
29 15.65 2.25 0; 30 0 2.25 6.6; 31 6.6 2.25 6.6; 32 9.05 2.25 6.6;
33 15.65 2.25 6.6; 34 9.05 2.25 9.7; 35 12.65 2.25 9.775; 36 0 2.25 13.2;
37 6.6 2.25 13.2; 38 15.65 2.25 9.7; 39 9.05 2.25 16.3; 40 12.65 2.25 16.225;
41 15.65 2.25 16.3; 42 9.05 2.25 19.8; 43 15.65 2.25 19.8; 44 0 2.25 19.8;
45 6.6 2.25 19.8; 46 0 2.25 26.4; 47 6.6 2.25 26.4; 48 9.05 2.25 26.4;
49 15.65 2.25 26.4; 53 12.65 0 9.775; 54 12.65 0 16.225; 55 6.6 2.25 9.7;
56 6.6 2.25 16.3; 57 12.305 0 0; 58 12.305 0 3.74; 59 12.305 0 6.6;
60 15.65 0 3.74; 61 12.305 2.25 0; 62 12.305 2.25 3.74; 63 12.305 2.25 6.6;
64 15.65 2.25 3.74; 65 0 5.55 0; 66 6.6 5.55 0; 67 9.05 5.55 0;
68 15.65 5.55 0; 69 0 5.55 6.6; 70 6.6 5.55 6.6; 71 9.05 5.55 6.6;
72 15.65 5.55 6.6; 73 9.05 5.55 9.7; 74 12.65 5.55 9.775; 75 0 5.55 13.2;
76 6.6 5.55 13.2; 77 15.65 5.55 9.7; 78 9.05 5.55 16.3; 79 12.65 5.55 16.225;
80 15.65 5.55 16.3; 81 9.05 5.55 19.8; 82 15.65 5.55 19.8; 83 0 5.55 19.8;
84 6.6 5.55 19.8; 85 0 5.55 26.4; 86 6.6 5.55 26.4; 87 9.05 5.55 26.4;
88 15.65 5.55 26.4; 92 6.6 5.55 9.7; 93 6.6 5.55 16.3; 94 12.305 5.55 0;
95 12.305 5.55 3.74; 96 12.305 5.55 6.6; 97 15.65 5.55 3.74; 98 0 8.85 0;
99 6.6 8.85 0; 100 9.05 8.85 0; 101 15.65 8.85 0; 102 0 8.85 6.6;
103 6.6 8.85 6.6; 104 9.05 8.85 6.6; 105 15.65 8.85 6.6; 106 9.05 8.85 9.7;
107 12.65 8.85 9.775; 108 0 8.85 13.2; 109 6.6 8.85 13.2; 110 15.65 8.85 9.7;
111 9.05 8.85 16.3; 112 12.65 8.85 16.225; 113 15.65 8.85 16.3;
114 9.05 8.85 19.8; 115 15.65 8.85 19.8; 116 0 8.85 19.8; 117 6.6 8.85 19.8;
118 0 8.85 26.4; 119 6.6 8.85 26.4; 120 9.05 8.85 26.4; 121 15.65 8.85 26.4;
125 6.6 8.85 9.7; 126 6.6 8.85 16.3; 127 12.305 8.85 0; 128 12.305 8.85 3.74;
129 12.305 8.85 6.6; 130 15.65 8.85 3.74; 131 0 12.15 0; 132 6.6 12.15 0;
133 9.05 12.15 0; 134 15.65 12.15 0; 135 0 12.15 6.6; 136 6.6 12.15 6.6;
137 9.05 12.15 6.6; 138 15.65 12.15 6.6; 139 9.05 12.15 9.7;
140 12.65 12.15 9.775; 141 0 12.15 13.2; 142 6.6 12.15 13.2;
143 15.65 12.15 9.7; 144 9.05 12.15 16.3; 145 12.65 12.15 16.225;
146 15.65 12.15 16.3; 147 9.05 12.15 19.8; 148 15.65 12.15 19.8;
149 0 12.15 19.8; 150 6.6 12.15 19.8; 151 0 12.15 26.4; 152 6.6 12.15 26.4;

