**Reviewer’s Responses to Questions:**

Question 1 – In Decision on submission: 1. Are the objectives and the rationale of the study clearly stated?

Reviewer #1: The objectives of the study are clearly stated, but the rationale of the study is not very clear. In the introduction：1. Why was this methodology used for the study? 2. A clear summary of existing research to highlight the innovations of this work. These two aspects can be improved.

Tentar resumir os problemas que envolvem túneis gêmeos. Estender o último parágrafo da introdução com mais detalhes: o que de fato será feito, a metodologia e o que há de novo.

Question 2 – In Decision on submission: 4. Could the manuscript benefit from additional tables or figures, or from improving or removing (some of the) existing ones?

Reviewer #3: Put color scales to Figure 13

Será adicionado as escalas na figura 13.

Question 3 – In Decision on submission: 5. If applicable, are the interpretation of results and study conclusions supported by the data?

Reviewer #3: No comparison with any case studies.Reviewer #5: Yes, but they need to be significantly improved - see attached pdf file.

Procurar um estudo de caso? Ou enfatizar os casos de comparação analíticas. E explicar as dificuldades em se obter os dados do revestimento.

Question 4 – In Decision on submission: 6. Have the authors clearly emphasized the strengths of their study/theory/methods/argument?

Reviewer #1: No. 1. Emphasized in the introduction; 2. Further elaboration in the methodology section; 3. Comparison with traditional methods in results.

Reviewer #2: No, please see the comments in detail as follows.

Reviewer #3: I understand the authors have spent many hours fighting against ANSYS and get those results. However, there is no comparison with case studies. Generally, speaking, it is difficult to publish a manuscript stating just calculation using a commercial software as a full paper.

Reviewer #4: not much novelty in methods

Reviewer #5: NO - it must be improved.

Explicar que o software é apenas uma ferramenta. O modelo constitutivo foi programado a parte no software. Tentar de alguma forma justificar a falta de estudos de caso.

Question 5 – In Decision on submission: 7. Have the authors clearly stated the limitations of their study/theory/methods/argument?

Reviewer #3: No, they haven't. Excavation sequence should be better followed. One tunnel advances and the other follows. This is a natural sequence and should be simulated in particular for inelastic analyses. In other words, if they don't simulate these sequences, there are almost no advantage of complex visco-elasto-plastic analyses. Comparison with case studies should be done. Consideration of discontinuities and pore water is very important.

A rigor está declarado claramente as limitações do estudo. Talvez explicar que pode ser um caso mais desfavorável usar escavações simultâneas (ou quem sabe procurar algum túnel na realidade em que foi escavado com as duas galerias ao mesmo tempo). Justificar melhor o pq de desconsiderar descontinuidades e poro pressão (argilas profundas).

Question 6 - In Decision on submission: 8. Does the manuscript structure, flow or writing need improving (e.g., the addition of subheadings, shortening of text, reorganization of sections, or moving details from one section to another)?

Reviewer #1: Yes. “7. Numerical Results and Discussion” This section is too long and not clear. Dividing it into sub-sections, e.g., 7.1 and 7.2, maybe helpful.

Reviewer #4: paper is too long

Tentar dividir o capítulo de resultados e deixar mais claro.

**Comentários para os autores**

**Reviewer #1**

\*Page 2 of 28, "… making three-dimensional finite element analyses essential…". From the Introduction I can get that "developing a realistic and safe design for tunnel junctions" is important, but why is using 3D finite element analysis? From the Introduction, it does not seem to understand that 3D finite element analysis is essential.

Explicar melhor a necessidade de análises 3D FEM nesse caso. É importante para:

1 – Representar um domínio complexo da ligação entre os túneis e a galeria (não é possível fazer isso com outros modelos que não sejam 3D.

2 – Poder simular o processo de escavação do túnel através da ativação/desativação dos elementos finitos.

3 – Capacidade de lidar com leis constitutivas não-lineares.

No artigo é apenas escrito que foi usado o método ativação-desativação, mas não é dado maiores explicações.

Pode ser um parágrafo anterior ao último parágrafo da introdução.

\*“The 3D finite element model is essential for this analysis as it not only can represent a complex domain (such as the connection between longitudinal and transverse tunnels) but also enables simulation of the excavation process and lining placement through the activation-deactivation method.”

Page 2 of 28, "…but little research has been done on twin tunnels, especially with a gallery". It is hard for me to get useful information. It is recommended to summarize the issues that need to be solved in twin tunnels to highlight the focus of this paper. So what is the novelty of this paper? This should be stated clearly in the Introduction.

