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Comparative Study on Equivalent Static Analysis and Response Spectrum Analysis for Irregular Multi-story Structure in Seismic Zone IV

Kapil Arora¹, Dr. Rajwinder Singh Bansal², Arun Verma³

Department of Civil Engineering, Ramgarhia Group of Institutes (Ramgarhia Institute of Engineering and Technology,
Phagwara, India¹

Head of Department, Department of Civil Engineering, Ramgarhia Group of Institutes (Ramgarhia Institute of
Engineering and Technology, Phagwara, India²

Assistant Professor, Department of Civil Engineering, Ramgarhia Group of Institutes (Ramgarhia Institute of
Engineering and Technology, Phagwara, India³

ABSTRACT: Earthquakes are very disastrous and cause a great harm to living life, material life and buildings. Hence proper dynamic analysis for building having earthquake threat is needed. This will ensure proper designs resulting in an earthquake proof structure. In this thesis, the earthquake responses of symmetric multi-storied building by two methods are studied. The methods include seismic coefficient method as recommended by IS Code and modal analysis using response spectrum method of IS Code. The seismic analysis of multi-storeyed building by above two methods includes the results of base shear, lateral force, storey shear and section displacement. The responses obtained by above methods in extreme zone V as mentioned in IS code are then compared. Test results Base Shear, Lateral Force, Storey Shear & Section Displacement are compared. This study presents a comparative evaluation between two seismic design codes, the International Building code (IBC 2009) and IS 1893 which are well known and the seismic design code for earthquake design of Structure in India. In order to make possible comparison among the codes, a particular location and the most common residential frame model has been chosen. In this research, a building of moment-resisting frame and moment-resisting frame with shear wall plan of reinforced concrete (RC) frames were analysed for low-rise to mid-rise structures. Response spectrum method (RSM) and equivalent lateral force method (ELFM) were performed using extended three dimensional analysis of building system (ETABS) software package. The main objective of this study is to examine the seismic provisions of the first edition of IS 1893 seismic code to determine whether it provides a generic level of safety that incorporate in well established code. The results obtained from both static and dynamic analysis are presented in the form of base shear, story shear, displacement, axial forces and bending moments for selected columns for three different codes

KEYWORDS: Seismic design code; equivalent lateral force method; response spectrum method; moment-resisting frame; moment-resisting frame with shear wall IS 1893

I. INTRODUCTION

Earthquake is one of the most destructive natural hazard. Earthquakes do not destroy the settlement area only. It may be de-stabilize the economy and social structure of the economy. Earthquakes occur several times a day in various parts of the world. Major earthquakes occur most frequently in particular areas of the earth's surface that are called zones of high probability. The global seismic hazard map shown in Figure 1.1 which is based on data from the Global seismic hazard assessment program, highlights the areas where there is an increased risk of seismic activity. In the countries, which are placed on the major earthquake zone of the world, designing and constructing earthquake resistance structures is of great importance. Highly destructive earthquakes hit around the world resulting in injuries and deaths of humans and left a lot of constructions with extensive damage. The main reason of substantial damage is due to the weakness of buildings to withstand with earthquake effects due to the insufficient detailing of the seismic resisting building according to inadequate detailing. Therefore, to improve the safety of the constructions, numerous of seismic

codes were provided worldwide (Ozcebe et al., 2004). All over the world countries placed on earthquake zones, publish their own codes to improve the safety and to control the design and construction of the structures.

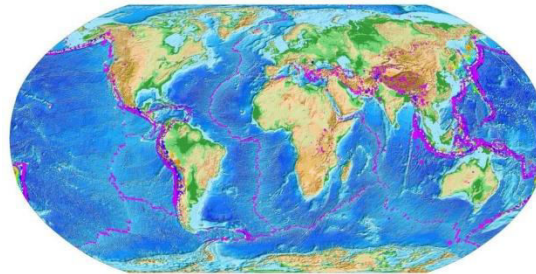


Figure (a): Map of global seismic hazard (Giardini, Grünthal, Shedlock, & Zhang, 1999)

II. SIGNIFICANCE OF THE STUDY

The objectives of this study is to analyze different methods and even guidelines used when performing calculations on high-rise buildings in regards to deflections, resonance frequencies, accelerations and stability. The results from these methods are then compared with manual calculation in order to evaluate differences and verify the methods and models.

