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A PARAMETER INVESTIGATION ON STATIC STABILITY OF TUNNEL IN HILLY REGION

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ABSTRACT

This current study undergoes a parametric investigation of the static stability of tunnels located in hilly regions. There are numerous factors that can contribute to tunnel failure under both static and dynamic conditions. Our research employs a numerical technique to assess the impact of static loading on tunnel stability through a comprehensive parametric study. This study explores the variations in critical parameters, including displacement, bending moments, and tunnel characteristics. Additionally, in this investigation, the effects of minimum and maximum displacement have been found on the stability of the tunnel.

Keywords: Tunnel, FEM, Grouting, GTS NX, Segment, Soft Rock.

I. INTRODUCTION

One of the oldest, most fascinating and most difficult engineering specialties is tunnel engineering, which necessitates not only theoretical understanding but also real-world expertise in geology, structural design, concrete construction, machine technology, construction process technology, and construction management. An actual tunnel is far more than that. It serves a variety of purposes, including those of a highway, rail line, rapid transit artery, and pedestrian subway, source of pure water, drinking water supply, collection or transportation of wastewater, hydropower generator, or utility corridor. A tunnel is eventually built in one of the countless media, including soft ground, mixed face, rock, and uniform, jumped, layered, dry, wet, stable, flowing, and squeezed. Tunnel-boring machines (TBMs) have been taken into consideration when designing the tunnel layout (Kuesel, T. R., King, E. H., & Bickel, J. O. 2012). The effect of dynamic stress on design distortion is one of the major critical factors influencing structural design (Dhatrak and Dhengal 2014). Increased societal growth and advancements in tunnel construction techniques have resulted in a rise in the number of extremely long highway tunnels. When compared to a normal two-lane tunnel, a long-span tunnel is distinguished by a huge excavation area, a minimal height-spanning ratio, and challenging construction methods (Manchao et al. (2023). It has three methods for determining the load change pattern, from the entire mass of the uppermost soil over the station tunnels to the total mass of the soil in the collapsed vaults of the interstation tunnels. Full experimentation or modeling using mathematics (A.N. Konkov et al.2023). On the other hands there are four type of road tunnel construction discovered in the study are out and cover, bore, or mine tunneling, soft surface tunneling and hard rock tunneling. The tunnel construction has significantly impact to the environment through various source such as generation of construction waste material, sludge generation, waste water generation, noise and vibration. As a fundamental matter, one of the most important things to consider in any road tunnel construction project is a comprehensive examination of the suitability of the soil, surface, geology and hydrology prior project development (Mahumad 2022). It should be considered to develop the high-level programming for the numerical simulation analysis about metro station and tunnel near deep excavation in the future near the sub way (cong chen 2016). The effect of tunnel excavation with and against dip of the rocks major structure planes are explored through 3D finite element method FEM (Vitali et al 2021 a). The tunnel behaviour due to the blast induced vibration was investigated in the terms of partial velocity, displacement and stress of lining and a guideline for the blast protection zone was proposed based on a parametric study on blast location, tunnel depth and the amount of explosive (Beyabanaki et al.2017). The tunnel support is typically short creating reinforcement with steel ribs and steel fibres ore wire mesh (Vitali et al 2022 b). Slip and no slip approach at the lining ground interface to evaluate the moment and thrust. One of the most important challenges of any geotechnical Engineer problem associated with tunnelling is to determine the deformation produce during tunnel excavation (MOHAMMED, J. A. (2020). Most of the project were performed for the partial and short distance replacement of the definitive lining (Liu et al.2023).

