ANALYSIS & RAPID PROTOTYPING OF HUMAN HUMER BONE

A Project Report Submitted in partial fulfillment of

the requirements for the award of degree of

Bachelor of Technology

In

MECHANICAL ENGINEERING

By

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DEPARTMENT OF MECHANICAL ENGINEERING

SASI INSTITUTE OF TECHNOLOGY & ENGINEERING

(Approved by AICTE-New Delhi, Permanently Affiliated to JNTUK, Kakinada

and SBTET-Hyderabad, Accredited by NAAC with 'A' Grade

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Kadakatla, TADEPALLIGUDEM- 534 101

Academic Year 2021-2022

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CERTIFICATE

This is to certify that the project work entitled ***ANALYSIS & RAPID PROTOTYPING OF HUMAN HUMER BONE*** *is being submitted by* ***N. CHANDRA SEKHAR (19K65A0347), S. JAIKANTH (19K65A0364) and M. GOWTHAM (19K65A0378)*** *in partial fulfilment for the award of Degree of* ***BACHELOR OF TECHNOLOGY*** *in* ***MECHANICAL ENGINEERING*** *to the Jawaharlal Nehru Technological University, Kakinada during the academic year 2021-22 is a record of bonafide work carried out by them under our guidance and supervision.*

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Assistant Professor	**Assistant Professor**

External Examiner

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With Gratitude,

1.	N. Chandra Sekhar	19K65A0347
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SASI INSTITUTE OF TECHNOLOGY & ENGINEERING

KADAKATLA TADEPALLIGUDEM - 534 101. W.G.Dt., (A.P.)

Institute Vision and Mission

VISION

Confect as a premier institute for professional education by creating technocrats who can address the society's needs through inventions and innovations.

MISSION

1. Partake in the national growth of technological, industrial arena with societal responsibilities.
2. Provide an environment that promotes productive research.
3. Meet stakeholders' expectations through continued and sustained quality improvements.

Principal

DEPARTMENT OF MECHANICAL ENGINEERING - VISION AND MISSION

Vision

To be a recognized department in providing professional education, producing well-qualified mechanical engineers to serve the society.

Mission

1. Provide high quality education in Mechanical Engineering to cater the needs of industry and society.
2. Provide sustained conducive research-based learning environment.
3. Organize / participate in collaborated trainings related to managerial, interpersonal and leadership skills.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Graduates of B.Tech. Mechanical Engineering program will be able to

PEO1. Demonstrate academic excellence, managerial skills for a successful professional career with life-long learning

PEO2. Exhibit professional attitude, interpersonal and leadership skills

PEO3. Take up technical roles with professional ethics, innovativeness and social commitment

B1Gmurthy.
HOD

Department of Mechanical Engineering

Academic Year 2021-22

PROGRAM OUTCOMES

1. **Engineering Knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis:** Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. **Design/ Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
4. **Conduct investigations of complex problems** using research based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.
5. **Modern Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an under- standing of the limitations.
6. **The Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
7. **Environment and Sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9. **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
11. **Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long Learning:** Recognize the need for and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

PSO1. **Thermal & Production engineering Practice:** Ability to specify, fabricate, test, operate, or document the thermal & production systems or processes

PSO2. **Design using Solid Works & AutoCAD:** Ability to analyze, design, develop, implement, engine components.

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HOD

ABSTRACT

Bones are living tissues, consists of minerals like calcium and phosphorus. They grow rapidly during one's early years and renew themselves. The Bone is considered as a linear-elastic, isotropic and homogeneous material. Bones are the essential part of the human skeleton. Trauma (physical injury) is a major cause of death and disability. Most of the Bone fractures in daily life occur within the Humer Bone and Femur Bones. To beat this stress concentration and unsustainable pain correct Bone implant is needed. The project describes to find best suitable material for Human Bone implant by evaluating specific properties of material. The Material properties are evaluated by using Ansys Workbench software and the prototype model is created by using Rapid Prototyping technique. The objective of this Project is to study Humer Bone under various loading conditions, such as Tensile Load, compressive Load, Shear Load, and Point Load. By doing Analysis on different materials (Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, PLA) we had found out the best material based on the stresses, strains, Total deformation, shear stress in static analysis and the deformations at different frequencies in modal analysis. Finally, project concluded with the best materials that suitable for Human Humer Bone.

Expected POs, PSOs

PO1: Engineering knowledge

PO2: Problem analysis

PO5: Modern tool usage

PO7: Environment and sustainability

PO9: Individual and team work

PO11: Project management and finance

PSO1: Thermal and Production Engineering Practice

PSO2: Use of Auto CAD and SOLIDWORKS

LIST OF FIGURES

CHAPTER-1

INTRODUCTION

BONES IN HUMAN SKELETON

Bones are the most essential parts of the body. There are 206 bones in the Human skeleton and the Humer bone is the longest bone in upper part of skeleton. The main function of the human bones is to provide support. Bones are made up of

a framework of a protein called collagen, with a mineral called calcium phosphate that makes the framework hard and strong. Bones store calcium and release some into the bloodstream when it's needed by other parts of the body.

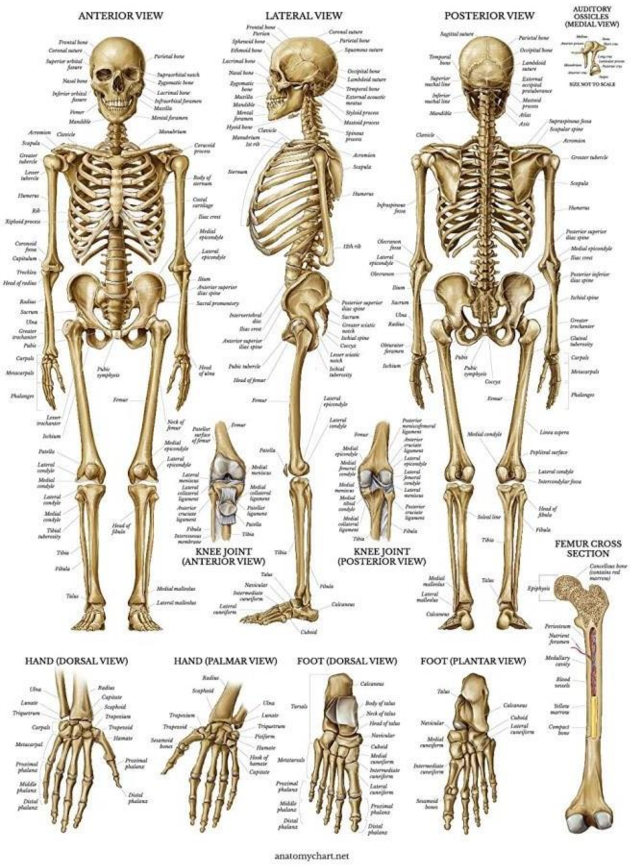


Fig.1.1 Bones of Human skeleton system

HUMER BONE

- The Humer is the only bone in the thigh and it is the longest bone in the body. It acts as the site of origin and attachment of manymuscles and ligaments.
- The Humer is Long, Strong, and Heavy

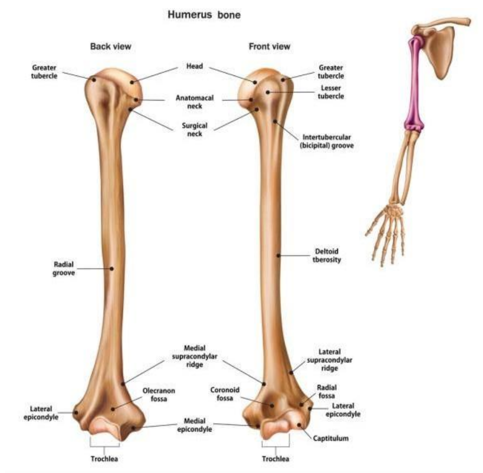


Fig.1.2 Humer Bone

FRACTURES IN HUMER

Based on the type of load acting on the Humer it is subjected to various types of failures. As per we have studied we can say that Humer bone is mainly exposed to Point Load, Shear Load, and Compressive loads.

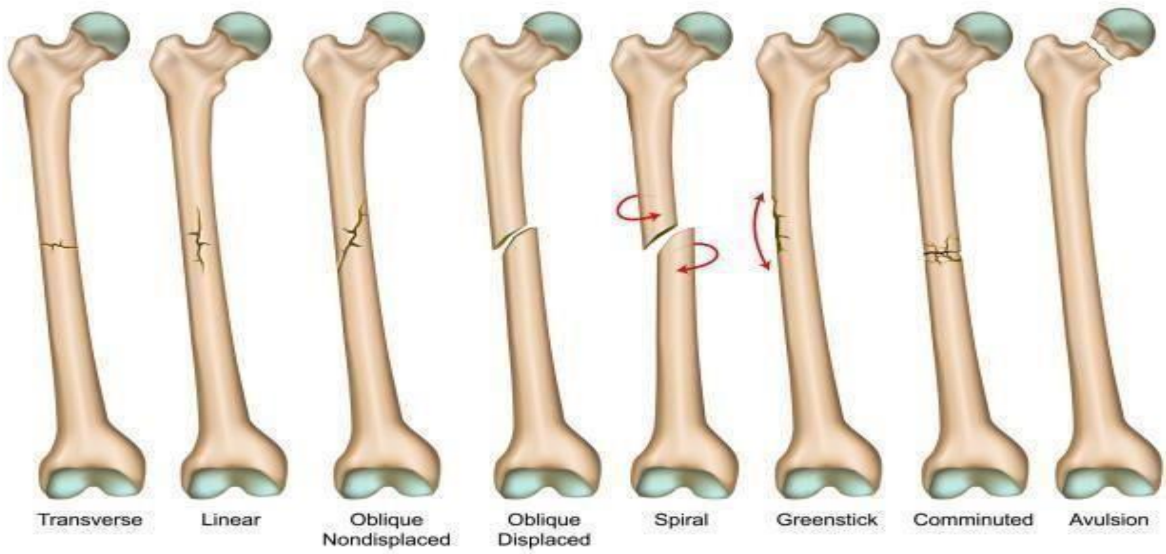


Fig.1.3 Fractures in Humer

TYPE OF LOAD & APPLICATION

1. Point Load - Bullet Shot, & Vehicle Collision
2. Compressive Load - Human Body Weight, & Climbing Steps
3. Shear Load - Crush between Elevator Doors

BONE FAILURE IDENTIFICATION METHODS

- X-RAY

- MAGNETIC RESONANCE IMAGING
- COMPUTERIZED TOMOGRAPHY SCAN

HUMER X-RAY SHOW

A Humer X-ray can help find the cause of symptoms such as pain, tenderness, swelling, or deformity of the upper arm.It can detect a broken bone, and after a broken bone has been set, it can help determine whether the bone is in satisfactory alignment.

Fig.1.4 Humer bone in X-Ray

MAGNETICRESONANCE IMAGING

This technique has good sensitivity and specificity for humeral joint fractures and also shows soft tissue injuries that are often present in isolation or associated with such fractures. Early magneticresonance imaging is more cost effective than other diagnostic strategies.

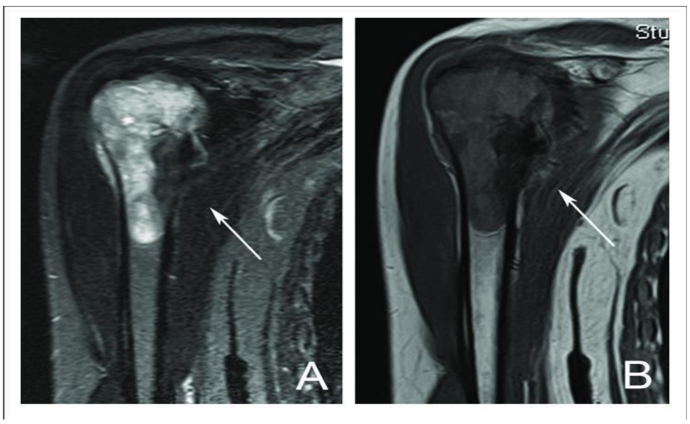


Fig.1.5 Humer bone in MRI

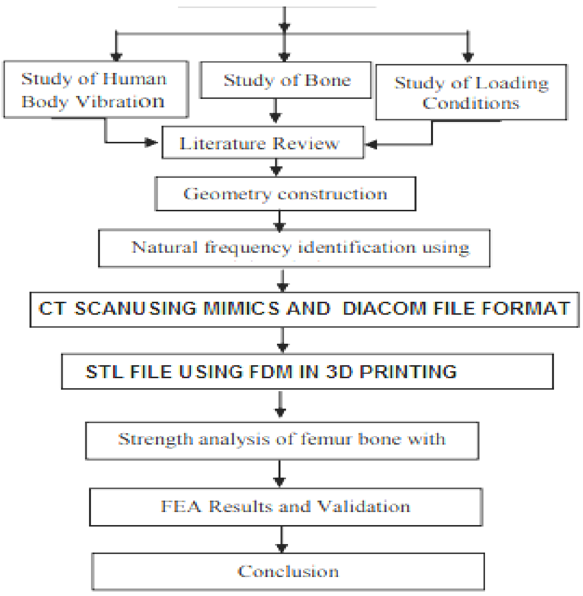
COMPUTERIZED TOMOGRAPHY SCAN

A CT scan of the bones may be performed to assess bones, soft tissues, and joints for damage, lesions, fractures, or other abnormalities, particularly when another type of examination, such as X-rays or physical examination are not conclusive.

Fig.1.6 Humer bone in CT

METHODOLOGY

HUMER BONE



SCOPE OF STUDY

In the case of bone surgery after consulting with Doctors most of the bone fracture in day-to- day life happens within the Femur bone and Humer bones.

Mismatches will occur between real bone and implants typically inflicting stress concentrations and premature implant failure. Additional conventional machining of metallic element implants, with 5-Axis High Speed machining that offers benefits. However, they have disadvantages like Machining of metallic element will be done economically on a routine production basis and the dimensions may be fluctuated. The paper contains process of preparing prototype of Humer bone and also do the stress analysis by using CT scan as input data. About Humer bone, Humer is the longest bone in the upper extremity. And also the strongest bone in the human body. Its length on average is 16.9% of a person's height. Humer fractures can happen when a great force is put on the side of the arm or when the arm is pushed/pulled on, extending the force upward to the Humer. This kind of force happens with a fall from a great height or an automobile injury. Fractures of the Humer can happen near the ball at the upper part of Humer and are called “proximal Humer fractures”. A true Humer fracture happens in the shaft of the Humer. Such fractures operate under the force of a great deal of muscle strength so they almost always displace.

OBJECTIVES OF THE PROJECT

- Design of CAD Model/Reference CAD Model
- Identifying the Material that used for Bone Implant
- Static Analysis
- Model Analysis
- Rapid Prototyping

CHAPTER-2

LITERATURE REVIEW

A literature survey is an essential part of performing any investigation. A lot of research articles and papers have been published in the field of Static and Modal analysis of Humer bone and different materials of Humer bone among which some of important literature survey discussed below:

- Francis and Kumar performed the three dimensional finite element modeling using Computed Tomography (CT) data that accurately predicts information about bone morphology and tissue density. Modeling of the proximal Femur of the three samples (17 yr, 32 yr, 40 yr) was done using CT data for their individual weights. When half of the load of the body was applied on the head of the right proximal femur it was discovered that safety factor was highest in case of the middle aged (32 yr) sample. Same was the case when the data for the bone mineral density was observed.
- Yousif and Aziz had done the biomechanical analysis of human Femur bone during normal walking and standing conditions. They modeled a human Fumer bone of a 40-year-old healthy individual whose weight is 75 kg and which was reconstructed from DICOM (CT) images. They had fixed the distal end of the Femur and on the head of the Femur the hip contact forces had been applied for the calculation of the normal stresses in normal walking and standing up conditions. After that the boundary conditions were interchanged and the result average was considered. It was observed maximum normal stress for both normal walking and standing up conditions was observed at the neck of the Femur.
- Jennie Walker, System of Life Skeletal System, Nursing Time [online], Research Article, February 2020. He tells about the bone is important part of musculoskeletal system and serve many core functions, as well as supports the entire body.
- Aydin Kabakci, et. al, International Journal of Morphology, an osteometric study on humerus bones, October 2017. This journal tells about morphometric measurements were classified into three groups such as proximal epiphysis, humerus diaphysis and distal epiphysis of humerus.

