International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072

VIBRATION ANALYSIS OF STRUCTURE USING TUNE MASS DAMPER

Mr. Khemraj S. Deore[1], Prof. Dr. Rajashekhar S. Talikoti[2], Prof. Kanhaiya K. Tolani[3]

[1]M.E. (Structure) Student, Late G.N. Sapkal College of Engineering, Nashik,Maharashtra, India
[2]Head of Department, Sandip Institute of Engineering & Reaserch Center, Nashik, Maharshtra, India
[3]Associate Professor, Late G.N. Sapkal College of Engineering, Nashik, Maharashtra, India

---***---

Abstract - *Current trends in construction industry demands taller and lighter structures, which are also more flexible and having quite low damping value. This increases failure possibilities and also problems from serviceability point of view. Now-a-days several techniques are available to minimize the vibration of the structure, out of the several techniques available for vibration control , concept of using TMD is a newer one. This study has made to study the effectiveness of using TMD for controlling vibration of structure. At first practical plan model with and without TMD has prepared. And perform Response Spectrum Analysis. In which calculate Maximum Deflection, Storey Drift, Base shear, Natural Frequency and Fundamental period of building. From the study it was found that, TMD can be effectively used for vibration control of structures. TMD was more effective when it is attached at the top floor of building. TMD results in gradual decrement in the displacement, storey drift and fundamental period of the structure.*

Key Words: TMD, Response Spectrum Analysis, Story Displacement, Story Drift, Base Shear, ETABS.

1. INTRODUCTION

An earthquake is a natural phenomenon associated with violent shaking of the ground. They are vibrations of the earth's surface caused by sudden movements of earth crust mostly due to tectonic movements. Since earthquake forces area unit random in nature and unpredictable, the engineering tools must be sharpened for analyzing structures below the action of those forces. Time History Analysis and Response Spectrum Analysis is a vital technique for structural seismic analysis particularly once the structural is high rise. This thesis study of the damper effect in the frame (MRF) is an important factor for the analysis. For Analysis purpose practical (G+16) storey building modelled with and without tuned mass damper by using software ETABS. Constant loading parameters are used for both cases. Load combinations are taken from IS code 875 Part 5. A tuned mass damper (TMD) is placed on top floor of building and Response spectrum analysis has performed. The result obtained from software analysis of building with and without tuned mass damper are compare with each other.

1.1 Tuned Mass Damper

It is also known as as passive mass damper (PMD) or harmonic absorber. It is a device mounted in structures to reduce the amplitude of mechanical vibrations. Their application can prevent discomfort, damage, or outright structural failure.

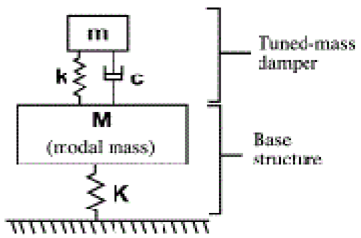

Fig -1 : Basic Principle of TMD

It is a passive damping system. Utilizes a secondary mass attached to a main structure through spring and dashpot. Secondary mass system has a natural frequency closed to the primary structure which depends on its mass and stiffness. The excess energy that is built up in the structure can be transferred to a secondary mass and is dissipated by the TMD.

By specifying the mass ratio of the secondary mass to the primary body, the optimum frequency ratio between the two masses and the optimum damping ratio of the secondary mass can be obtained. This secondary mass can be made of any material such as concrete or steel, while damping is generally provided by viscous damping devices.

1.2 Response spectrum Analysis

A response spectrum is simply a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency, that are forced into motion by the same base vibration or shock. The resulting plot can then be used to pick off the response of any linear system, given its natural frequency of oscillation. One such use is in assessing the peak response of buildings to earthquakes. The science of strong ground motion may use some values from the ground response spectrum (calculated from recordings of surface ground motion from seismographs) for correlation with seismic damage. If the input used in calculating a response spectrum is steady-state periodic, then the steady-state result is recorded. Damping must be present, or else the response will be infinite. For transient input (such as seismic ground motion), the peak response is reported. Some level of damping is generally assumed, but a value will be obtained even with no damping.

