# OPPORTUNITIES FOR LOW INVESTMENT RECYCLING WASTE TIRE DERIVED MATERIALS INTO RUBBER PAVERS

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**Abstract:**
Over the years, recycling waste tires into civil engineering applications, especially into asphalt paving mixtures and Portland cement concrete, has been gaining more and more interests. In this study, the use of crumb rubber to replace coarse and fine aggregates in concrete pedestrian block was studied. This review summarizes the recent advances in the use of waste tire rubber into civil engineering. The main objective of this study was to investigate the potential utilization of rubber waste in concrete matrix, as fine aggregates, to develop lightweight construction materials such a rubber paver. Due to the increasingly serious environmental problems presented by waste tires, the feasibility of using elastic and flexible tire–rubber particles as aggregate in concrete is investigated in this study. Tire–rubber particles composed of tire chips, crumb rubber, and a combination of tire chips and crumb rubber, were used to replace mineral aggregates in concrete.

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## 1. INTRODUCTION

The waste has become a major problem for the various industrial sectors [1-3]. Concepts like prevention, reuse, recycling, recovery, disposal and their ranking are on the order of the day in the management of the different streams of waste [2]. But the implementation of these concepts implies the very good knowledge of waste characteristics. Thus, recovery and recycling has become increasingly important both domestically and globally [1-3]. The trends are continually increasing resource recovery rates with a particular focus on reduction of losses to and diversion from landfill [1-4].

Recovery and reuse recyclable resources represent the means of give back total settlement of the requirements of the economic growth process and the restrictive character of the resources [2-10]. At the same time the activity of recycling deep interferes with the activity of the environment protection, to increase recycling by decreasing the polluting pressure on the environment [2-10].

The general trend is for improvements to be sought in every area possible new ways of applying existing technologies are sought to gain improvements along with the development of new technologies for solutions to existing and emerging applications [1,2]. The waste tires recyclers are also focusing on increasing both their material recovery rates and the quality of the recovered material [1,3-10].

The specific strategic objective of all eco–technologies is to implement new concepts, new technologies for sustainable processes in industry and environmental protection (standards and best practices in industry). This scientific objective aims to focus on the following broad lines of activities:

– research to develop new innovative technologies and solutions for sustainable

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growth of resources and for the substitution of critical materials [1,2,5,6,10,11] ;
- research to identify innovative recycling and re-use technologies of waste materials [1,2,7] ;
- research to develop new technologies and materials in order to improve the recovery and reduce hazardous emissions [2,3]; and,
- research to identify innovative solutions for waste prevention and minimization in industry and rehabilitation of sites polluted from industrial activities [1,2,8-10] .

The specific objective is to develop materials with new functionalities and improved in service performance that minimize the impact on the environment and the consumption of resources. In this sense, multidisciplinary approaches involving science, technology and economic aspects are needed [4].

The management of end–of–life tires is a great environmental challenge. Recycling of waste rubber tires in civil engineering is considered as ecological and economical solutions due to the advantages it can offer. It preserves natural resources and produces an eco–friendly material. The application of recycle waste tires into civil engineering practices, namely asphalt paving mixtures and cement based materials has been gaining ground across the world [2-10].

## 2. MATERIAL AND METHODS

Dynamic development of the automotive industry is responsible for the increase of waste rubber, especially used tires, which are a serious threat to the natural environment [1-3]. Legal regulations as well as economic and ecological factors contribute to heightened interest in the technologies based on recycling of the used tires. The recycle and reuse of rubber materials has become a global environment problem with the fast-increasing amount of waste rubber.

Recycling used tires is a global challenge. Traditionally, used tires have either been disposed of in landfills or incinerated for energy [1-3]. However, the material extracted from used tires could be reused in many ways [2,3]. With respect to tires, the disposal options on a global level are re-treading, recycling, incineration and landfill. The waste hierarchy is adapted by the EU as the standard for the correct treatment of waste (Fig.1).

Until now, the easiest and most common way to get rid of scrap tires has been to dump them in landfills. This, however, is not a good idea for many reasons. The disposal of used tires is a significant environmental problem both in terms of the huge amount of space that would result in landfills and other related problems.