Mean, minimum, maximum and standard deviation values of all parameters were determined

- Dilpreet Singh et al. prepared a report on This work discusses the biomechanical testing of 3elbow bones, namely the humerus, ulna, and radius. The following tests were performed: 3-point bending, fracture toughness, and axial compression. Six sets of whole-bone samples of human male cadaveric humerus, ulna, and radius (age of donor: 35 to 56 years) were tested. The results were analyzed for statistical significance by 2-stage, repeated-measure analysis of variance (ANOVA). The difference between the bending strength of the humerus, ulna, and radius was statistically significant (P = .001) when compared to one another. However, the fracture toughness and compressive strength were observed to be similar for the 3 bones. However, in the case of compressive strength and modulus for bending, no significant difference was observed among the elbow bones. The elbow bones' properties such as bending strength, bending modulus, compression strength, compression modulus, fracture toughness, and elastic modulus are observed to be different from the femur bone properties. They concluded that as the number of bones taken was small so significant differences were shown in the result.
- Salim Mulla and Dr. Subim Khan studied the bones comes in a variety of shapes and sizes and has complex internal and external structure. During daily activities, the skeletal system is subjected to a complicated loading exerted by the different loading conditions. Such loading modes for femur bones are include tensile, compressive, bending, and torsional forces applied to the bones of the skeletal system. Modeling the patient's unaffected bone by scanning it through CT scan as a source and then designing it three dimensionally by using ANSYS software. In their project femur bone is modeled and analyzed with four different materials. Out of these materials used TI-6AL-4V & PLA is found out to have less equivalent stress & corrosion and wear resistance of the materials.
- Pressure at different joints like hip joint, elbow joint a Popa et al. presented the method and steps to model a virtual bone. The model was prepared with the help of the CAD software and it was attached to the other bones. Finite

element method can be used for stress analysis and model prepared can be used for kinematic and dynamic simulation. In their study all the important steps explaining all the features required for the modeling of a human Humer was explained in detail. That detailed explanation could be utilized for the model development. and knee joint was also compared.

- M M Rashid et al. discussed about geometrical model creation methods for human humerus bone and modified cloverleaf plate. In the field of orthopedic surgery, for the treatment of bone fracture orthopedic surgeons use external and internal fixation methods, or combinations of these two techniques. Geometrical 3D models of internal fixation implants and human bones are being created by various computer based methods and technical features. These methods include application of computer visualization techniques like Medical Imaging, Computer-Aided Design, Finite Element Analysis, etc. They also discussed about newly developed methods for the creation of surface model of human humerus and parametric model of the modified cover leaf plate.
- Dr. D. Chandramohan et al. obtained data from CT images combined with digital CAD and rapid prototyping model for surgical planning and this new application enables the surgeon to choose the proper configuration and location of internal fixation of plate on human bone during orthopedic surgery.
- Ludmila Novakova et al. discussed about rapid prototyping technologies the initial state of material can come in either solid, liquid or powder state. The current range materials include paper, metals and ceramics. In fused deposition modeling are used as basic material ABS - Acrylonitrile Butadiene Styrene, polyamide, polycarbonate, polyethylene. In its place of these materials in special FDM applications can be used silicon nitrate, PZT, aluminum oxide, hydroxyapatite and stainless steel for a variety of structural, electro-ceramic and bio-ceramic applications

CHAPTER-3

MATERIALS FOR ANALYSIS

CLASSIFICATION OF MATERIALS

Calcium Phosphate

Calcium is necessary for many normal functions of the body, especially bone formation and maintenance. Calcium can also bind to other minerals (such as phosphate) and aid in their removal from the body. Calcium phosphate-based biomaterials and bio ceramics are now used in a number of different applications throughout the body, covering all areas of the skeleton. Applications include dental implants devices and use in periodontal treatment, treatment of bone defects, fracture treatment, total joint replacement (bone augmentation), orthopedics, cranio- maxillofacial reconstruction, otolaryngology and spinal surgery. Because of the existence of pores, calcium phosphate exhibits mechanical properties such as high brittleness, low impact resistance, and low tensile stress.

Strontium

Strontium is the chemical element with the symbol Sr and atomic number 38. An alkaline earth metal, strontium is a soft silver-white yellowish metallic element that is highly chemically reactive. The metal forms a dark oxide layer when it is exposed to air. Strontium has physical and chemical properties similar to those of its two vertical neighbors in the periodic table, calcium and barium. It occurs naturally mainly in the minerals Celestine and Strontianite, and is mostly mined from these.

While natural strontium (which is mostly the isotope strontium-88) is stable, the synthetic strontium-90 is radioactive and is one of the most dangerous components of nuclear fallout, as strontium is absorbed by the body in a similar manner to calcium. Natural stable strontium, on the other hand, is not hazardous to health

Steel (304)

Stainless steel 304 is widely used in all sorts of industrial and domestic applications. Within the medical device industry, 304 are used where high corrosion resistance, good formability, strength, manufacturing precision, reliability and hygiene is of particular importance. Stainless Steel 304 is regarded the world over as one of the most suitable materials for the manufacture of medical devices for all sorts of applications. In fact, it is the most common stainless steel used in the world today. No other grade of stainless steel comes in so many forms, finishes and with such diverse applications. Stainless Steel 304 Properties offer unique material characteristics at a competitive price point, thus making it the logical choice for medical device specification. A high corrosion resistance and low carbon content are key factors that make Stainless Steel 304 suitable for medical applications over and above other grades of Stainless steel.

TI-6AL-4V

Ti-6Al-4V (UNS designation R56400), also sometimes called TC4, Ti64, or ASTM Grade 5, is an alpha-beta TI-6AL-4V alloy with a high specific strength and excellent corrosion resistance. Ti- 6Al-4V (UNS designation R56400), also sometimes called TC4, Ti64 or ASTM Grade 5, is an alpha-beta TI-6AL-4V alloy with a high specific strength and excellent corrosion resistance. It is applied in a wide range of applications where low density and excellent corrosion resistance are necessary such as e.g. aerospace industry, and biomechanical applications (implants and prostheses). Studies of TI-6AL-4V alloys used in armors began in the 1950s at the Watertown Arsenal, which later became a part of the Army Research Laboratory. Increased use of TI-6AL-4V alloys as biomaterials is occurring due to their lower modulus, superior biocompatibility and enhanced corrosion resistance when compared to more conventional stainless steels and cobalt- based alloys. These attractive properties were a driving force for the early introduction (Ti— 6Al—4V) alloys.

PLA

PLA, short for Polylactic acid, is a common material for FDM 3D printing and one of the most used bioplastics in the world. Unlike petrochemical-based plastics, PLA is considered to be biodegradable and eco-friendly. This material is extremely affordable and, is easiest to 3D print. PLA is a great first material to use as you are learning about 3D printing because it is easy to print, very inexpensive, and creates parts that can be used for a wide variety of applications. It is also one of the most environmentally friendly filaments on the market today.

TABLE 3.1: material properties

Materials	Density G/Cm^3	Possions Ratio (μ)	Young's Modulus (Mpa)	Tensile Strength (Mpa)
Calcium Phosphate	3.16	0.27	105	180
Strontium	2.6	0.28	157	88.6
Steel(304)	8.00	0.3	193	650
TI-6AL-4V ALLOY TI-6AL-4V	4.429	0.3	119	1200
PLA	1.25	0.29	3100	35.6

Chapter 4

CAD MODEL IN SOLIDWORKS

INTRODUCTION

As your first step to mastering the use of solid works we are going to review the user interface or the SolidWorks window. To begin, using the left mouse button double click on the SolidWorks icon on the PC desktop screen to open the program. If there is no icon visible the program can be started through Start - All Programs – SolidWorks 2017. You can access commands in SolidWorks using menus, toolbars and the mouse. The SolidWorks interface is dynamic in that different toolbars and menus appear depending on the active document type.

System Requirements

Processor: 3 GHz or higher clock speed (preferably closer to 4 GHz)Operating System: Windows 10 (64-bit)

Memory: 32GB to 64GB

Hard Drive: Solid State Drive (SSD), maintaining at least 20GB free space Graphics Card: NVIDIA Quadro P1000/2200, AMD Radeon Pro WX 3100/4100

DESIGN PROCEDURE IN SOLIDWORKS

Modeling methods and processes the modeling process mainly includes image processing, information extraction, surface reconstruction and entity reconstruction. Firstly, the original information of Humer is obtained from the gray-scale image of CT image through the processing of CT image acquisition, threshold segmentation, region growth and mask editing, and triangular mesh surface is obtained by rapid pre-modeling. If there are no noise points, the surface is reconstructed by reverse engineering, and the data in reverse engineering modeling are divided into blocks. The three-dimensional solid model of Humer is completed by surface fitting and entity generation.

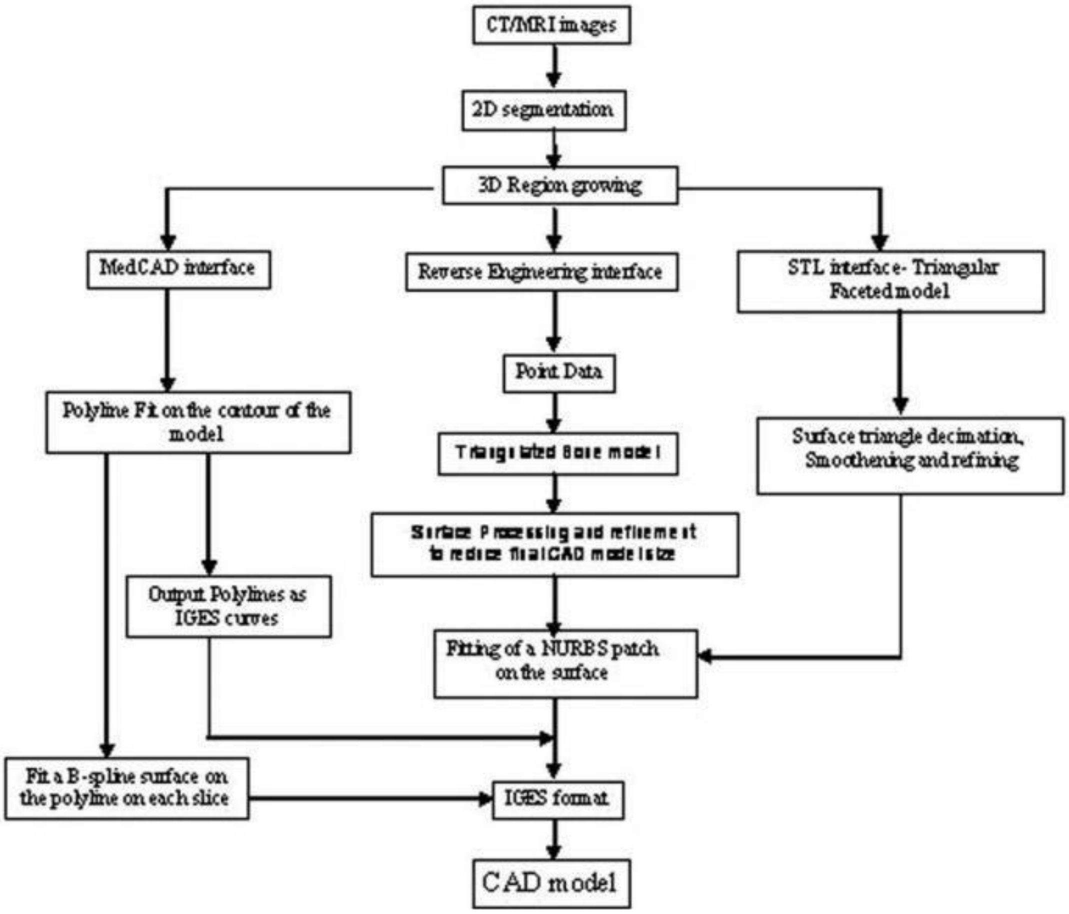


Fig.4.1 Flow chart for CAD Model

The Image acquisition and processing of CT after CT image in the DICOM format is imported into Mimics, the image information with different gray characteristics, including bone tissue, muscle, cartilage and so on, is obtained. When acquiring CT scanned image, it will be obtained due to interference of external factors. Images are affected by noise, resulting in local blurring and ambiguity of the image. These interference factors will have a great impact on subsequent image processing and analysis. Therefore, the imported image must be processed by threshold segmentation, region growth and mask editing. The import of the CT image shows that the untreated CT image information of Humer is highly integrated with surrounding tissues and other structures, and cannot directly extract the image information of Humer.

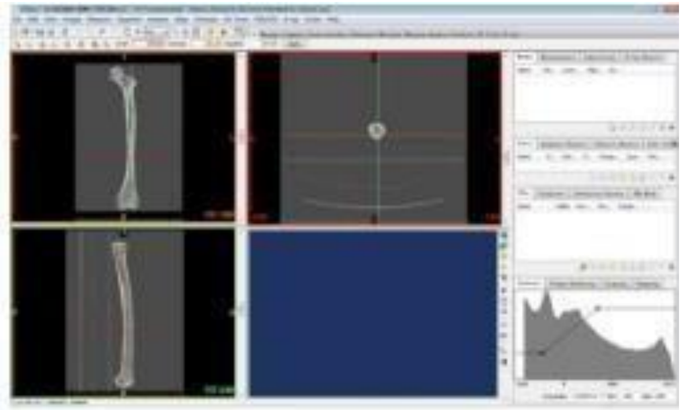


Fig.4.2 CT scan image

Threshold Segmentation

In the practical application, in order to divide the Humer tissue information and surrounding tissue information in the gray image according to the level, the threshold selection method of gray histogram is often used to binarize the gray image the binary method can extract the Humer from the tissue.

Fig.4.3 Image grayscale processing of CT (a) Original image (b) Binarization

Preliminary modeling After the above processing, all the features of the Humer have been selected, and then the selected femoral mask is pre-modeled and the three-dimensional skin model calculated from the humeral tomography image is generated. If there are noise points in the generated three-dimensional skin, the mask edition is refined again, and if there are no noise points, the edition begins. The comparison of mask editing before and after repair It can be seen from that the noise points after mask editing are significantly reduced.

Fig.4.4 Mask Editing

Solid Model Building

The reconstructed models are only triangular meshes enveloped on the surface of the model, not entities. However, these triangular meshes can be reconstructed by the reverse engineering method, and femoral entity can be generated, which lays the foundation for subsequent mechanical analysis. Because of the complexity of the femoral contour surface, and soildworks has powerful function of surface modeling design and powerful ability of surface comprehensive analysis, this paper reconstructs the femoral surface based on the solidworks platform. The flow chart of surface modeling.

Data Segmentation

Because the external contour of Humer is a complex surface and the change of curvature is large, triangular meshes need to be regionalized according to the change of curvature, and different facet elements need to be constructed accordingly. The Humer is divided into three segments according to its convexity and concavity, and the upper and lower segments are reconstructed in turn.

Curve Reconstruction

Taking the middle Humer as an example, different datum planes are selected to form intersecting lines with triangular meshes, and the intersecting lines are reconstructed on the datum planes. The intersecting lines between the grid planes and the datum planes respectively. Because the intersections on the reference plane are reconstructed by B-spline lines, and the three-point collocation method is used to reconstruct the curves in this paper, the saw tooth edge of the periphery is effectively avoided, and the quality of the whole curve is reduced due to the excessive local curvature.