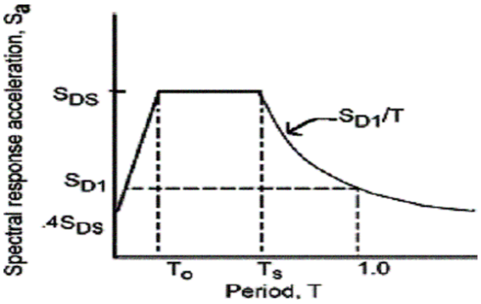

Fig -2 : Response Spectrum Analysis

Response spectra can also be used in assessing the response of linear systems with multiple modes of oscillation (multi-degree of freedom systems), although they are only accurate for low levels of damping. Modal analysis is performed to identify the modes, and the response in that mode can be picked from the response spectrum. These peak responses are then combined to estimate a total response. A typical combination method is the square root of the sum of the squares (SRSS) if the modal frequencies are not close. The result is typically different from that which would be calculated directly from an input, since phase information is lost in the process of generating the response spectrum.

The main limitation of response spectra is that they are only universally applicable for linear systems. Response spectra can be generated for non-linear systems, but are only applicable to systems with the same non-linearity, although attempts have been made to develop non-linear seismic design spectra with wider structural application. The results of this cannot be directly combined for multi-mode response.

1.3 Objectives

The main objective of this dissertation is focused on the behavior of RC frame building with and without damper during earthquake.

Followings are the objectives of the present work:

1) To perform response spectrum analysis of high rise (G+16) building frame with and without damper in E-tab software.

2) sTo study the behaviour of building in different modes of the structure.

3) Critical study of results in terms of maximum displacement, maximum story drift, base reactions, fundamental time period and natural frequency of building

2. LITERATURE

In this section, we summarize the investigations of various authors working in the field of Structural control as part of the literature survey.

Shetty et all (2012)[1] In this study Dynamic response of a base isolated multi-storey plane frame structure with Multiple Tuned Mass Dampers (MTMD) subjected to harmonic ground excitation and Mexico earthquake excitations. And concluded that the effectiveness of MTMD in suppressing the dynamic response of base isolated structure is determined by comparing the response of corresponding structure without MTMD. The reaction of base isolated shape with MTMD is found to be much less as compared to the corresponding reaction whereas now not MTMD, implying that the MTMD is powerful in lowering forces and displacement of a base isolated shape.

Suryawanshi et al (2012) [2] during this study of investigate tuned mass damper systems as vibration controller in multi-storey building, and study regarding its analyze the effectiveness of their use in giant structures, so as to preserve structural integrity. The idea in the back of a tuned mass damper is that if a more than one-diploma-of-freedom machine carries a smaller mass set up thereto, and therefore the parameters of the smaller mass place unit tuned precisely, then the oscillation of the machine are frequently decreased by using the smaller mass. The thesis report describes the history and inner-workings of tuned mass dampers, and investigates the technology of tuned mass dampers in the Taipei Tower in Taiwan, the tallest building in the world. It requires a mass damper tuned to the fundamental mode of the structure, consisting of a massive steel sphere, in order to counteract the building's oscillations and concluded tuned mass damper technology is an essential part of maintaining the structural integrity of structures.

Umachagi et all (2013)[3] Presents an outline of literature associated with the behavior of dampers on seismically affected structures. The review includes differing types of dampers like aluminiferous dampers, elastic dampers, and resistance dampers. They try to supply an outline of various styles of seismic response management devices, and highlight a number of the recent developments. . The experimental and analytical investigations carried out by various researchers clearly demonstrate that the seismic control method has the potential for improving the seismic performance of structures And concluded that controlling devices reduce damage significantly by increasing the structural safety, serviceability and prevent the building from collapse during the earthquake.

Khan(2014)[4] In this paper author has describes the results of an extensive study on the seismic behaviour of a structure with damper and without damper under different earthquake acceleration frequency like EQ Altadena, EQ Lucerne, EQ Pomona, EQ Smonica and EQ Yarmouth proposed system is placed the dampers on the floors of the ninth-floor and 5-floor of a ninth story constructing frame then examine the distinctive overall performance of shape with damper as much as ninth-flooring, damper up to fifth-floors and without damper of 9th-tale constructing frame the use of SAP2000 V15. As per IS-1893 2002 non-linear time-history analyses of body shape imply that maximum displacement, most base shear and maximum acceleration successfully lessen with the aid of providing the damper in building body from base assist to fifth- ground and base guide to ninth-floor contrast to as traditional frame.

