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Experimental Vibration Analysis Of Goat Femur Bones

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Abstract—**The unique relationship between resonant frequencies and material properties has led to the use of vibration. Vibration Technique is a non-invasive technique for determining the stiffness of long bones and also assess the effect, that osteoporosis may have on the mechanical properties. This technique has also been used to diagnose the occurrence of a bone fracture, determine the rate of healing of fractures, and detect loosening of hip prosthetic. Osteoporosis is a disease with the systemic skeletal disorder and the most common metabolic bone disease. It is specified by low bone mass, microarchitectural deterioration, and increased bone fragility and likelihood to fracture with no known trauma. Osteoporosis related fractures tend to mostly occur in the wrist, spine, and hip. Hip fractures have the greatest morbidity and mortality, but all osteoporotic fractures result in pain and suffering to the individuals experiencing them and considerable socioeconomic losses to the society. This technique is cost-effective, transportable. In this method, vibration measurement was carried out on goat femur bones in vitro condition. Natural Frequency of goat femur bones increased with decreasing bone mineral density. The data obtained from this technique is directly related to the mechanical condition of the bone.**

Keywords—biomechanics, vibration analysis, natural frequency, goat femur

I. INTRODUCTION

Osteoporosis is a histological description of aged human bone, emphasizing its apparent porosity [2, 3]. Osteoporosis is a disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility. It consequently increases the fracture risk and a high socioeconomic impact [3, 5, 6, 12. 14, 15, 16]. Osteoporosis is a disorder characterized by abnormal rarefaction of the bone occurring most frequently in postmenopausal women. It is also called a silent epidemic or a silent disease [11]. That may go undetected till the harmful consequences occur like fragility fractures, bone pains, spine fractures, etc. Osteoporosis is three times more in women than in men. The bone loss occurs in women during perimenopause and is associated with estrogen insufficiency, a condition of menopause. 70% of Women age over 80 years have osteoporosis [1]. Osteoporosis means 'porous bones. It arises when the struts which make up to the mesh-like structure within bones become thin, fragile, and break easily following a minor bump or fall. These broken bones are often mentioned as fragility fractures. Although fractures can occur in any part of the skeleton, the wrists, hips, and spine are most commonly affected following low-trauma injuries (e.g. a fall from standing height). These fractures lead to the pain associated with osteoporosis. It is the most common metabolic bone disorder and remains an increasingly significant problem, affecting 200 million individuals worldwide. [4].

II. EASE OF USE

A. Need of Vibration

Vibration technique has been used for many engineering applications for many years, but its potential in medical diagnostics is now beginning to emerge. The unique relationship between resonant frequencies and material properties has led to the use of vibration. Vibration Technique is a non-invasive technique for determining the stiffness of long bones. This technique assesses the effect that osteoporosis may have on the mechanical properties [3, 8, 10, 15]. Vibration technique has also been used to diagnose the occurrence of a bone fracture, determine the rate of healing of fractures, and detect loosening of hip prosthetic [9, 10]. This technique is cost-effective, transportable. The data obtained from this technique is directly related to the mechanical condition of the bone [15].

B. Indian and Asia Scenario

Based on 2001 statistics, around 163 million Indians are over the age of 50 this number is expanded 230 million by 2015. The conservative estimates propose 20 % of women and about 10-15 % of men would be osteoporotic [5, 7]. Around 25 million people were affected by this osteoporosis disease in the Indian population in the year 2001 and it increases in numbers in the year 2015 to 50 million. If the lower bone density is shown to confer a greater risk of fracture [5]. A recent conservative estimate suggests that hip fracture rates in India may be lower than in Western Caucasians and the number of hip fractures occurring annually in India exceeds 140,000 (80,000 women; 60,000 men) [5]. In 1994, the World Health Organization (WHO) declared that osteoporosis was a worldwide issue and prescribed bone mineral density (BMD)

study for early detection of osteoporosis with the postmenopausal population.

III. MATERIALS AND METHODOLOGY

3.1 Test specimens

For experimentation testing, femur goat bones were used. Femur goat bones weight is near about 60 to 80 gm and an overall length varies from 150 to 200 mm and the shaft length is between 80 to 140 mm.

3.2 Experimental method

Each femur goat bone was processed by first removing its soft tissues (skin and muscle). It was then placed on 50 mm thick soft foam to approximate a free-free support condition. An accelerometer (352c33 TYPE) is fixed with the help of beeswax on the bone at the middle of the length and used impact testing to find the natural frequency of the bone. The recording duration of each trial was two seconds. LabVIEW and a National Instrument data acquisition system 9234 (c-DAQ) was used to digitally record and store the responses.

