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EUROPEAN SCIENTIFIC DISCUSSIONS

PROCEEDINGS OF VIII INTERNATIONAL SCIENTIFIC AND PRACTICAL CONFERENCE JUNE 20-22, 2021

ROME 2021

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UDC 504.03

ASSESSING THE POTENTIAL OF WOOD AS A GREEN CONSTRUCTION RAW MATERIAL FOR THE CIRCULAR ECONOMY OF THE EU AND THE WORLD

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Abstract. Circular economy principles are vital for improving resilience in the supply of raw materials upon which the economy of the EU. Green raw materials are renewable, non-toxic, improve occupancy health and conserve energy and water use and waste products. Wood is an important green raw material. Wood building materials have many environmental advantages. Wood products from responsible sources are a good choice for most green building projects. Wood grows naturally using energy from the sun and CO_2, is renewable, sustainable and recyclable. It is an effective insulator and uses far less energy to produce than concrete or steel.

Key words: green raw material, circular economy, wood building materials, carbon footprint, energy efficiency, natural forest ecosystem.

Introductions. 6 years ago the *European Commission* adopted its first circular economy action plan. It included measures to help stimulate Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth and generate new jobs. The plan established concrete actions, with measures covering the whole life cycle: from production and consumption to waste management and the market for secondary raw materials and a revised legislative

proposal on waste.

In 2019, the *European Commission* adopted a comprehensive report on the implementation of the action plan. The report presents the main achievements and sketches out future challenges to shaping our economy and paving the way towards a climate-neutral, circular economy where pressure on natural and freshwater resources as well as ecosystems is minimised [1].

The new action plan announces initiatives along the entire life cycle of products. It targets how products are designed, promotes circular economy processes, encourages sustainable consumption, and aims to ensure that waste is prevented and the resources used are kept in the EU economy for as long as possible.

For the EU to remain competitive and to preserve environment, natural resources should be used in the most efficient way and without depleting the planet's resources. It also promotes the fair and sustainable sourcing of primary raw materials globally. Even if we recycle better and more, primary raw materials will continue to play an important role in the economy [2]. Despite centuries of technological advances, wood is still an important raw material.

Materials and methods. *The Raw Materials Initiative* is the EU's raw materials strategic policy framework. It aims to secure a sustainable supply of raw materials for Europe and deals with all types of raw materials except those produced by *agriculture* and *forestry*. Green raw materials today are defined as materials that are renewable, non-toxic, improve occupancy health, lower cost, and conserve energy and water use and waste products. Green materials are also materials that have low embedded energy in their harvesting or collection, production, transportation and use. Wood is a main green raw material.

Results and discussion. The European Commission is exploring ways to ensure that the bioenergy derived from plants, is sustainable and does not increase pressures on the environment. The EU also promotes the sustainable management of the Union forests and works with other countries around the world to combat deforestation and tackle illegal logging. The EU also has a strategy to preserve and restore biodiversity so that healthy ecosystems continue to provide us with raw

materials such as food, medicines, wood.

Durable and strong, wood is a resilient material that can provide decades, even centuries, of service. Today's building codes coupled with advances in wood science and building technology have expanded the options for wood construction. Building codes recognize wood's safety and structural performance capabilities and allow its use in a broad range of applications – from the light-duty repetitive framing common in small structures to the larger and heavier framing systems used to build mid-rise/multi-residential buildings, multi-story offices, industrial facilities, schools, recreational centers and stations [3].

Excellent technological characteristics of wood made it possible to start using it even for the construction of modern skyscrapers. From light-frame and mass timber to new hybrid designs, wood construction is meeting and exceeding rigorous performance standards.

Wood structures can withstand earthquakes. In the aftermath of an unfortunate disaster, wood is a versatile and resilient building material well-suited to repairing and rebuilding structures. Wood has a lower thermal conductivity compared to cement, lime, steel-frame, and masonry construction and is well-suited to energy-efficient design [4].

Wood products typically offer advantages in terms of material and construction costs. Building with wood is fast and efficient, and can be undertaken year-round in almost any climate. Experienced wood contractors are widely available, and workers of varying skill levels can quickly learn wood construction techniques. In addition to ease and speed of construction, wood's relative light weight can reduce the need for foundation capacity, and most communities have a large pool of skilled workers with wood framing experience [3].

Wood's light weight and workability make it easy to apply to specific applications. With the exception of major members that are made to spec off-site, wood can be adapted in the field, allowing quick solutions if changes are required. Wood is also well suited to additions and retrofits, and wood systems can be dismantled with relative ease and the materials used elsewhere. As a building

material, wood is easily adapted, reused or recycled.

Innovative wood products have made wood a viable alternative to other materials in many applications where long spans and tall walls are required. Wood's design flexibility makes it suitable for a wide range of building types and applications, both structural and aesthetic. Advances in wood science and building technology continue to expand the opportunities for wood construction. Cross laminated timber (*CLT*), parallel strand lumber (*PSL*), glued laminated timber (*glulam*) and prefabricated paneling systems are among the products contributing to a wider range of wood buildings [3].

