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## Cork composites and their role in sustainable development

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### Abstract

With the current challenges that the industrial world faces regarding the unavoidable environmental impact of manufacturing goods, companies have been turning to sustainable design in order to reduce this impact and to minimize the damage to the environment while at the same time reaping the marketing bonus that is the claim of a greener product.

This reduction of environmental impact is being done at multiple levels and especially at the design stage and one of the ways taken by companies to reduce this impact is to replace fuel-based materials such as polymers with natural materials.

But in order for this replacement to take place, engineers and designers need to know the behavior of these materials.

With that idea a set of mechanical tests and studies, namely bending and compression tests, have been performed on cork composites. Those composites were chosen for its importance to the Portuguese economy and its peculiar growth cycle and harvesting techniques, in order to ascertain the mechanical properties of cork composites and how it stands against polymers.

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### 1. Introduction

Possibly one of the most important events in the history of mankind, the industrial revolution almost completely transformed the social and economical landscape of the world, with Gross Domestic Product (GDP) per capita increasing 10fold and population increasing 6-fold [1]. From manufactured goods at a lower price, the invention of the internal combustion engine, the creation of transportation networks and the development of capitalism the impact was felt in all aspects of the society. Unfortunately this revolution had a price. The increase in production was achieved from what was considered infinite resources, and those resources turned out to be anything but infinite.

The first call of attention was made by Thomas Malthus in his book “An Essay on the Principle of Population” [2] where he warned that the potential for growth of the human population is vastly superior to nature’s ability to

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sustain it, with the inevitable outcome of strife to all involved. In it laid the foundations of Malthusianism where the geometric growth of a population would at some point overtake the linear growth of the resources.

This idea has been expanded beyond Malthus original scope but retains the same impact. The growth of population, coupled with the basic tenets of the economic model used since the industrial revolution (one of continuous economic growth), lead to a geometric growth on the need of resources, which at some point will (or have depending on the point of view), overtake earths ability to supply them. This model can also be applied to other effects of the population growth.

## 2. Sustainable Development

Environmental issues remained largely under the radar for the next 150 years resurfacing with the Club of Rome, and its publishing of the book “The limits of growth” [3]. This book, commissioned by the Club of Rome to the Massachusetts Institute of Technology (MIT), utilized a computer model (world 3) to analyse the evolution of the world through the interplay of five systems comprising a total of 8 variables. Several scenarios were run including a standard run, *i.e.*, a run where the observed trends in the world would be maintained throughout [4].

The results were dramatic. In the standard run, the model predicted a full collapse of the economy in the middle of the 21<sup>st</sup> century, due to resource depletion, pollution, and population growth.

The United Nations, trailing in the wake of the book, created the World Commission on Environment and Development (WCED) in 1983 that published in 1987 “Our common Future” otherwise known as the Brundtland Report [5], where the word Sustainable development is first coined. But what is exactly sustainable development? According to the report "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

In other words the ability to produce, today, whatever goods necessary without endangering the ability of doing the same in the future, avoiding the collapse predicted by “The Limits of growth”.

How to do it has been the concerns of academics and companies for the past twenty years with numeral solutions proposed [6]. All of them take into account that there is always an environmental impact inherent to manufacturing a good [7].

## 3. The role of natural materials

One of the ways to achieve sustainable development is to substitute non-renewable resources or resources nearing depletion due to overconsumption, with renewable ones [8]. One way to do so is to turn to natural materials such as vegetable fibers, natural resins and other materials such as chitin that can combine the minimal environmental impact in harvesting and producing with sufficient mechanical performance to replace some non-renewable materials currently in use. These materials are being studied and promise to be of great importance in the future, combining good environmental performance low environmental impact.

One of such materials has been studied quite thoroughly in the past decade, and, due to its unusual combination of characteristics seems a promising candidate. Cork based composites are extracted from the Cork Oak tree (*Quercus Suber L.*).

### 3.1. Cork

Cork is extracted from the cork oak tree (*Quercus Suber L.*), one of the most prolific trees in the Mediterranean Ecosystem. It's forests are valued for its biodiversity [9], Livestock feeding [10], CO<sub>2</sub> Retention rates [11, 12] and economical value. The defining feature of the Cork oak is the production of its outer layer, a technically waterproof viscoelastic material known as cork.

Cork has been used for millennia in the production of bottle stoppers, and has a place in the annals of science, since it was a cork cell that Robert Hooke studied in his microscope, and from which the name “cell” arises. As a material it has an unusual array of properties such as high coefficient of friction, heat resistance, sound proofing, among others, have made it an object of study with multiple publications on the subject [13-15].

Economically, cork has a significant importance on the Portuguese GDP, with a sales volume of 698,3 million Euros, representing 0,7 of the Portuguese GDP and 2,2% of the total exports in 2009 [16]. Environmentally there

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