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FLEXURAL BEHAVIOR OF WIRE-REINFOFCED CONCRETE BEAM

HAYDER BIN FAKHARAZI

A report submitted in partial fulfillment of the requirements for the award of the degree of Master of Engineering (Civil – Structure)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

DECEMBER 2010

"I declare that this report entitled "*Flexural Behavior of Wire-Reinforced Concrete Beam*" is a result of my own research except as cited in the references. The research has not been accepted for any degree and is not currently concurrently submitted in candidature of any other degree"

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ABSTRACT

This study presents the experimental result in term of flexural behavior of doubly reinforced concrete beam and reinforced with high carbon steel wire rod. Three specimens with the overall dimensions of 150 x 200 x 2300 mm were cast and tested to failure under four-point loading. All the beams are labels B12W13, B23W13 and B32W11 respectively, were B1 equal to beam number one and 2W13 are for two wire rods at diameter size of 13 mm. The performance of the beam was analysed in term of their load-deflection behavior, ultimate load, concrete strain during loading, crack pattern and mode of failure. The experimental results show that using bigger size and number of wire rods give more visible crack and higher load carrying capacity, but decrease in term of deflection. However, wire rods can be used as reinforcement, but not for high load carrying capacity.

Keywords: *High Carbon Steel Wire Rod, Concrete Beams, Flexural Behavior*

ABSTRAK

Penyelidikan ini mempersembahkan hasil kajian dalam hal perilaku lentur konkrit bertetulang berganda dan diperkuatkan dengan batang dawai besi tinggi karbon. Tiga spesimen dibentuk dengan dimensi keseluruhan 150 x 200 x 2300 mm dan diuji dengan pembebanan empat titik sehingga gagal. Semua rasuk ditandakan denagn B12W13, B23W13 dan B32W11 masing-masing, dimana B1 bersamaan rasuk pertama dan 2W13 adalah untuk dua batang dawai yang berukuran 13 mm diameter. Prestasi rasuk dianalisis dalam hal perilaku beban-lenturan mereka, regangan konkrit semasa pembebanan, corak retak dan mod kegagalan. Keputusan kajian menunjukkan bahawa menggunakan saiz yang lebih besar dan jumlah batang dawai memberikan lebih banyak retak kelihatan dan lebih tinggi kapasiti beban yang dapat ditanggung, tetapi penurunan dalam hal lenturan. Namun, batang dawai boleh digunakan sebagai tetulang, tetapi tidakbukan untuk menanggung beban yang tinggi.

Kata kunci: *Batang Dawai Besi Tinggi Karbon, Rasuk Konkrit, Kelakuan Lentur*

TABLE OF CONTENT

CHAP	CONTENT	PAGE
	TITLE	**i**
	DECLARATION	**ii**
	ACKNOWLEDGEMENT	**iii**
	ABSTRACT	**iv**
	ABSTRAK	**v**
	TABLE OF CONTENT	**vi**
	LIST OF TABLES	**x**
	LIST OF FIGURES	**xi**
	LIST OF APPENDICES	**xiii**
1	**INTRODUCTION**	1
	1.1 Background Study	1
	1.2 Problem Statement	2
	1.3 Research Objectives	3
	1.4 Research Questions	3
	1.5 Scope of The Research	4

CHAP	CONTENT	PAGE
2	**LITERATURE REVIEW**	5
	2.1 Introduction	5
	2.2 Definition of Wire	6
	2.3 History of Wire Production	6
	2.4 Kiswire	7
	2.4.1 Background	7
	2.4.2 Products	8
	2.4.3 Applications	8
	2.4.4 Fabrication of PC Wire and Strand	10
	2.5 Concrete Properties	12
	2.6 Failures in Concrete Structures	12
	2.7 Reinforcement	13
	2.8 Wire Rod for any Application	14
	2.9 Advantages of Reinforced Concrete	15
	2.10 Criteria for Safe Design	16
	2.11 Stress Block	16
	2.12 Mode of Section Flexural Failure	19
	2.13 Failure Mode in Concrete beam	20
	2.14 Previous Study	21

