Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

COMPARATIVE CASE STUDY OF SMRF AND SHEAR WALL RC STRUCTURE UNDER TIME HISTORY AND RESPONSE SPECTRUM ANALYSIS

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Abstract: *Shear wall is a structural member used to resist lateral forces parallel to the plane of the wall. Shear wall resists the loads due to cantilever action. In other words, Shear walls are vertical elements of the lateral force resisting system (wind and seismic forces). This study aims to compare the seismic performance of two model of G+6 story real life reinforced concrete building located in Zone 3. Model 1 is generated with special moment resisting frame (SMRF) as the lateral load resisting system whereas same building is converted into model 2 which consists of number of shear walls replacing the columns (SW). The objective of the present study is to compare the seismic performance of the two models. The designs of the buildings were carried out by response spectrum analysis. Nonlinear dynamic responses of these buildings were analyzed using Etabs. The base shear, storey drifts, storey displacement and storey stiffness from the analysis were used for the evaluation of the responses of the building. The quantities of steel and concrete consumed are calculated and compared. It has been found that the building with R.C. shear wall is economical and shows better response then the same building with special moment resisting frames.*

Key words*: Special moment resisting frame, Shear wall, Response spectrum, Nonlinear dynamic analysis, Storey drift, Storey displacement, Quantities*

1. INTRODUCTION

It would be correct to say that there are as many kinds of lateral resisting systems as there are intellectual humans like Engineers, Scientist etc. Basically, most of them are divided into three sections.
1. Reinforced concrete frame system
2. Shear wall system
3. Dual system, the Shear wall - frame system

From the engineering point of view, the most preferred system for design of high-rise buildings is the shear wall-frame system i.e dual system. Now a days, reinforced concrete frame buildings with the application of structural walls like reinforced concrete shear walls and these buildings are performing better under seismic action in comparison to reinforced concrete frame buildings by reducing the probability of excessive deformations and hence collapse.

Generally, shear walls are normally constructed at the foundation level and are continuous following the height of the building. The provision of thickness starts at minimum value of 150 mm and ends at maximum of 400 mm in high-rise structures. These structural walls are usually provided in both directions of the building. Shear walls support gravity loads and simultaneously resist lateral loads by diaphragm action and transfer them to the foundation. Lateral or horizontal forces applied to the building are derived from earthquakes result shear and overturning moments in shear walls. The shear force tends to tear up the shear walls in various parts. The tendency of the shear wall to be lifted up at one end where lateral load is applied and to be pushed down at the other end resists the overturning moment produced due to earthquake loads. The maximum amount of lateral or horizontal shear force is completely resisted by shear walls due to this action, these structural walls are named as shear walls. The capability of shear walls to resist lateral storey shear forces, storey torsion and overturning moments primarily based on its location, orientation and geometric configuration within the structure.

For tall buildings, these systems typically utilize a centrally located reinforced concrete core wall to resist most of the seismic forces. This results in relatively small gravity systems at the perimeter of the building. Alternatively, these systems could be designed as dual systems by combining core walls and reinforced concrete moment resisting frames. To compare the seismic performance of reinforced concrete core wall systems with and without the moment resisting frame, a G+6 story real life building located in Zone 3 is designed and analyzed. The current work compares the seismic performance of these two systems in terms of costs and structural responses.

2. TIME HISTORY ANALYSIS

Nonlinear time-history analyses is carried out to compare structural response of building. According to the ASCE 7-05, a minimum of three accelerograms are required for two-dimensional analysis of buildings. If less than seven accelerograms are used, then the maximum value of the response should be considered for the design and seven or more excitations are used, then the average values of the response parameters should be used in the design.

2.1 SELECTION OF GROUND MOTIONS AND THEIR SCALING

Four natural records were selected from PEER-NGA database and were made compatible with IS 1893:2016 spectrum for medium soil. Both the fault-normal and fault-parallel components were taken and the SRSS spectrum of each pair is generated. Scaling was done based on ASCE 7:05.

1. For each earthquake in the suite, the square root of the sum of the squares (SRSS) of the spectra for each pair of horizontal components is computed. When computing the SRSS, the motion as recorded, without scale factors, is used.
2. Individual scale factors are applied to the SRSS spectra such that the average of the scaled SRSS spectra does not fall below 1.3 times the design spectra by more than 10 percent for any period between 0.2T and 1.5T.

