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A Comparative Study of A G+10 Building Subjected to Seismic Forces Using IS 1893:2016 & ASCE 7-10

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ABSTRACT: In this paper, a comparative study is made of seismic codes of India and America. The name of the codes is IS 1893:2016 and ASCE7-10. A residential building irregular in plan is considered in this study. The building is analysed and designed in STAAD Pro V8i software. The building is assumed to be a Ordinary Moment Resisting Frame (OMRF). The water tank load is also considered in this study. IS 456:2000 and ACI 318 2011 are used for the design purpose. The results obtained were compared with respect to Axial Force acting on columns, Shear force and Bending Moment acting on beams in X and Z direction.

KEYWORDS: Seismic design, building codes, reinforced concrete frame structure, lateral loads

I. INTRODUCTION

A building code sets the rules that specify the standards for constructed objects such as buildings and non-building structures having irregularities in plan and/or elevation. Buildings must conform to the code to obtain planning permission, usually from a local council. The main purpose of building codes is to protect public health, safety and general welfare subjected to loads which are time dependent. Different countries have various design codes for seismic analysis and design of the structure. In this study we have considered two countries for comparison. Design codes of countries like India, America and Europe have been studied and discussed in this study.

Following codes are considered:

IS 1893:2002 and IS 1893: 2016

ASCE 7-10

1. IS 1893:2002 and IS 1893: 2016:

These standards deal with earthquake resistant design of structures. IS 1893 is applicable to buildings; elevated structures; bridges; dams etc. In this code, India is divided into five seismic zones based on the seismic intensity. The name of the code is, "Criteria for Earthquake Resistant Design of Structures."

2. ASCE 7 -10

This standard provides minimum load requirements for the design of buildings and other structures that are subject to lateral loads as well as vertical loads. Chapter 11 of ASCE 7-10 presents criteria for the design and construction of buildings and other structures subject to earthquake ground motions.

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II. SCOPE AND OBJECTIVES

1. To study and understand International standard namely American code ASCE7-10 and Indian Code IS1893:2016
2. To plan a G+10 building
3. Analyze and design the building in STAAD Pro V8i for IS 1893:2016 & ASCE 7-10
4. Design building as per IS 456:2000 for IS 1893:2016 and ACI 318: 2011 for ASCE 7-10
5. Compare the results obtained

III. METHODOLOGY

- First a G+10 building is planned and drafted in Auto CADD
- Import the building in STAAD Pro
- Each floor has one staircase and a lift
- The water tank load is also considered
- The building is irregular in plan
- Marble and Granite finish is given for the structure for interiors, parapet walls are provided for balconies and terrace.

Following dimensions of beam and columns were assigned for the two codes:

MEMBER	IS 1893:2016	ASCE 7-10
COLUMN	350 X 950 MM	450 X 950 MM
BEAM TYPE 1	300 X 500 MM	250 X 400 MM
BEAM TYPE 2	300 X 400 MM	230 X 450 MM
BEAM TYPE 3	300 X 450 MM	300 X 450 MM
BEAM TYPE 4	350 X 620 MM	300 X 550 MM

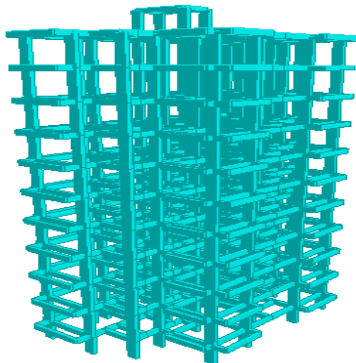


Fig. 1 Rendered view of building

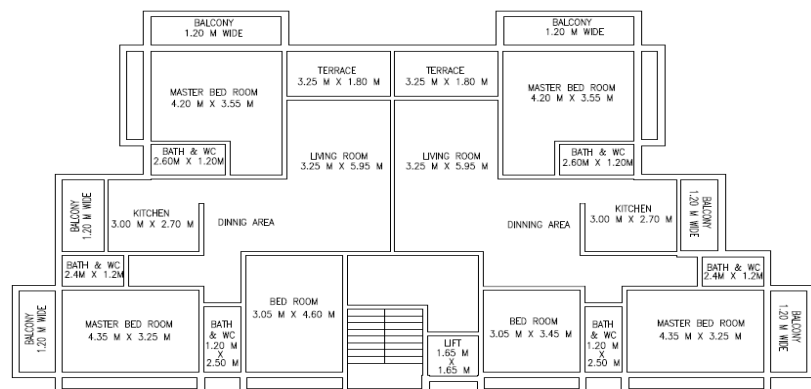


Fig 2 Plan of the Building

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IV. SEISMIC PARAMETERS

IS 1893:2016 –

As per IS 1893:2016, following parameters are needed to for calculation of base shear of a building:

Zone Factor (Z):

The building is assumed to be situated near Mumbai Region. Thus, it lies in Zone III. The zone factor is 0.16.

