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# Study of Dynamic Analysis for Immersed Tube Tunnel

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**ABSTRACT**
*The main aim of the project is to connect the two coats of the Dharamtar creek i.e. Rewas in Alibaug and Karanja in Uran by an immersed tunnel. The construction of proposed immersed tunnel will reduce the travel time from Mumbai to Alibaug from 3 hours to 1 hour. But this reduction in time includes the consideration of the sea-link from Sewri to Nhava Seva (Uran).Which was proposed by government and is already under construction. Thus construction of this immersed tunnel will ease the transportation of the city. In this study, a preliminary analysis of IZMIR immersed tube is carried out for validating purpose. The static analysis of the tunnel was made in finite element program. The vertical displacement of the tube unit under static loads was calculated. Afterwards, the seismic analysis was made to investigate stresses developed due to both racking and axial deformation of the tunnel during an earthquake. It was found that, maximum stress due to axial deformation is longer than compressive strength of the concrete. The high stresses in the tube occur, because of the tube stiffness.*
***Keywords:*** *Immersed Tunnel, racking deformation, tube stiffness, SAP, etc.*

## I. INTRODUCTION

**"1. Introduction "**

With the recent rapid development of global economy and engineering technology, tunnel construction has become increasingly important in regional economic and social development. An immersed tube is underwater tunnel composed of segments, constructed elsewhere and floated to the tunnel site to be sunk into place and linked together. They are commonly used for road and rail crossing of rivers, estuaries and sea channels/harbors. Immersed tubes are often used in conjunction with other forms of tunnel at their end, such as a cut and cover or bored tunnel, which is usually necessary to continue the tunnel forms near the water's edge to the entrance (portal) at the land surface. The immersed tunnel has been proposed in Dharamtar creek to link two place i.e. Karanja and Rewas, situated on the opposite on the bank of creek which will provide an alternative access between Mumbai and Alibaug.As shown in the below figure 1 red line represents the alignment of the immersed tunnel whereas the blue line represent the alignment of the Mumbai-Uran link proposed by the Government company.


**Figure.1.** Site selection

Government of India has proposed a bridge from Sewri to Uran through the Butcher Island. This will provide a direct entry to Mumbai into Uran. If one has to the travel to Alibaug, they should travel all the way from Uran to Panvel and then get linked to the NH-4 and then enter into Alibaug which would require an entire journey of 102 Km from Uran to Alibaug, But if this Immersed tunnel project comes into existence the Uran and Alibaug would be linked by a very short route of about 10-15 Km. This would provide a cheap and fast excess into Alibaug from Mumbai. This would give rise to industrialization and also improve the transport facility.

## II. "SITE SURVEY"

### A. Preliminary data

After the area has been selection for the immersed tunnel the main task arises is to check whether the site selected is appropriate and economical for the tunnel manufacturing, its construction and utilization. The below figure 2 shows the sea bed profile between Karanja (left) and Rewas (right). Based on this profile diagram the depth of the sea at various positions were located and the favorable alignment was considered for the placement of the tunnel blocks, The alignment of the tunnel is an shown in the figure 2 with the blue line. The maximum depth of the sea in this alignment is just 7.4 m. and thus, this region is very much favorable for the tunnel with respect to the depth criteria.

