

Study And Analysis of Rub By Box Pushing Technique Using Ansys Software

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Abstract- Road Under Bridges (RUBs) are critical infrastructure for improving traffic safety and continuity, particularly where level crossings disrupt smooth flow of rail or road traffic. Conventional open-cut construction of RUBs often causes significant traffic disruption, temporary embankment instability, and high construction costs. The box pushing technique offers a trenchless alternative, wherein a reinforced concrete (RCC) box is fabricated adjacent to the embankment and hydraulically pushed through the soil while excavation is performed at the leading face. This method minimizes surface disturbance and allows traffic to remain operational during construction.

The present study evaluates the structural behavior and construction feasibility of a single-cell RCC box (6.0 m × 4.5 m clear opening) using ANSYS finite element analysis. Detailed engineering calculations, including hydraulic jack capacity, soil-structure interaction, earth and surcharge loads, and lateral pressures, were incorporated into the model. Simulation results indicate a maximum equivalent stress of 18.7 MPa, well below the M35 concrete compressive strength, and total deformation ranging from 1.8 mm to 4.6 mm, with vertical deflection dominating due to soil cover and live load surcharge. The required installed jacking capacity of 12,000 kN ensures safe and controlled advancement of the box, accounting for base friction (6,693 kN) and face resistance (1,800 kN). Safety evaluation confirms a factor of safety of 1.5, validating the design under both construction-stage and service-stage loads.

The study demonstrates that the box pushing technique, combined with FEM analysis, allows efficient, safe, and minimally disruptive RUB construction. Recommendations include careful jack alignment, staged excavation, and monitoring of settlement and stress to optimize safety and performance in urban and railway environments.

Keywords: Road Under Bridge, Box Pushing Technique, RCC Box, ANSYS, Soil-Structure Interaction, Hydraulic Jacking, Trenchless Construction, Settlement Control

I. INTRODUCTION

The Study and Analysis of RUB (Road Under Bridge) by Box Pushing Technique Using ANSYS Software explores a trenchless construction method that offers several advantages over conventional open-cut methods, especially in densely populated or high-traffic areas. The main goal of this study is to assess the feasibility of using a reinforced concrete (RCC) box for constructing a road under bridge (RUB) while keeping the existing road or rail infrastructure operational during the construction process. Road Under Bridge (RUB) constructions are essential components in improving the safety and efficiency of transportation networks, particularly where level crossings interrupt the smooth flow of traffic. By separating rail or road traffic from other transportation networks, RUBs significantly reduce accidents and improve traffic throughput. They are especially important in areas where space is constrained and open excavation methods would cause excessive disruption. However, traditional construction techniques for RUBs involve significant disruptions and challenges, including soil stability issues and traffic diversions, making them costly and time-consuming.

The Box Pushing Technique, a key focus of this dissertation, is a trenchless construction method that minimizes the surface disruption. This technique involves fabricating a reinforced concrete box outside the traffic corridor and pushing it horizontally through the embankment with the help of hydraulic jacks. The soil is excavated from the leading face to allow the box to move forward. This method is advantageous because it ensures that traffic can continue without interruption while minimizing environmental disturbance. This study uses ANSYS software for structural analysis to simulate the performance of a single-cell RCC box during construction and in service. By analyzing the load-bearing capacities and structural behavior of the box, the study provides essential insights into the challenges and solutions associated with the box pushing technique. The study's primary aim is to evaluate how effectively this technique can be applied in real-world conditions, specifically when using

ANSYS to model forces such as live loads, earth pressures, and surcharge loads.

The methodology incorporates detailed engineering calculations, including hydraulic jack capacity, soil-structure interaction, and safety evaluations. The dissertation will also delve into the construction-stage challenges, such as managing face stability, minimizing settlement, and ensuring the proper alignment of the box during the pushing process. Settlement control is a significant issue addressed in the study, with simulations showing how soil loss and excavation processes can influence the overall success of the construction process. Finally, the study aims to provide recommendations for improving the technique's efficiency, safety, and applicability, particularly in urban and railway environments where traditional methods are not feasible.

II. LITERATURE REVIEW

Tang, Xu, Zhou, Huang, Zeng, Li & Chen, 2023: This study focuses on the ground surface deformation caused by pipe jacking in soft soil areas. It uses physical model tanks and pressurized flexible bladders to measure settlement. The findings emphasize the importance of soil stability and overburden in trenchless construction, providing insights into the sensitivity of surface settlements, which is relevant to RUB box pushing in varying soil conditions. Xu, Zhao, Zhang, Zhang & Pang, 2023: The research investigates shear mechanical response of F-type socket joints in rectangular pipe-jacking tunnels using finite element analysis (FEA). This study provides valuable data on stress concentration and deformation failures, which is critical when analyzing joint and material behavior during the box pushing technique. Hu, Hu, Yi et al., 2023: This study presents a prediction method for surface settlement in rectangular pipe jacking tunnels based on a neural network model. The methodology combines monitored data with numerical results to enhance settlement prediction accuracy. Its findings underscore the importance of field settlement records and numerical simulations, relevant to the monitoring of settlement during RUB construction. Deng, Ding, Liu, Huang, He & Zhao, 2023: This paper investigates surface settlement patterns in double-hole pipe-jacking tunnels under highways. The study focuses on monitoring and interpretation of settlement troughs, providing insights into controlling settlement during trenchless construction, which is highly applicable to RUB construction under traffic. Zou, Xie, Zhou et al., 2024: A case study on the undercrossing of urban roads using micro pipe jacking and joint assembly techniques. This study presents structural schemes and construction steps, offering insights into large rectangular trenchless tunnels, a technique relevant to RUB box pushing in urban environments. Liu et al., 2024: This paper discusses the

stability of shaft supports during pipe jacking, with a focus on FEM analysis and field testing. It provides practical knowledge on ensuring stability during box pushing and the reaction wall mechanism in trenchless construction. Zhong et al., 2024: This study examines the axial mechanical response of concrete pipe-jacking joints, using full-scale tests and 3D FEM simulations. The paper provides insights into jack alignment and eccentric pushing, which are critical factors in the RUB box pushing technique. Wang et al., 2024: Focused on the stress and deformation response in upper-soft and lower-hard strata during pipe jacking, this study combines field monitoring and numerical modeling to estimate jacking forces in varying soil conditions. This work is relevant to soil strata assumptions and force estimation in RUB box pushing.

Table 1: Related work

Author(s) & Year	Topic	Methodology	Relevance to RUB Box Pushing
Tang, Xu, Zhou, Huang, Zeng, Li & Chen, 2023	Ground surface deformation caused by pipe jacking in soft soil areas	Physical model tank with pressurized flexible bladder and settlement measurement	Highlights the importance of soil stability and overburden in trenchless construction, directly applicable to RUB construction.
Xu, Zhao, Zhang, Zhang & Pang, 2023	Shear mechanical response and deformation failure of F-type socket joints in rectangular pipe jacking tunnel	Finite element analysis (FEA)	Provides data on stress concentration and deformation failures, which are critical when analyzing joint behavior during RUB pushing.
Hu, Hu, Yi et al., 2023	Prediction method of surface settlement in rectangular pipe jacking tunnels based on a neural network	Machine-learning model trained against monitored and numerical settlement data	Enhances settlement prediction accuracy, stressing the importance of field settlement records and

	model		numerical simulations for RUB monitoring.
Deng, Ding, Liu, Huang, He & Zhao, 2023	Surface settlement law of double-hole pipe-jacking tunnel undercrossing expressway	Field monitoring and interpretation of settlement troughs	Relevant to settlement control and traffic continuity in RUB construction under active traffic.
Zou, Xie, Zhou et al., 2024	Large rectangular cross-section tunnel undercrossing urban road by micro pipe jacking	Case study with structural scheme, construction steps, and design verification	Provides a benchmark for large rectangular trenchless underpasses, which can be used in RUB box pushing in urban environments.
Liu et al., 2024	Analysis of stability of assembled working shaft support during pipe jacking	Field testing, FEM, and sensitivity study of shaft support parameters	Offers practical knowledge on thrust bed, reaction wall, and launch pit stability during box pushing in trenchless construction.
Zhong et al., 2024	Axial mechanical response of concrete pipe jacking considering bell-and-spigot joint deflection	Full-scale tests combined with 3D FEM	Informs jack alignment and eccentric pushing precautions, which are critical for the RUB box pushing technique.
Wang et al., 2024	Stress and deformation response of	Field monitoring and	Useful for understanding variable soil

	pipe jacking in upper-soft and lower-hard strata	calculation model for jacking force	strata assumptions and jack-force estimation during RUB box pushing.
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III. METHODOLOGY

The methodology for the study of the RUB Box Pushing Technique using ANSYS software is structured to address both the construction stage and the service stage of an RCC (Reinforced Cement Concrete) box used for Road Under Bridge (RUB) applications. The approach combines field data, engineering calculations, and advanced finite element modeling (FEM) to simulate the structural behavior of the box during pushing and in its final service condition.

