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

# Seismic Vulnerability Assessment of Existing RC Building by Structural Health Monitoring

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**Abstract** --- *There is a phenomenal rise in construction activities in the field of civil engineering in the recent years. Major structures like buildings, bridges, dams are subjected to severe loading and their performance is likely to change with time. It is, therefore, necessary to check the performance of a structure through continuous monitoring. There are different types of sensors which can be used for SHM. The use of sensors in the structure will help to overcome the problems such as vibration, deflection, settlement, cracks etc. This paper aims to focus on seismic vulnerability assessment of the building by structural health monitoring. The Dynamic analysis of RC Industrial Building by using STAAD.Pro Software. Then the installation of MEMS Accelerometer sensor on the actual building & obtaining the data. Then the comparison of variations of both the Analytical & Field Data & finding out the approximate Solutions.*

**Keywords** - *Vibration Analysis, Accelerometer Sensor, RC Building Structural Health Monitoring, STAAD.Pro Software.*

## I. INTRODUCTION

The process of implementing a damage detection and characterization strategy engineering structures is referred to as structural health monitoring (SHM). The SHM process involves the observation of a system over time using periodically sampled dynamic response measurements from an array of sensors, the extraction of damage-sensitive features from these measurements, and the numerical analysis of these features or blast loading, SHM is used for fast state screening and aims to provide, in near real time, reliable information regarding the reliability of the structure. Qualitative and non-continuous methods have long been used to evaluate structures for their capacity to serve their intended purpose. Since the beginning of the 19th century, railroad wheel-tappers have used the sound of a hammer striking the train wheel to estimate if damage was present. In rotating machinery, vibration monitoring has been used for decades as a performance evaluation technique. Two techniques in the field of SHM are wave propagation based techniques and vibration based techniques. Commonly known as Structural Health Assessment (SHA) or SHM, this concept is widely applied to various forms of infrastructures, especially as countries all over the world enter into an even greater period of construction of various infrastructures reaching from bridges to skyscrapers.


**Figure 1: Structural Health Monitoring**

 

If structures are monitored periodically or continuously, better understanding will be achieved about the behaviour of the structure. It will be very useful for design improvement. By proper SHM, the number of catastrophic events can be decreased, which will be helpful for economy of the country and also for psychology of human beings. By proper monitoring, it may be possible that the life of the structure be increased and serviceability enhanced, resulting in huge savings.

## II. OBJECTIVE OF THE STUDY

- To Perform Dynamic Analysis of Building using STAAD PRO.
- To Perform Field Data of Building by using Accelerometer Sensor.
- To Analyze the Column for Vibration Analysis in Ansys.
- Comparison of Analytical & Field Data.

## III. MODELLING AND ANALYSIS OF RC INDUSTRIAL BUILDING

The Industrial Preheater Building is analyze in STAAD.Pro. Following are its dimensions:
G+7 Storey Industrial Building
Length of the Building- 37 M.
Width of the Building- 22.2 M.
Height of the Building- 105.90 M.
Load on the Building = Dead load, live load, wind load and load combinations.
Dead load is calculated on the basis of the unit weights taken in accordance with IS: 875 (Part I)-1987.
Live load is taken as specified in IS: 875 (Parts 2)-1987.
Wind load is taken as specified in IS: 875 (Parts 3)-2015.
Earthquake load is taken as specified in IS: 1893-2016
Load Combinations is taken as specified in IS: 1893-2016
Dead Load- 4 KN/m^2.
Live Load- 5 KN/m^2.

