Comparative study of IS: 1893 part-6 (draft code) Base Isolated buildings with International codes

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Abstract: Base isolation has been advancement in the field of Structural Engineering over the past decade in India. It has arguably become one of the most resourceful methods for providing improved protection of buildings against earthquake-generated movements, by providing a clear separation between the structure and the ground or any of the consecutive levels. This design application has shown its efficacy in defending both structural and non-structural members, hence protecting their life even in the occurrence of a major seismic event.
The present study provides an overview of the analytical and theoretical comparison of the IS 1893:2020 part 6-Base Isolated Buildings (draft code) with International Codes. The design performance requirements, the analysis procedures, the design review process outlined in each code are discussed.

Index Terms – Base isolation system, Earthquake resistant structure, Analysis methods, Comparative study

I. INTRODUCTION

The earthquakes in the past have provided enough evidence of performance for different types of structural configurations under different seismic excitations for Engineers and Scientists to carry out extensive research work in the field which has given rise to different types of techniques to save the structures from the damages caused due to earthquakes. Even the buildings built with highly developed methods and appropriate construction measures in the past have failed to perform satisfactorily against earthquake vibrations leading to enormous loss of life and property. In particular , the 2001 Bhuj Earthquake, Gujarat, India which recorded 7.7 on Ritcher scale cost a life of around 20,000 people and damage of around 2 billion U.S.D. This has compelled the engineers and scientists to think of innovative techniques and methods to save the buildings and structures from the damaging forces of earthquake.

II. PRINCIPLE

Base Isolation term was coined by engineers as early as in the year 1923 and thereafter different methods of isolating the buildings and structures from earthquake forces have been developed all over the world. Many countries including US, Japan, New Zealand, China, Japan and European countries have adopted this method for over decades now. Thousands of buildings are being built every year with base isolation technique worldwide.
Under this technique, horizontally flexible devices (isolators) are placed between the superstructure and the foundation, which offers advantage of filtering the high frequency ground motions which can be damaging to the structure and also creates a safe location for seismic energy dissipation.

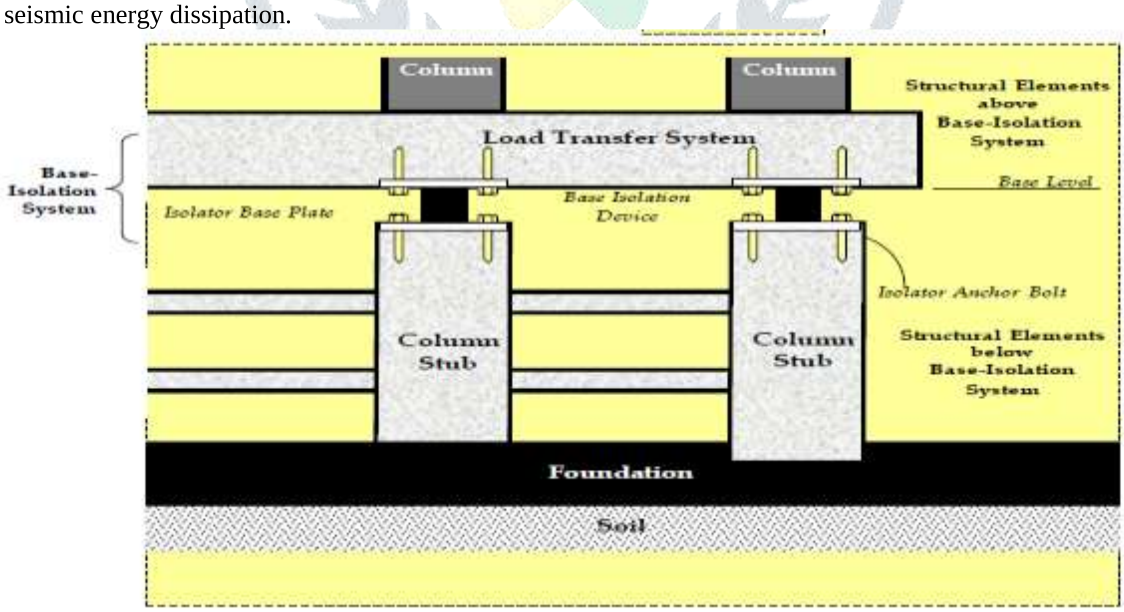

Figure 1.1: Typical isolation-level cross section

Base isolation provides two main advantages on the seismic response of the structure. First, is the reduction of lateral forces in the superstructure and second is concentration of lateral displacements at the isolation interface. .