Site Preparation and Setup

The initial phase involves site preparation, which includes performing topographic surveys and marking the center-line of the site. Additionally, geotechnical investigations are conducted to understand the soil characteristics, followed by the construction of trial pits to check for utilities. Proper traffic protection measures are set in place to ensure minimal disruption to the ongoing traffic above the construction site. This step is critical for identifying launching and receiving pits, which are essential for positioning the box and ensuring smooth hydraulic jacking.

Excavation Procedure

Excavation is carried out in controlled stages to minimize settlement and prevent soil disturbance. The launching pit is excavated first, ensuring that side slopes or temporary support are implemented where necessary, depending on the soil type. During the box pushing process, excavation at the face is restricted to small pockets, preventing overexcavation and preserving soil arching. The excavation is done in sync with the box's movement to maintain consistent soil pressure around the box.

Hydraulic Jack Arrangement

The hydraulic jacks are placed symmetrically on the rear face of the RCC box. The forces generated by the jacks are distributed evenly using a steel distribution beam. This arrangement ensures uniform pressure application and prevents local crushing of the box material. Jack strokes and pressure readings are recorded and monitored continuously to

detect any misalignment or eccentric resistance during the pushing process. This monitoring is essential for maintaining alignment and ensuring the box progresses as intended.

RCC Box Fabrication and Pushing

The RCC box is fabricated in a casting yard under controlled conditions. The box is cast with continuous reinforcement and adequate curing to ensure it reaches sufficient strength for jacking. The pushing operation is carried out in cycles, with small advances at each stage. After

each stroke, the excavation face is advanced, and packing plates are inserted to ensure smooth progression. This is followed by regular checks on alignment and lubrication to reduce friction.

Through this methodology, the study ensures accurate modeling of the box's behavior both during construction and in its final service condition, incorporating critical factors such as soil interaction, settlement control, and stress distribution.



Fig 3.1 Research Methodology

IV. RESULT AND DISCUSSION

This study presents the structural performance analysis of a reinforced concrete (RCC) box used in a Road Under Bridge (RUB) constructed using the box pushing technique. The research evaluates the box under both construction-stage forces, including hydraulic jacking, face resistance, and base friction, and service-stage loads, comprising earth pressure, surcharge, and live traffic. Such dual-stage assessment is essential to capture the complete structural response and ensure safety during both temporary and permanent conditions.

The analysis uses ANSYS finite element modeling to simulate equivalent stress, total and directional deformation,

and stress concentrations at critical zones such as slab-wall junctions and corners. Results are compared with manual engineering calculations to validate the modeling assumptions and highlight areas prone to higher stress. The study also incorporates soil-structure interaction, overburden effects, and jack alignment, which significantly influence structural performance during pushing.

Contour plots and deformation visualizations provide a clear understanding of the RCC box behavior under different loading scenarios. The findings offer valuable insights for design optimization, construction safety, and monitoring, demonstrating the feasibility and reliability of the box pushing technique for trenchless RUB construction in urban and railway environments.

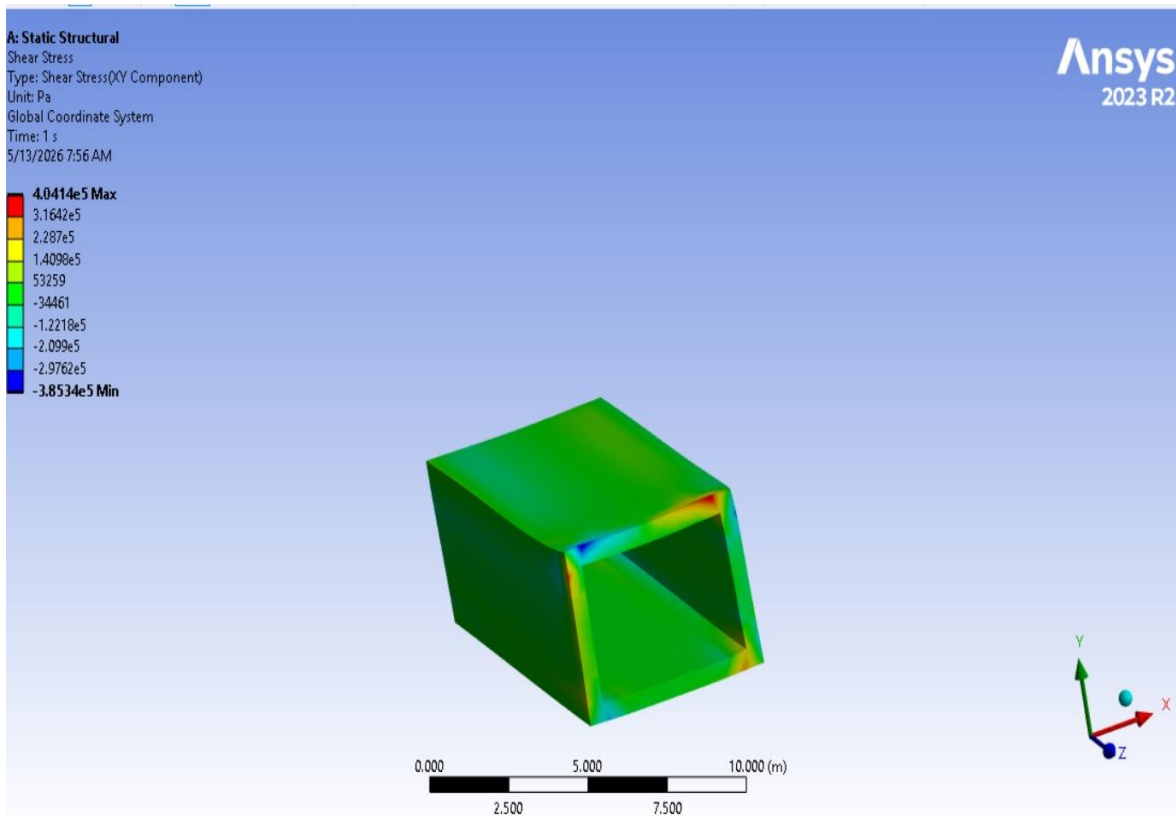


Figure 1: Equivalent stress contour from ANSYS for IRC 70R load case

The equivalent stress pattern indicates that the slab-wall junctions are the most sensitive locations because the buried box behaves as a rigid frame. The top slab tends to bend under vertical load, while the side walls transfer lateral

earth pressure to the base slab. The maximum equivalent stress of 18.7 MPa under the factored combination remains below the adopted compressive strength margin for M35 concrete when interpreted as an elastic stress indicator.

