



Steel Foam Inspired from Human Bones

Mohd Umair¹, Dr. D. K Chauhan², Tanveer Ahmad Wani³

¹Ph.D, ²Technical Director, ³Professor of Physics & Material
Noida International University, Greater Noida, Uttar Pradesh, India

ABSTRACT

Historically, the concept to create synthetic cellular substances have to have been stimulated by means of herbal materials such as pumice stone, timber or bone that have all been in use for a lengthy time due to their special properties. Since the 20th century, cell substances are engineered from dense primary materials, their houses are investigated systematically and it is decided in which situations they are the highest quality to their dense counterparts. The matrix fabric of cellular substances or, greater specific, foams can be a polymer or another organic material, a glass, a ceramic or even a metal.

Bones have an internal structure similar to a honeycomb, which makes them rigid yet relatively light. Bones are more than just the scaffolding that holds the body together. it comes in all shapes and sizes and have many roles.

Key words: *Bones, Timber, Foam, Metal, Cellular*

INTRODUCTION

Flexible but rigid like a human bone and straight away capable of bearing loads. A new sort of material, made of steel foam, resembles the inside of a bone in phrases of its structural configuration. It additionally promotes in growth into surrounding bones. The Creation of steel foam with foam like structure, inspired through the spongy nature of bone. The metal foam does a higher job than stable steel when it comes to matching the mechanical properties of bone, such as flexibility, and this encourages more superb bone regrowth.

The mineral calcium phosphate hardens this framework, giving it strength. More than 99 % of our body's calcium is held in our bones. An organic tissue is regularly described in terms of its structural and material proper-ties. Structural homes signify the

tissue in its intact form. Important structural residences are represented by a relationship between pressure and deformation, or stress and strain.

MATERIAL PROPERTY

The behaviour of the material comprising the tissue and to a first approximation is independent of the dimension of the tissue. The material properties are typically expressed in terms of the stress strain relationship of the material. The energy of a material, which is the breaking or last power underneath different modes of loading, such as tension, compression, torsion, or bending, will be different, as will the corresponding modulus of elasticity or stiffness, without bending.

The stiffness of a material represents the material's ability to withstand deformation. Stiffness is commonly characterized with the support of the slope of the linear place of a stress curve, also referred to as Young's modulus when examined underneath tension. To describe the slope of different areas of the stress strain curve, a tangent modulus is frequently defined. A tangent modulus ought to have related with it a strain cost or a vary of strains. There can be exclusive sorts of module depending on the loading sorts (e.g., shear modulus, compression modulus). The larger the stiffness, the higher the pressure required to reason a given deformation. If the stress in a material is at once proportional to the pressure for traces up to the elastic limit, the material is known as a Hooke a material.

Bones Composition

Bone is a composite material consisting of each fluid and stable phases. Two predominant stable phases, one organic and every other inorganic, supply bones their difficult structure. An organic extracellular mixture nous matrix is impregnated with inorganic materials, in particular hydroxyapatite Ca_{10}

(PO₄)₆(OH)₂ (consisting of the minerals calcium and phosphate). Unlike collagen, apatite crystals are very stiff and strong. However, a bone's energy is greater than that of either apatite or collagen because, similar to what happens with concrete, the softer factor prevents the stiff one from brittle cracking, whilst the stiff element prevents the tender one from yielding. The natural material gives bone its flexibility, while the inorganic fabric offers bone its resilience. Calcium and phosphate account for roughly 65–70% of a bone's dry weight. Collagen fibres compose approximately 95% of the extracellular matrix and account for 25–30% of the dry weight of bone. Surrounding the mineralized collagen fibres is a ground sub-stance consisting of protein, polysaccharides, or glycosaminoglycan's (Gags), primarily in the structure of complicated macromolecules referred to as proteoglycans. The Gags serve to cement collectively the number of layers of mineralized collagen fibres. Water bills for up to 25% of the total weight of bone, with about 85% of the water being placed in the natural matrix around the collagen fibres and ground substance. The different 15% is positioned in canals and cavities that house the bone cells.

