Compressive Cyclic Loading Response of Smart Oilwell Cement

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Abstract

In this study, the effect of compressive cyclic loading on the smart oil well cement was investigated using the change in electrical resistivity. The cement samples tested under uniaxial cyclic compression after 40 days of curing. The smart cement showed good repeatability and was very responsive to the loading and unloading. During compressive loading the resistivity increase and duing unloading the resistivity decreased.

1.Introduction

Once oil and gas wells are cemented in place, they will be subjected to cycling loading during the entire service life of the well. This also due to pressurizing and depressurizing of wells as a result of various activities including testing (well log analysis) and producing reservoir fluids. Fluid injection in enhanced oil recovery and hydraulic fracturing operations in unconventional reservoirs may result in damaging the cement due to cyclic loading. It is also critical to monitor the condition of the cement during its service life.

2.Objective

The specific objectives of this study are the following:

a) Verifying the sensitivity smart cement to cyclic loading.
b) Verify the repeatability of the resistivity measurement method.
c) Perform cyclic loading of smart cement under repeated loading and unloading.

3.Materials and Method:

The method used in the study is the two-probe method developed by Vipulanandan (2013-2018) and used by many authors including Zhang et. al., 2020 as the method proved to be practical for rapid testing of cementitious materials. The methods and materials used in this study are summarized as follows:

- Class G cement, W/C ratio of 0.44 and Conductive fillers (BWOC 0.05%).
- Mixing of cement was according API RP 10B-2 standards.
- Uniaxial compressive cyclic loading up to 800 psi (5.5 MPa) and unloading.
- Resistance measured using the two probe method with the LCR meter and alternating current (1 volt) at a frequency of 300 kHz.

4. Results and Discussion

The loading and unloading test results are summrized in the Table 1. The changes in resistances where collected in a 100 psi increment (0.69 MPa) compressive loading and unloading. When the cement sample was first preloaded with weight of 150 lbf (about 50 psi), the electric resistivity increased rapidly and continously increased with the increase in compressive loading. At 800 psi loading the resistivity cahnge was about 109%. When stared to unload the resistivity decrease as summrized in Table 1 and also shown in Figure 1. At zero load the resistivity decrease to between 1 % to 2% based on the number of cycle.