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II. METHODOLOGY

Midas Finite Element Methods

A simulation tool termed GTS NX was created using the finite element method to assess soil-structure interactions. Engineering professionals may undertake detailed analyses of excavation, financing, the structure's location, loads, and other elements that have a direct impact on design and construction using GTS NX. To simulate authentic events, the program supports a variety of conditions (soil properties, water level, etc.) and analytical methods. In GTS NX, there are actually two fundamental systems. Work-plane coordinate systems (WCS) and the global coordinate system (GCS) The red (X-axis), green (Y-axis), and blue (Z-axis) arrows in the bottom right corner represent the fixed global coordinate system (GCS). The work plane is used to enter the two-dimensional coordinates of shape; therefore, the WCS (work-plane coordinate system) changes as you glide around the workspace. It is located in the centre of the work screen. To create a shape in space, absolute three-dimensional coordinates are required, although in most cases, just relative coordinates, such as length, are provided. In this situation, by adjusting the work plane to the proper place and then entering the two-dimensional coordinates (the XY plane on the WCS), modelling can be performed easily.

III. MODELING AND ANALYSIS

This project represents the finite element modelling of a tunnel using MIDAS GTS NX software to examine the factors of safety, displacement, and seismic behaviour in soft rock to fulfil the requirements of a tunnel. The tunnel is modelled in 3D with ground dimensions of 50m in height and 30m in length. The properties of soft rock are defined in the Coulomb model; segment, grouting, and steel are defined with the general elastic model in Mohr's Coulomb; the material property is different for each layer. The schematics of the tunnel, considered in the present study have been shown in Fig. 1. Also, the engineering properties of the tunnel materials and foundation are presented in Table 1.

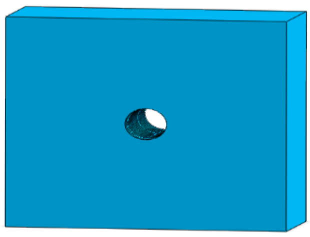

Figure 1: Schematics of the problem considered in the present

Table: 1. Tunnel soil properties used in finite element analysis

Parameter	Soft rock	Segment	Steel	Grouting
Model	Mohr coulomb	Elastic	Elastic	Elastic
Material	Isotropic	Isotropic	Isotropic	Isotropic
General				
E	25000	27000000	210000000	1800000
μ	0.3	0.18	0.25	0.3
ɣ	22	24	77	23
k_0	0.5	0.5	0.5	0.5
Porous				
ɣ (saturated)	23	24	77	22.5
Void ratio	0.5	0.5	0.5	0.5
Non linear				
C	20	15		
ϕ	30	32	34	36

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Meshing

A 3D solid shape's mesh is impulsively built by using auto-solid mesh. Tetrahedral and hexahedral-cantered hybrid (tetrahedral and hexahedral combination forms) meshes are available. To adjust the mesh size, either enter the number of divisions on the edges of the solid generating or use the mesh size manually. Select the option to separate the region and have it automatically formed if the closed region is located within another closed region. The option specifies the location of the lines or points and creates a node if an inside line (edge) or point is chosen. When creating a structural element, the option to extract sub-shapes from edges is especially important. Different meshes are generated for different layers of material properties. The generated meshing in MIDAS GTS NX has been shown in Fig. 2, 3, 4 and 5 respectively. (Midas, G. 2019).

