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# Numerical analysis of break-off test method on concrete

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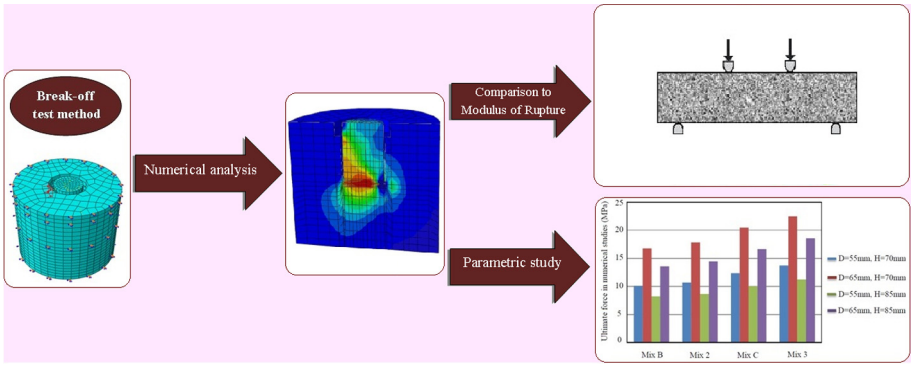
## HIGHLIGHTS

- The break-off (B.O.) test is investigated by finite element software ABAQUS.
- Parametric study is performed to examine the behavior of B.O. test method.
- The FE modeling of B.O. test method is compared with modulus of rupture.
- There is a satisfactory agreement between models and experiments.

## GRAPHICAL ABSTRACT

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## ABSTRACT

The present study is numerically focused on the break-off (B.O.) test method as a partially destructive method for assessing the in-situ strength of concrete. In this test method, a mechanical manometer is applied to a cylindrical concrete specimen in parallel to the finished surface, and it causes fracture at the base of the B.O. test specimen. Concerning the test procedure, the B.O. test method seems to be similar to the conventional modulus of rupture test. The present study intends to analyze fracture zone stress distribution by means of finite element (FE) method using ABAQUS software. The analysis demonstrates that the approximate location of fracture zone is predictable with contours of damage that have been indicated by concrete damaged plasticity which is one of the material models available for concrete in ABAQUS. Furthermore, parametric studies have been carried out for different testing dimensions. It is noteworthy that in B.O. method, surrounding area of the base of the core specimen can influence on the results and it causes an increase in ultimate force.



## 1. Introduction

The break-off (B.O.) test method known as a partially destructive test for measuring the in-situ concrete strength was first proposed by Johansen [1] and it was subsequently surveyed by other researchers [2–6]. The B.O. test consists of measuring the force required to break a cylindrical concrete specimen in parallel to finished surface. In this case, specimen operates similar to a cantilever beam with circular cross section. The test specimen is prepared in the concrete with predetermined plan by using a disposable tubular plastic sleeve which is cast into the fresh concrete and then removed at the planned time of testing (shown in Fig. 1), or with unpredicted plan by drilling the hardened concrete at the time of the B.O. test shown in Fig. 2. Currently available core dimensions are shown in Fig. 3, using 70 mm height (H) and 55 mm diameter (D), where H/D is approximately equal to 1.3.

A number of researchers have investigated the B.O. test in experimental studies (Johansen [1]; Byfors [3]; Nishikawa [4]; Carlsson et al. [5]; Naik et al. [6]). Among the researchers, Naik et al. [6] performed the B.O. test method using inserted a plastic sleeve into the fresh concrete and drilled the hardened concrete. It has been

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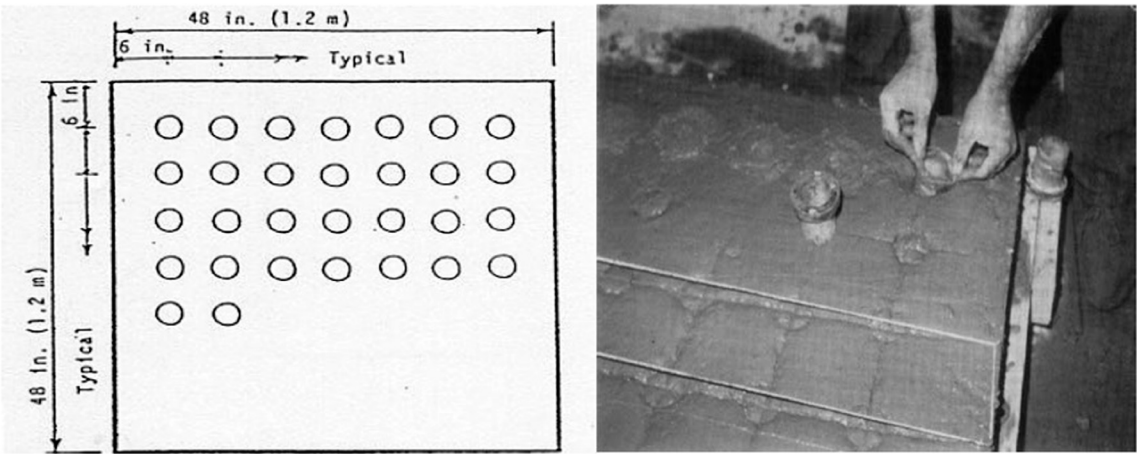


