

# Research Project Status Report

January 1, 2008 – March 31, 2008

<i>Project Title</i> <b>Subsurface Drainage for Landslide and Slope Stabilization</b>		<i>Agmt./Task No.</i> <b>T4120-10</b>	<i>Item No.</i>	<i>Agency Bgt. No.</i>
<i>Research Agency</i> <b>WSU/UBC</b>		<i>Start Date</i> <b>3/2007</b>	<i>Estimated Completion</i> <b>12/2010</b>	<i>Revised Completion</i>
<i>Principal Investigator(s)</i> <b>Balasingam Muhunthan (Washington State University) and Roger Beckie (University of British Columbia)</b>		<i>Technical Contact</i> <b>Tom Badger 360.709.5461</b>		
<i>WSDOT Program Manager</i> <b>Kim Willoughby 360.705.7978</b>		<i>FHWA or Other Technical Contact</i> <b>Mike Adams</b>		
<i>Funding Source</i> <b>CA, MD, MS, MT, NH, OH, PA, TX, WA, WY</b>		<i>Schedule Status</i> <input checked="" type="checkbox"/> On schedule <input type="checkbox"/> Ahead of schedule <input type="checkbox"/> On revised schedule <input type="checkbox"/> Behind schedule		
<i>Research Area</i> <input type="checkbox"/> Bridges & Structures <input type="checkbox"/> Environment <input checked="" type="checkbox"/> Highway Design & Safety <input type="checkbox"/> Mobility & Intermodal Planning <input checked="" type="checkbox"/> Operations & Materials <input type="checkbox"/> Traffic & Intelligent Transportation Systems Evaluation				
<i>Original Estimated Cost</i> <b>\$ 300,000</b>	<i>Revised Cost</i>	<i>% Funds Expended</i> <b>7%</b>	<i>% Work Completed</i> <b>15%</b>	
<i>Objective</i> <b>(1) Provide best practices and guidance for subsurface drainage applications for slope stabilization, including subsurface investigation and testing, groundwater-flow characterization, analysis, drain configurations and design, installation methods, monitoring, and maintenance. (2) Evaluate new applications of existing materials and technologies, such as trenchless technologies (horizontal directional drilling, micro tunneling, guided boring, etc.) and other innovative technologies and materials, for stabilizing slopes using subsurface drainage.</b>				

## Project Progress:

Literature review on subsurface drainage applications was updated with information on ground water flow characterization and subsurface characterization.

Based on our research on different software, we purchased the computer software TOUGH for use in the project. This is the updated version of the TRUST program used by Lau and Kenney in their analyses of horizontal drains in slopes. The program is applicable to 3-D problems and to soils which are inhomogeneous and anisotropic. It utilizes an integrated finite difference scheme and provides the 3-D distribution of piezometric levels that can be used in stability calculations. The program, however, is not very user friendly. But, we have made sufficient progress in mastering it.

TOUGH is currently being used to model the WSDOT subsurface drainage project on SR 101 at MP 69.8. The finite difference grid has been set up along with the necessary soil parameters. The model results will be compared with observed changes in groundwater flow pattern and pore pressure distribution as documented in WSDOT reports. Once the model is verified it will be used to conduct a parametric study the effects of i) direction of drains (on the direction of flow, orthogonal to directional of flow), ii) spacing between the drains, iii) the elevation of drains with respect to flow, iv) length of drains, and (v) number of drains, on slope stability. Based on the success of this suite of analyses, we will extend it to other case studies.

## New Period Proposed Activity:

- Complete the ground water flow analyses of SR 101 project.
- Conduct a parametric study of the effect of system variables on flow pattern and piezometric surface.
- Examine the effect of changes in ground water flow pattern and piezometric heads on slope stability.