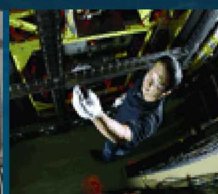
SAND2020-0610PE

Further Evaluation of WIPP Crushed Salt Model Applied to the Triaxial Compaction Test TK-031



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SAND2020-XXXXX PE

Introduction

- Using the WIPP Crushed Salt Model (WIPP CSM) described in Callahan (1999).
- This work represents our latest simulation of the combined oedometric compression VK-020 and triaxial compaction test TK-031 test conditions. Earlier results presented at the KOMPASS Project Meeting on September 5, 2019 started the TK-031 triaxial compaction test with no hardening.
- VK-020 Test data was provide by Dieter Stührenberg (Excel file BGR-Precomp_VK-020.xlsx) and TK-031 was provided by Svetlana Lerche of TUC (MS Excel file TK-031-030913-KOMPASS.xlsx)
- We have not adjusted the constitutive model parameters to improve the comparison with the TK-031 data

WIPP Crushed Salt Model

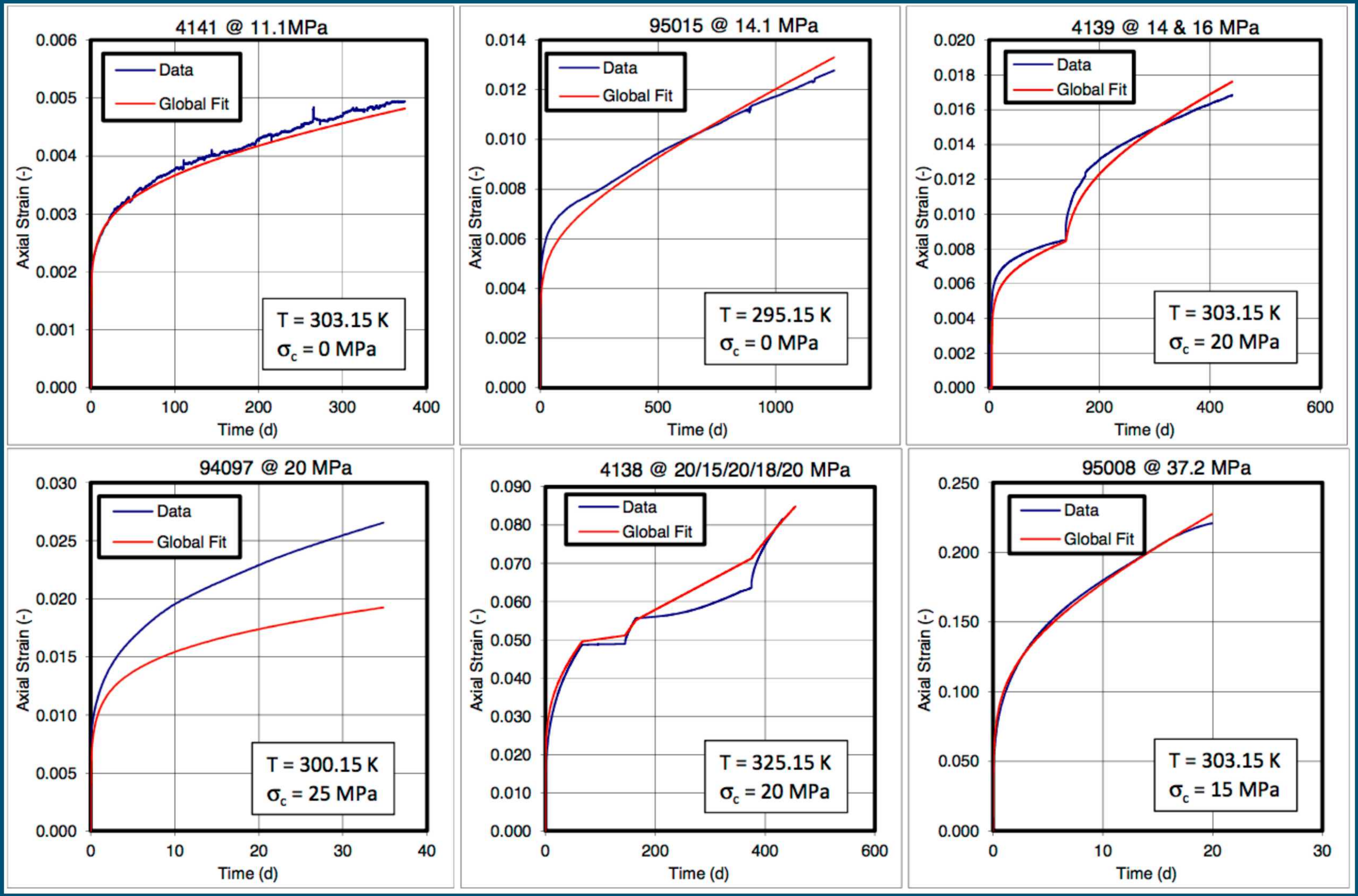
- **The WIPP Crushed Salt Model includes:**
  - **density dependent elastic shear and bulk modulii**

