Engineering Structures 33 (2011) 107–117

Contents lists available at ScienceDirect

Engineering Structures

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

The composite effect of steel fibres and stirrups on the shear behaviour of beams using self-consolidating concrete

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ARTICLE INFO

Article history:
Received 22 January 2010
Received in revised form
20 September 2010
Accepted 26 September 2010
Available online 4 November 2010

Keywords:
Steel fibre self-consolidating concrete
Beam
Shear strength
Failure mode
Workability
Composite effect

ABSTRACT

Based on the investigation of the influence of steel fibre on the workability of fresh self-consolidating concrete (SCC), this paper presents the experimental results carried out on a series of simply supported SCC rectangular beams, using steel fiber reinforcement with and without stirrups, and subjected to four-point symmetrically placed vertical loads. The major test variables are the steel fibre content and stirrup ratios. The current study on the shear strength of conventional reinforced concrete (RC) beams verifies the shear strength of SCC beams with steel fibres. The investigation indicates that the shear strength significantly increases by increasing the fibre content; the addition of steel fibres in an adequate percentage can change the failure mode from a brittle shear collapse into a ductile flexural mechanism. The stirrups can be partially replaced by steel fibres. The combination of steel fibres and stirrups demonstrates a positive composite effect on the mechanical behaviour. The shear strength recorded experimentally is compared with the value obtained from the proposed formula, and the correlation is satisfactory.

1. Introduction

A diagonal crack in a reinforced concrete (RC) beam occurs when the principal tensile stress of concrete within the shear span exceeds the tensile strength of concrete [1]. The addition of steel fibres to an RC beam can increase its shear strength, and if sufficient steel fibres are added a brittle shear failure can be suppressed in favour of more ductile behaviour, which also tends to reduce the crack width and spacing [2–5].

The published research works confirm the effectiveness of steel fibres and shear reinforcement, and empirical equations for estimating the shear strength of steel fibre reinforced conventional RC beams have been suggested [2–6]. Steel fibres are used to boost the shear capacity of concrete or to partially replace the vertical stirrups in RC structural members. This relieves reinforcement congestion at critical sections such as beam–column junctions and tubing segments [3,7]. The steel fibres can improve the post-crack performance and reduce the brittle behaviour of normal concrete and high-strength concrete (HSC). As a result, the structural performance of HSC can be maximized.

The interface bond between aggregates and paste for SCC is better than that of normal concrete, and there are fewer internal defects in SCC than in normal concrete [8,9]. The difference between steel fibre reinforced self-consolidating concrete (SFSCC) and traditional fibre reinforced concrete (FRC) is that the fibre content of FRC is mainly determined by the post-cracking behaviour, and the fibre content of SFSCC is mainly restricted by the workability of fresh SCC. Using SFSCC can significantly reduce the construction period and costs, and the binding of reinforcement, and it can be easily placed in thin or irregularly shaped sections where the arrangement of stirrups may be difficult. SFSCC combines the advantages of both SCC and FRC. However, research work on the study of SFSCC beams, especially dealing with the shear behaviour of SFSCC, is still limited.

The objectives of studying FRSCC under loading include a number of issues, such as the flexural behaviour of FRSCC beams and FRSCC elements subjected to shear, fiber orientation and distribution on bending and shear properties, reinforced SCC members with fiber addition subjected to multiple stress states (bending and shear), and the failure pattern under cyclic loading. However, it is not intended in this study to present complete knowledge of every aspect of the FRSCC. This paper presents the results of an experimental research program on the shear behaviour of steel fibre reinforced SCC beams. The major aims of this program are to evaluate the possibility of replacing stirrups by steel fibres, to study

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doi:10.1016/j.engstruct.2010.09.023