With regard to point 2, the period T is generally different in the two orthogonal directions, and thus, the scale factors would be different in the two directions. Selection of the two periods for 3D analysis may not be straightforward for buildings in which there is a strong coupling of lateral and torsional response.

Having different scale factors in the two different directions is not rational, and a different interpretation of the ASCE 7 requirements is warranted. One approach for handling different periods in different direction is to select the scaling range as 0.2Tsmall to 1.5 Tlarge, where Tsmall and Tlarge are the smaller and larger of the two fundamental periods of vibration. Another approach would be to select the scaling range as 0.2Tavg to 1.5 Tavg, where Tavg is the average of the two periods.

The SRSS spectra of each pair of ground motions together with their average spectrum and 1.3 times the design spectrum are shown in Fig. 1.

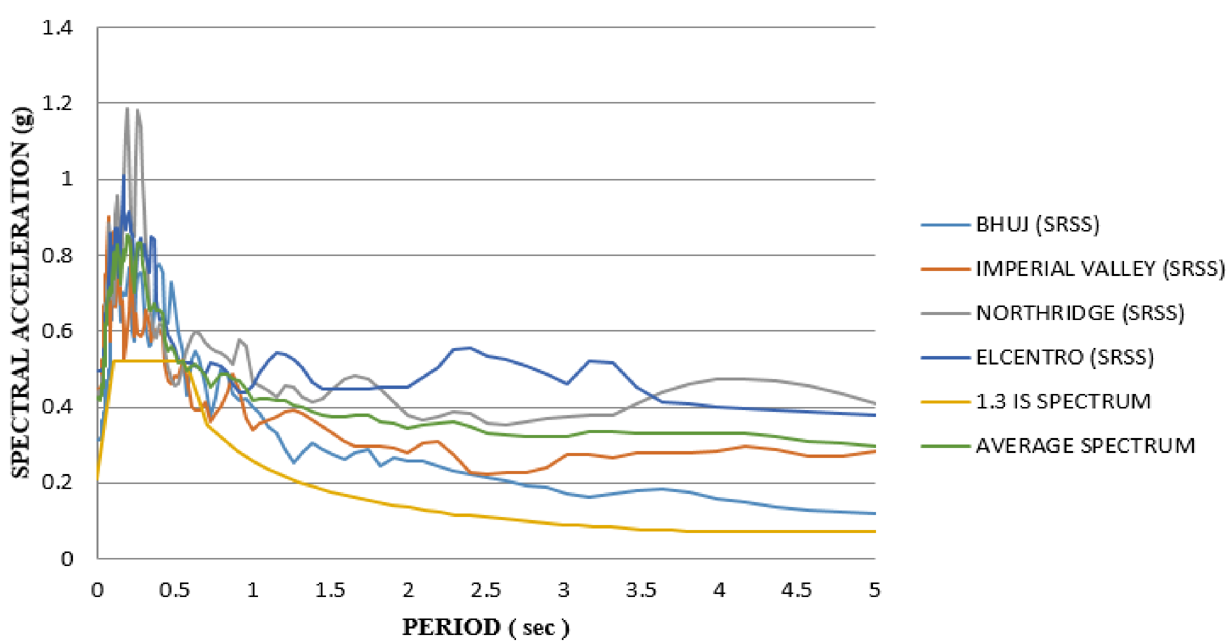

Fig. 1: Response Spectra of selected Time Histories

3 DESCRIPTION OF BUILDING AND DESIGN PARAMETERS

GEOMETRICAL DETAILS :

Typical Storey height	: 3.6 m
Bottom Storey height	: 4.0 m
No. of Storey	: 7 Storey
Slab thickness	: 150 mm
Shear wall thickness	: 150, 175, 200 mm

MATERIAL PROPERTIES :

Grade of Concrete	: M25 in all cases
Grade of Steel	: Fe 500 (HYSD) for reinforcing steel

LOADING :

Dead Load	: Self Weight
Live Load on typical floor	: 2 kN/m^2
Live Load on terrace	: 1.5 kN/m^2
Floor Finish	: 2 kN/m^2
Water Proofing	: 3 kN/m^2
Masonary Wall	: 7 kN/m
Parapet Wall	: 2.5 kN/m

SEISMIC DEFINITION :

Zone Factor (Z)	: 0.16 For Zone 3
Importance Factor (I)	: 1
Response Reduction Factor (R)	: 5
Time Period	: 0.4168 Sec For X direction 0.5543 Sec For Y direction
Soil Type	: Medium or Stiff Soil

The Analysis and Design is done according to indian codes. The general finite element package ETABS 16.2 has been used for the analyses.