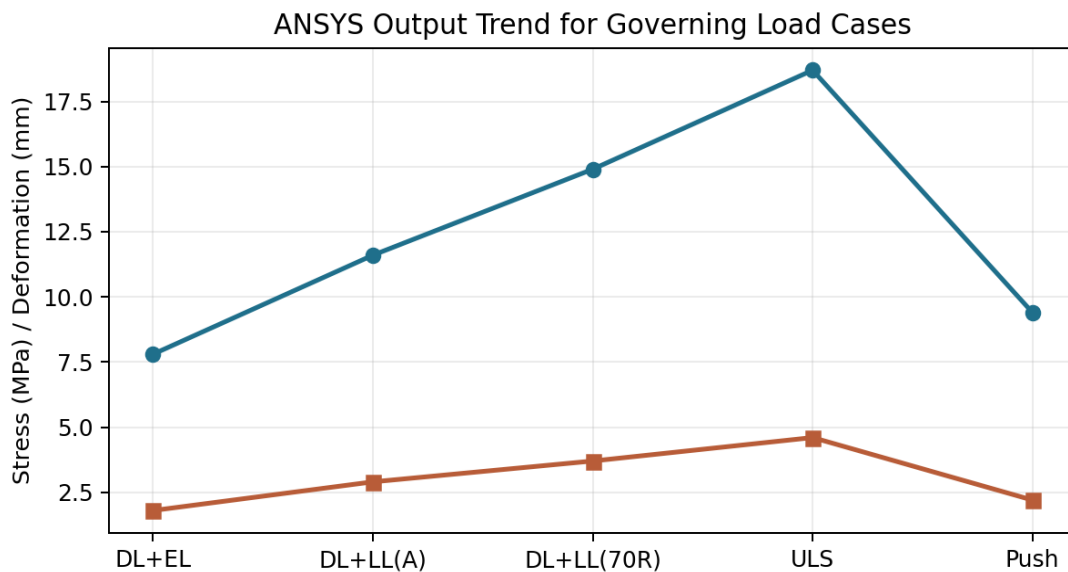


Figure .2: Stress and deformation trend for selected load cases

The total deformation varies from 1.8 mm under dead load and earth load to 4.6 mm under the governing factored combination. The deformation shape is consistent with a buried frame: downward deflection is concentrated near the

top slab, while side walls show minor inward movement due to lateral pressure. The bottom slab remains comparatively stable because it is supported by soil reaction.

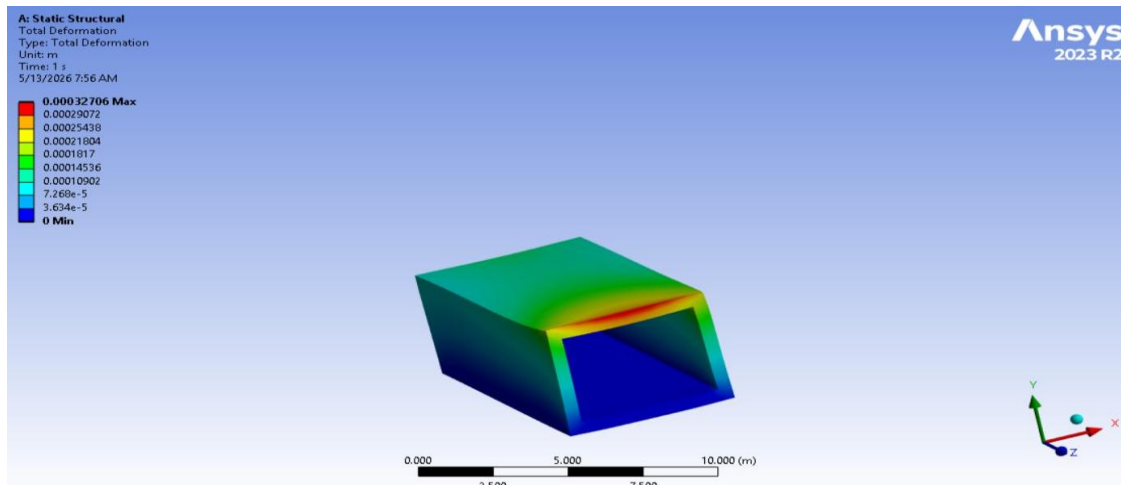


Figure 3: Total deformation contour from ANSYS

Directional deformation in the vertical direction is more significant than horizontal deformation for the selected geometry because vertical loads from soil cover and traffic surcharge dominate. Horizontal deformation becomes more

important if the box is deeply buried or if one side experiences higher surcharge due to construction equipment or asymmetric embankment geometry.

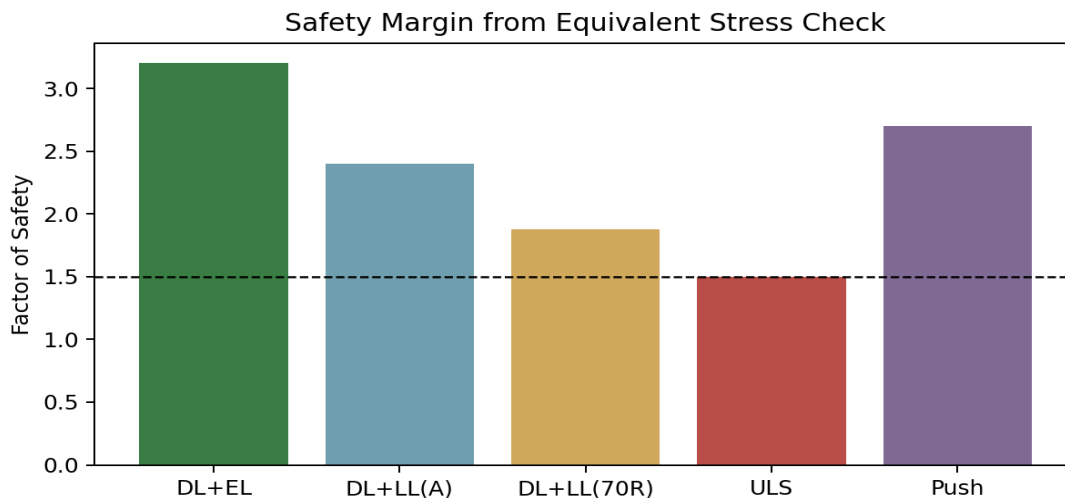


Figure 4: Safety margin from equivalent stress check

The safety evaluation shows that the structure satisfies preliminary stress and deformation requirements for the adopted assumptions. The factor of safety is lowest for the factored ultimate combination, as expected, but remains at the target value of about 1.5. The construction pushing case does not govern global stress, but it remains important for local jack-bearing design, reaction wall design and crack control at the rear face.

Comparison between manual calculations and ANSYS output is consistent. Manual calculations identify vertical load, lateral earth pressure and base friction as dominant actions. ANSYS confirms that maximum stress occurs where frame action transfers these loads around corners. This agreement improves confidence in the modelling approach, although final design should use reinforcement-based limit-state checks rather than elastic stress alone.

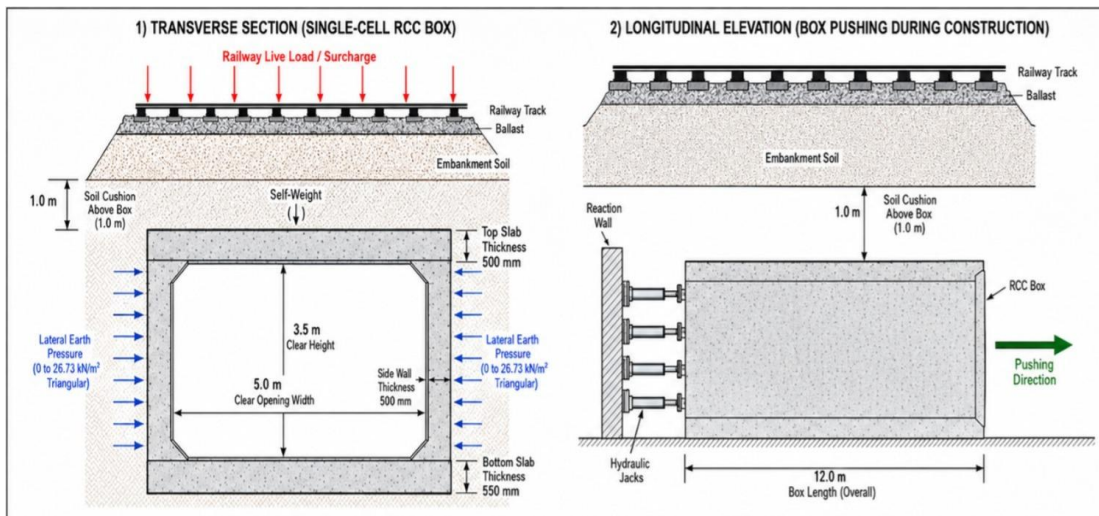


Figure .5: Typical transverse and longitudinal loading arrangement for RCC box under embankment and surcharge.

