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Numerical Analysis of Different Types of Tunnels

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***Abstract-* Tunnel construction has now become a major part in modern construction. Tunnels helps us to sometimes reduce the distance between two points. This paper tells us about the different types of tunnel cross-sections and also tells us that which kind of tunnel is suitable for a particular site conditions. This paper provides information on various types of tunnel sections suitable for construction, depending on the availability of soil or rock on which the structure is to be made. Analysis of different types of tunnel sections include some very basic operations and steps, which are to be followed in sequence in order to observe the major principle stresses minor principle stresses and displacement at critical sections. In this project the analysis of tunnel cross sections i.e., circular tunnel, semi-circular tunnel and horse shoe tunnel is done with the help of Rocscience software by putting the values of soil parameters. And by this we have come to know that in elastic analysis the best suitable cross section is circular cross section.**

***Keywords-* Displacement, Rocscience, Soil parameters, Tunnel, Tunnel section.**

I. INTRODUCTION

A few cross-sections may require removal like passage exhuming, yet are not really burrows. Shafts, for instance, are regularly hand-burrowed or burrowed with exhausting gear. In any case, in contrast to burrows, shafts are vertical and shorter. Frequently, shafts are fabricated either as a feature of a passage task to break down the stone or soil, or in passage development to give headings, or areas, from which a passage can be exhumed." The graph underneath demonstrates the connection between these underground tunnel structures in a run of the mill mountain burrow. The opening of the passage is an entryway. The "rooftop" of the passage, or the upper portion of the cylinder, is the crown. The base half is the alter. The fundamental geometry of the passage is a nonstop curve [1-4]. Since passages must withstand gigantic weight from all sides, the curve is a perfect shape [5-9]. On account of a passage, the curve essentially goes right around..”Passage engineers, similar to extension engineers, must be worried about a territory of material science known as statics. Statics depicts how the accompanying powers interface to deliver balance on structures, for example, passages and scaffolds. So as to stay static, burrows must probably withstand the heaps set on them [10-11].

II. METHODOLOGY

Analysis of different types of tunnel sections, include some very basic steps and operations, which are to be followed in sequential manner in order to observe the major and minor principle stresses and displacement at critical sections.

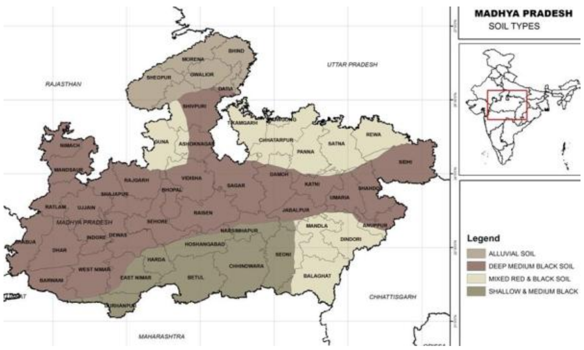

Fig. 1. Soil Map of M.P.

A. *Survey Region*

Gwalior is one of the district of Madhya Pradesh, India. It is located at latitude of 26º21'N and Longitude 78º18'E. The climate is semi arid to sub humid summer with an average temperature of 40.5ºC, cool and dry winter with average winter temperature of 6.6ºC. The average annual rainfall is 91 cm and most of it occurs during rainy season.”

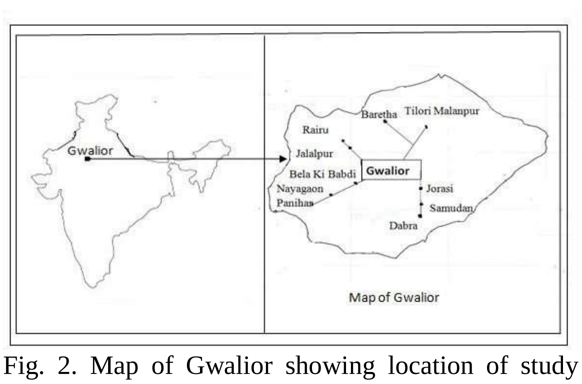

Fig. 2. Map of Gwalior showing location of study sites.

