The Influence of Interface Behavior on the Dynamic Earth Pressure Analyses

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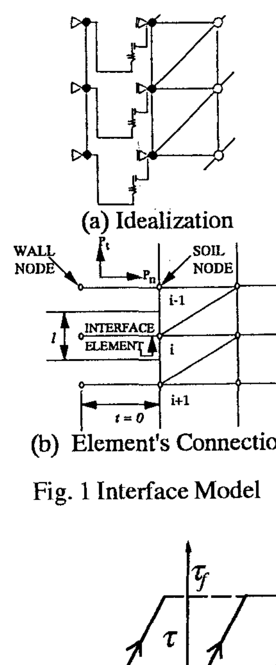
INTRODUCTION: The interaction between the structure and the geological material is an important aspect of dynamic analysis and the response may be significantly affected by the interface between the structure and the material. Modeling of the interface is an integral part of the earth pressure analysis since it involves the interaction between the retaining structures and the backfill soil. Often, analysis under dynamic loading is performed by assuming complete bonding at the interface at all stages of loading. However, interface can experience relative motions under dynamic loading. In the actual system, separation may occur at the interface especially at the higher acceleration levels for the active movement of the wall when the minimum inertia force acts away from the wall, in which case the assumption of perfect bonding will induce tensile stresses on the contact surface. Thus for a realistic analysis, it may be necessary to incorporate the relative motions of the interface. In this paper, an experimental model on the dynamic earth pressure (Ref. 1) has been simulated using two interface models to examine the influence of interface behavior on the numerical simulation. In one (Model I), only the sticking and the sliding modes of the interface is considered while in the other (Model II), the separation aspect of the wall and the backfill is also taken into consideration.

INTERFACE MODELS: The interface element has been idealized with a shear spring in the tangential direction and a slider representing the Coulomb friction as shown in Fig. 1a (Ref. 2). The elements are assumed to have an effective length l with zero thickness and are introduced by connecting the corner nodes of the backfill elements and the wall nodes as shown in Fig. 1b. In view of the fact that the friction between the wall and the backfill represents the Coulomb friction between two material surfaces without any dilatancy, interface element of nondilatant type is used. Interface is also taken to be one producing no velocity discontinuity. The stress-displacement relationship for the interface elements is assumed to be bilinear as shown in Fig. 2.

In Model I, no separation is considered by assuming that the interface undergoes only sliding type of motion. The strength characteristics of the interface for the cohesionless backfill considered in the analyses may be expressed in terms of the maximum value of the angle of wall friction, δ_f as $\tau_f = -\sigma_n \tan\delta_f$; σ_n being the normal stress acting on the element. Sliding will take place when the absolute value of the shear stress will reach the yield shear stress τ_f. In Model II, separation is allowed between the wall and the backfill. When separation occurs, the shear stress is not transmitted through the interface. Hence in the analyses at the instant of separation, the particular interface element has been discarded by replacing the normal stress acting on the element with zero.



(b) Element's Connection

Fig. 1 Interface Model

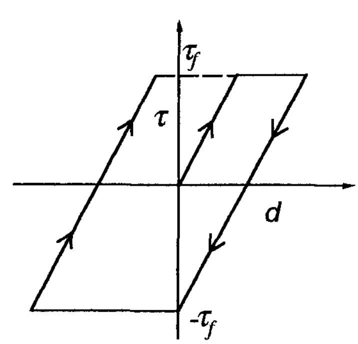


Fig. 2 Stress-Displacement Relation

ANALYSES, RESULTS AND DISCUSSION: Analyses are performed in time domain using Wilson's theta method. The backfill has been modeled using the *double shear band method* (Ref. 3) developed by the authors. The relative displacement in the normal direction between the wall and the backfill is kept zero during the analyses by giving equal forced displacement to both the wall nodes and the backfill element nodes. This technique alleviates the necessity of assuming arbitrary value of normal stiffness of the linkage element frequently used in the conventional analyses.