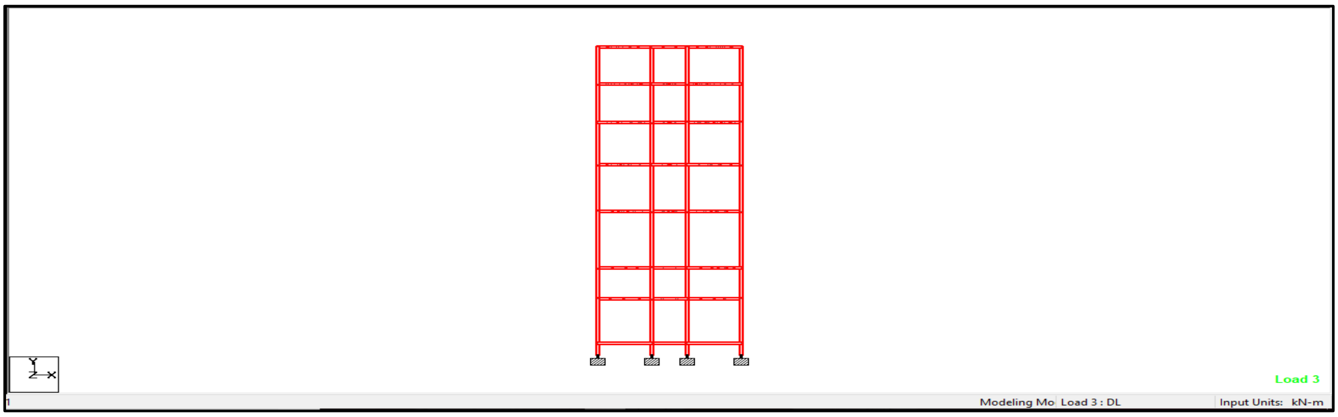


**Figure 2: STAAD Model**

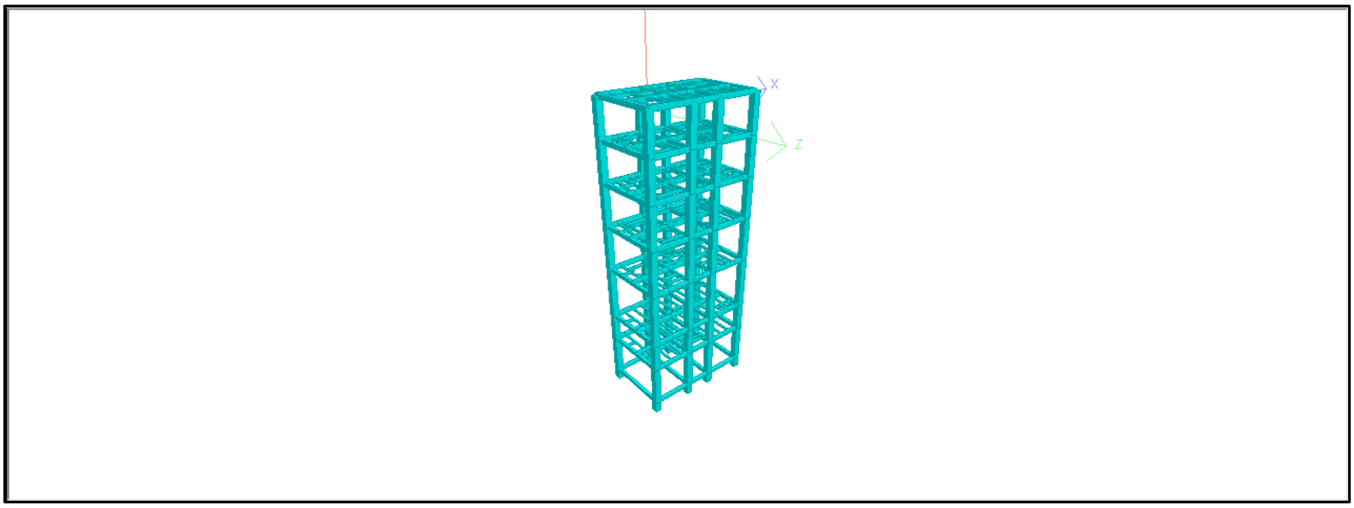

**Figure 3: Rendered View Model**

 

## IV. METHODOLOGY

The Response Spectrum Method as Specified in IS 1893-2016 is taken into the Account for the Dynamic Analysis of the Industrial Building.

**Methods for Dynamic Analysis:**
1) Response Spectrum Method.
2) Time History Method.
3) Modal Time History Method.

**Response Spectrum Method:** Response Spectrum Analysis is a Linear-dynamic statistical analysis method which measures the contribution from each natural mode of Vibration to indicate the likely maximum Seismic response of an essentially elastic structure.