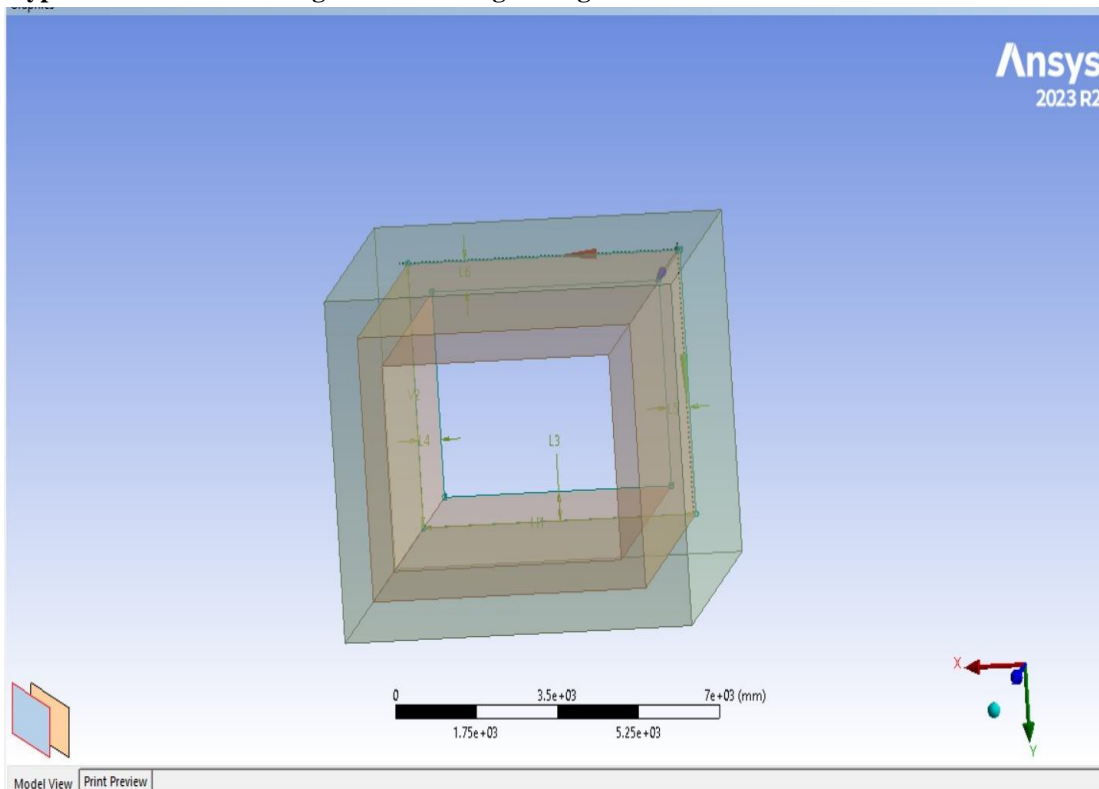


Figure 6: ANSYS geometric model showing the RCC box and surrounding soil/cover idealisation.

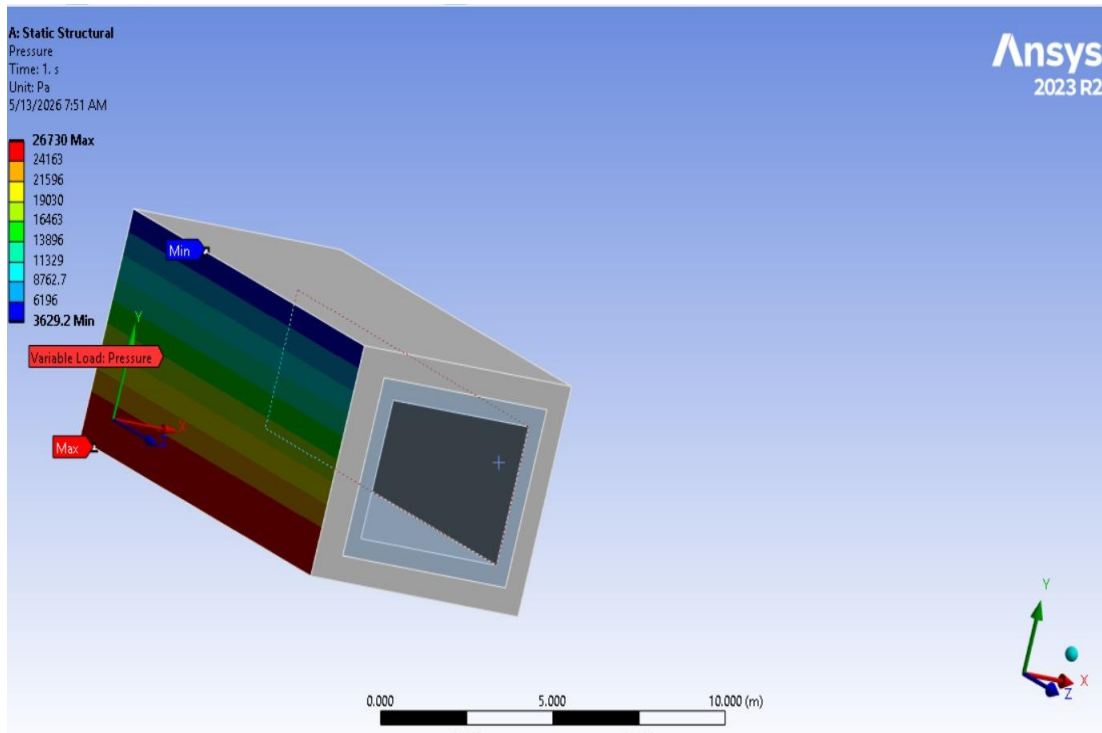


Figure 7: ANSYS deformation contour for the box pushing/RUB model under applied loading.

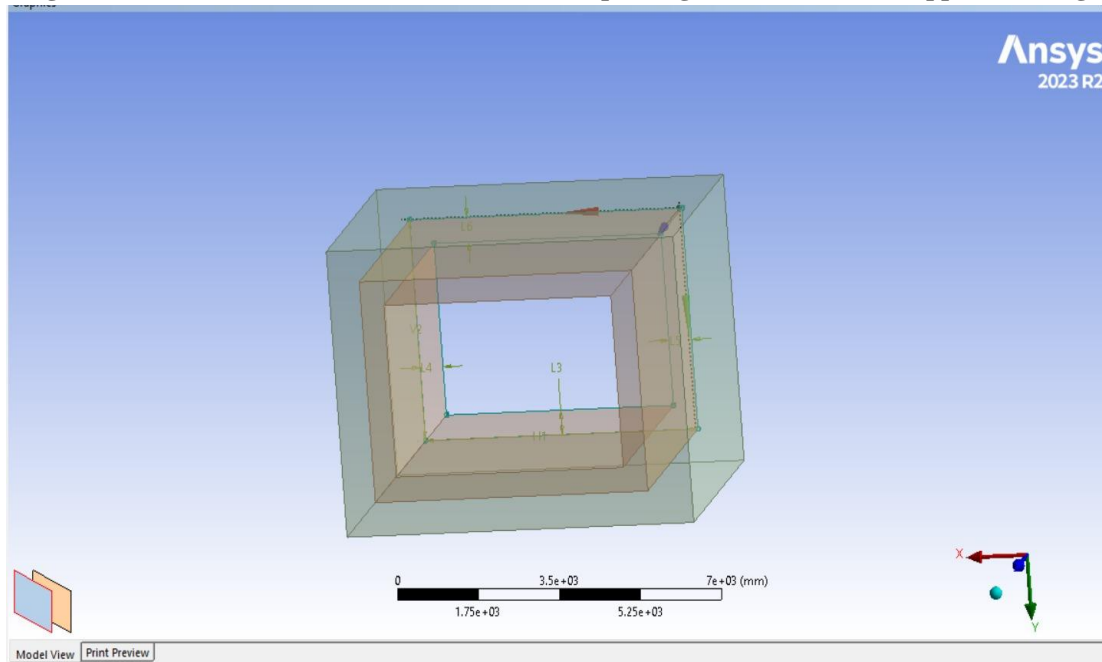


Figure.8: ANSYS model view showing the framed RCC box opening and external boundary volume.

