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Investigations on cement compressive strength determination using ultrasonic, mechanical and visual aids

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Abstract

Oilwell cement is considered a very important well integrity barrier, designed to support the casing and isolate various formations during the life of the well. Mechanical properties of cement such as unconfined compressive strength (UCS), Young's modulus and Poisson's ratio are critical input data in well integrity simulations and analysis.

Understanding wellbore integrity requires, first of all, to comprehend the cement behavior under exposure to complex downhole loads. However, full scale testing may not always yield reliable results and therefore, laboratory small scale samples are commonly used. Mature fields have used cements tested according to older standards, and the assessment of their integrity also becomes difficult when old data has to be translated into parameters needed for well integrity assessments.

Literature on wellbore cement shows that it is a common practice to use different shapes for cement samples, deviating from specifications of the American Petroleum Institute (API). API states that the UCS should be measured on 2 inch cubes, but some other researchers have reported the use of cylinders with different diameter-to-length ratios. In some cases, e.g. when confining pressure is considered, cylindrical samples are the preferred option, especially for high-pressure, high-temperature (HPHT) cement testing.

This paper shows the outcomes of an extensive literature research of UCS determination methods, as well as data obtained out of more than 6 months of intensive experimental work using various investigation tools such as ultrasonic pulse velocity, unconfined compressive strength testing, and visual documentations. The results show that during the early stage of the cement setting, the UCS for cylindrical samples is similar to the cube's UCS. Moreover, a novel, more precise correlation between UCS and UPV was generated, which also shows the sensitivity to cement composition.