Kim, Lee (2014)[5] In this work analysis of a structure installed with visco-elastic dampers the modal strain energy method has been generally applied to predict the equivalent damping ratios of the system. The method derives the equivalent damping ratios supported the belief that the damping is proportional to mass and/or stiffness of the structure system. In this study some of efficient analytical procedures are applied to obtain the seismic response of a non-proportionally damped building structure with added visco-elastic dampers; the complex mode superposition method, direct integration method combined with matrix condensation, modal strain electricity method, and the method disregarding the off-diagonal terms of a converted damping matrix. unique attention has been paid for the derivation of the complicated modal superposition procedure, and the reliability of the approximate strategies is checked by way of comparing the approximate answers with those received from the complex mode superposition.

Murad, Lavanyag (2016)[6] This paper is to study the comparison of shear wall and TMD for reducing vibration of all buildings due to wind earthquake loading by using SAP2000 software. Shear walls and Tuned Mass Dampers square measure appointed within the structure as an alternative. Numerous arrangements of Tuned Mass Dampers during this thirty level building square measure studied, complete the value of TMDs is sort of like that of shear enclose thirty storey's structure. But less base shear, storey displacement, joint acceleration, and frequency makes TMDs more applicable than shear wall.

3. METHODOLOGY

Tuned mass damper made with welded steel work is attached on the top of the structure consists of a mass , spring and a damper, which is attached to one side of the building to control the responses in two directions. Steel is used because it's more prone to vibration and high damping capacity. Furthermore, by placing the TMD centrically, the torsional response of the building may also be controlled.

1) Intensive literature survey by referring books, technical papers distributed to know basic construct of topic.

2) Choice of form of structures.

3) Modeling of the chosen structures.

4) Analytical work is to be distributed.

5) Interpretation of result and conclusion

In the present work Tuned mass damper (TMD) is placed on its top and through it to study its effects on Storey drift, storey displacement and base shear and analysis with and without the tuned mass damper (TMD) in ETAB.

For investigation of the dynamic response of the structure with TMD, the following assumptions are adopted.

1) The columns are assumed to be inextensible so that there is no axial deformation in the columns.

2) The slab is assumed to be rigid and there is no bending deformation in the slab.

3) The self-weight of the columns is neglected

4. PROBLEM STATEMENT

1) A (G+16) storey building subjected to earthquake loading in Zone 3 has been considered. In this regard, ETABS software have been considered as tool to perform Displacements, Storey drift and Base Shear.

2) The regular plan and practical plan of building with and without tuned mass damper has been considered to carry out the study. And I performed equivalent static analysis and response spectrum analysis.

3.1 Modeling and Analysis

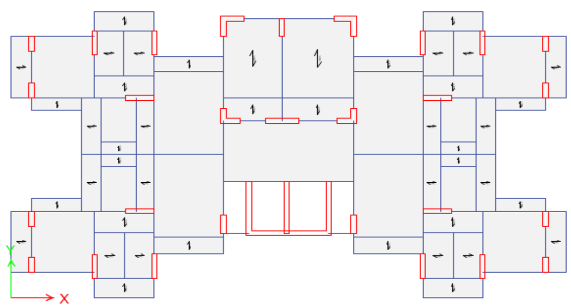

Fig -3 : Plan of practical building.

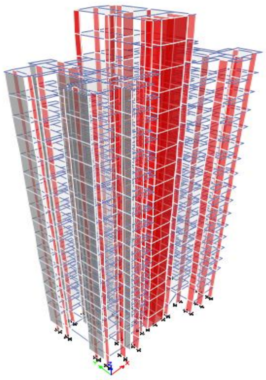

Fig -4 : 3D view- Without Tuned Mass Damper.

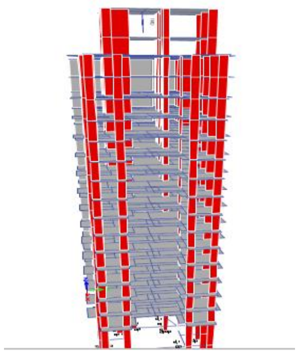

Fig -5 : Elevation- With Tuned Mass Damper.

