MECHANICAL PROPERTIES OF RECYCLED STEEL FIBRE REINFORCED CONCRETE

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To my beloved family and friends

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ABSTRACT

Large quantities of scrap tires are generated each year globally. In Malaysia, huge quantities of scrap tires are produced every year resulting in environmental hazards. This paper discusses the feasibility of adding recycled steel fibre from scrap tires as reinforcement of normal concrete. A number of experimental tests were conducted to investigate slump, Ve-be time, compressive strength, splitting tensile strength, flexural strength and ultrasonic pulse velocity of recycled steel fibre reinforced concrete (RSFRC). The effect of the incorporation of various aspect ratios (*l/d*) and volume fraction (V_f) of recycled steel fibre were experimentally investigated. There were three different *l/d* ratios of 45, 67 and 89 were used. The compressive strength and splitting tensile strength of RSFRC reached a maximum at *l/d* ratio of 67. On the other hand, four different volumes fraction of recycled steel fibres (*l/d* ratio of 67) were added to concrete mixes at 0.5%, 1.0%, 1.5% and 2.0% by volume of concrete. The results indicated that the workability of RSFRC significantly reduced as the *l/d* ratio and volume fraction (V_f) of fibre increases. The compressive strength of RSFRC is not significant increases by incorporation of recycled steel fibre, being a 3.3% improvement over plain concrete at 2.0% volume fraction. The splitting tensile strength and flexural strength of RSFRC dramatically improved with increasing the volume fraction, achieving 148.6% and 51.7% improvement respectively, at 2.0% volume fraction. In addition, the results showed that the ultrasonic pulse velocity of RSFRC increased with the increase of the compressive strength. The experimental results suggest that the recycle steel fibre from waste tyre has potential to be used as reinforcing material in concrete.

ABSTRAK

Terdapat banyak tayar buruk dihasilkan setiap tahun di seluruh dunia. Di Malaysia, kuantiti tayar buruk yang banyak telah dihasilkan setiap tahun menyebabkan kebahayaan terhadap alam sekitar. Kajian ini membincangkan kemungkinan menambah gentian keluli yang dikitar semula dari tayar buruk sebagai tetulang dalam konkrit. Beberapa ujian uji kaji telah dijalankan untuk menyiasat kemerosotan, masa Vebe, kekuatan mampatan, kekuatan tegangan membelah, kekuatan lenturan dan halaju denyutan ultrasonik untuk konkrit bertetulang gentian keluli kitar semula (RSFRC). Kesan penambahan pelbagai nisbah aspek *(l / d*) dan quantiti (V_f) gentian keluli kitar semula telah disiasat melalui uji kaji. Tiga nisbah *l/d* yang berlainan 45, 67 dan 89 telah digunakan. Kekuatan mampatan dan kekuatan tegangan membelah RSFRC mencapai nilai maksimum pada nisbah *l/d* 67. Sebaliknya, empat pecahan gentian keluli kitar semula (*l/d* nisbah 67) ditambahkan kepada campuran konkrit pada 0.5%, 1.0%, 1.5% dan 2.0%. Keputusan menunjukkan bahawa kebolehkerjaan RSFRC semakin berkurangan apabila *l/d* nisbah dan quantiti (V_f) gentian keluli kitar semula bertambah. Kekuatan mampatan RSFRC tidak mempunyai peningkatan yang ketara dengan penambahan gentian keluli kitar semula, iaitu 3.3% peningkatan berbanding konkrit biasa pada 2.0% V_f. Kekuatan tegangan membelah dan kekuatan lenturan RSFRC bertambah baik dengan ketara apabila peningkatan kuantiti gentian keluli, mencapai peningkatan 148,6% dan 51.7% masing-masing pada 2.0% V_f. Di samping itu, hasil kajian menunjukkan bahawa halaju denyutan ultrasonik untuk RSFRC menaik apabila kekuatan mampatan meningkat. Keputusan eksperimen mencadangkan bahawa gentian keluli kitar semula dari tayar buruk mempunyai potensi untuk digunakan sebagai bahan tetulang di dalam konkrit.