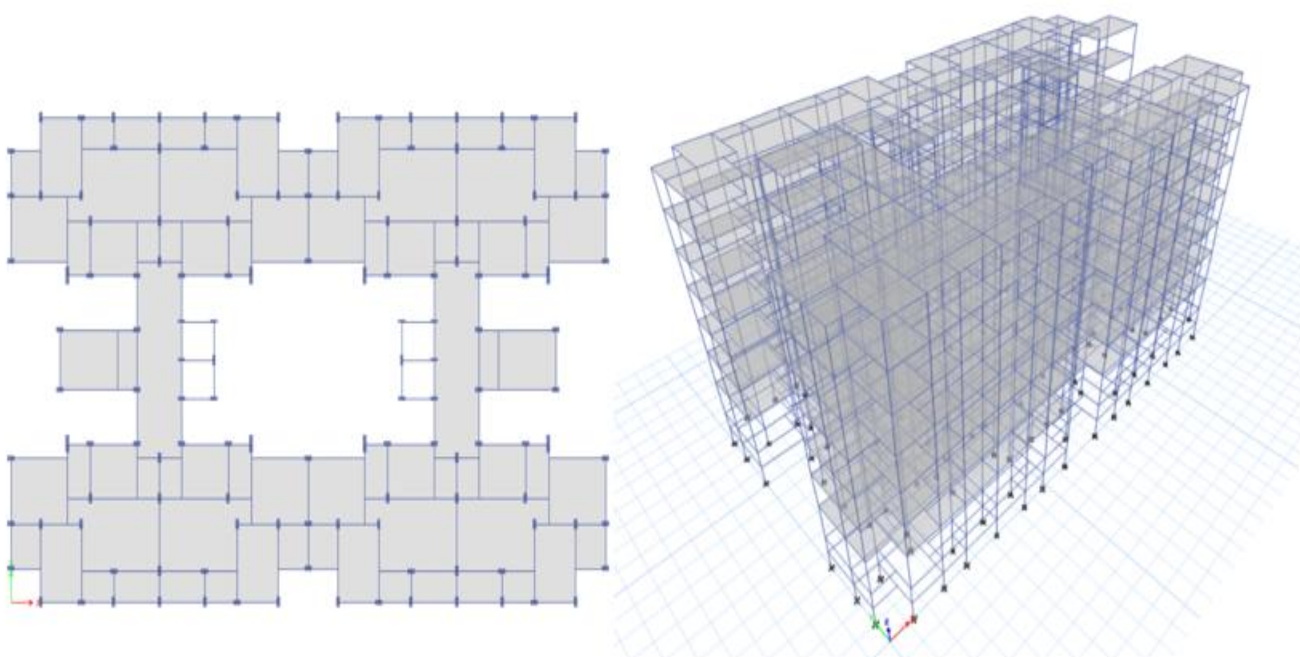

*Fig. 2: Model 1: **SMRF** (Building with Special Moment Resisting Frame)*

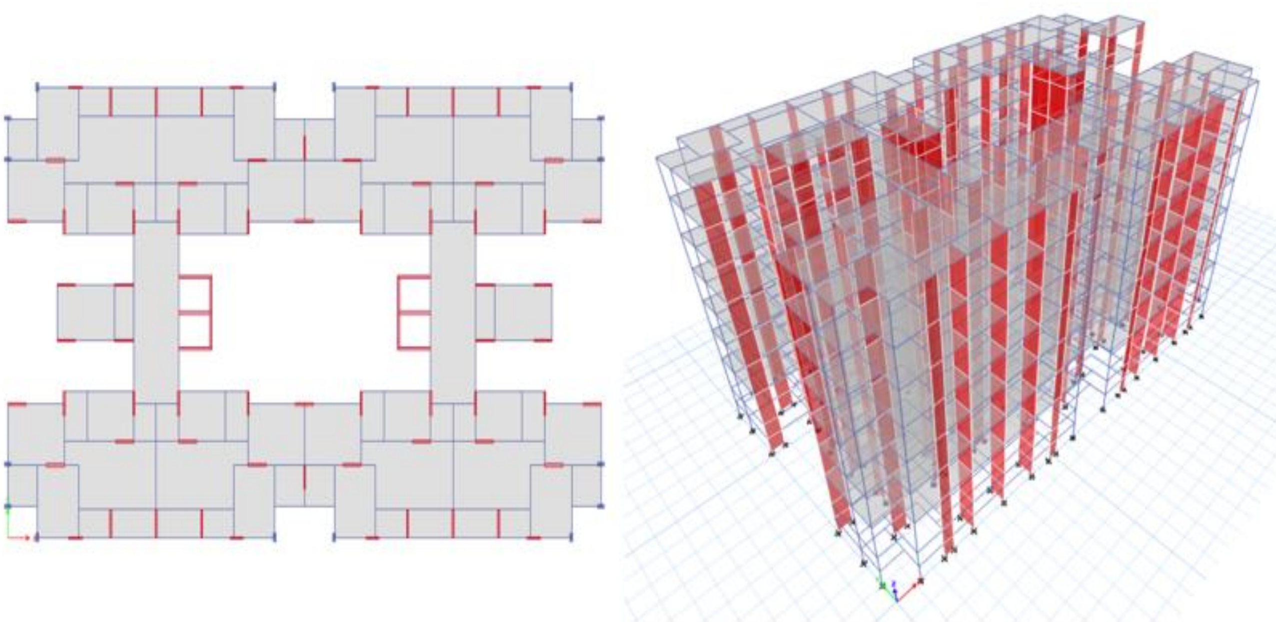

Fig. 3: Model 2: SW (Building with only shear wall)

4. ANALYSIS AND RESULT :

The response parameters that were considered in this study were the Base shear, Maximum top-storey displacement, Maximum storey drift and Storey Stiffness of the building. Results from response spectrum and time history are present here.

Base Shear (kN):

Fig. 4: Base shear under Response Spectrum

Fig. 5: Base shear under Time History Avg

Storey Displacement (mm):