CHAP	CONTENT	PAGE
3	**RESEARCH METHODOLOGY**	25
	3.1 Introduction	25
	3.2 Research Design	25
	3.3 Experimental Procedures	27
	3.4 Design Procedure of Rectangular Beam	27
	3.5 Laboratory Work	29
	3.5.1 Preparation of Concrete Beam	29
	3.5.2 Curing	31
	3.6 Laboratory Test	32
	3.6.1 Slump test	32
	3.6.2 Cube Test	33
	3.6.3 Tensile Test	35
	3.6.4 Flexural Test of Concrete Beam	36
4	**RESULT AND DISCUSSION**	39
	4.1 Introduction	39
	4.2 Tensile Test	39
	4.3 Cube Test	43
	4.4 Flexural Strength Test	44
	4.4.1 Load-Deflection Behavior	44
	4.4.2 Ultimate Load at Failure	46
	4.4.3 Load-Concrete Strain	47
	4.4.4 Crack Pattern and Mode of Failure	49

CHAP	CONTENT	PAGE
5	**CONCLUSION AND RECOMMENDATION**	52
	5.1 Conclusion	52
	5.2 Recommendation	53
REFERENCES		54
APPENDICES		56

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	The load (P_1), flexural strength (S_1) and displacement (D_1) at the initiation of the first crack, maximum load (P_m) and flexural strength (S_m), and toughness (G) obtained from four-point bending tests for unreinforced cement, CSS-wire-reinforced cement and BSS-wire-reinforced cement specimens	22
4.1	Details of compressive strength	43
4.2	Mid-span deflections at failure of all the beams tested	46
4.3	Ultimate load from experimental and theoretical of all the beams tested	47
4.4	Concrete strain of all the beams tested at failure	48
4.5	Details of crack for all beams	50

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Wire rods from Kiswire	6
2.2	Some application on wire rod	15
2.3	Stress block	18
2.4	BS 8110 Short term design stress-strain curve for normal-weight concrete	18
2.5	Bone-shaped steel wires. The wire length is 25mm	22
2.6	Photograph of a broken blank cement specimen following the four-point bending test	23
2.7	Photographs of a broken CSS-steel-wire-reinforced cement specimen following the four-point bending test	23
2.8	Photographs of a broken BSS-steel-wire-reinforced cement specimen following the four-point bending test: (a) multiple cracks and (b) magnified view of the main crack	24
3.1	Schematic diagram of the test setup	26
3.2	Detail of beams	26
3.3	Wire rod	30
3.4	Placement the reinforcement in formwork	30
3.5	Final product of casting	31

FIGURE NO.	TITLE	PAGE
3.6	Curing using wet sacks	32
3.7	Slump test	33
3.8	Steel mould	34
3.9	Cube test	34
3.10	Tensile test	35
3.11	Data logger and hydraulic jack	37
3.12	(a) All equipments setup for testing	37
	(b) Schematic diagram for equipment setup	38
	(c) Laboratory photograph test setup	38
4.1	Specimen number one for size 11 mm diameters	40
4.2	Specimen number two for size 11 mm diameters	40
4.3	Specimen number three for size 11 mm diameters	41
4.4	Specimen number one for size 13 mm diameters	41
4.5	Specimen number two for size 13 mm diameters	42
4.6	Specimen number three for size 13 mm diameters	42
4.7	Graph of compressive strength at 7, 14, and 21days	44
4.8	Load-deflection curves for all beams tested	46
4.9	Load-concrete strain for all the beams tested	48
4.10	Crack pattern of all the beams tested	49
4.11	Failure mode of B12W13 concrete beam	50
4.12	Failure mode of B23W13 concrete beam	51
4.13	Failure mode of B32W11 concrete beam	51

LIST OF APPENDICES

APPENDIC NO.	TITLE	PAGE
A	Design for beam B12W13	56
B	Design for beam B23W13	63
C	Design for beam B32W11	70

CHAPTER I

INTRODUCTION

1.1 Background Study

As we know, concrete is strong in compression, but weak in tension, thus adding reinforcement increases the strength in tension. Unreinforced concrete cracks under relatively small loads because of low tensile strength. The cracks are unsightly and can cause structural failures. To prevent cracking or to control the size of crack openings, reinforcement is incorporated in the concrete. Reinforcement may also be used to help resist compressive forces and also improve the structural characteristic.

Reinforced concrete is a desirable building material because of one it is availability world-wide, two it is relatively cheap and required relatively energy to produce, and third, it does not require very skilled labor to place [5]. Flexural design of reinforced concrete beams concentrates on the provision of adequate strength for resisting applied load at ultimate limit state and sufficient stiffness for limiting the deflection of serviceability limit state [1].

