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A New Method for Constructing Fractured Synthetic Cores with Defined Roughness Pattern Suitable for Testing in Reservoir Conditions

Lotfi M.[1], Tokhmechi B.[2*]

1- Ph.D of Mining Engineering, Faculty of Mining, Petroleum and Geophysics Engineering, Shahrood University of Technology, Shahrood, Iran
m.lotfi139@yahoo.com

2- Associate Professor, Faculty of Mining, Petroleum and Geophysics Engineering, Shahrood University of Technology, Shahrood, Iran
tokhmechi@ut.ac.ir

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Abstract: This article focuses on the process of manufacturing of 1.5-inche diameter synthetic cores for fracture studies. The results of this study are suitable for rock mechanical studies as well as reservoir engineering and geomechanical experiments. These cores were manufactured by a fracture pattern, and the main focus on them was the possibility of performing the surface roughness characteristic in a controlled manner. In these cores, unlike the same examples, the roughness pattern was created non-randomly. For this purpose, the Triangular form (Sawtooth) was used as a supposed synthetic structure in the design of rough patterns. To achieve this goal, Reactive Powder Concrete (RPC) has been selected as the main material after studying on a variety of materials to make synthetic samples. To perform concrete, and considering RPC, several mixing designs were tested. The accepted mixing designs are compared together and presented as the results of the research. The structure and texture of provided core are similar to natural ones, in comparison with the other common samples were made of fiberglass. High Uniaxial Compressive Strength (UCS), and ability to implementation a variety of specific and complex geometric patterns such as Triangular Pattern (Sawtooth form), are two complementary advantages of the proposed samples. It should be mentioned that making the patterns on natural rocks is usually impossible, and also expensive, while cheap with high UCS in the case of synthetic samples. Also these cores haven't any micro-fractures. The capability of perfectly suiting the particles helps to implement variety patterns.

Keywords: Computer Numerical Control (CNC), Reactive Powder Concrete (RPC), Triangular form, Synthetic rock, Waterjet cutting.

INTRODUCTION

Sampling process and experimental studies in the field of reservoir engineering and geomechanical investigations require sufficient access to the suitable samples as well as many engineering projects. Due to some limitations on destructive tests such as economic parameter which leads to the reduction of cores; it would be difficult to obtain suitable results from insufficient tests. In fact, low number of expensive reservoir's plugs can be increased uncertainty and this problem must be controlled [1-4]. On the other hand, the cores used in the Routine Core Analysis (RCAL) and Special Core Analysis (SCAL) are cylindrical plugs with radius 1.5" and different lengths. According to the special size of these plugs used to high pressure / high temperature (HPHT) tests, implementation of specific forms such as saw-tooth pattern with non-random structure is difficult. This problem can be solved applying suitable material and appropriate aggregation.

METHODS

According to the Figure 1, saw-tooth pattern has been considered as a new idea for manufacturing non-random roughness. This scenario using two technologies waterjet and laser engraving was applied to natural plug and synthetic plug made of Reactive Powder Concrete (RPC). Finally, using waterjet causes change of cross-section and this is not acceptable. Therefore, molding was selected using laser engraving.

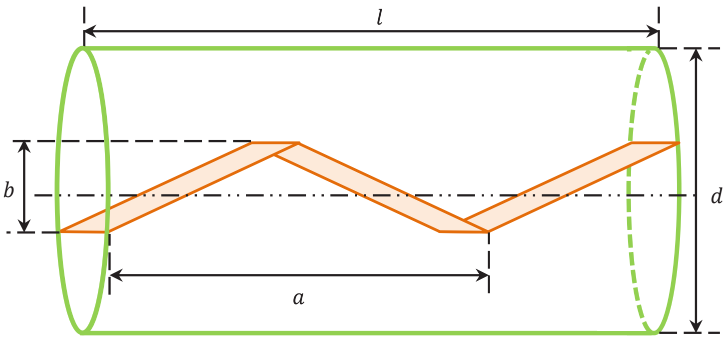

Figure 1. Design parameters in sample construction

In the core manufacturing process, three different mixing programs were designed according to Tables 1, 2 and 3. In mix design 1, the dry components of the mixture were first mixed for 6 minutes. Then 70% of the superplastisizer and water was added to the mix. After 5 minutes, the residue was added to the mixture and combined for another 5 minutes. This process was similarly repeated for mix design 2 and the molding process was performed. In mix design 3, the dry components were mixed for 10 min and the rest of the process and molded to standard dimensions.

Table 1. Mixing Design 1 (kg/m^3)

Material	Mass (kg)
Cement	800
Sand (150 – 600 μm)	1010
Microsilica	200
Superplastisizer	12
Water	190

Table 2. Mixing Design 2 (kg/m^3)

Material	Mass (kg)
Cement	794
Sand (150 – 600 μm)	1241.78
Microsilica	198.5
Superplastisizer	11.91
Water	198.5

Table 3. Mixing Design 3 (kg/m^3)

Material	Mass (kg)
Cement	794
Sand (0 – 0.3 mm)	175.6
Sand (0.3 – 0.6 mm)	112.9
Sand (0.6 – 1.2 mm)	238.3
Sand (1.2 – 2.0 mm)	163.1
Sand (2.0 – 3.2 mm)	238.3
Sand (3.2 – 4.75 mm)	313.58
Microsilica	198.5
Superplastisizer	11.91
Water	198.5

FINDINGS AND ARGUMENT

In order to control the quality of the manufactured cores, they were subjected to ultrasonic wave velocity testing and Uniaxial Compressive Strength (UCS). Examination of the obtained results showed that the acquired resistance in mixing design 2 and 3 is quite appropriate.

The result showed that, as with other laboratory studies, the proposed approach is accompanied by strengths and weaknesses. Overall, the proposed approach is considered economically and temporally cost-effective. Also, by making the sample in this way, it is possible to simulate the reservoirs at a lower cost by performing numerous repeated destructive tests.

CONCLUSIONS

The results obtained from the manufacturing cores with different mixing designs shows that the capability to build and withstand pressure, synthetic cores are economically feasible and comparable to the methods applied to natural samples for complex patterns. Like the roughness designed, they do not conform to the saw-tooth pattern. This requires an appropriate plan for mixing the materials, and the results indicated that this section is successful.

Examination of the different mixing designs shows that all three designs have applicable strength; but two designs 2 and 3, with compressive strengths > 9890 psi and 11380 psi are perfect, respectively.

Implementation of special pattern on natural cores using advanced technologies is extremely expensive. This coupled with technical limitation such as cross-section reduction, make it difficult to manufacture cores; but the approach proposed can help us to have many economics plugs with no technical problem such as controlled roughness.

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