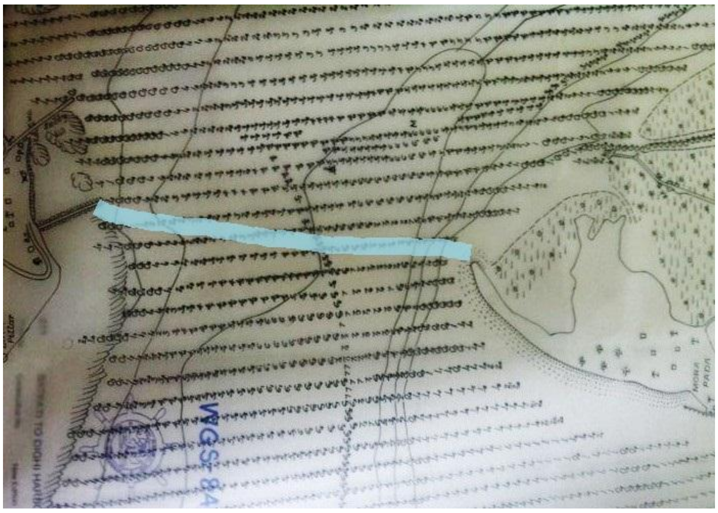


**Figure 2** Contour plan

### B. Tunnel description

The proposed immersed tunnel is composed of two lane highways. The length is 2.4 Km including the immersed tunnel selection of 1.9 Km in the middle. The tunnel has about 19 tunnel units. The shape of each tunnel element has 24 m width, 9 m height and the length is 100 m. The technical properties and typical cross section of the immersed tunnel unit were illustrated in the figure 3 shown in below.

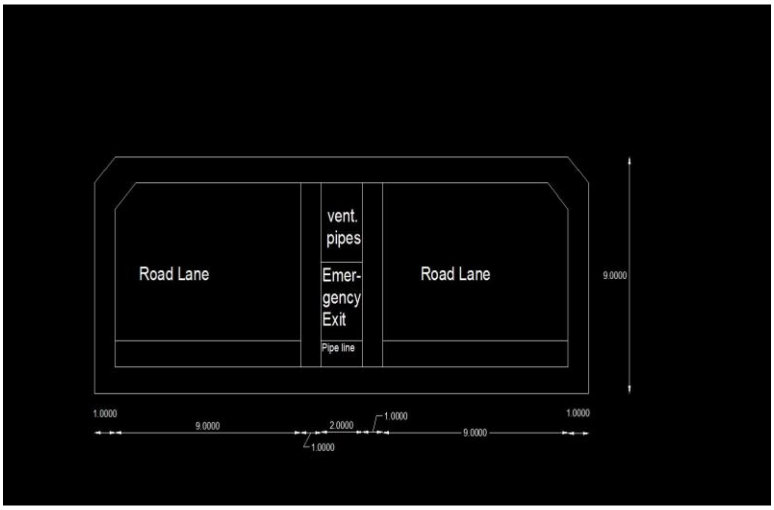



**Figure 3.** Cross section details of proposed tunnel element

1. Length: 2.2 Km
2. Number of element: 19
3. Section of Box size : (120*24*9) m
4. Number of emargency and ventilation shafts: 1

**C. Validating Study**

Analytical work is based on details study of IZMIR bay immersed tunnel.[1]. This tunnel was measured 40 m in width and 7.6 m in length. The tunnel was characteristic by rectangular cross section had $2 \times 3$ Road traffic. The tube was measure 40 m in width and 7.6 Km in length. The Height of tube was 10 m.

**Figure 3** Site Location of IZMIR tube tunnel.

***A. Current Allowable Bearing Capacity***

Ultimate bearing capacity is the maximum bearing capacity of the soil without its any failure and its settlement. It is calculated by two different criteria. One is shear failure criteria and other is tolerable settlement criteria. The smaller value from above this is adopted as a net allowable bearing capacity of soil. From shear failure criteria, the Allowable bearing capacity is calculated as

$$q_a = \frac{q_{ult}}{FS} \qquad (1)$$

Where $q_{ult}$ is the final caring capacity of the sea bed sub-soil. It is calculated from following equation

$$q_{ult} = 0.04882 \left(3 \times N^2 \times B \times R_w^{'''} + 5(100 \times N^2) \times D.R_w\right) \qquad (2)$$

For determining net vertical stress increase 'Pnet' due to construction of tunnel and its subsequent operation, including the possibility that tunnel may be temporarily full of water, but should not float when the water is emptied. Thus, $P^i_{net}$ is calculated from equation [3].

$$P^i_{net} \equiv P_{soil} + P_{seawater} + P_{protective\ layer} + P_{traffic} + P_{buoyancy} \qquad [3]$$

***B. Static analysis for settlement calculations***

Using the finite element method (FEM) and the SAP 2000, the vertical displacement of tunnel segment is calculated as follows.

