Project Title	*Agmt./Task No.*	*Item No.*	*Agency Bgt. No.*
SPR-3(072) Strength and Deformation of Mechanically Stabilized Earth (MSE) Walls at Working Loads and Failure	**SPR-3(072)**		
Research Agency	*Start Date*	*Estimated Completion*	*Revised Completion*
Royal Military College of Canada	**12/1/99**	**04/30/04**	**3/31/09**
Principal Investigator(s)	*Technical Contact*		
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Funding Source	*Schedule Status*		
WA, NY, ID, CA, WY, ND, MN, OR, AZ, AK	☐ On schedule ☐ Ahead of schedule ☒ On revised schedule ☐ Behind schedule		
Research Area			
Geotechnical			

Original Estimated Cost	*Revised Cost*	*% Funds Expended*	*% Work Completed*
$360,104	**$690,000**	**83%**	**89%**

Objective

Develop a design procedure for the internal stability of MSE walls, especially those reinforced with geosynthetics.

Project Progress:

1. A paper was accepted for publication in the ASCE Journal of Geotechnical and Geoenvironmental Engineering that describes a sophisticated constitutive soil model (Lade's model) that has been implemented in our FLAC numerical code and verified against RMC test walls. This paper is the keystone reference paper for future journal papers by providing background validation to the use of our FLAC model to carry out parametric analyses to extend our physical database to a wider range of wall types, reinforcement layers and types, different soils etc.

2. A series of full-scale block-leveling pad direct shear tests were carried out to quantify block wall toe stiffness. The data showed that the sliding resistance at the base of a modular block wall seated on typical gravel bases is equivalent to the horizontal toe support used in the RMC retaining wall test facility. This testing confirms the relevancy of the toe boundary condition used in this test facility to actual field walls.

3. A numerical parametric analysis paper is in review with the Canadian Geotechnical Journal that investigates the influence of toe support on modular block walls. The results of these independent numerical analyses are in good agreement with reinforcement load predictions using the latest version of the K-stiffness Method.

4. The results of four physical RMC test results were published in a paper appearing in Geosynthetics International. This paper quantifies the effect of reinforcement stiffness and compaction equipment on wall performance. The reinforcement load predictions were demonstrated to be in good agreement with the current version of the K-stiffness Method.

5. A paper is in press with the journal Soils and Foundations (Japanese Geotechnical Society) that proposes a new design method for steel multi-anchor walls.

6. A paper was published in the ASCE Journal of Geotechnical and Geoenvironmental Engineering that examines the accuracy of the AASHTO Simplified Method for steel reinforced soil walls by comparing predicted loads to measured loads.

7. Seven more full-scale steel strip reinforced soil wall case studies have been found from Japanese sources. These walls were built with lower friction angle backfills than walls in the current database. These data are being analyzed to further refine the current AASHTO and K-stiffness methods for steel strip walls.

8. More than 500 geosynthetic pullout test results have been collected and analyzed. The data will appear in a paper that is currently in preparation for the next quarter. The data are being used to: a) quantify the accuracy of the current AASHTO/FHWA pullout model; b) propose modifications to the current AASHTO/FHWA model to improve accuracy; c) propose a new model with greatly improved accuracy; and, d) provide resistance factors for LRFD calibration of current AASHTO, BS8006 and K-stiffness design methods.

9. A new large pullout box with transparent soil is 50% completed. This will allow us to directly observe geogrid-soil load transfer mechanisms. The data will allow us to back-calculate in-situ geogrid stiffness and equivalent interface shear stiffness values required in numerical codes.

10. Analyses are complete for an evaluation of the BS8006 method for calculation of reinforcement loads. The data show that the British approach is less accurate than the AASHTO Simplified Method. A paper will be submitted to the journal Geotechnique in the next quarter.

11. A paper that reports the influence of facing batter on the performance of three of the RMC walls is in review with the Canadian Geotechnical Journal.

12. A paper published with Miyata in the Geosynthetics Engineering Journal won the best paper award of the Japanese Geosynthetics Society. The paper examines the accuracy of the K-stiffness Method for battered walls.

New Period Proposed Activity:

Continue with construction of Wall 14 (Phase 5).

Continue with LRFD calibration of BS8006, AASHTO and K-stiffness Method for geosynthetic reinforced soil walls.

Continue with LRFD calibration of AASHTO and K-stiffness Method for steel reinforced soil walls.

Continue with large-scale transparent soil pullout box testing.

Continue with development of numerical database that will be used to fill in data gaps for further refinement of the K-stiffness Method.

Recent related publications:

Huang, B., Bathurst, R.J. and Hatami, K. 2009. Numerical study of reinforced soil segmental walls using three different constitutive soil models, ASCE Journal of Geotechnical and Geoenvironmental Engineering (in press)

Miyata, Y. and Bathurst, R.J. 2009. Measured and predicted loads in multi-anchor reinforced soil walls in Japan, Soils and Foundations, Vol. 49, No.1 (in press)

Bathurst, R.J., Nernheim, A., Miyata, Y. and Allen, T.M. 2009. Predicted loads in steel reinforced soil walls using the AASHTO Simplified Method, ASCE Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 2, 177-184.

Bathurst, R.J., Nernheim, A., Walters, D.L., Allen, T.M., Burgess, P. and Saunders, D. 2009. Influence of Reinforcement Stiffness and Compaction on the Performance of Four Geosynthetic Reinforced Soil Walls, Geosynthetics International, Vol. 16, No. 1, 43-59.

Miyata, Y. and Bathurst, R.J. 2009. Measured and predicted loads in multi-anchor reinforced soil walls in Japan, Soils and Foundations, Vol. 49, No.1, 1-10.

Miyata, Y. and Bathurst, R.J. 2008. Prediction model of reinforcement load for geogrid soil walls with facing batter, Geosynthetics Engineering Journal, Japan chapter of IGS, Vol. 23, pp. 195-200 (in Japanese).

Bathurst, R.J., Allen, T.M. and Nowak, A.S. 2008. Calibration concepts for load and resistance factor design (LRFD) of reinforced soil walls, Canadian Geotechnical Journal Vol. 45, pp. 1377–1392