THE ARCHING MECHANISM ON THE MICRO LEVEL UTILIZING PHOTOELASTICITY MODELING

Principal Investigator: Samuel G. Paikowsky
Graduate Research Assistant: Hsien-Jen Tien (D.Eng.)
Research Funded By: National Science Foundation
Date: Summer 2001

ABSTRACT

Arching is an intrinsic phenomenon of granular material independent of scale effect. Its fundamental mechanism relates to the ability of discrete units to transfer loads through interaction in a preferable geometry and thus to bridge between the zone (or point) of load application to the zone (or points) of reaction. Arching plays an important role in geotechnical engineering related to soil- and rock-structure interaction such as; excavations, retaining structures, pile groups, tunnels, culverts and underground facilities. For example, the reduction of stresses experienced by yielding underground structures.

An experimental system based on Photoelastic Discrete Simulation (PDS) was developed by Paikowsky and DiRocco (1992), and Paikowsky and Xi (1997). The system is capable of recording and interpreting the response of discrete material on the micro and macro levels, simultaneously. The system was modified and utilized in this research and applied to a model of granular material made of photoelastic particles in order to observe, track and analyze the fundamental mechanism of arching. The model and PDS along with sophisticated image and global data acquisition systems, allows the observer to follow the generation of the arching within a granular material during a trap door experiment.

Visual and quantitative analyses are presented demonstrating the relationship between the global arching phenomenon and the particle interaction on the individual particle level. The global responses of the active arching match the results from previous studies carried out on ideal and natural discrete media. For one-inch particles, the development of the active arch was found to take place within a small displacement of the trap door (of about 1mm) and the formation of a triangular no-force zone above it. The phenomenon was found to be associated with the relative movement of individual particles relative to each other and hence transferring forces in a preferable orientation and bridging over the yielding areas. The mobilization of internal resistance in the granular sample and the roughness of sidewalls were the major factors affecting the passive arching generation.