Smart Rock Technology for Real-time Monitoring of Bridge Scour and Riprap Effectiveness – Design Guidelines and Visualization Tools

Project Kickoff Meeting with Technical Advisory Council committee and Program Manager on November 14, 2014

Introduction:

Dr. Genda Chen called the meeting at 11:00 am (central time). Self introduction is followed.

East coast representation
Caesar Singh: US DOT Program Manager. This is a new project as an extension of the previous project.

Dr. Kornel Kerenyi: Hydraulic Research Program Manager at FHWA Turner Fairbanks Highway Research Center. The smart rock technology is very interesting and proved to be a reliable monitoring system for scour monitoring.

West coast representation
Kevin Flora: Hydraulic Engineer at Caltrans. I am interested in smart rock technology for bridge scour monitoring.

Mid-west representation
Malcolm Hodge: SmartSensys. I am interested in all bridge monitoring systems and wireless transmission in particular for scour monitoring.

Jennifer Harper: Research Engineer at MoDOT
William Stone: Research Administrator at MoDOT
Dale Henderson: Hydraulic and Structural Engineer at MoDOT

Presentation by Genda Chen:

Briefly review what has been done in Phase I and some latest developments of smart rock technology in this phase. Mainly focus on discussion and comments/feedback from Technical Advisory Council members.

Current phase is focused on the implementation and case study of passive smart rocks with the following research tasks:

- ***Movement Characterization and Design Guidelines of Smart Rocks***. Design smart rock (density and size) and characterize the incipient motion of rock.
- ***Design, Prototyping, and Deployment of Smart Rocks***. The so-called "rock compass" will be designed and fabricated. A smart rock design with "zero friction" in magnet rotation is designed, fabricated, and tested for accurate localization of smart rocks. A magnetic field detector will be designed, fabricated, and tested to accurately measure the environmental magnetic field near bridges under consideration. Specifically, the orientation of ambient magnetic field is determined. To be cost effective for each long trip, two bridge sites may be tested in California. Kevin will look into this action item.
- ***Measurement Protocol, Field Tests and Visualization Tools***. Field test protocol will

be established and test results will be validated with the measurement from ground penetrating radar or diver inspection. A graphical tool will be developed to show the measured smart rock movement on an area map around a bridge site.

Project timeline:
The current project will be carried out in 24 months, starting October 1, 2014. All laboratory development, design, fabrication, prototyping, and calibration will be done in the first 6 months. Smart rocks will be deployed at bridge sites. The initial installation of smart rocks will likely be in late spring.

Bridge site in California:
Waddell Creek Bridge is a steel girder bridge structure near the Pacific Ocean with its Southeast abutment protected from scour with rocks. However, scour has already developed at intermediate bents since the bridge was built in 1947. The river bed profile has been changed significantly over the past 30 years.

Questions and Comments:

Kevin Flora*:* Some bridges have such strong influences on their environmental magnetic field. For example, would the steel effect from a bridge be overwhelming to the magnet field of smart rocks.
Genda Chen*:* A custom-made magnetic field detector will be utilized to detect the environmental magnetic field. The effect of steel in bridge will be included in the baseline measurement. The baseline accounting for the effect of both bridge and Earth's magnetic field will be measured prior to smart rock deployment.

Kornel Kerenyi: Two types of sensors were mentioned during the presentation. The first type is that smart rocks will naturally roll to the bottom of a scour hole and give us the needed scour depth. We can actually use the same scour sensor to monitor like a toe's failure of a riprap.
Genda Chen: That is exactly what this project intends to do. Smart rocks can be placed around the toe of the riprap rock solution at Waddell Creek Bridge. If it started to move, the smart rocks give us an indication of incipient riprap failure. However, if time permits, smart rocks can be mixed with natural rocks. When the smart rocks begin to move, the natural rocks above the smart rocks must have been eroded away. In this case, the level of riprap loss can be monitored in real time. But for this particular project, our main focus is to deploy smart rocks at the toe of a riprap measure and monitor the incipient motion of riprap rocks.

Genda Chen: I suggest that we add another bridge test bed in California. It would be nice that the second bridge is close to Waddell Creek Bridge, say within 1 hour driving distance. It would also be desirable to identify the second bridge across a creek or river that creates different scour condition so that more data representative to various application cases can be collected.
Kevin Flora: Okay, I will work on it.

Genda Chen: I propose that we install 5 smart rocks at each pier close to upstream. A magnetometer measures the total magnetic field intensity from all smart rocks; the effect of individual rocks is difficult to sort out. When deployed at least 1 meter apart, 5 smart rocks may be able to tell apart through multiple measurements in surrounding area, especially when the smart rocks roll to the bottom of a scour hole one by one. As an example, 2 smart rocks

can be placed next to foundation, another 2 smart rocks are placed a little away from the foundation, and the last one smart rock is deployed a little further away. In this way, the evolution of the scour hole can be monitored.

Kornel Kerenyi: If a magnet is buried under 6 feet deep into soil deposits, can you still communicate with the magnet 15 meters away?
Genda Chen: We will dig a hole in open site and find out the maximum embedment depth that the magnetic field intensity can be credibly measured. The resetting of smart rocks should not affect the measurement so long as the resetting materials do not have strong ferromagnetic substance. This point will be confirmed in 6 months. In theory, no effect from the deposits would be found. But we will test it out.

Genda Chen: We will continue to shoot for a location detection accuracy of 0.5m. Our preliminary plan is to conduct field tests every 6 months in California or prior to and after a significant storm. We will coordinate with Kevin for field tests. In Missouri, however, bridges can be tested every 3 months on a regular basis or prior to and after a significant storm.
Kevin Flora: The rainy season in California is likely throughout March. It is better to do a couple measurements during the rainy season if ready.
Genda Chen: We will shoot for smart rock installation in March or maybe earlier so that more data can be taken during storms or floods. We will coordinate with Kevin for the best time of installation.

Genda Chen: If no other questions and comments, let us fix the next meeting. Should this group meet every year? We don't know if we need traffic control during tests.
Kornel Kerenyi: Caesar: should we meet more frequently like every 6 months?
Caesar Singh: Yes. It would be good to receive feedback from the TAC every 6 months.
Genda Chen: Okay. Our next meeting will be in 6 months, maybe right after the field installation.

Genda Chen: In Missouri, field testing on the bridge deck supporting the Interstate 44 requires traffic control. What about California?
William Stone: Two week notice is required for any request on traffic control assistance.
Kevin Flora: Waddell Creek Bridge has a very narrow sidewalk. Testing on bridge deck would require traffic control. I will look into it upon request.

The meeting is adjourned at 12:00 pm (central time).