153 9.05 12.15 26.4; 154 15.65 12.15 26.4; 158 6.6 12.15 9.7;
159 6.6 12.15 16.3; 160 12.305 12.15 0; 161 12.305 12.15 3.74;
162 12.305 12.15 6.6; 163 15.65 12.15 3.74;
MEMBER INCIDENCES
1 26 27; 2 27 28; 3 28 61; 4 30 31; 5 32 63; 6 26 30; 7 27 31; 8 28 32;
9 29 64; 10 34 35; 11 36 37; 12 30 36; 13 31 55; 14 32 34; 15 33 38; 16 35 38;
17 34 39; 18 35 40; 19 40 41; 20 44 45; 21 36 44; 22 37 56; 23 39 42; 24 41 43;
25 46 47; 26 48 49; 27 44 46; 28 45 47; 29 42 48; 30 43 49; 36 1 26; 37 2 27;
38 3 28; 39 4 29; 40 5 30; 41 6 31; 42 7 32; 43 8 33; 44 9 34; 45 10 38;
46 11 36; 47 12 37; 48 13 39; 49 14 41; 50 17 44; 51 18 45; 52 15 42; 53 16 43;
54 21 46; 55 22 47; 56 19 48; 57 20 49; 61 53 35; 62 54 40; 63 31 32; 64 45 42;
65 47 48; 66 55 37; 67 56 45; 68 55 34; 69 56 39; 70 61 29; 71 64 33; 72 63 33;
73 61 62; 74 62 64; 75 62 63; 76 57 61; 77 58 62; 78 59 63; 79 60 64; 80 41 38;
81 26 65; 82 27 66; 83 28 67; 84 29 68; 85 30 69; 86 31 70; 87 32 71; 88 33 72;
89 34 73; 90 35 74; 91 36 75; 92 37 76; 93 38 77; 94 39 78; 95 40 79; 96 41 80;
97 42 81; 98 43 82; 99 44 83; 100 45 84; 101 46 85; 102 47 86; 103 48 87;
104 49 88; 108 55 92; 109 56 93; 110 61 94; 111 62 95; 112 63 96; 113 64 97;
114 65 66; 115 66 67; 116 67 94; 117 69 70; 118 71 96; 119 65 69; 120 66 70;
121 67 71; 122 68 97; 123 73 74; 124 75 76; 125 69 75; 126 70 92; 127 71 73;
128 72 77; 129 74 77; 130 73 78; 131 74 79; 132 79 80; 133 83 84; 134 75 83;
135 76 93; 136 78 81; 137 80 82; 138 85 86; 139 87 88; 140 83 85; 141 84 86;
142 81 87; 143 82 88; 149 70 71; 150 84 81; 151 86 87; 152 92 76; 153 93 84;
154 92 73; 155 93 78; 156 94 68; 157 97 72; 158 96 72; 159 94 95; 160 95 97;
161 95 96; 162 80 77; 163 81 82; 164 42 43; 165 78 79; 166 39 40; 167 65 98;
168 66 99; 169 67 100; 170 68 101; 171 69 102; 172 70 103; 173 71 104;
174 72 105; 175 73 106; 176 74 107; 177 75 108; 178 76 109; 179 77 110;
180 78 111; 181 79 112; 182 80 113; 183 81 114; 184 82 115; 185 83 116;
186 84 117; 187 85 118; 188 86 119; 189 87 120; 190 88 121; 194 92 125;
195 93 126; 196 94 127; 197 95 128; 198 96 129; 199 97 130; 200 98 99;
201 99 100; 202 100 127; 203 102 103; 204 104 129; 205 98 102; 206 99 103;
207 100 104; 208 101 130; 209 106 107; 210 108 109; 211 102 108; 212 103 125;
213 104 106; 214 105 110; 215 107 110; 216 106 111; 217 107 112; 218 112 113;
219 116 117; 220 108 116; 221 109 126; 222 111 114; 223 113 115; 224 118 119;
225 120 121; 226 116 118; 227 117 119; 228 114 120; 229 115 121; 235 103 104;
236 117 114; 237 119 120; 238 125 109; 239 126 117; 240 125 106; 241 126 111;
242 127 101; 243 130 105; 244 129 105; 245 127 128; 246 128 130; 247 128 129;
248 113 110; 249 114 115; 250 111 112; 251 98 131; 252 99 132; 253 100 133;
254 101 134; 255 102 135; 256 103 136; 257 104 137; 258 105 138; 259 106 139;
260 107 140; 261 108 141; 262 109 142; 263 110 143; 264 111 144; 265 112 145;
266 113 146; 267 114 147; 268 115 148; 269 116 149; 270 117 150; 271 118 151;
272 119 152; 273 120 153; 274 121 154; 278 125 158; 279 126 159; 280 127 160;
281 128 161; 282 129 162; 283 130 163; 284 131 132; 285 132 133; 286 133 160;
287 135 136; 288 137 162; 289 131 135; 290 132 136; 291 133 137; 292 134 163;
293 139 140; 294 141 142; 295 135 141; 296 136 158; 297 137 139; 298 138 143;
299 140 143; 300 139 144; 301 140 145; 302 145 146; 303 149 150; 304 141 149;
305 142 159; 306 144 147; 307 146 148; 308 151 152; 309 153 154; 310 149 151;

