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The Utilization of end-of-Life Tire Fragments Rubber in Concrete, in Place of Sand Aggregate

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Abstract. *The use of reclaimed tires in civil engineering practices, specifically asphalt paving mixtures and cement-based materials, is gathering traction throughout the globe. This article provides a comprehensive summary and comparison of recent accomplishments in the field of ordinary rubberized concrete (PRC). Different treatment methods to enhance the efficacy of rubberized Portland cement concrete have been discussed. The analysis also contains the effects of tire rubber size and quantity on the mechanical and durability properties of PRC. The behavior of the rubberized concrete's microstructure was elaborated.*

Keywords. *porosity aggregates, compressive and flexural straight, easy concrete*.

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Introduction:

Recycling used tires in civil engineering is considered an environmentally friendly and cost-effective solution due to the benefits it can provide. It conserves natural resources and generates environmentally beneficial material. In addition to its significant environmental benefits, such as reducing the detrimental environmental contamination caused by the disposal of tires in landfills, the greatest advantage of PRC is its superior energy-absorbing properties. Researchers have discovered that PRC can enhance ductility, reduce weight, and prevent brittle failures. However, one of the most significant disadvantages of PRC is its reduced strength, which prohibits its use in structural components subject to impact and dynamic load.

Concrete, the second most extensively used material in the world, can utilize a significant quantity of waste rubber tires by substituting them with natural aggregate. In addition, waste tires can be used as feedstock in cement furnaces for energy purposes and pyrolyzed to produce carbon black. They are typically used to replace a portion of natural aggregates or as a concrete additive. The thermal decomposition of these residual rubbers in the absence of oxygen can also generate economically unviable byproducts. Consequently, repurposing waste rubber tires as a substitute in concrete could be a viable solution. The following specifications apply to refuse rubber tires used in the construction industry: Chipped tire aggregate with a size range of 10 to 40 millimeters is produced by mechanical milling at room temperature and is considered coarse aggregate. Fine aggregates are supplanted by crumb rubber aggregates (4.75 mm to 0.42 mm) produced by cryogenic pulverizing at temperatures below the glass transition temperature. Ground tire rubber aggregates that pass through sieve No. 40 (0.425 mm), as well as short fiber rubber aggregates ranging in length from 8 to 21.5 mm with an average of 11.5 mm. The disintegration of tires can produce tire fragments and fibers [1, 2].

Several properties of crumb rubber concrete (CRC) are examined in detail in this section. Based on recent research findings, the function of rubber particulates in the matrix of concrete is critically examined. Additionally, the impacts of various types of recycled rubber on the properties of concrete are discussed. Reduced compressive strength of concrete containing rubber particulates precludes its use in most applications (Khatib & Bayomy 1999; Zachar et al. 2010; Bewick et al. 2010; Ling et al. 2009; Khaloo et al. 2008). Rubberized concrete may have many advantageous properties, such as a lower density (Khaloo et al., 2008; Khatib & Bayomy, 1999) and increased durability and ductility (Topcu 1997; Zheng et al., 2008). In addition, the enhanced sound insulation, fire resistance (Bewick et al. 2010; Sukontasukkul 2009; Rangaraju et al. 2012), and fracture resistance (Topcu 1995; Eldin & Senouci 1994) of rubberized concrete make it a more desirable material for use in pavement applications. Regardless of whether it contains rubber aggregate or not, concrete is a relatively fragile substance. Rubber, however, can change the mechanical properties of concrete from brittle to ductile, particularly when added in significant quantities (Eldin & Senouci, 1994). This efficacy is largely due to the elasticity of recycled rubber particulates in the concrete matrix. Numerous building applications, including driveways and roads, can benefit from the less brittle nature of particle rubber concrete (Siddique & Naik 2004; Bewick et al. 2010). Numerous attempts were made to replace coarse or fine particulates in concrete mixtures with rubber. Previous research has shown that the type, size, and quantity of additional rubber have a substantial effect on the properties of rubberized concrete. According to Khaloo et al. (2008), the method of rubber refining and incorporation into concrete mixtures had a significant effect. The most common sources of recycled tires are bicycle tires, passenger vehicle tires, and truck tyres (Atech Group, 2001). Figure 2.1 illustrates the degradation induced by tire use.

