Our planet faces some major environmental challenges such as climate change and depletion of natural resources. One of the biggest problems is the production of concrete, which requires the use of huge amounts of aggregate and cement. Around 5 billion tons of cement are produced annually worldwide. By mid-century, that number could double with urbanisation growth alone. The world consumes around 48 billion metric tons of aggregates per year, which would mean about 5.5 ton per inhabitant. The key solution to address this problem lies in the recycling of construction and demolition waste, including concrete. This not only effectively reduces the amount of bulk waste sent to landfills, but also plays a key role in protecting valuable natural resources and significantly reducing greenhouse gas emissions associated with cement production. Recycled concrete aggregate (RCA) has a wide variety of uses in civil engineering, e.g., it is capable of providing good performance as a sub-base material for pavements and roads. It can also be used to build reinforced earth structures or backfill retaining walls. In some cases, RCA can be even more effective as an embankment fill than the natural aggregates currently used. What will happen if we combine RCA with yet another waste with different properties, namely rubber from recycled scrap car tyres?

Recycling scrap car tyres is among the most pressing environmental issues today. An estimated 1000 million tyres reach the end of their useful life each year, and by 2030, another 5000 million are expected to be regularly discarded. At present, only a small proportion is recycled and millions of tyres are simply landfilled or buried. Many countries, including the entire European Union, prohibit the disposal of tyres in landfills. One of the reasons for that is the fact that tyres create an excellent habitat for the development of pests and insects, such as mosquitoes, in tropical countries, responsible for the spread of malaria. Furthermore, if such a landfill is set on fire intentionally or accidentally, it produces thick toxic smoke that poses a huge threat to people and the environment. Unfortunately, such fires are not uncommon. So what can we do with scrap tyres? They can be burnt in a controlled manner and thus recover energy, but considering air pollution, a better solution is to shred the tyres and use them as alternative aggregate (TDA). This material can be used, for example, in the production of innovative concrete. Over the past two decades, recycled rubber has also been used in many geotechnical projects around the world as a lightweight construction material, backfill, or in drainage, vibration-insulating, or thermal insulation layers. In recent years, several scientific studies have been carried out to investigate the physical, chemical, and mechanical properties of mixed natural soils, mainly sand or gravel, and shredded car tyres. These works have shown that the addition of rubber improves the behaviour of the material when subjected to dynamic loads, such as vibrations caused by the operation of construction machines, the passage of vehicles, or the occurrence of earthquakes or rock bursts in mining areas.

The aim of the proposed project is to design and investigate a new "geomaterial" produced by appropriate mixing of RCA and TDA, without the use of hydraulic binders such as cement. The work will be innovative, both on a national and international scale. Our goal will be to determine the most important physical and mechanical properties of the tested material in order to obtain all the information necessary for its future use in geotechnical structures. In our project, we will be looking for RCA-TDA mixtures that will provide the structures with stability and bearing capacity in a wide range of strains, i.e. when subjected to not only static loads, but also dynamic and cyclic loads. For this reason, we will devote considerable attention to determining the most favourable shapes and sizes of the RCA and TDA particles, their proportions and mixture density. We will use the most advanced laboratory equipment, such as an electron microscope, a cyclic triaxial apparatus, piezoelements, a resonant column, and a cyclic simple shear apparatus, to truly understand the interaction between the particles, the relationship between stress and strain in the loaded material, and its ability to damp vibrations. It will be equally important to check whether the proposed mixtures are safe for the environment after they are incorporated into the structure, which is why we will determine, among others: pH, chemical composition, presence of organic matter, heavy metals, and leachability of potentially hazardous ingredients. We will compare the results with the applicable guidelines. We will also build virtual models of typical geotechnical structures: foundation, road embankment, and retaining wall, and check which mixtures provide the best results.

Our project will reveal the properties and behaviour of the mixtures made of stiff particles of crushed concrete and deformable, elastic rubber from used car tyres, working under various types of loads. The project results will create new opportunities to use these difficult waste materials in the spirit of sustainable development.