The aim of the research is to provide insight on how different ways of modeling buildings in finite element programs the results. This is especially investigated when comparing the vertical and horizontal loading with different modeling techniques. A comprehensive literature study have been made in the area of high-rise buildings, regarding the history, design process, code regulations, finite element modeling as well as static and dynamic response.

III. OBJECTIVES OF THE STUDY

The primary objective of this study is to create a comparative evaluation among two seismic design codes including; International building code (IBC2009), IS 1893:2016 to achieve the main aim of this study, the following objectives will be performed:

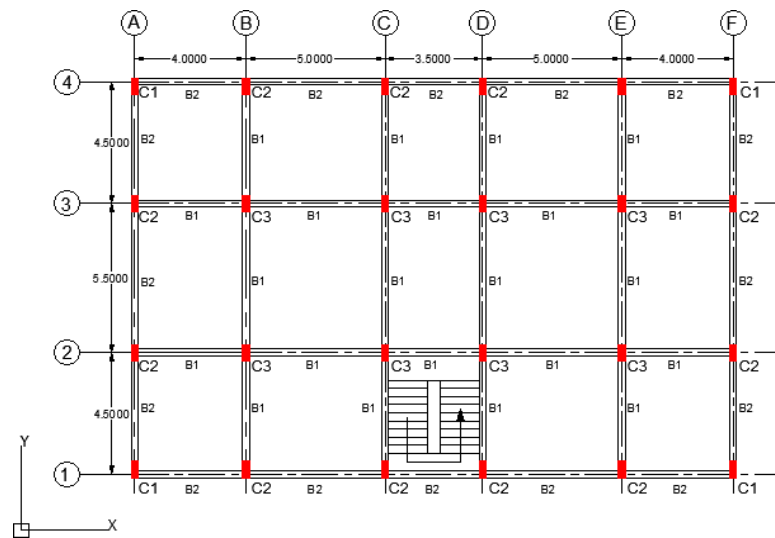
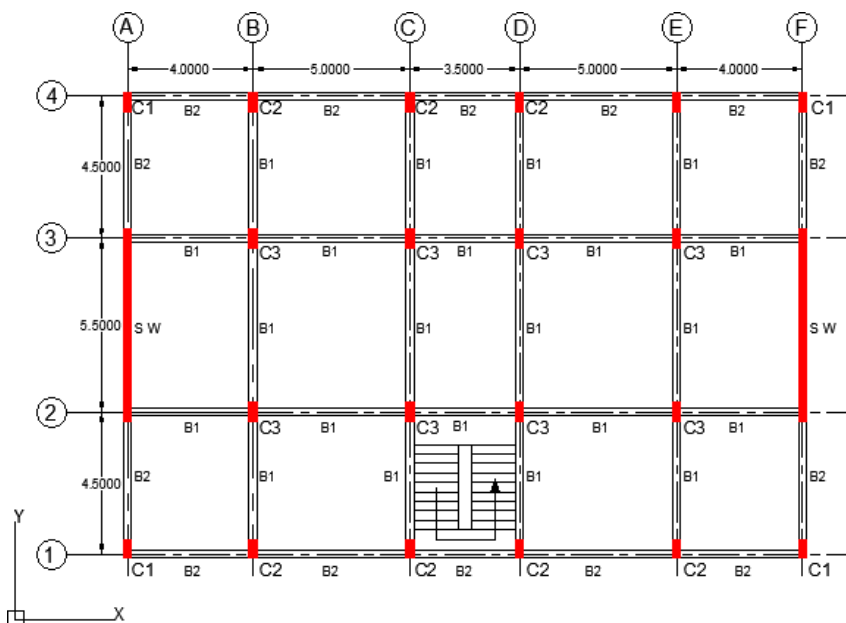
- To investigate moment-resisting frame (MRF) in regular form and moment-resisting frame with shear wall (MRF+SW) in regular form RC framed buildings.
- To explore the variation in the results obtained.
- To perform equivalent lateral force methods (ELFM) and response spectrum methods (RSM) using ETABS software.
- To verify the seismic design base shear, story shear, displacement, axial force and bending moments for selected columns under different parameters suggested by codes mentioned above.