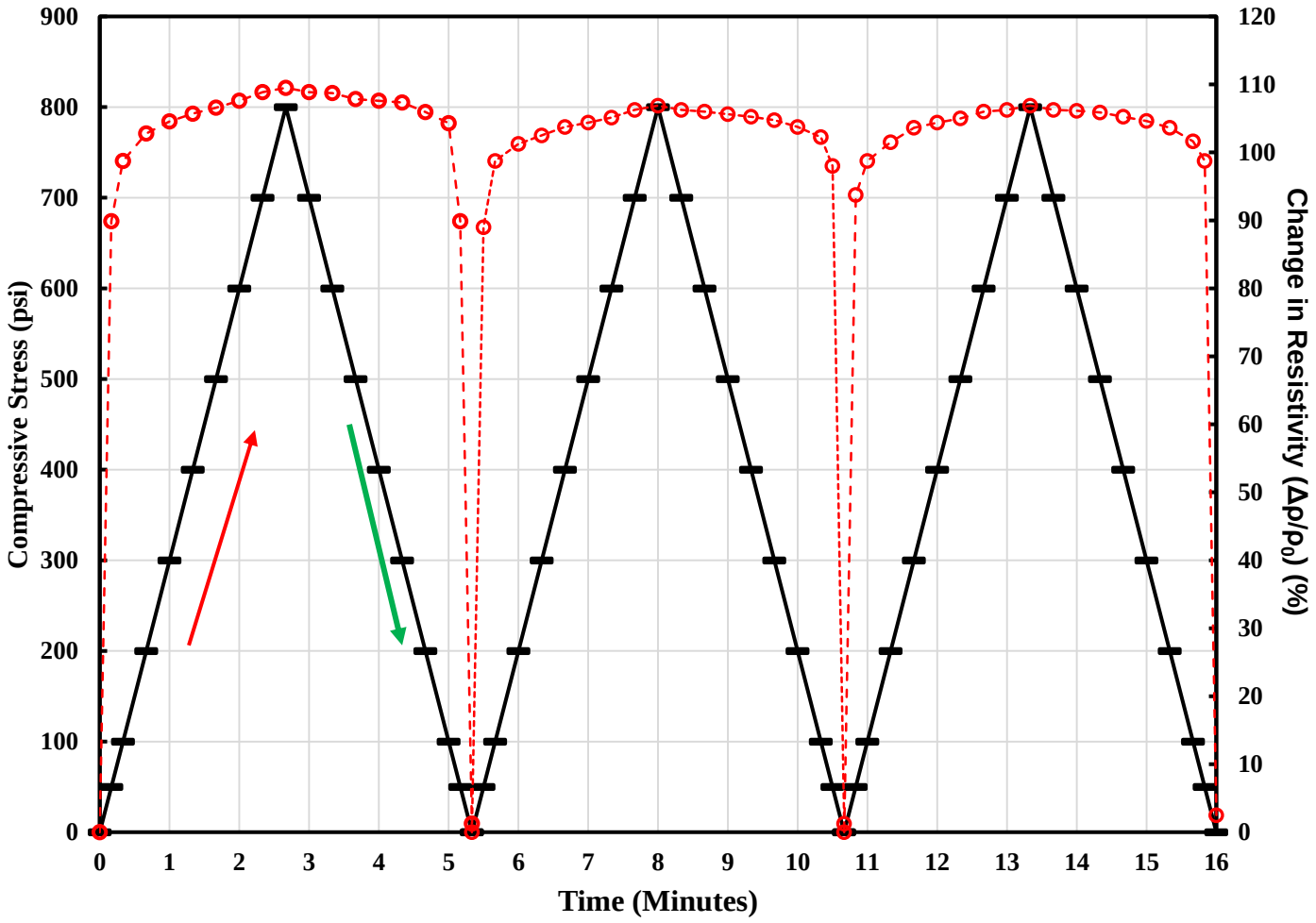
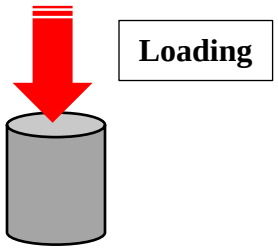
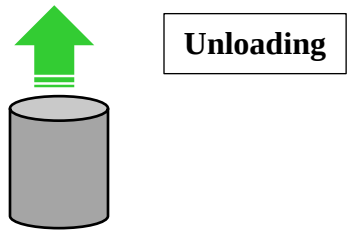


Figure 1. Cyclic loading and change in resistivity response using uniaxial compressive stress tester

Table 1. Cycles Change in Resistivity during Loading (left) and during unloading (right)



Cycle	1	2	3
Load	Δρ/ρ	Δρ/ρ	Δρ/ρ
psi	%	%	%
0	0	0	0
50	89.87	89.00	93.75
100	98.73	98.75	98.75
200	102.78	101.25	101.50
300	104.56	102.50	103.63
400	105.70	103.75	104.38
500	106.58	104.38	105.00
600	107.59	105.13	106.00
700	108.86	106.25	106.25
800	109.49	106.88	106.88



Cycle	1	2	3
Load	Δρ/ρ	Δρ/ρ	Δρ/ρ
psi	%	%	%
800	109.49	106.88	106.88
700	108.86	106.25	106.25
600	108.73	106.00	106.13
500	107.85	105.63	105.88
400	107.59	105.25	105.25
300	107.34	104.75	104.63
200	105.95	103.75	103.63
100	104.30	102.25	101.63
50	89.87	98.00	98.75
0	1.27	1.25	2.50

5. Conclusions

Based on the experimental study following conclusions are advanced:

5. The cement sample was sensitive to small loads 50 psi (0.69 MPa) increment and up to 800 psi (5.5 MPa) with high repeatability.
6. The electrical resistivity increased with the loading and decreased with the unloading. Another clear indication of the smart cement sensing capability of loading and unloading.
7. After the cement preloaded with 50 psi the uniaxial machine starts to load the sample with constant 5 psi/second rate and the change in resistivity becomes steady.

6. Acknowledgements

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7. References

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