Fig. 3 shows the variation of the coefficient of earth pressure K, the relative height of the point of application of the resultant, h/H and the coefficient of wall friction angle, tan δ as a function of mean wall displacement s for the acceleration of 180 gals at the maximum inertia force. It can be observed that although initially the results from both the models coincide, with increasing wall displacements they differ, with the results from the Model II coming more close the experimental values. Figs. 4a and 4b show the same variations for the acceleration of 360 gals at the maximum and the minimum inertia force respectively. Comparing Fig 3 and Fig 4a it can be observed that for the higher acceleration levels the results from the two models differ even at the small wall displacement and as the wall displacement increases the differences of the results from Model I and the experimental results widen. This implies that the separation mode of the interface, which is not considered in Model I, play an active role in the calculation of seismic earth pressure. The influence of the separation becomes crystal clear if we observe the performance of the two models in the case of minimum force as shown in Fig. 4b. Model II predicts the experimental trends satisfactorily whereas Model I results in weird variations of the parameters K, h/H and tan δ.

Fig 5 shows the variation of the mean earth pressure at two different accelerations. This figure too divulges the merit of Model II and demonstrates that the effect of separation becomes more pronounced when the acceleration level increases. In fact it was observed during the analyses that at 180 gals of acceleration the separation occurs only at the top interface element, whereas at the acceleration of 360 gals the separation spreads till the 3rd element from the top.

CONCLUDING REMARKS: The phenomenon of separation has a significant influence on the dynamic earth pressure calculations and the sensitivity of the numerical calculations to this phenomenon increases with acceleration. Hence for a realistic analysis of dynamic earth pressure problems separation between the wall and the backfill should be considered as in Model II rather than assuming complete bonding at the interface. Complexity has been sacrificed in favor of simplicity in this analysis. Adoption of more sophisticated interface model, although involves numerical difficulties could enhance the simulation capability.

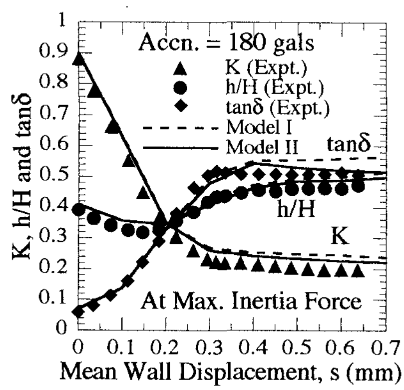
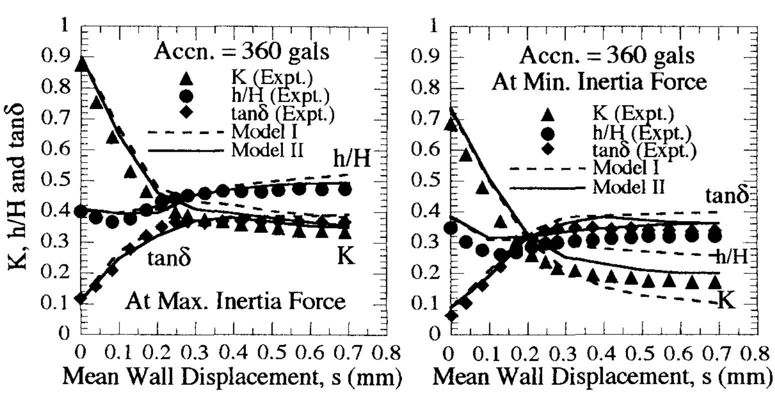


Fig. 3 Variations of the Earth Pressure Parameters with Displacement (180 gals)



(a) (b)

Fig. 4 Variations of the Earth Pressure Parameters with Displacement (360 gals)

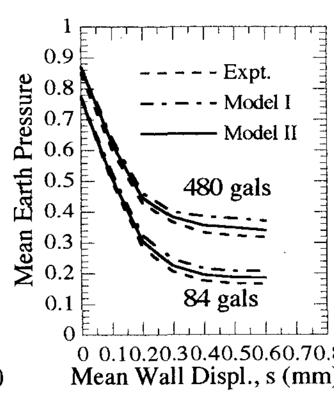


Fig. 5 Mean Earth Pressure at Different Acceleration

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[3] Matsuzawa, H., Hazarika, H. and Sugimura, M., "Seismic Earth Pressure Analyses Considering the Localized deformation of the Backfill Sand", *2nd Intl. Workshop on Wind and Earthquake Engg. for Offshore and Coastal Facilities*, USA, January, 1995 (Under Submission).