Evaluate the Cushion Layer used in Rock Shed by Monitoring the Piezoresistive Response of Smart Cement

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Abstract: Rock fall is one of the major natural hazard for mountainous countries. Rock shed have been widely used to prevent blockade of road due to falling rocks and number of experiments have been conducted. The cushion layer above the RCC slab dissipates some amount of the impact energy of the rock and transfer rest to the RCC structure below. Considerable progress in rock shed design has been made by Switzerland and Japan in last few decades. It is important to evaluate the possibility of real-time monitoring of the protection system. Smart cement was tested to evaluate the response due to impact loading on cushion layer. This paper includes evaluation of cushion layer on impact loading with real-time monitoring of smart cement.

1. Introduction:

The combination of RCC elements, retaining walls--monolithically built with the inclined RCC slab--and a cushion layer constitutes a rock shed that acts in a different mechanism to transfer the impact energy of heavy falling rocks from mountains. A concept of rock sheds without a cushion layer has been proposed in France; however, use of cushion layer in rock shed not only helps in the energy dissipation and direct impact of falling rocks on RCC structure, but also makes the structure economical and durable. A cushion layer in any rock shed dissipates the impact energy, acts as a shock absorber, increases the impact duration and decreases the acceleration of the falling rock in some extent (Schellenberg et al. 2007). In Japan, 0.90m of sand is widely used as a cushion layer but Styrofoam and rubber tires have also been used extensively (Kishi et al.1999). And in Switzerland, locally available sand and gravel is primarily used (Schellenberg et al. 2007). Most recently, Peng Zhao (2018) in China conducted a large scale experiments to compare the cushioning performance of EPE, EPS and soil. EPE is an engineered plastic foam whereas, EPS is an expanded polystyrene also known as Styrofoam. They proposed a new cushion layer composed of sand and EPE and concluded the combined cushion layer to be more impact resistive and economical.