High carbon steel wire rods also known as “wire rods,” means semi-finished hot rolled carbon steel products with a circular cross-section in the form of coiled wire. The products of wire rod are use from Kiswire Company and it’s involved in manufacturing and supplying a wide assortment of industrial wire products in various countries. High carbon steels are widely used in many common applications. Increasing carbon as the primary alloy for higher strength and hardness of steels is usually the most economical approach to improved performance. However, some of the effects of elevated carbon levels include reduced weldability, ductility and impact toughness. The diameter range for wire rods is normally 5.5 to 15 mm, but up to 30 mm are available on request. Wire rods shall be evenly round, free from fractures, cracks, pits, and other defects harmful to use. Surface rusting is acceptable. Some common applications are ropes, springs, hardened nails and concrete reinforcement wires and strands.

In this study, the experimental result in term of flexural behavior of singly reinforced concrete beam and reinforced with high carbon steel wire rod. Three specimens with the overall dimensions of 150 x 200 x 2300 mm were cast and tested to failure under four-point loading. All the beams are labels B12W13, B23W13 and B32W11 respectively, were B1 equal to beam number one and 2W13 are for two wire rods at diameter size of 13 mm, B2 equal to beam number two and 3W13 are for three wire rods at diameter size of 13 mm, and lastly B3 equal to beam number three and 2W11 are for two wire rods at diameter size of 11 mm.

1.2 Problem Statement

The conventional material that been used for reinforced concrete is steel. As we know, the problem face with steel is corrosion. Corrosion can lead to costly repair and maintenance operations, reduced service life of the structure and, in severe cases, structural failure. Because of this problems occur, many researches have been

conducted to find out the best solution to solve the steel corrosion problem in the concrete structures and replace it using other materials. For this study, wire rods are the other materials that replace steel in concrete structure. Wire rods are high tensile strength and high flexibility compare to steel.

1.3 Objectives

The objectives of this research are as follows:

i. To study the flexural behaviour of concrete beam reinforced with wire rod.
ii. To study the effect of wire rod reinforcement on bending resistance.
iii. To investigates the suitability of wire rod as tensile reinforcement for concrete beam.

1.4 Research Questions

By the end of this research, it is aimed that the following questions will be answered.

1. How wire rods behavior as reinforced on concrete beam?
2. How does the wire rod react due to bending when load is applied?
3. What about the crack pattern and mode of failure for wire rods?
4. Can wire rod use as reinforcement bars?

1.5 Scope of Study

Three singly reinforced concrete beams with rectangular cross-section of 150 mm wide by 200 mm deep and a total length of 2300 mm each, with concrete cover of 25 mm were cast and tested to failed in bending. The concrete grade been use is 30. Each beam was provided with 6 mm diameter of shear reinforced at 200 mm center-to-center spacing. All of the beams were cast in the formwork and cured in the structural laboratory.

The simply supported beam with the effective span of 2000 mm was tested under four-point loads up to failure. The two-point loads were applied in the middle of the beams at a distance of 300 mm apart. All the beams were extensively instrumented to adequately record their behavior under load. Deflections at mid-span and under the two point loads were measured with linear variable displacement transducers (LVDT). The load was applied at mid-span of the beams using a hydraulic jack and monitored by a high accuracy load cell. Demec disc were installed at the middle half of top and bottom concrete surface.

The flexural performance of the beams was analysed in term of:

i. Load-deflection behavior
ii. Concrete strain during loading
iii. Crack pattern
iv. Mode of failure.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The common reinforcement in use worldwide is steel. But, in the last few decades, recent study or research and finding have been done to change or improve steel as reinforcement with something new such as reinforced polymer as the alternative materials in construction industry. In this study, the material that been use is wire rods from Kiswire company, as shown in Figure 2.1. This chapter will provide on definitions, types of product, application and fabrication of wire. In this study, the wire that been used is from company name of Kiswire.

Figure 2.1: Wire rods from Kiswire

2.2 Definition of Wire

Wire a usually pliable metallic strand or rod made in many lengths and diameters, sometimes clad and often electrically insulated, used chiefly for structural support or to conduct electricity. A group of wire strands bundled or twisted together as a functional unit, cable (worldiQ.com).