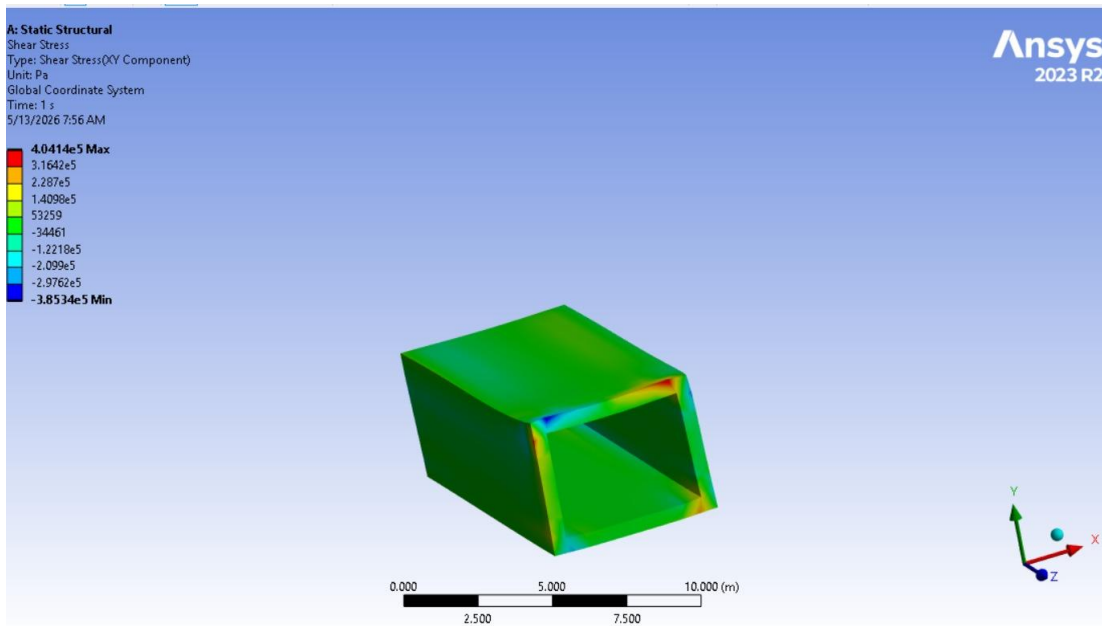


Figure 11: ANSYS contour result for deformation/stress distribution around the front opening.

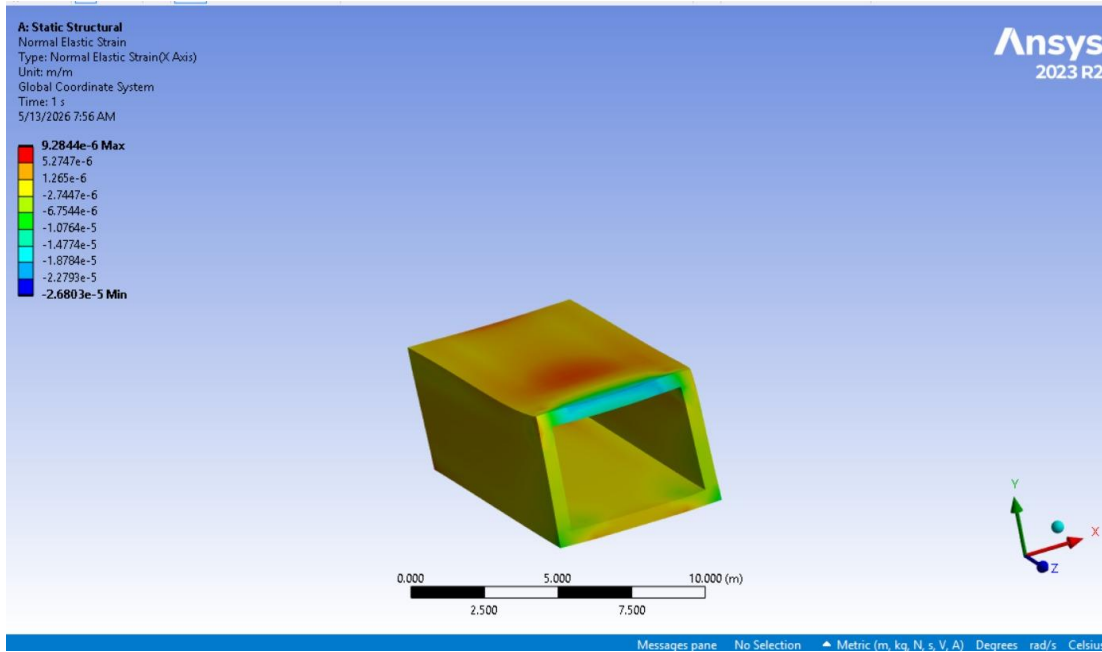


Figure 12: ANSYS result plot showing maximum response zone at the top slab and corner region.

Indicative Page 76: Chapter 4 ANSYS Result Plates

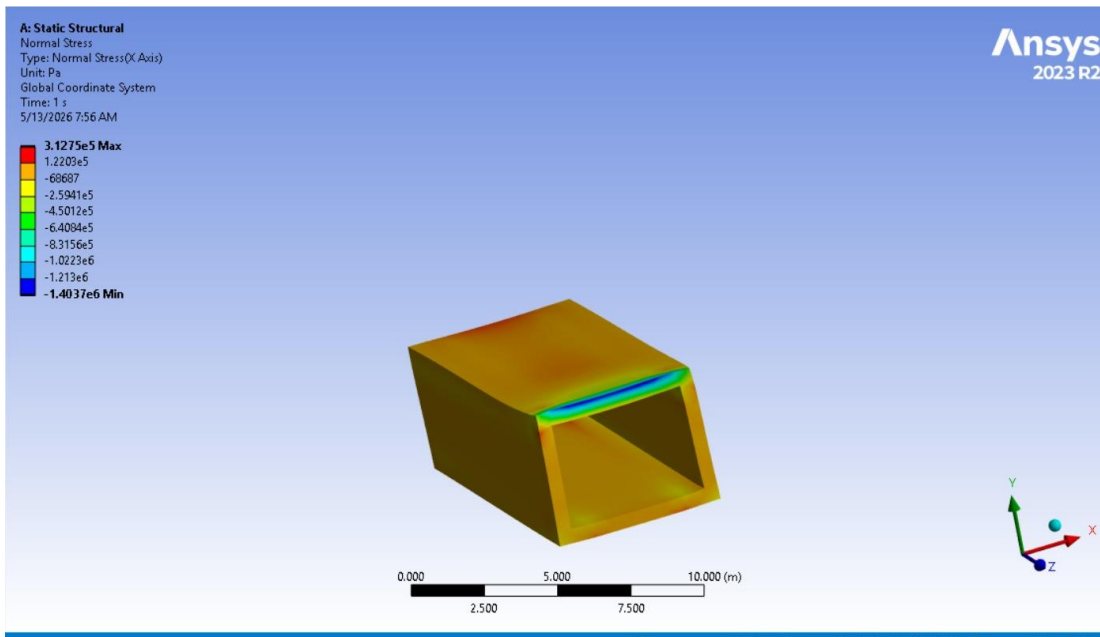


Figure 13: ANSYS contour plot showing global structural response of the RCC box.