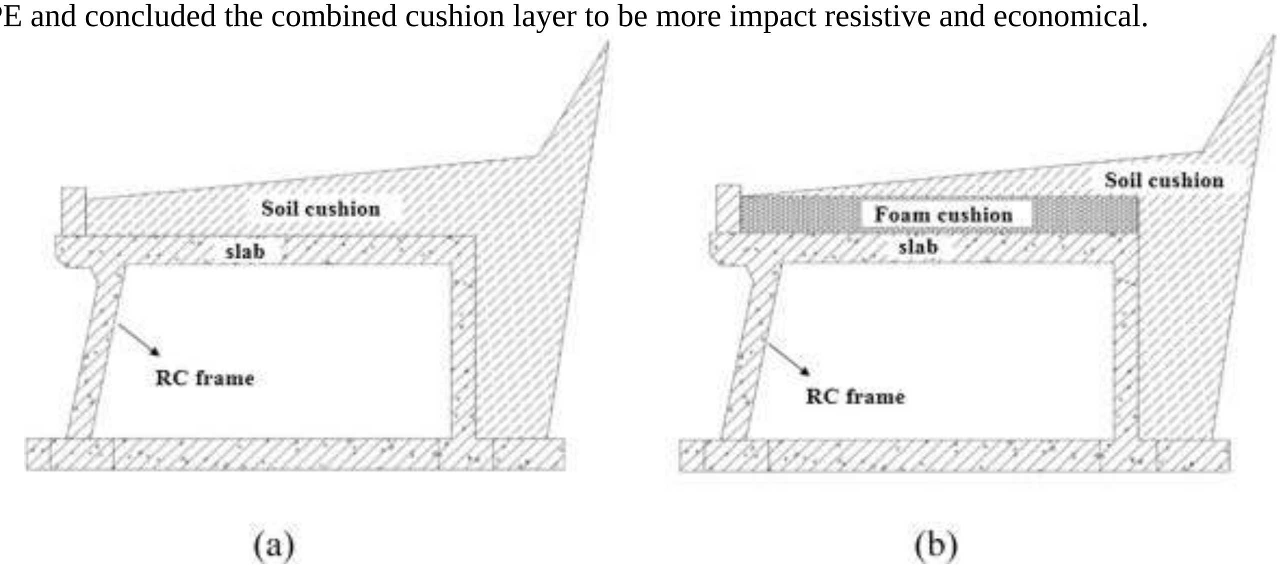

Figure 1. Schematic Diagram of Rock shed

2. Objective:
The objective was to test the smart cement response to impact loading with and without cushion layer.

3. Experiment:
3.1 Preparation of Sample: Class H cement was used for the mixing. Water cement ratio for the mixing was 0.4 and 0.05% of conductive fillers (CF) by weight were used while mixing to make the cement sample piezoresistive making it smart cement. The smart cement technology can monitor the changes in the cement at very high magnification of about 2500 times after one day curing (Vipulanandan et al., 2014). The mix was poured in a mold of cylinder of diameter 2” and height 4”.

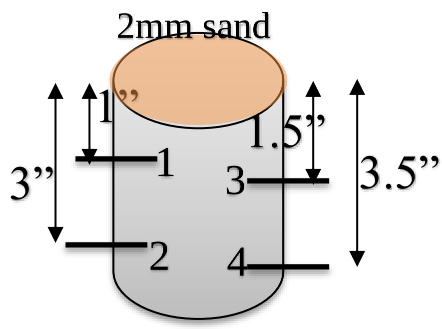

Figure 2. Smart cement specimen with sand cushion on top

3.2 Measurements: LCR meter was used for measuring impedance of the specimen with and without cushion layer at 300 kHz frequency using two probe method. Cushion layer used in the testing was sand of about 2mm height above smart cement specimen. Three different loads of 83gm, 104gm and 230gm were used as impact load in the testing.

3.3 Method and Results: Firstly, the resistance of the smart cement with and without cushion layer was measured when impact load was not applied. Then, resistance was measured when loads were dropped from height of 2”. Total of four probes were inserted at different height in the specimen while casting as shown in fig 2. and the LCR meter reading was taken for vertical, horizontal and diagonal combinations. The smart cement was as much as sensitive with sand cushion as without sand cushion for every impact load.
Every load is calculated in the form of energy using formula:

$$E = m*g*h$$

And the value of resistance for every change in energy is calculated in percentage change with the previous value of resistance and graph is plotted for energy vs percentage change in resistance below.