311 150 152; 312 147 153; 313 148 154; 319 136 137; 320 150 147; 321 152 153;
322 158 142; 323 159 150; 324 158 139; 325 159 144; 326 160 134; 327 163 138;
328 162 138; 329 160 161; 330 161 163; 331 161 162; 332 146 143; 333 147 148;
334 144 145;
DEFINE MATERIAL START
ISOTROPIC CONCRETE
E 2.236e+007
POISSON 0.17
DENSITY 25
ALPHA 1e-005
DAMP 0.05
END DEFINE MATERIAL
CONSTANTS
MATERIAL CONCRETE MEMB 1 TO 30 36 TO 57 61 TO 104 108 TO 143 149 TO 190 194 -
195 TO 229 235 TO 274 278 TO 313 319 TO 334
MEMBER PROPERTY INDIAN
*COLUMN
36 TO 57 61 62 76 TO 79 81 TO 104 108 TO 113 167 TO 190 194 TO 199 -
251 TO 274 278 TO 283 PRIS YD 0.3 ZD 0.3
MEMBER PROPERTY INDIAN
1 TO 30 63 TO 75 80 114 TO 143 149 TO 166 200 TO 229 235 TO 250 284 TO 313 -
319 TO 334 PRIS YD 0.35 ZD 0.25
SUPPORTS
1 TO 22 53 54 57 TO 60 FIXED
SLAVE RIGID MASTER 26 JOINT 27 TO 49 55 56 61 TO 64
SLAVE RIGID MASTER 65 JOINT 66 TO 88 92 TO 97
SLAVE RIGID MASTER 98 JOINT 99 TO 121 125 TO 130
SLAVE RIGID MASTER 131 JOINT 132 TO 154 158 TO 163
CUT OFF MODE SHAPE 12
DEFINE 1893 LOAD
ZONE 0.24 RF 3 I 1.5 SS 2 ST 2
SELFWEIGHT
LOAD 1 EQX
JOINT LOAD
1 Fx 2.531
2 Fx 2.531
3 Fx 2.531
4 Fx 2.531
5 Fx 2.531
6 Fx 2.531
7 Fx 2.531
8 Fx 2.531
9 Fx 2.531
10 Fx 2.531
11 Fx 2.531

12 Fx 2.531
13 Fx 2.531
14 Fx 2.531
15 Fx 2.531
16 Fx 2.531
17 Fx 2.531
18 Fx 2.531
19 Fx 2.531
20 Fx 2.531
21 Fx 2.531
22 Fx 2.531
26 Fx 90.589
27 Fx 134.537
28 Fx 69.361
29 Fx 32.988
30 Fx 175.774
31 Fx 218.474
32 Fx 102.01
33 Fx 48.875
34 Fx 125.75
35 Fx 120.055
36 Fx 173.869
37 Fx 147.485
38 Fx 78.272
39 Fx 129.443
40 Fx 123.721
41 Fx 73.939
42 Fx 182.574
43 Fx 140.605
44 Fx 176.166
45 Fx 207.829
46 Fx 90.874
47 Fx 123.3
48 Fx 123.2
49 Fx 92.243
53 Fx 2.531
54 Fx 2.531
55 Fx 80.302
56 Fx 80.434
57 Fx 2.531
58 Fx 2.531
59 Fx 2.531
60 Fx 2.531
61 Fx 60.966
62 Fx 94.851
63 Fx 74.662

64 Fx 55.774
65 Fx 92.215
66 Fx 134.804
67 Fx 71.886
68 Fx 34.413
69 Fx 176.944
70 Fx 217.481
71 Fx 104.917
72 Fx 50.725
73 Fx 127.737
74 Fx 120.698
75 Fx 175.215
76 Fx 147.064
77 Fx 79.442
78 Fx 131.701
79 Fx 124.191
80 Fx 75.937
81 Fx 183.475
82 Fx 141.478
83 Fx 177.272
84 Fx 207.527
85 Fx 92.451
86 Fx 124.585
87 Fx 124.489
88 Fx 93.701
92 Fx 84.45
93 Fx 84.816
94 Fx 62.028
95 Fx 95.376
96 Fx 75.653
97 Fx 56.751
98 Fx 92.994
99 Fx 134.014
100 Fx 73.361
101 Fx 34.721
102 Fx 177.102
103 Fx 214.166
104 Fx 106.128
105 Fx 51.513
106 Fx 128.568
107 Fx 120.239
108 Fx 175.788
109 Fx 146.066
110 Fx 79.245
111 Fx 132.889
112 Fx 123.374