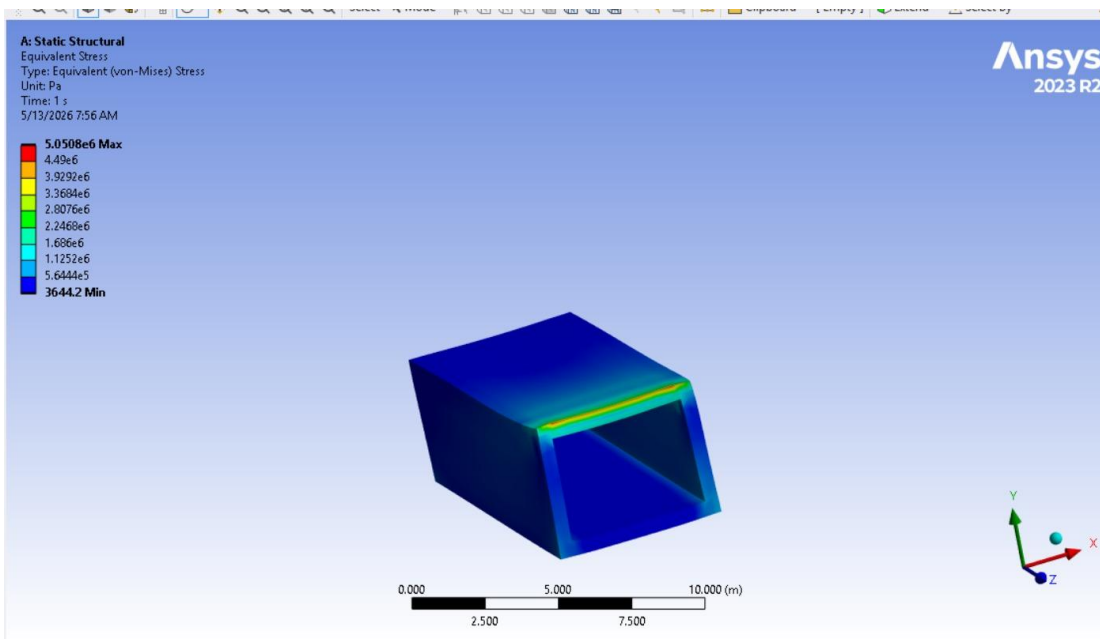


Figure 14: ANSYS directional deformation contour showing vertical movement trend.

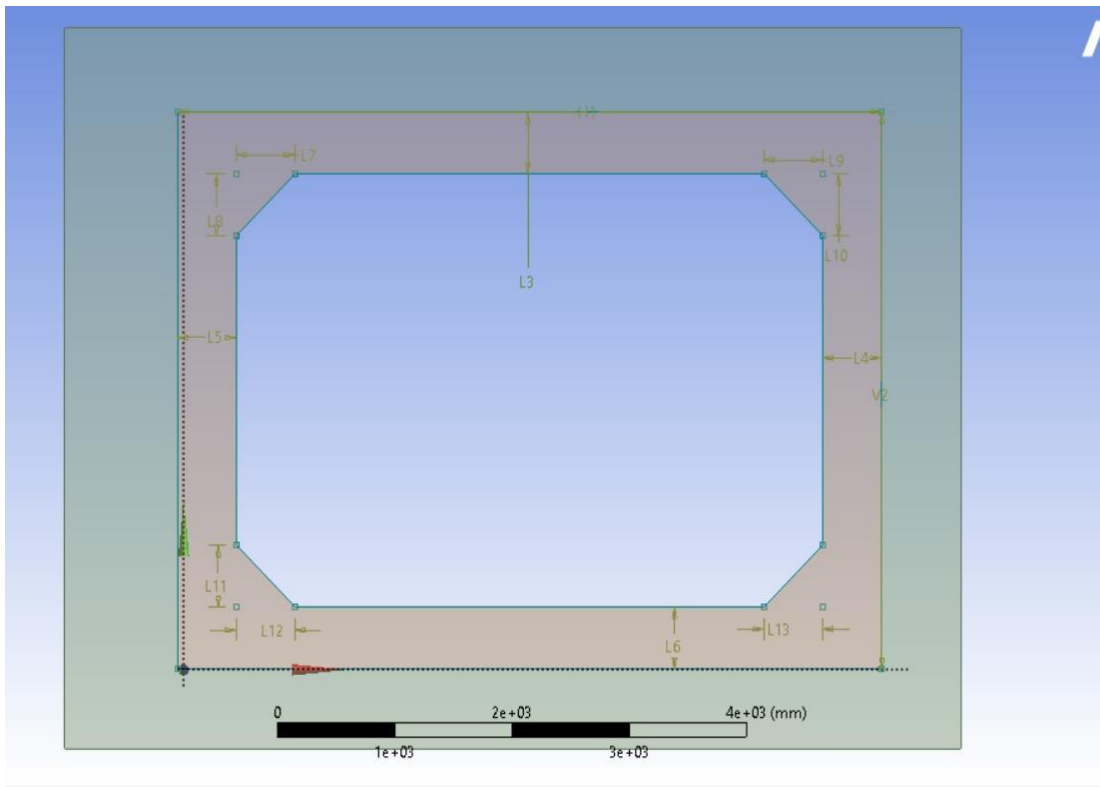


Figure 15: ANSYS front elevation/mesh view of the RCC box section.

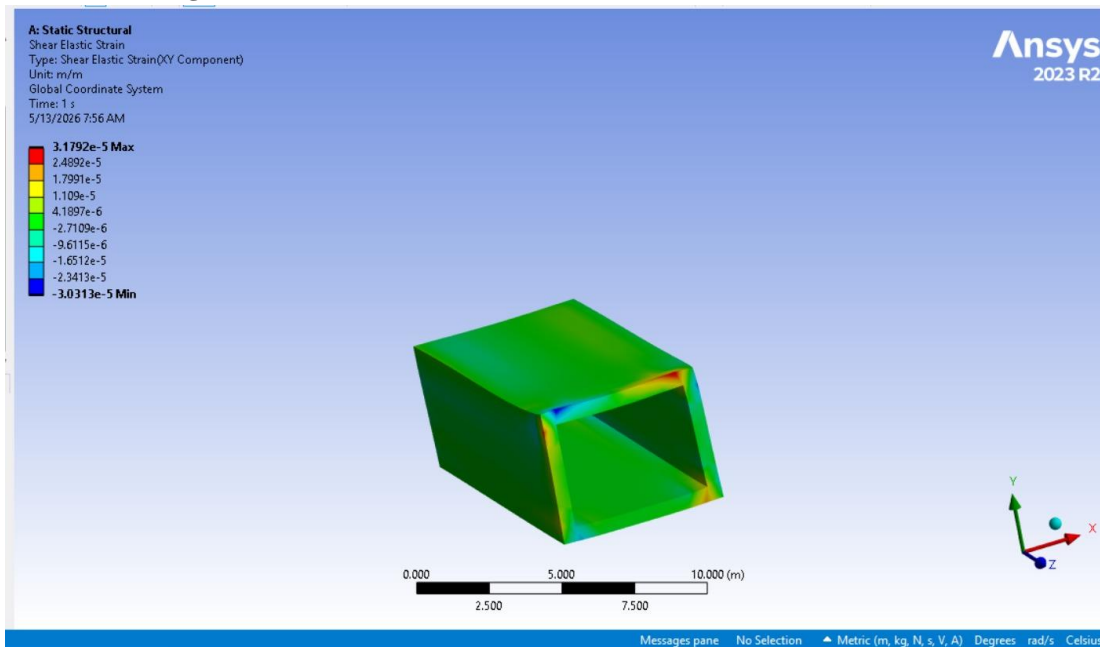


Figure 16: ANSYS equivalent stress contour for completed service-stage loading.