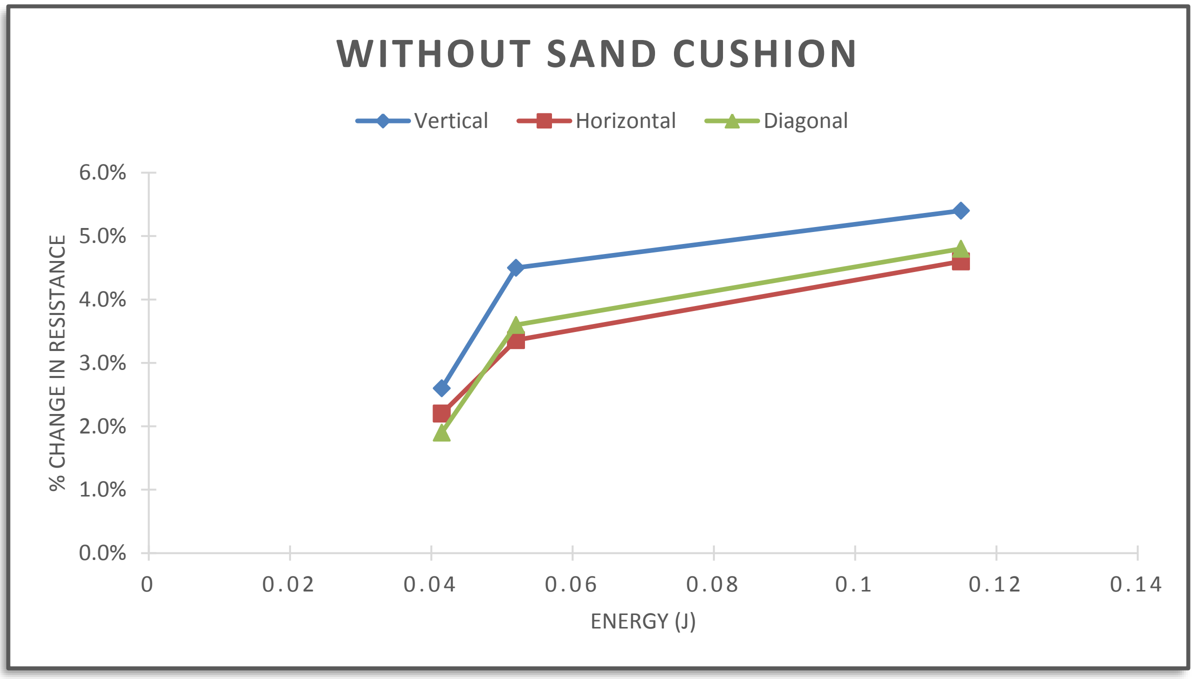

Figure 3. Energy vs Percentage change in resistance without sand cushion

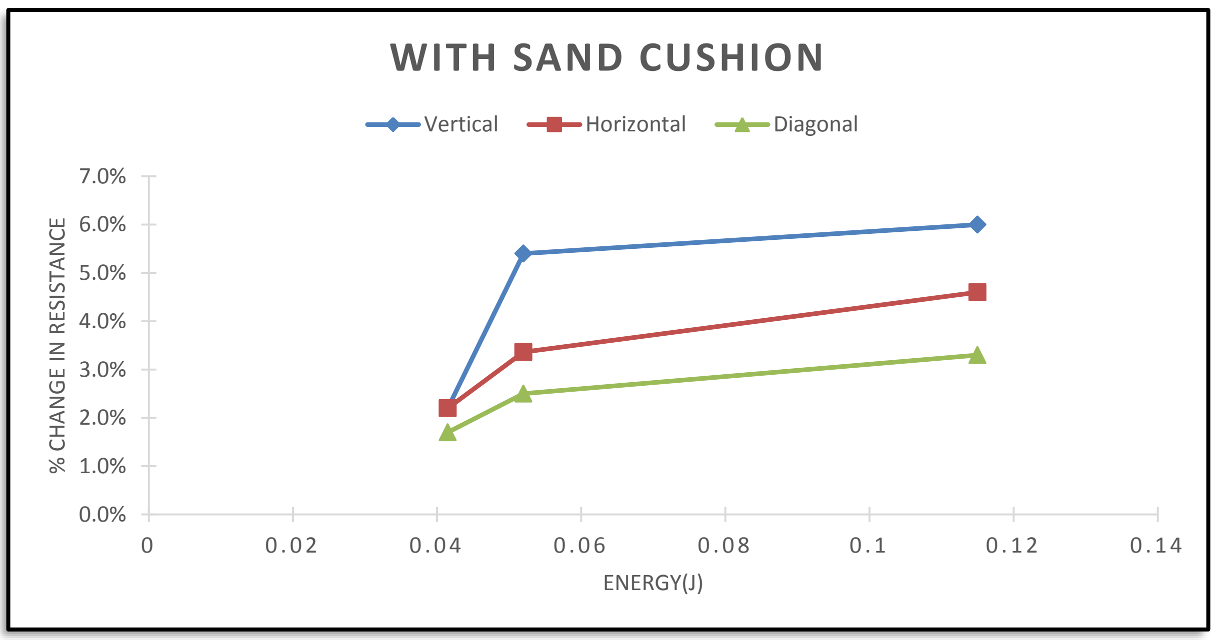

Figure 4. Percentage change in resistance vs energy with sand cushion

Here, in fig.3 and fig.4, we can see that for every impact energy there is a positive increment in the value of resistance of smart cement specimen. With the increase in energy, the percentage change is higher for all the combinations increasing from about 2%-3% for load 83gm to around 5%-6% for load 230gm.

4. Conclusion:

1. There is a possibility of real-time monitoring the behavior of cushion layer under different impact loadings using Smart Cement. The sensitivity of smart cement is same even with cushion layer above it.
2. Quantification of impact energy can be done by analyzing the percentage change in resistance value of smart cement.

5. Acknowledgements:

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6. References:

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