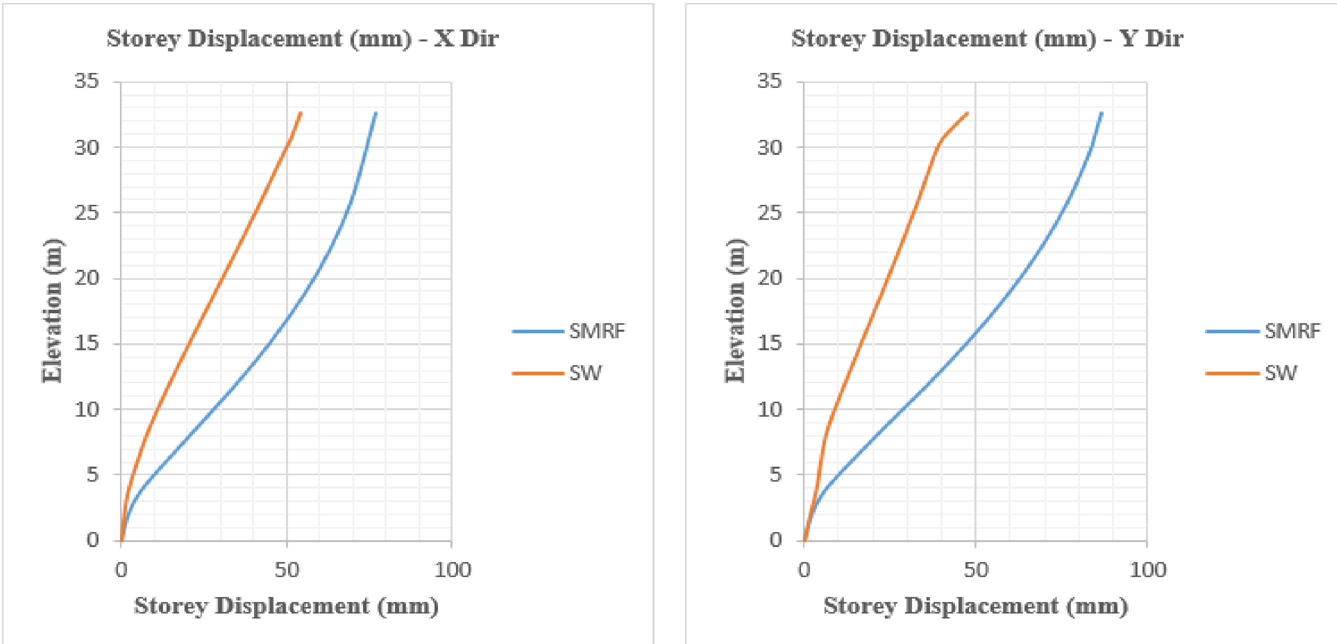

Fig. 6: *Storey Displacement under Response Spectra*

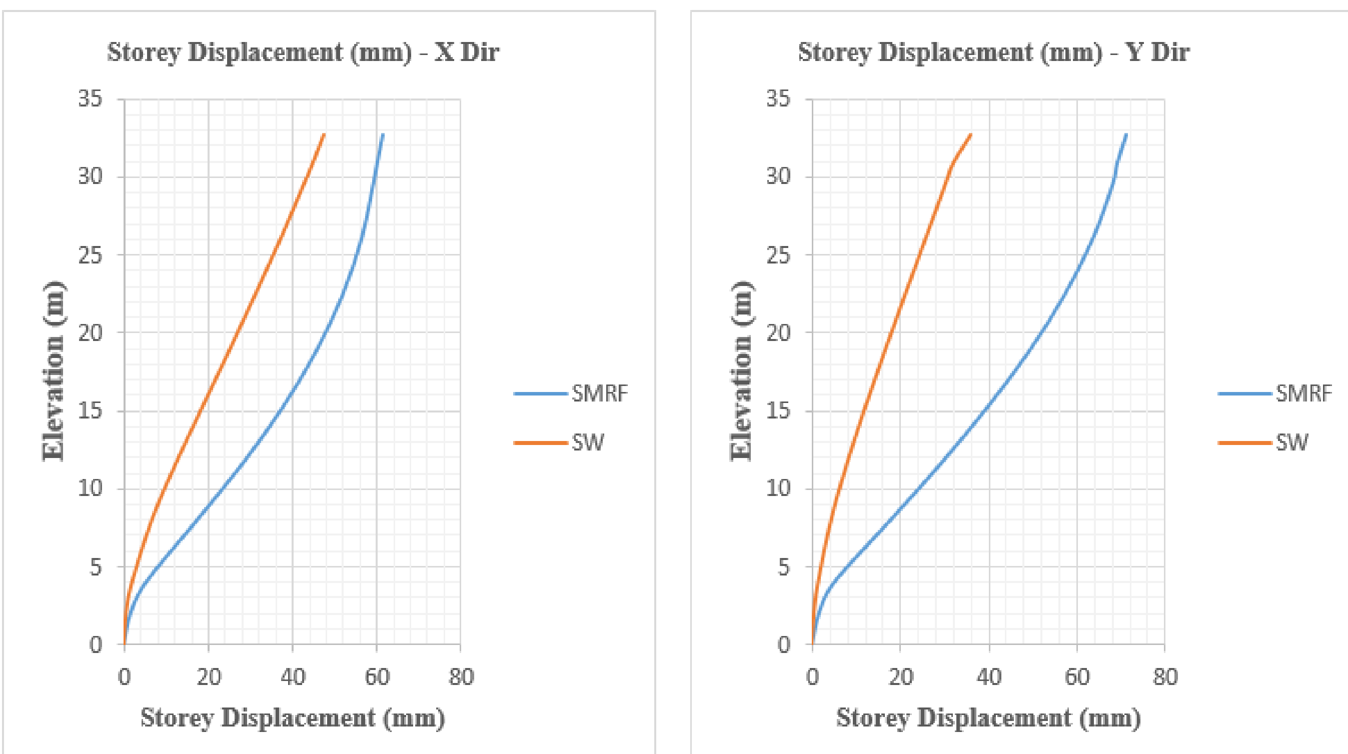

Fig. 7: *Storey Displacement under Time History Avg*

Storey Drift (Unitless):