IV. METHODOLOGY

The total height of the building above the ground level considered for the study is 15.6 m. In the present study, five stories (ground+4) reinforced concrete residential building of 21.5m 14.5m in the plan has been considered for the comparison, as shown in Figures (b) and (c), respectively.

Four types of RC buildings have been modelled and analysed in this study, namely:

- 1) Five-story moment-resisting frame (MRF) in regular form analysis using ELFM
- 2) Five-story moment-resisting frame (MRF) in regular form analysis using RSM
- 3) Five-story moment-resisting frame with shear wall (MRF+SW) in regular form analysis using ELFM
- 4) Five-story moment-resisting frame with shear wall (MRF+SW) in regular form analysis using RSM

**Figure (b) :** Floor plan for five story moment-resisting frame in regular form**Figure (c) :** Floor plan for five story moment-resisting frame with shear wall in regular form

Typical floor height of RC building is 3 m, and all stories are considered as typical floors. The compressive strength of concrete was considered as 30 MPa, and the yield strength of the steel was selected as 420 MPa. The damping ratio was taken as 0.05. The dimensions of slabs, beams and columns are listed in Tables 1-3 respectively. In the frame buildings, some members were selected for the aim of the analysis. The selected column members (corner, exterior, interior) are shown in Table 1

Table 1: Layout of slab for the residential building

Number of floors	Type of slab	Thickness (mm)	Description of slab
G, 1, 2, 3 and 4	S1	150	Slab for floors
	S2	150	Slab for stairs

Table 2: Layout of beams for the residential building

Number of floors	Type of beam	Dimensions (mm)	Carrying
G, 1, 2, 3 and 4	B1	500*250	Internal walls
	B2	500*250	External walls

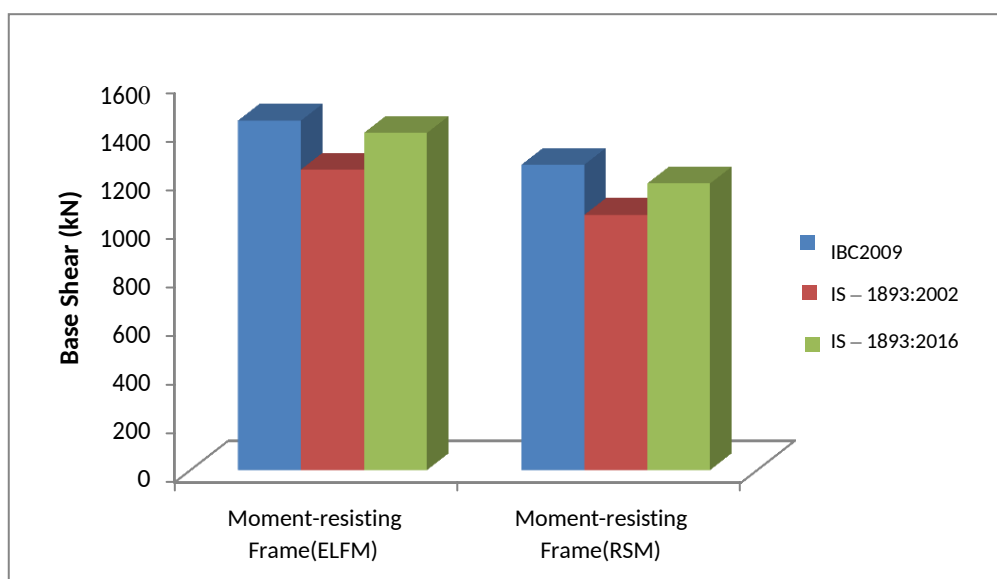
Table 3: Layout of columns for the residential building

Number of floors	Type of column	bx (mm)	by (mm)
G, 1, 2, 3 and 4	Corner Column(C1)	300	400
	Exterior Column (C2)	300	500
	Interior Column(C3)	300	600

The three-dimensional (3D) analysis is carried out under static and dynamic seismic analysis in both x and y directions. ELFM and RSM have been used for performing static and dynamic analysis respectively. The methods were used to verify the seismic design base shear, displacement, story shear, axial force and maximum bending moments for selected columns under different parameters suggested by codes mentioned above.

