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Comparative Study on Different Shape of Tunnel Section

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Abstract—*In this paper we have analyzed circular, D-shaped, Horse-shoe & rectangular tunnel for a given soil profile. Structural parameters are the main sought information required for designing a tunnel. These parameters mainly depend on the soil parameters and type of section considered. It is a difficult task to select the section of tunnel with wide variation of soil properties. In this study, we have investigated structural performance for different sections of tunnel. A comparative study of displacement, shear force, bending moment at the crown as well as at the side for different section of tunnel has been made.*
Our study will help us to select a suitable section of tunnel if the soil properties are available and so it will be useful for the tunnel engineering to select the shape for tunnel in the practical application.

1. INTRODUCTION

A tunnel is an underground passage through a mountain, beneath a city or under a waterway. It may be for pedestrians and/or cyclists, general road traffic, motor vehicles, rail traffic, or for a canal. In this project, a tunnel with different cross section will be investigate thoroughly based on the soil properties supplied by N.F. Railway, Silchar from a site which is selected for tunneling in the Bairabi-Aizawl section in Mizoram. In the present work, different shape of tunnel section has been analyzed for the given type of soil obtained from the railway site. It has been observed that the various stress properties vary abruptly with the variation of section properties of the shape of tunnel. So is of utmost importance to compare the various shape of tunnel section before starting the construction of tunnel.

For this project, certain literature survey have been done. Some of them has been mentioned below:

M. Azadi,[2011] has carried out a study on the behaviour of urban tunnel in a soft saturated soil.

In this paper, the effects on forces and bending moment of the tunnel has been evaluated.

A. Giannakon et al,[2005] worked on the behaviour of tunnels in soft saturated soil, parametric numerical analysis and investigation on the causes of failure of the Bolu tunnel, Turkey.

Mohammed Ahmed Abdel et al,[2013] examined the mutual interaction between tunnels and the the surrounding granular soil.

Hisham Mohamed et al,[2015] has done the stability of shallow circular tunnel in soil considering variations in cohesion with depth.

Elefterija Zlatanovic[2008] has done comprehensive work on the stress and strain state of the shallow tunnel structures in saturated soil of low bearing capacity.

2. SELECTION OF SECTION

For this project, 4(four) different types of tunnel shape has been selected. They are:

1. Circular

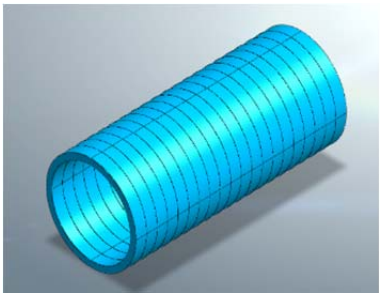
2. D-shaped

3. Horse-shoe

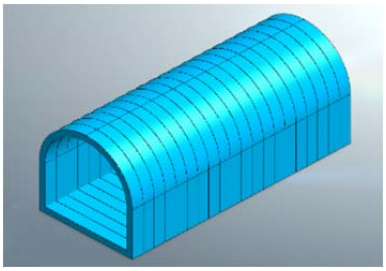
4. Rectangular

The railway is proposed to be B.G(Broad Gauge), so an internal diameter/dimensions of 7.5 meters and outer diameter/dimensions of 8.5 meters have been selected, so as to fulfill the norms of IRC 99-2013.

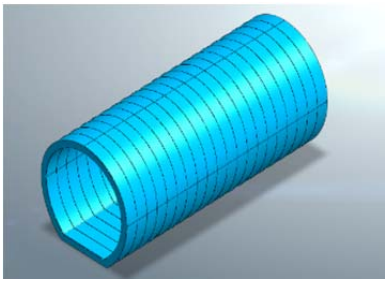
The pictorial diagram of the proposed tunnel shape has been shown as follows:



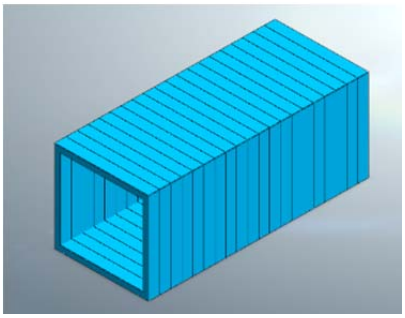
Circular



D-shaped



Horse-shoe



Rectangular

For the analysis, there are 4(four) materials considered: soil/rock, segment/shotcrete, grout. Their properties are as follows:

a. Soil/Rock:

