Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 7, July -2017

# SEISMIC ANALYSIS OF MULTI-STOREY RCC BUILDING AND STEEL BUILDING USING ETABS

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**Abstract** — *The present Study is aims to evaluate the seismic response of the multistory building made up of different material, i.e. Concrete and Steel so that one can choose best alternative which has good seismic performance as well as economy. To show importance of effect of infill masonry wall modeling is done with and without considering stiffness of infill wall. Equivalent Static Method of Analysis is used. For modeling of Steel and R.C.C. structures, ETABS software is used and the results are compared; and it is found that RCC building has more seismic weight, brick infill walls present in the building reduces the structural drift but increases the strength, which ensures good seismic behavior and gives economical structural design. Stiff structures attracts the more seismic force but have performed better during past earthquake Usually infill is provided in structures and thus RCC building will be more stiffer than Steel building and therefore RCC structure is one of the best options for construction of multistory building as well as for earthquake resistant structure.*

***Keywords****- ETAB software, Steel Building, Conventional RCC Building*

## I. INTRODUCTION

Structures on the earth are generally subjected to two types of load i.e. static and dynamic. Static loads are constant with time while dynamic loads are time varying. In general majority of the civil structures are designed with the assumption that all applied loads are static. The effect of dynamic load is not being considered because the structure is rarely subjected to dynamic loads, more its consideration in the analysis makes the solution more complicated and time consuming. This aspect of neglecting dynamic forces may sometimes become the cause of disaster, particularly in case of earthquake. An Earthquake is a natural disaster that unlike the other disasters like floods etc leaves no time for evacuation of people to safer places thus causing a huge loss of lives as well as property. Hence designing our buildings to resist these seismic loads is the only feasible alternative. Each damage case has provided important information for improving the design and construction practices thus trying to protect the occupants of the buildings. This chapter includes the code based procedure for seismic analysis, structural modeling concept and objective of the present study.
Indian tectonic plate being one of the most active tectonic plates, India has faced a number of deadly earthquakes that left thousands of people dying each time. The Bureau of Indian standards (BIS) has been doing a considerable effort to mitigate the hazards due to these earthquakes. Scientists in India have concentrated on bringing up a code of practice for seismic resistant design (IS 1893), which gives guidelines to Engineers on the amount of forces to be accounted in the seismic regions. Development of Seismic Zoning map has been a subject of research in India for the past 40 years. Seismic zoning map is a map that divides entire country into different regions according to the earthquake potential in those regions.

## II. OBJECTIVES OF THE STUDY

- The present Study is aims to evaluate the seismic response of the multistory building made up of different material, i.e. Concrete and Steel so that one can choose best alternative which has good seismic performance as well as economy.
- To show importance of effect of infill masonry wall modeling is done with and without considering stiffness of infill wall.
- To understand the response of the building under earthquake, static seismic coefficient method will be performed and the response of the structure in terms of frequency, Storey displacement, story shear, Storey stiffness, is compared for all type of models.

## III. Problem Statement

In present work in order to compare reinforced concrete and steel for use in Earthquake prone area G+6 multi storey building having plan dimension 22.5mx30m is modeled and analyzed in Etabs 9.2 Non Linear Version software. Equivalent static analysis is performed on the structure.

| Geometrical Data | | Earthquake Data | |
|---|---|---|---|
| Type of Building | Commercial building | Frame | Special moment Resisting Frame |
| Location of Building | Surat | Location | Surat (Zone III) |
| Height of Building : | 21.5 m | Importance Factor | 1.5 |
| Typical Storey Height | 3 m | Response Reduction Factor | 5 |
| Bottom Storey Height | 3.5 m | Type of Soil | Medium (Type 2) |
| Infill Walls | 120 mm thick Exterior wall | | |

**Material Data**

| Material | Weight (kN/m3) | Modulus of Elasticity (E) (kN/m2) | Shear Modulus (G) | Poissons Ratio | Coeffi. Of Thermal Expansion |
|---|---|---|---|---|---|
| Concrete (fck=M25) | 25 | $25x10^{6}$ | 10416666.7 | 0.2 | $9.9x10^{-6}$ |
| Steel (Fe-415) | 78.5 | $2x10^{8}$ | 76884615 | 0.3 | $11.7x10^{-6}$ |
| Masonry | 20 | $11x10^{6}$ | 521739.13 | 0.15 | $7x10^{-6}$ |

**Member sizes**

| Element | Steel Structure | RCC structure |
|---|---|---|
| Column | Built up column ISWB 600-2 with 40 mm thick cover plates on both side | 500mmx800mm |
| Main Beam | ISWB 500 | 350mmx600mm |
| Secondary Beam | ISMB 400 | 350mmx500mm |
| Bracing | 0.12mx1.22m | 0.12mx1.22m |

## IV. Analysis, Result and Discussion

In present work in order to compare seismic response of RCC and STEEL building, Equivalent Static analysis is performed.
Storey drift, Base shear distribution, seismic load, Storey displacement, time period are tabulated and compared. It should be noted that all comparison is made for X direction.