113 Fx 76.836
114 Fx 182.676
115 Fx 141.191
116 Fx 177.358
117 Fx 205.317
118 Fx 93.174
119 Fx 124.692
120 Fx 124.649
121 Fx 94.36
125 Fx 85.095
126 Fx 85.487
127 Fx 61.992
128 Fx 94.577
129 Fx 75.423
130 Fx 56.423
131 Fx 84.918
132 Fx 136.364
133 Fx 59.503
134 Fx 29.033
135 Fx 172.877
136 Fx 232.877
137 Fx 91.946
138 Fx 42.575
139 Fx 120.631
140 Fx 119.974
141 Fx 169.445
142 Fx 148.411
143 Fx 76.278
144 Fx 123.093
145 Fx 124.961
146 Fx 66.982
147 Fx 182.86
148 Fx 139.624
149 Fx 173.622
150 Fx 215.319
151 Fx 85.475
152 Fx 120.201
153 Fx 119.978
154 Fx 87.331
158 Fx 75.483
159 Fx 75.554
160 Fx 58.848
161 Fx 96.078
162 Fx 73.198
163 Fx 54.606
1 Fz 2.531

2 Fz 2.531
3 Fz 2.531
4 Fz 2.531
5 Fz 2.531
6 Fz 2.531
7 Fz 2.531
8 Fz 2.531
9 Fz 2.531
10 Fz 2.531
11 Fz 2.531
12 Fz 2.531
13 Fz 2.531
14 Fz 2.531
15 Fz 2.531
16 Fz 2.531
17 Fz 2.531
18 Fz 2.531
19 Fz 2.531
20 Fz 2.531
21 Fz 2.531
22 Fz 2.531
26 Fz 90.589
27 Fz 134.537
28 Fz 69.361
29 Fz 32.988
30 Fz 175.774
31 Fz 218.474
32 Fz 102.01
33 Fz 48.875
34 Fz 125.75
35 Fz 120.055
36 Fz 173.869
37 Fz 147.485
38 Fz 78.272
39 Fz 129.443
40 Fz 123.721
41 Fz 73.939
42 Fz 182.574
43 Fz 140.605
44 Fz 176.166
45 Fz 207.829
46 Fz 90.874
47 Fz 123.3
48 Fz 123.2
49 Fz 92.243
53 Fz 2.531

54 Fz 2.531
55 Fz 80.302
56 Fz 80.434
57 Fz 2.531
58 Fz 2.531
59 Fz 2.531
60 Fz 2.531
61 Fz 60.966
62 Fz 94.851
63 Fz 74.662
64 Fz 55.774
65 Fz 92.215
66 Fz 134.804
67 Fz 71.886
68 Fz 34.413
69 Fz 176.944
70 Fz 217.481
71 Fz 104.917
72 Fz 50.725
73 Fz 127.737
74 Fz 120.698
75 Fz 175.215
76 Fz 147.064
77 Fz 79.442
78 Fz 131.701
79 Fz 124.191
80 Fz 75.937
81 Fz 183.475
82 Fz 141.478
83 Fz 177.272
84 Fz 207.527
85 Fz 92.451
86 Fz 124.585
87 Fz 124.489
88 Fz 93.701
92 Fz 84.45
93 Fz 84.816
94 Fz 62.028
95 Fz 95.376
96 Fz 75.653
97 Fz 56.751
98 Fz 92.994
99 Fz 134.014
100 Fz 73.361
101 Fz 34.721
102 Fz 177.102

103 Fz 214.166
104 Fz 106.128
105 Fz 51.513
106 Fz 128.568
107 Fz 120.239
108 Fz 175.788
109 Fz 146.066
110 Fz 79.245
111 Fz 132.889
112 Fz 123.374
113 Fz 76.836
114 Fz 182.676
115 Fz 141.191
116 Fz 177.358
117 Fz 205.317
118 Fz 93.174
119 Fz 124.692
120 Fz 124.649
121 Fz 94.36
125 Fz 85.095
126 Fz 85.487
127 Fz 61.992
128 Fz 94.577
129 Fz 75.423
130 Fz 56.423
131 Fz 84.918
132 Fz 136.364
133 Fz 59.503
134 Fz 29.033
135 Fz 172.877
136 Fz 232.877
137 Fz 91.946
138 Fz 42.575
139 Fz 120.631
140 Fz 119.974
141 Fz 169.445
142 Fz 148.411
143 Fz 76.278
144 Fz 123.093
145 Fz 124.961
146 Fz 66.982
147 Fz 182.86
148 Fz 139.624
149 Fz 173.622
150 Fz 215.319
151 Fz 85.475

