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# A COMPARATIVE STUDY OF OMRF & SMRF STRUCTURAL SYSTEM USING DIFFERENT SOFTWARES

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***Abstract-- This study is carried out to investigate the seismic behaviour of the structure having various structural configurations like OMRF (Ordinary Moment Resisting Frames), SMRF (Special Moment Resisting Frames) using different softwares i.e. Stadd.Pro & Etabs. A comparative study of all the types of frames will shed light on the best suited frame to be adopted for seismic loads in Indian scenario. For this purpose, a G+6 storey R.C.C. regular building are analysed for OMRCF, SMRCF framing configurations in Seismic Zone III & IV according to Indian codes. Linear static Analysis or Equivalent static Analysis are carried out to evaluate their structural efficiencies in terms of storey drifts, average storey displacement, Time period. In OMRF structures the design and detailing of reinforcement are executed as per the guide lines of I.S. 456-2000 which make the structure less tough and ductile in comparison of SMRF structures. The basic approach of earthquake resistant design should be based on lateral strength as well as deformability and ductility capacity of structure .In SMRF structures Beams, columns, and beam-column joints are proportioned and detailed as per I.S. code 13920(2002) which give adequate toughness and ductility to resist severe earthquake shock without collapse. Thus it has been observed that SMRF structures behave well in earthquake than OMRF structures.***

***Keywords:- Moment resisting frames, SMRF, OMRF, Equivalent static lateral force procedure, ductility, earthquake engineering, response reduction factor, seismic weight, fundamental natural period, STADD.PRO.***

## 1. INTRODUCTION

Some of the largest earthquakes of the world have occurred in India and the earthquake engineering developments in the country started rather early. After the 1987 Assam earthquake a new earthquake resistant type of housing was developed which is still prevalent in the north-east India. The Baluchistan earthquakes of 1030's led to innovative earthquake resistant constructions and to the development of first seismic zone map. The institutional development started in the late 1950's and earthquake engineering concepts have been applied to numerous major projects in high seismic regions in the country. Extensive damage during several moderate earthquakes in recent years indicates that despite such early gains, earthquake risk in the country has been increasing alarmingly. Most buildings even in high seismic regions of the country continue to be built without appropriate earthquake resistant features. At the higher end of earthquake technology, the gap between state-of-the-practice of earthquake engineering and research in India, bench-marked against the advanced countries, has been widening.

Indian earthquake problem cannot be overemphasized. More than about 60% of the land area is considered prone to shaking of intensity VII and above (MMI scale). In fact, the entire Himalayan belt is considered prone to great earthquakes of magnitude exceeding 8.0 and in ashort span of about 50 years, four such earthquakes have occurred; 1897 Assam (M8.7), 1905 Kangra (M8.6),1934 Bihar-Nepal (M8.4),and 1950 Assam-Tibbet (M8.7). Despite an early start, the seismic risk in the country has been increasing rapidly in the recent years. Five moderate earthquakes in the last eleven years(1988 Bihar-Nepal; M6.6,about 1004 dead;1991 Uttarkashi: M6.6, about 768 dead; 1993 Lathur : M6.4, about 8000 dead; 1997 Jabalpur: M6.0, about 38 dead; and 1999 Chamoli: M6.5, about 100 dead) have clearly underlined the inadequate preparedness of the country to face damaging earthquakes. The selection of particular type of framing system depends upon two important parameters i.e. Seismic risk of the zone and the budget. The lateral forces acting on any structure are distributed according to the flexural rigidity of individual components. Indian Codes divide the entire country into four seismic zones (II, III, IV & V) depending on the seismic risks. OMRF is probably the most commonly adopted type of frame in lower seismic zones. However with increase in the seismic risks, it becomes insufficient and SMRF need to be adopted.

## 2. DESCRIPTION OF STRUCTURAL MODELS

A total of 8 moment resisting frames are selected of similar number of story, number of bays, and of same configurations, and different design methodology with regard to response reduction factors Rand Zone factor Z are adopted. The storey height is 3.0 m and bay width is 4m in width and 5m in length, which is same for all frames.The foundation depth is assumed 1.5m and all supports are fixed. The section of all columns is rectangular of size0.500*0.500 m and sections of all beams are rectangular of size 0.300*0.450 m. Each frame is analysed as OMRF and SMRF considering response reduction factors such as 3 and 5 using Stadd.pro. And Etabs softwares. IS code suggests a response reduction factor of 3 for OMRF and 5 for SMRF. The analysis of the frames is carried out by conducting static linear analysis of bare frames as per loading suggested by IS 1893Part-1(2002).