2.3 History of Wire Production

Wire was originally made by beating the metal out into plates, which were then cut into continuous strips, and afterwards rounded by beating. The art of wire-

drawing does not appear to have been known until the 14th century, and it was not introduced into England before the second half of the 17th century. Wire is usually drawn of cylindrical form, but it may be made of any desired section by varying the outline of the holes in the draw-plate through which it is passed in the process of manufacture. The draw-plate or die is a piece of hard cast-iron or hard steel, or for fine work it may be a diamond or ruby. The object of utilizing precious stones is to enable the dies to be used for a considerable period without losing their size, and so producing wire of incorrect diameter. Diamond dies must be rebored when they have lost their original diameter of hole, but the metal dies are brought down to size again by hammering up the hole and then drifting it out to correct diameter with a punch (worldiQ.com).

2.4 Kiswire

2.4.1 Background

The chairman of Kiswire is Hong, Young-Chul. Kiswire are establishing in 1945, as Korea's special steel wire industry. This company based in Korea, and currently, there are production facilities in Malaysia, the U.S. and China. In addition to these facilities, there are branches and sales offices in strategic areas such as Japan, Singapore, the U.S., the Netherlands and China all working together to form a global network. KISWIRE has been advancing one step at a time, with strong conviction to abide by the basic principles and not to fear change. Guided by expert management, they have been extremely proactive in responding to the rapidly changing future. They have continuously invested in technological innovations and quality improvement.

2.4.2 Products

The product that is available at Kiswire is showed below:

1. Spring Wire
2. Bead Wire
3. Steel Cord
4. Galvanized Steel Wire
5. Wire Rope
6. PC Wire and Strand

2.4.3 Applications

The application for all type of Kiswire in section 2.3.2 is shown below:

1. Spring Wire

   Spring wire is high-tensile strength wire, different from mild steel wire, and is classified as high-carbon spring wire, piano wire, music wire, shaped wire and oil-tempered wire. These high-tensile strength wire products are manufactured according to product function, and thus are widely used in various industries including automotives, high-tech and precision machines, and auto parts.

2. Bead Wire

   Bead wire is an essential reinforced material for tires on automobiles, earthmoving equipment, large trucks and aircraft. This product tires from

changing shape due to air pressure or external forces, and it safely locks the tire onto the rim to prevent vibration while driving.

3. Steel Cord

   Steel cord is a steel radial tire reinforcement product that stabilizes tires during long hours of extreme driving conditions, and used in the belt and carcass of the tire.

4. Galvanized Steel Wire

   Galvanized steel wire and strand are the culmination of state-of-the-art technology and excellent quality galvanization. Those products are mainly used for reinforcement of distribution/transmission electricity cable, fiber optic cable, and sheathing of underwater fiber optic cable.

5. Wire Rope

   Wire rope is a multi-purpose product being used in numerous industries for power transmission, load tolerance, tensile purposes and many other applications. This product is utilized over a wide spectrum of industries including mine excavation, petroleum exploration and the fishing industries. Shipping equipment, machinery, aircraft, cranes, elevators, cable cars, and bridges also require our product.

6. PC Wire and Strand

   PC wire strand is mainly used in the upper plates of bridges, as a cable for special bridges and for the maintenance of bridges. In construction, this product is used in concrete pilings and support for construction of building, domes for nuclear power plants and reinforcement of LNG concrete tanks. It is also used in floor and roof reinforcement of sport stadiums. Besides these general uses, the products are essential in large-scale cargo recovery and offshore platform jobs in which cranes and other recovery equipment cannot used, in construction maintenance, anchors for civil engineering work, and of course, for rail ties for railroad and high-speed trains. Additionally, these

products can be extensively used in construction materials for PC panels, high-pressure concrete water pipes, marine structures, towers and runways.

2.4.4 Fabrication of PC Wire and Strand

a) PC Wire

i. Wire rod

Raw material for steel wire product supplied by steel mill. Steels mills make wire rod by hot rolling process from billet.

ii. Surface treatment

Descailling wire rod to move rust and scales on the surface of wire surface of wire. Surface coating wire rod to facilities drawing.

iii. 1st drawing

Descailed and surface coated wire road is brought to 1st drawing machine to draw down to required diameter and to give mechanical properties suitable for application.

iv. Stabilizing

Heat Treatment process using high frequency to relieve and remove stress.