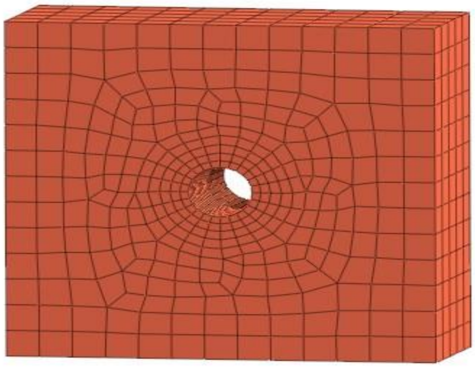

Figure 2: Soft rock mesh

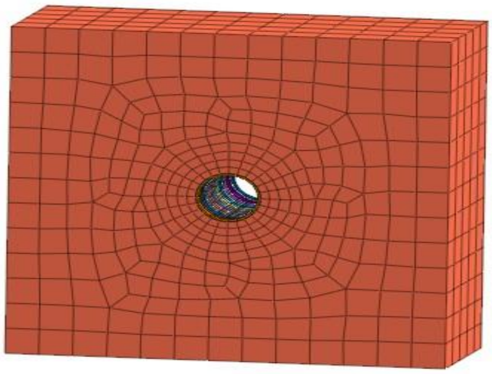

Figure 3: Segment mesh

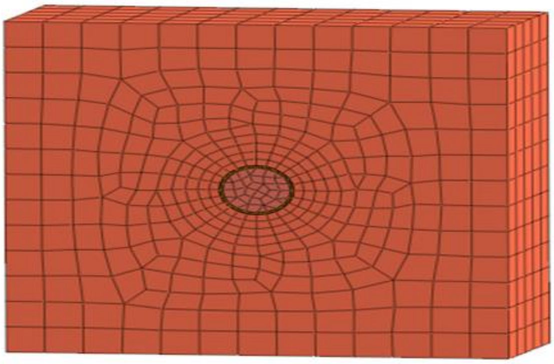

Figure 4: Grouting mesh

Figure 5: Steel mesh

IV. RESULTS AND DISCUSSION

Different load effects on tunnels occur during the designing phase of construction. The shield was forced forwards in its excavation plane by an external axial load known as jack thrust. Another external force acting along the tunnel wall is grouting pressure. Grouting is used to mitigate and avoid displacement from the soil around it. In generally, increasing the grouting load raises the effective stresses on the tunnel lining, which raises overburden stresses. static loads are applied to the surface or edges of the plate element, plane stress element, solid element (segment), shell, or shield. The distribution of displacements in the tunnel is (a) with soft rock and (b) without soft rock. Shown in fig:4. (a) and (b). The maximum and minimum displacement with soft rock are 0.728 and 0, respectively. Similarly, without soft rock, the maximum and minimum displacement are 0.59 and 0.000556, and the displacement graph is shown in fig. 7(a) and 7(b).

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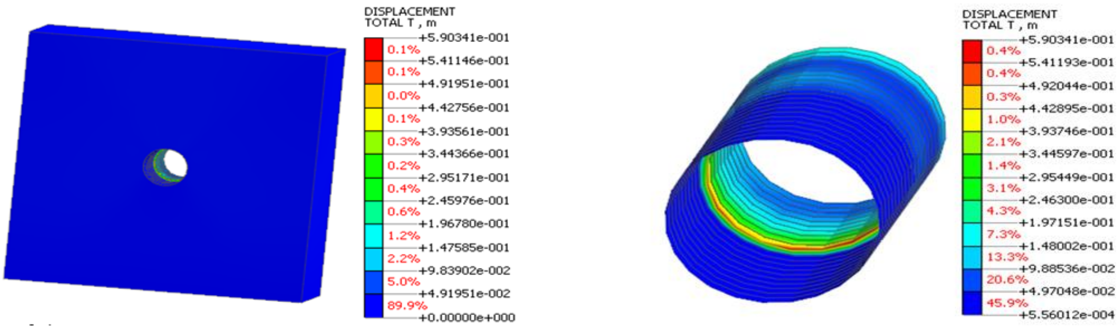

(a) (b)

Figure 6: The distribution of displacements in the tunnel is (a) with soft rock and (b) without soft rock.