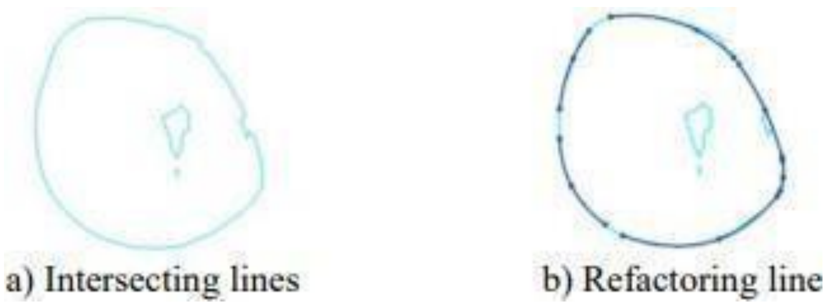


Fig.4.5 Curve construction

Surface Reconstruction

In the process of surface reverse design, Bezier, B-Spline and NURBS surfaces are mainly used. Because NURBS method has good surface quality, relatively fast speed, stable algorithm, and can accurately represent quadratic regular curves and surfaces, this paper mainly uses NURBS surface method to fit femoral surface. The principle is as follows: Using NURBS surface method, the initial surface of surface reconstruction, i. e. the basic surface, is constructed by extracting the curves with the same convexity and concavity on different reference surfaces. The basic surface constitutes the main part of the whole surface and provides the basis for the subsequent creation of transition surface. shows the curve used to construct the initial surface, and Figure 8-B completes the creation of the initial surface.

Fig.4.6 Surface reconstruction

Transition Curved Surface

After the initial surface is completed, the adjacent boundary is the curve generated in the processof the plane, which will interfere with the creation of the following transition surface. The boundary is trimmed by stretching plane, which provides a basis for the successful creation of the transition surface. Fig. 9-a and 9-b are before and after basic surface trimming respectively. After pruning, the two adjacent initial surfaces are basically in a parallel state, so that the transition surfaces between the two surfaces can be reconstructed smoothly and the quality of the surface can be improved, thus effectively avoiding the sharp corner phenomenon in the creation of the transition surface

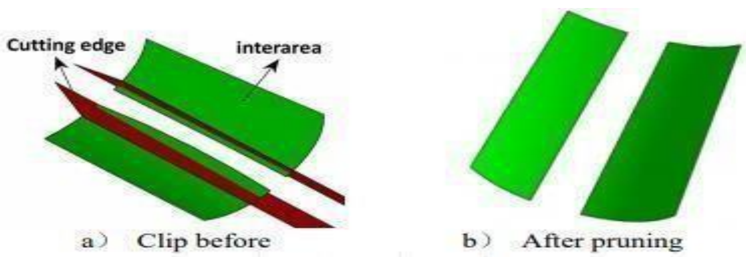


Fig.4.7 Transition curved surface

Entity Model

After the transition between pavement and adjacent surfaces is completed, some closed polygonal holes will be produced, which can be filled with appropriate curved surfaces and be continuous with the surrounding curvature or tangent. After the above process, although the external contour of Humer has been formed and there is a continuous relationship between them, it is not a whole. Surface stitching should be used to merge them into one. Firstly, the middle Humer is designed, then the upper Humer is designed, and finally the lower Humer is modeled, and the three parts are connected by the above transition surface and filling surface. As shown in Fig.11, for the process of creating the whole femoral surface, comparison between the effect of the three-dimensional model of the whole femoral entity and the triangular mesh surface introduced. From the 12 drawings, it can be seen that the reconstructed three-dimensional entity model has a high coincidence with the triangular mesh surface.

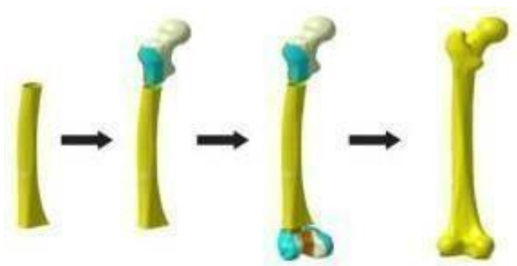


Fig.4.8 Reconstruction of the humeral surface

Fig.4.9 CAD Final object

The errors of reconstructed surface mostly come from the discrete errors of points cloud and the errors in the process of reconstructing reverse surface. The distance between the original points cloud and the reconstructed surface is analyzed by the method of distance measurement. If the maximum distance error between the reconstructed surface and the original point cloud is less than 0.5mm, it can meet the design requirements

Fig.4.10 Multiple views of Humer bone

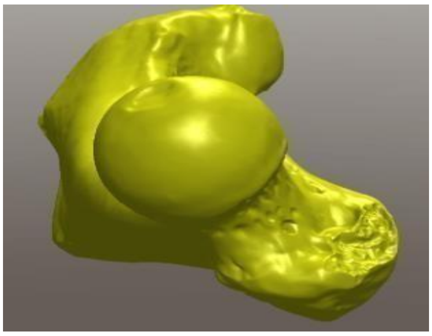


Fig.4.11 Top view of Humer bone

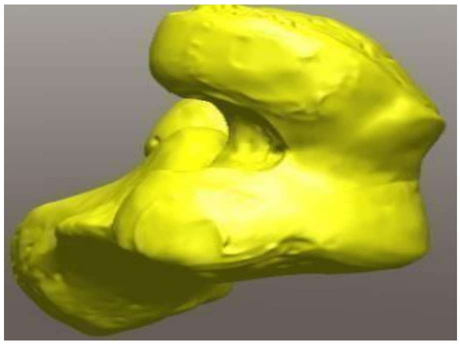


Fig.4.12 Bottom view of Humer bone

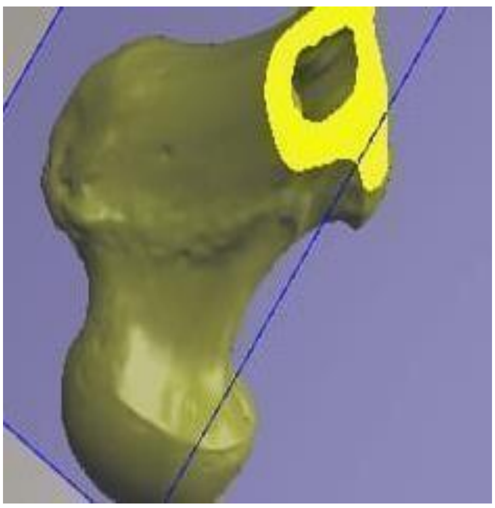


Fig.4.13 YZ Sectional view of Humer bone

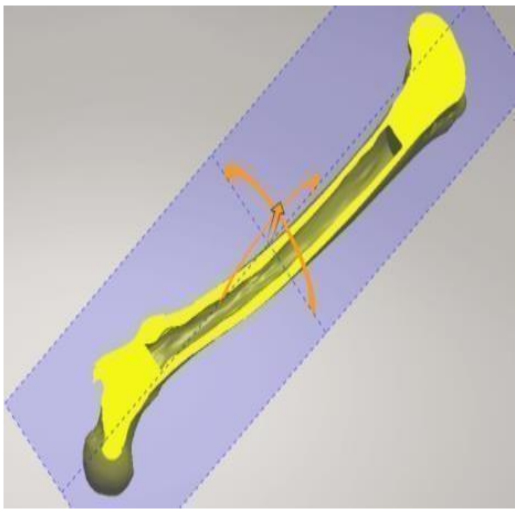


Fig.4.14 XY Sectional view of Humer bone

Chapter 5

ANALYSIS

INTRODUCTION TO ANSYS

ANSYS is a large-scale multipurpose finite element program developed and maintained by ANSYS Inc. to analyze a wide spectrum of problems encountered in engineering mechanics**.**

Material Models

ANSYS allows several different material models like:

- Linear elastic material models (isotropic, orthotropic, and anisotropic).
- Non-linear material models (hyper elastic, multi linear elastic, inelastic and Viscoelastic)
- Heat transfer material models (isotropic and orthotropic)
- Temperature dependent material properties and Creep material models.

Loads

The word loads in ANSYS terminology includes boundary conditions and externally or internally applied forcing functions, as illustrated in Loads. Examples of loads in different disciplines are:

Structural: displacements, forces, pressures, temperatures (for thermal strain), Gravity.

Thermal: temperatures, heat flow rates, convections, internal heat generation, Infinite surface.

Magnetic: magnetic potentials, magnetic flux, magnetic current segments, source currentdensity, infinite surface.

Electric: electric potentials (voltage), electric current, electric charges, chargeDensities, infinite surface

Fluid: velocities, pressures Loads are divided into six categories: DOF constraints, forces (concentrated loads), surface loads, body loads, inertia loads, and coupled field loads.

Chapter 5 ANALYSIS

Analysis Types

The following types of analysis are possible using ANSYS

- Structural Analysis: Static Analysis, Modal Analysis, Harmonic Analysis, Transient Dynamic Analysis, Spectrum Analysis, Buckling Analysis, Explicit Dynamic Analysis, Fracture mechanics, and Beam Analysis.
- Thermal Analysis: Steady-state thermal analysis, transient thermal analysis.
- CFD (Computational Fluid Dynamics) Analysis: Laminar or turbulent, Thermal or adiabatic, Free surface, Compressible or incompressible, Newtonian or Non-Newtonian, Multiple species transport.
- Several types of Electromagnetic field analysis and Coupled field analysis.

Commercial FEM Software Packages

1. ANSYS (General purpose, PC and workstations)
2. SDRC/I-DEAS (Complete CAD/CAM/CAE package)
3. NASTRAN (General purpose FEA on mainframes)
4. LS-DYNA 3D (Crash/impact simulations)
5. ABAQUS (Nonlinear dynamic analysis)
6. NISA (A General purpose FEA tool)
7. PATRAN (Pre/Post processor)
8. HYPERMESH (Pre/post processor)

Steps Involved in Ansys

1. Engineering materials (material properties).
2. Create or import geometry.
3. Model (apply meshing).
4. Set up (boundary conditions)
5. Solution
6. Results

STATIC STRUCTURAL ANALYSIS

The static structural analysis calculates the stresses, displacements, shear stress and forces in structures caused by a load that does not induce significant inertia and damping effects. A static structural load can be performed using the ANSYS WORKBENCH solver. The types of loading that can be applied in a static analysis include.

Mesh and Boundary Conditions

In order to get accurate results, it is required to have smaller aspect ratios and hence tetrahedron meshing is used for outer cylinder as it provides aspect ratio close to unity