III. ANALYTICAL STUDY

The study is undertaken to carry out Response Spectrum analysis for buildings situated in highly seismic zones.

In ETABS 2016, the models will be analyzed by defining Response Spectrum according to Indian Standard as well as American code of practice. Different structural configurations will be considered with respect to -

1. Storey height	2. Base system	3. Isolation using
G+3	Fixed base building	Lead Rubber bearing
G+6	Base-Isolated building	Friction Isolator
G+9		
G+12		

With respect to change structural configurations the following parameters will be analyzed for the performance of R.C. Building under seismic excitation cases.

Storey drift

Storey displacement

Storey shear

Modal analysis

IV. STRUCTURAL CONFIGURATION

Structural data of the building model of G+3, G+6, G+9, G+12 storey buildings are as follows

Table 1.1: Structural configuration details

Type of structure	Multi-storey rigid jointed 3D frame (SMRF)
Seismic zone	IV
Zone Factor	0.24
Importance factor	1
Response reduction factor	5
Type of soil	Type II (Medium soil)
Number of storeys	G+3, G+6, G+9, G+12
Dimension of building	8.00 m x 15 m
Floor Height	3.1 m
Live load	3 kN/m^2 on all floors & 1.5 kN/m^2 on roof
Dead load	1 kN/m^2 on all floors w/o including self-weight
Materials	Concrete (M20) and Reinforcement Fe 415
Beam Dimension	300 mm X 450 mm
Column Dimension	300 mm X 450 mm
Number of columns	12
Depth of slab	150 mm
Wall thickness	230 mm external & 115 mm partition walls
Specific weight of RCC	25 kN/m^3 and 20 kN/m^3 for masonry
Structural Damping	5%

V. Load application details

Load application

1. Self-Weight of the Building
2. Slab load:
   Dead Load = 1 kN/m^2

Live Load = 3 kN/m^2 on floors and 1.5 kN/ m^2 on terrace

3. Wall load on Beams:
   Dead Load = 14.5 kN/m (Main wall)

   = 8.6 kN/m (partition wall)

4. Earthquake static load (IS code)
   Zone factor (Z) =0.24
   Soil type II (Medium soil)
   Importance factor (I) =1
   Response reduction factor (R) =5
   Damping ratio = 5%

5. Earthquake static load (ASCE code)
   Ss and S1- User defined
   0.2 sec spectral acceleration (Ss) - 1.145
   1 sec spectral acceleration (S1) - 0.52
   Long period transition period – 8
   Fa, Fv= 1
   SDS= 2/3 x Fa x Ss = 0.7633
   SD1= 2/3 x Fv x S1 = 0.3467
   Damping ratio= 5%

VI. Base isolation properties and models

Properties of Base Isolator assigned in the building are described as below-

Table 1.2: Lead rubber bearing properties

Type of Bearing	Lead rubber isolator
U1 linear stiffness	1500000 kN/m
U2 & U3 linear stiffness	800 kN/m
U2 & U3 non-linear stiffness	2500 kN/m
U2 & U3 yield strength	80 kN
U2 & U3 post yield stiffness ratio	0.1

Table 1.3: Friction pendulum bearing properties

Type of Bearing	Friction pendulum isolator
U1 linear stiffness	1500000 kN/m
U2 & U3 linear stiffness	750 kN/m
U2 & U3 non-linear stiffness	15000 kN/m
U2 & U3 friction coefficient	Slow : 0.03, Fast : 0.05
U2 & U3 rate parameter	40
U2 & U3 radius of sliding surface	2.23