    The elastic model parameters were adjusted to give a bulk and shear modulus for intact salt density of ~2170 Kg/m^3 consistent with the values given in (DeVries, 2011, Lux and Eberth, 2007) (intact salt Young's modulus = $2.5x10^{10}$ Pa and Poisson's ratio = 0.25)
  - **3 mechanisms for dislocation creep (DC)**

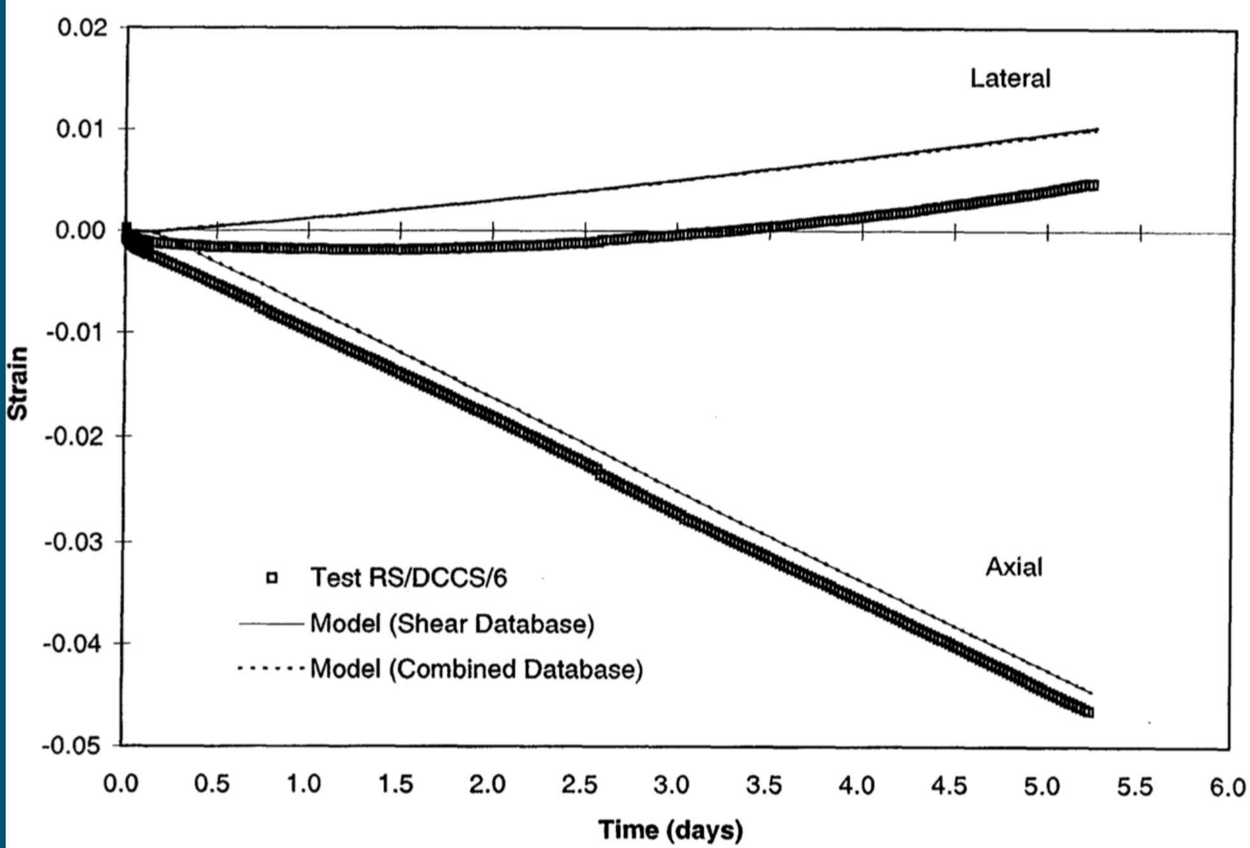
    The DC model of Munson and Dawson (1979, 1982, 1989) was parameterized by RESPEC based on data for Asse salt (DeVries, 2011)
  - **Pressure solutioning (PS) term when moisture is present in the crushed salt**