Building codes require all building systems to perform to the same level of safety, regardless of material. Wood-frame construction has a proven safety and performance record for fire protection. Such construction is readily accepted in the *International Building Code*. Some wood products, such as the large beams used in heavy and mass timber construction may perform better in a fire situation than non-combustible materials. Because they are thick and solid, these products char at a slow and predictable rate. This char protects the wood from further degradation, helping to maintain the building's structural integrity and reducing its fuel contribution to the fire, which in turn lessens the fire's heat and flame propagation [3].

This charring effect offers increased safety and means mass timber is predictable when exposed to fire. In a fire test, a 7-inch thick wall (about 17,8 *cm*) of *CLT* lasted 3 hours and 6 minutes – 1 hour longer than code requirements [5]. To maximize a project's allowable size, a designer's options include protected construction, heavy timber construction and the use of fire-retardant-treated construction.

Wood buildings are known to perform well in earthquakes. Forces in an earthquake are proportional to the structure's weight and wood is substantially lighter than other major building materials. The fact that wood buildings tend to have numerous nail connections is another benefit as it results in more load paths and better redundancy, so there's less chance the structure will collapse should some connections fail. This is why wood buildings have inherent ductility, which allows

them to dissipate energy when faced with the sudden loads of an earthquake [3].

With proper design and maintenance, wood structures can provide long and useful service lives equivalent to other building materials. The key is careful planning and understanding of environmental loads and other external factors likely to impact a building over its lifetime.

Wood can contribute to a building's energy efficiency, and is thought to have a positive impact on the health and well-being of occupants. Research is showing that incorporating wood and natural materials into our buildings – sometimes called *biophilic* design – can reduce stress and contribute to good mental health [4]. Wood's natural beauty and warmth have been shown to generate improved productivity and performance in schools, offices and better patient outcomes in hospitals.

Wood is the most important renewable – green raw material. Wood materials have many environmental advantages. The choice of products used to build, operate and renovate structures has a significant impact on the environment. When specifying any material, it's important to consider its life cycle environmental impacts. Wood products have less embodied energy, are responsible for less air and water pollution than other commonly used building materials.

The fact that wood is durable and adaptable also creates opportunities for renovation, re-use and recycling.

Wood offers distinctive value from its aesthetic warmth and health benefits to its versatility and small carbon footprint (the quantity of CO_2 and other greenhouse gases released per unit of product during a product's manufacturing and, in some cases, end use and disposal [6]).

Wood as a material is often compared with concrete, steel and brick. The latter construction materials, however, are not developed from renewable raw materials and require a great deal of energy to be produced. They entail higher emissions of carbon dioxide, making them have a positive carbon footprint.

Among the commonly used building materials, wood has the lowest energy consumption and develops the lowest carbon dioxide emission. To combat climate

change on the planet and reduce negative environmental impact, wood is the certainly ideal choice of green raw material provided that proper forest management is stringently implemented.

A tree absorbs carbon dioxide from the air and grows through the process of photosynthesising using sunlight, water and carbon dioxide. The carbon then stays in the tree while oxygen is released into the atmosphere. 1 m^3 of wood contains about 0,9 tonnes of CO_2 [7] that has been extracted from the atmosphere by the tree. The longer the material is in use, the longer the carbon stays out of the atmosphere.

London architects *Waugh Thistleton* have designed a timber residential tower – *the Murray Grove tower*. The building has been designed using a cross-laminated timber panel system. This is the first building in the world of this height to construct not only load-bearing walls and floor slabs but also stair and lift cores entirely from timber. The fabric of *the Murray Grove tower* will store over 181 tonnes of carbon. Additionally, by not using a reinforced concrete frame, a further 125 tonnes of carbon are saved from entering the atmosphere. This is equivalent to 21 years of carbon emissions from a building of this size [8].

Japanese timber company Sumitomo Forestry has plans for the world's tallest wooden building in Tokyo, a 350-metre skyscraper. Named W350, the ambitious tower will be the world's tallest timber building. According to the preliminary estimates, the construction of the *W350* will take 185 000 cubic meters of wood [9]. So the fabric of the *W350* tower will store over 166 500 tonnes of CO_2 or over 50 000 tonnes of C^{2+} (wood contains about 45-50 % carbon by weight).

Thus, use of wood products can help to reduce contributions to greenhouse gases in the atmosphere that increase the greenhouse effect, with the caveat that sustainable forestry continues to occur from product substitution.

If properly harvested, we can obtain timber materials for generations to come while still maintaining the natural forest ecosystem. With internationally-recognised forest certification bodies such as *Programme for the Endorsement of Forest Certification* and *Forest Stewardship Council* in operation, there are systems in place that can help ensure that the wood we use derives from sustainable forests that

undergo specific measures, implementation, system and proper auditing.

Conclusions. Circular economy principles are vital for improving resilience in the supply of raw materials upon which the economy of most European countries and regions depend. Green raw materials are defined as materials that are renewable, non-toxic, improve occupancy health, lower cost, and conserve energy and water use and waste products. Wood is one of the main green raw material. Wood offers distinctive value from its aesthetic warmth and health benefits to its versatility and very small carbon footprint.

Wood grows naturally using energy from the sun, is renewable, sustainable and recyclable. It is an effective insulator and uses far less energy to produce than concrete or steel. A tree absorbs carbon dioxide from the air. The longer the wood is in use, the longer the carbon stays out of the atmosphere. If properly harvested, we can obtain timber materials for generations to come while still maintaining the natural forest ecosystem.

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