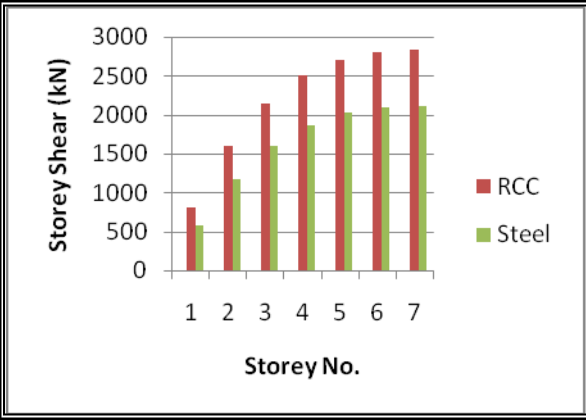
## V. Storey Shear and Moment

The magnitude of the lateral force depends on the mass of the building lumped at each floor level, the distribution of stiffness over height and the storey displacement in a given mode.

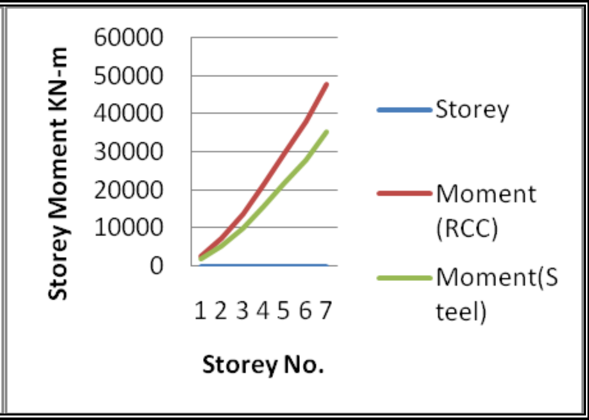
**Storey Shear & Moment In X Direction**

| Storey | Shear (RCC) | Shear (Steel) | Moment (RCC) | Moment(Steel) |
|---|---|---|---|---|
| 7 | 809.73 | 576.87 | 2429.18 | 1730.61 |
| 6 | 1594.85 | 1173.22 | 7213.72 | 5250.29 |
| 5 | 2145.98 | 1591.85 | 13651.66 | 10025.83 |
| 4 | 2504.42 | 1864.11 | 21164.92 | 15618.15 |
| 3 | 2711.45 | 2021.36 | 29299.27 | 21682.23 |
| 2 | 2808.37 | 2094.98 | 37724.38 | 27967.17 |
| 1 | 2836.65 | 2116.40 | 47652.66 | 35374.56 |