    The PS model parameters are the same as developed for WIPP crushed salt described in Callahan (1999). The mean value of moisture content w= 0.05 wt-% and grain size parameter d = 8mm (Stührenberg, 2013) were used in the PS model
- A constant temperature of 22 C was used during the pre-compaction phase and 50 deg C was used during the triaxial compaction phase

Comparison of tests on Asse (Speisesalz) Salt and MD model fit for dislocation creep (DeVries, 2011)



Example comparison of a WIPP Crushed Salt Model prediction with crushed salt experimental data (Callahan, 1999)

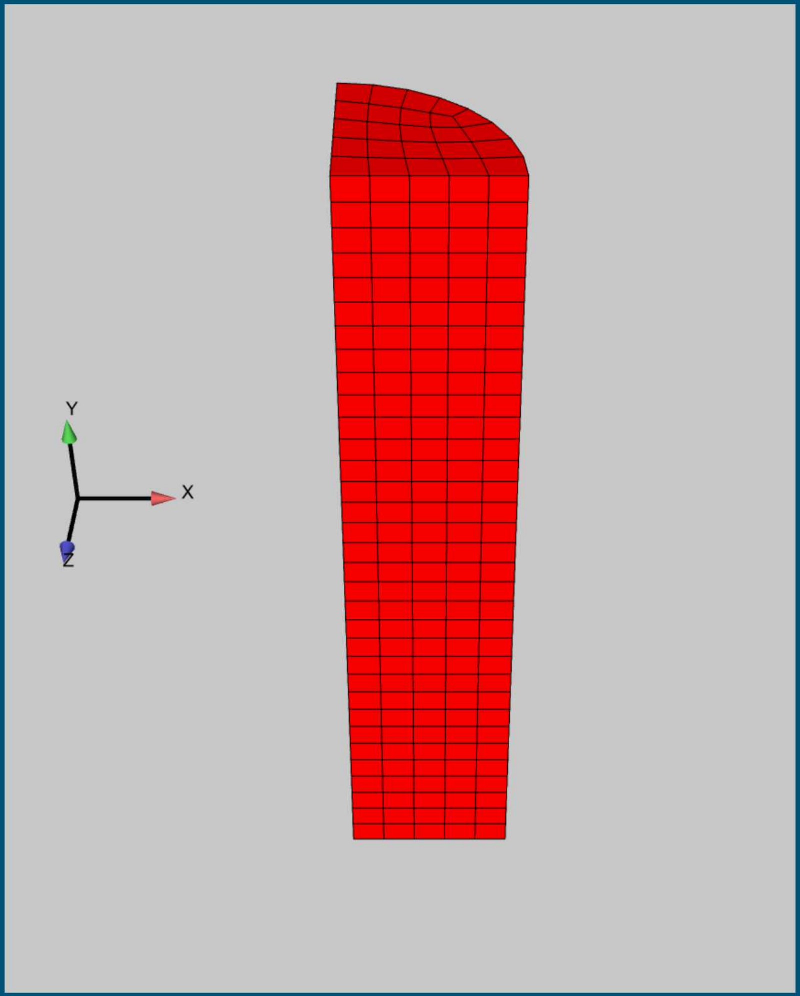


Test Details

- Constant axial strain rate test
- Axial compressive strain rate = $1x10^{-7}$/s
- Axial compressive confining stress 1MPa
- Initial fractional density (initial density/intact salt density) = 0.921
- T= 20C

