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Comprehensive review of chemical and mechanical degradation of well cement in Co_2 environment for Ccs operations

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Statement of the Problem: Carbon capture and storage operations reduce emission of carbon dioxide into the atmosphere which has a large impact on the environment. Long-term storage of carbon dioxide in a reservoir depends on the degradation of Portland cement used to cast these wells due to carbon dioxide. The objective of this research is to provide a comprehensive review of past investigations to help understand the cement's degradation, the provided solutions to this problem and discuss a potential alternative.

Methodology: Tables were made with information about the types of cement, the curing conditions and the exposure conditions (experimental conditions) used in different studies and their conclusions. Tables comprised of experimental studies conducted on neat Portland cement and cement mix (Portland cement + additives) were included. Field studies were also discussed. Possible migration paths of CO_2 and exposure conditions that are likely to happen inside the reservoir were discussed. Quantitative data was extracted from these investigations to understand the structural changes after the exposure. Histograms were made from the data acquired to determine the most used type of cement, exposure condition and additive. The data were constructed to explain different curing and exposure conditions.

Findings: Data analysis shows that wide ranges of curing and exposure conditions made the comparison of structural changes impossible between the studies. However, the increase or decrease in porosity, strength, permeability and density of cement cores after CO_2 exposure, and alteration depths were compared. Mostly, researchers used class H and class G well cement with CO_2 saturated brine/water at static conditions. Flyash is found to be best known pozzolan and can be reliably mixed with cement to provide long term integrity in CO_2 storage operations. However, studies suggest that higher amounts of this additive have a negative impact on the cement mix for this environment. Flyash-based geopolymer cement was suggested to be used in CO_2 storage operations due to its environmentally friendly nature and higher durability in CO_2 environment than Portland cement.

Novel Information: The research provided a critical review about the past investigations, which became helpful in understanding the degradation process of Portland cement in a CO_2 environment and the behavior of additives. A new flyash-based geopolymer cement was proposed and discussed.