Storey Shear for Static analysis



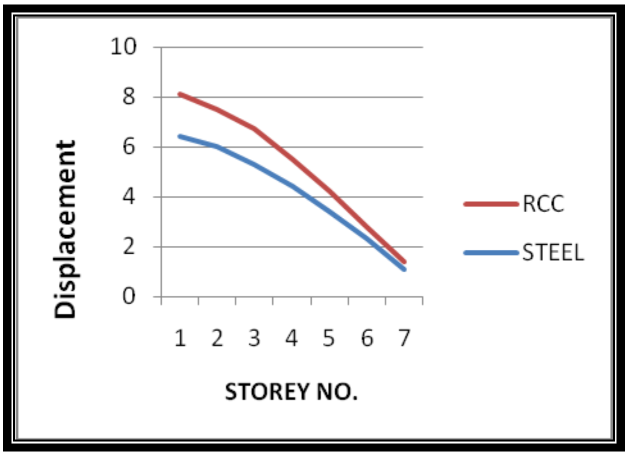

Storey Moment for static analysis

## VI. Storey Displacement

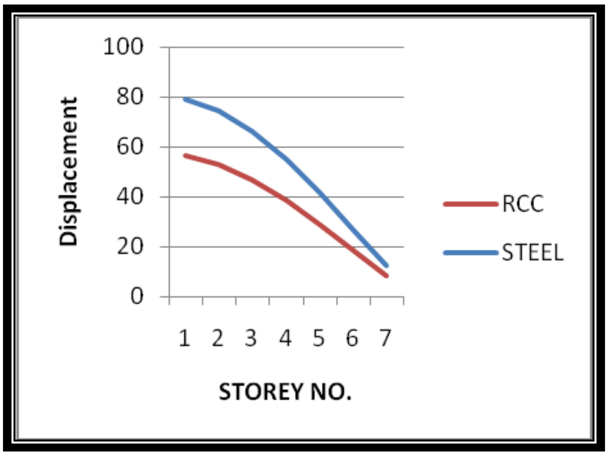
Storey drift is calculated from the storey displacement. More storey displacement indicates less stiffness of structure.

**Maximum Storey Displacement**

| Storey | RCC | | Steel | |
|---|---|---|---|---|
| | With infill | without infill | With infill | without infill |
| 7 | 8.1 | 56.3 | 6.4 | 79.0 |
| 6 | 7.5 | 52.7 | 6.0 | 74.3 |
| 5 | 6.7 | 46.7 | 5.3 | 66.0 |
| 4 | 5.5 | 38.5 | 4.4 | 54.6 |
| 3 | 4.2 | 28.9 | 3.4 | 41.3 |
| 2 | 2.8 | 18.5 | 2.3 | 26.8 |
| 1 | 1.4 | 8.3 | 1.1 | 12.2 |




With infill




Without infill

## VII. Storey Stiffness

Stiffness is calculated by assuming that supports are fixed and load is applied at floor level. Horizontal displacement is measured at floor level and lateral stiffness is calculated by dividing horizontal deflection to lateral load. In other words stiffness is the force needed to cause unit displacement and is given by slope of force displacement relationship. Strength is a maximum force that a system can take.

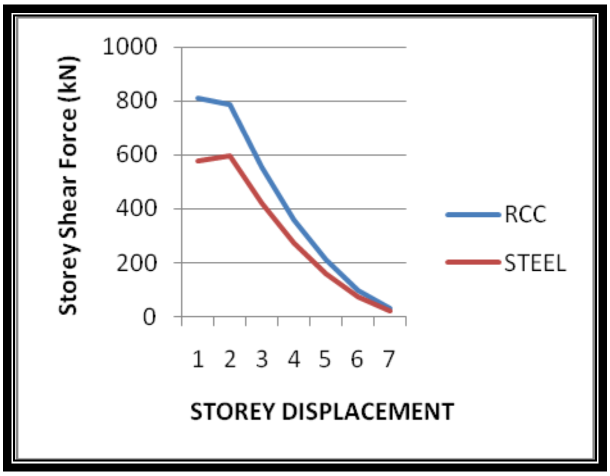
**Storey Displacement in X direction considering Infill Wall**

| Storey | RCC | | STEEL | |
|---|---|---|---|---|
| | Force | Displacement | Force | Displacement |
| 7 | 809.73 | 8.1 | 576.87 | 6.4 |
| 6 | 785.12 | 7.5 | 596.35 | 6.0 |
| 5 | 551.13 | 6.7 | 418.62 | 5.3 |
| 4 | 358.44 | 5.5 | 272.26 | 4.4 |
| 3 | 207.03 | 4.2 | 157.26 | 3.4 |
| 2 | 96.92 | 2.8 | 73.62 | 2.3 |
| 1 | 28.28 | 1.4 | 21.42 | 1.1 |

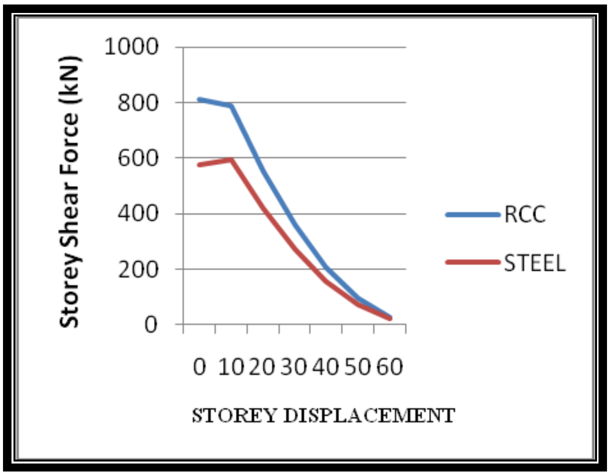
 

**Storey Displacement in X direction not Considering Infill Wall (mm)**

| Storey | RCC | | STEEL | |
|---|---|---|---|---|
| | Force | Displacement | Force | Displacement |
| 7 | 809.73 | 56.3 | 576.87 | 79.0 |
| 6 | 785.12 | 52.7 | 596.35 | 74.3 |
| 5 | 551.13 | 46.7 | 418.62 | 66.0 |
| 4 | 358.44 | 38.5 | 272.26 | 54.6 |
| 3 | 207.03 | 28.9 | 157.26 | 41.3 |
| 2 | 96.92 | 18.5 | 73.62 | 26.8 |
| 1 | 28.28 | 8.3 | 21.42 | 12.2 |