Weathered rock

Elastic modulus (E) = $3.24*10^5$ KN/m^2

Poisson's ratio (μ) = 0.28

Unit weight (γ) = 21.28 KN/m^3

Saturated unit weight (γ_{sat}) = 21.28 KN/m^3

Cohesion (C) = 32.4 KN/m^2

Angle of friction (ϕ) = 30^o

b. Segment:

Elastic modulus (E) = $2.1*10^7$ KN/m^2

Poisson's ratio (μ) = 0.30

Unit weight (γ) = 25 KN/m^3

c. Grout:

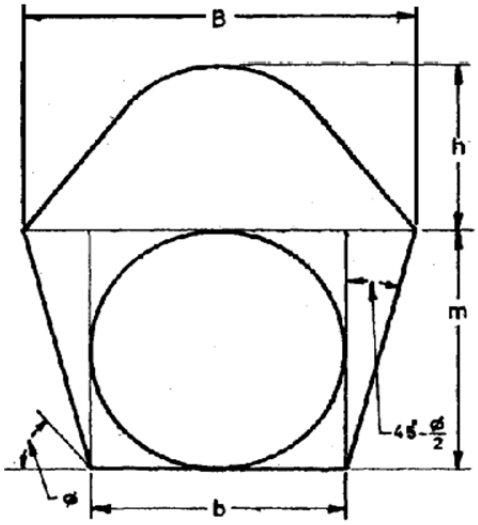
Elastic Modulus (E) = $1*10^7$ KN/m^2

Poisson's ratio (μ) = 0.3

Unit weight (γ) = 22.5 KN/m^2

3. CALCULATION OF LOAD

The load acting on the tunnel is calculated using IS 4880: part V.



h or H_p = effective height of rock load over the tunnel support

m or H_t = height of tunnel

b = width of tunnel

B = 2[(b/2) + mtan(45-ϕ/2)]

ϕ = angle of friction of the soil

The vertical load(P_v) is given as

$$P_v = B\frac{[\gamma sat - \frac{2C}{B}]}{2Ktan\Phi}[1-e^{-ktan\Phi 2H/B}]$$

P_v = 205 KN/m^2

The lateral load(P_h) is given as

$P_h = 0.3\gamma_{sat}(0.5m + h)$

P_h = 140 KN/m^2

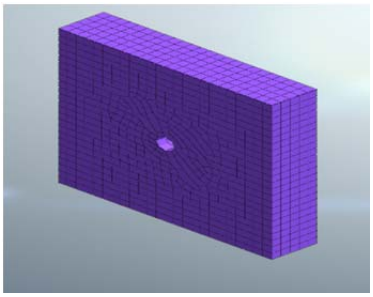
Shield external pressure(S) is taken as 5% of the total vertical and horizontal pressure acting on the tunnel

$S = 17.25\ KN/m^2$

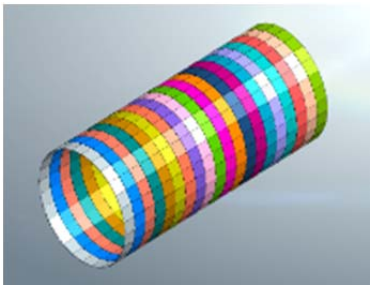
4. ANALYSIS

The analysis of the tunnel structure has been done by MIDAS-GTS NX software. This software is geotechnical analysis system which can calculated different structural performance such as displacement, shear force, bending moment.

This analysis is done by considering the tunnel after the construction have been complete. We have analysis by non-linear static method. The effective soil/rock grid is taken as 95mX95m. The tunnel is of 20m long and is divided into 20 sections. There is grout (grout is a particularly fluid form of concrete used to fill gaps) between the tunnel and the ground. The typical pictorial representation of grout and the ground is given below.