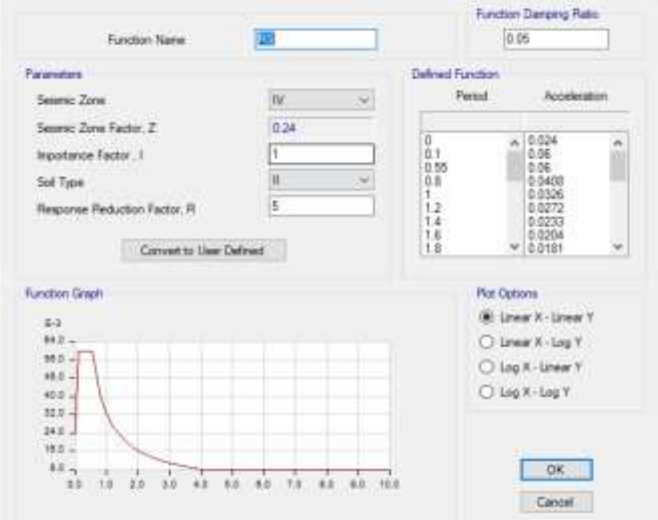

Figure 1.2: Response spectrum definition (IS CODE)

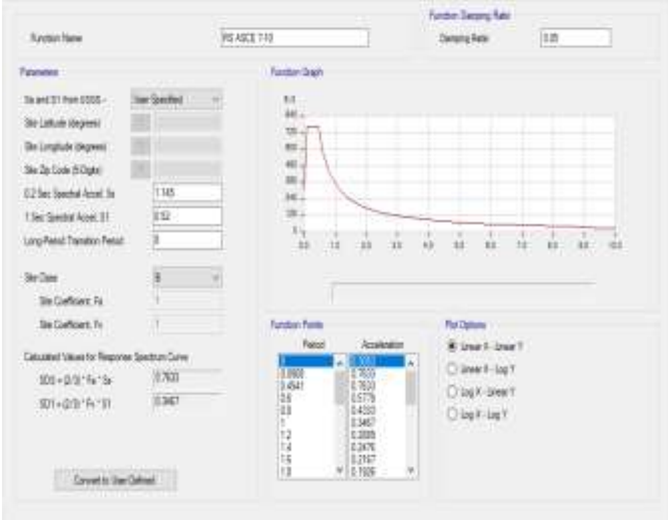

Figure 1.3: Response spectrum definition (ASCE CODE)

VII. Analysis Results

- **Fixed base system**

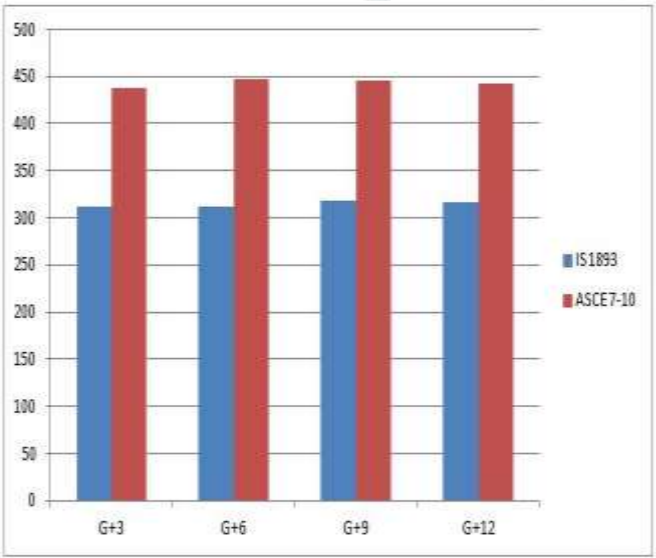

Figure 1.4: Base shear comparison result (Fixed base)

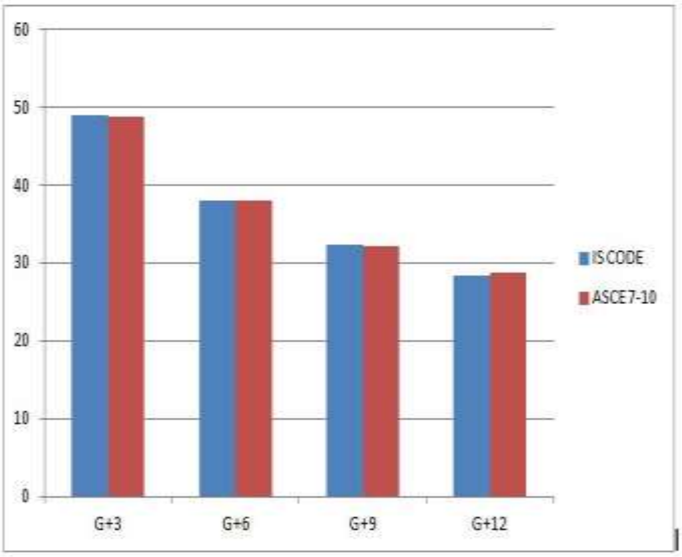

Figure 1.5 Maximum storey displacement result (Fixed base)