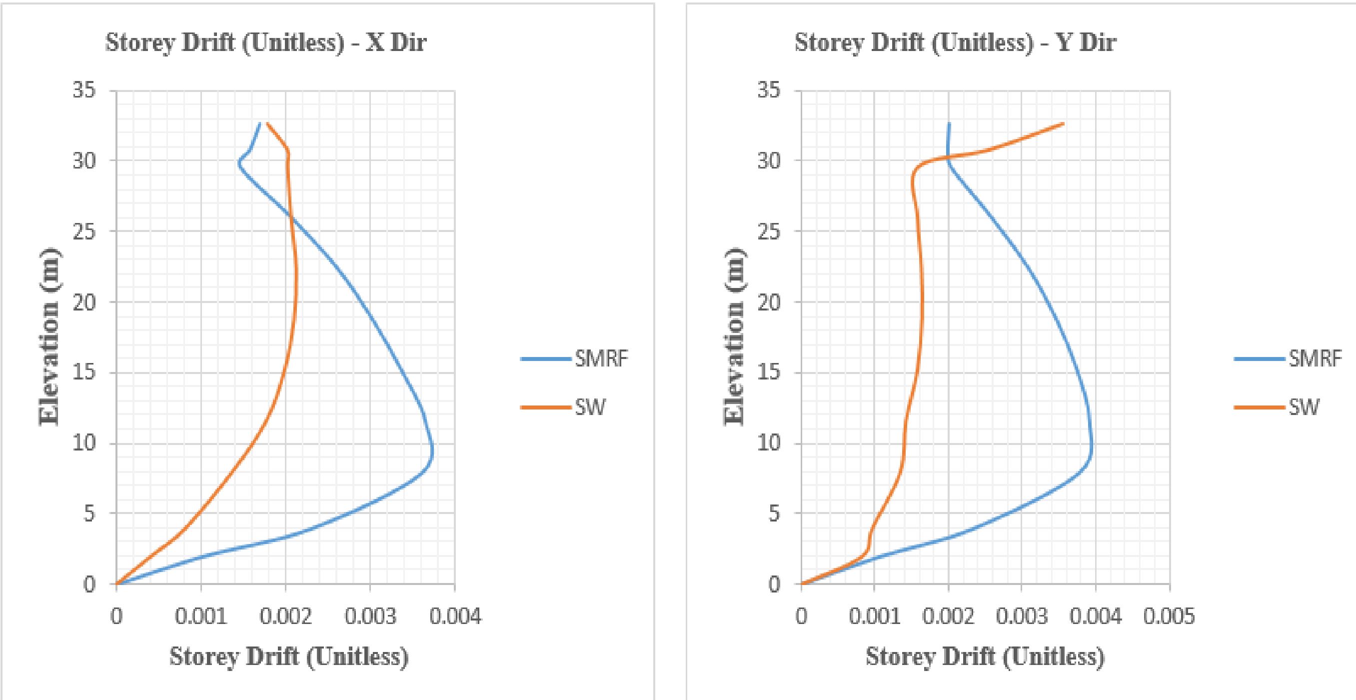

Fig. 8: Storey Drift under Response Spectrum

