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The analysis of the reason why our bones are created as composite material via comparing other materials

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Abstract
In this study, the reasons why the bones, which make up the skeletal system and were subjected to continuous compression, were created as a natural composite structure were investigated. They had been compared by being subjected to compression test separately together with sheep bone, wood, plastic and steel pipes prepared in the same dimensions. Thus, the advantages of being a composite material of the bone to our body were investigated by comparing with other materials; the data obtained from the experiments were evaluated and reported. Besides the results obtained from after the compression tests were supported by using the graphics and photographs.

Keywords: biomaterials, compression test, bone, damage, composites

1. Introduction

Composites are solid materials obtained by combining two or more different materials on a larger scale than the atomic structure, ie without chemical reaction [1]. According to this definition, some kind of materials or biological tissues found in nature can be counted as natural composites such as wood, tooth and bone [2-4]. Two or more types of materials that make up composite materials work together to provide unique composite properties. However, since they are not dissolved in the composite and subjected to chemical bonding, ie, they do not interfere with each other; the different materials therein can be distinguished from each other. Again, one of the biggest advantages of modern composite materials is that they are light as well as strong. With a suitable combination of matrix and reinforcement (fiber) material, a new material can be obtained that fully meets the requirements of a particular application [5-6].
Bones in our bodies and animals, which are considered to be natural composites of excellent grade, consist of a hard but brittle material called hydroxyapatite (predominantly composed of calcium phosphate) and a soft and flexible material called collagen (a protein type) [7]. The bones are composed of hydroxyapatite, which acts as a fiber that forms the composite structure, and collagen, which functions as a matrix and, at the same time, provides the necessary properties for transporting the body to the bones, although it does not have much impact on the skeletal structure itself.
In this study, as mentioned above, they were subjected to compression tests together with three different types of materials to investigate why the bones that make up the skeletal system and were subjected to continuous compression were created as a natural composite structure. Thus, the advantages of being a composite of the bone to our body were examined by comparing with other materials; the data obtained from the experiments were reported and investigated.

2. Materials And Experiments

Four different types of material, namely bone, rounded and hollow wood, plastic pipe and galvanized pipe, were subjected to compression testing primarily to determine their compressive strength. Experiments were carried out on a computer controlled tensile tester with a capacity of 30 tons of Shimadzu brand at Gaziantep University.

As shown in Fig. 1., the test specimens were made of four different materials, 20 mm diameter, 80 mm long hollow materials. Sheep bone was used for bone. The other materials were made of wood, galvanized and plastic water pipes, respectively, as rounded and hollowed out, as previously mentioned. In addition, during the compression tests, the speed of application of force was taken as 1 mm / min and experiments were performed. The obtained data and graphs were taken from the computer controlling the device and evaluated in the results section. In addition, the weights of the materials were measured before the experiments were carried out and given in Table 1. As can be seen here, as expected, the galvanized pipe is the heaviest and the others are bone, plastic pipe and wood, respectively

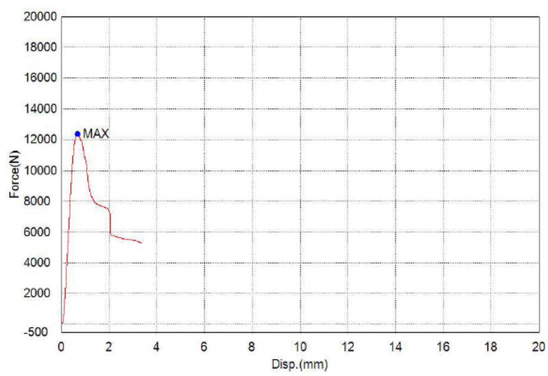
Fig. 1. Experiment Samples respectively; wood, galvanized pipe, plastic pipe and bone

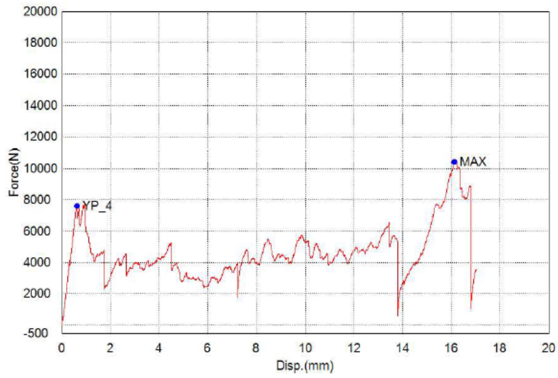
Table 1. The Weight of the Experiment Samples from highest to the lightest