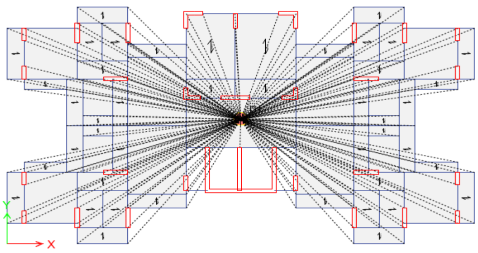

Fig -6 : Location of Tuned Mass Damper in plan.

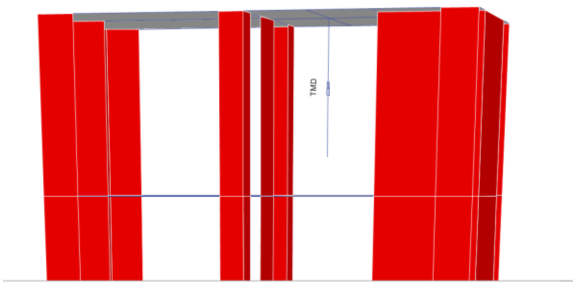

Fig -7 : Location of Tuned Mass Damper in elevation at top story.

3.2 Geometrical parameters of the practical building are as follows

Type of building	-Residential Building
Floor height of each story	-3 m
Base supports	-Fixed
Structural type	-R.C.C. Framed Structure
Type of slab on typical floor	-One, Two-Way Slab
Thickness of two-way slab	-125, 135, 140 mm
Density of concrete:-	-25 kN/m^3
Type of slab at staircase	-One-Way Slab
Thickness of staircase slab	-150 mm.
Size of column:	-300X750, 900, 1200, 1350, 1500mm
Size of beam:	-230X450, 530, 600 mm
Wall material	-Brick
Wall load (parking)	-12.42 kN/m
Wall load (floor)	-11.04 kN/m
Wall load (parapet)	-5.52 kN/m
Unit weight of water proofing	-20 kN/m^3
Waterproofing load on terrace	-3.04 kN/m^2
Floor finish:-	-1 kN/m^2
Live load:-	-3 kN/m^2
Importance factor (I):-	-1
Soil Type:-	-2 (Medium)
Seismic zone:-	-III
Zone Factor:-	-0.16
Responded reduction factor:	-5

3.2 Geometrical parameters of the Tuned Mass Damper are as follows

Assume mass ratio	-5%.
Mass of damper	-10.31 kN.
Frequency of damper	-12.175 rad/sec.
Stiffness of damper	-152844 N/m.
Optimum damping ratio	-0.13.
Value of damping, (Cd)	-3300 Ns^2/m.