MATERIAL PROPERTIES AND GEOMETRIC PARAMETERS ASSUMED

| Sl No. | DESIGN PARAMETER | VALUE |
|---|---|---|
| 1 | UNIT WEIGHT OF CONCRETE | 25 kN/m$^3$ |
| 2 | UNIT WEIGHT OF INFILL WALLS | 20kN/m$^3$ |
| 3 | CHARACTERISTIC STRENGTH OF CONCRETE | 20 N/mm2 |
| 4 | CHARACTERISTIC STRENGTH OF STEEL | 415 N/mm2 |
| 5 | DAMPING RATIO | 5% |
| 6 | MODULUS OF ELASTICITY OF STEEL | 2e+5 N/mm2 |
| 7 | SLAB THICKNESS | 150 mm |
| 8 | EXTERNAL WALL THICKNESS | 230 mm |
| 9 | INTERNAL WALL THICKNESS | 115 mm |

SEISMIC DESIGN DATA ASSUMED FOR SPECIAL MOMENT RESISTING FRAMES

| S No. | DESIGN PARAMETER | VALUE |
|---|---|---|
| 1 | SEISMIC ZONE | III and IV |
| 2 | ZONE FACTOR (Z) | 0.16 and 0.24 |
| 3 | RESPONSE REDUCTION FACTOR (R) | 5 |
| 4 | IMPORTANCE FACTOR (I) | 1 |
| 5 | SOIL TYPE | Medium soil |
| 6 | DAMPING RATIO | 5% |
| 7 | FRAME TYPE | Special Moment Resisting Frame |

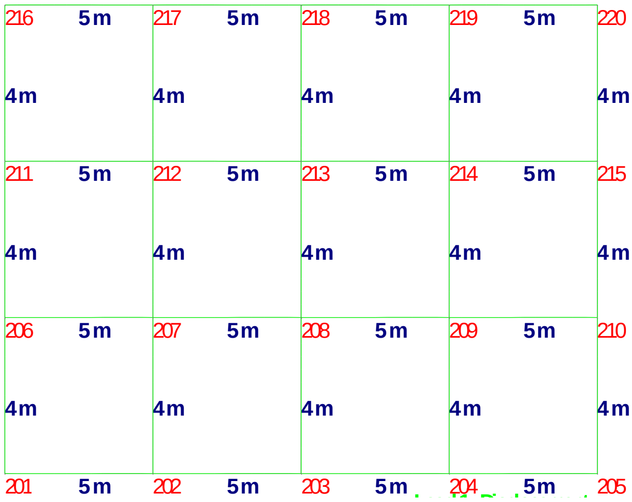
SEISMIC DESIGN DATA ASSUMED FOR ORDINARY MOMENT RESISTING FRAMES

| S.NO. | DESIGN PARAMETER | VALUE |
|---|---|---|
| 1 | SEISMIC ZONE | III and IV |
| 2 | ZONE FACTOR (Z) | 0.16 and 0.24 |
| 3 | RESPONSE REDUCTION FACTOR (R) | 3 |
| 4 | IMPORTANCE FACTOR (I) | 1 |
| 5 | SOIL TYPE | Medium soil |
| 6 | DAMPING RATIO | 5% |
| 7 | FRAME TYPE | Ordinary Moment Resisting Frame |

LOADS CONSIDERED FOR DESIGNING BUILDINGS

| S NO. | LOAD TYPE | VALUE |
|---|---|---|
| 1 | SELF-WEIGHT OF BEAMS AND COLUMNS | As per dimensions. |
| 2 | WEIGHT OF SLAB | 3.75 KN/m2 |
| 3 | INFILL WEIGHT(230MM THICK BRICK WALL) | 13.8 KN/m |
| 4 | PARAPET WEIGHT | 4.14 KN/m |
| 5 | FLOOR FINISH | 1.0 KN/m$^2$ |
| 6 | LIVE LOAD(FLOOR) | 3.0 KN/m$^2$ |
| 7 | INFILL WEIGHT(115MM THICK BRICK WALL | 6.9 kn/m |
| 8 | WATER PROOFING LOAD | 2.0 kn/m2<br>2.0kn/m2 |
| 9 | LIVE LOAD ON TERRACE | 1.5 kn/m2<br>1.5 kn/m2 |

BUILDING PLAN FOR ANALYSIS




## 3. RESULTS AND DISCUSSION

In this paper the results of all the building models are presented. Analysis was carried out using ETABS and Stadd.pro. And different parameters studied such as Fundamental natural time period, Base shear, storey displacement and storey drifts for EQX Loading in X direction, the tables and figures are shown below