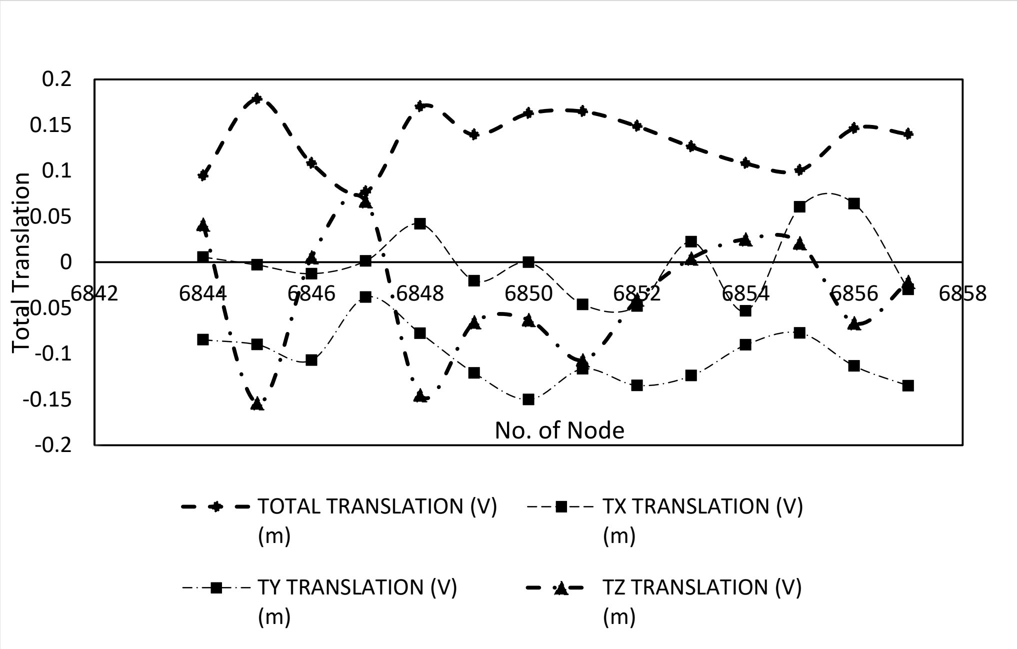

Figure 7(a): With soft rock.

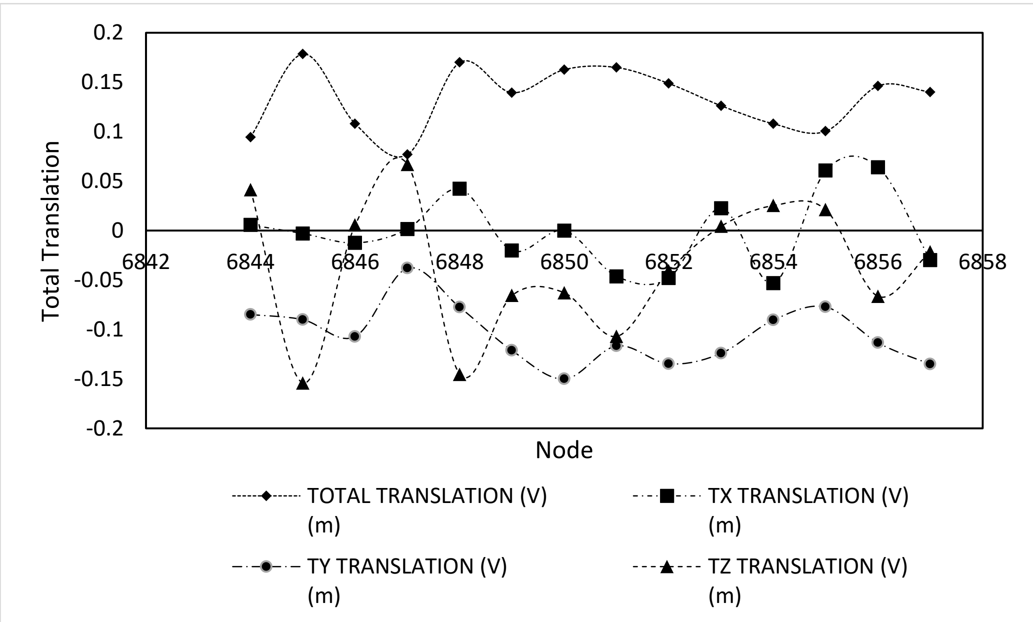

Figure 7(b): Without soft rock.

V. CONCLUSION

In the current investigation, the proposed paper has examined the static stability of a tunnel and documented our findings concerning various levels of displacement. When dealing with soft rock conditions, our results indicate that the maximum displacement is 0.728, while the minimum displacement is 0. On the other hand, when no soft rock is present, our analysis reveals that the maximum displacement is 0.59 and the minimum displacement is 0.000556.

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