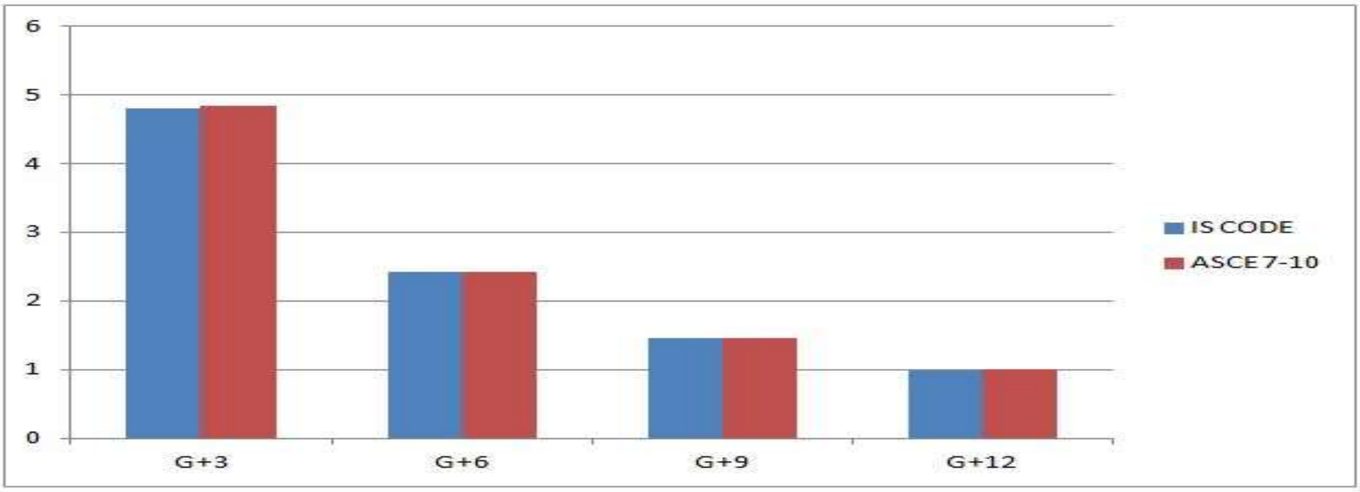

Figure 1.6: Maximum storey drift comparison result (Fixed base)

- **Base isolated system (Lead Rubber bearing)**

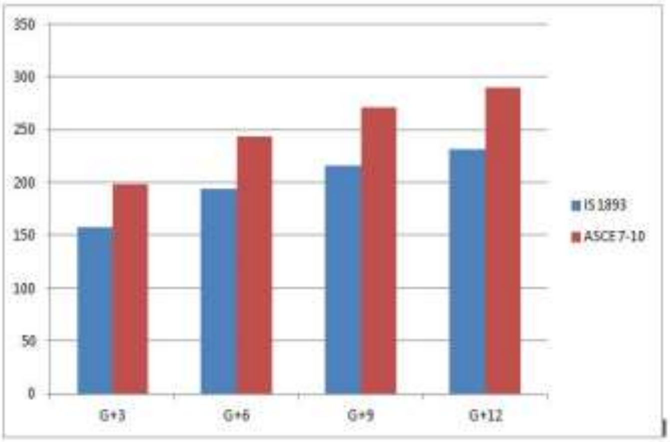

Figure 1.7: Base shear comparison result (LRB)

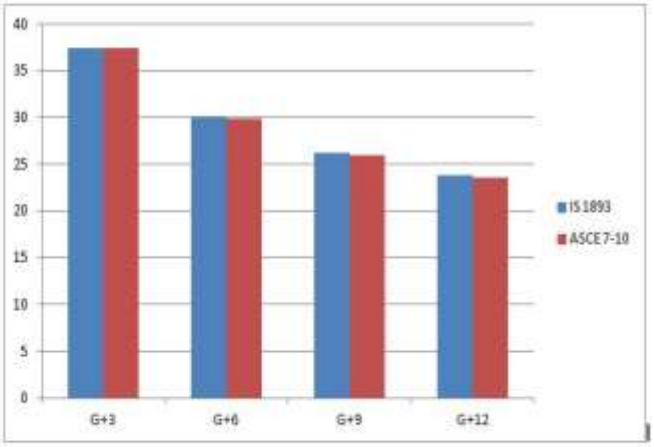

Figure 1.8: Maximum storey displacement result (LRB)