Finite Element Model of Cylindrical Specimen

Oedometric Pre-compaction phase (VK-020)



VK-020 Test Duration ~16 days @ 22C

¼ symmetry model with no normal displacement boundary conditions specified on symmetry planes

No y displacement on bottom of the cylinder

Axial displacement rate was 0.136 mm/hr and radial displacements were zero

No friction on outer surface of cylinder during pre-compaction

Initial Height is 0.249 m

Initial Radius is 0.10 m

Initial Porosity is 0.34

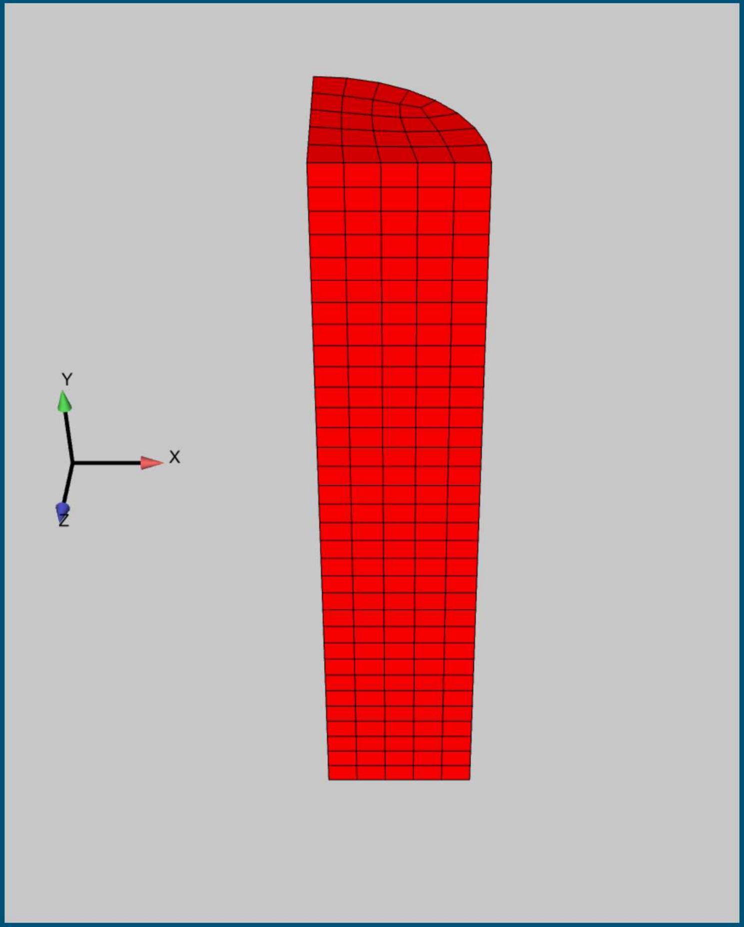
VK-020 Modelling Result

- At the end of the VK-020 pre-compaction phase the model predicted an axial stress of 14.4 MPa and a radial stress of 5.5 MPa. In the VK-020 experiment an axial stress of 29 MPa was measured.

- Friction was not considered in the modelling of the VK-020 test phase which could account for some of the difference between axial stress from the simulation and the test. However, it is likely that the model parameterization results in too “soft” response based on the simulation results of the TK-031 test phase.

Finite Element Model of Cylindrical Specimen

Triaxial compaction phase (TK-031)



TK-031 Test duration ~ 298 days @ 50 C

¼ symmetry model with no normal displacement boundary conditions specified on symmetry planes

