**UDC 624**

# EFFICIENT CONSTRUCTION WITH USED CAR TIRES

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**Annotation**. The article is devoted to an overview of the using of such a non-traditional material as used car tires in various sectors of construction. Examples of structures and materials with using of tires are considered, the efficiency and safety of construction, which makes it possible to put into practice energy and resource-saving technologies, is substantiated.

**Relevance**. The use of cheap and available building materials, which at the same time have sufficient strength and reliability, is one of the priority tasks of construction. At the same time, millions of used tires, having served their service life, are thrown into landfills without finding further using.

**Ecological aspect**. According to statistical information, the global stock of used tires is estimated at 25 million tons, and the annual increase in used tires is at least 7 million tons (10.5 billion pieces), of which about 30% is in European countries. Only 23% of used tires are used in the future, including through export to other countries, incineration, grinding, etc.

In Ukraine, 180 thousand tons of used car tires appear every year. Of which, 10% are recycled, the rest goes to landfill. The EU generates 3.19 million tons of tires annually, 91% of which is recycled. The material is reused or energy is generated from it. In some countries, the disposal of tires that have completed their life cycle is prohibited. In Germany, Japan and the Scandinavian countries, the level of recycling of used tires is approaching 100%, the average for the EU is 82%; in other countries - only 10-15%.

Tire recycling or reuse prevents soils and groundwaters and helps to conserve landfill space. Greenhouse gas emissions are also drastically reduced thanks to tire recycling. For example, 4 re-profiled tires can reduce approximately 323 pounds of $CO_2$ (or 18 gallons of gasoline).

**Tire composition**. The main components of car tires are materials such as rubber (about 71%), metal threads and wire (21%), textile cord (8%). Cord fabric can be made from metal threads (metal cord), polymeric and textile threads. Textile and polymer cords are used in passenger and light truck tires, metal cord - in trucks.

Isolated from tires rubber is used in the construction and manufacture of a wide range of rubber products. Textile cord is used as a raw material for the manufacture of heat and sound insulating materials, for plugging wells during drilling, as a reinforcing filler in the manufacture of composite elastomeric materials. Metal cord is used as a raw material for the manufacture of steel and reinforcing filler for building and road structures. In this regard, when using tires in construction, it is better to use tires from trucks, because they often use metal cord and also given their larger diameter, so that the weight of the building is distributed more evenly.

The metal threads that are used in car tires are actually their kind of reinforcing component. They add strength and stability to the tire, contributing to its wear resistance. For construction purposes, metal threads can be used as additional reinforcement of foundations or other structures, which can increase their strength and stability.

**Analysis of practical use**. In construction, car tires can be used for various purposes, for example:

1. foundations: for the construction of a strip foundation, which consists of used tires filled with soil or other material;
2. road surfaces: for road surfaces in parking or for road surfaces in environmentally sensitive areas such as protected areas or nature reserves;
3. fences and barriers: when erecting fences and barriers to protect the environment or to control access to construction sites;

4. geotextile: for slope reinforcement and soil and water protection at construction sites and in industrial areas;

5. retaining walls: as anti-landslide structures for slopes.

In addition, unrecycled tires are used to strengthen coasts, create artificial reefs, erosion barriers, breakwaters, to protect ships from impacts during mooring, create shock-absorbing barriers on roads, shock-absorbing fences, flower beds, etc.

**Foundation construction**. The use of car tires in foundation construction began over 30 years ago. It was the idea of socially oriented engineers and designers who sought to create more affordable and sustainable building solutions. The use of tires as a foundation allows them to be reused, reducing the burden on the environment.

Various types of foundations can be built from car tires, including:

1. strip: used for the foundation of a house on clay or soft soil. It consists of a series of strips of used car tires that are poured with concrete or filled with other building materials.

2. slab: used for the foundation of a house on solid ground. It involves completely covering the foundation with a layer of used car tires, which are poured with concrete or covered with other building materials.

3. columnar: used for the foundation of a house on relief or rocky soil. It includes pillars made from used car tires that are poured with concrete or filled with other building materials.

Construction practice has shown that the most reliable types are columnar and slab foundations.

Benefits of a tire foundation:

- free source material that can be reused or recycled;
- low cost and labor intensity;
- durability – more than 100 years (with the exclusion of exposure to UV rays, rubber does not decompose and does not rot);
- tires do not pass water and are a waterproofing material;
- increased seismic stability of the foundation. Tires serve as a kind of buffer that can absorb tremors;
- high resistance to seasonal deformations of soils and foundations. This feature allows using tires on heaving soils without considering their freezing depth.

Disadvantages of a tire foundation:

- environment: used car tires contain chemicals that can be hazardous to the environment and human health if not properly disinfected and cleaned. This problem is solved by using structures in which the tires are "hidden" in another material, such as concrete;
- the upper (open) part of the foundation may smell of rubber in summer.
- the tire foundation has an unaesthetic appearance. This disadvantage is easily solved by using facing materials.
- this technology is recommended for shallow foundations without a high plinth or cellar.

**Retaining walls**. The first tire retaining walls were built in developing countries where traditional building materials and skilled labor were scarce or expensive. The use of tires as a building material in these projects provided an inexpensive and readily available solution.

In recent years, tire retaining walls have also been seen as a sustainable solution in developed countries as they can be covered with earth and planted with vegetation, creating a "green" and visually pleasing wall.