Working Structure

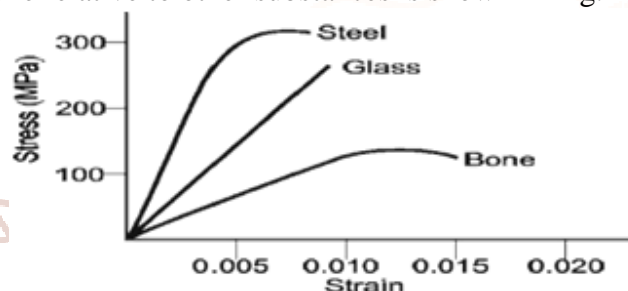
Bones are recognized as either cancerous (also referred to as trabecular or spongy) or cortical (also referred to as compact); see Figs. 2.2a and b. Cortical bone is roughly 4 instances the mass of cancerous bone, in any lengthy bone. The primary material comprising cancellous and compact bone seems identical; thus, the big difference between the two is the degree of porosity and the organization. The porosity of cortical bone degrees from 5 to 30%, while cancellous bone's porosity levels from 30 to 90%. Bone porosity is now not fixed and can trade in response to altered loading, disease, and the growing old process.

The fibrous layer protecting all bones is the peritoneum. This membrane covers the entire bone without the joint surfaces, which are protected with articular cartilage.

There are several terms used to describe the complex structure of bone at a finer resolution. Both cortical and cancelous bone may additionally incorporate two sorts of fundamental architecture, woven and lamellar. Bone can additionally be described as principal or secondary bone; regions within cortical bone are often

described as either aversion or laminar. Details about this may additionally be discovered in any textbook on the biomechanics of bones.

Bone shows a linear vary in which the stress will increase in proportion to the strain. The slope of this region is described as Young's modulus, or the elastic modulus. An illustration of the material houses of bone relative to other substances is shown in Fig. 1



Comparative properties of different materials

STEEL FOAM POROSITY

Any metallic with a fluid phase (liquid or, most usually, gas) distributed in the course of it ought to be categorized as a porous steel, even though in practice the learn about of these materials is normally constrained to these displaying big degrees of porosity (greater than 50%) and the place the second phase regions are uniformly distributed in the course of the material (unlike the case of a solid section with a giant inside pore, for example). In these structures, the regions of free house are known as pores or cells and the stable phase is referred to as the dense or dad or mum steel, with the character structural elements being termed struts, if they are thin relative to the pores, and being referred to as picture partitions if they are larger.

PROPERTY OF BONES	Femur 1500 TO 1750 C	Steel Foam 1500 TO 1600 C
Ultimate tensile strength (MPa)	124 ± 1.1	275
Ultimate compressive strength (MPa)	107 ± 4.3	188
Density kg/m ³	700 TO 1400	500 TO 2000

Biological properties

Foams made from titanium, magnesium and NiTi are regularly counselled for use as biomaterial implants even if no biological trying out is performed (Thieme et al., 2001; Wen et al., 2002a; Oh et al., 2003;

Dunand, 2004; Nomura et al., 2005; Nouri et al., 2010) and sufficiently excessive purities for use in the body have been executed (Laptev et al., 2004; Hong et al., 2008). This is largely as the dense variations of these metals are presently used, or are leading candidates for authentic implants, and the bio inertness is known. Titanium foams have been pre-treated to create a bottom appropriate for implants (Wen et al., 2002b). Porous titanium has been uncovered to simulated body fluid after bottom redress to grant a applicable bottom for cell attachment (Hong et al., 2008). While this gave an exceptional porous texture to the surface of the foam, which should perform well, no cell checks have yet been reported. Highly porous (90%) Ti-6Al-4V alloy has been subjected to cell culture tests, by means of seeding MC3T3-E1 osteoblast-like cells on samples of foam in cell tradition means, with lifestyle instances of up to three days (Li et al., 2005). It used to be located that cells connected to the material surface and unfold and that there was once proof of extracellular matrix production. Magnesium can degrade in the physique environment, producing compounds that can be excreted through biological approaches and is consequently attractive for degradable implants. In assessments in a saline answer representing the body environment, breakdown of porous magnesium has been observed with, as expected, the dissolution rate being accelerated via growing the porosity (Zhuang et al., 2008). Porous NiTi is specifically eye-catching for implants into bone, owing to the similarities in the stress strain curve possible between the two substances (like bone, NiTi can display hysteresis within the super elastic region) (Bansiddhi et al., 2008). Foams of NiTi have been produced and implanted into animal models (rabbits) (Kim et al., 2004). In these tests, no exasperation was observed and after six weeks bone ingrowth came about in all specimens examined. However, in the absence of a manipulate check on different porous materials it is tough to say how this behaviour ranks with different types. As more candidate porous biomaterials are produced from steel powders, a more comprehensive trying out programme will be required.

