CHAPTER 1

INTRODUCTION

General

Development of strength design method for reinforced concrete members is based upon several experimental and analytical investigations. The one conducted by Whitney around 1930 on beams and columns concentrated to the ultimate strength of concrete members with bending and combined bending and axial loads. After that many researches were considered other aspects of reinforced concrete member at failure. However, most of these investigations were considered concrete with compressive strength less than 560 ksc.

With better quality admixtures and some improved construction techniques, it is now possible to produce economical concrete with a compressive strength higher than 600 ksc. with reasonable workability. Thus, the advent of very-high strength concrete has intensified the need to extend the present test data to higher ranges of concrete strength.

The advantages of very-high strength concrete become remarkably significant in both precast industry and cast in-situ concrete construction. The higher concrete strength would result in reducing dead weight of the structural members due to smaller cross-section. Reinforced concrete members constructed with stronger concrete members will produce less deflections than corresponding members of the same size of lower strength. Very-high strength can be utilized in column member where compressive strength is dominated to provide more desirable stiffness and remarkable strength.

The procedures currently used in the flexural strength due to the current ACI 1977 Standard Requirements for Reinforced Concrete (1977 ACI Code[1] are mainly based on studies by Mattock, Kriz and Hognestad[2]. The ACI Code does not cover very-high strength concrete member reinforced with high strength steel wires.

Literature Review

In 1958, Klieger and Paul[3] found that some of the more finely ground portland cements such as Type III (high-early strength) would have higher mixing water requirements for equal workability, particularly at low water-cement ratios, and might promote more rapid stiffening in hot weather.

In 1960, Walker, Stanton and Bloem[4] found that high strength concrete of rich mixes, size of the aggregates, $\frac{3''}{8}$ to $\frac{3''}{4}$, can affect the strength by amount of water-cement ratio. The size of coarse aggregate of $\frac{1''}{2}$ appeared to give optimum strength.

Bloem and Gaynor[5], in 1963, found that there was a considerable difference in the strength of concrete produced by different aggregates of the same size and gradation from different sources when they were mixed in comparable batches of identical proportions. The difference was greater in flexure than in compression.

In 1963, nine under-reinforced concrete rectangular beams made of concrete with 390-420 ksc. in cylindrical compressive strength and reinforced with steel with 5,500-6,000 ksc. in ultimate strength were tested by Karasudhi[6]. He found that the working stress method gave also good predictions of curvature and strain distribution.

Saucier, Kenneth, Smith, Eugene and Tynes[7] found, in 1964, that the gradation of the fine aggregate within typical specification limits was not highly critical except that a slightly coarse sand probably would be benefical if available and not economically prohibitive.

Freedman[8], in 1970, found that the strength of concrete up to around 350 ksc. depended essentially on the strength of the aggregate in addition to the quality of the hardened cement paste that held the aggregate particles together and coarse aggregate gradation was of minor importance in mixes with high cement contents. Concrete of a constant cement content and maximum aggregate size, variations in compressive strength were attributed mainly to differences in mixing water requirements among aggregate sources.

In 1973, Leslie, Rajagopalan and Everard[9] concluded the same as Karasudhi with the test results of twelve under-reinforced rectangular beams made of concrete with compressive strength 651-826 ksc. and reinforced with steel, 3,900-4,680 ksc. in yield strength.

Nedderman[10] studied flexural stress distribution in very-high strength concrete in 1973. He concluded that the ratio of distance between the extreme fiber and the resultant of compressive stresses to the distance between the extreme fiber and the neutral axis was constant at failure. The average of that was 0.37. As anticipated, it did not decrease continually with increasing concrete strength as implied by 1971

ACI Code. Second, the ratio of average compressive stress to cylindrical strength at failure, also remained constant with an average value of 0.58.

In 1979, Perera[11] studied about mechanical properties of high strength concrete by four types of concretes which target strength ranged from 300 to 800 ksc. He found that both modulus of elasticity and tensile strength increased in a compressive strength range of 150 to 800 ksc., high strength concrete could resist very high bearing strength than normal strength concrete and fatigue life of concrete under uniaxial compression decreased as the compressive strength increased.

Ramon, Nilson and Floyd[12] studied the properties of high strength concrete subjected to short-term loads in 1980 and found that high strength concrete, compressive strength 300-770 ksc., was less affected by different rates of loading than normal strength concrete and within a given strength range, the strain obtained varied more than the compressive strength for different loading conditions.

In 1981, six I-shaped prestressed concrete beams made of very-high strength concrete, having 10 cm. in flange width, 20 cm. in depth and 270 cm. in length were tested by Pochanart[13]. He concluded that prestressing loss in very-high strength prestressed concrete beam, elastic shortening and deflection could be very accurately predicted by elastic theory due to the long range of linear relationship of stress and strain. The modulus of rupture could be predicted by 1977 ACI Code with slight discrepencies and the ultimate strength was more accurately predicted by the parabolic or triangular stress distribution than the rectangular stress block distribution. Ductility of test beams varied with the prestressing index and if the ductility index was limited at 4.00, the percentage of prestressing could be used twice the value for ordinary prestressed concrete beam.

In 1982, eleven columns made of very-high strength concrete, having 15 cm. square in cross section and 100 cm. height, categorized into two series concentric and eccentric loading with variables of vertical reinforcement percentage ranging from 0 to 10.6 % and eccentricity respectively, were tested by Siwakul[14]. He found that the ultimate strengths predicted by means of Khan and 1977 ACI Code yielded conservative values about 9 and 13 % lower than the test results respectively and the interaction diagrams predicted by 1977 ACI Code and Nedderman showed good agreement with the test results when tension failure mode governed, however, slight discrepencies were indicated when compression failure mode controlled and the test results were higher than the predicted ones.

Scope of Study

The purpose of this study was to investigate flexural behavior of very-high strength concrete beams reinforced with high strength steel wires for short-term loading subjected to two symmetrically concentrated loads at middle-third point of the span. Test beams, having a rectangular cross section of 10 cm. in width, 18 cm. in depth and 240 cm. in length, were tested at 210 cm. span length and the variable in this study was the percentage of steel.

The objectives of this study were to study about

1. Load-deflection relationship
2. Ductility
3. Flexural strength
4. Crack pattern and mode of failure