Review of the use of waste tires in concrete

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INTRODUCTION

As a result of the development of the society in the world, the demand for tires is rising and the production of waste tires is proportionally related to this fact. Waste tires represent a global problem and an increasing risk to the environment, because they are not biodegradable and are often improperly stored and disposed of. These stocks pose a threat of uncontrolled fires and other environmental risks. It is estimated that almost 1,000 million tires end their life cycle every year and more than 50% are scrapped without any further use.

METHODS AND POSSIBILITIES OF USING WASTE TIRES

Tire recycling makes it possible to obtain rare materials, to save energy in relation to primary production, and to reduce waste.
Fig. 1 shows the percentage composition of tires used for passenger and freight transport.

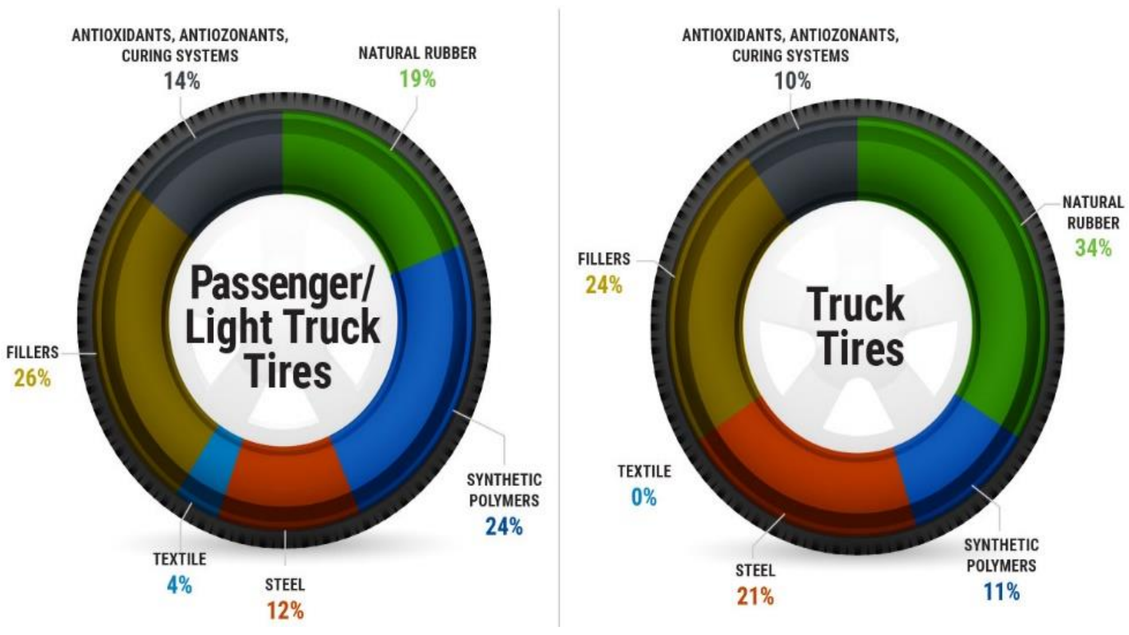

Fig. 1 Composition of tires for passenger and freight transport

When recycling tires, certain measures have to be taken, namely:
- reducing the risk of pollution from the temporary storage of used tires,
- increasing the usability of used tires,
- reducing the consumption of raw materials, especially those originating from non-renewable sources and the use of used tires as secondary raw materials.

The use of tires as a source of raw materials leads to three product categories. They are
- **rubber granules,**
- **steel wires,**
- **and nylon,**
- **textile fibres.**

Energy recovery is one of the most common ways of using tires at the end of their life cycle. The company Považská cementáreň, a.s. has extensive experience in this area. They have used whole tires at the end of their life cycle as fuel for the rotary kiln when firing clinker since 1983.

Another way of processing tires at the end of the life cycle includes **pyrolysis**.

Rubber asphalt is one of the relatively new possibilities for using tires at the end of their life cycle. The main advantages of rubber asphalt include its elasticity, reduced noise and resistance to weathering.

Other options for processing of tires at the end of their life cycle include **ozonation**. It is a technology that uses selective oxidation effect on tires and turns them into rubber granulate. The steel frame remains intact. About 500 kg of rubber granules can be obtained from a ton of tires using this method.