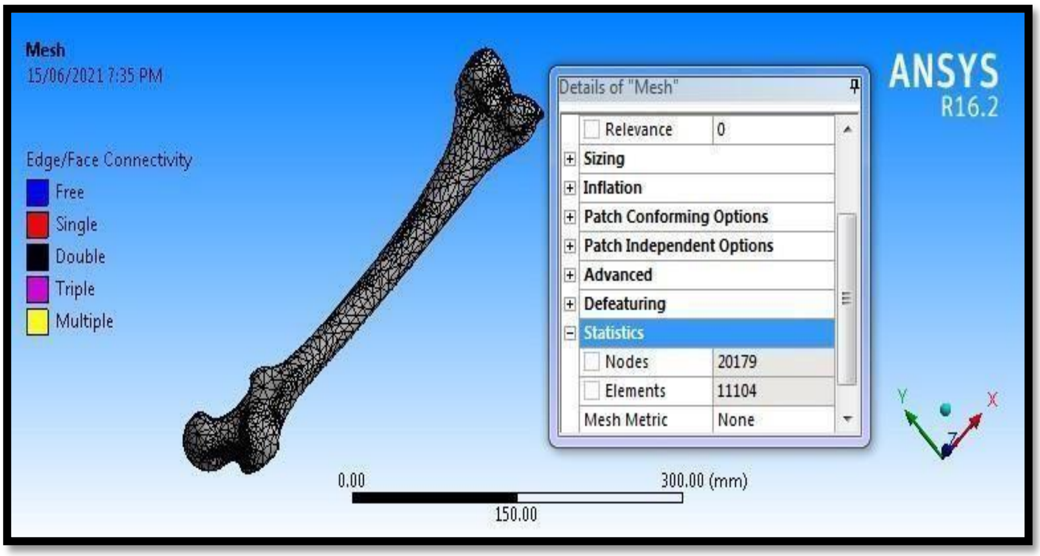


Fig.5.1 Mesh, Nodes: 20179, Elements: 11104

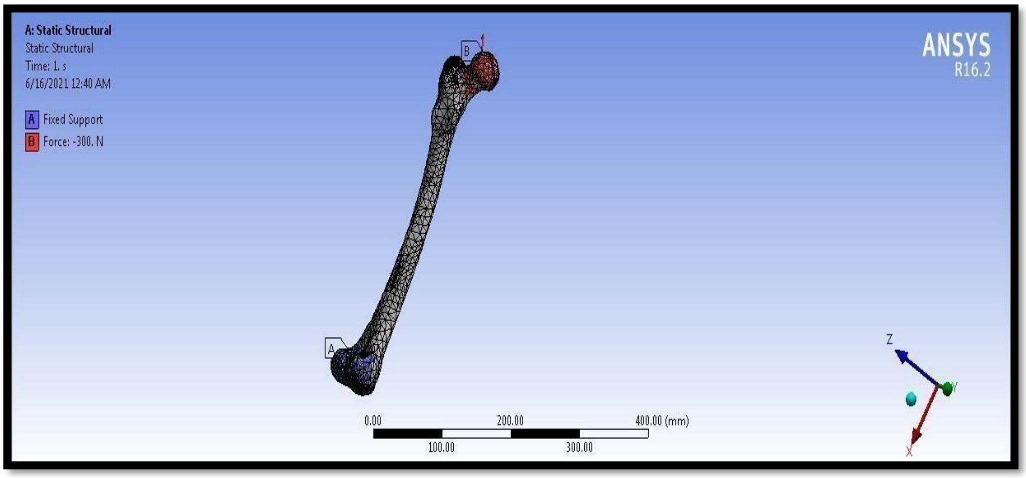


Fig.5.2 Tensile load 390N

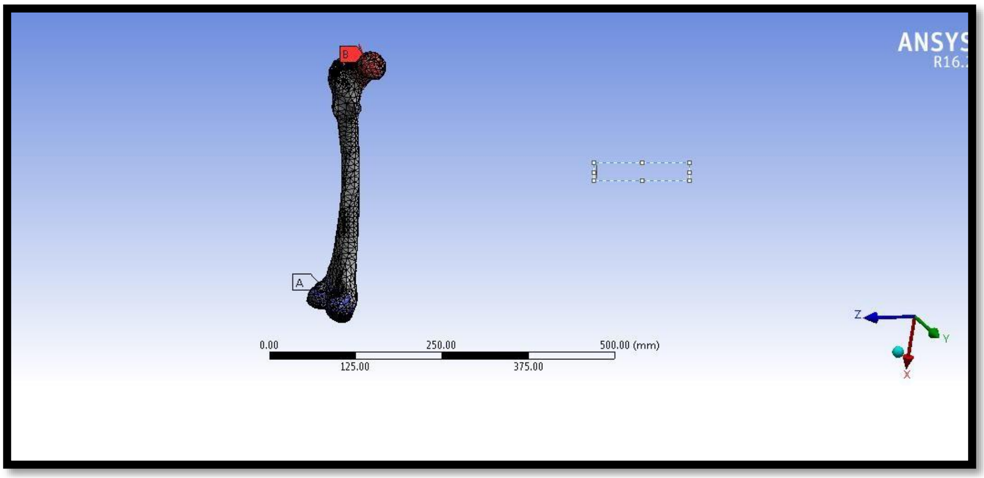


Fig.5.3 Compressive load 390N

Loads

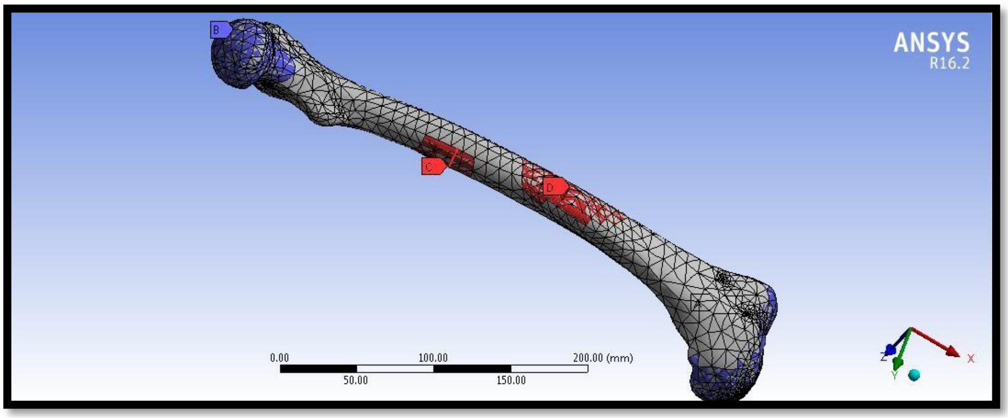


Fig.5.4 Shear Load 390N

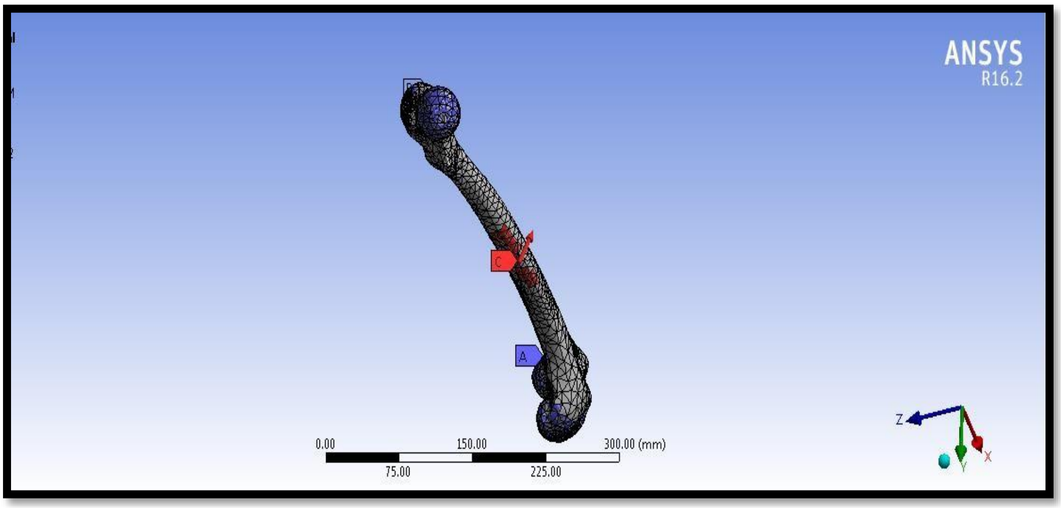


Fig.5.5 Point Load 390N

RESULTS AND DISCUSSIONS

In this project, the Humer bone is analyzed Static and Modal analysis method with the following materials (CALCIUM PHOSPHATE, STRONTIUM, STEEL 304, TI-6AL-4V, and PLA) to find out the best material.

Various loading conditions consider in this project tensile load, Compressive load, shear load, point load. Consider the dimensions of the Humer bone form existing patient from CT scan, MIMICS, and DICOM

To perform the static and modal Analysis Using the Ansys software of the Humer bone.

