Materials and Design 32 (2011) 4122–4151

Contents lists available at ScienceDirect

Materials and Design

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

Review

Recent trends in steel fibered high-strength concrete

Abid A. Shah [a,1], Y. Ribakov [b,*]

[a] Specialty Units for Safety and Preservation of Structures, College of Engineering, King Saud University, P.O. Box 800, Riyadh 11421, Saudi Arabia
[b] Department of Civil Engineering, Ariel University Center of Samaria, Ariel 40700, Israel

ARTICLE INFO

Article history:
Received 21 February 2011
Accepted 11 March 2011
Available online 21 March 2011

Keywords:
A. Concrete
G. Destructive testing
G. Nondestructive testing

ABSTRACT

Steel fibered high-strength concrete (SFHSC) became in the recent decades a very popular material in structural engineering. High strength attracts designers and architects as it allows improving the durability as well as the esthetics of a construction. As a result of increased application of SFHSC, many experimental studies are conducted to investigate its properties and to develop new rules for proper design. One of the trends in SFHSC structures is to provide their ductile behavior that is desired for proper structural response to dynamic loadings. An additional goal is to limit development and propagation of macro-cracks in the body of SFHSC elements. SFHSC is tough and demonstrates high residual strengths after appearance of the first crack. Experimental studies were carried out to select effective fiber contents as well as suitable fiber types, to study most efficient combination of fiber and regular steel bar reinforcement. Proper selection of other materials like silica fume, fly ash and super plasticizer has also high importance because of the influence on the fresh and hardened concrete properties. Combination of normal-strength concrete with SFHSC composite two-layer beams leads to effective and low cost solutions that may be used in new structures as well as well as for retrofitting existing ones. Using modern nondestructive testing techniques like acoustic emission and nonlinear ultrasound allows verification of most design parameters and control of SFHSC properties during casting and after hardening. This paper presents recent experimental results, obtained in the field SFHSC and non-destructive testing. It reviews the experimental data and provisions of existing codes and standards. Possible ways for developing modern design techniques for SFHSC structures are emphasized.

1. Introduction

Concrete is a widely used material in structural engineering all over the world. Its history begins since cement was introduced. Unreinforced concrete was a brittle material, with a low tensile strength and a low strain capacity. A revolutionary improvement of concrete properties was using steel bar reinforcement allowing getting tensile forces. Reinforced concrete (RC) became an alternative to other materials that were used in bending elements. Scientists worked intensively to find appropriate ways for increasing compressive strength of concrete in order to decrease the dimensions of structural elements and their self weight leading to more economical design solutions. As a result of these research activities, using high-strength concrete elements became a common trend in modern construction.

Fibers were used to reinforce brittle materials before cement was known since Egyptian and Babylonian civilisations [1]. It is well known that the main role of fibers is to bridge the cracks that develop in concrete and increase the ductility of concrete elements. Fibers increase the strain at peak load, and provide additional energy absorption ability of RC elements and structures. It was recently reported that they also considerably improve static flexural strength of concrete as well as its impact strength, tensile strength, ductility and flexural toughness [2].

Fiber reinforcement is usually randomly distributed throughout the whole element, but it can be also used in a part of the element's section, for example in composite elements like two-layer beams [2,3] or in high-strength concrete columns, covered by fiber reinforced concrete [4]. Steel, textile, organic, glass and other kinds of fibers are widely used to improve performance of concrete for about 90 years [5].

For design purposes a very detailed knowledge about the tensile carrying behavior of fibered concrete is required. It is affected by various parameters like fibers' geometry and content, bond strength between fiber and binder matrix, strength of the matrix, shrinkage of the concrete orientation of fibers, etc. [6]. Effectiveness of fibers added to concrete can be investigated experimentally or numerically. The routine laboratory testing methods are impact test, compressive test, tensile and flexural tests, etc. [7].

* Corresponding author. Tel.: +972 3 90 66 327; fax: +972 3 90 66 351.
E-mail addresses: draashah@yahoo.com (A.A. Shah), ribakov@ariel.ac.il (Y. Ribakov).
1 Tel.: +966 1 467 06 31.

0261-3069/$ - see front matter
doi:10.1016/j.matdes.2011.03.030