The Design Lateral Force at each in each Mode is computed by:
$Q_{ik} = A_k * \varphi_{ik} * P_k * W_i$

Where,
$\Phi_{ik}$ = Mode Shape Coefficient.
$W_i$ = Seismic Weight of Floor.
$A_k$ = Design Horizontal Acceleration Spectrum.
$A_h = [z/2] \times [S_a/g]/[R/I]$
Where,
Z= Seismic Zone Factor.
I= Importance factor.
R= Response Reduction Factor.
Sa/g= Design Acceleration Co-efficient For Different Soil Types.
For Seismic Weight the Percentage of Imposed Load to be considered:
- Up to and Including 3 KN/m2 = 25%.
- Above 3 KN/m2 = 50%.

**Table 1: Time vs. Frequency table STAAD.Pro**

| Mode | Frequency | Time |
|---|---|---|
| | | |
| | | |
| 1 | 3.063 | 0.32 |
| 2 | 3.416 | 0.29 |
| 3 | 3.621 | 0.28 |
| 4 | 3.67 | 0.27 |
| 5 | 3.689 | 0.27 |
| 6 | 3.792 | 0.26 |
| 7 | 3.833 | 0.26 |
| 8 | 3.943 | 0.25 |
| 9 | 4.061 | 0.25 |
| 10 | 4.137 | 0.24 |
| 11 | 4.221 | 0.24 |
| 12 | 4.275 | 0.23 |
| 13 | 4.346 | 0.23 |

 