2 cases for BC's on sample ends: No slip and slip (frictionless) allowed

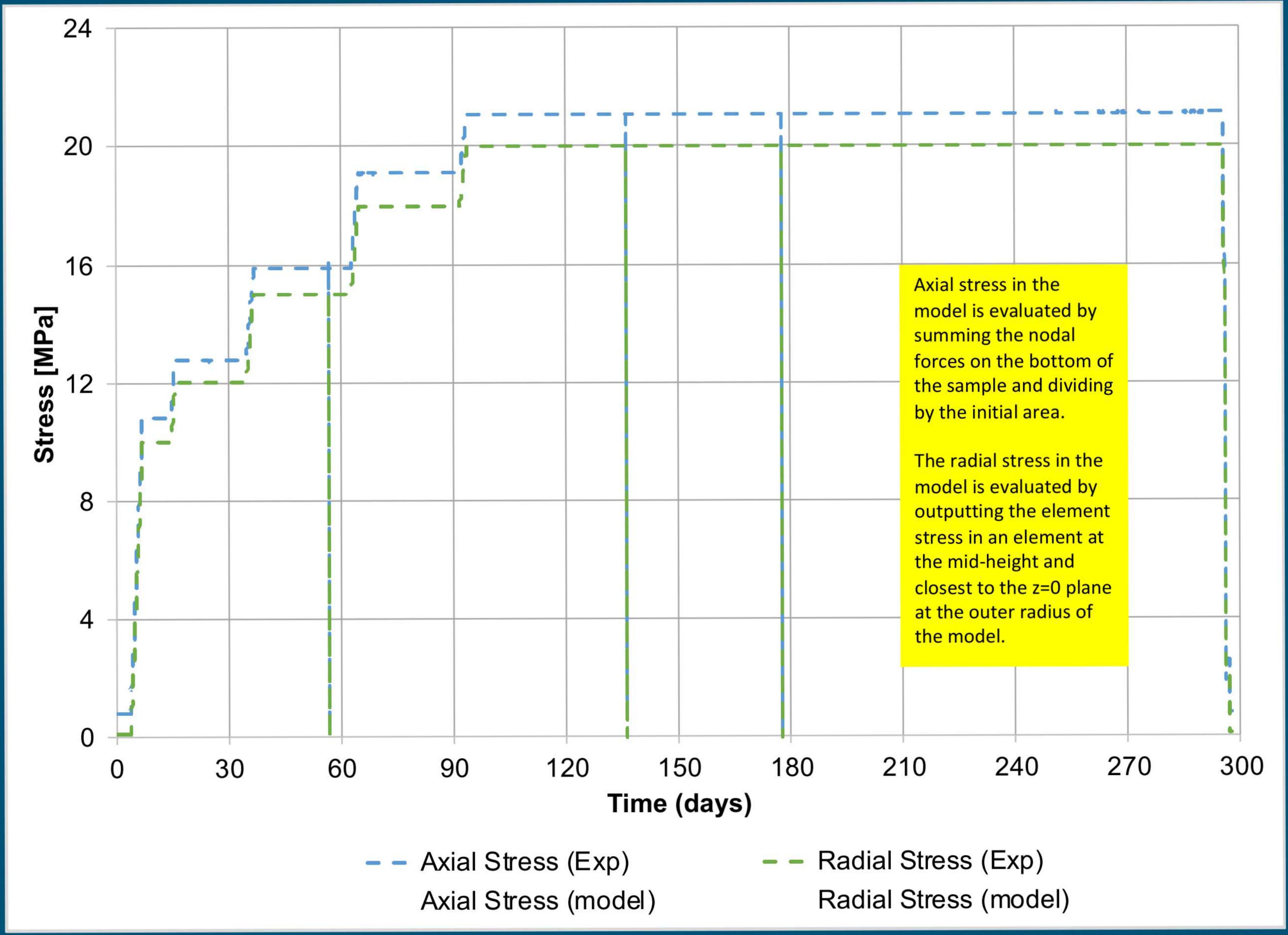
No y displacement on bottom of the cylinder

Total axial force* on top of sample and lateral pressure were specified according to test conditions

