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KICK-OFF PRESENTATION OF THE PROJECT "*Tyre4BuildIns*" – RECYCLED TYRE RUBBER RESIN-BONDED FOR BUILDING INSULATION SYSTEMS TOWARDS ENERGY EFFICIENCY

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Abstract *This paper provides a kick-off presentation of the project "Tyre4BuildIns" - Recycled tyre rubber resin-bonded for building insulation systems towards energy efficiency. The main goal of this project is to develop a new cost-effective eco-friendly thermal insulation material, that will be used mainly, but not exclusively, as a thermal break in Lightweight Steel Framed (LSF) building structures, taking advantage of recycled tyre rubber as a main raw-material and mixed it with an advanced state of the art material within a resin-bonded composite. It is planned to evaluate and optimize the performance of this new composite insulation at material level and building elements level (e.g. walls) in order take maximum thermal and acoustic advantage of it. It will be also assessed its environmental impacts and costs from a life cycle perspective. "Tyre4BuildIns" is a three years duration challenging project involving researchers from different scientific backgrounds, namely civil and chemical engineering from University of Coimbra (UC), comprising two research units, the Institute for Sustainability and Innovation in Structural Engineering (ISISE) and the Chemical Process Engineering and Forest Products Research Centre (CIEPQPF).*

1. INTRODUCTION

Statistics are showing that buildings represent 40% of the total primary energy consumption in Europe, more than industry or transports sectors [1]. In the European Union, residential buildings cooling and heating energy demand represents nearly 70% of the total operational energy [2]. The most recent updates to the Energy Performance of Buildings Directive (EPDB) introduce two fundamental concepts, namely the cost-optimal energy requirements and nearly Zero-Energy Buildings (nZEB).

Over the last few years, alternatives to the traditional constructive method have emerged and proliferated worldwide. The Lightweight Steel Framed (LSF) system is an example of this growing trend, offering some advantages in such fields as production, transportation, durability, adaptability and construction economy. However, if not correctly designed and built, thermal bridges created by the steel high thermal conductivity can penalize buildings' exterior envelope thermal performance and consequently their overall energy efficiency [3]. Recent research has shown that thermal bridging can be responsible for up to 30% of traditional construction dwellings' heat loss [4]. Thus, mitigating LSF thermal bridges is a key premise in meeting EPDB requirements.

2. STATE-OF-THE-ART

The research team already has experience in evaluating LSF buildings thermal performance [5] [6] [7] [8] [9] as well as to improve it [10] [11]. In facade walls, one of the existing strategies is to assemble an insulating material, such as rubber [12] or aerogel strips between the steel studs and the sheathing materials, acting as a thermal break. Due to LSF buildings low mass and rigid connections between the outer and the inner sheathing of the walls, some acoustic performance drawbacks can emerge. Undue vibrations, airborne and impact sound insulation should also be correctly addressed [11].

The development of low cost and eco-friendly materials which can provide both thermal and sound insulation become a major alternative, capable of combine cost-optimal energy concept, sustainable development and nZEBs. Some recycled materials have the potential to fulfil all these requirements. Furthermore, the use of recycled materials in the construction process is beneficial in a life cycle analysis evaluation of the building [13]. Environmental credits derive from the substitution of primary materials for recycled constituents.

Among the many waste materials produced worldwide, waste tyres are a major concern. The annual global production of tyres is about 1.4 billion, corresponding to an estimated 17 million tons of used tyres each year [14]. However, the Directive 1999/31/EC on the landfill of waste has prohibited landfilling of used whole tyres since 2003 and shredded tyres since 2006. With decreasing disposal options and increasing production, the volume of used tyres is becoming a major waste management issue.

Nowadays, End-of-Life Tyres (ELTs) are valorised as material and processes to obtain rubber granulate or fibers for construction products have already been developed. Among its most relevant properties, this material is lightweight, has good elasticity, energy absorption, insulation (acoustic and thermal), anti-caustic and anti-rot properties [15].

Research works aim for its introduction in materials such as concretes, mortars or composite panels [15], upgrading both thermal and acoustic properties. No work was found for the utilization of this material in rubber strips, as an LSF thermal bridge mitigation strategy. For this purpose, it will be crucial to develop composites containing the waste tyre rubber mixed with a highly insulating material, blended with polymeric resins. In our research team some work has already been done in this area, for instance a composite of natural rubber with polyester resin (polyhydroxylalcanoate) [16].

The commercial price of recycled tyre crumbs is less than 0.25 €/kg, enabling its valorisation and articulation with EPDB goals. Thus, the combination of these two materials would be a wise strategy to decrease the overall price of the final product, while maintaining the insulation performance at a high level and solving several environmental problems. In this context, some polymeric resins will be needed for the composite preparation. Several kinds of polymeric materials have been applied for the development of foams for insulation purposes. In this area can be enhanced epoxy resins, polyurethanes, polyester resins and maleic anhydride derivatives [17]. Even so, considering the thermal insulation performance of these polymeric materials (hundreds of mW/m/K), their ratio in the composite must be necessarily low, being only need to bind the other two materials.

3. RESEARCH PLAN AND METHODS

Within this project, the research team aims to merge efforts in order to:

1. Develop a new eco-friendly and cost-effective insulation composite material based on recycled tyre rubber and other insulation materials;
2. Evaluate and optimize the performance of this new composite insulation material by characterizing its properties (hygrothermal, acoustic, fire reaction, mechanical resistance and durability);
3. Optimize the use of the new insulation material in building elements (e.g. walls) in order take maximum advantage of it regarding thermal and acoustic performance, and;
4. Assess the environmental impacts and cost of this new insulation material from a life cycle perspective.

To achieve their goals, the team proposes a research plan composed by six main tasks:

1. State-of-the-art update;
2. Development of new thermal insulation composites;
3. Performance evaluation of the new composites;
4. Development and performance evaluation of LSF elements;
5. Life cycle assessment;
6. Dissemination.

Task 1 aims to keep the team updated regarding the research topics addressed in this project, given the frequent new advances achieved.

Task 2 intend to develop a new eco-friendly and cost-effective insulation composite material based on recycled tyre rubber and aerogel materials, being this the most important task and

therefore a very significant share of human and monetary resources was assigned to it.

Task 3 purpose the characterization of the previously developed composite materials in order to evaluate its performance.

Task 4 aims to evaluate the thermal and acoustic performance and optimize the use of the material in LSF walls in order take maximum advantage of it.

Task 5 intend to perform a life cycle evaluation of the new insulation material in terms of environmental impacts and costs.

Task 6 involves the dissemination of the research project achievements using a webpage and organizing a technical workshop.

4. FINAL REMARKS

This paper presented an overview of the 3-year funded research project "*Tyre4BuildIns*" - *Recycled tyre rubber resin-bonded for building insulation systems towards energy efficiency*. After a brief introduction, a state-of-the-art regarding building's energy efficiency, insulation materials and recycled tyre rubber was presented. Then, the research plan and methods were shortly described regarding the main tasks of the project.

Notice that the new insulation composite, developed during this project, can be useful not only for LSF building elements, but also in other types of buildings, wherever a thermal bridge mitigation strategy is needed. Moreover, given its advantages the use of LSF constructive system is very suitable also to buildings refurbishment, being this, one of the main current strands in the construction sector.

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