TABLE 1: COMPARISON OF TIME PERIOD BETWEEN IS CODE, STADD PRO AND ETABS.

| STRUCTURE SYSTEM | ZONE | IS CODE METHOD | STADD ANALYSIS | ETABS ANALYSIS |
|---|---|---|---|---|
| OMRF | III | 0.775 | 0.775 | 1.27 |
| SMRF | III | 0.775 | 0.775 | 1.27 |
| OMRF | IV | 0.775 | 0.775 | 1.27 |
| SMRF | IV | 0.775 | 0.775 | 1.27 |

BAR CHART 1: COMPARISON OF TIME PERIOD BETWEEN IS CODE, STADD PRO AND ETABS

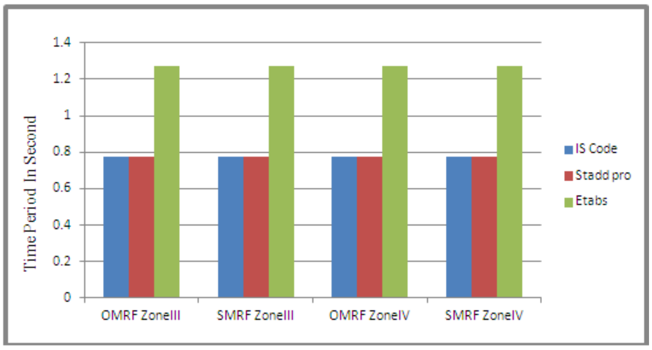



TABLE 2: COMPARISON OF BASE SHEAR WITH IS CODE METHOD, STADD.PRO TIME PERIOD, ETABS (IS CODE TIME PERIOD) AND ETABS TIME PERIOD IN ZONE III& IV.

| STRUCTURAL SYSTEM | IS CODE TIME PERIOD METHOD | STADD.PRO. TIME PERIOD | ETABS(IS CODE TIME PERIOD) | ETABS.TIME PERIOD |
|---|---|---|---|---|
| OMRF ZONE III | 1202.90 | 1193.93 | 1196.15 | 728.3 |
| SMRF ZONE III | 721.74 | 716.86 | 717.68 | 440.35 |
| OMRF ZONE IV | 1804.35 | 1790.89 | 1794.22 | 1093.73 |
| SMRF ZONE IV | 1082.61 | 1074.02 | 1076.53 | 660.53 |

BARCHART 2: COMPARISON OF BASE SHEAR WITH IS CODE METHOD, STADD.PRO TIME PERIOD, ETABS (IS CODE TIME PERIOD) AND ETABS TIME PERIOD IN ZONE III&IV