B. *General information about soil at site*

During the survey we knew about the region ,In that we also get to know about the types of soil which is present at site that was alluvial soil : a first-class-grained ripe soil stored by way of water streaming over flood fields or in waterway beds. alluvial keep, alluvial dregs, alluvium, alluvion : dust or sediment or rock conveyed by surging streams and saved in which the circulation backs off. We have selected this data from research paper which is relevant to the project to analyze the terms of designing tunnels ,In this table, we have selected the parameters of alluvial soil which is available at site. In this paper we have also used the soil parameters *i.e.,* tensile strength, cohesion, internal frictional angle, possion’s ration and Elastic modulus (Youngs modulus of elasticity). In this paper to analyze the sections of the tunnels we have pursue the mohr coulomb failure criteria ,there are two zones Elastic as well as plastic. We have analysed the tunnel in these both zones.

We have selected three types of tunnels:
1. Circular Tunnel
2. Semi-circular Tunnel
3. Horseshoe Tunnel

III. Mohr-coulomb failure criteria

The methods which are used in designing the tunnels is mohr coulomb failure criteria which states as the material fails when the shear stress of failure plan, at failure is equal to the function of the normal stress on the plane.”

$$\tau_{ff} = f\,(\sigma_{ff})$$

where,

τ_{ff} : shear stress of failure plan at failure
$f(\sigma_{ff})$: normal stress, of failure plan at failure
the mohr-coulomb is generally used to define the strength of soil.

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IV. Calculation Part

This is a very important process because all the values and result depends on this step so while starting first of all we will tell you that we are assuming the value of stress ratio that is denoted by k is equal to 1 this is only the case which we are considering right now and anyone can easily find out various values of principal stresses by considering the values of k equal to 0.5 and 1.5.so we find all the result, if the value of k is equal to one.

Now to find out the weight which is applied by the soil on the tunnel for that we assume some parameters like the depth of soil, length of tunnel. And we also have the width of tunnel that is 20 m and depth of soil is the depth at which the tunnel is made that is assumed to be 500 m and the length of tunnel is assumed was 3 km.

The one method is to find the volume of soil and then multiply by its unit weight of soil and then divide it by area of cross section of tunnel which is equal to the area of soil which is spread all over it and the other method is to find it directly by the formula which is subjected by research paper of ("international journal of mining science and technology") and the paper name is ("Prediction of plastic zone size around circular tunnels in non-hydrostatic stress field"). In this paper we have selected the formula's to find the values of sigma 1, sigma 3 and sigma Z

Now, the suggested formula are:

$K = \sigma_h/\sigma_v$

Where , σ_h = horizontal stress experience by tunnel

σ_v = vertical stress which is applied by the soil

And then later on,we have to find out the value of σ_v which is determined by the formula: $\sigma_v = \gamma*Z$, =500*2*10^4 =10*10^6 =10MPa Where, = unit weight of soil i.e 2*10^4(N/m^3) Z= depth of soil i.e 500 m Now put all the values in above formula's and then, values are obtained is represent below: This is the case for k=1.

We entered the values:

Table 1. The Summation Of Original Parameters For Analysis

S.No	Parameters	sign	values	units
1	Field Stress	$\sigma 1$	32	MPa
		$\sigma 3$	32	MPa
		σz	32	MPa
2	Angle of stress	α	0	Degree
3	Ratio of Stress	$\sigma 1/\sigma 3$	1	-

Table 2. The summation of Parameters for analysis

S.No	Parameters of soil	Sign	values	units
1	Modulus Elastic modulus	Em	1500	MPa
2	Poisson ratio	μ	0.29	-
3	Tensile strength	σk	0.05	MPa
4	Cohesion	C	0.074	MPa
5	Friction angle	φ	24	degree

V. Circular Part

Using Rocscience software we have excavated the section of tunnel, this is easy to represent through software. And all the

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important steps are completed now we have saved it and compiled it for elastic material type singly. After the steps the circular tunnel look like as shown in figure.

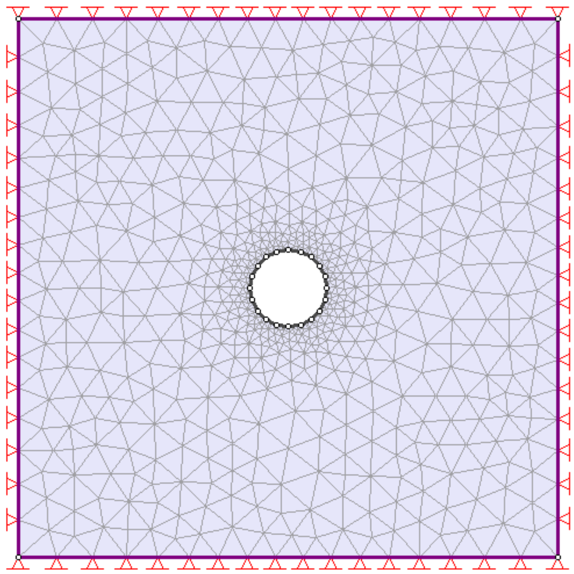

Fig 3. Circular Tunnel In Rocscience Software

Dimensions of circular tunnel are:
Radius = 10.70m
Area of excavation: 353.794 m^2
Perimeter of excavation: 66.954 m
Area of external boundary: 22440.040 m^2
Perimeter of external boundary: 599.200 m