5. RESULTS AND DISCUSSION

4.1 Results

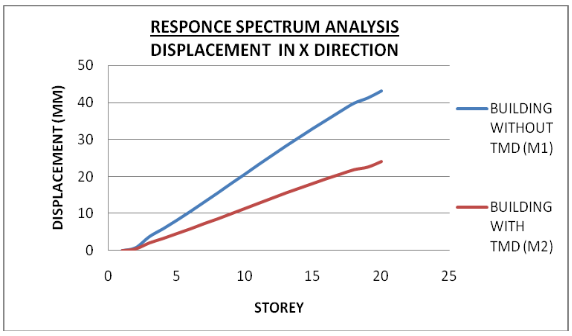

Chart -1: Comparison of Displacement in X Direction

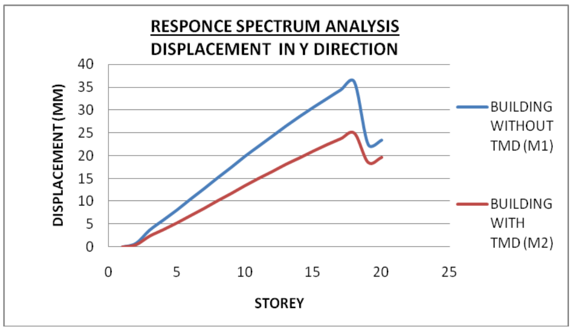

Chart -2: Comparison of Displacement in Y Direction

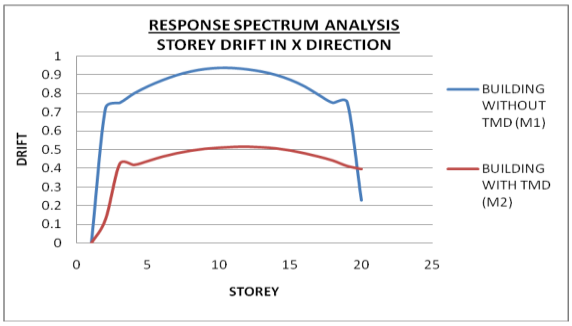

Chart -3: Comparison of Storey Drift in X Direction

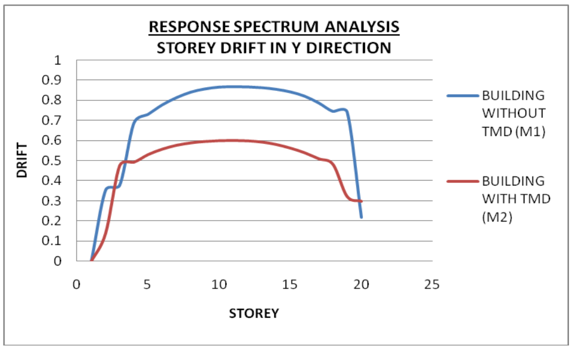

Chart -4: Comparison of Storey Drift in Y Direction

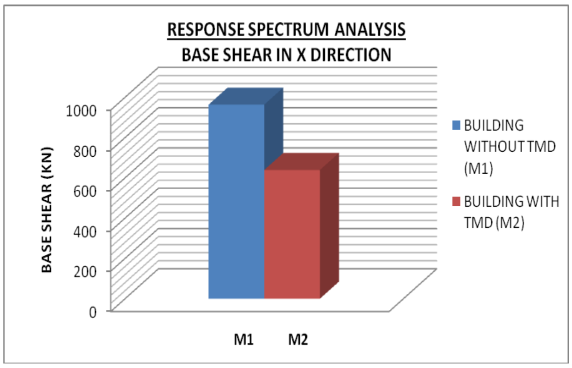

Chart -5: Comparison of Base Shear in X Direction

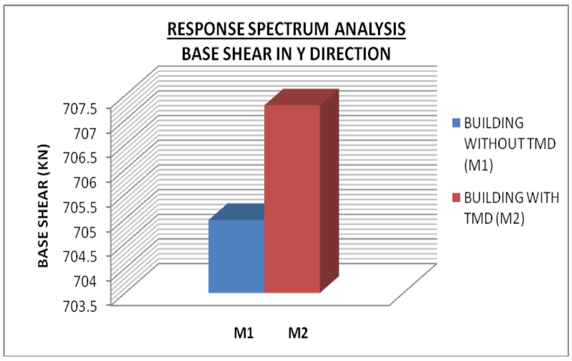

Chart -6: Comparison of Base Shear in Y Direction

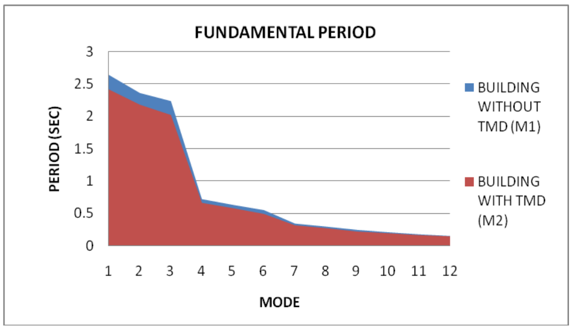

Chart -7: Comparison of Fundamental Period

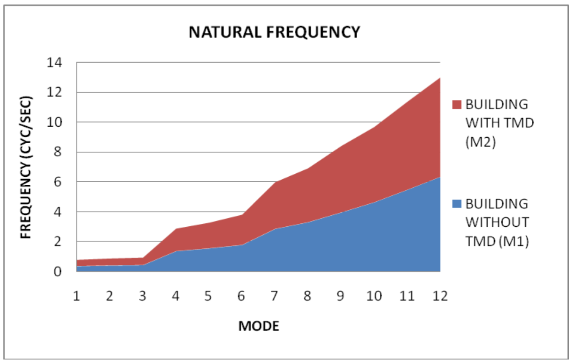

Chart -8: Comparison of Natural Frequenecy

4.1 Discussion

The reduction of Maximum deflection of top storey in X direction by 44.21% and in Y direction by 15.81 %

The reduction of Maximum Storey Drift of top storey in X direction by 41.35% and in Y direction by 35.38 %

The reduction of Fundamental Period By 4.43 %,

The increasing of Natural Frequency By 4.69 %,

5. CONCLUSION

On the basis of present study and reviewed literature The following conclusions can be drawn:

1. Seismic performance of building after application of damper is much better when we provide to top of storey.

2. It has been found that the TMD can be successfully used to control vibration of the structure.

3. For story drift which is important behavior for finishes such as sliding windows, performance is better for building with TMD.