Tentar resumir os problemas que envolvem túneis gêmeos. Estender o último parágrafo da introdução com mais detalhes: o que de fato será feito, a metodologia e o que há de novo. Tentar complementar o seguinte parágrafo:

“Therefore, in this work, the aim is to investigate the influence of the distance between the tunnels and the effect that the gallery has on the long-term convergence profile of deep-lined twin tunnels, considering various constitutive laws for the rock mass and the lining.”

\* Page 5 of 28, "E0 is the modulus of elasticity of the concrete aggregates and microscopic particles of the cement paste" Is the modulus of elasticity of both the concrete aggregates and microscopic particles of the cement paste equal to E0? The microscopic particles of the cement paste include both hydration products and unhydrated cement particles and are not equal to the elastic modulus of the aggregate.

\* O E0 representa o módulo de elasticidade de uma forma homogeneizada dos agregados e da pasta de cimento (hidratada e não hidratada). Corrigir o parágrafo da seguinte forma:

\* "E0 is the modulus of elasticity that represents the concrete aggregates together with the microscopic particles of the cement paste"

The title highlights the plasticity and time-dependent constitutive models. The importance of plasticity and time dependence needs to be explained at the appropriate places in Sections 3 and 4.

Quem sabe explicar a questão dos domínios no interior do maciço conforme ocorre o carregamento. Que não é captado por modelos que não tem esse aspecto. Quem sabe a observação 3 e a Figura 15, podem suprir essa explicação ao coloca-las no capítulo 3.

Page 5 of 28, Eq. (7). How is D\* determined?

No artigo é dito que ele incorpora o envelhecimento do concreto. Porém, não é mostrado como ele é determinado. Ele é calculado da mesma forma que o D elástico-linear, porém com um módulo de elasticidade modificado que incorpora o envelhecimento do concreto (expressões na p. 97 e 98 da dissertação).

Page 13 of 28, "7. Numerical Results and Discussion". This section is too long and not clear. Dividing it into subsections, e.g., 7.1 and 7.2, maybe clear. The "Results and discussion" of the following paper may be helpful. <https://doi.org/10.1016/j.cemconres.2023.107267>.

No artigo referenciado está separado por: efeito de tal coisa, efeito de tal coisa...Fazer uma subdivisão parecida. Poderia ser:

7.1 Análises nos curto e longo prazos com a presença de galeria para d1 = 16, 8 e 4;

7.2 Análises no longo prazo com modelos viscosos para o maciço e revestimento elástico e viscoelástico com a presença de galeria para d1 = 4, 8 e 16 (comparação com um túnel)

7.3 Efeito da rigidez do revestimento na evolução da convergência para d1 = 4 e 16 (comparação com um túnel);

\* What is the mechanical behavior of concrete of the lining? What are the causes of shrinkage and creep of concrete here? External loads or due to cement hydration?

\* Explicar melhor o que causa o fenômeno da fluência e retração no concreto. A princípio é um fenômeno conjunto, devido a hidratação e as cargas externas. (p. 75 da dissertação)

In the Conclusion, it is helpful to define the acronyms that appear.

Na conclusão aparece apenas dois acrônicos EPVP-EL e EPVP-VEL. Colocar ao lado: EPVP (elastoplastic-viscplastic rock mass), EL (elastic lining) e VEL (viscoelastic lining).

The serial numbers in the references are missing and the reference numbers in the manuscript do not start at [1]. In addition, the number of references seems inadequate.

O número das referências no modelo segue a ordem alfabética. Por isso não é a ordem de citação. Isso é do modelo da revista.

Line numbers are missing, resulting in some specific problems I can't easily point out.

No modelo não tinha números nas linhas.

**Reviewer #2**

There are numerous discussions in the paper on well-established phenomena, such as the impact of liner stiffness and tunnel distance on convergence. Unfortunately, the discussions have not yielded any novel or insightful conclusions. As a result, the manuscript reads more like an engineering report than a research paper.

Qual resultado poderia resultar uma conclusão nova e perspicaz? Alguns aspectos são apontados na conclusão:

* O papel fundamental da rigidez do revestimento de concreto no perfil de convergências;
* A influência da interação é significativa a 4 raios;
* Modelos viscosos o tempo é um fator significativo. Devido a espera da escavação da galeria as convergências evoluem.
* O potencial de ovalização experimentada pelos modelos EPVP-EL e EPVP-VEL;
* Influência da galeria localizada.