With Infill Wall




Without Infill Wall

**Frequency and Storey Drift**

The stiffer structures have lesser natural period and their response is governed by the ground acceleration; most buildings fall in this category. The flexible structures have larger natural period and their response is governed by the ground displacement, for example, large span bridges.

Storey drift is directly related to the stiffness of the structure. The higher the stiffness lowers the drift and higher the lateral loads on the structure.

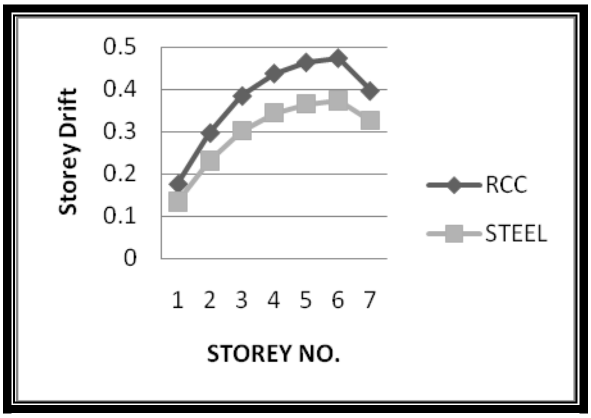
**Frequency (Cycle/Sec)**

| Mode | RCC | | Steel | |
|---|---|---|---|---|
| | with infill | without infill | with infill | without infill |
| 1 | 1.8889 | 0.7983 | 2.1420 | 0.6718 |
| 2 | 2.0994 | 0.8805 | 2.3566 | 0.8632 |
| 3 | 5.7380 | 2.4995 | 6.3121 | 1.0251 |
| 4 | 6.2489 | 2.9017 | 6.5100 | 2.0915 |
| 5 | 7.0758 | 2.9427 | 6.5362 | 3.0225 |
| 6 | 7.3361 | 4.4718 | 6.6989 | 3.7052 |
| 7 | 7.4287 | 5.5928 | 6.7056 | 5.5403 |
| 8 | 7.9264 | 6.7592 | 6.7796 | 6.1890 |
| 9 | 9.5470 | 7.0565 | 6.9970 | 6.4961 |
| 10 | 9.5708 | 7.8080 | 7.8064 | 7.0576 |

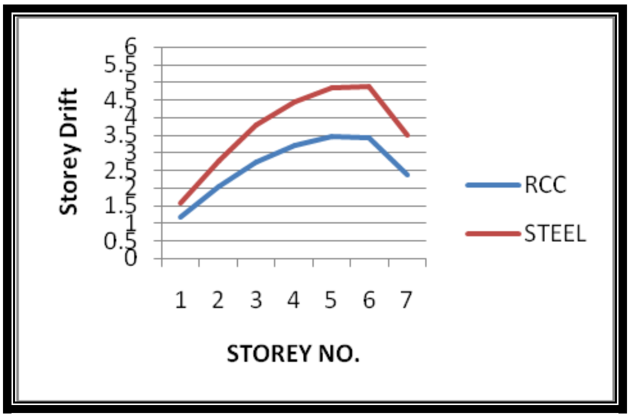
**Maximum Storey Drift In X Direction (mm)**

| Mode | RCC | | Steel | |
|---|---|---|---|---|
| | with infill | without infill | with infill | without infill |
| 7 | 0.1770 | 1.1860 | 0.1340 | 1.5630 |
| 6 | 0.2970 | 2.0280 | 0.2320 | 2.7800 |
| 5 | 0.3840 | 2.7250 | 0.3020 | 3.7820 |
| 4 | 0.4370 | 3.1970 | 0.3450 | 4.4590 |
| 3 | 0.4630 | 3.4490 | 0.3660 | 4.8340 |
| 2 | 0.4730 | 3.4280 | 0.3740 | 4.8620 |
| 1 | 0.3960 | 2.3580 | 0.3260 | 3.4800 |




With infill wall




Without infill

## VIII. Concluding Remarks

From seismic analysis it is clear that infilled wall play an important role in structures seismic response.
Following Concluding remarks can be made.