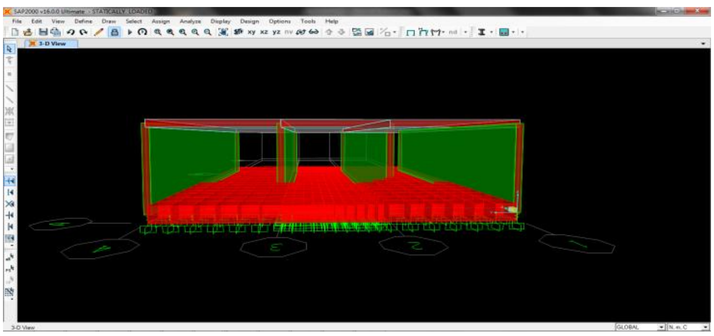


**Figure 4.** 3D modelling of tube

By using the subsoil data, the coefficient of (vertical) Subgrade reaction (Ks) was calculated from following equation.

$$k_s = \frac{1}{B \times E_s \times I_s \times I_f} \quad \text{.......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ....[ 4]}$$

where,
$B$ – Half of the tunnel width
$E_s$ – corrected elasticity modulus
$I_s$ and $I_f$ - influence factors.

***F. Preliminary seismic analysis of the tunnel***

The seismic behavior and of tunnels is differs from the behavior and design of structures built above ground. As immersed tunnels are confined within surrounding soil inside the trench, they do not subject to any vibration amplifications. There are two types of deformation that are affect immersed tunnels one is Axial and lateral deformation and second -one is Sinking deformation source files in one of the following:

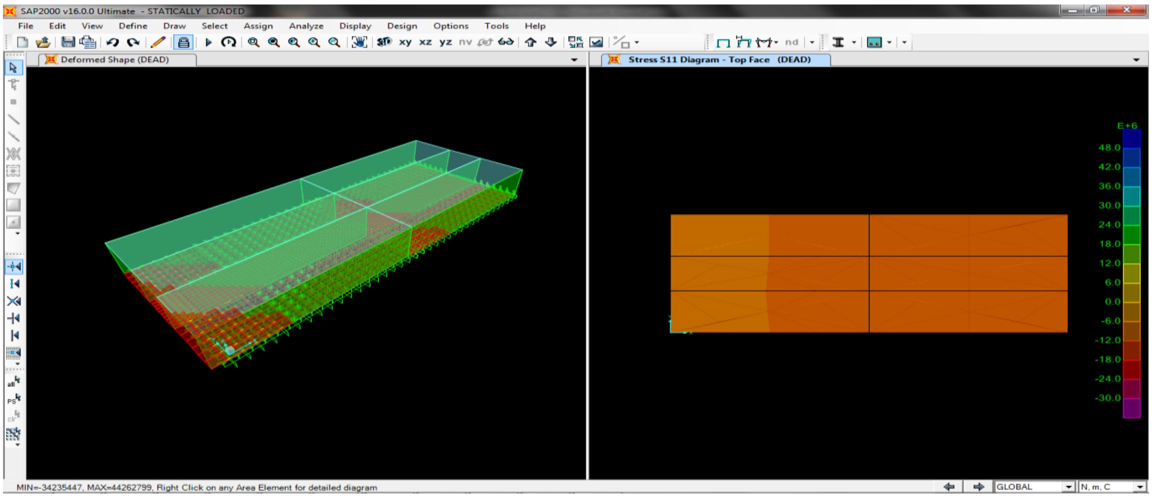



**Figure 5.** Compressive stress in longitudinal direction

Also, the resultant Mmax value under the static load is account as 19.06 KN-m.