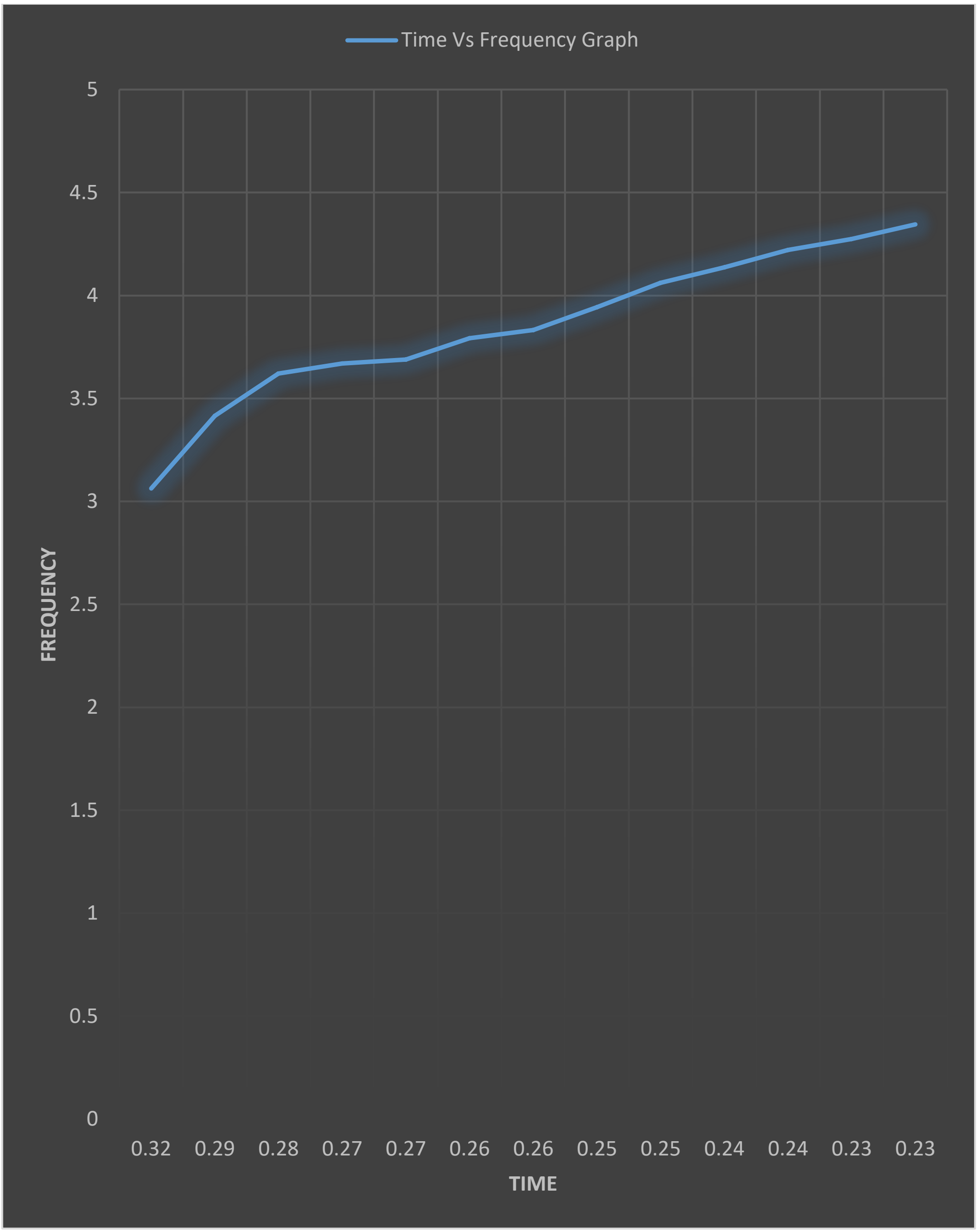


**Figure 4:Time vs. Frequency Graph**

## V. SENSOR INSTALLATION AND COLLECTED DATA USING MEMS ACCELEROMETER SENSOR

An accelerometer is a device that measures proper acceleration. Proper acceleration, being the acceleration (or rate of change of velocity) of a body in its own instantaneous rest frame, is not the same as coordinate acceleration, being the acceleration in a fixed coordinate system. Single- and multi-axis models of accelerometer are available to detect magnitude and direction of the proper acceleration, as a vector quantity, and can be used to sense orientation (because direction of weight changes), coordinate acceleration, vibration, shock, and falling in a resistive medium (a case where the proper acceleration changes, since it starts at zero, then increases).Accelerometers have multiple applications in industry and science. Highly sensitive accelerometers are components of inertial navigation systems for aircraft and missiles. Accelerometers are used to detect and monitor vibration in rotating machinery. Accelerometers are used in tablet computers and digital cameras so that images on screens are always displayed upright. Accelerometers are used in drones for flight stabilization. Coordinated accelerometers can be used to measure differences in proper acceleration.

 


