Dear Dr. Quevedo,

We have received the reports from our advisors on your manuscript, "Numerical analysis of the rock deformation in twin tunnels with transverse gallery considering plasticity and time-dependent constitutive models", which you submitted to Geotechnical and Geological Engineering.

The manuscript number is GEGE-D-24-01227

Based on the advice received, I feel that your manuscript could be reconsidered for publication should you be prepared to incorporate major revisions.

When preparing your revised manuscript, you are asked to carefully consider the reviewer comments which are attached, and submit a list of responses to the comments.

Submit your response as separate submission item.

PLEASE VISIT THE WEBSITE FOR POSSIBLE REVIEWER ATTACHMENTS

In order to submit your revised manuscript, please access the Editorial Manager Website.

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We look forward to receiving your revised manuscript within eight weeks.

With kind regards,

Jia-wen Zhou, Ph.D.

Associate Editor

Geotechnical and Geological Engineering

**COMMENTS TO THE AUTHOR:**

**Reviewer #2:** The research work is based on pure theoretical derivation and simulation analysis. Many mature commercial software has good calculation and analysis functions. Therefore, the innovation of the research work is insufficient, and the practical guiding role of the project is insufficient. In addition, there are too many sections and too long length. It is suggested to carry out targeted research on an innovative problem to avoid lengthy discussion. Unfortunately, the existing manuscript cannot be supported.

**Reviewer #5:**

In this manuscript, the authors study rock deformation in twin tunnels with a transverse gallery, considering plasticity and time-dependent constitutive models. After reviewing the manuscript, I believe the following questions should be addressed in the revised version:

**1) The title could be changed to "Evaluation of Rock Deformation in Twin Tunnels with a Transverse Gallery, Considering Plasticity and Time-Dependent Constitutive Models."**

**2) Is the twin tunnel mentioned in Section 5 an actual case study? If so, the geotechnical properties, as well as details regarding the size, excavation method, and lithological units of the study area, should be provided.**

The twin tunnel mentioned in Section 5 is not a real-case study but an academic configuration used to validate and demonstrate the application of the developed numerical model. The geometrical properties, material parameters, and boundary conditions were defined based on data from the literature and idealized assumptions. There are no specific geotechnical data, excavation methods, or lithological unit details, as the study aims to explore generic scenarios of interaction between twin tunnels and a transverse gallery.

This response can be incorporated into Section 5: "Spatial and Time Discretization of the Domain", immediately after introducing the model geometry and conditions, with the following text:

"This study does not represent a real-case scenario. The twin tunnel configuration is an academic setup designed to validate and illustrate the applicability of the proposed numerical model. Geometrical parameters, material properties, and boundary conditions were idealized and based on data from the literature, without referencing specific geotechnical, excavation methods, or lithological units."

**3) Which software was used for simulating the tunnel?**

The software used was ANSYS, but the constitutive models were implemented within it using the UPF/USERMAT resource. The software doesn't have these models. This information is in the text of the article.

**4) How was the numerical model calibrated?**

**5) How were the results of the numerical simulation verified?**

The results of the numerical simulations were verified by comparing them with analytical solutions and numerical results available in the literature for similar configurations without transverse gallery. For example, comparisons were made with the analytical stress solutions for twin tunnels under plane strain conditions proposed by Guo et al. (2021) and Ma et al. (2020). Preliminary numerical tests were conducted to evaluate the accuracy of the finite element implementation, including stress distributions and plastic zone boundaries. These comparisons demonstrated the ability of the model to capture the key interaction effects and deformation mechanisms.

**6) The support systems of the tunnels and gallery should be clearly presented in a specified table.**

This presented in Table 1.

**7) The boundary conditions, assigned material properties, and model size should be illustrated in the text.**

Boundary conditions are detailed in Section 5 and illustrated in Figure 5, including the geostatic initial stresses (Equation 11) and symmetry conditions. The model size is described in Section 5, with domain dimensions and mesh details shown in Figure 5 and Table 1. Assigned material properties are provided in Section 7.1 and summarized in Table 2, covering both rock mass and lining parameters.

**8) How were the normal and shear stiffness between the initial and secondary support systems considered in the model?**

The concrete lining is modeled as a continuous structure with constant thickness, without distinguishing between primary and secondary support systems. The interaction between the support and rock mass was modeled assuming perfect bonding, eliminating the need to explicitly consider normal and shear stiffness. This simplification is valid for scenarios with good material connection. For interfaces with potential sliding or separation, advanced interface models with specific parameters could be applied.

This response can be incorporated in Section 2: "Fundamental Assumptions":

"The lining was modeled as a continuous structure, assuming perfect bonding with the rock mass and without distinguishing between primary and secondary supports. This simplification avoids explicitly modeling normal and shear stiffness and is valid for scenarios with strong material connections."

and eliminate alinea:

"Perfect bonding is assumed at the interface between concrete lining and the rock mass."

and change alinea:

"The simulation excavation processes are curried out assuming a constant tunnel advancement rate (i.e., constant excavation speed), together with a constant thickness of concrete lining."

to:

"The simulation excavation processes are curried out assuming a constant tunnel advancement rate (i.e., constant excavation speed)."

