Monitoring Ground Water Table Rise Using the Smart Cement

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Abstract
Piezoresistive smart cement sheath supporting a casing was used to monitor the water table rise. The effective shear in the cement is reduced under the water table resulting reduced resistivity. Due to 11" of rain resulted in water table rise by 4 ft (due to the distance of measurements).

1. Introduction
As an important element of the oil well, cement sheath, placed in the annulus between casing and formation, provides zonal isolation and structural support to the casing throughout the life of a well (Goodwin, 1997). It must withstand high stresses under extreme service conditions and also should maintain the integrity of the oil well (Ravi, Bosma, and Gastebled, 2002). Hence knowledge of the cement properties during and after cementing is very important.
Several methods have been used to monitor the behavior of cementatious material such as X-ray diffraction, calorimetric analysis, scanning electron microscopy and ultrasonic methods. Electrical resistivity is one of the method can be used to investigate the behavior of the oil well cement (Vipulanandan, Heidari, Qu, Hughes, and Farzam, 2014) due to the accuracy, ease of testing and nondestructive characteristics (Li and Wei, 2003) of this method.
Houston, Texas was hit by an unprecedented downpour of torrential rain which triggered flash flooding on May 25, 2015. Flash flood watches and warnings were issued across 7 states. A state of disaster was declared for 24 Texas counties on May 25, 2015. There was 11" of rain fall. There were 18 confirmed deaths and 13 people are unaccounted for. The death toll is still climbing. In Houston, more than 80,000 lost power and closed roads include Interstate 10 and Interstate 45. At least 4,000 homes were damaged in Houston.

2. Objective
The objective of this study was to determine the raise in the water table due to a rain storm by monitoring the changes in resistivity of the smart cement sheath.

3. Results and Discussion
The water table was located 25 feet below the ground level. After flooding the ground water level changed which was monitored through resistivity measurements. In this study, the ability of sensing changes in material characteristics was investigated by measuring resistance. The cement was monitored in 15 levels. Rise in the water table will result in increased pore pressure resulting in reduced effective stress and piezoresistivity. The effective stress versus depth is shown in Fig. 3, while the resistivity versus depth is monitored and analyzed in Fig. 4. The highest value of resistivity in depth of 25 ft under the ground is the good indicator to know the water level. After flooding the resistivity came up to 21 ft under the ground which is captured by resistivity (the distances between the measurements in downhole was about 4 ft). resistivity of the piezoresistive cement was effected by water table rise. $\rho = \rho_0(curing) + \rho(\sigma')$

Figure 1. Flooding in Houston

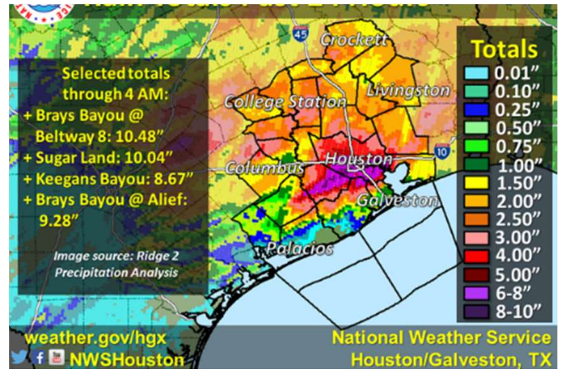

Figure 2. Rain fall overnigth, May 26th

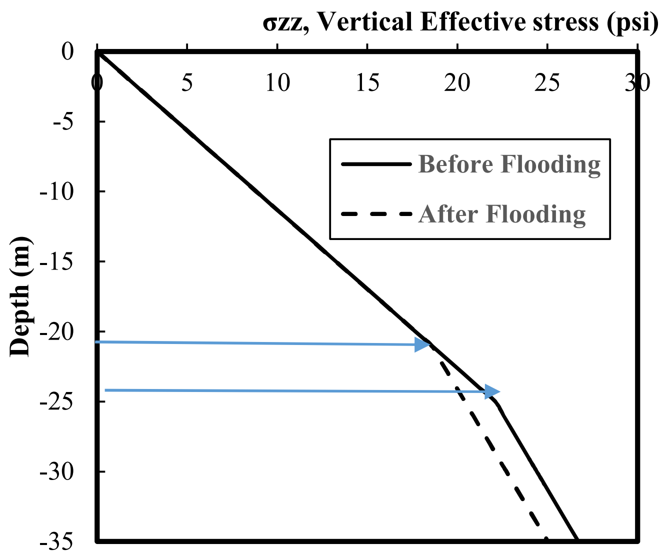

Figure 3. Vertical effective stress versus depth

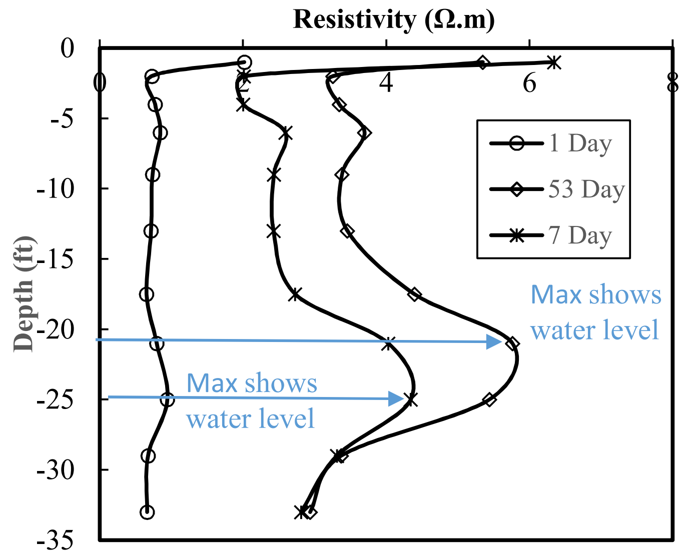

Figure 4. Resistivity versus depth

4. Conclusion

The smart cement which is acting as a bulk sensor can captured the rise in the water level change of material properties during installation and for long term monitoring.

5. Acknowledgments

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6. References

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