- RCC building has more seismic weight. Steel building has 25.39% less seismic weight when compared to RCC building.
- Steel building has average 26% lower storey shear than RCC building.
- When infill wall is not considered in the analysis, Storey displacement is increased by 6 times for RCC and 11 times for steel building. When infill wall is considered in analysis, steel building undergoes 20% less storey displacement than RCC building. When infill wall is not considered in analysis, steel building undergoes 40% more storey displacement than RCC building.
- When infill wall is not considered in the analysis, Storey drift is increased by 6 times for RCC and 11 times for steel building. When infill wall is considered in analysis steel building undergoes 21% less storey drift than RCC building. When infill wall is not considered in analysis, steel building undergoes 38% more storey drift than RCC building.
- When infill wall is considered in analysis RCC building shows lower stiffness and strength, but when infilled wall is not considered in the analysis RCC building shows more stiffness and strength as compared to steel building.

**Comparison of buildings when infill wall is considered in analysis**

| Parameter | RCC | Steel |
|---|---|---|
| Seismic weight | More | Less |
| Storey shear | More | Less |
| Storey displacement | More | Less |
| Storey drift | More | Less |
| Storey stiffness | More | Less |

**Comparison of buildings when infill wall is not considered in analysis**

| Parameter | RCC | Steel |
|---|---|---|
| Seismic weight | More | Less |
| Storey shear | More | Less |
| Storey displacement | Less | More |
| Storey drift | Less | More |
| Storey stiffness | Less | More |

- Above tables indicate that Steel building has higher stiffness and strength than RCC building at lesser dead weight when infilled wall is considered in analysis, while stands lower when infill wall is not considered in analysis.
- Above conclusions indicates that brick infill walls present in the building reduces the structural drift but increases the strength, which ensures good seismic behavior and gives economical structural design.
- For good seismic performance a building should have adequate lateral stiffness. Low lateral stiffness leads to large deformation and strains, damage to nonstructural component, discomfort to occupant.
- Stiff structures though attracts the more seismic force but have performed better during past earthquake.
- Usually infill is provided in structures and thus RCC building will be more stiffer than Steel building and therefore RCC structure is one of the best options for construction of multistory building as well as for earthquake resistant structure.

**REFERENCES**


- Agarwal P. and Shrinkhade M. " Earthquake resistant design of tructures ", Eastern economy edition, PHI press, New delhi,2008.
- Das D. and Murty CVR, " Brick Masonry infills in Seismic Design of RC Frame Building : Part 2- Behaviour ", The Indian Concrete Journal, Aug -2004, pp 31-38.
- Etabs Manual version 9, ETABS – Integrated Building Design Software, Computer and Structures, Inc., Berkeley, California, USA, November 2005.
- IS: 800-1984," Indian Standard Code Of Practice For General Construction In Steel "Bureau of Indian Standards (Second Revision), New Delhi, February 1985.
- IS: 800-2007," Indian Standard Code of Practice For General Construction In Steel "Bureau of Indian Standards (Third Revision), New Delhi, December 2007.
- IS 456: 2000, "Indian Standard Code of Practice of Plain and Reinforced concrete", BIS, New Delhi.
- IS 1893 (Part 1): 2002, "Criteria for Earthquake Resistant Design of Structures", BIS, New Delhi.
- IS 1893 (part 1): 2002, commentary "Criteria for Earthquake Resistant Design of Structures". BIS, New Delhi.
- IS 13920: 1993, "Indian Standard Code of Practice of Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Force", BIS, New Delhi.
- IS 4326: 1993, "Indian Standard Code of Practice for Earthquake Resistant Design and Construction of Building", BIS, New Delhi.
- Jain S.K., "Review of Indian Seismic Code, IS 1893 ( Part-1), 2002 " IITK-GSDMA-EQ02-V1.0, pp 1-9.
- Makar N. " How to model and design high rise building using Etabs", scientific book house cairo,2007.
- Santoshkumar, Dyavanal S.S. and Annigeri S.A., "Performance Evalution of Multistoreyed Buildings", Earthquakr Engineering, Volume II, pp. 704-714.
- Sattar K. A., Dyamvanal S.S. and Annigeri S.A., " Seismic Evalution of Asymmetric Multistorey Building by Pushover Analysis", Earthquakr Engineering, Volume II, pp. 715-726.