The mesh effect of the FEM model should be considered and checked. Especially, in this paper, the liner is discretized into two layers. And, there is no information provided in the paper regarding the adequacy of the mesh size for both the rock and tunnel structures.

O que suportaria o revestimento ser discretizado em duas camadas? Que informações poderiam ser trazida para ilustrar a adequação do tamanho da malha para estruturas de rochas? A comparação com as duas soluções analíticas no capítulo 6 era para ser uma amostra disso.

The size effect is crucial due to the nonlinear material properties. However, there are concerns about the model's geometry. The tunnel radius is only 1m, which is unreasonably small. Furthermore, the tunnel is in a circular shape, which deviates from the typical geometry of rock tunnels. Therefore, the applicability of the numerical results is questionable.

Explicar o pq do raio do túnel ser 1m.

Não há túneis em formato circular em rocha? Quem sabe na introdução citar alguns exemplos de túneis gêmeos com seção circular. Inclusive, me parece que esses túneis são aproximadamente circulares.

**Reviewer #3**

Why is Poisson's ratio of rock is 0.498? This is a very eccentric value.

O valor está na referência de Piepi (argila profunda Callovo-Oxfordien de l’Aisne p. 131 e p. 142). Pode ser explicado como uma forma de modelar um material incompressível (ver no trabalho do PIEPI, se tem mais informações).

**Reviewer #4**

Thanks for submitting your work to RMMS. the authors conducted parametric analysis on deformation behavior in twin tunnels considering different constitutive modes. However, this is pure an application study using commercial software. Limited novelty can be found in this paper regarding the methodology or numerical techniques. The authors assumed isotropic stress state, which could hardly be the case in reality. Therefore, the conclusions drew from those analysis may not be reliable. The result analysis part is too long and somehow reductant and the findings are pretty common sense with limited novel findings. Based on this, I cannot recommend this paper for further consideration for RMMS.

Como distanciar o estudo da ideia de pura aplicação do uso de um software comercial? Explicar um pouco melhor sobre essa questão da customização do modelo constitutivo. Ver exemplos de estado de tensões isotrópico? Ou explicar melhor essa limitação. A parte de análise de resultados será dividida em subcapítulos. Tentar enxergar descobertas novas.

**Reviewer #5**

Dear Authors, I have carefully read your paper and to be honest: on one hand it is quite interesting, but on the other one there is so much doubt and assumptions that are not clearly described. Furthermore after reading your paper, beyond all my remarks summarized in attached file, I do not really know how your paper impacts the filed of numerical analyses in tunneling. Most of the finding in conclusions seem to be very predictable without making calculations. To be honest I was hesitating between "rejection" and "major revision". Finally I decided to give you the chance to improve the paper, so my decision is "major revision". Please find my comments in pdf file. Regards.

Ver como o artigo afeta o campo de análises numéricas em tunelamento. Ver conclusões que não sejam tão previsíveis sem a realização de cálculos. Talvez adicionar os resultados das galerias. (Ver o que temos em relação as galerias que pode ser alguma novidade)

Page 2 of 28: “[…] They recognizing […]”. Please revise this sentence.

Ma et al. [13] proposed an analytical method, verified by a numerical solution using FLAC3D software for determining the plasticization zones around deep circular twin tunnels without linings, restricting themselves where there is no overlap between the two plastic zones. In this case, they adopted the perfectly plastic elastic constitutive model for the homogeneous and isotropic mass, with the Mohr-Coulomb criterion for the flow surface. They also carried out parametric studies to understand the influence of the distance between the twin tunnels, cohesion, the angle of internal friction, and the vertical and horizontal stresses acting on the shape and depth of the plastic zones. These authors stated that the plastic zone around the tunnel provides a relevant theoretical basis for defining and designing the support. In addition, they mention that an excessive plastic zone significantly affects the stability and functionality of a tunnel. Therefore, the delimitation of the plastic zone around tunnels is of great importance for the development of projects.

Page 2 of 28: “The long-term effect has been investigated for single tunnels, but little research has been done on twin tunnels, especially with a gallery. Therefore, in this work, the aim is to investigate the influence of the distance between the tunnels and the effect that the gallery has on the long-term convergence profile of deep-lined twin tunnels, considering various constitutive laws for the rock mass and the lining.”