Importance Factor (I):

It is a factor used to estimate design seismic force depending on the functional use of the structure and characterized by the hazardous consequences after its failure. For residential building, it is assumed to be 1.0

Response Reduction Factor (R):

It is a factor by which the base shear induced in a structure, if it were to remain elastic, is reduced to obtain the design base shear. For a RC OMRF (Ordinary Moment Resisting Frame), it is 3.0

Response Acceleration Coefficient of Structure (Sa/g)

It is a factor denoting the normalised design acceleration spectrum value to be considered for ground shaking. It depends on dimension of building, type of soil and approximate fundamental time period.

Damping Ratio:

Damping ratio is assumed to be 5%

Approximate Fundamental Time Period (Tx and Tz)

It is calculated by using formula:

$$T_a = (0.09 * h) \sqrt{d}$$

Where,

h = Height of building in meters

d = Dimension of Building in X and Z direction

Type of Soil is assumed to be Type 2

ASCE 7-10 –

SDs:

The design spectral response acceleration parameter in the short period range

Zip Code (Z):

The building is assumed to be situated near San Francisco Region. The Zip Code is 92014

Spectral Response Acceleration Parameter at Short Period (Ss):

For this structure, the value of Ss is calculated as 0.5

Spectral Response Acceleration Parameter at a Period of 1 Second (S1):

For this structure, the value of Ss is calculated as 0.2

Long Period Transition Period (TL):

This factor depends on Location of the building and varies from 8 to 16. For this structure, it is assumed to be 4 seconds

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Occupancy Factor (I):

It is a factor used to estimate design seismic force depending on the functional use of the structure and characterized by the hazardous consequences after its failure. For residential building, it is assumed to be 1.0

Response Modification Coefficient (R):

It is a factor by which the base shear induced in a structure, if it were to remain elastic, is reduced to obtain the design base shear. For a RC OMRF (Ordinary Moment Resisting Frame), it is 5.0

Short Period Site Coefficient (Fa):

This factor depends on two things namely Site Class and Spectral Response Acceleration Parameter at short period. It is obtained from Table 11.4-1 and is found to be 1.24

Long Period Site Coefficient (Fa):

This factor depends on two things namely Site Class and Spectral Response Acceleration Parameter at Period of 1 Second (S1). It is obtained from Table 11.4-2 and is found to be 1.8

Damping Ratio:

Damping ratio is assumed to be 5%

Approximate Fundamental Time Period (Tx and Tz)

It is calculated by using formula:

$$T_a = C_T h^x$$

Where,

h = Height of building in meters

C_t = Building period coefficient in X and Z direction and is assumed to be 0.4

Type of Soil is assumed to be Type 4

V. RESULTS AND DISCUSSION

1. Axial Loads on columns:

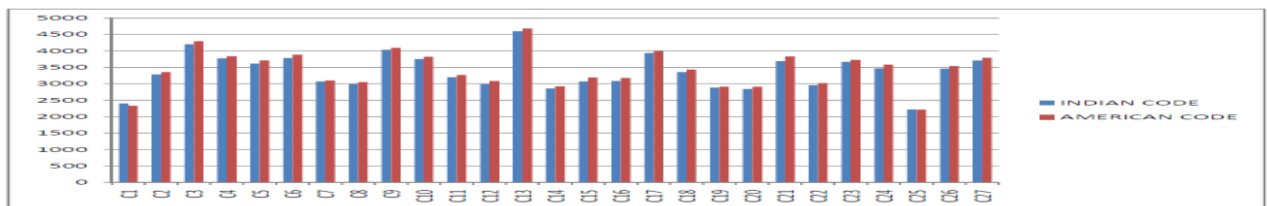


Fig 3 Axial Load Comparison

2. Shear Force Diagram in +X Direction:

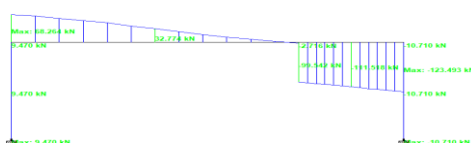


Fig 4 Shear Force (IS 1893:2016)

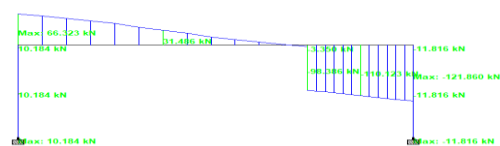


Fig 5 Shear Force (ASCE 7-10)

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3. Bending Moment Diagram in +X Direction:

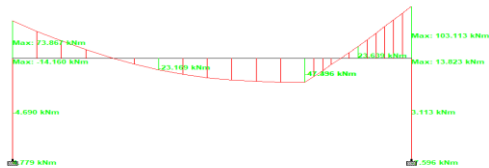


Fig 6 Bending Moment (IS 1893:2016)