Static Analysis Results of Tensile Load

1. TENSILE LOAD OF CALCIUM PHOSPHATE MATERIAL

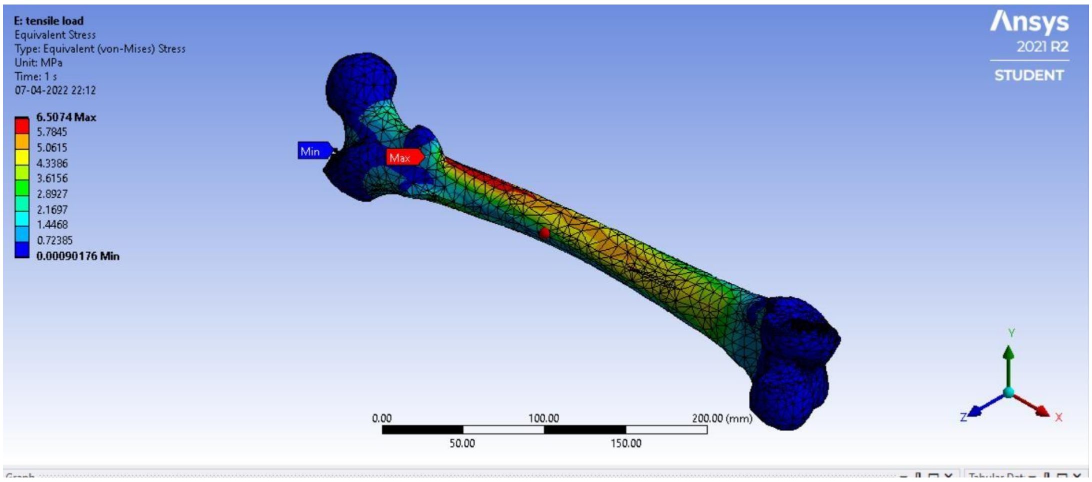


Fig.5.6 Von-misses stress of Calcium Phosphate Material

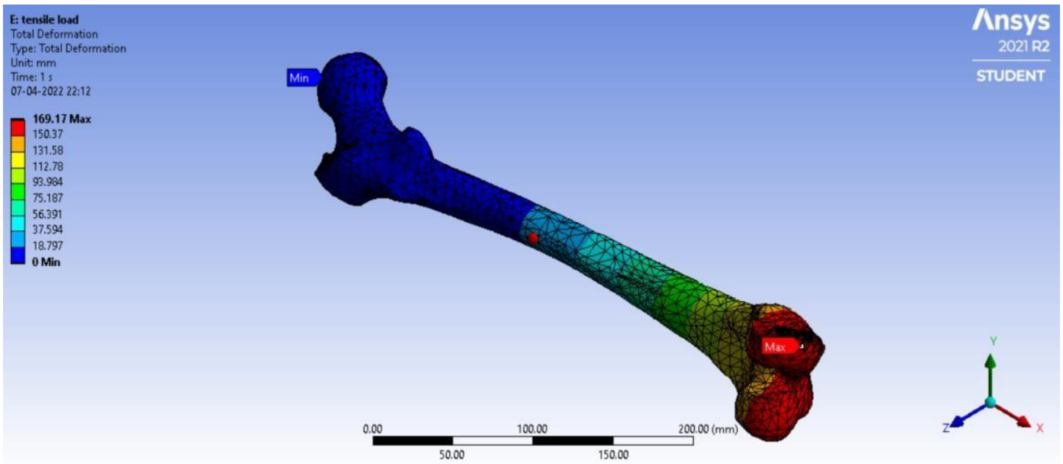


Fig.5.7 Total deformation of Calcium Phosphate Material

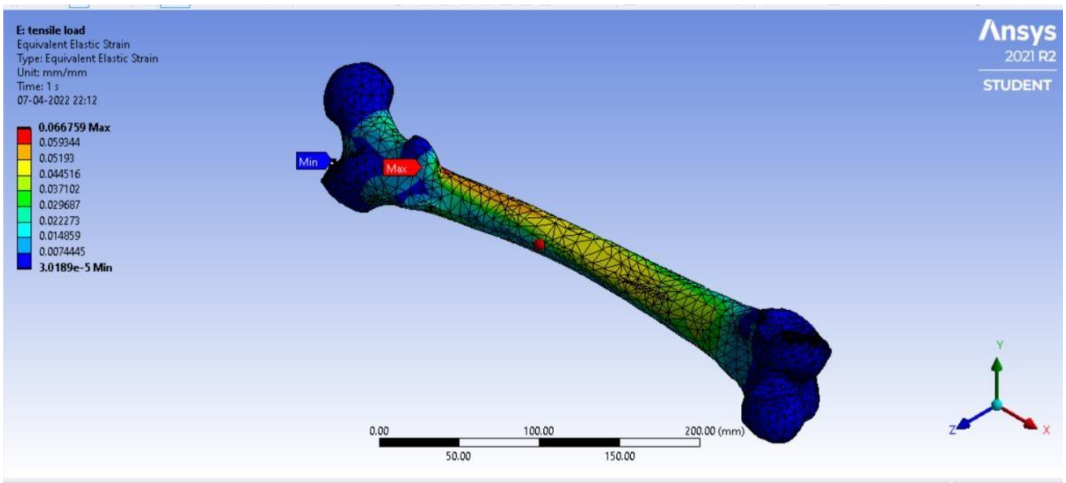


Fig.5.8 Strain of Calcium Phosphate Material

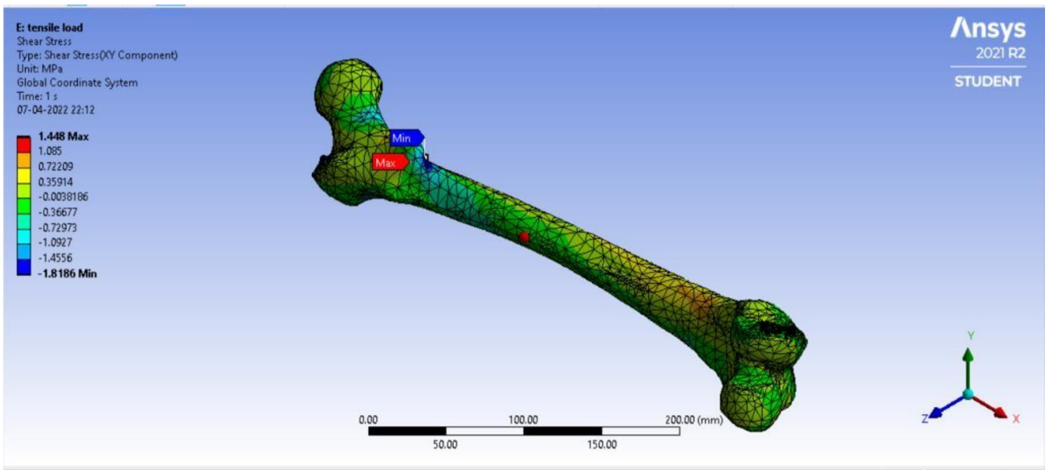


Fig.5.9 Shear stress of Calcium Phosphate Material

2. TENSILE LOAD OF STRONTIUM MATERIAL

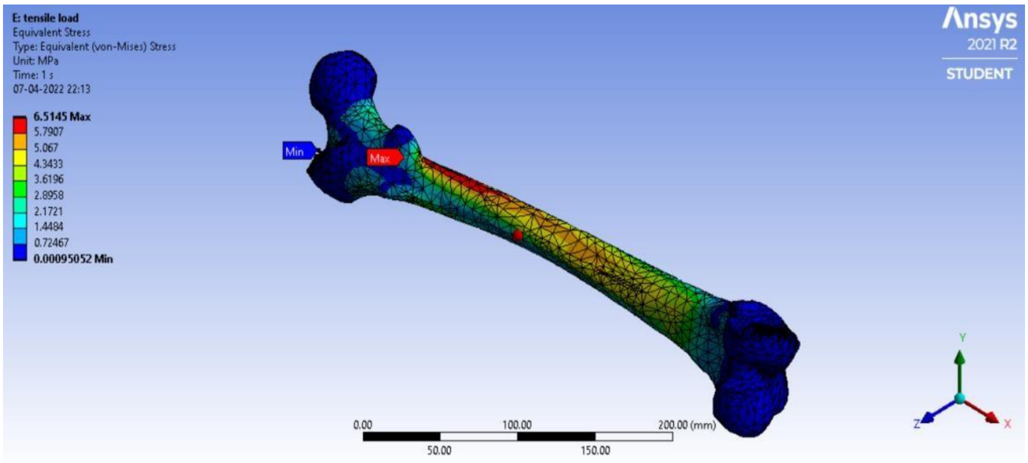


Fig.5.10 Von-misses stress of Strontium Material

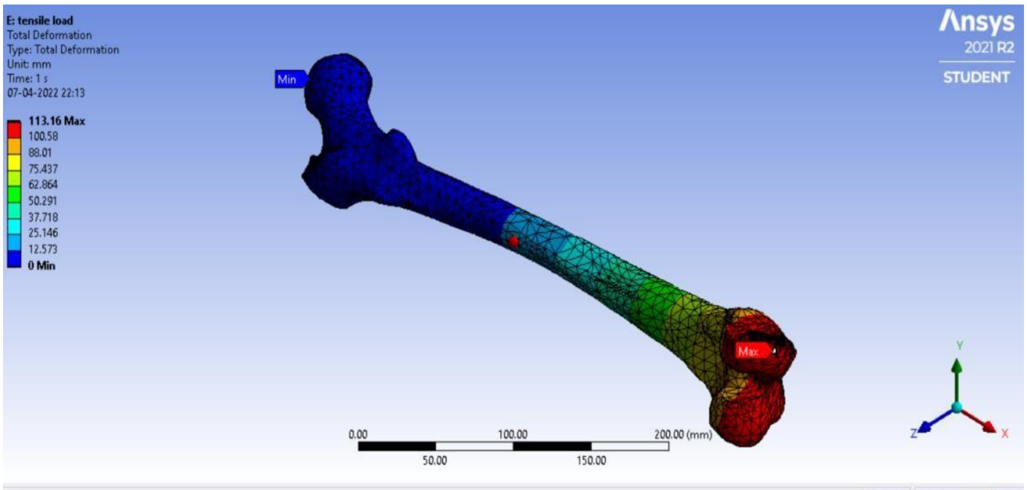


Fig.5.11Total deformation of Strontium Material

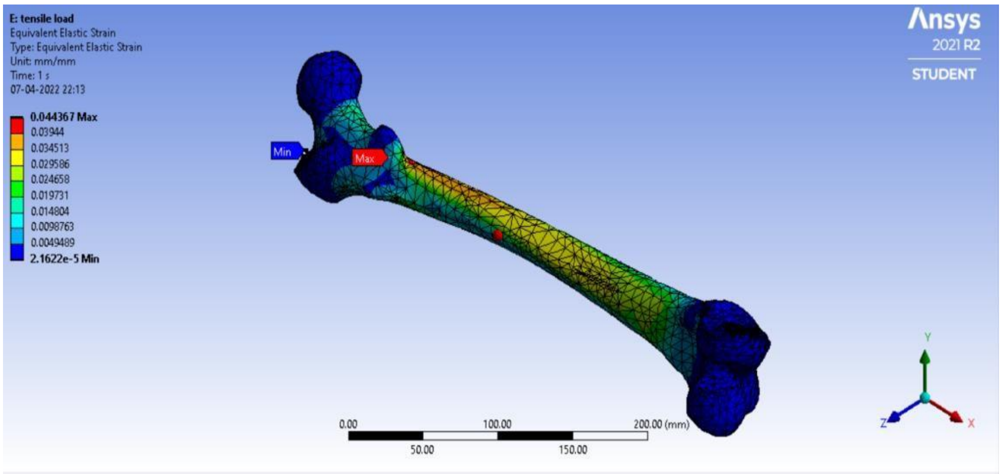


Fig.5.12 Strain of Strontium Material

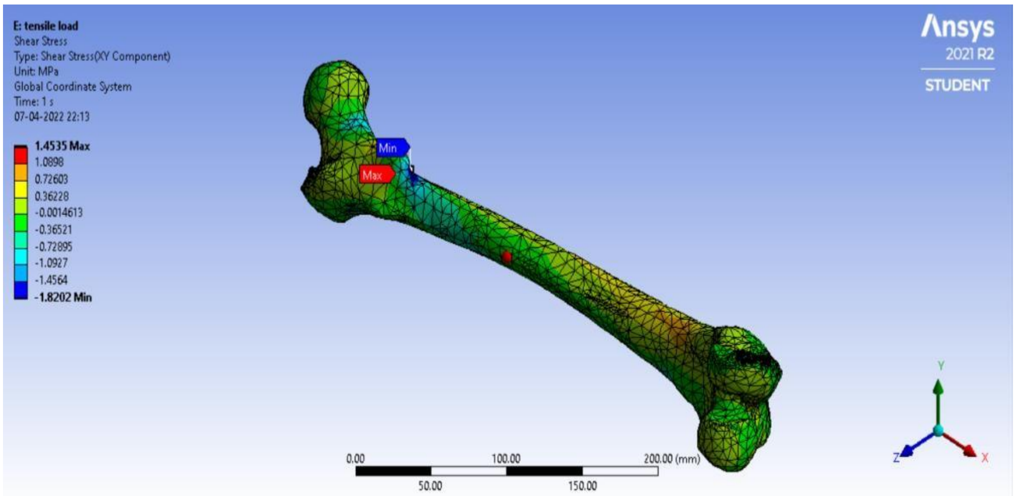


Fig.5.13 Shear stress of Strontium Material

3. Tensile Load of Steel 304 Materials

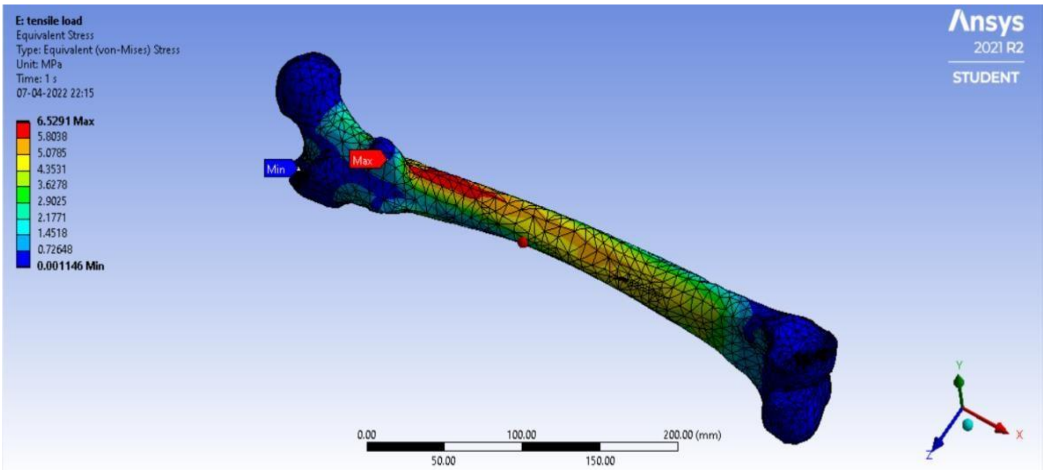


Fig.5.14 Von-misses stress of Steel 304 Material

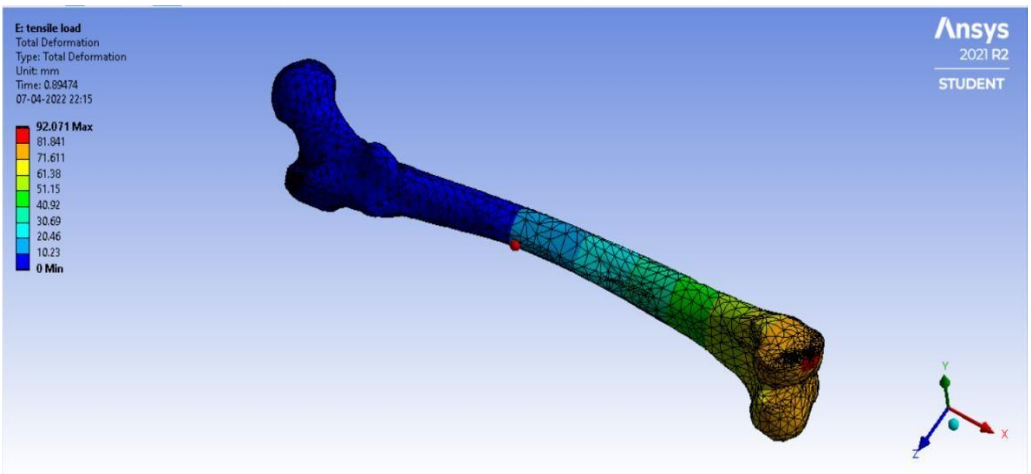


Fig.5.15 Total deformation of Steel 304 Material

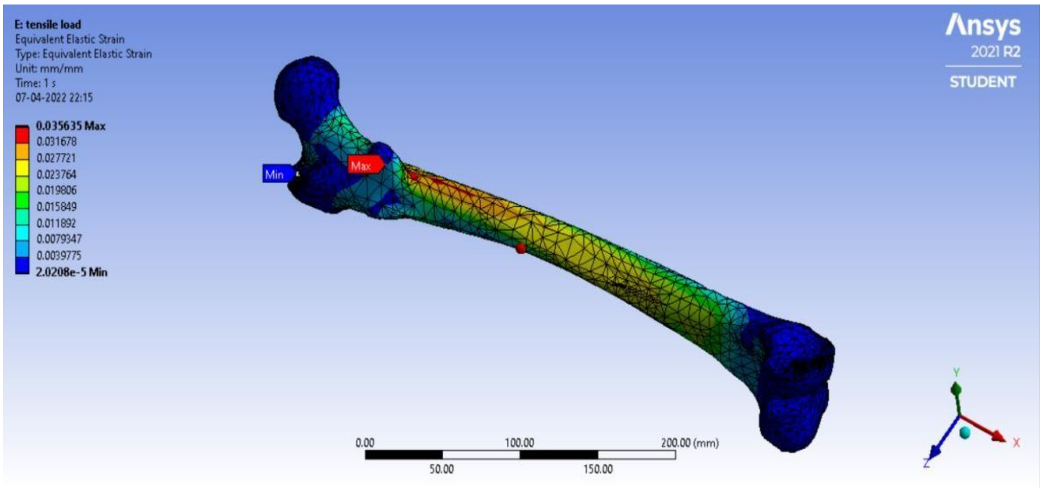


Fig.5.16 Strain of Steel 304 Material