A. Various Stresses

Principal stress are the most and minimal normal stress on a selected plane, properly we can also determine extreme values of normal stresses feasible inside the material. And the plane on which these principal stresses will act are known as principal planes. Maximum normal strain is named as major stress and minimum normal strain is called as minor stress.

We have analysed these two stresses and displacement under elastic criteria, so here we have discussed the elastic criteria.

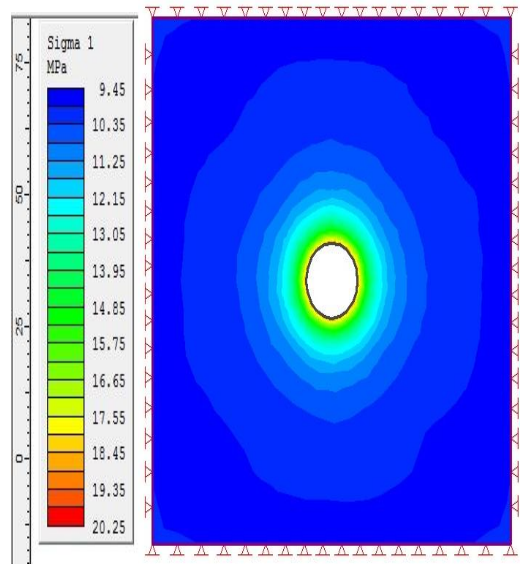

Fig 4. Sigma 1 (major principal stress) for elastic

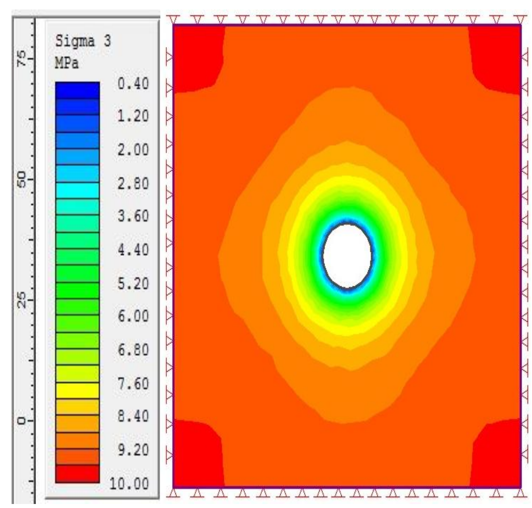

Fig 5. Sigma 3(Minor Principal Stress) For Elastic

Similarly, we select the total displacement dialog and we obtain the data.

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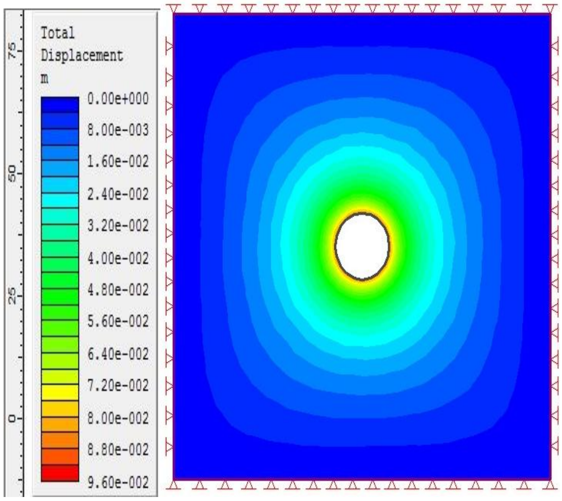