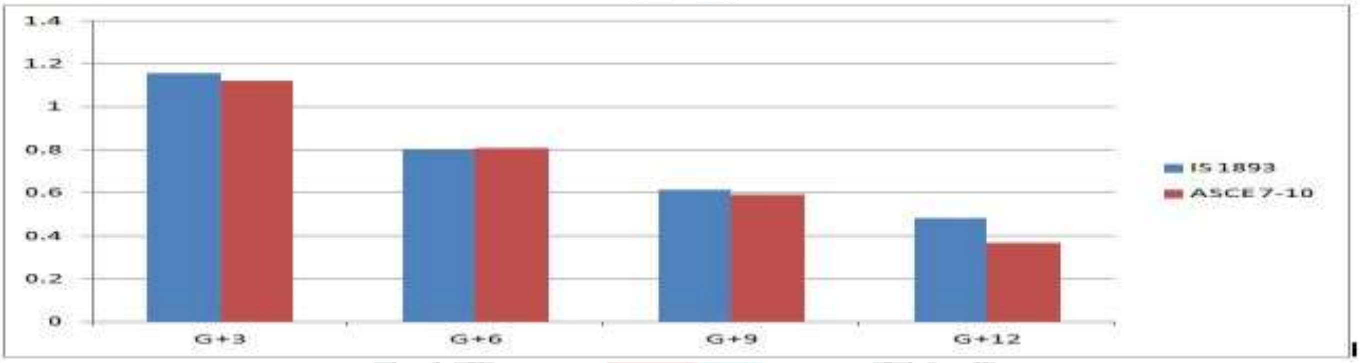

Figure 1.9: Maximum storey drift comparison result (LRB)

- **Base isolated system (Friction pendulum bearing)**

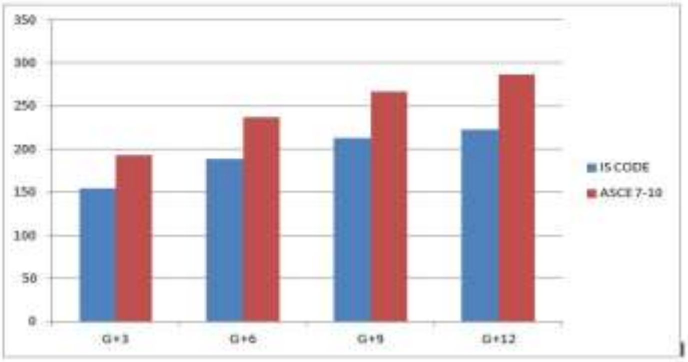

Figure 1.10: Base shear comparison result (FP)

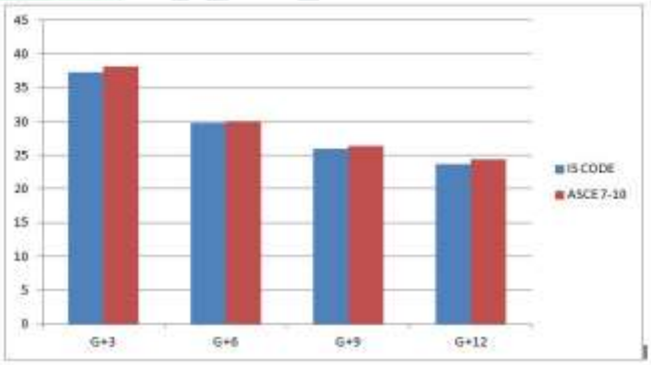

Fig 1.11: Maximum storey displacement result (FP)