**Figure 5: Data Collection**

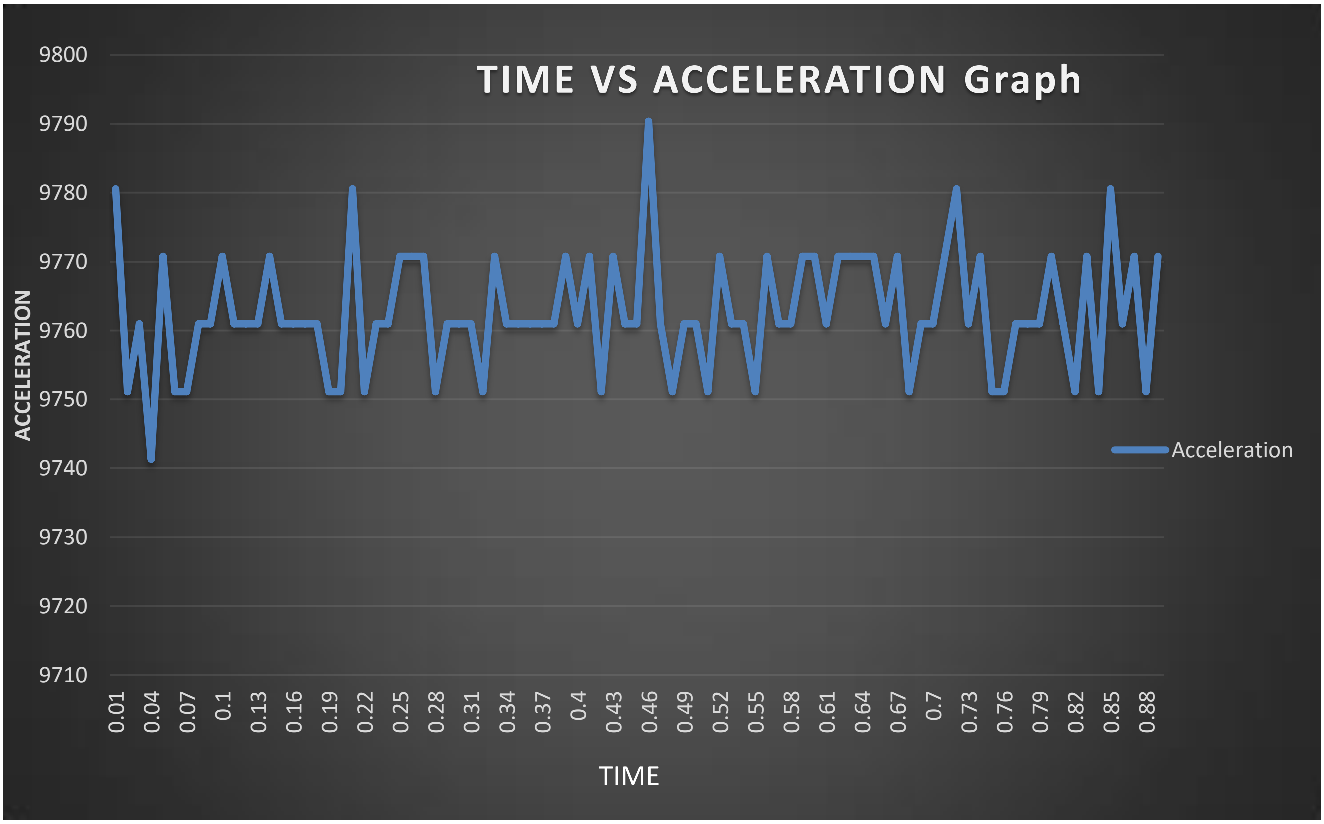


**Figure 6: Time vs. Acceleration Graph**

## VI. VIBRATION ANALYSIS OF COLUMN IN ANSYS

- Boundary Conditions:

1) Both the Ends are fixed.

- Material Properties:

 

1) Grade of Concrete- 25.

2) Grade of Steel- 500.

3) Young Modulus- 25000 N/mm^2.

4) Density- 25.

5) Ultimate Tensile Strength- 545 N/mm^2.

6) Tensile Yield Strength- 500 N/mm^2.

7) Compressive Ultimate Strength- 250 Mpa.

8) Compressive Yield Strength- 250 Mpa.

9) Poisson's Ratio- .125.