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LIST OF SYMBOLS AND ABBREVIATIONS

RSFRC	Recycled Steel Fibre Reinforced Concrete
SFRC	Steel Fibre Reinforced Concrete
RSF	Recycled Steel Fibre
ISF	Industrial Steel Fibre
V_f	Fibre Volume Fraction
HRWRA	High range water reducing agent
LVDT	Linear Variable Differential Transducer
UPV	Ultrasonic Pulse Velocity
OPC	Ordinary Portland Cement

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Concrete is by far the most important building material. Worldwide, more than 10 billion tons are produced each year in the world. However, plain concrete is a brittle material with low tensile strength and strain capacities. Since the late 1960s, use of fibre reinforced concrete (FRC) has been increase steady in order to overcome these disadvantages [1]. According to Colin D. J. [2], fibre reinforced concrete (FRC) may be defined as a composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibres. The role of randomly distributes discontinuous fibres is to bridge across the cracks that develop provides some post-cracking "ductility". If the fibres are sufficiently strong and sufficiently bonded to material, they permit the FRC to carry significant stresses over a relatively large strain capacity in the post-cracking stage.

Different types of steel fibres can be used to reinforce concrete. Steel fibres may be produced either cutting wire, by shearing sheets or from a hot-melt extract. The first generation of steel fibres were smooth so they did not develop sufficient bond with the cementitious matrix. Major efforts have been made in recent years to optimize the shape and size of the steel fibres to achieve improved fibre-matrix bond characteristics. It was found that SFRC containing hook-ended stainless steel wires has better physical properties than those containing straight fibres. This is attributed to the better anchorage provide and higher effective aspect ratio than that for the equivalent length of straight fibre [3]. The addition of steel fibres to concrete necessitate an alteration to the mix design to compensate for the loss of workability due to the extra paste required for coating the surface of the added steel fibres.

The uses of SFRC over the past thirty years have been so varied and so widespread. The most common applications are pavements, tunnel linings, pavements and slabs, shotcrete and now shotcrete also containing silica fume, airport pavements, bridge deck slab repairs, and so on. The fibres themselves are unfortunately relatively expensive. A 1% steel fibre addition will approximately double the material costs of the concrete, and this has tended to limit the use of SFRC to special applications.

1.2 Statement of Problem

Large quantities of waste tires are generated every year. The proper disposal of the tires creates an increasing problem that needs to be addressed. There has been an increased interest in using the recycled waste tire products. This interest is proven by a higher than 80% use of scrap tires produced in the United States for beneficial use, as opposed to only 25% in 1990 [4]. Many researchers have investigated the use of recycled tire products in several traditional Civil Engineering materials. The steel component separated from rubber can be used as fibres in concrete. As well known, the presence of steel fibres in concrete improves in different ways the performances of this material, including post-cracking behaviour and impact resistance.

Recent research, carried out at the University of Sheffield, demonstrated that steel fibres recovered from waste tires (RSF) can be successfully used to prepare fibre reinforced concrete (FRC) [5-7]. In particular, the authors studied the pull-out behaviour and the flexural strength of concrete reinforced with RSF, industrial steel fibres (ISF) and pyrolysed RSF (PRSF). They also proposed a new tensile stress-strain model to predict the flexural resistance of concrete reinforced with conventional and recycled steel fibres.

The results obtained by the pioneer research is suggest the need for further experimental and theoretical studies to get reliable design information for possible structural and non-structural applications related to the use of RSF in concrete. Moreover, the optimum balance between mechanical performances and economic considerations must be addressed and taking into account the possible contribution to the solutions of the fundamental problem of waste recovery.

1.3 Objective of Study

i. To study the effect of aspect ratio *l/d* of recycled steel fibre on the mechanical properties of Recycled Steel Fibre Reinforced Concrete (RSFRC).
ii. To study the effect of volume fraction of recycled steel fibre on the mechanical properties of Recycled Steel Fibre Reinforced Concrete (RSFRC).
iii. To investigate some mechanical properties of Recycled Steel Fibre Reinforced Concrete (RSFRC).
iv. To study the fresh and harden properties of Recycled Steel Fibre Reinforced Concrete (RSFRC).

1.4 Scope of Study

i. The RSFRC reinforced by recycled steel fibre recovered from waste tire.
ii. Fresh properties of RSFRC; slump and Vebe time.
iii. Hardened properties of RSFRC; compressive strength, splitting tensile strength, flexural strength and ultrasonic pulse velocity.

1.5 Significant of Study

The mechanical properties of concrete reinforced with RSF were studied in this paper, where steel fibres recovered from waste tires were employed in the concrete mix without preliminary treatment. Basically, the investigation demonstrates that the RSF affects the concrete matrix similarly to the ISF, mainly improving the tensile strength and post-cracking behaviour. The incorporation of RSF recovered from waste tire in concrete could lead to a viable and environmentally friendly material with attractive properties.

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