Sample 1

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the existing literatures of short and slender HSC columns, external confinement, confined rectangular columns and confined slender RC columns are critically reviewed. Although the present study only focuses on slender circular HSC columns externally confined by steel straps, some of the literatures for short, rectangular and conventional RC columns are also reviewed in this chapter in order to highlight the necessities of this research, as well as to find the existing research gaps.

The chapter begins with an introduction of HSC and a description of the behaviour of HSC columns both subjected to concentric and eccentric loads. The effectiveness of confinement in improving the performances of columns are next reviewed. After that, the behaviour of eccentrically and concentrically loaded confined columns are discussed. Lastly, existing literature of slender confined RC columns and slender HSC columns are reviewed as the preparation for the study on slender SSTT-confined HSC columns.

5.2 Results of Material Tests

In this section, the results obtained from the material tests are presented. The material tests include concrete cube tests and tensile tests for steel reinforcement and steel straps.

'Table 5.1' diceritakan dalam teks dahulu kemudian dipamerkan dibawah

Table 5.1 shows the average cube compressive strength for each batch of concrete, testing at corresponding cube age. A total of 27 concrete cubes were tested. The mean compressive strength of the cubes at the age of 28 days is 64.1 MPa as shown in Table 5.1. A total of three batches of concrete were cast. For each batch, six columns and nine cubes were cast. The concrete cubes were tested at the age of 7 days, 28 days and the day of the column tests.

'caption' untuk jadual ditulis dibahagian atas.

Table 5.1 Summary of concrete cube compressive tests

Batch	**Strength (MPa)**		
	7 days	**28 days**	**Day of testing**
1	49.6	67.3	65.5 (154*)
	47.6	67.9	62.9
	49.8	65.3	62.5
2	42.3	63.4	66.7 (180*)
	42.5	62.9	67.1
	42.1	60.5	63.4
3	39.8	61.5	62.3 (175*)
	40.1	60.3	62.5
	41.3	67.8	70.3
Average	***43.9***	***64.1***	***64.8***

* Age in days at the time of column tests

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The actual stress distribution in the compression zone of concrete can be mathematically defined by k_1, k_2 and k_3. The parameter k_1 is defined as the ratio of the average compressive stress to the maximum compressive stress, σ_{ult}. The parameter k_2 is the ratio of the depth of the resultant compressive force to the depth of neutral axis. The parameter k_3 is the ratio of the maximum compressive stress achieved in the structural member to the compressive strength of concrete cylinder, f'_c. The design values of the stress block parameters are determined at the ultimate strain, ε_{cu}, which corresponds to the maximum capacity of the section. These parameters are shown in Figure 2.4.

'Figure 2.4' dinyatakan dalam teks dahulu sebelum dipamerkan

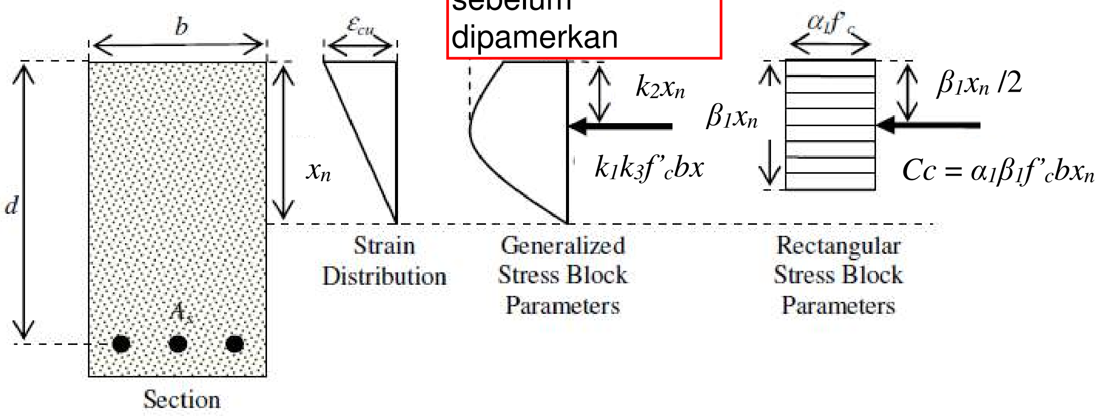


Figure 2.4 Stress block parameters for rectangular sections (reproduced from Hognestad, 1952)

"caption" bagi rajah yang lebih daripada satu line

The k_3, k_1k_3 and k_2 can be obtained from the equilibrium of the external and internal forces, given by equations 2.2, 2.3 and 2.4 as follows:

Persamaan kedua didalam Bab kedua hendaklah ditulis '2.2' dan begitulah seterusnya......