Fig 6. Total displacement for elastic

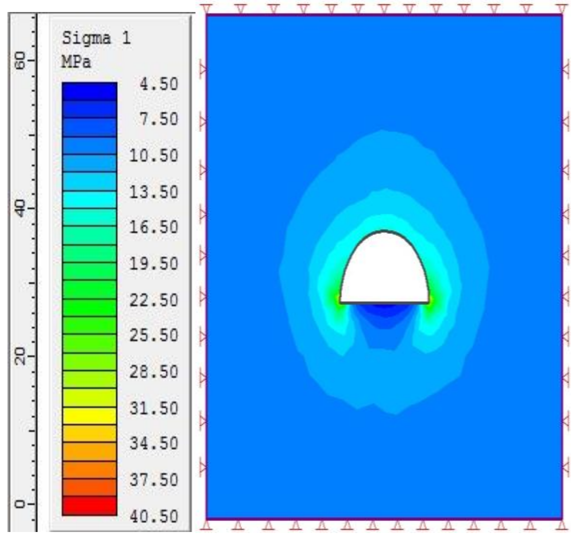

Fig 12. Sigma 1 (major principal stress) for elastic

VI. Semi-circular Tunnel

Similarly, for the semi-circular tunnel.

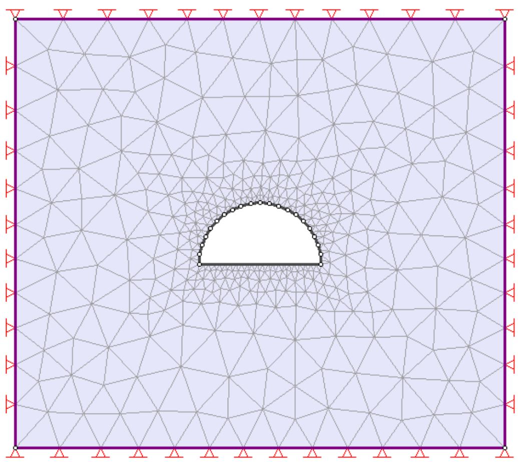

Fig 11. Semi-circular tunnel on rocscience software

Dimensions of semi-circular tunnel are:
Radius = 15.07m
Area of excavation: 356.686 m^2
Perimeter of excavation: 77.589 m
Area of external boundary: 12768.560 m^2
Perimeter of external boundary: 453.000 m

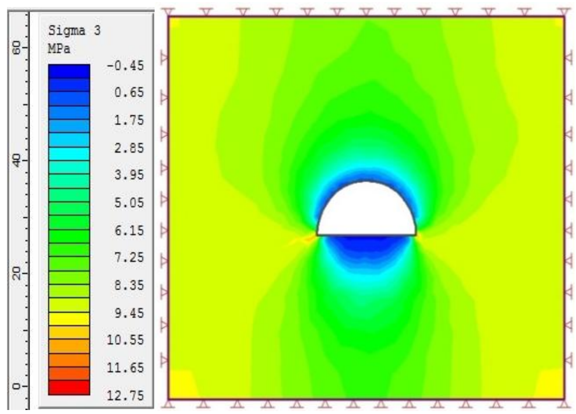

Fig 13. Sigma 3 (minor principal stress) for elastic

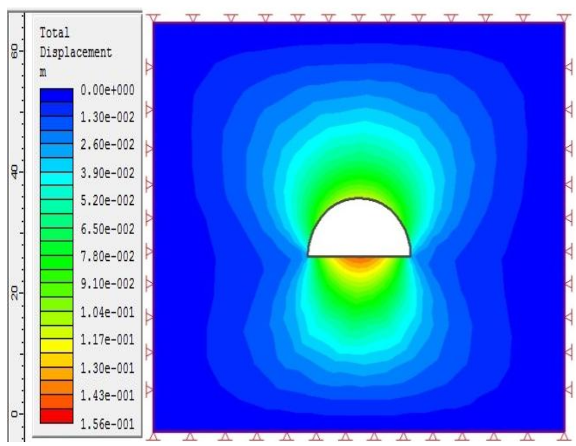

Fig 14. Total displacement for elastic

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VII. Horsrshoe Tunnel

Similarly, for the Horseshoe tunnel.

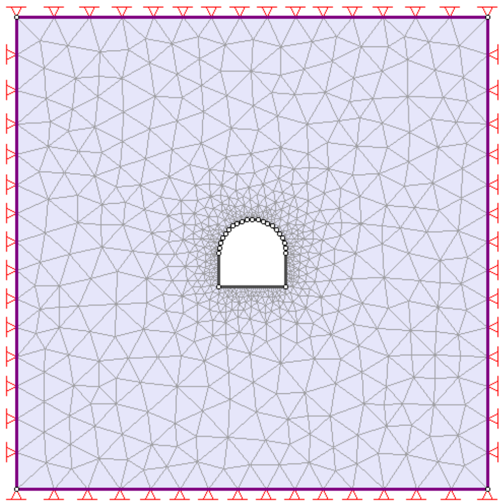

Fig 19. Horseshoe tunnel on rocscience software

Dimensions of horseshoe tunnel are:
Radius = 20m and coordinates are (-10,10),(-10,0),(10,0),(10,10).
Area of excavation: 356.434 m^2
Perimeter of excavation: 71.384 m
Area of external boundary: 19600.000 m^2
Perimeter of external boundary: 560.000 m