**Fig.1.** Trends of EU management of end–of–life management of tires

Burning tires for energy is economical but requires special equipment. Burning process also releases some harmful gases to the environment (Fig.2). For these two reasons, the trend of burning tires is reducing all the time and new solutions are constantly being searched. At present, grinding is one of the most commonly used methods of waste tires recycling. During this operation, used tires are mechanically disintegrated until the required particle size is reached.

**Fig.2.** Recycling of used tires

A tire consists of rubber, steel and textile (Fig.3). The proportional mix of these three components depends on the type of tire whether it is a passenger car tire or for a heavier type of car. With modern technology, it is possible to separate scrap tires back into these basic components, so everything can be recycled.

a) b) c)

**Fig. 3.** The tire derived materials
a) Elastomer phase (rubber granules or rubber powder); b) Textile phase; c) Metal phase (steel wires)

The output of the treatment process is shredded material of various sizes and types,

depending on the intended uses: rubber chips (size 20–50 mm), rubber granulate (0.8–20 mm) and rubber powder (<0.8 mm). The rubber powder (<0.8 mm) and the rubber granulate (0.8–20 mm) are two consolidated industrial products and more precisely, two secondary raw materials resulting from the recovery of used tires (Fig.4). Rubber granules are produced by crumbing used tires at ambient temperature through multiple cutting and purification processes. It is a non–toxic and a non–hazardous product that possesses basic rubber mechanical properties, especially impact resistance. The original colour is black (Fig.5).

a) b)

**Fig.4.** Elastomer phase derived rubber types
a) rubber granules; b) rubber powder

**Fig.5.** Rubber chips colors

The rubber can be produced in different sizes, from the finest powder to the course granulates used for a variety of purposes. In order for recycled rubber to find widespread applications as replacement for new rubber, it is extremely important that the quality of the recycled rubber is high. It must be totally pure and the size of the particles must be uniform. Only when these quality requirements have been met, will industry find that recycled rubber is fully able to substitute virgin raw material.

Various reuse applications of tire derived materials have been developed for years, including road surfaces, foundations of playgrounds and sports fields as well as noise barriers. There has been a gradual rise in the number of companies which use tire derived material in the production of various rubber products (Fig.6).

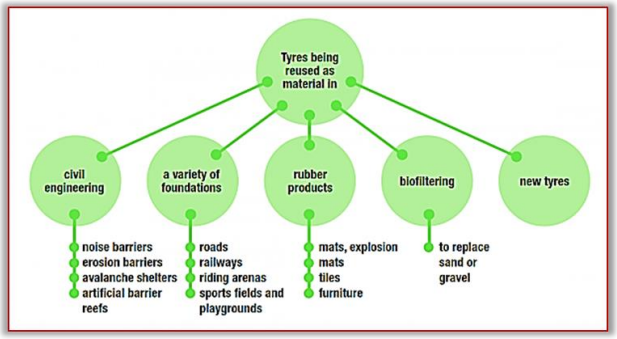


**Fig.6.** Profitable ways to reuse tire waste than only burning tires for energy

The use of crumb rubber in asphalt paving mixture has long been proven successful due to good compatibility and interaction between rubber particles and asphalt binder, leading to various improved properties and performance of asphalt mixtures. Investigations and research into the recent use of rubber particles in concrete has been well documented. However, information on the rubber particle sizes or their distributions within concrete which may also influence the concrete properties is still limited.

## 3. RESULTS AND DISCUSSION

A new possibility consist in producing advanced aesthetic and functional materials by using recyclable materials (rubber, plastics) for the development of ceramic composites. In practice, this means that recycled rubber can be used as a filler in new blends for the development of new composites. Since their appearance, the composites have been used in a wide variety of applications due to their outstanding performance. Having high mechanical characteristics and superior design and manufacturing capabilities, composite materials have superior advantages over traditional materials.

A large variety of waste materials are considered feasible and an valuable additives for concrete. Rubber obtained from scrapped tires is considered as the most recent waste materials that have been examined because of its vital use in the construction field. The recycled rubber tire waste is a promising material in the construction industry and the reason for this is the lightweight of the resulting concrete when the

rubber is incorporated in it as an aggregate replacement (partial or complete).