SOME EXAMPLES OF USE OF WASTE TIRES IN CONCRETE

Abdullah et al. [1] used recycled rubber crumb from tires as a partial replacement for cement in concrete in the amounts of 3% to 12%. The result of the research was the finding that the replacement caused a decrease in the strength of concrete by 6 to 21%.

Copetti et al [2] addressed the issue of surface treatment of rubber grains resulting from the recycling of tires for subsequent use in concrete, as a partial replacement of the fine fraction of aggregates in the amount of 15% and 30%. The purpose of the treatment was to improve the physical, mechanical and microstructural properties. NaOH was used to treat the surface of the rubber grains.

Gayathri and Raja [3] examined the mechanical properties of concrete based on rubber crumb and microsilica. Microsilica was used as an admixture (Portland cement substitute) in the amounts of 5%, 10%, and 15%. Rubber crumb was used as a 5% substitute for fine aggregate.

Habib et al. [4] studied the mechanical and dynamic properties of high-strength concrete prepared on the basis of fine and coarse rubber crumb from tires. CEM II/B-S 42.5 N was used as a binder. GLENIUM 27 superplasticizer based on polycarboxylate was used as the plasticizer. Microsilica and steel fibres were used as well. The replacement of fine and coarse aggregates was performed with rubber crumb in the amount of 15% and 25%. The rubber crumb was surface treated with 10% NaOH.

Jalal et al. [5] studied the design of concrete based on waste rubber from tire and pozzolan recycling. Natural aggregate was replaced by sorted rubber crumb in the amount of 10% and 15%. 10% of cement was replaced by microsilica and zeolite.

Li et al. [6] dealt with the design of self-compacting concrete based on rubber crumb from tire recycling. Small natural aggregate (sand) and coarse mined crushed aggregate were used in the design of the recipes. Rubber crumb served as a substitute for sand in the amount of 10%, 20% and 30%. Cement fly ash and slag in the total amount of 530 kg per m^3 were used as the binder.

Samuel and Seckley [7] studied the mechanical strength of concrete based on recycled rubber from tires. The replacement of natural aggregate with recycled rubber was performed in the amounts of 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5% and 20%.

CONCLUSION

Based on the current results of research dealing with the use of waste tires in concrete production, we can draw the following conclusions:
- ❑ Research into the use of rubber crumb, fibres and dust from recycling of tires at the end of their life cycle is a hot topic of research both at European and global level.
- ❑ The use of recycled rubber in concrete has been tested for plain concrete, high-strength concrete and self-compacting concrete.
- ❑ In high-strength concretes based on recycled rubber, admixtures (microsilica) were used to improve the strength characteristics.
- ❑ In most cases, natural aggregates (fine and coarse fractions) are replaced with recycled rubber in a maximum amount of 40%.
- ❑ When replacing natural aggregate with recycled rubber, the strength characteristics (compressive and flexural strength) and the modulus of elasticity are reduced. The decrease depends on the content of recycled rubber in the concrete.
- ❑ Replacement of natural aggregate with recycled rubber:
  - ➢ o increases the toughness of concrete and its resistance to vibration;
  - ➢ O reduces the value of concrete absorption capacity;
  - ➢ O when replacing natural aggregate up to 1%, no significant decreases in the strength characteristics of concrete are observed;
  - ➢ O increases the abrasion resistance of concrete;
- ❑ The use of fibres from tire recycling indicates an improvement in the flexural strength of concrete.
- ❑ The fine and small share of recycled rubber in concrete contributes positively to the reduction of cracks in concrete.
- ❑ The use of rubber crumb in rolled concrete (in the amounts of 10% and 25%) increases fracture toughness.
- ❑ Grain surface treatment to improve the contact zone between the recycled rubber grains and the cementing compound is possible using 20% of NaOH, $KMnO_4$ and $NaHSO_3$.
- ❑ Recycled rubber was used as partial filler in alkali-activated materials.
- ❑ The properties of recycled rubber have been tested and compared in cement and asphalt matrix. It has been established that the asphalt matrix shows better properties of the contact zone compared to the cement matrix.

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