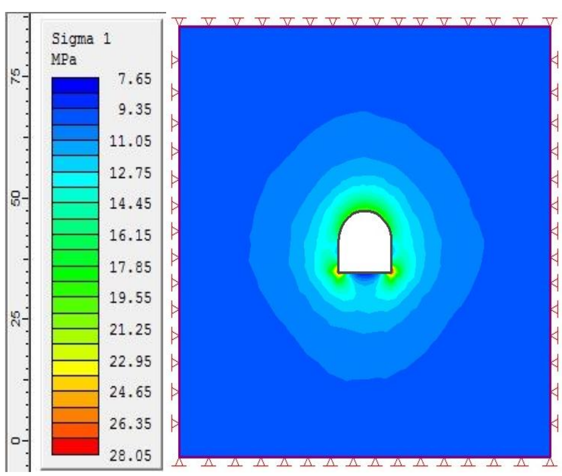

Fig 20. Sigma 1 (major principal stress) for elastic

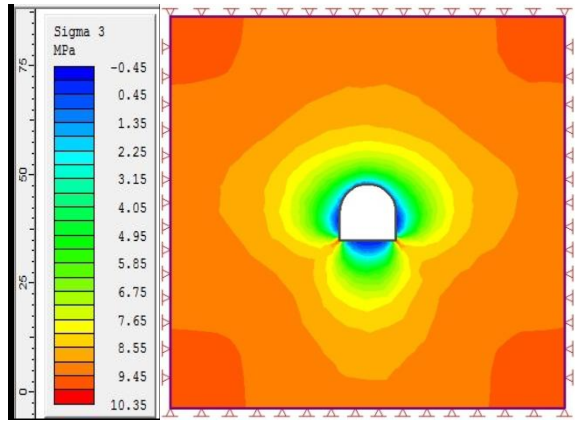

Fig 21. Sigma 3 (minor principal stress) for elastic

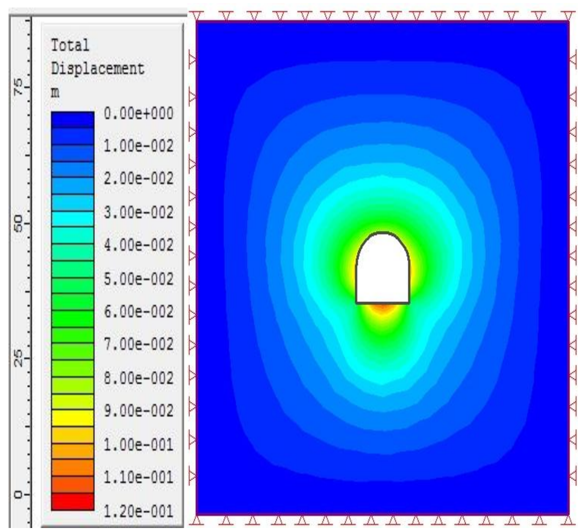

Fig 22. Total displacement for elastic

VIII. Results

Values of sigma 1 (major principal stress) for elastic material type.

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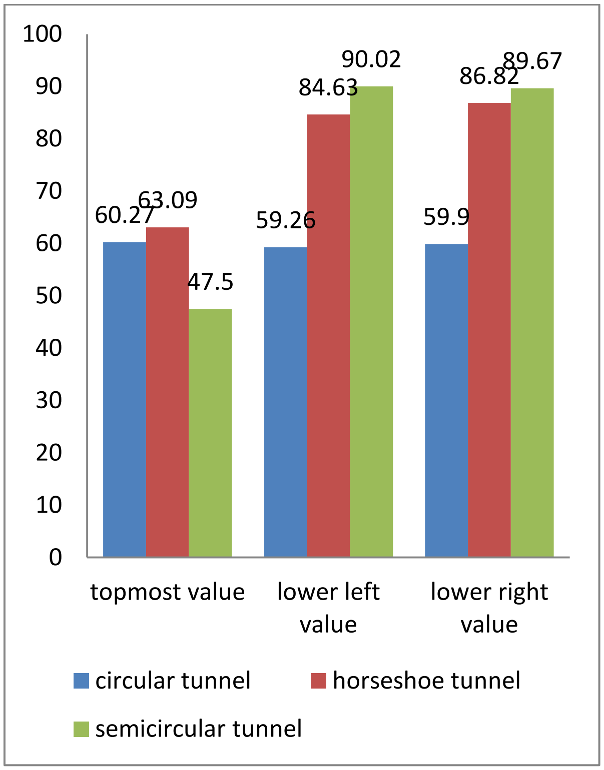