5. Application of TMD damper reduces large amount of displacement of the structure.

6. Due to absolute displacement reduction the structure have not require more ductility to resisting earth-quake forces.

7. With the using of TMD in the structure, the base shear slightly increases.

8. With the using of TMD in the structure, the Fundamental Period of structure reduces.

ACKNOWLEDGEMENT

I wish my gratitude towards Prof. Dr. Rajashekhar S. Talikoti and Prof. Kanhaiya K. Tolani for his constant interest, encouragement and valuable guidance during completion of this work. He constantly shored me up, enabling me to develop an understanding the concept of tuned mass damper.

REFERENCE

Webster, A.C., and Vaicaitis, R. “Application of Tuned Mass Dampers To Control Vibrations of Composite Floor Systems” Engineering Journal, pp116-124, 2003

Umachagi, V., and Katta, V., Reddy, G. R “Applications Of Dampers For Vibration Control Of Structures”: IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308, .2013

Murad, M.K., and Lavanyag “Dynamic resistance of tall buildings by using tuned mass damper’s” International Conference on Current Research in Engineering Science and Technology (ICCREST), 2016

Shetty, K.K., Moorthy, K., Nayak, G. and Nivedita, K. R. “Dynamic Response Control of Base Isolated Plane Frame Structure Using Multiple Tuned Mass Dampers” Bonfring International Journal of Industrial Engineering and Management Science, Vol. 2, No. 4, 2012

Mohite, A. A., and Patil, G.R. “Earthquake Analysis of Tall Building with Tuned Mass Damper” IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320–334X PP 113-122, 2015

Suryawanshi, Y. R., and Rahane, A. S. “Study of Tuned Mass Dampers System as Vibration Controller in Multistoried buildings” © 2012 IJAIR. ALL RIGHTS RESERVED ISSN: 2278-7844, 2012

Khan, W., Akhtar, S., and Hussain, A. "Non-linear Time history analysis of tall structure for seismic load using damper", International Journal of Scientific and Research Publications, Volume 4, Issue 4, 2014

KIM, J., And LEE, Y.C. "Dynamic Analysis of multyStroried Regular Building", IOSR Journal of Mechanical and Civil Engineering” (IOSR-JMCE), e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 1 Ver. II , PP 37-42, 2008

Jester, T.P. "Earthquake Analysis of High Rise building with and without in filled Walls", International Journal of Engineering and Innovative Technology (IJEIT), Volume 2, Issue 2, 2012

Xu, Z.D. "Seismic Damage and Damage-Control Design for RC Frames" J. Intell. Mater. Syst. and Struct. Vol. 1, pp. 476-495, 2009

V.M. Thakur, and P.D. Pachpor, Seismic Analysis of Multi-storeyed Building with TMD (Tuned Mass Damper), International Journal of Engineering Research and Applications, Vol. 2, Issue 1, 2012, 319-326, 2009

IS Codes

IS 1893 (Part I): 2002, Indian Standard- Criteria for earthquake resistant design of structures, part 1 general provisions and buildings,Bureau of Indian Standards, New Delhi, June 2002.

IS 875: 1987, Indian Standard code of practice for design loads (other than earthquake) for buildings and structure.

BIOGRAPHIES

Mr. Khemraj S. Deore
M.E. Structural Engineering Student-(Late G. N. Sapkal College of Engineering, Nashik Maharashtra, India

Prof. Dr. Rajashekhar S. Talikoti
Ph.D Structural Engineering-(IIT Bombay Maharastra, State India)
Head of Department, Sandip Institute of Engineering and Reaserch Center, Nashik, Maharashtra, India

Prof. Kanhaiya K. Tolani
M.Tech. Structural Engineering-(IIT Bombay Maharastra, State India)
Associate Professor, Late G.N. Sapkal College of Engineering, Nashik, Maharashtra, India