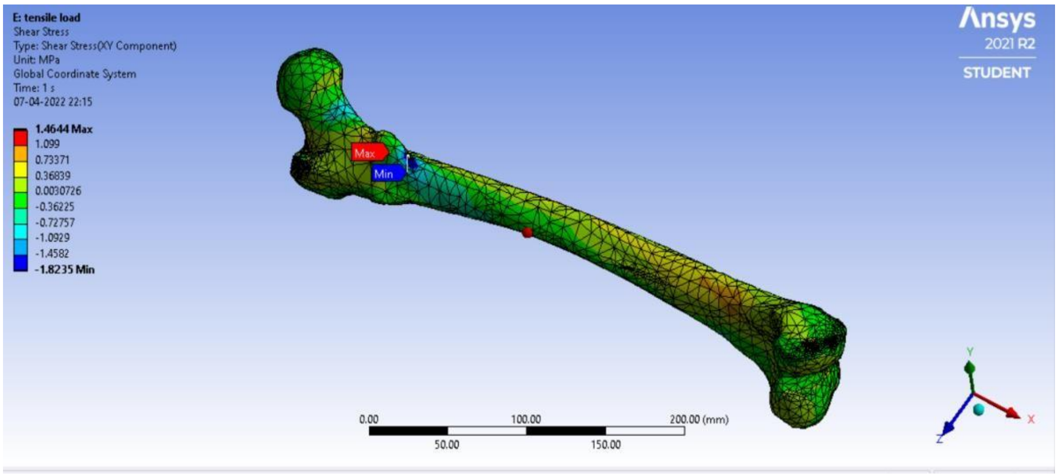


Fig.5.17 Shear stress of Steel 304 Material

4. Tensile Load of Ti-6AL-4V Material

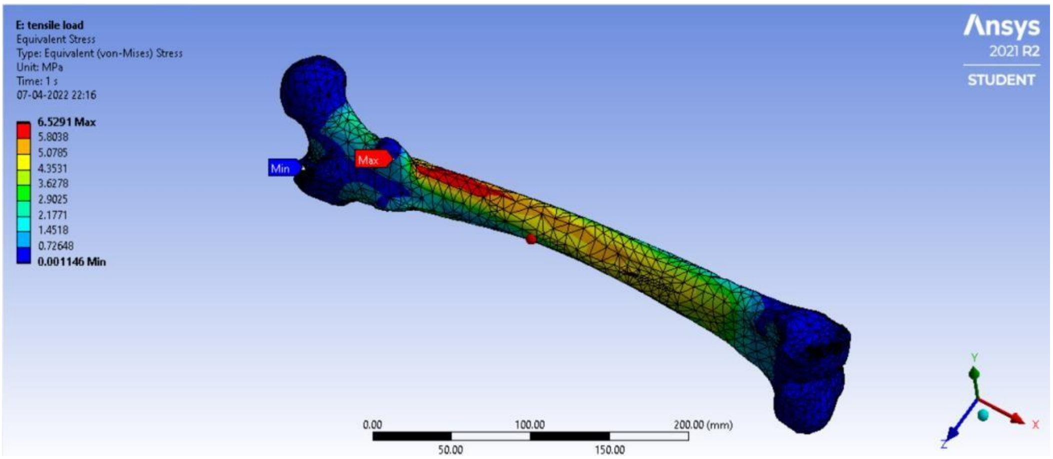


Fig.5.18 Von-misses stress of TI-6AL-4V Material

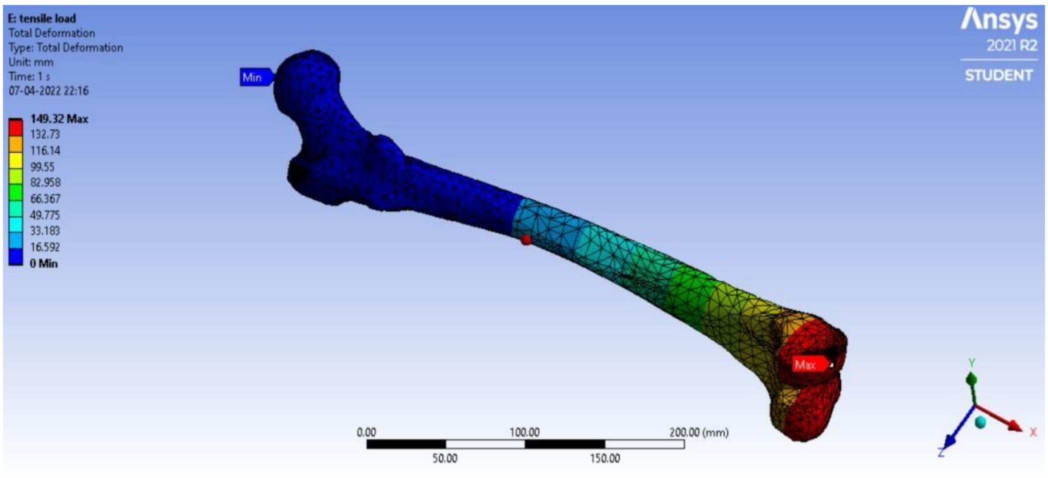


Fig.5.19 Total deformation of TI-6AL-4V Material

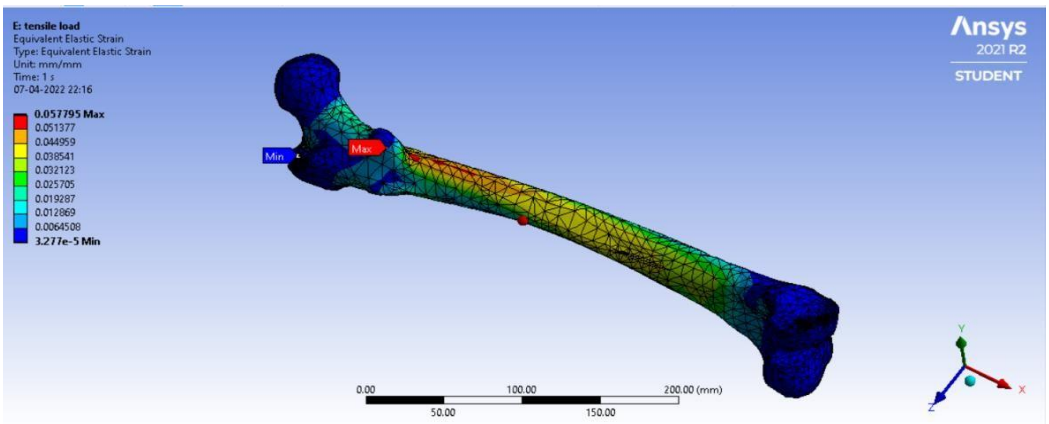


Fig.5.20 Strain of Steel TI-6AL-4V Material

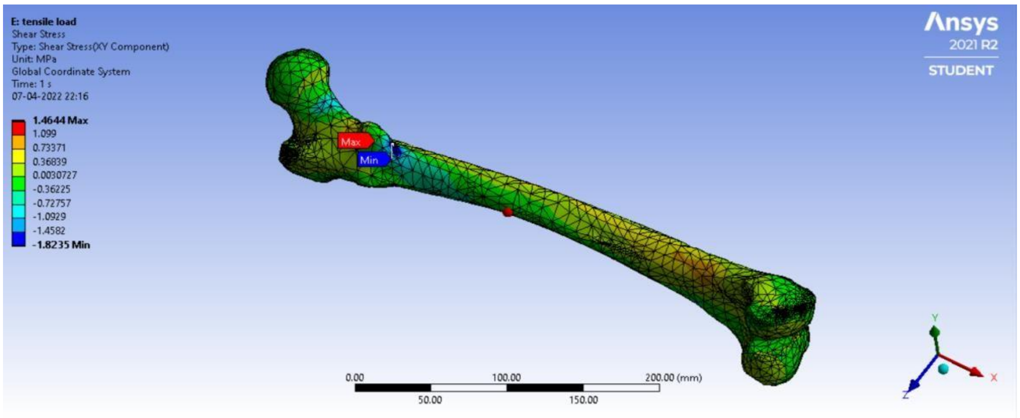


Fig.5.21 Shear stress of TI-6AL-4V Material

5. Tensile Load of PLA Material

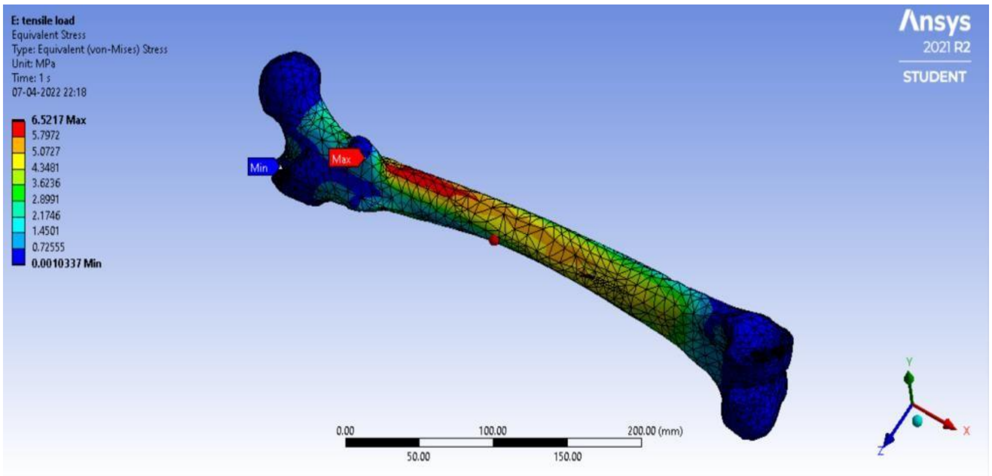


Fig.5.22 Von-misses stress of PLA Material

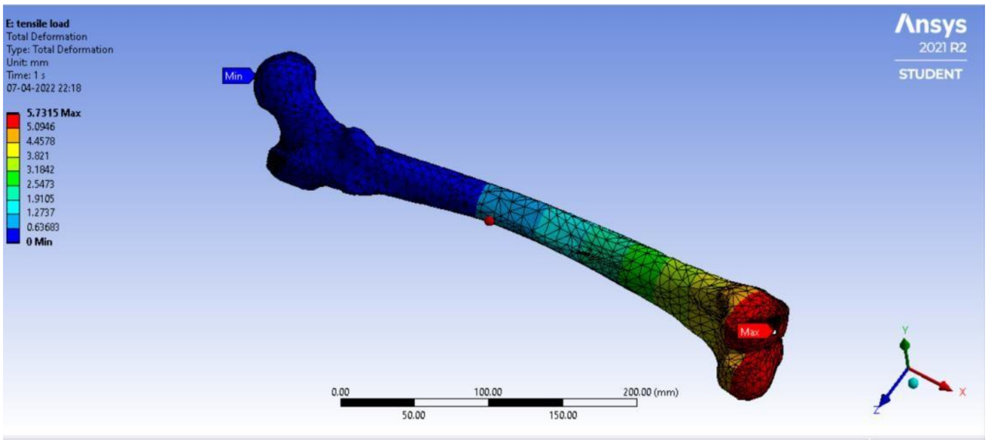


Fig.5.23 Total deformation of PLA Material

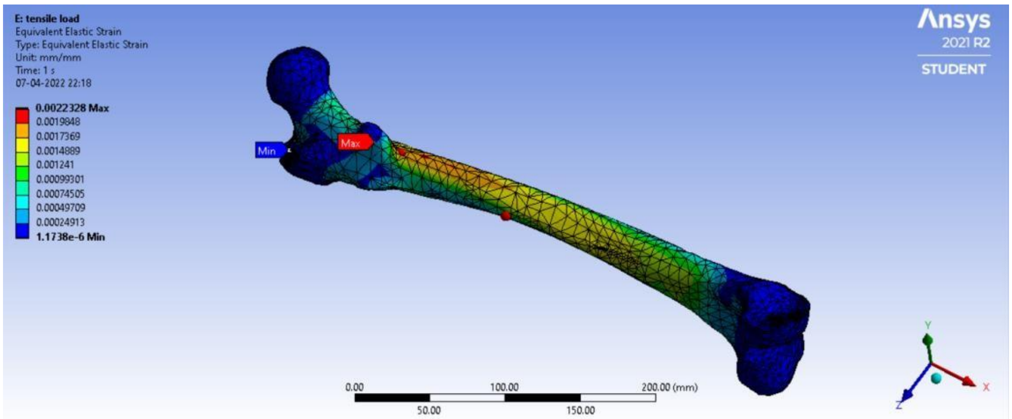


Fig.5.24 Strain of PLA Material

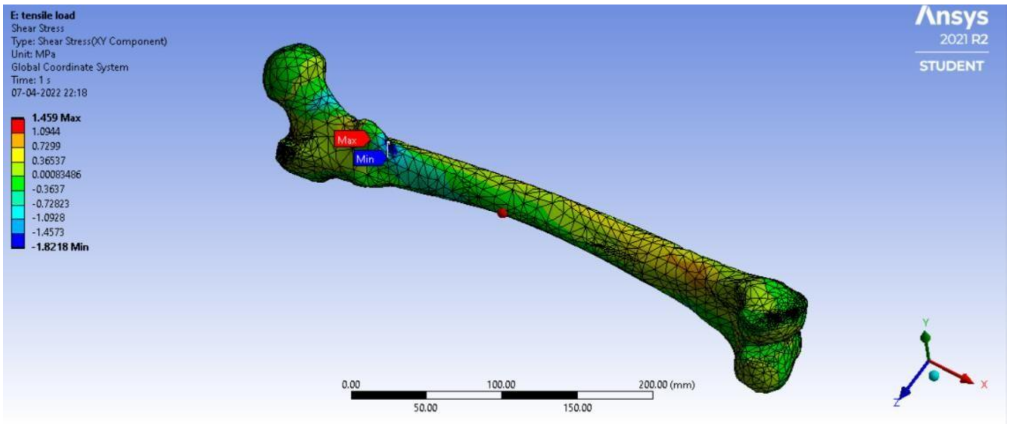


Fig.5.25 Shear stress of PLA Material

Static Analysis Results of Compressive Load

1. Compressive Load of Calcium Phosphate Material

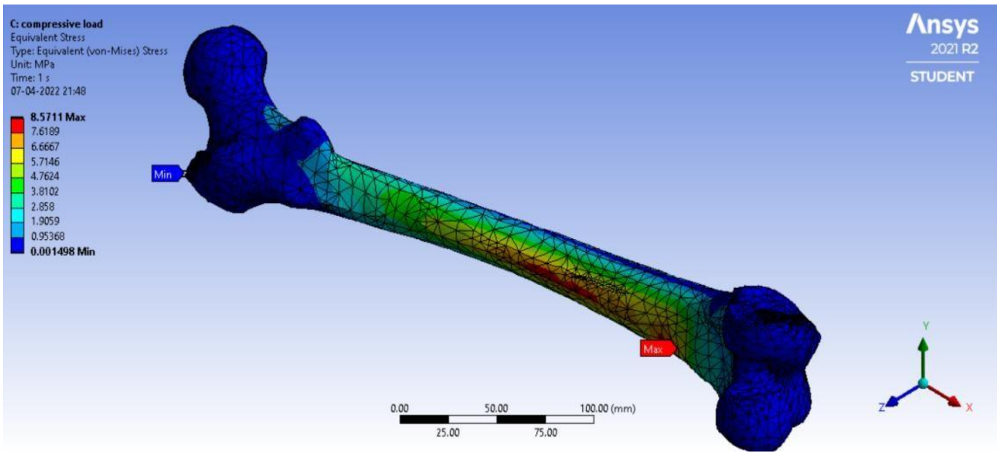


Fig.5.26 Von-misses stress of Calcium phosphate Material

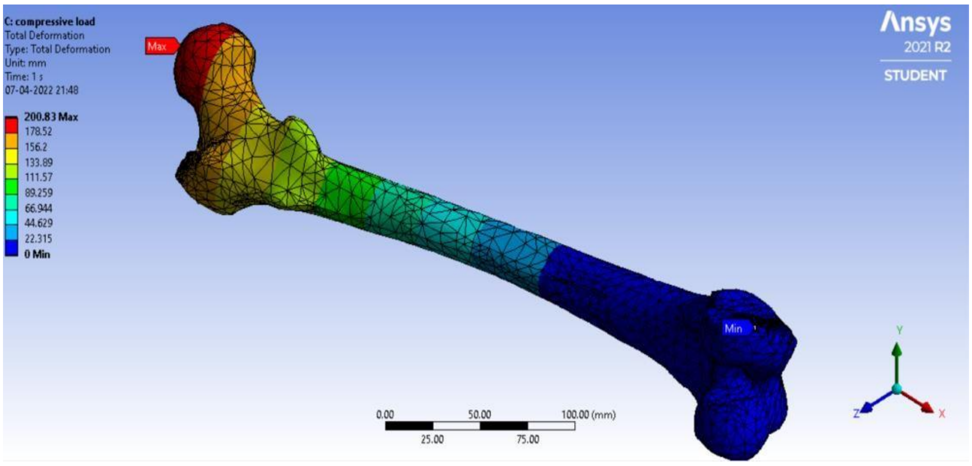


Fig.5.27 Total deformation of Calcium phosphate Material

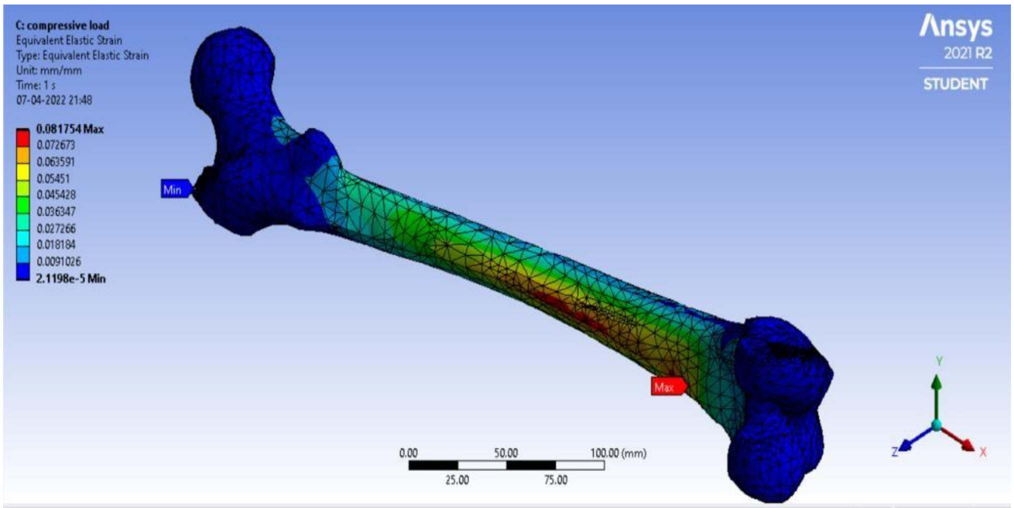