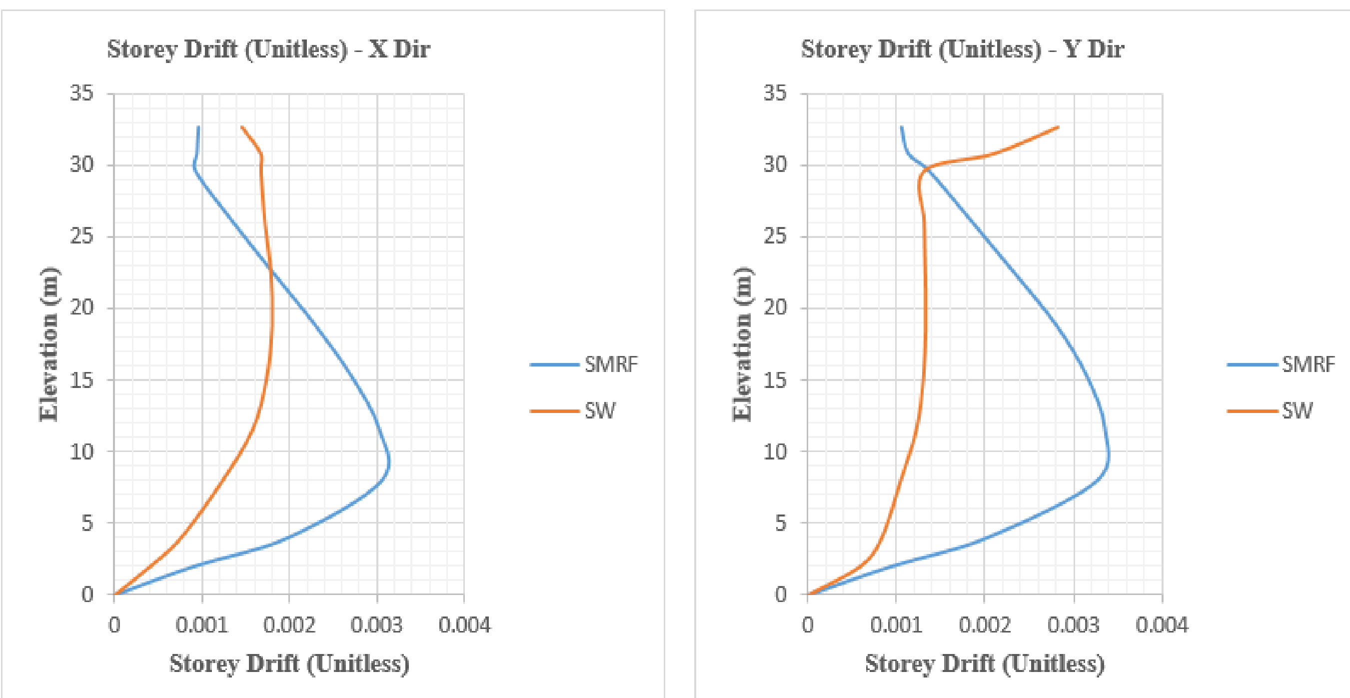

Fig. 9: Storey Drift under Time History Avg

Storey Stiffness (kN-m):