3.3 Experimentation on femur bone

In fig 1 experimental setup is shown. For experimentation femur goat bones were used. The weight, length and volume of bones were measured. The weights, lengths and volumes are different for different bones. Experiments were carried out with free–free boundary condition by placing the specimens (bone) on a 50 mm thick soft foam. The various instruments used for experimentation such as Data acquisition system 9234 (c DAQ), Accelerometer and Impact Hammer. Recorded modes of natural frequency of femur bone, which ranges from 0–1000 Hz.

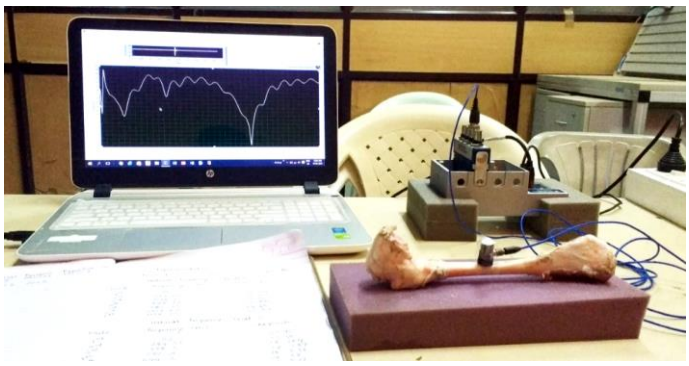


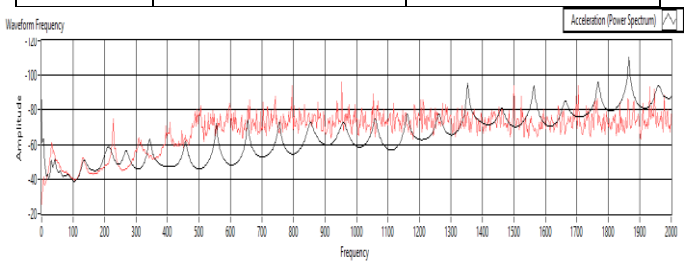
Fig 1: Experimental setup (Free-Free condition)

Experimentation on bone

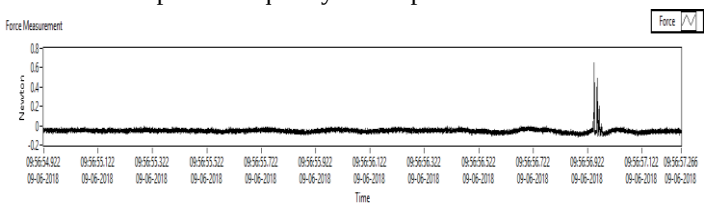
For bone, the weight, total length and shaft length of the bone are 65 gm, 170 mm and 80 mm respectively. The accelerometer position on bone is at the middle. NI instruments used to find out Natural frequencies of femur goat bone. The 1st Natural frequency of femur goat bone ranges from 25 to 32 Hz. For bone, 2 Trials have been carried out and this experimentation frequencies are closed to each other.

TABLE 1: EXPERIMENTAL NATURAL FREQUENCIES (HZ) GOAT FEMUR

Mode	Natural frequency (Hz) Bone	
	Trial 1	Trial 2
1st	25.6	32
2nd	85.33	94.5
3rd	170.7	185.2
4th	251.7	268.5
5th	307.2	343.4



Graph 1: Frequency vs Amplitude



Graph 2: Time vs Force

The fresh frozen femur goat bones were tested by modal analysis. The first mode of natural frequency varying between 25-40 Hz and impact force was applied on femur bone in between 1-10 N.

TABLE 2: EXPERIMENTAL NATURAL FREQUENCIES (HZ) GOAT FEMUR BONES

Mode Number	Bone 1	Bone 2	Bone 3	Bone 4	Bone 5
1st	25.6	25.5	27.75	27.5	25.6
2nd	96	95.5	115.2	98	85.33
3rd	160	158	198.4	160	170.7
4th	224	221.8	280	226	251.7
5th	288	285.8	363	290	307.2
6th	353	350	460	356	370.5
7th	425	436	531.2	430	454.6

IV. RESULTS AND CONCLUSIONS

For experimental modal analysis femur goat bones were used. Vibration analysis is used for finding fracture location of bone. Natural Frequencies also used to manufacture sport as well as biomedical equipment. The experimental results show that, the first fundamental frequency of various bone is nearly same if the weight, length and volume are different. It means that if the age of subject is near about same then the natural frequencies are also near to each other. Natural Frequencies also used to manufacture sport as well as biomedical equipment.

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