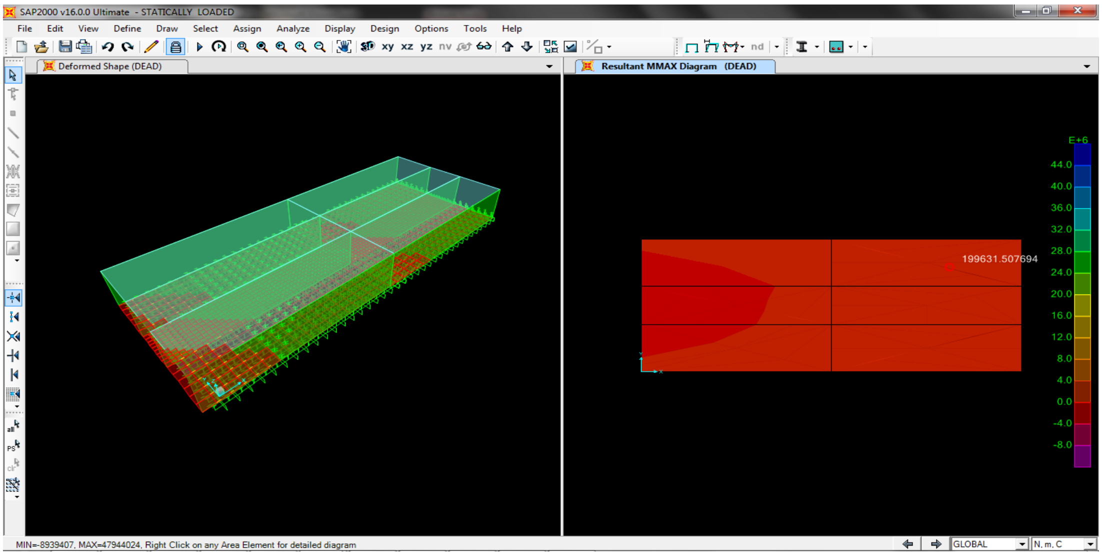



**Figure 6.** Resultant Mmax Diagram

The structure is deform under static loading is within the permissible limit. The deformed shape in lateral direction is calculated as 42 mm shown in bellow.

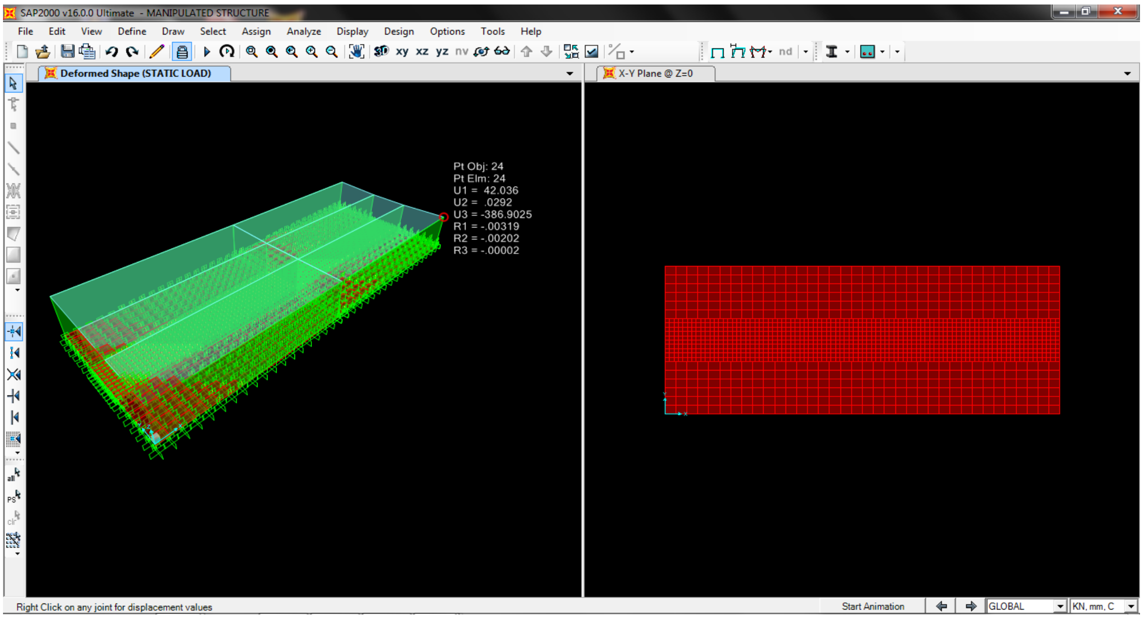



**Figure 7.** Deform shape under static load

***C. Response spectrum Analysis***

A response spectrum represents is graph of response versus frequency, where the response might be displacement, velocity, acceleration, or force. The models which were used for modal analysis were again run using single point Response spectrum method.