Please extend this paragraph as the reader gets more details on what you exactly propose, what is novel in your approach, what methods you use or formulate, etc...

Tentar resumir os problemas que envolvem túneis gêmeos. Estender o último parágrafo da introdução com mais detalhes: o que de fato será feito, a metodologia e o que há de novo.

- long-term effect (que não quer dizer nada)

- concreto (novidade – o modelo constitutivo)

- comportamento elastoplástico-viscoplástico (acoplado)

- a interação tridimensional incluindo o processo construtivo;

Page 2 of 28 : “…some delimitations…”. Are you delimitation is the proper work? I think limitations fits better here.

We change to: “The main assumptions of the constitutive and computational modeling, as well as related limitations, are summarized as follows:”

Page 2 of 28: “…the rock mass’s…”. I am native English speaker but pls verify this.

Only the configuration of deep tunnels is considered, thus neglecting deformations caused by surface loads and settlements arising from the excavation process;

Although the inherent complexity of the rock mass constitutive behavior..

Page 2 of 28: “...discontinuities, we simplify its overall behavior by treating it as a continuous medium.”

With this assumption application of your results and findings to engineering practice may be very limited - please elaborate this. Note also that whether the rock mass is terated as continuos or discontinuous is not only about the presence of joints. Jointed rock mass can also be assumed to be constuous if the number of cracks is large and the characteristic block size is small in the relation to the chcaracteristic sie of the tunnel. i am not really sure what you exaclty assume here. Please comment on this.

Although the inherent complexity of the ~~rock mass’s~~ rock mass behavior, is influenced by spatially varying properties, this study opts for ~~a simplified representation:~~ a homogeneous and isotropic medium. Jointed rock mass can also be assumed to (explicação de quando se aplica, qual a limitação envolvida – elaborar o que o revisor falou) ~~While the rock mass may exhibit discontinuities, we simplify its overall behavior by treating it as a continuous medium.~~ Consequently, the rock mass is considered single-phase and phenomenologically modeled using an elastoplastic-viscoplastic rheological law to capture instantaneous and long-term responses. This approach excludes considerations of other factors, such as temperature gradients, water flow, and pore mechanics. This is possible due…elaborate.

Page 3 of 28: “…speed for full, flat, and vertical excavation with homogeneous concrete lining with constant thickness...” it's not clear what you exactly assume.

In contrast to the variable conditions present in tunnel construction, where the excavation speed and lining installation fluctuate during the construction process, we adopt a constant speed ~~for~~ and full, flat, and vertical excavation face with homogeneous concrete lining with constant thickness. It’s considered a constant humidity and temperature in the concrete lining.

Page 3 of 28: “…We also adopt the hypothesis of small perturbations.” what you exactly mean by this ? Please elaborate.

We also adopt the hypothesis of the small strains and displacements for the calculations.

Page 3 of 28: “This model concern a serial association…” concerns ?

This model is a serial association of the plastic and viscoplastic constitutive models.

Page 4 of 28: “multiplier and 𝑔 is a potencial flow analogous to 𝑓” ?

Potencial é geralmente a palavra que se usa para a função g na descrição da teoria da plasticidade. Portanto, deixar assim.

Page 4 of 28: “utilize the Perzyna model as follows:” reference

Adicionar a referência inicial do modelo de Perzyna.

Page 4 of 28: “In this study’s coupled analysis,…” study’s?

In the coupled analysis of this study was adopted…

Page 5 of 28: “The CEB-FIP MC90 formulation also [5] determines the shrinkage component.” you refer to what ?

The CEB-FIP MC90 formulation in [5] is used to describe the deformation of the shrinkage component.

Page 5 of 28: “…as shown in Fig. 3.” Is this a case study? i mean the twin tunell with gallery

Na verdade, é uma representação geral do domínio, de forma parametrizada, que será usada para as comparações com soluções analíticas e o estudo paramétrico. Tentar deixar isso mais claro.

Page 5 of 28: “Figure 3: Problem domain” please provide some fundamental dimensions as the reader is able to find out how large, in general, the domain is.

Deixar claro que o domínio está parametrizado em função do raio do túnel. A ideia é ter um domínio grande o suficiente capaz de representar o campo de deformações sem ter a influência do contorno.

Page 6 of 28: have you verified the correctness of mesh density? I mean have you done some preliminary analyses to verify the mesh density is OK ?

Sim. Isso foi feito e inclusive validado com a comparação da solução analítica. Está escrito no primeiro parágrafo do capítulo 6. Talvez deixar isso mais claro nesse momento da leitura em que aparece a malha.