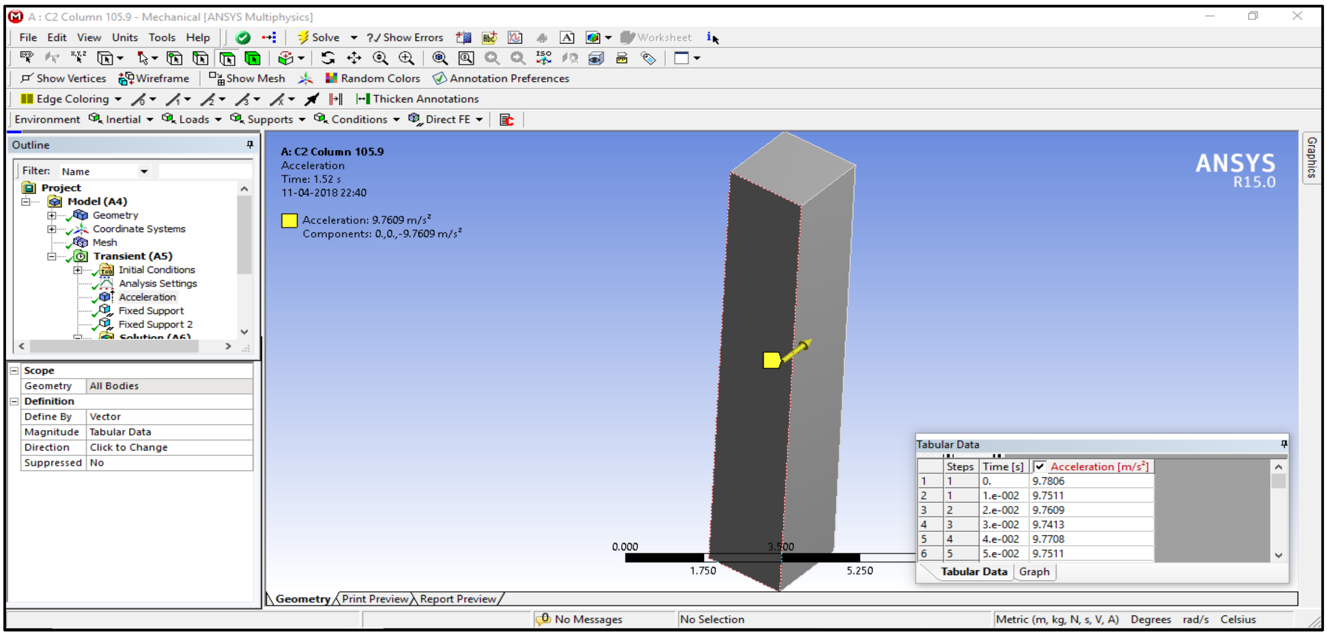


**Figure 7: Ansys Model & Inserting the Values of Acceleration on the Column.**

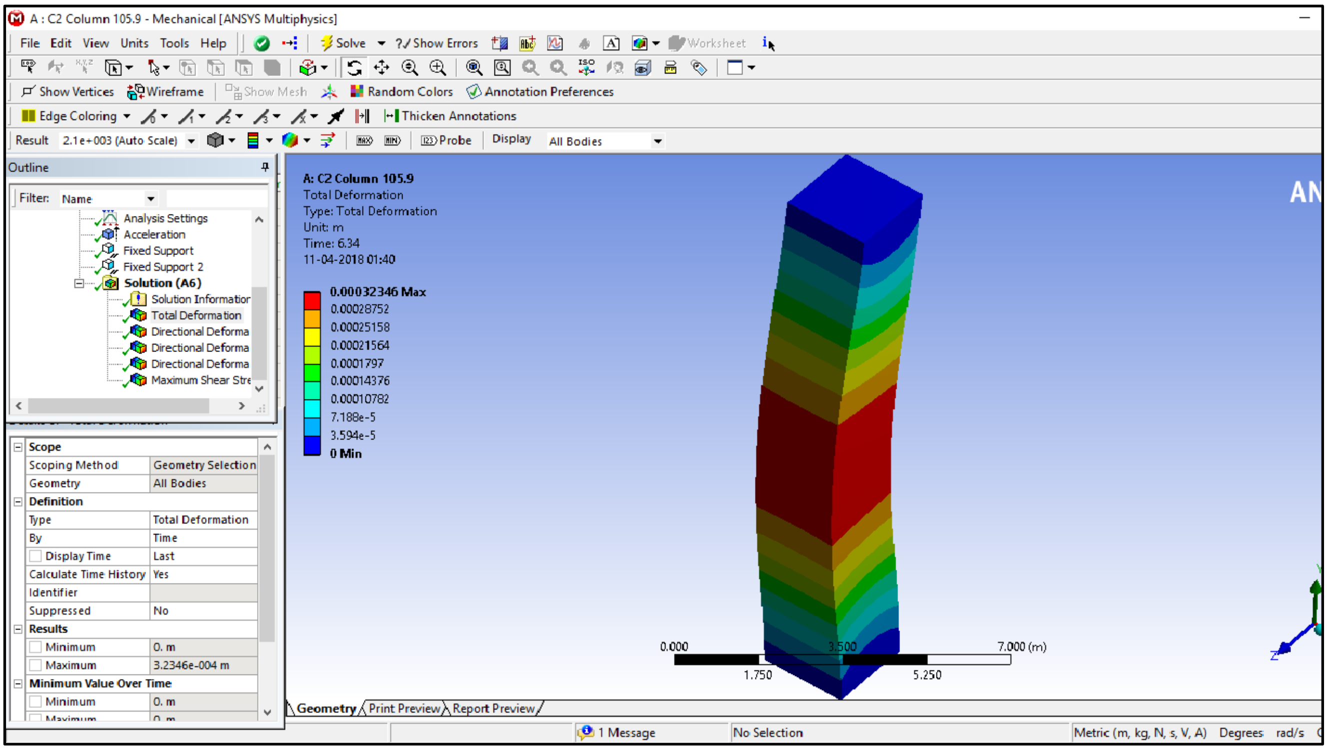


**Figure 8: Total Deformation of the Column**

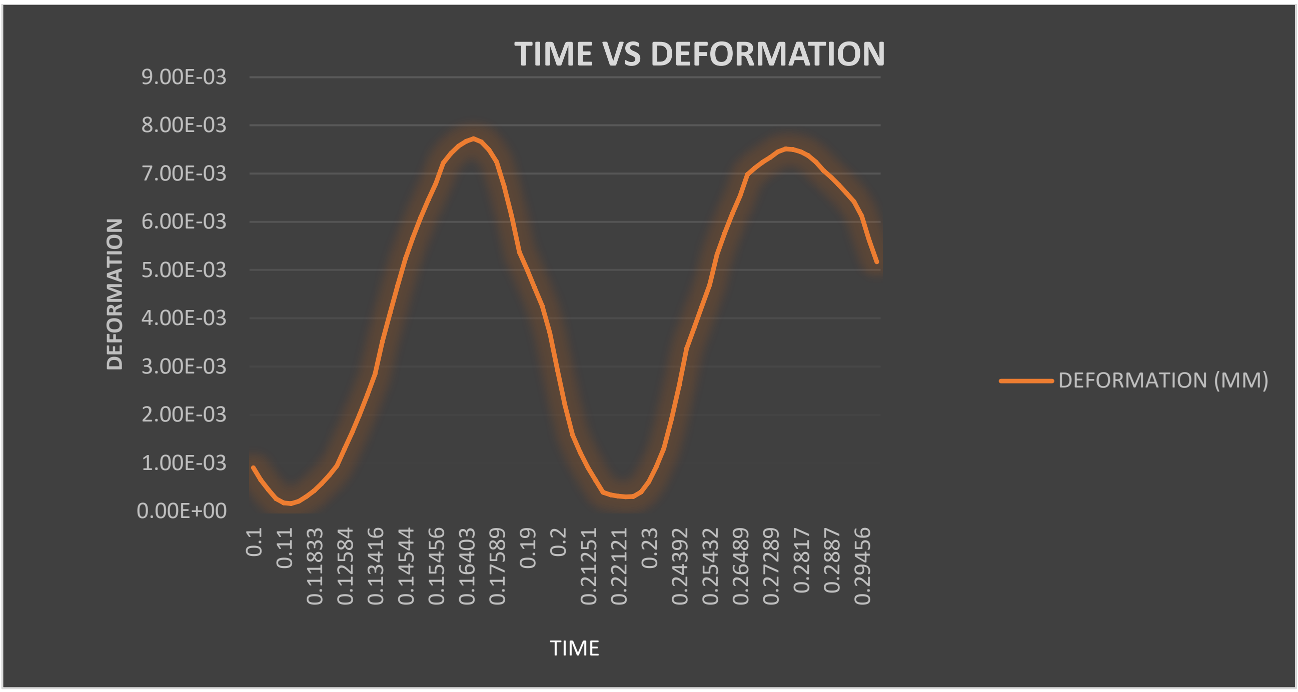


**Figure 9: Time vs. Deformation Graph**

## VII.RESULTS

**Table 2: Comparison of Results of Software & Field data**

| Support Condition | STAAD.Pro Data (Deformation) | Field Data (Deformation) |
|---|---|---|
| Fixed & Propped | 3.040 mm | 4.103 |

## VIII. CONCLUSIONS

- Deformation Values on the Column is within the Permissible Limits as per IS 456:2000 so it is Safe.
- Structural Health Monitoring using Wireless Accelerometer Sensor is in-situ and Non-Destructive tool for measuring Vibrations of the Structure & ensuring Condition of Structure.

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