## III. "PROPOSED TUNNEL"

The proposed tunnel is 24 m in width and 1900 m in length. This tunnel is divided into 20 m length segment with height 10 m. The vertical solid wall has 1 m thickness, Top thick slab is 1 m and bottom slab is 2.3 m thick. The soil pressure is calculated by Rankine's method which is 70 KN/m2 which absence of seepage and pore pressure. The water pressure act on top surface as gravity load is 80 KN/m2. The proposed 3D model is as follow. The 3D model is analyzed for response spectrum under the different loading condition. The tunnel is divided into 3 lanes. And assume that the all lane are open to vehicle transport. As per the validating paper it is assume that 25 vehicle are placed in each lane. Therefore total load transfer on bed is calculated as 0 .54 t/m2. The analyzed model shows following amount of result.

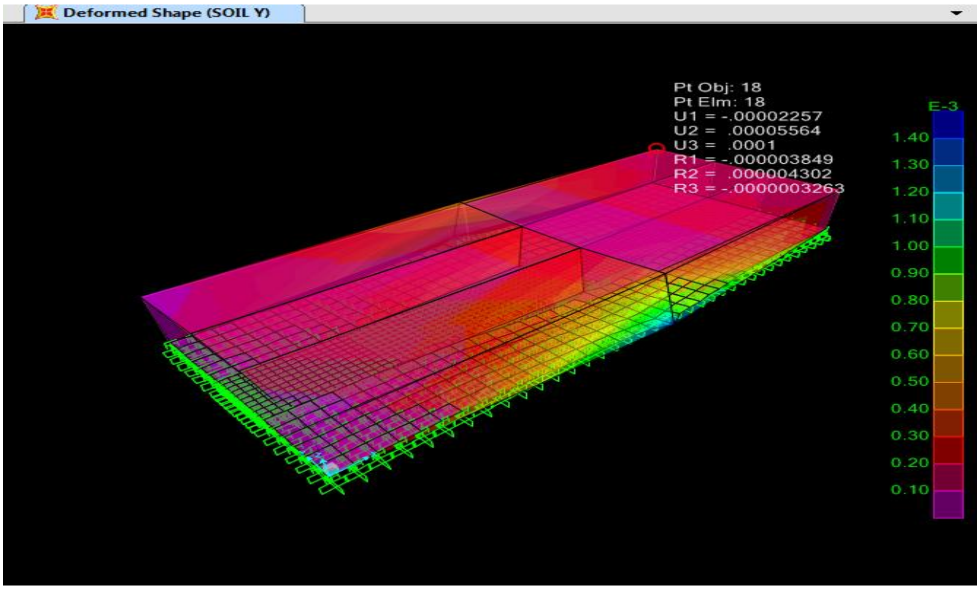



**Figure 8.** Deformed model under soil pressure

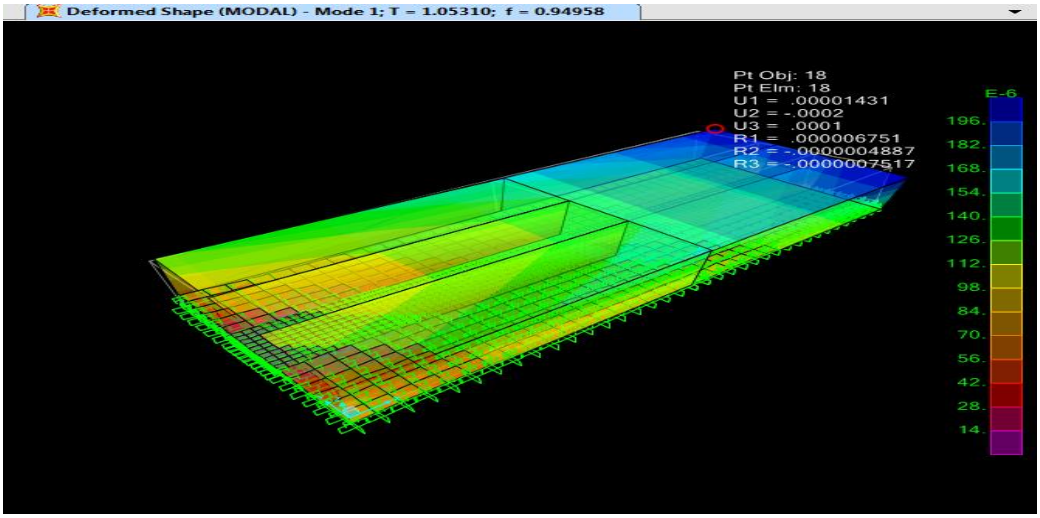



**Figure 9**. Deformed shape mode-1

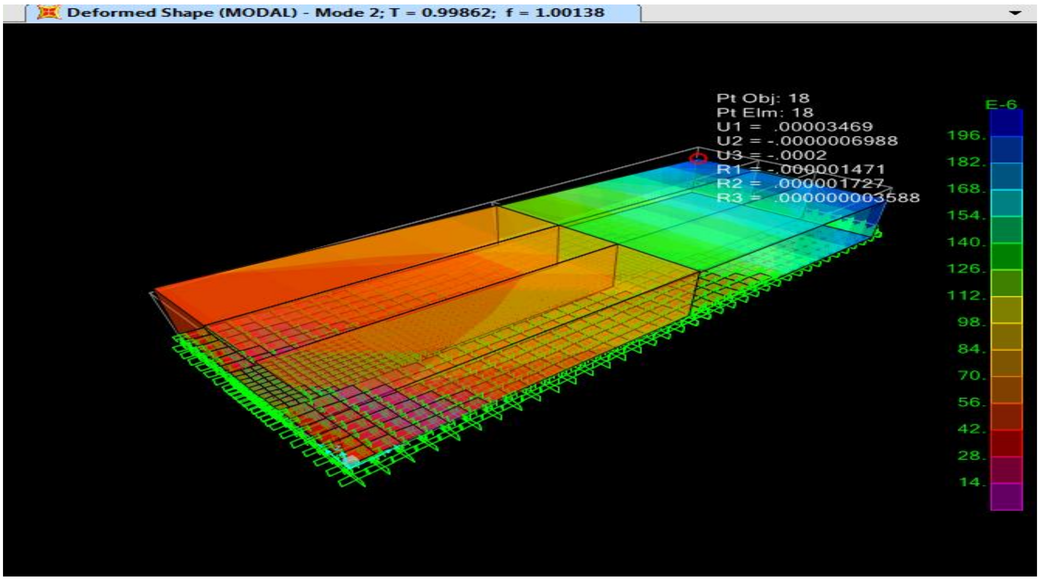



**Figure 10.** Deformed shape mode-2

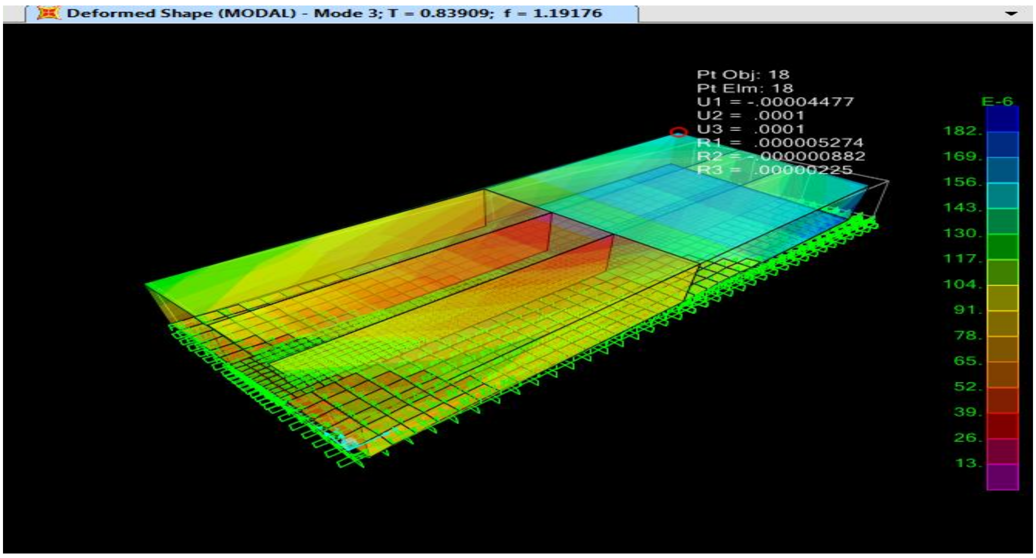
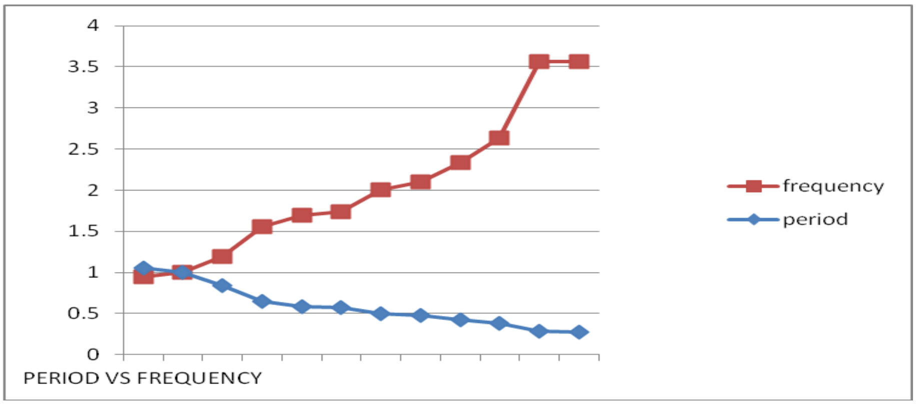
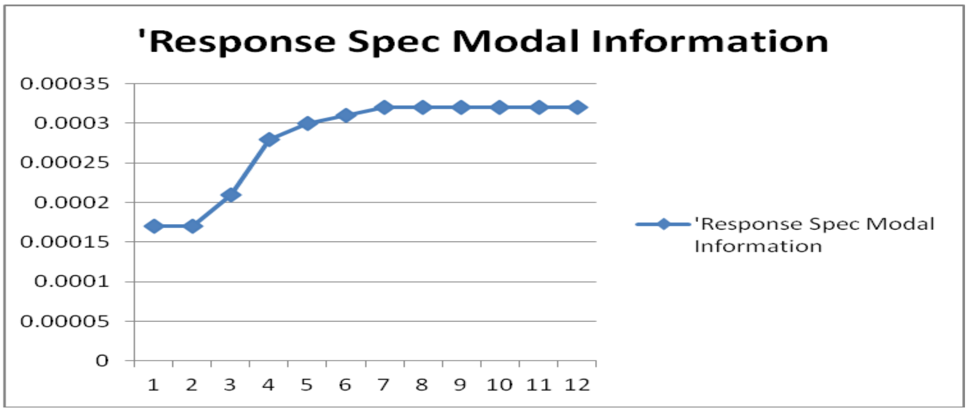



**Figure 11**. Deformed shape mode -3

The graph bellow represents the period and frequency variation against the mode value.




**Graph 1.** Period against frequency




**Graph 2.** Response spectrum moadl information

## IV. "CONCLUSION"

The primary results obtained in the validating study helps to analyze the proposed Mumbai Alibaug immersed tunnel. The IZMIR bay tube tunnel was analyzed for static result, after apply response spectrum method the results shows within permissible limit as per slandered. This helps in preliminary analyzing proposed immersed tube model with comparing validating results.

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