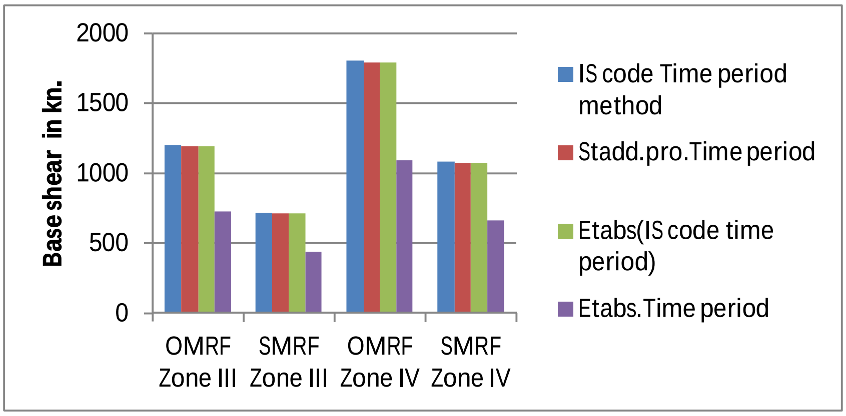



TABLE 3 COMPARATIVE AVERAGE DISPLACEMENTS IN ZONE III &IV

| STOREY | ELEVATION IN M | AVERAGE DISPLACEMENT IN MM. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | STADD | | | | ETABS | | | |
| | | OMRF | | SMRF | | OMRF | | SMRF | |
| | | ZONE III | ZONE IV | ZONE III | ZONE IV | ZONE III | ZONE IV | ZONE III | ZONE IV |
| 8 | 22.5 | 37.32 | 55.99 | 22.390 | 33.59 | 36.000 | 53.900 | 21.620 | 32.400 |
| 7 | 19.5 | 34.85 | 52.28 | 20.910 | 31.37 | 33.700 | 50.500 | 20.200 | 30.300 |
| 6 | 16.5 | 30.881 | 46.32 | 18.529 | 27.79 | 29.900 | 44.900 | 18.000 | 26.900 |
| 5 | 13.5 | 25.625 | 38.43 | 15.370 | 23.06 | 24.900 | 37.300 | 14.900 | 22.400 |
| 4 | 10.5 | 19.477 | 29.21 | 11.680 | 17.53 | 18.900 | 28.400 | 11.400 | 17.000 |
| 3 | 7.5 | 12.84 | 19.26 | 7.740 | 11.55 | 12.500 | 18.700 | 7.500 | 11.200 |
| 2 | 4.5 | 6.24 | 9.36 | 3.744 | 5.616 | 6.100 | 9.100 | 3.600 | 5.500 |
| 1 | 1.5 | .925 | 1.38 | 0.555 | 0.833 | 0.900 | 1.400 | 0.500 | 0.800 |
| BASE | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

GRAPH 1 COMPARATIVE AVERAGE DISPLACEMENT IN ZONE III &IV

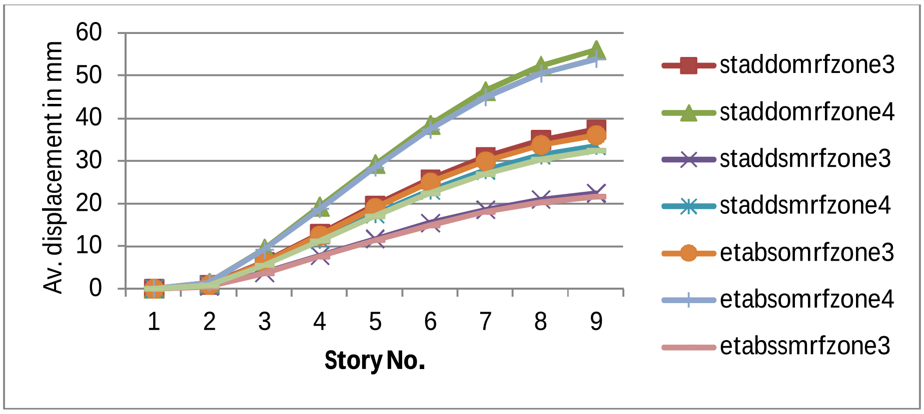
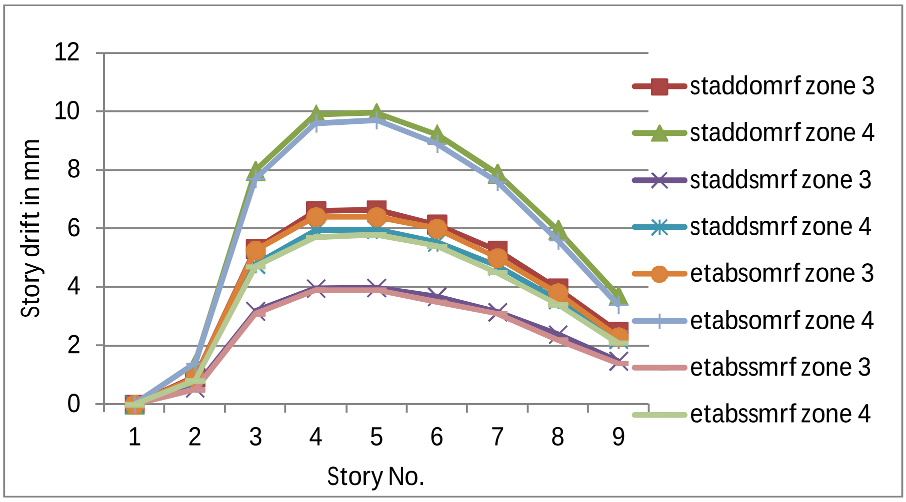


