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Technologies to manage risk for infrastructure

The Colony at White Pine Canyon, Park City, Utah

Phased development of The Colony at White Pine Canyon by Iron Mountain Associates (IMA) began in 1998 and is on-going. "The Colony" is a 4,400-acre enclave tucked into the trails of The Canyons, the continent's fifth-largest ski resort. The six plus-acre home sites afford ski-in and ski-out access to each home.

Aerial view of The Colony at White Pine Canyon

The extreme terrain conditions posed significant challenges to the on-going phased construction of necessary infrastructure such as roadways and utilities. An extensive system of retaining walls was (and is) required for side hill roadway construction, vehicle bridges and ski "cross-overs". Mechanically stabilized earth (MSE) retaining walls (Hilfiker System) were selected for use on the project. These consist of welded wire face elements and steel bar mats for primary reinforcement.

In 1999, several of the Phase 1 Hilfiker walls exhibited signs of distress on the face wire. By 2000, more of the Hilfiker walls in Phases 1 and 2 exhibited similar signs of distress and settlement, that resulted in pavement cracking and guardrail movement. Investigations conducted in 2001 by others concluded that construction deficiencies were the major factors contributing to the poor performance of the Hilfiker walls in Phases 1 and 2.

Remediation work was performed on six walls in 2004/2005. In May 2005, during repair of these walls, evidence of corrosion of the welded wire reinforcing mats was discovered. This triggered a series of investigations to evaluate the extent of corrosion in the Hilfiker walls in Phases 1, 2 and 3. In late 2005, Geocomp was retained by IMA to undertake a systematic approach to evaluate the condition of all the Hilfiker retaining walls.

A project-specific matrix rating system was developed and applied to all project walls (Phases 1, 2 and 3). The rating matrix incorporates factors such as condition level (current condition of the wall structure), hazard level (critical nature of the wall structure), and vulnerability level

Forensic deconstruction of Hilfiker wall, 2006

(Continued)

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The Colony at White Pine Canyon, Park City, Utah, cont'd.

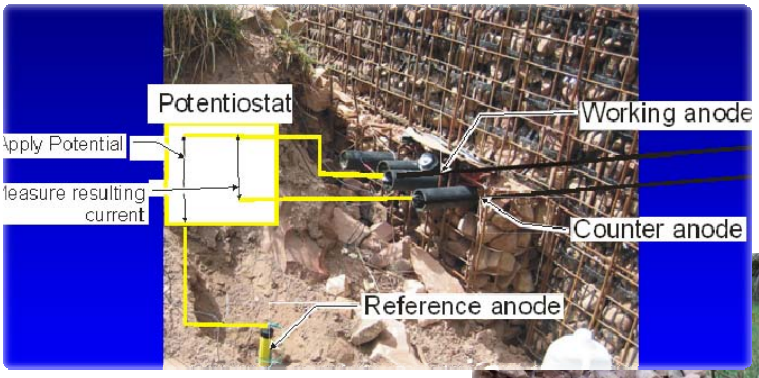
(likelihood of corrosion problems). The work has included complete deconstruction of 4 representative wall s over two construction seasons. These deconstruction activities have permitted assessment of the existing condition of the welded wire reinforcements and the rate of corrosion.

Remediation, to date, has focused on correcting construction deficiencies in the upper portion of Phase 1 and 2 walls. Corrosion issues will require additional remediation of the lower portion of some walls.

Since the performance of the MSE walls on the project is dependent on the strength of the welded wire reinforcement at the end of the design life, the focus of our evaluation has been to determine the thickness of the wire and evaluate the corrosion degradation rate. The factor of safety and remaining service life can then be evaluated for the existing and future wall conditions. A substantial amount of field and laboratory test data has, therefore, been compiled as a result of the wall deconstruction program. Statistical analyses have been performed on the data, and reliability analyses are being conducted to predict remaining wall life of the Hilfiker walls. A program of linear polarization measurements has been initiated to help establish project specific corrosion rates over the long term.

Based on work completed through 2006, we identified three technically viable solutions for future rehabilitation of the Hilfiker retaining walls/abutments: soil nailing, permanent ground anchors, and partial or complete reconstruction of the MSE structures. Design-Build proposals were solicited from a select group of specialty contractors to establish a cost basis for future budgeting for this type of remediation.

Soil nail remediation of Hilfiker wall, 2007



Linear Polarization Measurements

Soil nail remediation of two select walls was completed in 2007.