**Reviewer #6:** The paper is good and worthy explaining the finite element analyses of the twin circular tunnels deformation mechanisms taking into account the visco-elasto-plastic behavior of the surrounding rocks. the following comments are suggested:

**1- Title of the paper may be revised as the numerical modelling analyses are based on the FEM. For example the following title is suggested: "A three-dimensional finite element analysis of the rock deformation mechanisms in twin circular tunnels with a transverse gallery based on visco-elasto-plastic constitutive models".**

**2- The English of the abstract may be rechecked. Some lengthy and somewhat repetitive sentences exist.**

**3- The theoretical background and literature review on the stress analyses around rock tunnels may be improved. For example see the following papers:**

N Nikadat, MF Marji, 2016, Analysis of stress distribution around tunnels by hybridized FSM and DDM considering the influences of joints parameters, Geotechnical and Geological Engineering 11 (2 (April 2016)), 269-288.

M. S. Abdollahi, M. Najafi, AR Yarahmadi Bafghi, MF Marji, 2019, A 3D numerical model to determine suitable reinforcement strategies for passing TBM through a fault zone, a case study: Safaroud water transmission tunnel, Iran,Tunneling and Underground Space Technology 88, 186-199.

A Abdollahipour, MF Marji, AY Bafghi, J Gholamnejad, 2016, Time-dependent crack propagation in a poroelastic medium using a fully coupled hydromechanical displacement discontinuity method, International Journal of Fracture 199, 71-87.

A Abdollahipour, MF Marji, AY Bafghi, J Gholamnejad, 2016, A complete formulation of an indirect boundary element method for poroelastic rocks, Computers and Geotechnics 74, 15-25.

**4 - The explanations for Figures' captions may be improved, For example the caption of Figs. 11 is very concise. It may be divided into two parts (a) and (b) for the two figs, and explain them individually., The same is true for Figs. 19 and Figs. 20, etc..**

**Reviewer #7:** This paper conducted numerical analysis of the rock deformation in twin tunnels with transverse gallery. Overall, this paper is interesting. The following comments are for the authors to consider. After revision, I think this paper can be published.

**(1) In the introduction, the authors mentioned that tunnels are widely used and in the underwater environment. Therefore, the latest research regarding the interaction between rock mass around tunnels and water is recommended to be added (10.1016/j.engfailanal.2024.109137).**

**(2) For the fundamental assumptions, this section can be shortened.**

**(3) Please further check whether some equations or figures should be cited in Section 3, such as Figure 1 and Equation (2).**

The authors considered Figure 1 and Equation (2) important for understanding the mathematical description of the model.

**(4) The above comment is also applicable to section 4.**

The authors considered Figure 3 and Equations important for understanding the mathematical description of the model.

**(5) When author mesh the geometry to the corresponding number of elements, which guideline did the authors follow? I mean how did the authors determine the corresponding number of elements?**

The mesh density and element distribution in our study were defined based on a balance between accuracy and computational efficiency. We followed standard meshing practices for geotechnical problems, ensuring that the element size was sufficiently small in regions of high stress gradients, such as near the tunnel-gallery intersections. A mesh convergence study was performed, wherein we progressively refined the mesh and monitored key results (e.g., stress distribution and convergence profiles) until changes between successive refinements were negligible. Special attention was given to areas with complex interactions, such as the transverse gallery and surrounding rock mass, where 10-node tetrahedral elements were used to capture detailed stress redistribution. For the remaining structure, 8-node hexahedral elements were employed to optimize computational costs. The final number of elements was also influenced by the computational resources available, as we aimed to ensure the feasibility of running multiple simulations for different parametric studies.

To make it clearer, it will be added in section 5:

“The mesh density was determined based on a balance between accuracy and computational efficiency. A mesh convergence study was conducted comparing the results, such as stress distributions and displacements, between successive mesh refinements until changes were negligible. The results also were verified with analytical solutions presented in the following section.”

**(6) The authors conducted a comprehensive analysis and parameter study. However, it will be better to compare the numerical study with some in-situ tunnelling cases. I understand that the fundamental research will be quite difficult to have certain in-situ tunnelling cases. Therefore, this is a recommendation for the authors to consider.**

We sincerely thank you for your valuable comment highlighting the importance of comparing numerical study with in-situ tunneling cases. We fully agree that such comparisons are critical for validating and enhancing the practical applicability of the research findings.

As noted, the primary focus of this study is on fundamental research and the development of a robust numerical approach to model the interactions between twin tunnels and transverse galleries. While the current work does not incorporate specific in-situ cases due to limitations in accessing detailed and well-documented project data, we emphasize that the developed methodology is designed to be applied in future analyses of real tunneling projects.

We acknowledge the significance of this recommendation and are actively exploring opportunities to collaborate with tunneling projects to validate the computational model using field data in subsequent research. Thank you once again for your insightful suggestion, which we believe will be an important direction for future studies.

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