V. RESULT AND DISCUSSION

BASE SHEAR-the total base shear using ELFM and RSM for two types (moment-resisting frame and moment-resisting frame with shear wall) of rc framed structures has been adopted for different codes for the case region. Figures (d)–(e) shows the obtained base shear in the x and y directions, using both static and dynamic procedures.

**Figure (d): Total base shear MRF in x-direction**

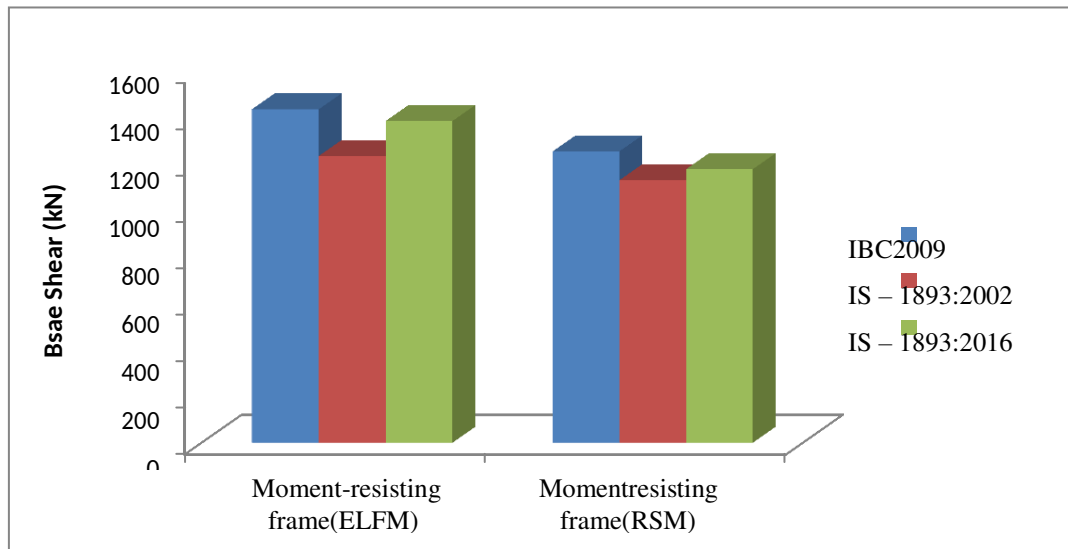


Figure (e): Total base shear MRF iny-direction

In the x-direction the total base shear obtained from EC 8 using ELFM (five stories MRF) are about 14% and 11% less than IBC 2009 and IS 1893:2002 , respectively. The same observation was made in the y-direction.

In the x-direction the total base shear obtained from EC 8 using RSM (five stories MRF) are about 14.4% and 10.9% less than IBC 2009 and 1893:2002, respectively. In the y- direction the total base shear obtained from EC 8 using RSM (five stories MRF) are about 9.9% and 4% less than IBC 2009 and IS 1893:2002 respectively