Page 6 of 28: “we apply the initial stress condition 𝝈0 = −𝑝𝟏 at…” please elaborate this initial stress condition - how you calculate this? And where exactly it is prescribed?

Explicar que a condição inicial é prescrita nas fronteiras do domínio e como tensão incial pontos de integração do modelo MEF. E que o cálculo é dado pela profundidade vezes o peso específico do maciço.

Page 6 of 28: “…thickness of the lining.” How the lining is modelled? Classicla elements or maybe beam elements? is there any interface between lining and ground? Is lining only elastic? Elaborate this...

Explicar melhor que o revestimento é modelado utilizando elementos finitos sólidos. E a interface é colapsada (ou rígida?) (ambos elementos do maciço e do revestimento compartilham seus nós). O revestimento é elástico linear.

Page 7 of 28: “…is the influence of the spacing 𝑑1 between longitudinal tunnels of the twin tunnel.” influence on...what ?

Influência no perfil de convergências longitudinal do túnel. Faltou completar a frase.

Page 10 of 28: In Table 1 Ri = 1. As I understand well, the radius of the main tunnels is 1 meter? So the diameter is only 2 meters? In relation to engineering practice what kind of tunnel it is? This is too small to represent for example road or railway tunnels.

Explicar um pouco mais no que consiste a análise paramétrica do artigo. E pq pode ser aplicado essa parametrização.

Page 10 of 28: In Table 1 Thickness of the lining e1. I can't find any information what kind of lining is that? Concrete? What is the method of tunneling that you assume here? This must be included in the paper.

Concreto com lei constitutive viscoelástica. Essa modelagem compreende métodos que envolvam velocidade de escavação constante e face de escavação cheia (não parcializada). O revestimento é de concreto (poderia ser pré-moldado ou projetado?).

Page 11 of 28: “…solution considering 𝑅𝑖 = 4 m”. in table above it is 1 meter ?

A tabela compreendeu as análises paramétricas. Nesse outro exemplo, como se trata de uma verificação com solução analítica de outro autor (Guo et al.), o raio é maior. Na comparação com Ma et al (o raio é unitário novamenteo). Quem sabe mudar a tabela de lugar.

Page 12 of 28: for the case with 𝑐 = 5 MPa, 𝑑1 = 5 m, 𝜎𝑥 = 𝜎𝑦 = 30 MPa. is it the boundary condition p?

A condição inicial é isotrópica.

Page 13 of 28: “…an isotropic initial stress state of 9 MPa is considered…” it is assumption? or a consequence of something?

Os dados vem da referência do Piepi que está citada no mesmo parágrafo.

Page 13 of 28: “…and the excavation speed is 12.5 m/day”. which method of tunneling is assumed? This is connected also with the lining - is it final or temporary one ?

Na presente análise o método de escavação não é relevante. O revestimento é o final. Colocar nas limitações que não será feita distinção entre revestimento primário e secundário.

Page 14 of 28: Table 2. Fictitious thickness. what do you mean by fictitious ?

É um parâmetro utilizado nos cálculos de retração e fluência. Envolve uma relação entre a área transversal do túnel e o perímetro exposto ao ambiente. Pode ser mostrada a expressão utilizada.

Page 14 of 28: • Observation 1: All the results presented in the following analyses pertain to the point located at the top of the tunnel section (crown), and we will monitor its convergence throughout the excavation process. Fig. 14 presents this point. Likewise, we will only analyze the convergence of the point located at the crown of the gallery.

not sure it is observation - rather your assumption. but why you do not want to monitor all displacement profile ? Or the convergence in chosen points on two oppoiste points of the profile? It is as we usually do in practice. Monintoring of just one point on the profile is not sufficient information in my opinion.

Foi uma escolha. Essa observação é uma limitação (ou aviso) dos resultados que aparecem na sequência.

Page 21 of 28: “This Figure shows”

Change to “Figure 21 shows”.

Page 21 of 28: “…without gallary”

Change to “…without gallery…”

Page 27 of 28: “The fundamental role of the stiffness of the concrete lining in the convergence profile of twin tunnels is understood from the analyses. Depending on the value of this stiffness, it is possible to condition the restriction of viscous effects that tend to manifest over time after the completion of the excavation process.

please extend conclusions with:

- how your work ipmacts on existing literture of this subject,

- where is the novelty,

- what you work gives for practical engineering?