152 Fz 120.201
153 Fz 119.978
154 Fz 87.331
158 Fz 75.483
159 Fz 75.554
160 Fz 58.848
161 Fz 96.078
162 Fz 73.198
163 Fz 54.606
SPECTRUM CQC 1893 TOR X 0.024 ACC SCALE 1 DAMP 0.05 LIN MIS
SOIL TYPE 2
LOAD 2 EQZ
SPECTRUM CQC 1893 TOR Z 0.024 ACC SCALE 1 DAMP 0.05 LIN MIS
SOIL TYPE 2
LOAD 3 DL
SELFWEIGHT Y -1
FLOOR LOAD
YRANGE 0 12.15 FLOAD -4.75 XRANGE 0 15.65 ZRANGE 0 33
LOAD 4 LL
FLOOR LOAD
YRANGE 0 12.15 FLOAD -4 XRANGE 0 15.65 ZRANGE 0 33
LOAD COMB 5 1.2*(DL+LL+EQX)
1 1.2 3 1.2 4 1.2
LOAD COMB 6 1.2*(DL+LL+EQZ)
2 1.2 3 1.2 4 1.2
LOAD COMB 7 1.2*(DL+LL-EQX)
1 -1.2 3 1.2 4 1.2
LOAD COMB 8 1.2*(DL+LL-EQZ)
2 -1.2 3 1.2 4 1.2
LOAD COMB 9 1.5*(DL+EQX)
1 1.5 3 1.5
LOAD COMB 10 1.5*(DL+EQZ)
2 1.5 3 1.5
LOAD COMB 11 1.5*(DL-EQX)
1 -1.5 3 1.5
LOAD COMB 12 1.5*(DL-EQZ)
2 -1.5 3 1.5
LOAD COMB 13 0.9*DL+1.5*EQX
1 1.5 3 0.9
LOAD COMB 14 0.9*DL+1.5*EQZ
2 1.5 3 0.9
LOAD COMB 15 0.9*DL-1.5*EQX
1 -1.5 3 0.9
LOAD COMB 16 0.9*DL-1.5*EQZ
2 -1.5 3 0.9
LOAD COMB 17 1.5*(DL+LL)

3 1.5 4 1.5

PERFORM ANALYSIS
LOAD LIST 5 TO 16
PRINT SUPPORT REACTION
PRINT STORY DRIFT
START CONCRETE DESIGN
CODE INDIAN
FC 20000 MEMB 1 TO 30 36 TO 57 61 TO 104 108 TO 143 149 TO 190 194 TO 229 -
235 TO 274 278 TO 313 319 TO 334
FYMAIN 415000 MEMB 1 TO 30 36 TO 57 61 TO 104 108 TO 143 149 TO 190 -
194 TO 229 235 TO 274 278 TO 313 319 TO 334
FYSEC 415000 MEMB 1 TO 30 36 TO 57 61 TO 104 108 TO 143 149 TO 190 -
194 TO 229 235 TO 274 278 TO 313 319 TO 334
MAXMAIN 25 MEMB 1 TO 30 36 TO 57 61 TO 104 108 TO 143 149 TO 190 194 TO 229 -
235 TO 274 278 TO 313 319 TO 334
MAXSEC 20 MEMB 1 TO 30 36 TO 57 61 TO 104 108 TO 143 149 TO 190 194 TO 229 -
235 TO 274 278 TO 313 319 TO 334
MINMAIN 10 MEMB 1 TO 30 36 TO 57 61 TO 104 108 TO 143 149 TO 190 194 TO 229 -
235 TO 274 278 TO 313 319 TO 334
MINSEC 8 MEMB 1 TO 30 36 TO 57 61 TO 104 108 TO 143 149 TO 190 194 TO 229 -
235 TO 274 278 TO 313 319 TO 334
DESIGN BEAM 1 TO 30 63 TO 75 80 114 TO 143 149 TO 166 200 TO 229 235 TO 250 -
284 TO 313 319 TO 334
DESIGN COLUMN 36 TO 57 61 62 76 TO 79 81 TO 104 108 TO 113 167 TO 190 194 -
195 TO 199 251 TO 274 278 TO 283
CONCRETE TAKE
END CONCRETE DESIGN
FINISH