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Fibre-reinforced cementitious composites (FRCCs) — Direct tensile test method —

Part 1: Strain hardening FRCCs

Composites à base de ciment renforcés par des fibres — Méthode d'essai de traction directe —

Partie 1: Composites à base de ciment renforcés de fibres à durcissement sous contrainte

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Foreword

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Introduction

Strain hardening fibre-reinforced cementitious composites (FRCCs) have been demonstrated to have superior tensile strength, ductility, energy absorption capacity and fracture toughness compared to normal concrete. Strain hardening FRCCs include high performance fibre-reinforced cementitious composites (HPFRCCs)[1,2], engineered cementitious composites (ECCs)[3,4] and ultra-high-performance fibre-reinforced concretes (UHPFRCs)[5-9]. The superior mechanical and material resistance of strain hardening FRCCs compared to normal concrete and strain softening FRCCs have motivated structural engineers to apply them to civil infrastructure and buildings[6,7,9,10].

Strain hardening is defined as the material behaviour observed over a specified tensile strain range following the initiation of cracking, in which the initial peak stress decreases or nonlinear behaviour begins, and the tensile stress subsequently increases to a value exceeding the initial cracking strength. Within the defined strain range, strain hardening is characterized by a monotonic increase in tensile stress with increasing strain. Local stress fluctuations or oscillations are not considered to satisfy the definition of strain hardening unless they are explicitly permitted and technically justified. This definition is intended to ensure an objective interpretation of test results and to enable clear identification of the peak tensile stress associated with strain-hardening behaviour.

The use of strain hardening FRCCs is highly expected to enhance the mechanical resistance of infrastructure and buildings especially under extreme loads including earthquakes, impacts and blasts. Moreover, the smaller width of multiple micro cracks of strain hardening FRCCs compared to that of normal concrete and strain softening FRCCs is expected to enhance the durability of structural members and eventually to lengthen the service life of infrastructure and buildings.

However, the use of strain hardening FRCCs is still very limited even though there have been increasing applications of those strain hardening FRCCs. The reasons for limited applications of strain hardening FRCCs are the absence of International Standard test methods and design codes in addition to the high cost of strain hardening FRCCs versus normal concrete[10]. Current ISO standards such as ISO 19044, ISO 21022 and ISO 21914 are applicable for evaluating the uniaxial and biaxial flexural behaviour of FRCCs, but not the uniaxial tensile response of strain hardening FRCCs.

Although many research papers have reported direct tensile stress versus strain response of various HPFRCCs, ECCs and UHPFRCs, the responses were obtained from the specimens with different geometry and different test setups[4,7]. Consequently, it is difficult to quantitatively compare the tensile resistance of various strain hardening FRCCs for the purpose of design consideration without standard test methods.

The test method defined in this document specifies requirements for specimen geometry and test setups of strain hardening FRCCs under direct tension. The reported test parameters of various strain hardening FRCCs using this document are expected to be classified into several categories of strain hardening FRCCs for structural engineers, contractors, etc. The tensile parameters are determined from the measured tensile stress versus strain curve obtained by testing a specimen under uniaxial tension without any parasitic bending moment during the test.

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Fibre-reinforced cementitious composites (FRCCs) — Direct tensile test method —

Part 1: Strain hardening FRCCs

1 Scope

This document specifies a test method for evaluating direct tensile resistance of strain hardening fibre-reinforced cementitious composites (FRCCs) using tensile parameters.

This test method provides tensile stress versus strain curve, first cracking strength, post cracking strength, strain capacity (strain at post cracking point), and the number of cracks within gauge length. This test method is primarily intended for use with FRCCs that exhibit strain hardening behaviour. This test method is not intended for materials that exhibit strain-softening behaviour.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
tensile stress versus strain curve
plot of *tensile stress* (3.2) versus *tensile strain* (3.3) obtained from the test of a uniaxial tensile specimen

3.2
tensile stress
σ
tensile load per unit area of cross section of tensile specimen

3.3
tensile strain
ε
tensile elongation per unit length of tensile specimen

3.4
first cracking strength
σ_{cc}
tensile stress (3.2) at first cracking point

Note 1 to entry: This is expressed in newtons per square millimetres (N/mm^2).

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