

STUDY ON METHODS OF TESTING TENSILE STRENGTH OF CONCRETE

Z. R. Dole, K. Baskaran *

Department of Civil Engineering, University of Moratuwa, Moratuwa

The tensile strength of concrete is a critical parameter in structural engineering, influencing crack resistance, durability, and overall performance. The brittle nature of concrete causes low tensile strength; hence, indirect methods for testing the tensile strength of concrete, such as the Direct Tension Test, Brazilian Splitting Test (BST), Flexural test, and other novel methods, present limitations related to stress distribution and real-world applicability. This research attempts to further investigate the applicability of a novel method by making certain improvements to past studies of a similar setup for determining the tensile strength of concrete using direct axial force and compares its performance with BST and Cube Compression Test (CCT) across different concrete ages and grades. The experimental procedure involved testing concrete grades C25 and C35 at 3, 7, 14, 28, and 56 days. Specimens were cast in separate batches and subjected to three testing methods: the novel method of Modified Direct Tension Test (MDTT), the Brazilian Splitting Test (BST), and a Cube Compression Test (CCT). The unstandardized MDTT specimen details, dimensions, and method of testing have been described, enabling further research on the proposed method. The novel method aims to provide a more representative measure of direct tensile behaviour while addressing limitations observed in BST. Tensile strength values obtained from both methods are analysed and compared, alongside cube compression test results, to establish correlations between tensile and compressive strengths. Preliminary findings suggest that the newly introduced method may offer improved reliability in capturing tensile failure mechanisms. The results also suggest that the tensile strength vs compressive strength gain patterns vary with time for both tensile strength testing methods. It was also found out that the novel method provides consistent results, and the specimen modification made to direct the tensile crack at the centre is successful in more than 80% of the cases. This research further attempts to discuss the practical applications for the MDTT in cases such as Precast concrete evaluation, bridge and tunnel structural performance, and FRC & UHPC strength and quality assessments. Modifications to be made to the testing apparatus to make it a more reliable method of testing the tensile strength of concrete are also discussed. Further recommendations have been provided to increase the number of test cases and investigate the influence of strain rate on the MDTT setup, which would contribute to the development of concrete testing methodologies as an alternative approach that would enhance accuracy and practical implementation in structural assessments.

Keywords: Modified direct tension test, Brazilian splitting test, Concrete tensile strength, Tensile strength development pattern

* Correspondence: baskaran@uom.lk

Study on Methods of Testing Tensile Strength of Concrete

The existing main methods of testing the tensile strength of concrete

Direct Tension Test

- Localised failure due to Poisson's effects at grips
- Challenges faced due to mechanical and chemical gripping

Brazilian Splitting Test

- Causes failure at a particular plane only
- Un-uniform stress distribution
- Approximation errors due to indirect measurements

Flexural Strength Test

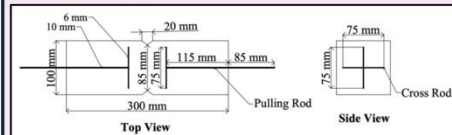
- Non-uniform stress distribution
- Causing failure at a particular line on the tension plate

Proposal for a new setup for testing the tensile strength of concrete

Modified Direct Tension Test -MDTT-

Setup is influenced on studies conducted by:

- Alhussainy et al. (2019)
- Khan (2011)



Experimental Procedure

MDTT

Brazilian Splitting Test -BST-

Comparison of Tensile Strength

Cube Compression Test -CCT-

Comparison of Compressive Strength

Concrete Grades

Grade 25

Grade 35

Age of Concrete

3 days

7 days

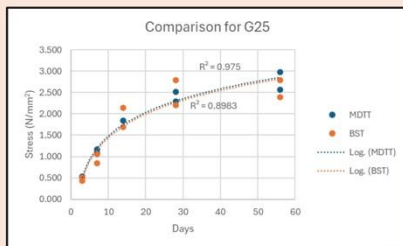
14 days

28 days

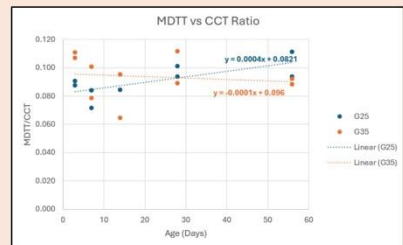
56 days

Experimental Results

Correlation between MDDT and BST Tensile Strength Testing Methods



Comparison of Tensile Strength Results with Compressive Strength



Investigation of Failure Modes in MDDT

Normal Results
(Cracks at Notch)
> 80%

Outlier Results
(Cracks away from
Notch)
< 20%

Possible Applications for the Proposed MDDT Method

Precast Concrete Quality Assessment

FRC & UHPC Strength Assessment

Bridge & Tunnels Performance Monitoring