Fig.5.28 Strain of Calcium phosphate Material

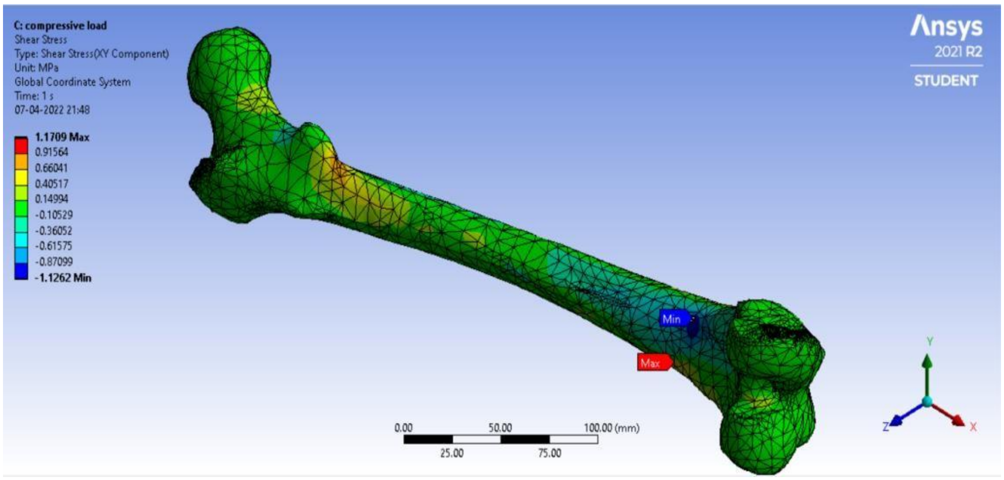


Fig.5.29 Shear stress of Calcium phosphate Material

2. Compressive Load of Strontium Material

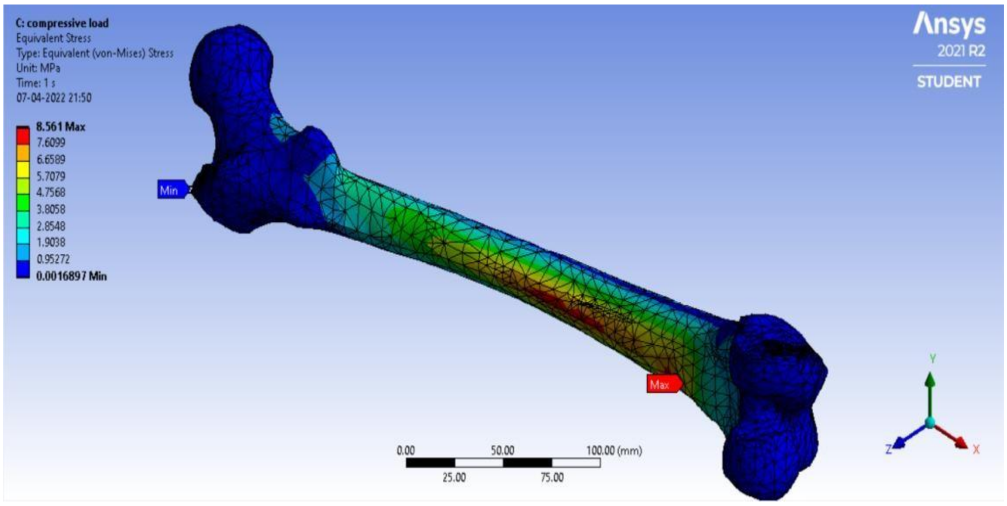


Fig.5.30 Von-misses stress of Strontium Material

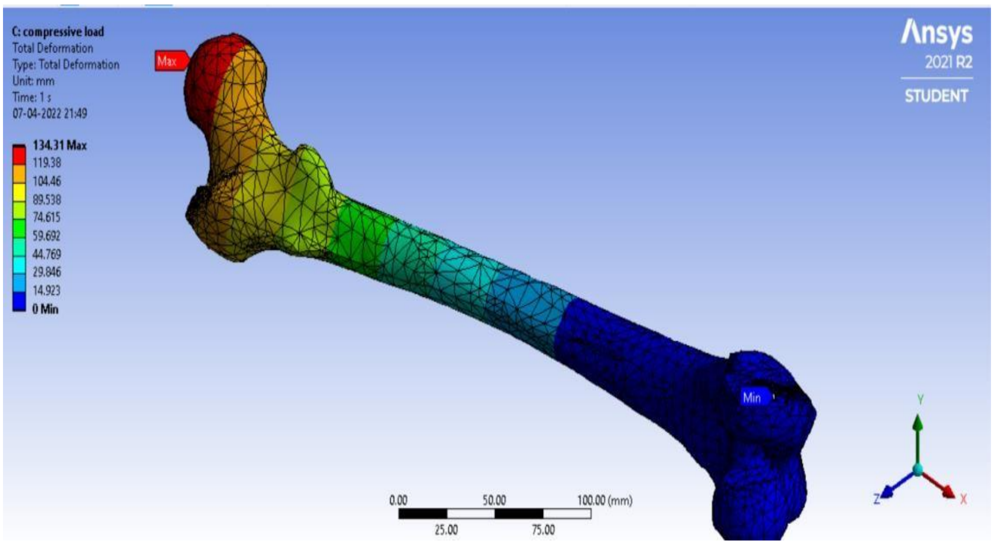


Fig.5.31 Total deformation of Strontium Material

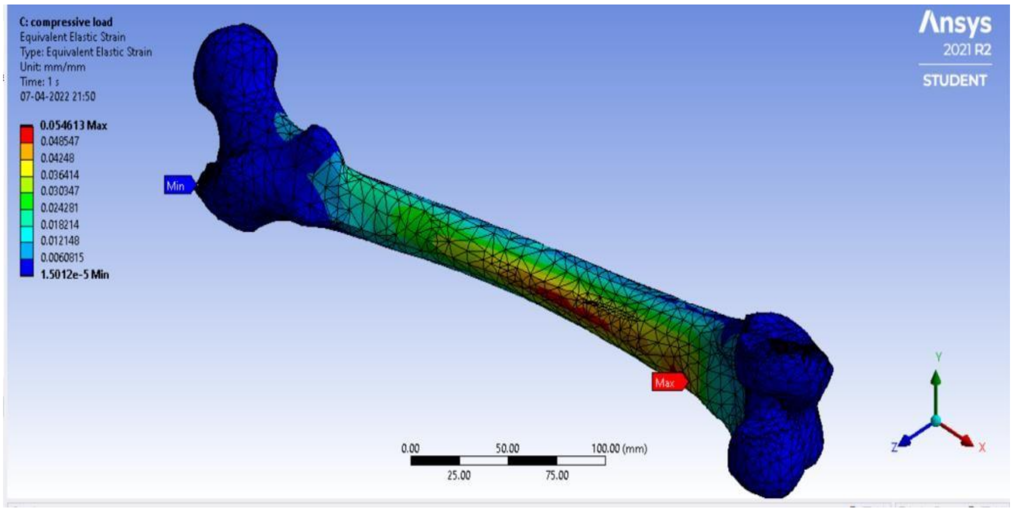


Fig.5.32 Strain of Strontium Material

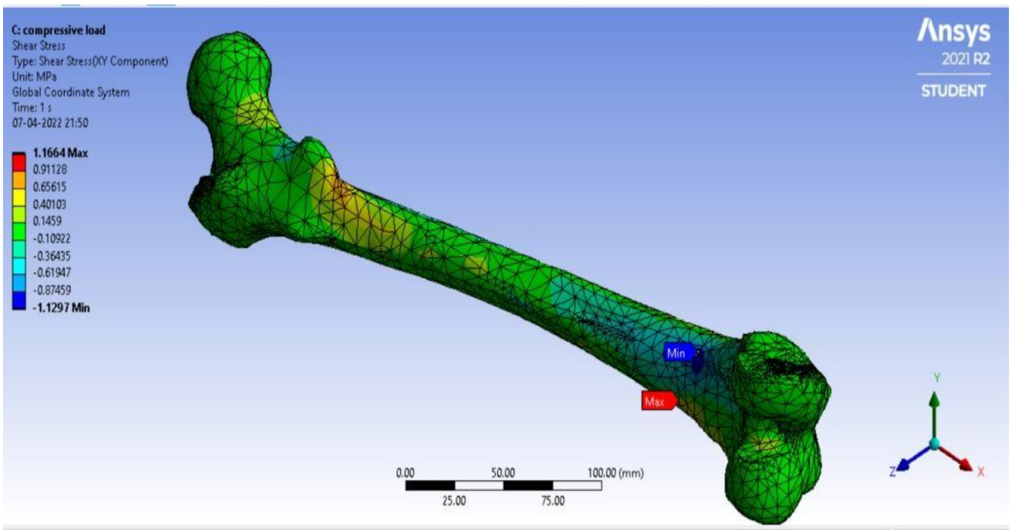


Fig.5.33 Shear stress of Strontium Material

3. Compressive Load of Steel 304 Material

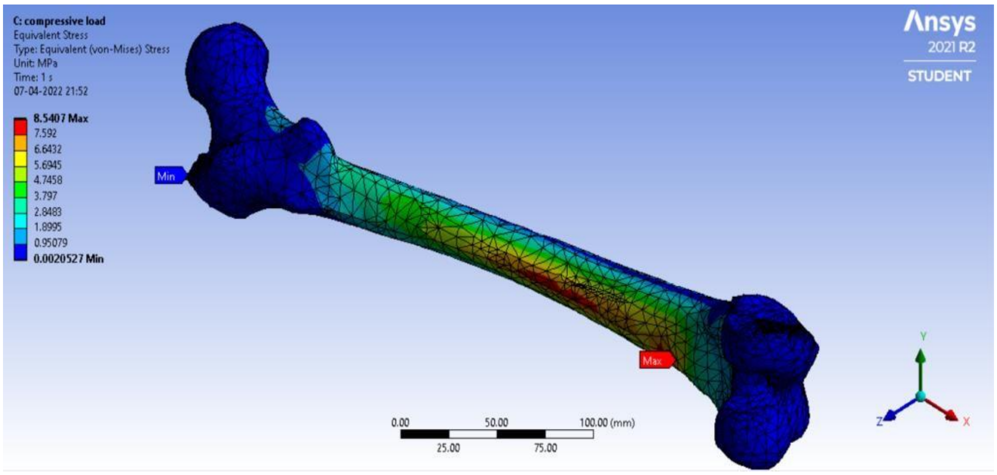


Fig.5.34 Von-misses stress of Steel 304 Material

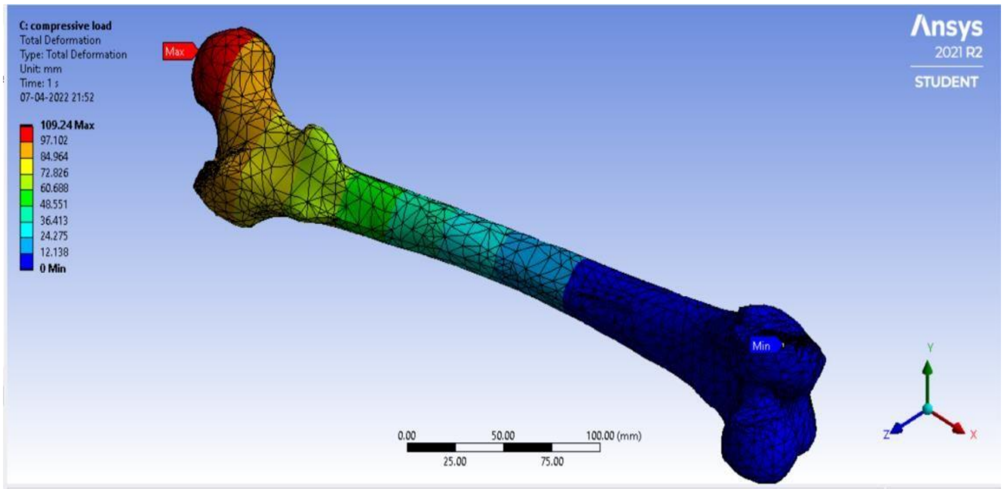


Fig.5.35 Total deformation of Steel 304 Material

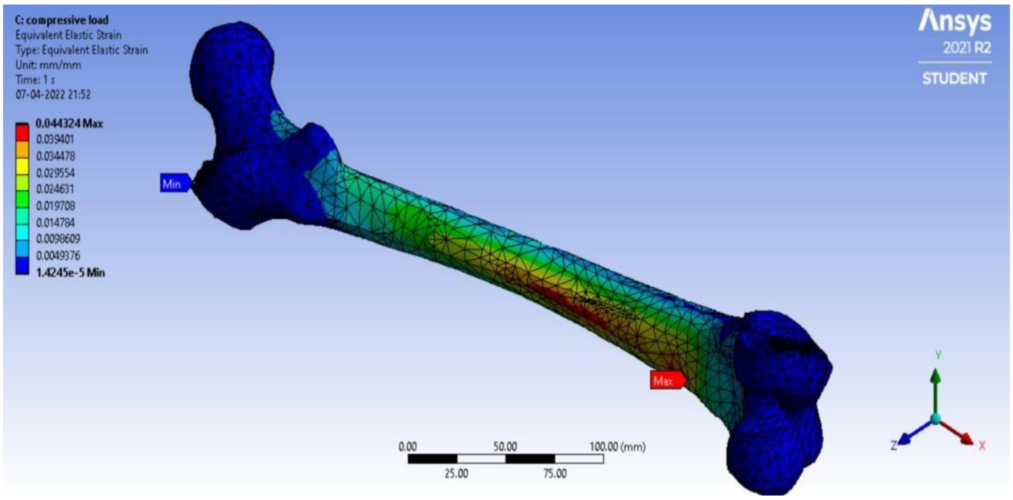


Fig.5.36 Strain of Steel 304 Material

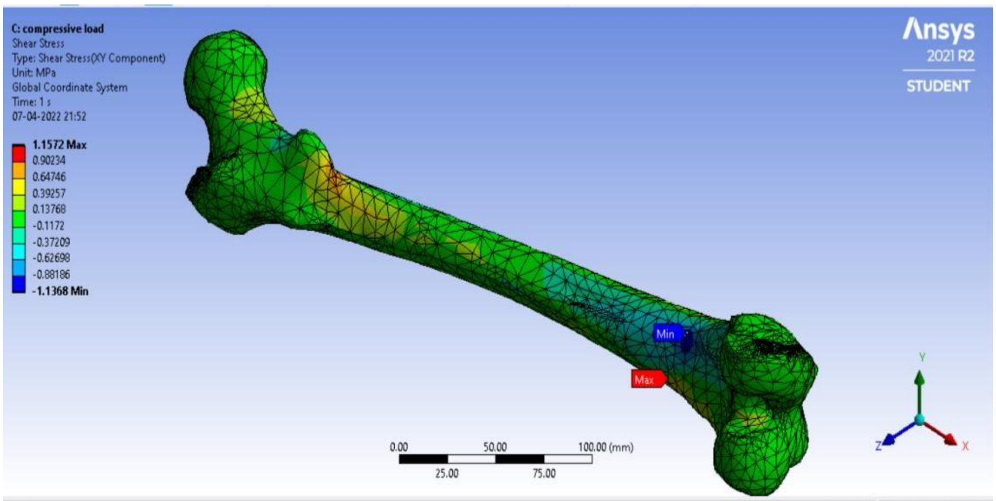


Fig.5.37 Shear stress of Steel 304 Material

4. Compressive Load of TI-6AL-4V Material

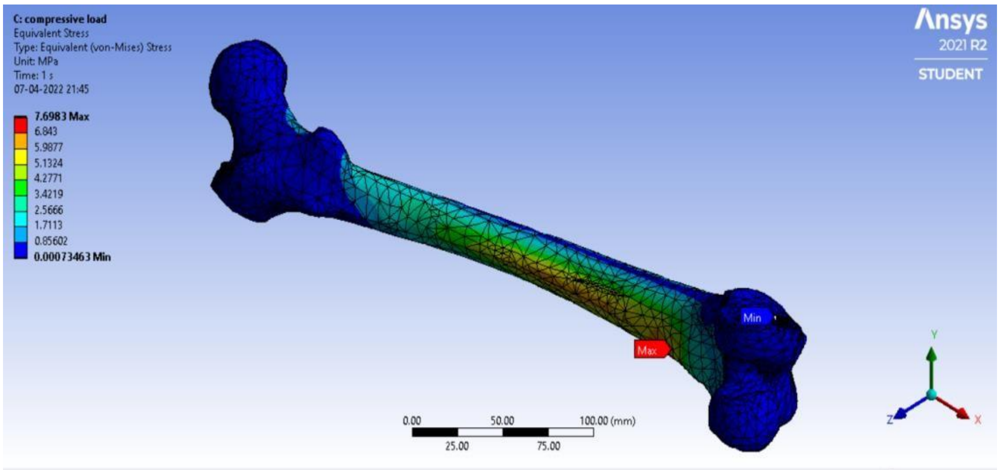


Fig.5.38 Von-misses stress of TI-6AL-4V Material

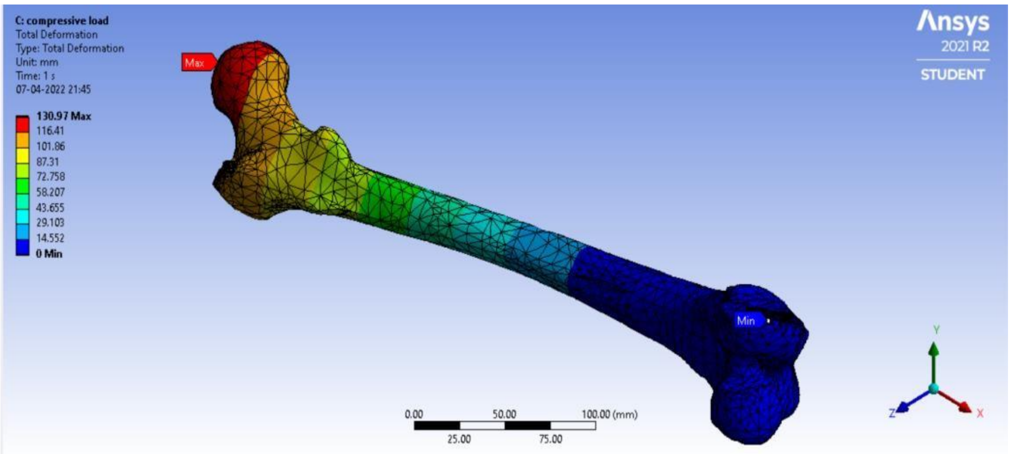


Fig.5.39 Total deformation of TI-6AL-4V Material

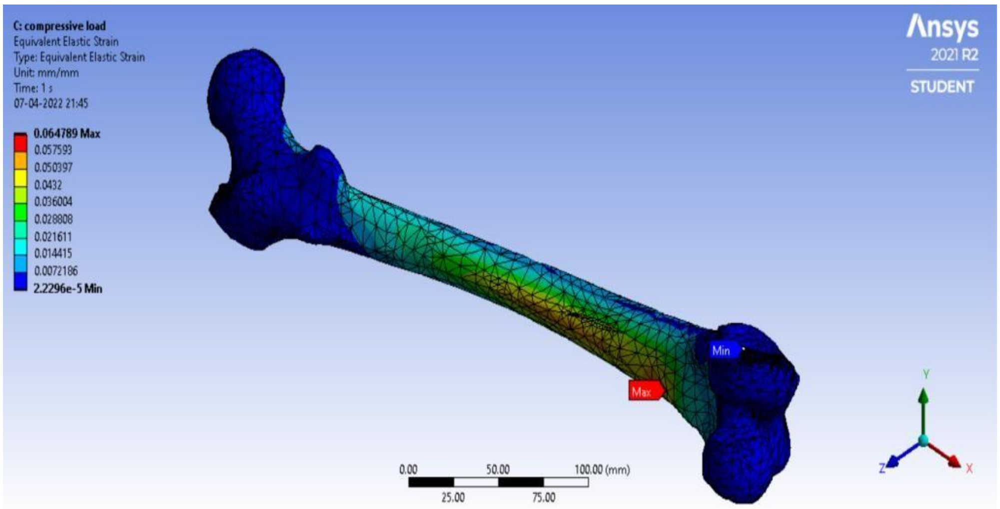


