Discussion of "Predicting Moisture-Dependent Resilient Modulus of Cohesive Soils Using Soil Suction Concept" by R. Y. Liang, S. Rabab'ah, and M. Khasawneh

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To enhance the prediction accuracy of resilient modulus for the Yang et al. (2005) model, the authors have presented a new predictive model for resilient modulus of cohesive soils. Although the accuracy of the proposed model by the authors was validated against experimental data conducted by the authors as well as by other data available in the literature, no attempt was made to clarify the variation of suction under repeated loading and its effect on resilient modulus. In this discussion, I would like to address the following issues:

1. The limitation of Yang et al. (2005) model for experimental data at different water contents; and
2. The variations of χ_w and suction under repeated loading.

The authors considered that to provide a reasonable prediction of resilient modulus, the parameters k_1 and k_2 of the Yang et al. (2005) model must be calibrated at each water content. I resurveyed the Yang et al. (2005) resilient modulus test data tested at three water contents. After regression, one set of model parameters can be obtained, as shown in Table 1. Fig. 1 plots the predicted resilient modulus calculated by the Yang et al. (2005) model against their laboratory data obtained from A-7–5 soil. Findings proved that the Yang et al. (2005) model parameters (k_1 and k_2) derived from A-7–5 soil exhibit a good correlation fit. In other words, the Yang et al. (2005) model is not necessary to derive separate regression parameters for different moisture conditions. There are no limitations due to the need for experimental data of the soils at different water contents. Yang et al. (2005) also indicated that the introduction of matric suction into their model enhances its predictive capability because the effects of seasonal variation of moisture content on the resilient modulus of subgrade soils are reflected by the matric suction.

The authors also adopted the same approach Yang et al. (2005) had used to develop a new model, and introduced the χ_w parameter into the model. There is no doubt that χ_w is quite difficult to obtain experimentally, particularly for very dry soils or for soils approaching saturation. In the past few years, many researchers attempted to develop the model of χ_w parameter. For example,

Table 1. k_1 and k_2 Constants for Yang et al. (2005) Model

Soil	k_1	k_2	R^2
A-7-5	5.83	0.467	0.918

Sparks (1963) calculated the χ_w parameter according to static theory. Blight (1967) and Khalili and Khabbaz (1998) calculated the χ_w parameter using the drained and undrained triaxial tests. Loret and Khalili (2002) obtained the χ_w parameter through the soil-water characteristic curve (SWCC). Here, χ_w is allowed to vary from 0 to 1 with a value of 1 at the air-entry pressure. Under this circumstance, soils can be treated as saturated soils. There is some validity in this approach because χ_w reflects the contribution of matric suction to effective stress. Prior to air entry, matric suction contributes wholly to effective stress and $\chi_w=1$. The contribution of matric suction to effective stress after air-entry begins to reduce, reflected as $\chi_w<1$, and soils are treated as unsaturated soils.

To determine the shear strength of unsaturated soils, Khalili and Khabbaz (1998) used the static triaxial tests to develop a unique relationship for χ_w. The authors also adopted the same relationship for χ_w to determine the resilient modulus. However, the resilient modulus tests are conducted under dynamic loading.

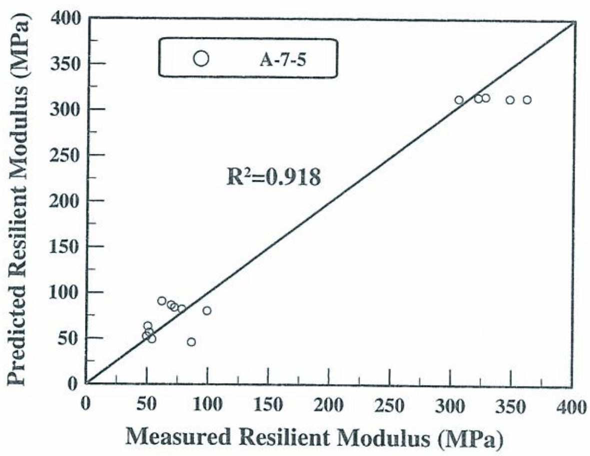

Fig. 1. Predicted versus measured resilient modulus using Yang et al. (2005) model (data from Yang et al. 2005)

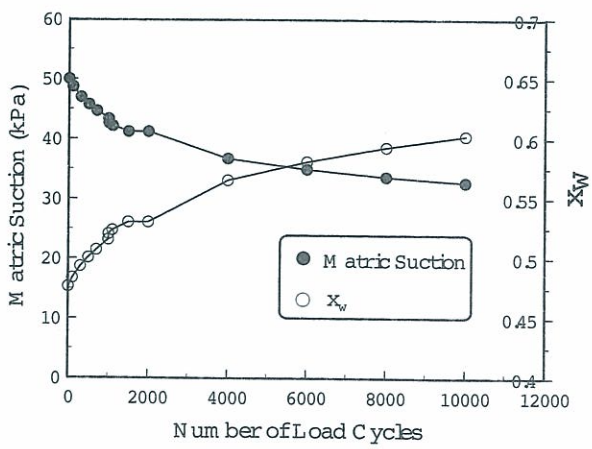

Fig. 2. Variations of χw and suction under repeated loading (data from Huang et al. 2006)

The relationship for χ_w parameter probably differs from that obtained from the static triaxial tests.

Finally and the most important, the authors determined the soil suction using the filter paper method. However, due to limitation of measurement of the filter paper method, measurement was conducted at the conclusion of resilient modulus test. Only a suction value is obtained for a soil specimen despite the fact that the soil specimen experiences various stress paths and loading applications. Hence, from Eq. (8) of the paper, the χ_w is a constant value for all deviator stress levels under repeated loading. However, it is possible that the internal pore air pressure and pore water pressure in the specimen change during the rapid application of each deviator stress cycle; consequently, the matric suction changes with loading cycles. Huang et al. (2006) indicated that the matric suction in the specimen decreases gradually with increasing number of load applications.

Using Huang et al. (2006) data to analyze the variations of χ_w and suction with repeated loading applications, the results are shown in Fig. 2. Fig. 2 shows the relationship between the matric suction and the χ_w for A-7–5 soil under repeated loading of 10,000 cycles with deviator stress of 32 kPa and confining pressure of 21 kPa. The matric suction is found to decrease with increasing load applications whereas the χ_w increases. In other words, the soil tends to saturation. After 10,000 load applications, the matric suction of the soil decreases from 50 kPa to 32 kPa. According to the relationship for χ_w proposed by Khalili and Khabbaz (1998), the χ_w increases from 0.48 to 0.61. It is evident that the use of the constant χ_w to determine the resilient modulus for different deviator stress levels is not suitable. Moreover, it is impossible to comprehend the variation of matric suction under repeated loading and its effect on resilient modulus. Besides, χ_w is not also constant under different deviator stresses and confining pressures. Unfortunately, the authors did not clarify these issues.

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