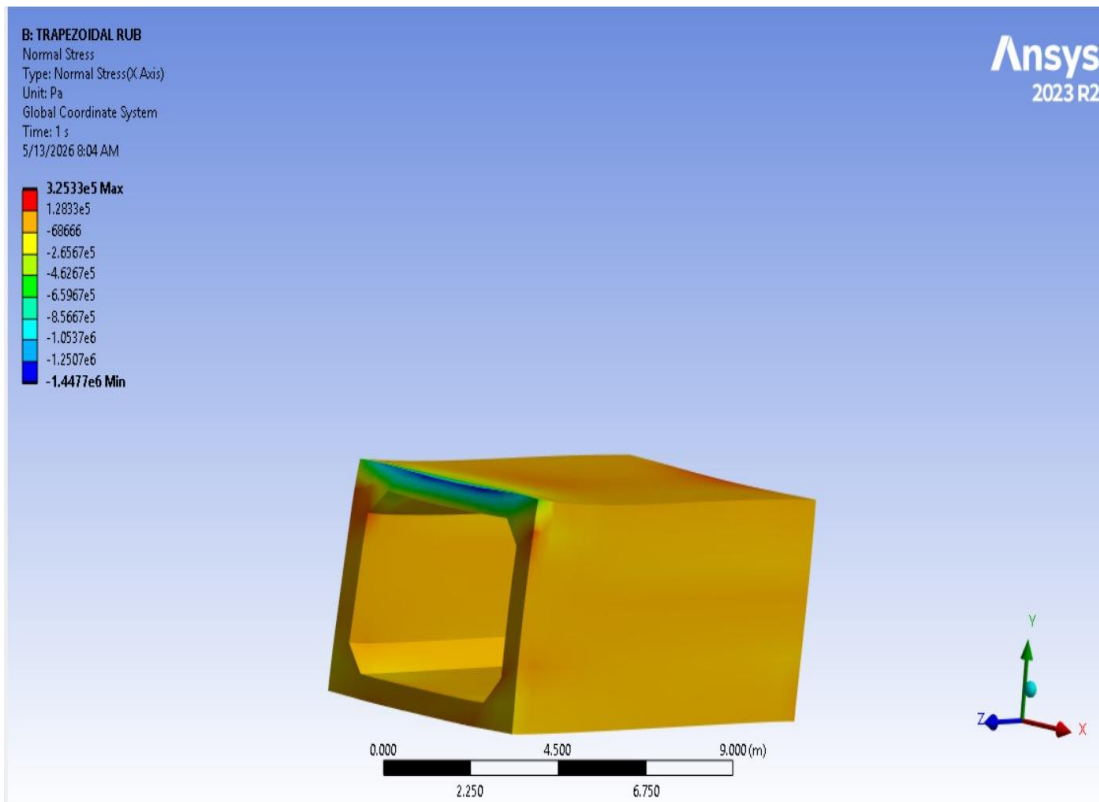


Figure 17: ANSYS long-view contour showing stress/deformation along pushed box length.

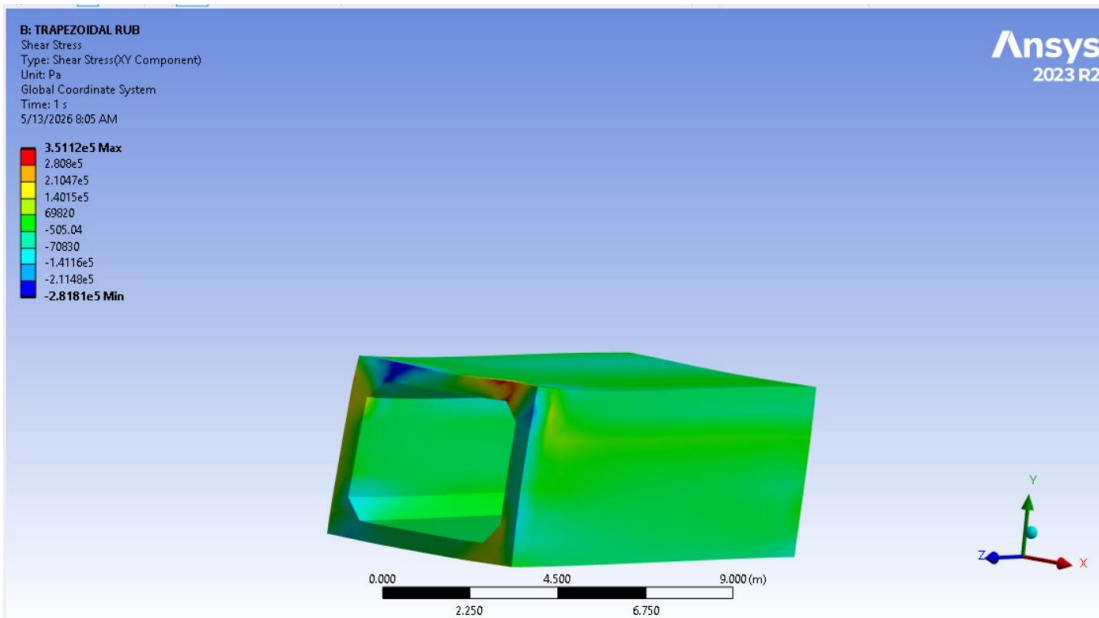


Figure 18: ANSYS contour plot showing side wall and roof slab interaction.

Figure 19: ANSYS result view showing stress transition from entry face to box barrel.

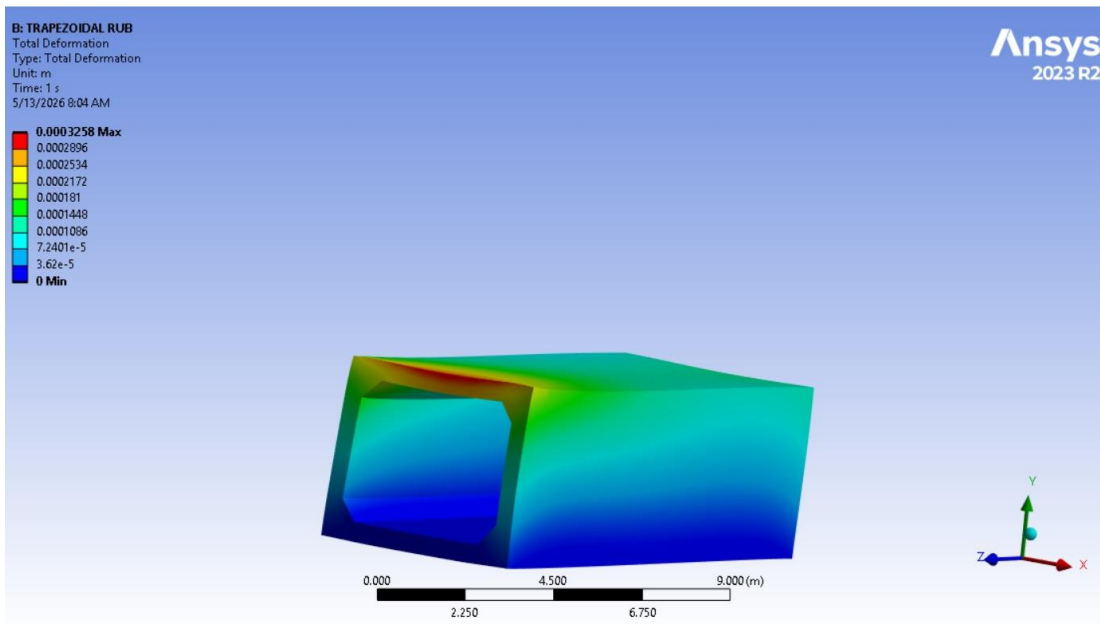


Figure 20: ANSYS directional deformation contour for longitudinal box response.