Experiment Material	Weight (gr)
Galvanized Pipe	90,0
Sheep Bone	29,5
Plastic Pipe	13,0
Wood	12,4

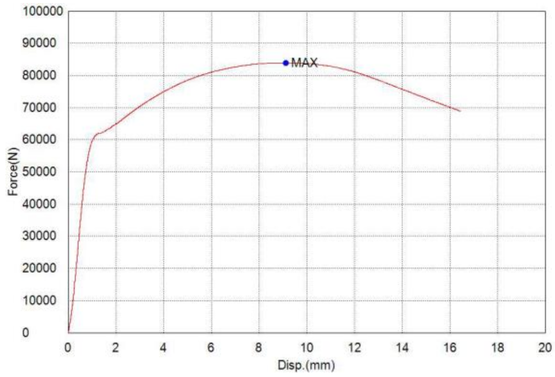
3. Results and Discussion

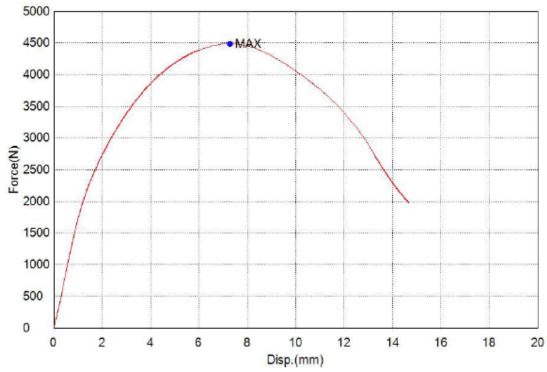
After compression tests, force and displacement, deformation graphs of four different materials consisting of bone, rounded and hollowed wood, plastic pipe and galvanized pipe were obtained from computer and examined. As shown in the graphs in Fig. 2., it is seen that galvanized pipe has the highest compressive strength with a value of approximately 85 KN. This is followed by wood, bone and plastic pipes. As expected, the graphs of the three materials except the bone have drawn a smooth graph due to the homogeneity of their structure. When the bone force-displacement graph is examined in detail, it is seen that the graph shows ups and downs. These fluctuations are due to the structure of the layers in the bone, and in this case the bone does not break immediately, in layers, before it fractures and then breaks.





(a) (b)





(c) (d)

Fig. 2. Force-Displacement Graphics of the samples after Compression Test
a-) Wood b-) Bone c-) Galvanized Pipe d-) Plastic Pipe

Damaged samples were examined one by one in order to obtain information on the occurrence of damage after the experiment. As it can be seen from the photographs in Fig. 3, it is observed that the event occurs with small fractures in the form of crumbs, which is not a complete break in the bone. In the case of plastic and galvanized pipes, it is observed that there is no breaking, bending, and distortion.
Also, the photographs taken during the experiment and the deformations of the materials on the device help us to understand how the bone fracture and deformation occurs in the plastic pipe, as shown in Fig. 4. It is seen that the bone is deformed by small cracks and fractures, while the plastic pipe is destroyed only by bending and distortion.




(a) (b) (c) (d)

Fig. 3. After Experiment, photos of the materials, which were deformed via compression, test during the experiment a) Wood b) Plastic Pipe c) Galvanized Pipe d) Bone

(a)

(b)

Fig. 4. The photos of the samples under compression force during the experiment
a-) Plastic Pipe b-) Bone

As it can be seen from the experimental results and graphs, it is seen that the bone, which is a light and natural composite biomaterial, has a hard but flexible structure and that cracks occur in the macro dimension before fracture, the fracture event does not show permanent plastic deformation and the damage occurs by breaking into layers. This means that we cannot know the number of pressing, pulling, blowing etc. in our daily lives. It shows that our bone, which is exposed to such effects, is not immediately broken but cracked even though we sometimes do not feel it, and then our biological structure repairs it and it is broken only because of big impacts. It also results in the fact that breakage occurs in an interesting and miraculous way without disintegration and deformation. In this way, our broken bone can be restored by medical treatment. If not, the integrity of our skeletal structure would be disrupted, which would cause many adversities in our biological structure, especially our movements. On the other hand, it’s extremely low density makes our skeletal system light in weight.

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