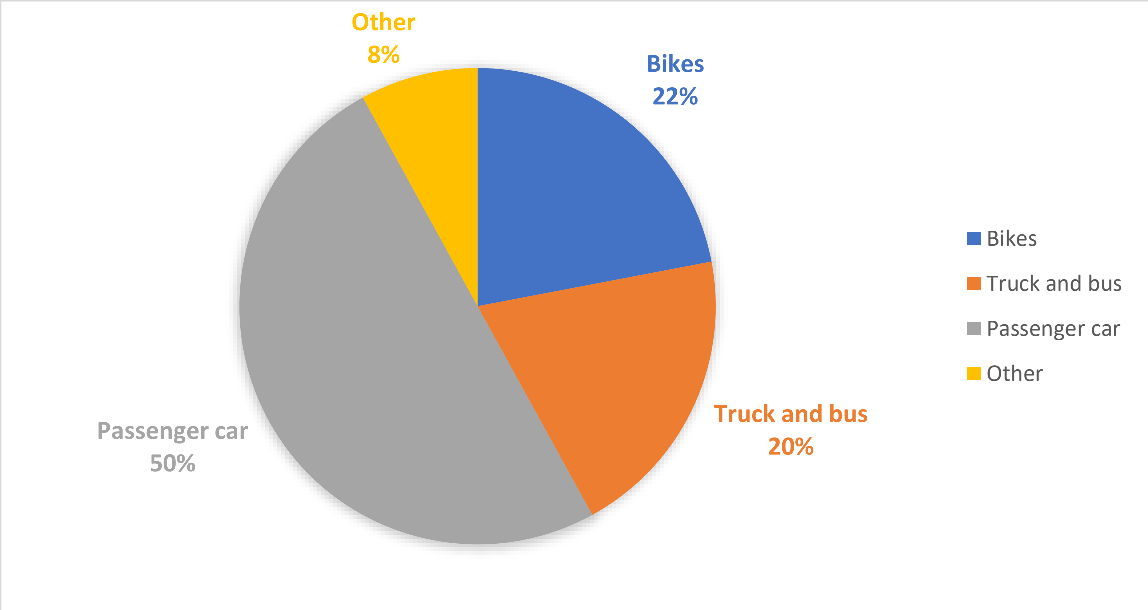

Figure 2.1: Calculated distribution of discarded tires in Latvia (Atech Group 2001)

Although the origin of the rubber particles is a significant aspect (Zachar et al., 2010), the most significant attribute of recycled rubbers is the particle size. As shown in Figure 2.2, recycled rubbers can be divided into two primary size categories:

Figure 2.2: The main types of recycled rubber used in the manufacture of cement products are (a) hard crumb rubber and (b) soft crumb rubber [3]

a) Hard crumb rubber (coarse size rubber): Recycled rubber with a dimension of 4.75mm or greater is defined in the literature as chipped or shredded rubber. Consequently, coarse particles in the concrete mixture can be replaced with rubber of this size (John & Kardos 2011).

b) Soft crumb rubber (fine-size rubber): Extremely irregular rubber particles that can be substituted for sand in concrete mixtures. The particle sizes of shredded rubber range between 4.75mm and 0.07mm (Siddique & Naik 2004; John & Kardos 2011).

Table 2.1: Commonly utilized recycled rubber possesses typical concrete composite product qualities.

Recycled Rubber Type	Average Particle Size [mm]	Specific Gravity [unitless]
Hard crumb rubber	>4.75	1.12 -1.15
Soft crumb rubber	0.075 to 4.75	0.60-1.21

As seen in Table 2.1, the given specific gravity values for various types of recycled rubber were not identical. Possible causes for the variance in the specific gravities of recycled rubber were provided. The origin of this variation may be attributable to the quality of rubber (Fattuhi & Clark 1996). In addition, certain recycled rubbers may contain metal wire fragments, which increases the specific gravity value. The disparity in specific gravity between recycled rubber and concrete aggregates is addressed as a source of mixing and compaction difficulties in the rubberized concrete mix [4].

Based on laboratory experimental research and the type of rubber tires used in this investigation, the following conclusions were reached: Rubberized concrete's compressive strength is appropriate for footpaths. At reduced replacement, the strength was approximately 5 MPa, which was sufficient [5].

The decrease in concrete's strength is complemented by a decrease in its density. Rubberized concrete is lighter in weight than conventional concrete. The 17% reduction could be advantageous for architectural completion. The quantity of rubber in concrete increases proportionally with the plastic energy of rubberized concrete [6].

In addition, the failure resistance increases proportionally with the amount of rubber in concrete. This concrete's ductile energy and resistance to failure made it advantageous for use on sports fields, particularly tennis courts, as well as basketball and volleyball courts. The flexural strength decreased by 60% as the percentage of rubber tires increased. Therefore, rubberized concrete was incapable of bending.

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