Rubber pavers (or elastic flooring) are an aesthetic and efficient paving solution in several areas of use where the comfort and adhesion of the surface is a priority regardless of weather conditions. The most common areas of application of rubber pads, with the proviso that they can be used for the same applications as tiles in the case of land and public playgrounds (alleys, pavements around the house, around the garden, patios, terraces, anti–slipping stuff). The careful choice of raw materials as well as state–of–the–art technology used in the manufacturing process are some important aspects that place these products first in terms of quality and differentiate it from the other traditional paving options (concrete, wood, stone, brick or other solutions). Sorting the rubber granules is very important because it helps to "uniformize" the distribution of cohesive forces to the granules, which gives the product a very good stability in time (Fig.7).


**Fig.7.** Tire recycling: From waste to final product

Advantages of using elastic pavers:

- impact shock absorption elasticity, comfort;
- protection and safety prevent hitting in case of a fall;
- long lifetime resistance;
- instant drainage avoiding water build up;
- impermeable surface anti slip;
- increased resistance to environmental factors;
- neat appearance cleanliness and safety; and,
- heavy traffic resistance.

Rubber flooring can be used both outside and inside (Fig.8). They are obtained from a new manufacturing technology with recycled rubber granules combined with a polyurethane binder and pigments for coloring. Thanks to the color impregnation process even during the manufacturing process, the color resistance is very high and the plates do not discolor no matter the cleaning process and the frequency of the operations. Being processed at high temperatures and pressures, they acquire elasticity and reliability characteristics.


**Fig.8.** Steps to obtaining the rubber flooring

Due to its properties, the rubber pavement is the wise choice of floor regarding to covering (Fig.9). Being anti slipping and elastic, the risk of injuries caused by moisture is almost completely reduced. Additionally, the product made from recycled rubber granules is not absolutely toxic, being also a top heat and sound insulator. Since it carries heavy loads, the ecological pavement can support any type of furniture (street or home, indoor or outdoor).

**Fig.9.** Rubber pavements

There are opportunities to bring in the productive circuit large quantities of wastes. They could be used as recycled materials and thus will reduce the quantities of exploited mineral resources. Also the organization of the collection and recovery of such waste can be very effective ways in the reduction of society's pressure upon the non–renewable resources.

## 4. CONCLUSIONS

Rubber pavers have become very popular in recent years in our country as well. Their popularity is due to the large variety of models, sizes, colors and thicknesses, qualities that successfully serve multiple areas of use. Thanks to the innovative technology, the elastic pavers are environmentally friendly, being granular rubber products, offering added strength and reliability, both in abrasion and heavy traffic. Ideal for both impact surfaces with playground protection and anti-skid surfaces, the elastic pavers will be a real

inspiration of elegance and style wherever they are placed. They can be used for decorative purposes, but also for industrial applications due to their high durability. Elastic pavers are the most stable rubber–based granular products and are therefore ready to handle all demands and have much more advantages over traditional paving options in concrete, wood, stone, brick or other solutions.

Rubber pavers are specially designed for areas where the risk of falling and hitting is high, and the manufacturers of such materials have developed a range of product lines suitable for many exterior or interior types designed to protect against the most diverse risks. Outside, it offers the advantage of resistance to repeated freeze–thaw cycles, and additionally the tile composition allows drainage of water, so the pavement is easy to dry.

The organization and management of more efficient reusable materials should be as a priority from the following preconditions:

- the potential of reusable materials is high, which is a prerequisite for ensuring an efficient economy;
- the technical and technological level of this activity is modest, but can be improved without special investment efforts; and,
- level of awareness of the economic agents regarding to the importance and the overriding the recycling of materials is reduced, but can be improved by a concerted actions in supported publicity and ecological education.

Recycling granulated waste tires (crumb rubber) has been widely studied for the last twenty years mostly relating to applications such as asphalt pavement. It is believed that concrete acting as a binder mixed with crumb rubber can make concrete blocks more flexible and thus, provide softness to the surface. The crumb rubber block also performed quite well in both skid and abrasion resistance tests. The production process was economical, due to the simplicity of the manufacturing process.

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