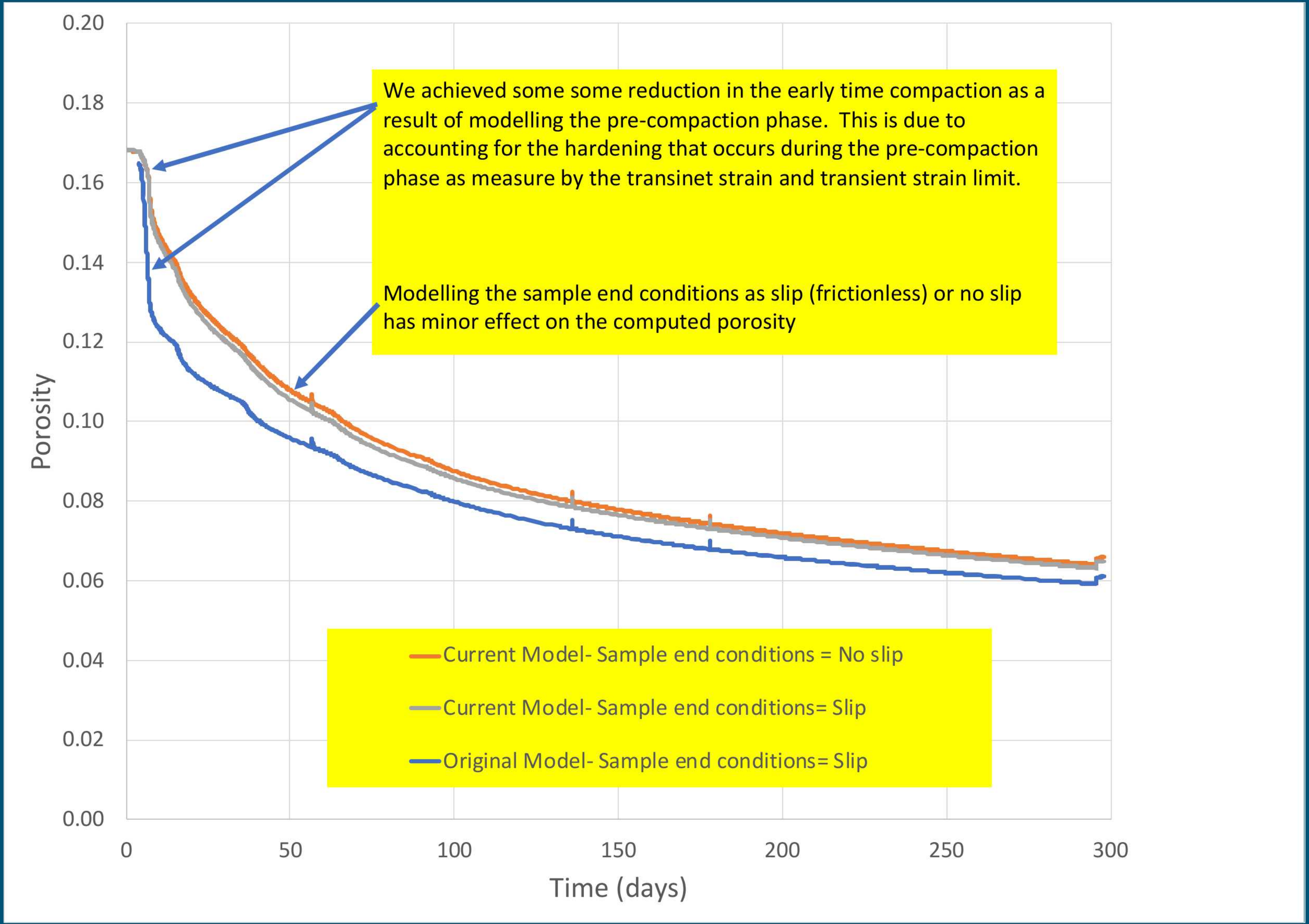
Initial Height is ~0.197 m
Initial Radius is 0.10 m
Initial Porosity is ~0.168

* The total axial force on top of sample is distributed to nodes according to weighted area