Fig 23. Graph Of Sigma 1 (major principle stresses)

Values of sigma 3 (minor principal stress)for elastic material type

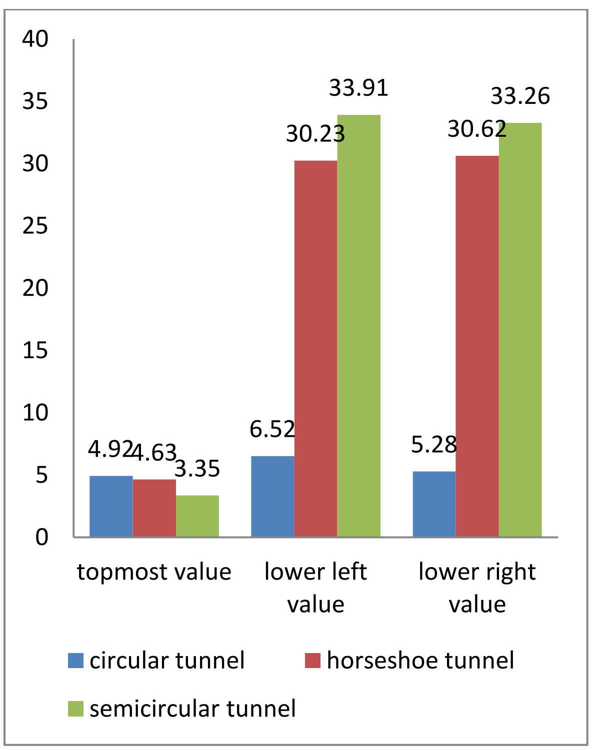

Fig 24. Graph Of Sigma 3 (minor principle stresses)

Value of total displacement for elastic

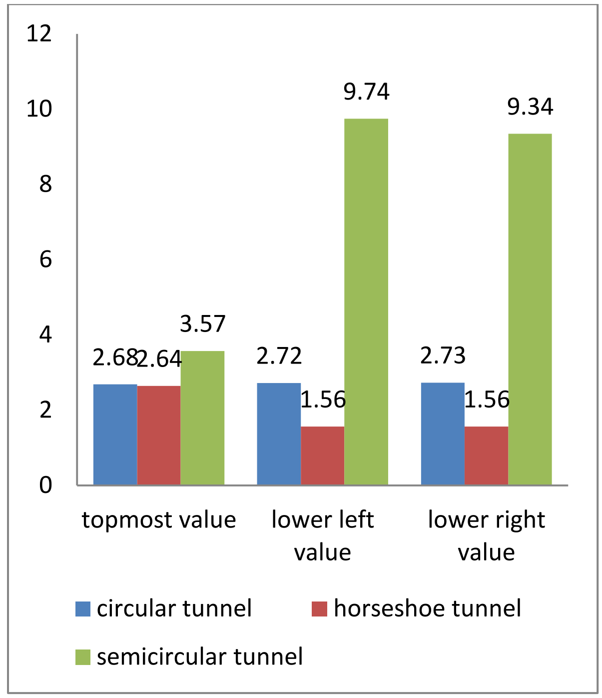

Fig 25. Graph Of Total Displacement

IX. CONCLUSION

In this part we shall talk about analysing the data of graph in the elastic criteria of tunnel, in which the consideration of values of sigma 1 and sigma 3 or we can also say it as principal stresses experience by tunnel at various point on the tunnel and later on ,we have also analyzed the displacement condition of each tunnels.

Now let us talk about elastic condition of tunnel,the minor and major principal stresses which is represented in graph shows that the circular tunnel has lesser values than the horseshoe and semicircular tunnel and after the circular tunnel the horseshoe tunnel has lesser stress values that the semicircular tunnel. After comparing all the data we can say that the circular tunnel is more compatible than the other two tunnel.

And accordingly we have come to know that for elastic analysis the best suitable tunnel section for a particular type of soil parameter is circular section then comes horse shoe section and then is the semi-circle cross section.

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