Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 171 (2017) 121 – 130

Procedia Engineering

www.elsevier.com/locate/procedia

Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

On the confined high-strength concrete and need of future research

Antonius[a,]*, Iswandi Imran[b] and Prabowo Setiyawan[a]

[a]Department of Civil Engineering, Universitas Islam Sultan Agung, Semarang-Indonesia
[b]Structural Engineering Research Group, Department of Civil Engineering, Institut Teknologi Bandung, Bandung- Indonesia

Abstract

Investigation about requirements of confining reinforcement on the structure of high-strength concrete has been progressed significantly since the last three decades. Research carried out intensively on high-strength concrete, produces a material which has a relatively brittle nature. Various parameters of the confining reinforcement design have been varied to obtain the optimal results regarding the behavior of high-strength concrete, especially for columns comprehensively. This paper discussed about the development roadmap of confined high-strength concrete research, includes constitutive equations of confined high-strength concrete developed by researchers. In this paper modified of analytical model for confined normal to high-strength concrete is also proposed. Results of this further discussion were associated with the need of the development research of confining reinforcement on high-strength concrete material adapted to the material properties and zones in Indonesia.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: High-strength concrete; strength; constitutive equations; confinement model

1. Introduction

Infrastructure development requires excellent material quality and durable so many innovations to produce a material that has a high quality have been intensively conducted. High strength-concrete (f'_c≥50 MPa) has superior mechanical properties and durability compared with normal-strength concrete because of the hardness of the breakdown of a high and a lower porosity. However, high-strength concrete material is brittle, less ductile and more sensitive to aspects of the planning and execution of construction compared with materials made of normal strength

* Corresponding author. Tel.: +62-81228659970; fax: +62-24-6582455.
E-mail address: antonius@unissula.ac.id

Peer-review under responsibility of the organizing committee of SCESCM 2016.
doi:10.1016/j.proeng.2017.01.318

concrete. High-strength concrete material's brittleness is characterized by the occurrence of crack propagation occurring faster than the crack propagation on normal strength concrete. This in turn leads to a more rapid loss of effectiveness of the concrete cover on the column, or the occurrence of which is premature shear failure on reinforced concrete beams. Brittle effect of high-strength concrete is generally solved by installing a confining reinforcement so that high-strength concrete is more ductile. Some researchers have been investigating the behavior of high-strength concrete columns by reviewing the compressive strength of concrete, confining reinforcement (i.e. ratio, spacing, yield stress) or configurations reinforcement and proposing design equations especially to ensure the safety and ductility of the columns that accept earthquake loads [1, 2].

This paper discusses the behavior of high-strength concrete, especially in the column structure that aims to evaluate some design equations that have been developed and adopted in the planning regulations. Confined concrete constitutive equations that affect the need of confining reinforcement are also discussed and compared to identify the accuracy of each model against experimental results that have been done by the author. At the end of the paper the development model of confinement of a general nature, which can be applied to normal and high-strength concrete.

2. The axial capacity of the concrete column

The axial capacity of the concrete column (P_o) to the concentric axial load is determined by the equation below.

$$P_o = \alpha f_c' (A_g - A_c) + A_s f_y \qquad (1)$$

Equation (1) does not take into account the effect of confinement. SNI 2847-2013 [3] to stipulate the value of α is equal to 0.85 for various concrete compressive strength. NZS 3101-2006 [4] also sets the value of α of 0.85 in the equation above but applies for concrete compressive strength up to 55 MPa. If the concrete compressive strength is higher then:

$$\alpha = 0.85 - 0.004\,(f'_c\text{-}55) \qquad (2)$$

The α value is limited to no less than 0.75. Equation (2) shows that NZS has been accomodating the decrease of the column axial capacity when using high-strength concrete.

Next the above equation accuracy with experimental results of high-strength concrete column against concentric load which has been done by several researchers have evaluated [5]. Figure 1 shows the relationship between $\rho_s.f_s/f'_c$ and the ratio between the axial load test results ($P_{exp.}$) to the axial capacity of columns by SNI (Equation 1). From these relationships show that the confining reinforcement ratio (ρ_s) significant role in increasing the capacity of the axial column. The higher the ratio of the installed confining reinforcement, the more increase the axial capacity will be. Generally from the image it is also be seen that the value of α is quite safe in the value of 0.85 when the value $\rho_s.f_s/f'_c$ is higher than 30. Conversely, when the ratio $\rho_s.f_s/f'_c$ lower, even below 20, then it is quite risky when using the 0.85 factor in the calculation of the column axial capacity. The results show that α values espoused in the SNI need to be modified to accommodate high-strength concrete.

Besides affecting the amount of axial capacity, one of the failure mechanism of high-strength concrete column is results cover spalling prematurely. Figure 2 shows data of test results by Cusson & Paultre [6] and Antonius [7] that the strain ratio at the time of the cover concrete spalling of the unconfined concrete peak strain under 1 on columns made of high-strength concrete. Cover spalling behavior of high-strength concrete column that affects the equation stress blocks of concrete which is often used for design against bending. Modification of the equation block stress for high-strength concrete has also been proposed by several investigators, including by Bae & Bayrak [8] and Mertol [9].