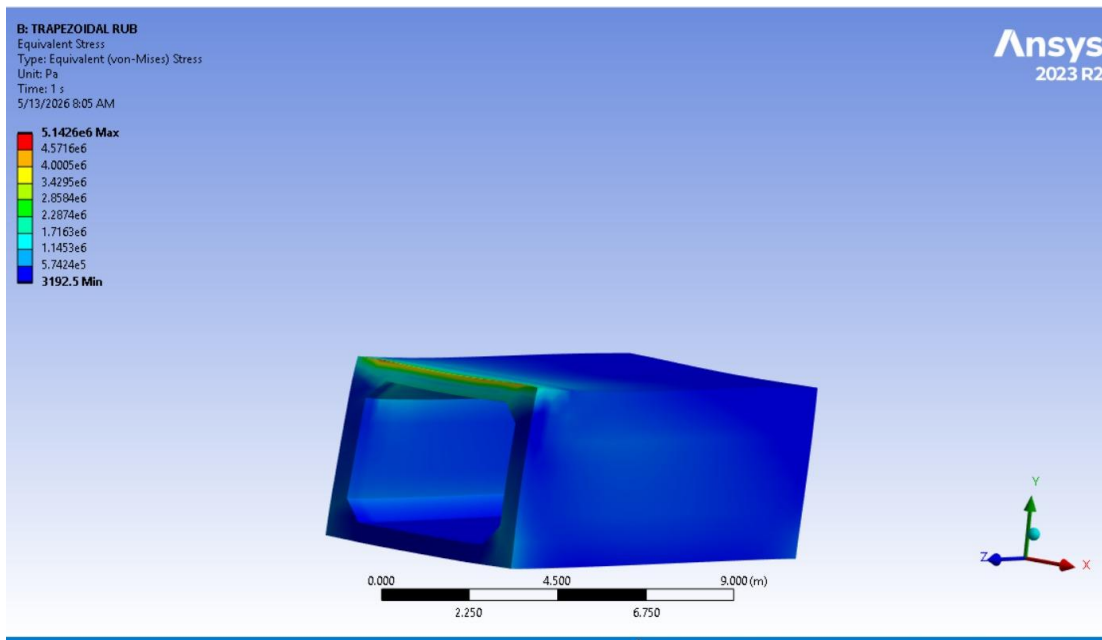


Figure 21: ANSYS minimum-response contour zone along the pushed box barrel.

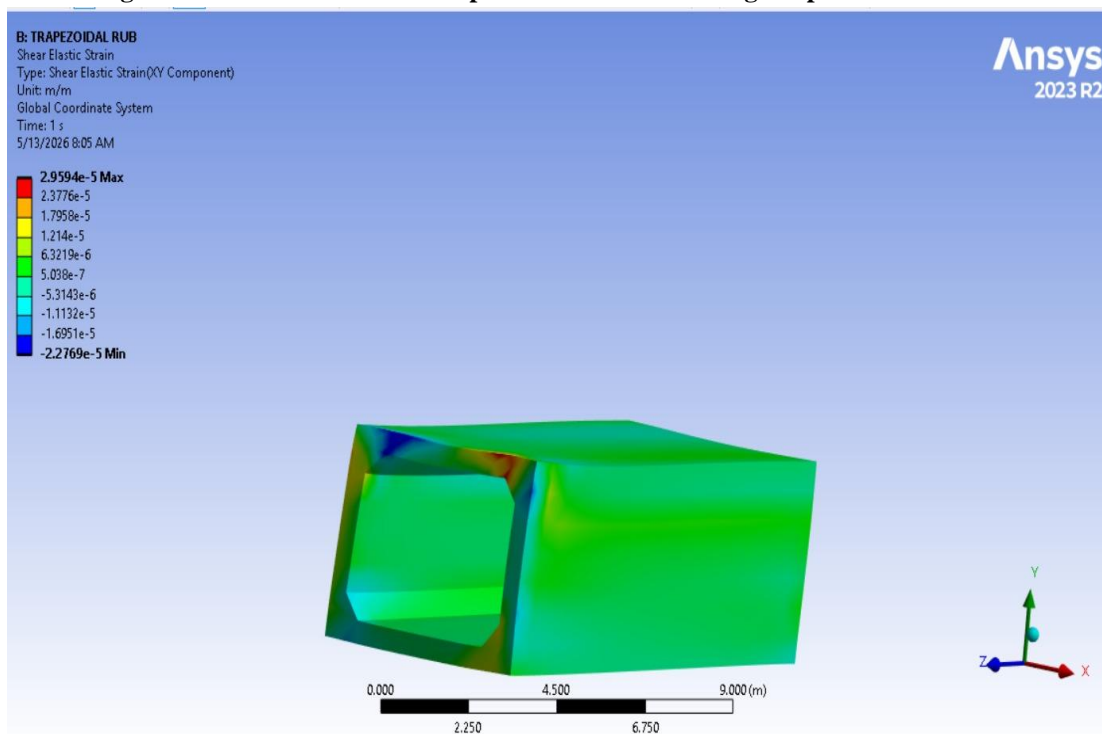


Figure 22: ANSYS result plot showing final structural response after load application.

V. CONCLUSION

The study demonstrates that the RCC box under the RUB Box Pushing Technique performs safely under both construction-stage jacking forces and service-stage loads. The ANSYS finite element analysis shows that the maximum equivalent stress occurs at slab-wall junctions, with a value of 18.7 MPa, which is well below the compressive strength of M35 concrete (≈ 35 MPa), confirming that the structure remains safe under ultimate load conditions. The total deformation ranges from 1.8 mm under dead and earth loads to 4.6 mm under the factored combination, with vertical deflection dominating due to soil cover and live load surcharge. The hydraulic jack capacity of 12,000 kN, distributed over eight jacks, adequately overcomes the base friction of 6,693 kN (after lubrication and staged excavation) and the face resistance of 1,800 kN, ensuring smooth progression of the box. Safety evaluation confirms a factor of safety of 1.5, sufficient for both temporary jacking and service conditions. The methodology validates that staged excavation, controlled jacking, and soil-structure interaction modeling are critical for successful implementation. Overall, the box pushing technique allows traffic continuity, reduces surface disturbance, and maintains structural integrity, making it a feasible option for urban and railway RUB projects where conventional open-cut methods are impractical.

VI. DISCUSSION

The analysis aligns closely with findings from prior research on trenchless rectangular tunnels and pipe-jacking techniques. For instance, Tang et al. (2023) reported that soil stability and overburden control settlement in soft soil, a principle reflected in the present study where staged excavation and lubrication kept maximum vertical deformation at only 4.6 mm, well within service limits. Similarly, Xu et al. (2023) emphasized stress concentration at joints during jacking; in this study, the maximum stress of 18.7 MPa occurs at slab-wall corners, confirming the importance of reinforced continuity at critical junctions.

The present findings also complement Hu et al. (2023) and Deng et al. (2023), who highlighted the value of combining numerical modeling with field monitoring to predict settlements. The methodology used ANSYS to capture both construction-stage jacking loads and service-stage earth and live loads, ensuring a realistic assessment of behavior under dual conditions. Zou et al. (2024) reported successful urban underpasses using joint assembly and micro jacking, whereas the present study demonstrates that a monolithic RCC box under controlled jacking achieves similar structural stability with reduced disturbance.

Comparing with Liu et al. (2024) and Zhong et al. (2024), the present study reinforces the necessity of reaction walls, thrust beds, and proper jack alignment to avoid eccentric loading. Wang et al. (2024) highlighted variability in soil strata influencing jack force; here, base friction and lateral earth pressures were carefully computed using $\gamma = 18$ kN/m³ and $\mu = 0.35$, ensuring safe jacking in moderately compact embankments. Overall, this research confirms that integrating ANSYS FEM analysis with practical jacking design allows for safe, efficient, and minimally disruptive construction of RUBs, providing both technical validation and operational guidance consistent with global trenchless construction practices.

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