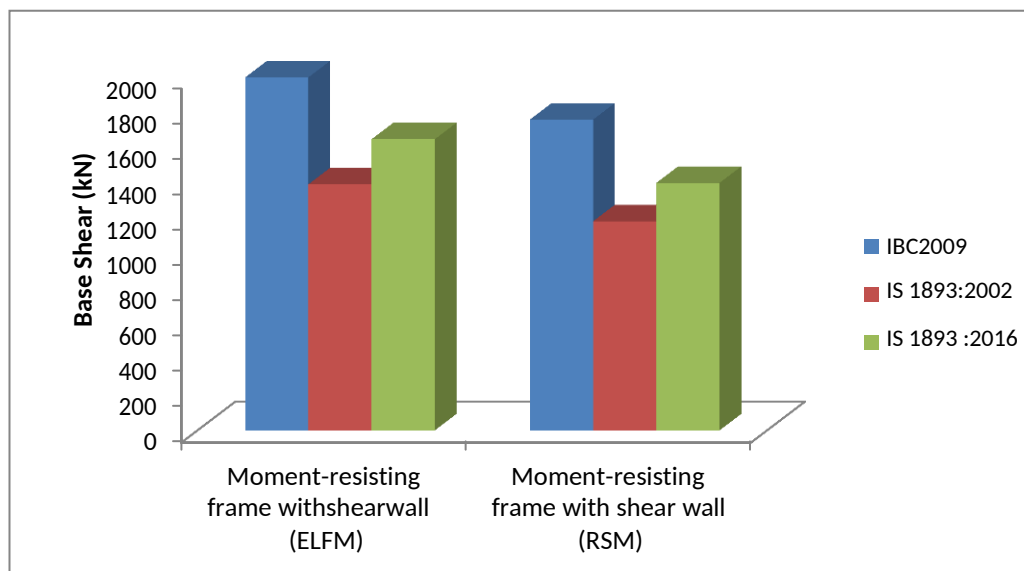


Figure (f): The base shear MRF+SW inx-direction

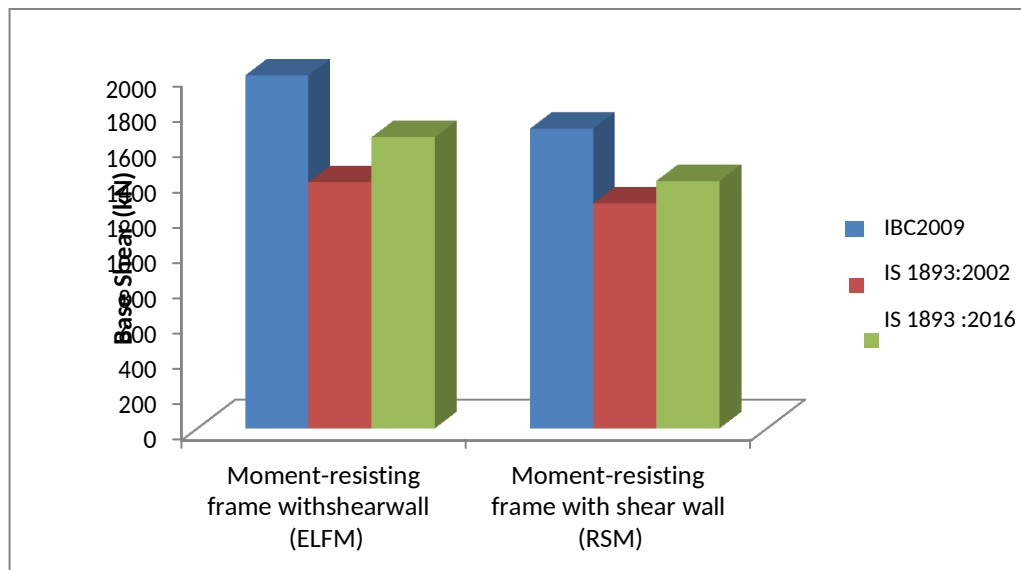


Figure (g): The base shear MRF+SW in y-direction

In the x-direction the total base shear obtained from EC 8 using ELFM (five stories MRF+SW) are about 30.3% and 15.5% less than IBC 2009 and IS 1893:2002, respectively. The same observation was made in the y-direction.

In the x-direction the total base shear obtained from EC 8 using RSM (five stories MRF+SW) are about 32.7% and 15.5% less than IBC 2009 and IS 1893:2002, respectively. In the y-direction the total base shear obtained from EC 8 using RSM (five stories MRF+SW) are about 24.9% and 9.1% less than IBC 2009 and IS 1892:2002, respectively.

VI. CONCLUSION

Based on the obtained results from the analysis of RC frame building in, it can be concluded that Base shear as per threecodes;

- Base shear as per IS 1893:2002 for MRF using ELFM is remain in between compared to othercodes.
- Base shear as per IS 1893:2002 for MRF using RSM is remain in between compared to othercodes.
- Base shear as per IS 1893:2002 for MRF+SW using ELFM is remain in between compared to othercodes.
- Base shear as per IS 1893:2002 for MRF+SW using RSM is remain in between compared to othercodes.

The results obtained from MRF and MRF+SW for both ELFM and RSM analysis are presented in the form of base shear, story shear, displacement, axial forces and bending moments for selected columns for three different codes. The edition of Indian standard seismic code which is named as IS 1893:2002 provides a generic level of safety that incorporate in well establishedcode.

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