Mineral Storage, Energy Storage in Bones

1. On a metabolic level, bone tissue performs several crucial functions. For one, the bone matrix acts as a reservoir for a variety of minerals necessary to the functioning of the body, specially calcium, and phosphorus. These minerals, included into bone

tissue, can be launched returned into the bloodstream to maintain tiers wished to assist physiological processes. Calcium ions, for example, are crucial for muscle contractions and controlling the flow of other ions involved in the transmission of nerve impulses.

2. Bones also serves as a site for fat storage and blood mobile production. The softer connective tissue that fills the indoors of most bone is referred to as bone marrow (Figure 4). There are two types of bone marrow: yellow marrow and purple marrow. Yellow marrow carries adipose tissue; the triglycerides stored in the adipocytes of the tissue can serve as a source of energy. Red marrow is the place haematopoiesis the manufacturing of blood cells takes place. Red blood cells, white blood cells, and platelets are all produced in the red marrow.

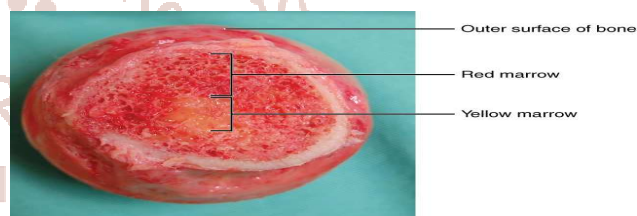


Figure2. Head of Femur Showing Red and Yellow Marrow. The head of the femur contains both yellow and red marrow. Yellow marrow stores fat. Red marrow is responsible for haematopoiesis.

(Credit: modification of work by "stevenfruitsmaak"/Wikimedia Commons)

Correlation between Structure and Function

The "crimp pattern" and the interplay and cross-linking of elastic, reticular, and collagen fibres of ligaments are critical for ordinary joint mobility. These features enable ligaments to have a confined vary of strains over which they produce minimal resistance to movement. As a result, joints may without problems be moved in certain instructions and over positive ranges. Additionally, if a joint is displaced towards the outer restriction of some normal vary of motion, the pressure in precise ligaments of those joint increases, causing recruitment of collagen fibres from their "crimp" kingdom to a straightened condition. Fibre recruitment causes the ligament to quickly enlarge its resistance to in addition elongation, for this reason stabilizing the joint.

Another feature of ligaments that may also be vital for retaining joint integrity is their neural network. Ligaments comprise a range of sensory receptors that

may additionally become aware of joint position, velocity, and acceleration. This function may additionally not directly contribute to retaining joint integrity by using initiating the recruitment (or decruitment) of dynamic stabilizers such as muscles. More work is wanted in this area to determine the role of these neural components.

Conclusion

Lightweight construction materials suitable for extremely stressed and safety-relevant components such as car wheel as well as bones replacement. The variability measured in properties of steel foam, despite it being the best foam available to date, is very large as compared to that of its parent metal. This implies that further refinements in manufacturing for extensive production in construction. Methodologies are necessary in order to improve the reliability of foams, which is a must in high performance applications that demand low failure probability and high reproducibility. In terms of strategies for generating mechanical test before ascertaining any property, especially when conducting parametric studies.

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Reference

1. Fung YC (1993) Biomechanics: mechanical properties of living tissues, 2nd edn. Springer, New York
2. Hawkins D. (2001) Tissue mechanics. Human performance laboratory, University of California, Davis. Lecture available at:
3. Mow VC et al (1991) Structure and function of articular cartilage and meniscus. In: Mow VC, Hayes WC (eds) Basic orthopedic biomechanics. Raven, New York
4. Fish R. (2000) Sinovial joints, PhD Thesis. Department of Biological Sciences, University of Manchester, Kingston, Canada.
5. Akeson WH, Woo SL-Y, Amiel D, Frank CB (1984) The chemical basis of tissue repair. In: Funk FJ, Hunter LY (eds) Rehabilitation of the injured knee. CV Mosby, St. Louis, pp 93–104
6. Menard D, Stanish WD (1989) The aging athlete. Am J Sports Med 17(2):187–196
7. Gray H (2000) Anatomy of the human body. Lea & Febiger, Philadelphia, Bartleby.com, 2000.
8. Fung YC et al (eds) (1972) Biomechanics: its foundations and objectives. Prentice-Hall, Englewood Cliffs, NJ
9. Gallagher RH et al (eds) (1982) Finite elements in biomechanics. Wiley, New York
10. Ratner BD, Hoffman AS, Schoen FJ, Lemons JE (eds) (1996) Biomaterials science: an introduction to materials in medicine. Academic, New York