**Fig. 1.** Inserting sleeve by rocking action and position of sleeve [2].

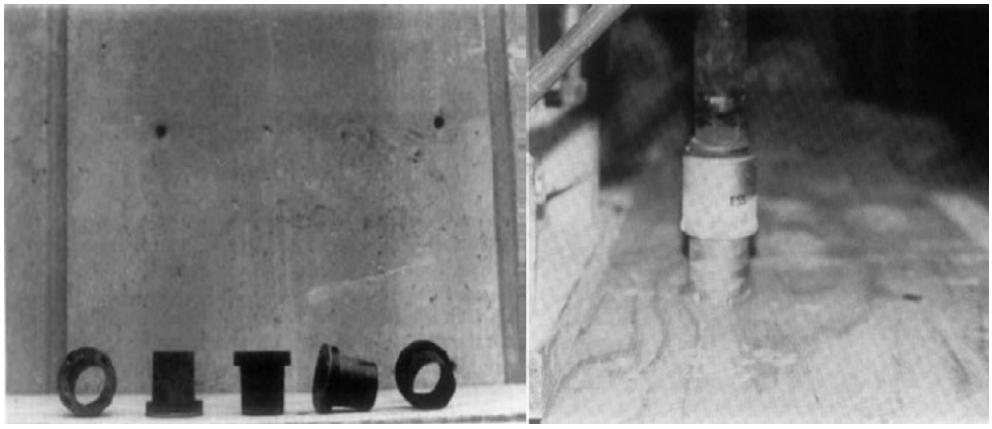

**Fig. 2.** Tubular plastic sleeves and Core drill bit for the B.O. test [2].

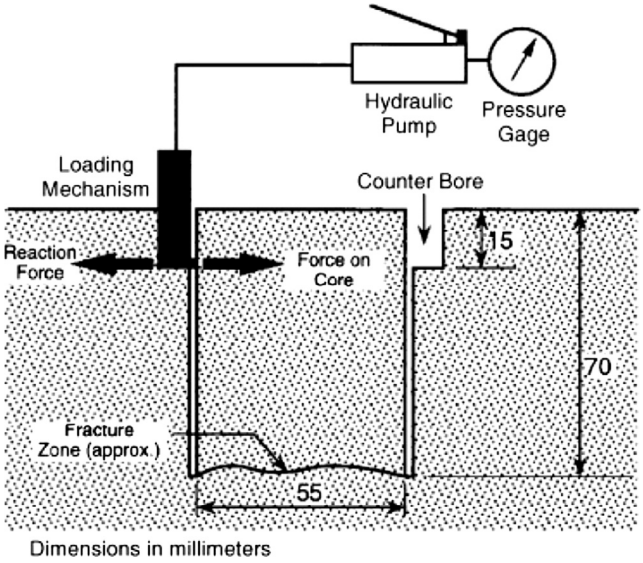


**Fig. 3.** Fracture zone of B.O. test [10].

concluded that the results for drilled hardened concrete were, on average, about 9 percent higher than the case of an inserted plastic sleeve into the fresh concrete. According to Naik et al. [6], the reason for this difference could be due to accumulation of bleeding water under the bottom edge of the sleeve which tends to create a weaker zone on concrete.

The B.O. method was standardized in England [7], Norway [8], Swedish Standard [9] and ASTM [10]. As mentioned in ASTM C1150 in 2002 [11], due to limited usage of the B.O. method, it is difficult to recommend meaningful revisions to this test method, but experimental studies by Naik [2] demonstrated that the B.O. test is capable of predicting the in-situ strength of concrete and also based on ASTM C78 [12], there is a linear relationship between the B.O. flexural strength and modulus of rupture. Furthermore, recent study by Lin et al. [13] showed that this method can evaluate the bond quality at the interface between steel bar and concrete. Their results indicated that there is a good coloration between the B.O. moment and the adhesive strength at the steel bar/concrete interface. Hence, it seems that B.O. test method could be capable to assess in-situ concrete strength and bond quality. For further investigation, this paper aims to present the results of finite element (FE) analysis of B.O. test method studied by concrete damage plasticity model available in ABAQUS. Also parametric studies on B.O. test method are carried out on this study based on nonlinear behavior of concrete materials.

## 2. Developing the material model using concrete damaged plasticity

Three crack models are available in ABAQUS software for simulating concrete elements including concrete smeared cracking,