Benefits of tire retaining walls:

- low cost;
- recycling: using tires as retaining walls helps reduce their amount in landfills;
- ease of installation: tire retaining walls are relatively easy to build, without the use of heavy equipment or specialized labor;
- durability: tires are made of durable materials that can withstand the weight of the soil and erosion;

- flexibility: tires can be easily cut and shaped to fit in tight spaces or around corners, making them a versatile option for a variety of construction projects;
- drainage properties: tires have a natural porosity that allows water to pass through and run off, reducing the risk of water damage to the wall;
- seismic resistance: Tire retaining walls have proven to be more seismic resistant than other types of retaining walls such as concrete or stone.

When building retaining walls from tires, two technologies are used:

1. The wall is assembled from tires arranged in steps along the slope and planted on vertical piles. Tires are fastened to piles as follows. The lower tires planted on piles with one edge of the inner diameter from the side of the slope abut against the piles, and the tires of the upper rows with the opposite edge of the inner diameter are attached to the piles using flexible clamps. The intermediate tires are freely planted on piles, fastened together, and connected to the upper and lower tires using a filler (round timber) located in their cavities.
2. Columns are formed from one, two or more rows of tires. For durability, anchor piles are driven in the center of the columns. The tires are filled (with compaction) with local soil. In the rows, the tires are fastened with clamps. It is possible to perform a wall of tires with one cut outside wall. Soil is rammed into the bottom row. A strong sheet material is laid on this row to prevent spillage of soil from a row of tires located above. The next rows of tires are laid in the form of brickwork (with bandaging). Their cavities are also filled with soil. Anchor piles (pins) are driven from the outer side of the wall to stop the bottom row and prevent horizontal displacement of the wall. Tires are attached to each other both in a row and between rows using plastic wire or propylene ropes.

**Road construction**. The use of vehicle tires in road construction is a relatively new concept that has attracted attention in recent years to recycle and repurpose used tires while addressing the environmental and economic issues associated with traditional road construction materials. Experiments on the use of automotive rubber as a modifying component for asphalt concrete began more than 50 years ago in the United States. In California, for example, half of the roads are made of asphalt with a rubber component.

The main idea is to grind tires and use the resulting rubber granules as a road surface. This rubberized asphalt can provide a more durable and slip-resistant surface than traditional stable asphalt and can also be less prone to wear and tear from heavy vehicles.

In addition to the environmental benefits of tire recycling, the use of rubberized asphalt can also be a cost-effective solution for road construction. Tires are a readily available material, and the use of recycled rubber can reduce the cost of road construction compared to traditional materials.

**High strength concrete**. The use of tires in high-strength concrete is also a relatively new concept that is gaining attention to recycle and repurpose used tires while addressing the environmental and economic issues associated with conventional concrete production.

The main idea is to grind tires and use the resulting rubber granules as a partial replacement for the traditional coarse aggregate in the concrete mix. Rubber granules can provide added strength and durability to concrete, as well as improved wear resistance.

It is worth noting that different tire pulverizing methods can result in particles of different sizes and shapes, which can affect the properties of rubberized concrete. In addition, the curing time of rubberized concrete can be longer than traditional concrete, depending on the rubber content, which can affect the planning of construction projects.

In addition, rubberized concrete may have various properties such as thermal insulation, coefficient of thermal expansion, and fire resistance that require further study. Further research and testing are needed before tire-derived material can be used more widely in concrete production.

**Environmental Safety.** The use of tires in construction can have both positive and negative environmental impacts. On the positive side, using tires in construction can help recycle and repurpose waste, reducing the number of tires that end up in landfills. It can also help reduce the environmental impact associated with tire recycling, such as the release of toxic chemicals and unsightly tire stacks.

The use of tires as a building material in construction projects can reduce the need for traditional building materials, which are often produced using energy-intensive processes that generate greenhouse gas emissions.

It is important to note that the environmentally sound use of tires for construction purposes depends on the correct collection, processing, and disposal of tires, as well as the use of appropriate technologies and materials to contain any potential contaminants.

**Prospects and proposals**. The use of tires in construction is an area of ongoing research and development, and new proposals and applications are being explored to find new ways to reuse and recycle this waste.

Insulation: Tires can be used to create insulating material for buildings, which can help improve energy efficiency and reduce heating and cooling costs.

Sound barriers: Tires can be filled with various materials such as soil or concrete and used as sound barriers to reduce noise pollution.

Offshore Construction: Tires can be used as an alternative to traditional materials in the construction of offshore structures such as breakwaters and wharfs.

Sustainable Building: Tires can be used to create sustainable and environmentally friendly buildings, such as earth-sheltered houses and other structures that are designed to minimize environmental impact.

It is possible to consider such options for foundation structures using car tires:

- a wall in the ground, made using car tires laid in the form of pillars with a certain step. The cavities are filled with gravel material followed by concreting. For the perception of bending forces, it is possible to use longitudinal reinforcement in the space between the pillars. This design is especially relevant with the development of underground buildings and modern requirements associated with the need to build bomb shelters. As mentioned earlier, tires have significant damping capacity;

- pile foundations strung on columns of tires in the lower part of the grillage, which ensures seismic resistance and flexibility of such a design scheme;

- retaining walls, behind which a prism is created from tires filled with gravel material, which will significantly reduce the pressure of the soil, especially if it is formed within the boundaries of the collapse prism.

It is worth noting that these proposals require further research, further tests and experiments are needed to prove their effectiveness and sustainability.

**Conclusions**. The presented material allows us to conclude that there is a positive international experience in the use of automobile tires at various construction sites. Thus, there is every reason to believe that worn-out tires will find a “second life” in technologically efficient and safe construction.

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