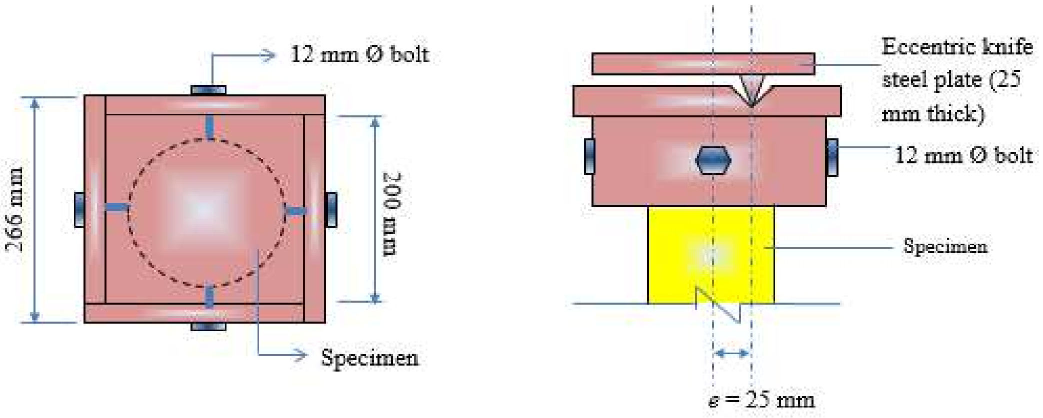
$$k_3 = \frac{\sigma_{ult}}{f'_c} \tag{2.2}$$

$$C_c = k_1 k_3 f'_c b x_n \tag{2.3}$$

$$M_c = k_1 k_3 f'_c b x_n (d - k_2 x_n) \tag{2.4}$$

It should be noted that in the eccentrically load tests, axle vertical load was difficult to achieve since the eccentric head would push the load actuator away at high level of loading. In order to ensure axle vertical load transfer during testing, the load actuator was pulled evenly by 4 numbers of 20 mm diameter tensile bars which connected to temporary steel columns at 4 sides. As the failure of HSC columns was expected to be sudden and explosive, hoarding frame was also erected around the specimen for safety purposes.

The column specimens were hinged at the both ends with eccentric heads. The load was applied with an initial eccentricity of 25 mm at bottom end. Each hinged end was formed by a steel knife-edged bearing plate that was contacted to a 40 mm thick steel plate fixed with the column end. The eccentric loading mechanism is illustrated in Figure 4.11. All columns were instrumented with strain gauges of 6 mm in the hoop direction at mid-height. Lateral deflection was monitored using 3 linear variable differential transformers (LVDTs), with one at the mid-height of the specimens and the other two at 1/4 of the total length of the specimens at both ends. Two Pi-gauges were attached at compressive and tension sides of the specimens to measure the evolution of concrete strain during testing. A Dartec 1,200 kN compression testing machine was used in all loading tests.



(a) Plan view (b) Section A-A

Figure 4.11 Developed eccentric loading mechanism

'caption' rajah satu line ditulis 'centered'

Sample 5

2.3.1.2 Effect of Transverse Reinforcement Volumetric Ratio

As discussed previously, the increase in the transverse reinforcement ratios can significantly improves the strength and ductility of HSC. Cusson and Paultre (1994) reported that HSC exhibits smaller lateral dilation compared with NSC due to the relatively smaller increment in the overall volume during micro-cracking propagation. This smaller lateral dilation of concrete core can delays the utilisation of transverse reinforcement. Bjerkeli *et al.* (1996) reported that a volumetric ratio of 1.1% was not sufficient to improve a column, but a volumetric ratio of 3.1% can significantly increases the ductility of identical column. It was also reported that columns with low transverse reinforcement ratios failed before the ultimate capacities (as calculated using Equation 2.1) were attained, but well-confined columns attained ultimate capacities higher than that calculated in Equation 2.1. The strength improvement can be obtained by the increase in confined concrete core strength, after the spalling of concrete covers.

2.3.1.3 Effect of Longitudinal and Transverse Reinforcement Strength

The yield strength of the transverse steel determines the upper limit of the confining pressure. Higher confining pressure applied to concrete core will result in higher strength and ductility of a column. Many studies have reported that the yield strength of transverse reinforcements can be fully utilised in a well-confined HSC column, but the maximum tensile stresses achieved at the time of failure in the transverse reinforcement of a poorly confined HSC column is lower than the yield strength (Yong *et al.*, 1988; Cusson and Paultre, 1996; Saatcioglu and Razvi, 1993).

pengarang lebih daripada 2 orang

pengarang 2 orang sahaja

Figure 2.3 shows the normalised axial load-axial strain responses of HSC columns. For each pair of columns, all parameters were kept constant except for the

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pengarang lebih daripada 2 - rujuk sampel 5 (ia ditulis Yong et al. didalam teks)

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