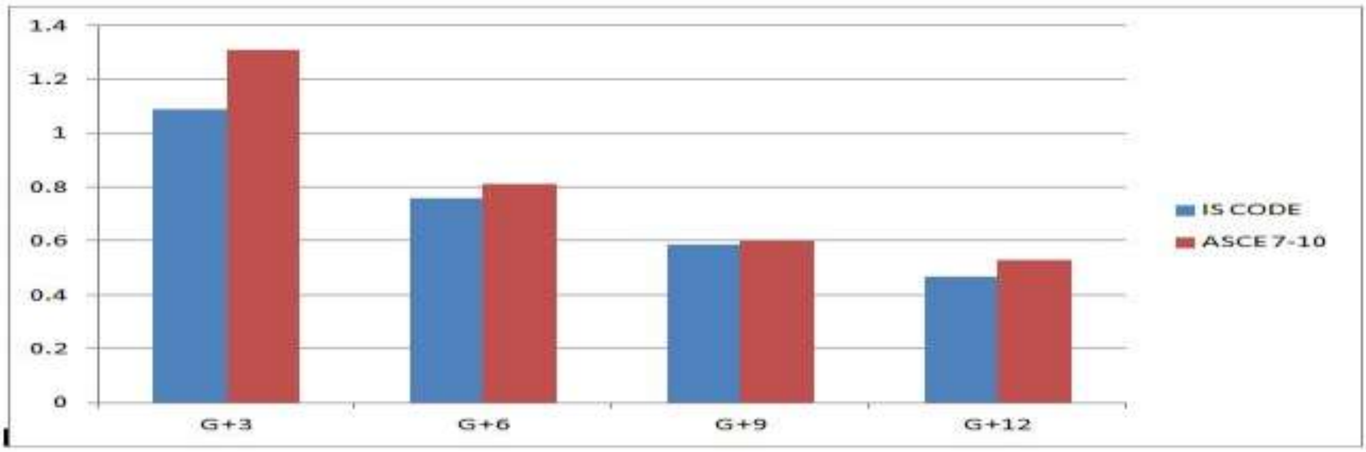

Figure 1.12: Maximum storey drift comparison result (FP)

VIII. Conclusion

- As compared to fixed base structure there is a period shift of 57.59%, 47.20%, 39.91%, and 34.33% for G+3, G+6, G+9, G+12 storey building respectively when analyzed with IS Code guidelines in case of isolation by Lead Rubber bearing.
- As compared to fixed base structure there is a period shift of 58.66%, 48.36%, 41.05%, and 35.37% for G+3, G+6, G+9, G+12 storey building respectively when analyzed with IS Code guidelines in case of isolation by Friction Pendulum bearing.
- As compared to fixed base structure there is a period shift of 57.25%, 47.68%, 38.67%, and 32.53% for G+3, G+6, G+ 9, G+12 storey building respectively when analyzed with ASCE Code guidelines in case of isolation by Lead Rubber bearing.
- As compared to fixed base structure there is a period shift of 58.33%, 46.50%, 39.83%, and 33.61% for G+3, G+6, G+ 9, G+12 storey building respectively when analyzed with ASCE Code guidelines in case of isolation by Friction Pendulum bearing.
- From above results we can conclude that there is an average time period shift of 44.75% and 45.86% with the provision of LRB and FP respectively under IS code analysis.
- From above results we can conclude that there is an average time period shift of 44.03% and 44.56% with the provision of LRB and FP respectively under ASCE code analysis.
- We can conclude that there is an average reduction of 26.31% and 29.72% in the values of Storey displacements as compared to fixed base and by the provision of Lead rubber bearing and Friction bearing respectively.
- We can conclude that there is an average reduction of 75% in the values of Storey drift as compared to fixed base and by the provision of Lead rubber bearing and Friction bearing.
- We can conclude that there is an average increase of 41.95%, 15% and 15.17% in the values of base shear under fixed base system, isolation by Lead rubber bearing and friction bearing respectively as compared to analysis by IS code provisions and ASCE code (American code giving values on the higher side).
- We can conclude that provision of Base isolation technique significantly increases the Time period of the structure, thereby decreasing the value of Spectral acceleration.
- From above obtained results we can conclude that there is significant variation in the values of all the considered seismic parameters with the provision of Base isolation with both IS code as well as ASCE code considered for analysis.
- There is no significant difference in the values of storey displacement and storey drifts compared by both IS code and ASCE code but there is noticeable difference in the values of base shear.

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- IS:1893:2016 (Part 1) Criteria for Earthquake Resistant Design of Structures
- ASCE Chapter-17 Seismic design requirements for seismically isolated structures