TABLE 4: COMPARATIVE STOREY DRIFT IN ZONE III &IV

| STOREY | ELEVATION IN M | STOREY DRIFT IN MM. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | STADD | | | | ETABS | | | |
| | | OMRF | | SMRF | | OMRF | | SMRF | |
| | | ZONE III | ZONE IV | ZONE III | ZONE IV | ZONE III | ZONE IV | ZONE III | ZONE IV |
| 8 | 22.5 | 2.47 | 3.70 | 1.48 | 2.22 | 2.30 | 3.40 | 1.40 | 2.10 |
| 7 | 19.5 | 3.97 | 5.96 | 2.38 | 3.57 | 3.80 | 5.60 | 2.20 | 3.40 |
| 6 | 16.5 | 5.25 | 7.88 | 3.15 | 4.73 | 5.00 | 7.60 | 3.10 | 4.50 |
| 5 | 13.5 | 6.14 | 9.22 | 3.68 | 5.53 | 6.00 | 8.90 | 3.50 | 5.40 |
| 4 | 10.5 | 6.63 | 9.95 | 3.98 | 5.97 | 6.40 | 9.70 | 3.90 | 5.80 |
| 3 | 7.5 | 6.60 | 9.90 | 3.96 | 5.94 | 6.40 | 9.60 | 3.90 | 5.70 |
| 2 | 4.5 | 5.31 | 7.97 | 3.18 | 4.78 | 5.25 | 7.70 | 3.10 | 4.70 |
| 1 | 1.5 | 0.925 | 1.38 | 0.555 | 0.833 | 0.90 | 1.40 | 0.50 | 0.80 |
| BASE | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

GRAPH 2: COMPARATIVE STOREY DRIFT IN ZONE III &IV




The following observations are made , based on the results presented in Table 1 to 4.

1: In table 1 results are presented regarding fundamental natural time periods. In the light of results the following observations are made:

a:The time period in special moment resisting frame and in ordinary moment resisting frame is equal in both seismic zones.

b:The time period in special moment resisting frame and in ordinary moment resisting frame obtained by IS code method (manual) and Stadd. Software are same.

c: The time period in special moment resisting frame and in ordinary moment resisting frame obtained by Etabs programe is about 64% higher than that of obtained by IS code method (manual) and Stadd. Software .

2: In table 2 results are presented regarding design base shear of the structure under seismic zone III& IV at a glance. In the light of results the following observations are made:

a:The design base shear in special moment resisting frame is about 40% lower than that of in ordinary moment resisting frame .

b:The design base shear in special moment resisting frame and in ordinary moment resisting frame obtained by IS code method (manual) and Stadd. Software are almost same.

c:The design base shear in special moment resisting frame and in ordinary moment resisting frame obtained by Etabs as per programmed time period is about 40% lower than that of obtained by IS code method (manual) and Stadd. Software.

d:The design base shear obtained under zone III is 33.33% lower than that of under zone IV.

3: In table 3 results are presented regarding Average displacements under seismic zone III & IV at a glance. In the light of results the following observations are made

a:The Average displacement in special moment resisting frame is about 40% lesser than that of in ordinary moment resisting frame.

b:The Average displacement in special moment resisting frame is about 40% lesser than that of in ordinary moment resisting frame obtained by Etabs Software.
c: The Average displacement obtained by Etabs software is almost same that of obtained by Stadd.Pro. software.
d: The max. Average displacement occurred at top story of the building .
e: The min. Average displacement occurred at bottom story of the building.
f: The pattern of storey wise variation of average displacement is same in special moment resisting frame and ordinary moment resisting frame.
g: The Average displacement under seismic zone III is 33.33% lower than that of under seismic zone IV.

4: In table 4 results are presented regarding story drift under zone III&IV at a glance. In the light of results the following observations are made:
a:The Story drift in special moment resisting frame is 40% lesser than that of in ordinary moment resisting frame obtained by Stadd. Pro. Software.
b: The Story drift in special moment resisting frame is 40% lesser than that of in ordinary moment resisting frame obtained by Etabs Software.
c: The Story drift obtained by Etabs software is almost same that of obtained by Stadd.Pro. Software.
d: The max. Story drift occurred at mid story of the building.
e: The of variation of story drift is increasing in nature from bottom story to mid story and decreasing in nature from midstory to top story of building.
f: The min. Story drift is at bottom floor.
g:The Storey drift under seismic zone III is 33.33% lower than that of under seismic zone IV.

## 4. CONCLUSION

In view of the results and observations obtained by the analysis of the considered building structures, following primary conclusions on the prediction of the concern thesis topic could be made as under.

a:The SMRF structural system is more efficient than OMRF structural system in earthquake design because for a particular seismic zone, design base shear , average displacement and story drift for SMRF is 40% lower than that of OMRF.
b:The design of buildings using Etabs software as per programmed calculated fundamental natural time period will be more economical design than that of Stadd.Pro. software because design base shear obtained in first case is 40% lower than that of second case.

## 5. SCOPE FOR FUTURE WORK

a:Another field of wide research could be the analysis and design of moment resisting frames considering the infill walls and shear walls as a part of the structure.
b:The study of seismic behavior of structural system could be extended using one another software.
c:The study of seismic behavior of structural system could be extended considering more than two seismic zones

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