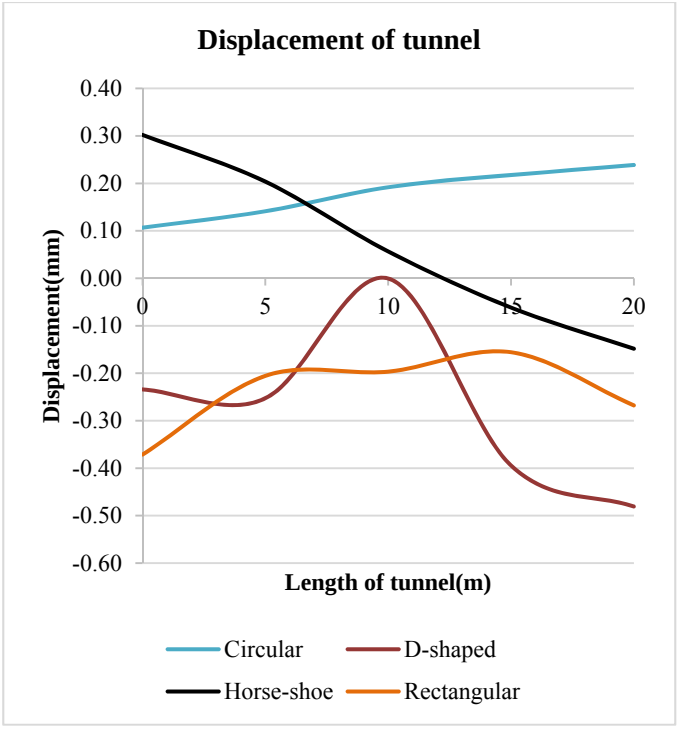
Ground



Grout

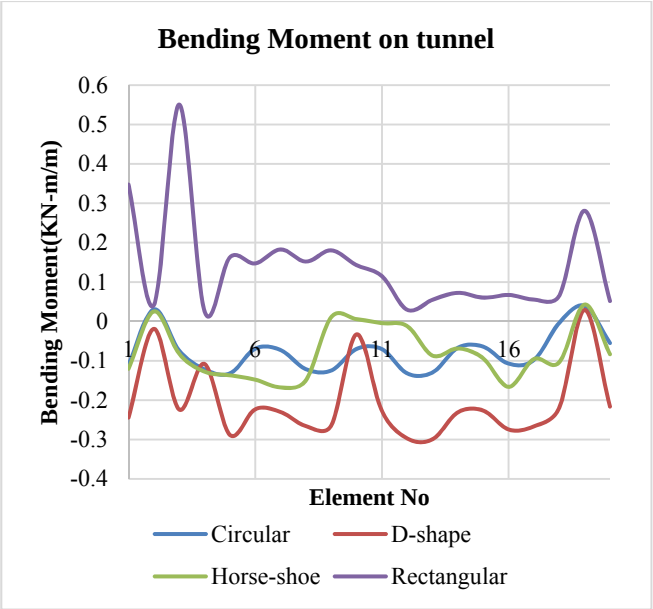
5. RESULTS

The structural performance has been calculated on the top of the tunnel i.e; crown of the tunnel. Comparison has been made on the different section of tunnel based on displacement, bending moment and shear force.

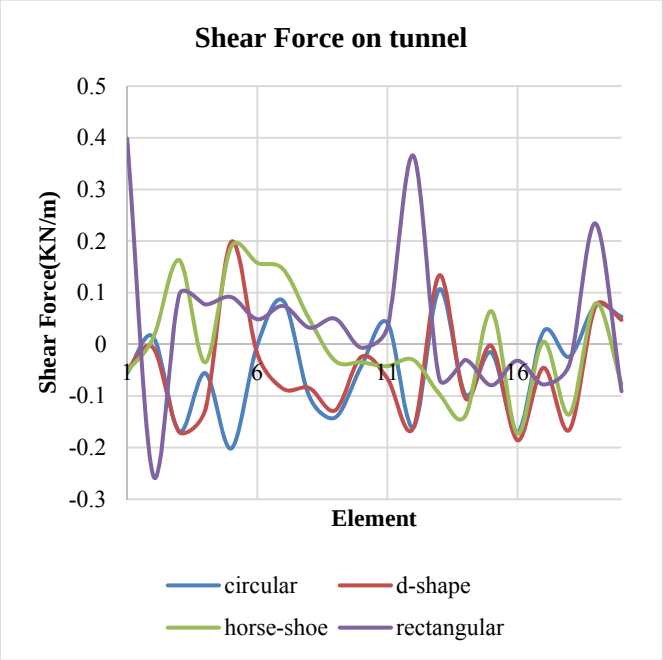


The above fig. give the displacement of tunnel in the perpendicular direction along the length of a tunnel.

At the start of a tunnel as well as at 5th meter, circular give the least displacement. At 10th meter, D-shape give almost zero/no displacement. At 15th meter, horse-shoe give least displacement as well as 20th meter of the tunnel.



Taking everything into consideration, horse-shoe has the least variation of bending moment value comparing all the others tunnel section. Hence in terms of bending moment, horse-shoe section is the most favorable for the tunnel shape.



At the start of the tunnel; circular, d-shape & circular has almost same value. But farther the length goes, horse-shoe and circular give the best results in terms of axial force.

6. CONCLUSION

As observe above, out of 3(three) structural performance, horse-shoe gives the best results for 2(two). So, for the given railway site horse-shoe shape must be the most favorable shape as compared to the other section.

REFERENCE

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