Piezoresistive Material for Repairing Damaged Oil Well Cement Beam

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Abstract: Modified ultrafine cement was used to repair broken oil well cement beam specimen to regain its strength and piezoresistivity. Results showed that the repaired sample recovered piezoresistive behavior and regained more than 75% of the initial flexural strength.

1. Introduction

Average life of an oil well is reported to be 20 to 30 years. Within this long duration maintenance and repair is necessary to make sure the integrity of the cement sheath holding the casing to the formation. Improper placement of cement, stress conditions in the wellbore due to operation and maintenance, stresses brought on by temperature and pressure cycling are some of the reasons for failure of cement sheath. When cement sheath loses its integrity, loss of zonal isolation can be result other formation fluids to enter the annulus and also possibly causes unwanted water production which finally reduce the economic life of the well.

Considering cost, safety and regaining the strength at high pressure - high temperature conditions in the well, cementitious material can be a better repair material compared to epoxy resins, chemical gels, and silicate materials (Peter White, Prentice et al). For successful repair, repair material need to deep penetrate into the fracture. Hence, small-particle-size cement can be used as repair material. Since ultrafine cement contains very fine particles, it is capable of invading narrow openings that other standard cement cannot access. Ultrafine cement is defined as d95 < 10 microns which is very smaller compared to Type I Portland cement of 70 microns and Blaine fineness of at least 900 m2/kg.

While regaining the strength of the damaged well, it is very challenging to regain the piezoresistivity of the material, if the cement sheath had self-sensing ability before the occurrence of the damage.

2. Objective

The objective of this study was to investigate the effectiveness of modified ultrafine cement in repairing broken oil well cement beams in terms of regaining piezoresistivity and strength.

3. Materials and Methodology

Modified class H oil well cement was used to prepare beam specimen of 11 x 3 x 3 inch with a water:cement ratio 0.4 by weight as shown in Figure 1(a). After 2 months of air curing, it was tested for three point load flexural strength. Figure 1(b) shows the specimen after repairing using modified ultrafine cement. Final Setting time of repair material was 5 hours. 3 days after the repair it was again tested and is shown in Figure 1(c) after test. It is very interesting to note that, out of 3 repaired samples 2 were failed not in the repaired location which shows the effectiveness of the repair.

Piezoresistivity of the specimen before and after repair was found using two probe method with 300 kHz AC device and results are explained in Figure 2.

4. Results and Discussion

Stress strain curve of the initial sample is shown in Figure 3, which shows the flexural strength of the initial sample to be 256 psi. Initial specimen showed maximum piezoresistivity of 60% while the corresponding failure strain was about 0.0003 which makes the self-sensing ability of the cement promising. The repaired sample showed above 125%. Initial resistance between the sensors was 22 kΩ for initial sample and 6 kΩ for repaired sample. The drop in initial resistance and increased in sensitivity before and after repair was because the cracked surface was soaked into water before repair and the repaired sample was cured in relative humidity 95%.

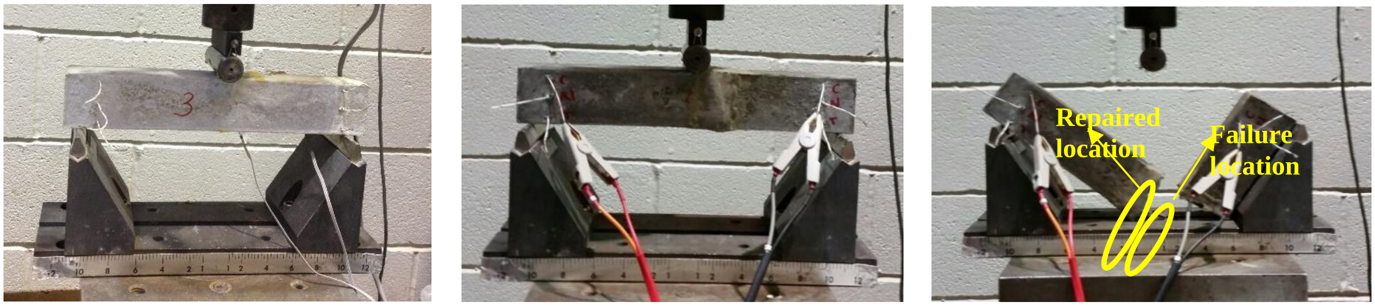

Figure 1: (a) Initial specimen (b) Repaired specimen (c) Failure of Repaired specimen

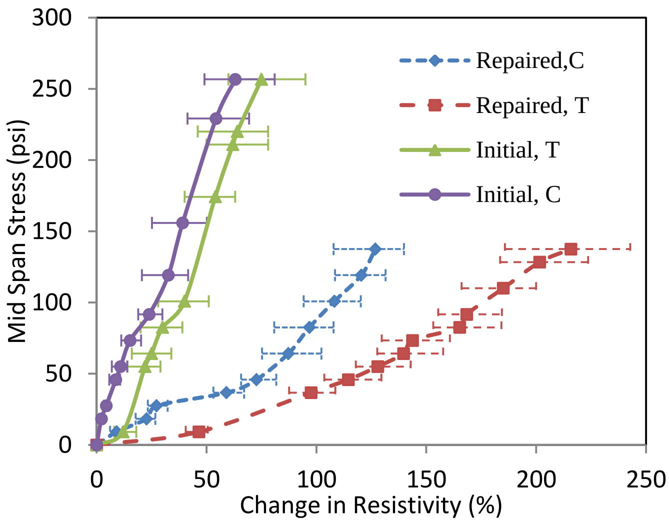

Figure 2: Piezoresistive Behavior of Repaired Oil Well Cement

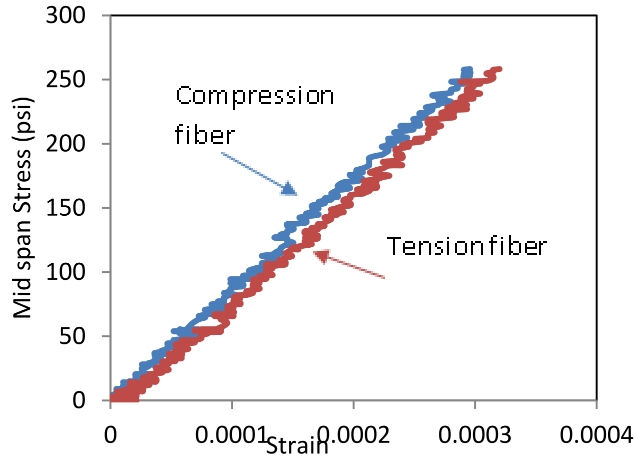

Figure 3: Change of Mid Span Stress with Strain

5. Conclusion

Repaired specimen showed more than 75% of strength regaining and it recovered self-sensing ability. Out of 3 tested specimen only one failed at the repaired location.

6. Acknowledgement

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7. Reference

[1] Harris K.L. and Johnson B.J (1992). Successful Remedial Operations Using Ultrafine Cement, 21-30

[2] Raymond W. H. and Nathan C. S. (2010). Ultrafine Cement in Pressure Grouting, ASCE Publications, - Technology & Engineering, 4-8

[3] Peter White, Grouts- Sealing the Future, Multiurethanes

[4] Prentice Creel and Ronald J. Crook, Cementing – Injectrol and Premseal sealants repair leaks, restore Integrity to casings

[5]http://www.halliburton.com/en-US/tools-resources/training/redtech-learning-series/redtech-papers/welllife-service-reduces-cement-failure-risk.page?node-id=hfci45k9