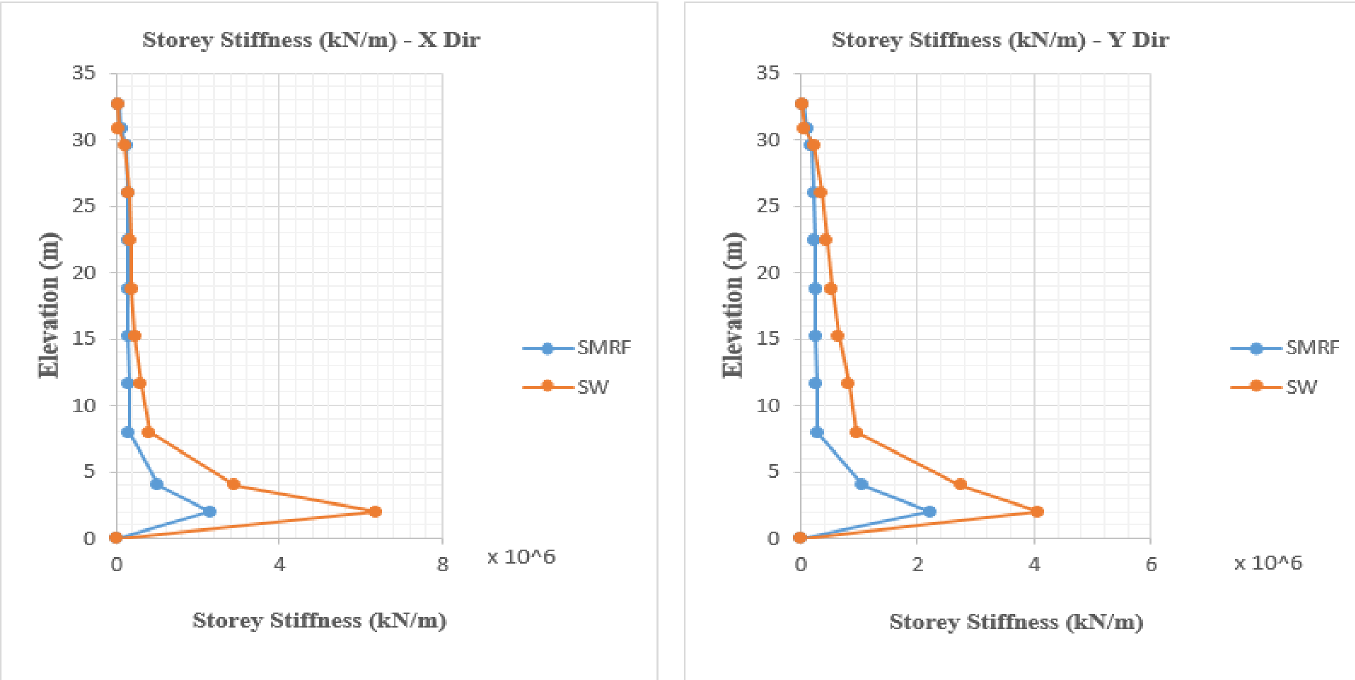

Fig. 10: *Storey Stiffness*

5. ESTIMATION :

The two models are designed and the quantities of steel and concrete are calculated as per IS 456:2000 & IS 13920:2016. The Results are tabulated below.

Comparison of Consumption of Concrete and steel for Model1 & Model 2:

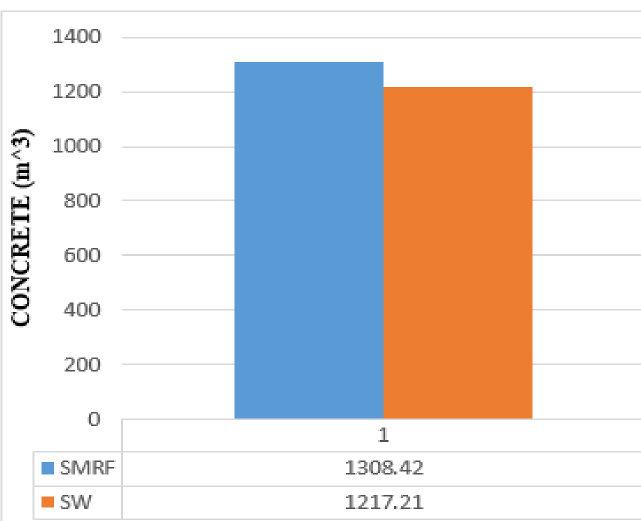

Fig. 11: *Consumption of Concrete (m^3)*

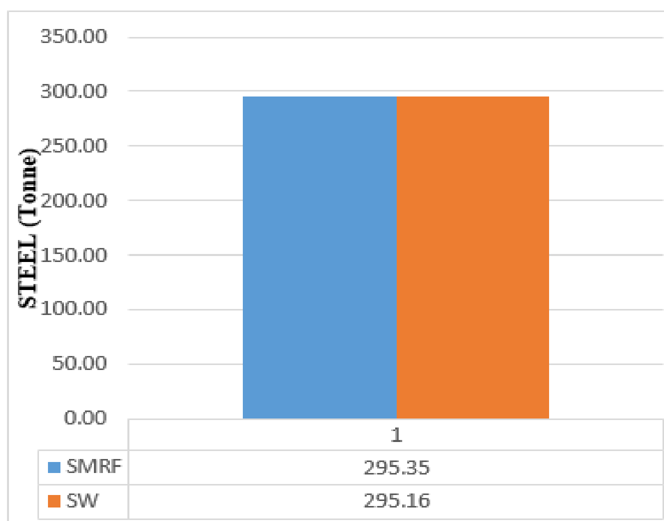

Fig. 12: *Consumption of Steel (Tonne)*

6. CONCLUSIONS :

By comparing Base shear, Storey Displacement, Storey Drift, Storey Stiffness and Quantities of steel and concrete following point can be concluded.

- From the plots of base shear in the both building, it is seen that the base shear of building with R.C. shear wall is 5% to 9% more than the building with SMRF.
- It is seen that from the plots of storey displacements that RC shear wall Building with Seismic Zone 3 has 30% to 45% lesser storey displacement than the building with SMRF and similarly 40% to 50% reduced in Storey Drift in RC shear wall building then the building with SMRF.
- It has been found that the building with R.C. shear wall has more Storey Stiffness then the building with SMRF.
- RC shear wall building gives less quantities of concrete and same quantities of steel as compared to the building with SMRF.
- From all results, it has been found that the building with R.C. shear wall is economical and shows better response then the same building with SMRF.

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