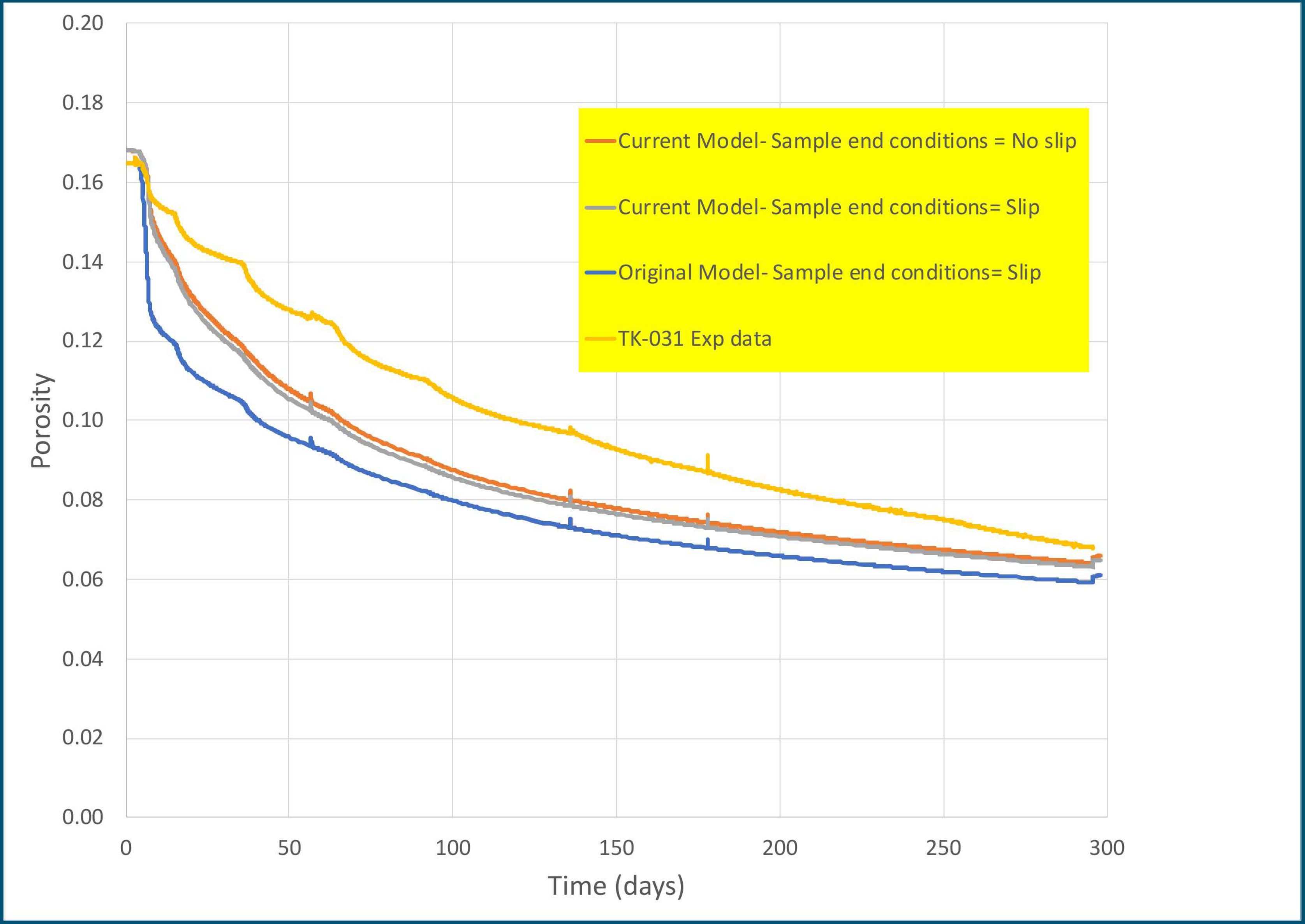
Axial and lateral stress loading conditions for triaxial compaction phase TK-031



