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SAND2014-17860D

INTRODUCTION

- Thousands of abandoned wellbores that lie within the aerial extent of a CO_2 storage operation represent potential leakage pathways.
- In order to restore seal integrity and ensure containment of the stored CO_2, these wellbores need to be repaired.
- Dysfunctions of the wellbores is mainly caused by debonding at the casing/cement interface due to pressure fluctuations, cement shrinkage, and continuous growth of the calcium hydroxide (CH) crystals at the interface.

OBJECTIVE

Experimentally investigate the use of epoxy nanocomposites as potential seal repair materials that have excellent bond characteristics with both steel and cement when cured in the subsurface environment.

METHODS

- Fourteen polymer cement nanocomposites repair materials in addition to the reference cement material were prepared using two types of epoxy and four different nano-particles.

Table 1: Repair materials used in this study.

Mixture Abbreviation	Base Material	Nano-particles	Content%
Reference	Microfine cement	None	----
PCNC1	Polysulfide Siloxane epoxy	None	----
PCNC2	Polysulfide Siloxane epoxy	MWCNTs	0.5%
PCNC3	Polysulfide Siloxane epoxy	MWCNTs	1.0%
PCNC4	Polysulfide Siloxane epoxy	MWCNTs	1.5%
PCNC5	Polysulfide Siloxane epoxy	Nanoclay	4.0%
PCNC6	Polysulfide Siloxane epoxy	Nanosilica	1.0%
PCNC7	Polysulfide Siloxane epoxy	Nanoalumina	2.0%
PCNC8	Novolac epoxy	None	----
PCNC9	Novolac epoxy	MWCNTs	0.5%
PCNC10	Novolac epoxy	MWCNTs	1.0%
PCNC11	Novolac epoxy	MWCNTs	1.5%
PCNC12	Novolac epoxy	Nanoclay	4.0%
PCNC13	Novolac epoxy	Nanosilica	1.0%
PCNC14	Novolac epoxy	Nanoalumina	2.0%

METHODS

- **Flowability test**

In order to investigate the effect of nano-particles on the workability of the repair material, flowability tests were conducted according to ASTM C 1437- 07

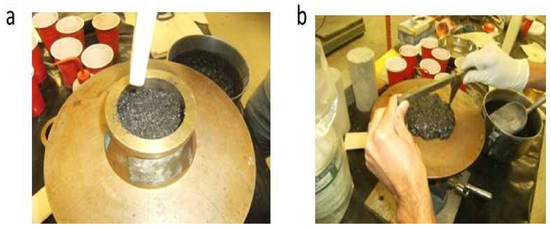

Figure 1: (a) Filling the flowability cone (b) taking readings using test caliber.

- **Slant shear test**

Slant shear tests were conducted to investigate the bond strength and stiffness between the fifteen repair materials and the steel surface.

- Steel surface was sandblasted to 4 mil clean surface roughness profile.
- Test was conducted according to ASTM C882-05.

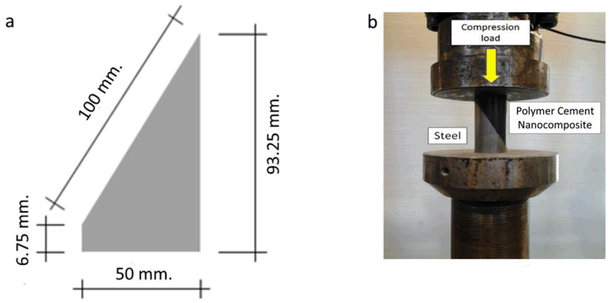

Figure 2: (a) Steel part dimensions (b) Slant shear test setup.

RESULTS

- **Flowabilty**

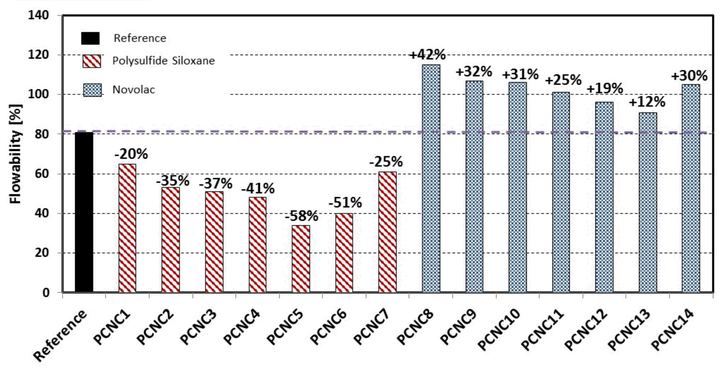

Figure 3: Flowability results for the 15 repair materials

RESULTS

- **Bond strength**

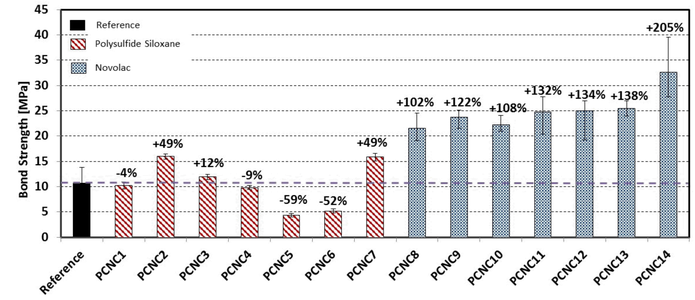

Figure 4: Bond strength results for the 15 repair materials

- **Stiffness**

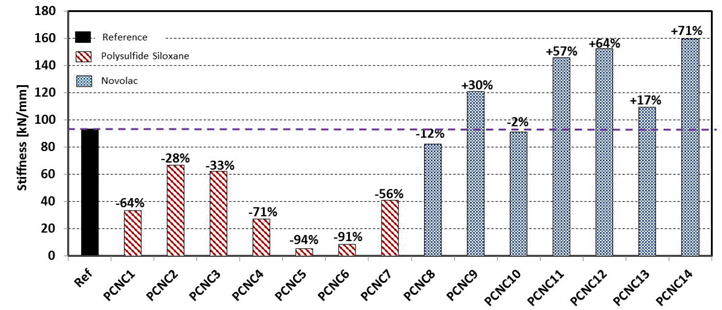

Figure 5: Stiffness results for the 15 repair materials

CONCLUSIONS

- The bond strength of all Novolac cement nanocomposites is higher than the bond strength of all Polysulfide Siloxane cement nanocomposites.
- All the nano-particles incorporated in the Novolac epoxy increased the bond strength of the polymer cement nanocomposites with the steel surface. However, the best results were achieved by using nanosilica and nanoalumina.
- Siloxane epoxy with nanoalumina and 0.5% MWCNTs significantly increased the bond strength of the polymer cement nanocomposites with the steel surface.
- Stiffness results show that any improvement of bond strength was accompanied with increase in the stiffness of the repair material which would decrease the true shear stress at the interface.

ACKNOWLEDGMENTS

This material is based upon work supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) under Grant Number DEFE0009562. This project is managed and administered by the DOE/NETL Storage Division and funded by DOE/NETL and cost-sharing partners. This paper was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

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