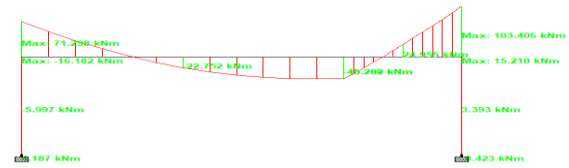


Fig 7 Bending Moment (ASCE 7-10)

4. Shear Force Diagram in +Z Direction:

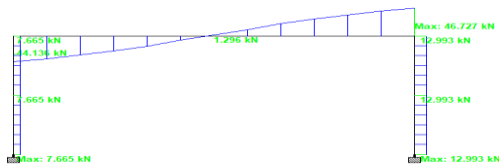


Fig 8 Shear Force (IS 1893:2016)

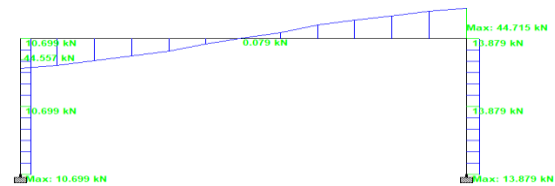


Fig 9 Shear Force (ASCE 7-10)

5. Bending Moment Diagram in +Z Direction:

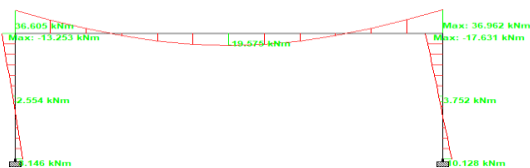


Fig 10 Bending Moment (IS 1893:2016)



Fig 11 Bending Moment (ASCE 7-10)

6. Graphical Representation of above points:

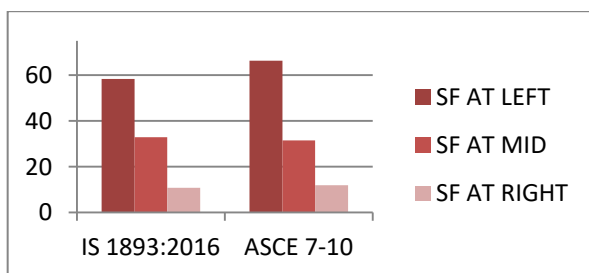


Fig 12 Shear Force Comparison (+X)

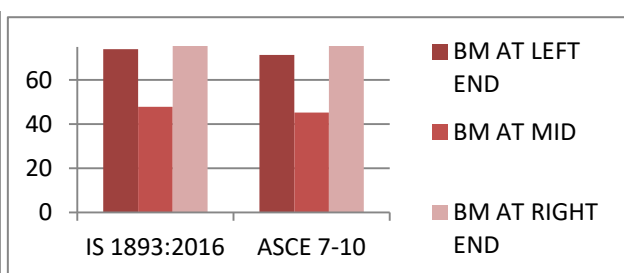


Fig 13 Bending Moment Comparison (+X)

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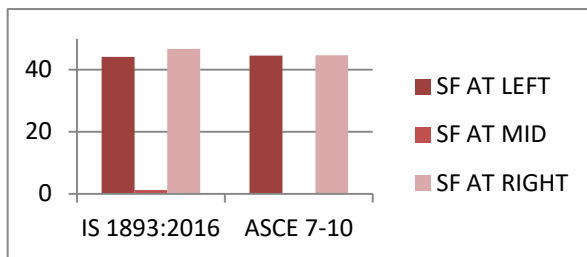


Fig 14 Shear Force Comparison (+Z)

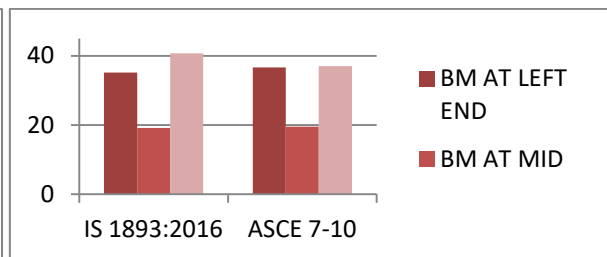


Fig 15 Bending Moment Comparison (+Z)

VI. CONCLUSION

COMPARISON OF AXIAL LOAD ON COLUMN:

There were 27 columns in the structure and the value of axial force acting on column due to various load combinations was calculated and compared. The difference in maximum value of axial load obtained by IS 1893:2016 was found out to 1.8% and the difference in minimum value was found to 3.1%

Comparison of Shear Force and Bending Moment of a Beam in X Direction:

The value of Shear force by Indian code was 58.264kN and by American code was 66.323kN. The value of bending moment acting on beam by Indian code was found out to be -47.896kN.m and by American code was -45.209kN.m.

Comparison of Shear Force and Bending Moment of a Beam in Z Direction:

The value of Shear force by Indian code was 46.727kN and by American code was 44.715kN. The value of bending moment acting on beam by Indian code was found out to be 40.696kN.m and by American code was 36.962kN.m.

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