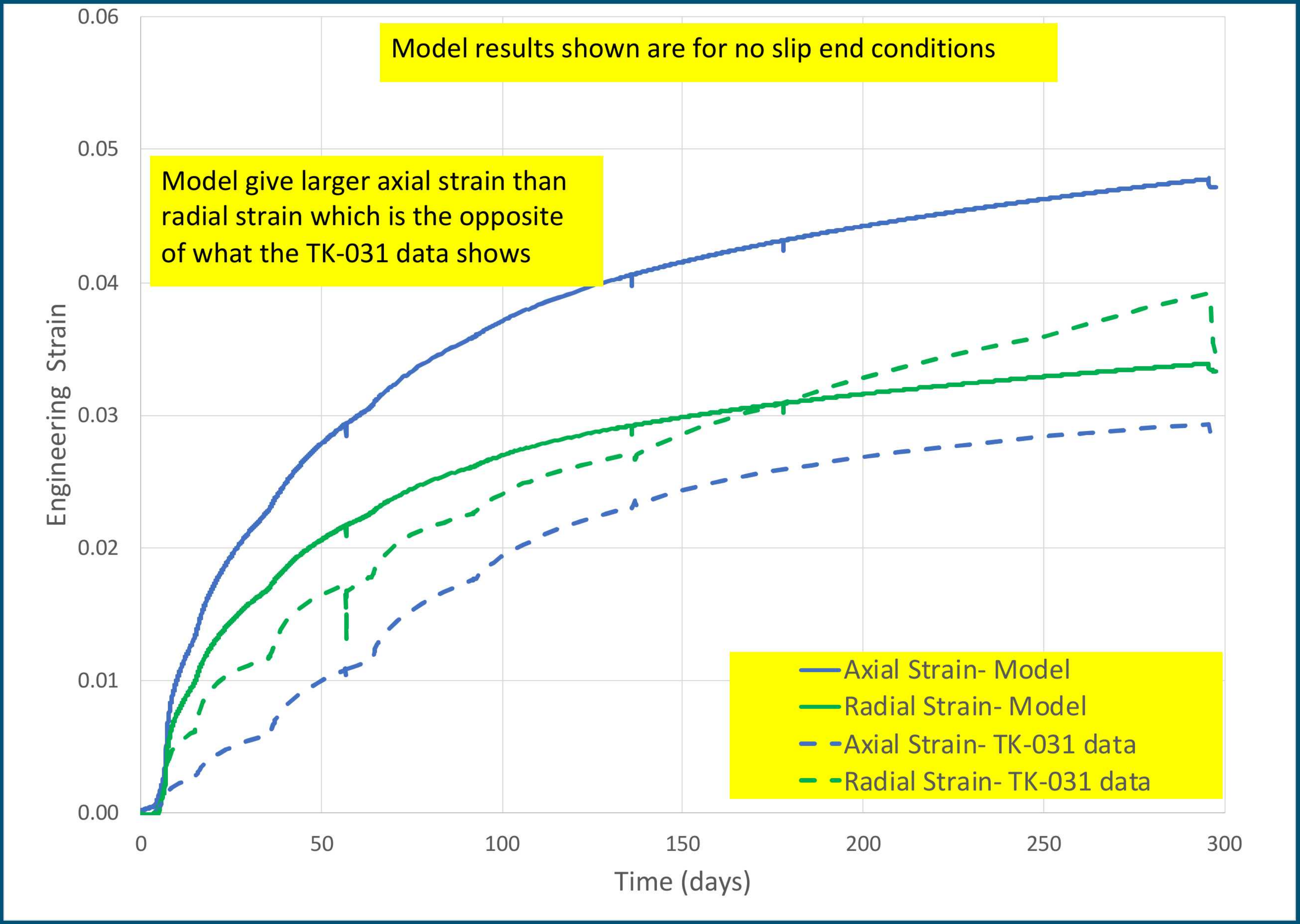
Comparison of porosity history for original 1-element model and current model for the triaxial compaction phase TK-031



Porosity
Comparison of models and experimental data
TK-031



Axial and Radial Strains
Comparison of model and experimental data
TK-031



Summary

- The results presented reflect our most recent simulation of both the VK-020 and TK-031 tests and provides a comparison of test data and WIPP Crushed Salt Model (WIPP CSM) for TK-031

- The model still overestimates the porosity decrease throughout the TK-031 loading period. Some small improvement has been made by including the hardening developed during the pre-compaction phase.

- The WIPP CSM also predicts larger axial strain than radial strain while the test data suggests the radial strain is larger than the axial strain. Can we confirm the reported axial and radial strains match post-test measurements on the specimen?

- We will need to determine what adjustments can be made to improve the comparison of model and experiment
  - Adjust the model to better match the total force reported in VK-020
  - Adjust the model to capture the behavior at fractional densities between 0.8 and 0.9 while maintaining the calibration between 0.9 and 1.0.

Thank you for your attention

References

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