Case Studies in Construction Materials 3 (2015) 83–91

Contents lists available at ScienceDirect

Case Studies in Construction Materials

journal homepage: www.elsevier.com/locate/cscm

Case study

Effect of construction joints on the splitting tensile strength of concrete

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ARTICLE INFO

Article history:
Received 16 February 2015
Received in revised form 25 June 2015
Accepted 14 July 2015
Available online 23 July 2015

Keywords:
Construction joints
Splitting tensile strength
Compressive strength
Concrete

ABSTRACT

The purpose of this study is to experimentally correlate the compressive strength (f'_c) of concrete to the splitting tensile strength (T) for plain concrete in the existence of a construction joint, and formulate an empirical equation relating T to f'_c. Both the American Concrete Institute code (ACI 318-08 (ACI Committee 318, 2008)) and the American Society for Testing and Materials (ASTM (ASTM Standard C496, 2002; ASTM Standard C192/C192M, 2002; ASTM Standard C39/C39M, 2005; ASTM Standard C617, 2002)) provide the testing methods and standards, as well as the applicable theoretical and experimental formulas for the correlation between T to f'_c for concrete specimens, which are monolithic, indicating that the specimens lack any construction joints. Providing a useful reduction factor in the splitting tensile strength of concrete due the existence of a construction joint is essential. It is a well known fact that construction joints are used in every concrete structure, which indicates that engineers would definitely benefit from an equation that could relate the splitting tensile strength of concrete in function of its compressive strength.

The results suggest that the reduction in the splitting tensile strength in the presence of a construction joint is not as much as most engineers tend to believe. Due to that belief, most engineers tend to overdesign for steel reinforcement at those joints to compensate for this reduction. The objective of the study is to better the understanding of the effects of a construction joint on the splitting tensile strength. Thus provide an empirical equation to assist engineers in their design calculations, therefore reducing the amount of steel reinforcement at the construction joints. Thus also leading to cost saving on projects.

1. Introduction

There are two traditional tests methods to measure the tensile strength of concrete, the splitting tensile strength of concrete cylinders and the flexural strength of beams. The splitting known as the Brazilian or the indirect tension test is a popular method of characterizing the tensile strength of concrete. This is mainly due to the fact that the cylinder is a commonly and routinely fabricated specimen. Moreover, the testing procedure is quite simple, and has been specified in several recommendations and standards (e.g., ASTM C496 (ASTM Standard C496, 2002) and RILEM CPC6 (RILEM, 1994)).

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http://dx.doi.org/10.1016/j.cscm.2015.07.001

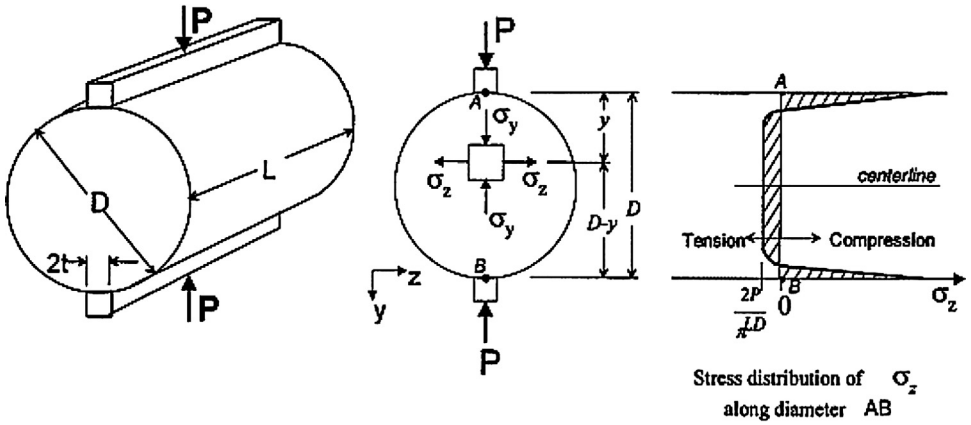

Fig. 1. Concrete cylinder splitting tensile strength test (ASTM Standard C496, 2002).

The splitting tensile strength test (Fig. 1) consists of applying a diametric compressive load along the entire length until failure occurs. This loading induces tensile stresses on the plane containing the applied load and compressive stresses in the area around the applied load. To avoid local compressive strength, plywood strips are used between the specimen and the plate. Tensile failure occurs instead of compressive failure since the areas under the load application are in a triaxial compression state, therefore allowing them to resist higher compressive stresses than what would have been indicated by a uniaxial compressive strength (ASTM Standard C496, 2002). Both tensile strength and compressive strength of concrete are important factors that affect the cylinder's ability to resist failure.

The ASTM designation C496 describes the test method for splitting tensile strength of concrete, and details the procedure for obtaining the results by breaking cylinders measuring 300 mm by 150 mm. These mentioned standards require the cylinder to be monolithic. It should be noted that the strength obtained from the splitting test depends on the diameter of the specimen (Bazant et al., 1991; Tang et al., 1992). However, the use of a standard diameter, such as 150 mm, circumvents this problem, as in compression tests. The resulting strength is not necessarily a material property but nevertheless, a reliable value that can be used for comparison and design.

The ACI code (ACI Committee 318, 2008) under section (8.6.1) provides the relationship between the splitting tensile strength of concrete (T) and the compressive strength of concrete (f'_c) with equation as follows:

$$T = \frac{\sqrt{f'_c}}{1.8} \tag{1}$$

where

T = splitting tensile strength in MPa.

f'_c = compressive strength of concrete in MPa.

It is often not possible to complete a job at one go, for example because of the size or complexity of the structure or because of limited materials or manpower. When work resumes it will be necessary to place fresh concrete on or against the previous pour that will have already hardened. The resultant contact surface is known as a construction joint or day work

Fig. 2. Aluminum plate inserted at mold centerline to create CJ.