Fig.5.40 Strain of Steel TI-6AL-4V Material

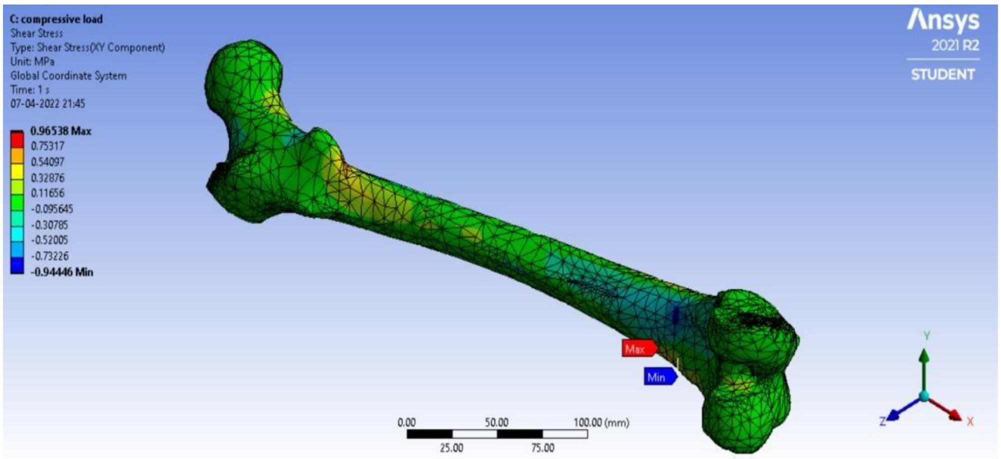


Fig.5.41Shear stress of TI-6AL-4V Material

5. Compressive Load of PLA Material

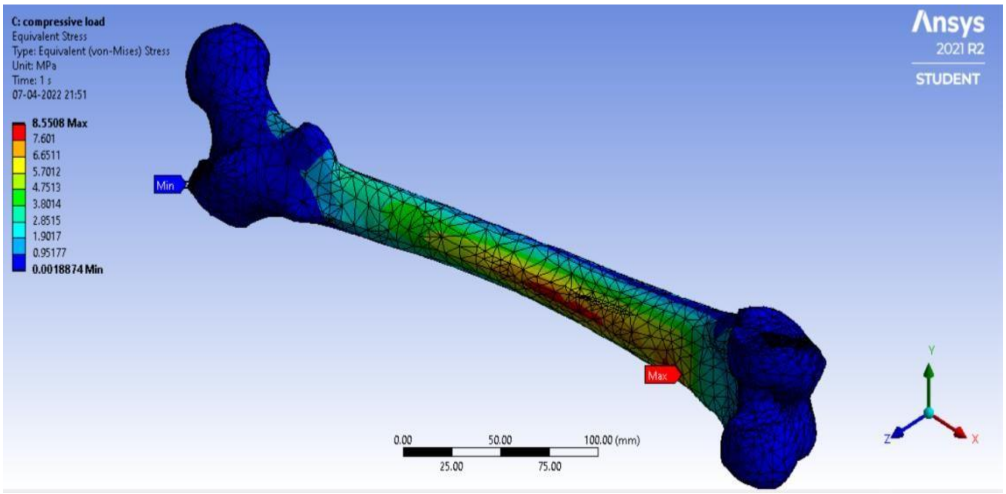


Fig.5.42 Von-misses stress of PLA Material

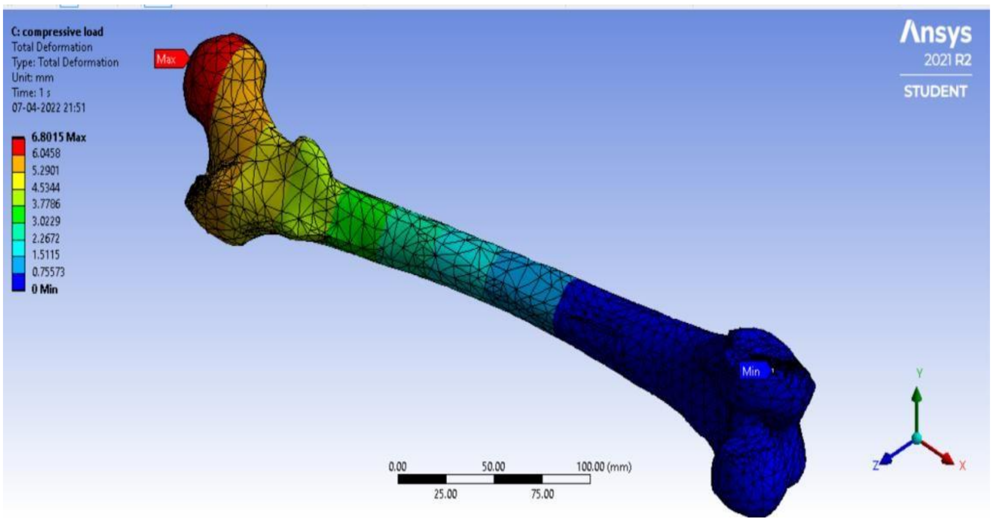


Fig.5.43 Total deformation of PLA Material

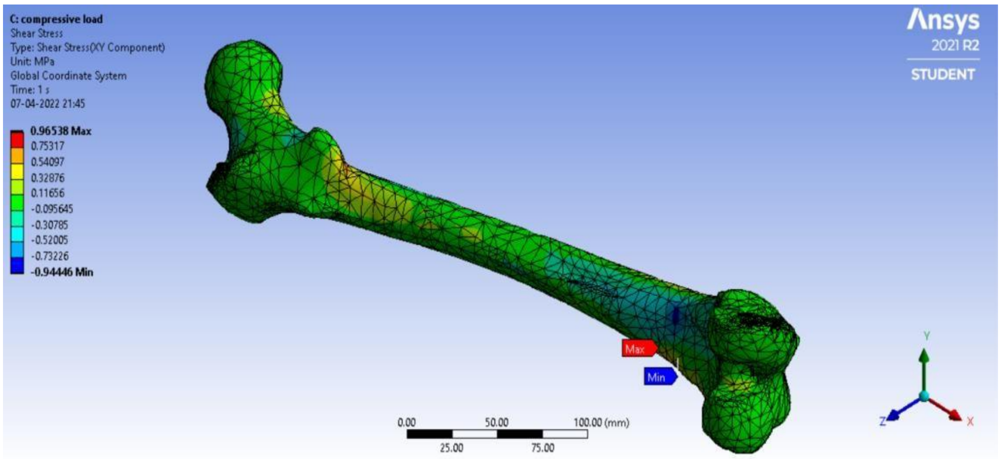


Fig.5.44 Strain of PLA Material

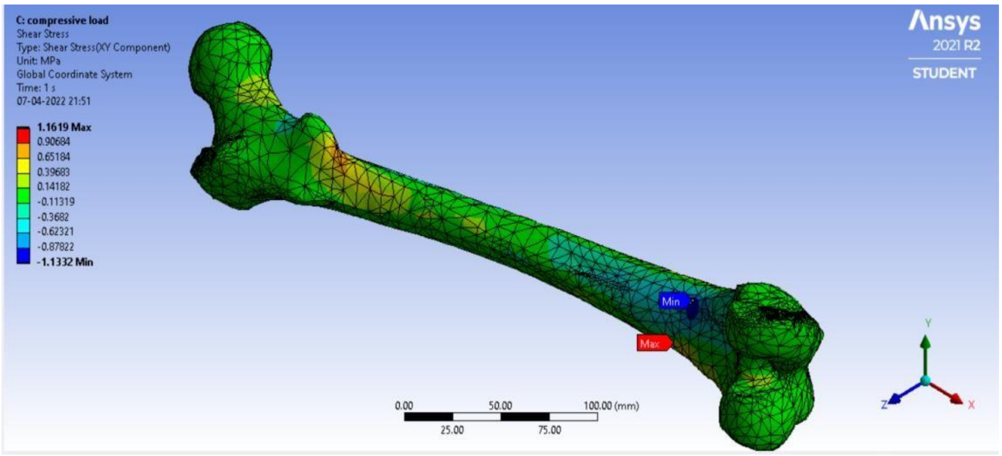


Fig.5.45 Shear stress of PLA Material

Static Analysis Results of Shear Load

1. Shear Load of Calcium Phosphate Material

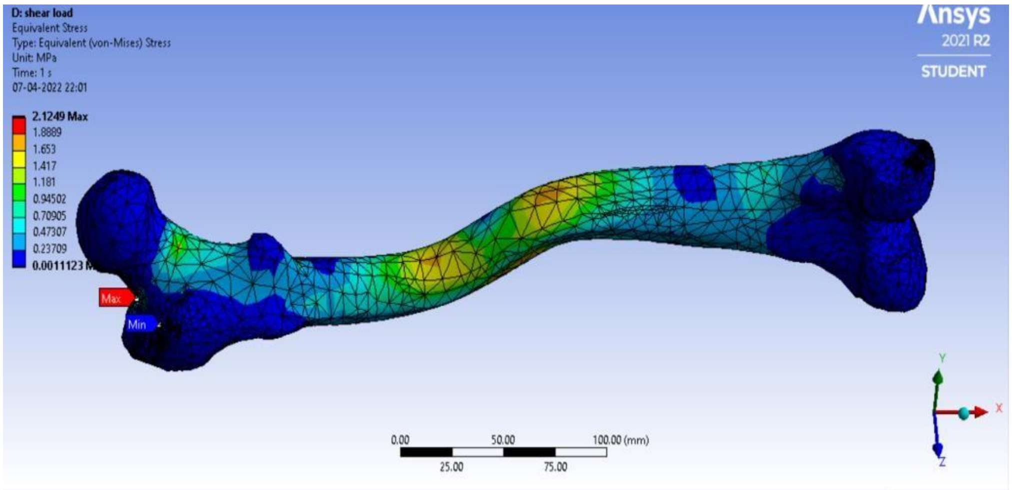


Fig.5.46 Von-misses stress of Calcium Phosphate Material

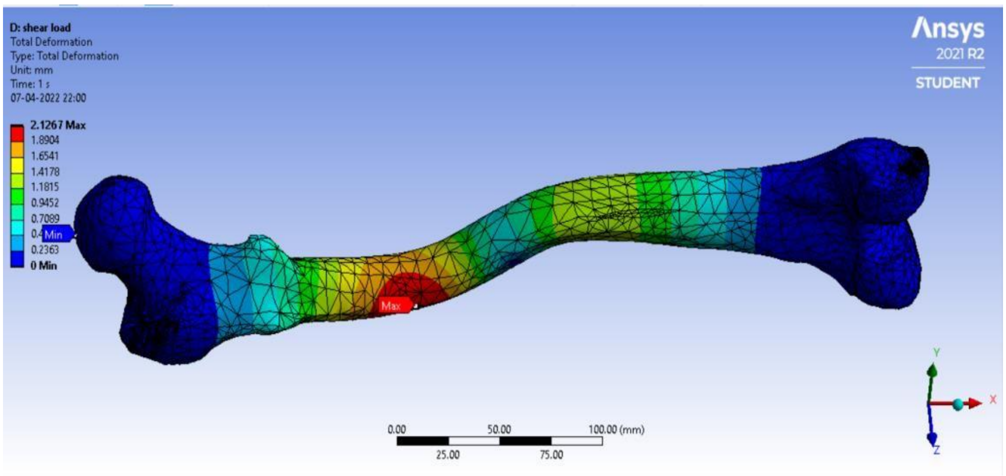


Fig.5.47 Total deformation of Calcium Phosphate Material

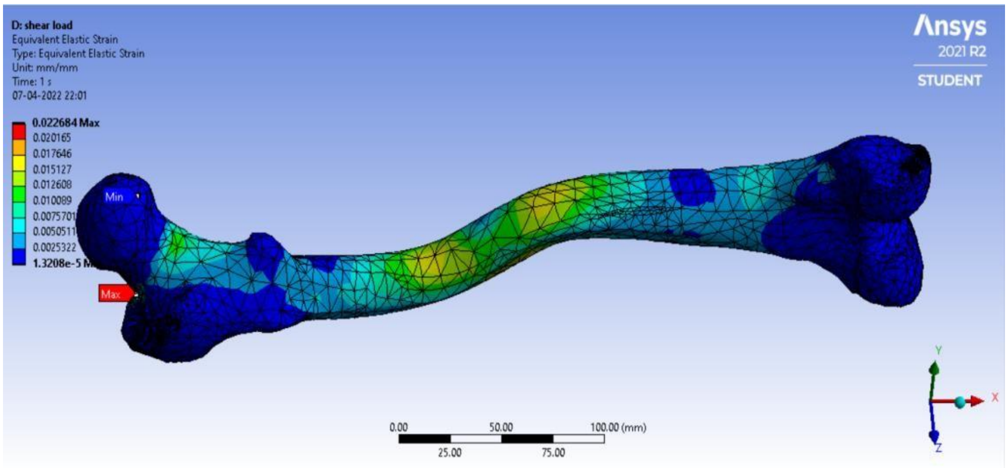


Fig.5.48 Strain of Calcium phosphate Material

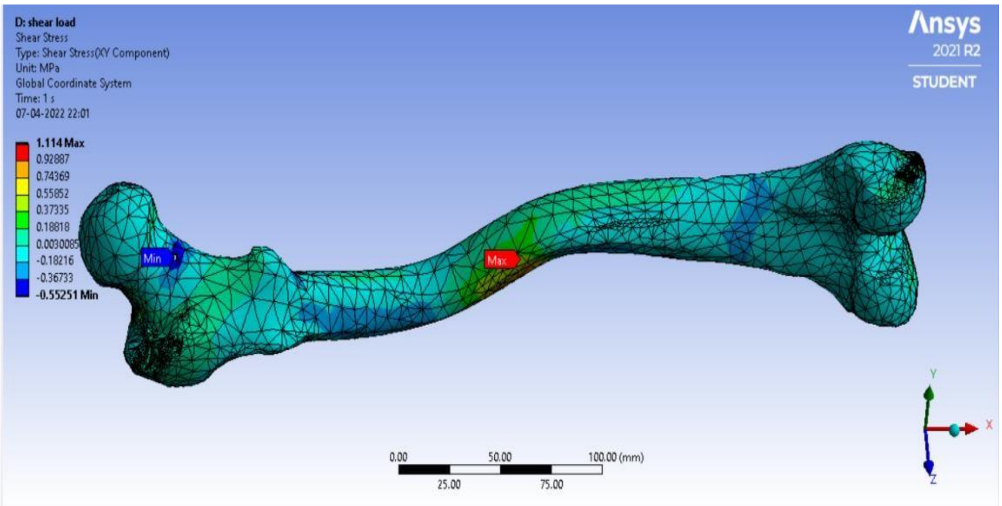


Fig.5.49 Shear stress of Calcium phosphate Material

2. Shear Load of Strontium Material

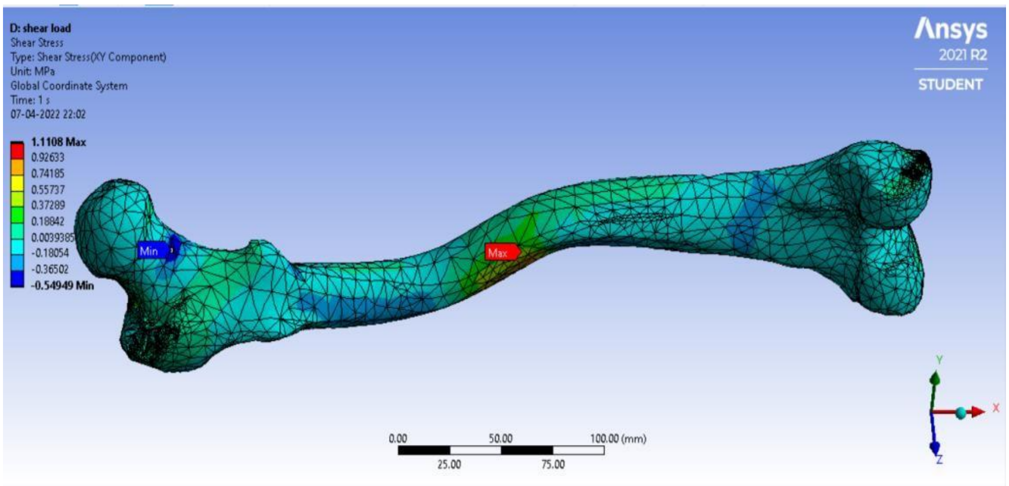


Fig.5.50 Von-misses stress of Strontium Material

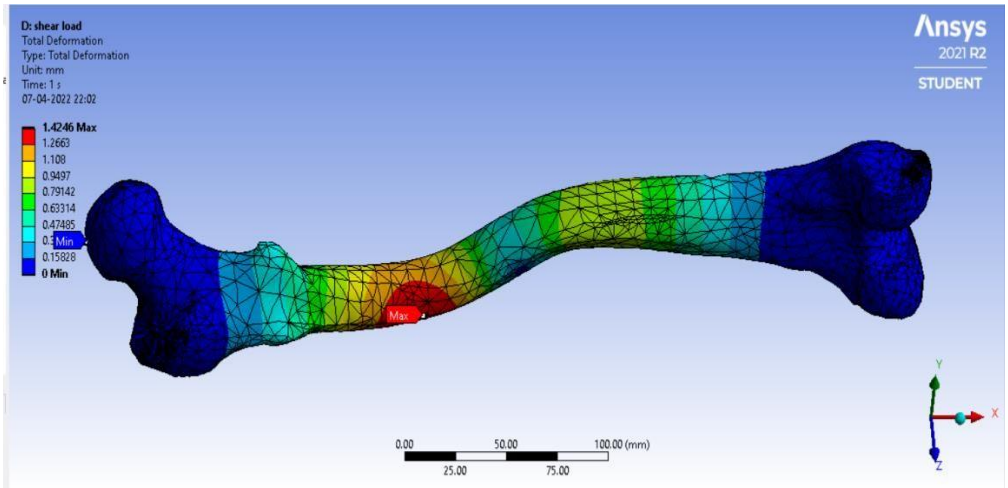


Fig.5.51 Total deformation of Strontium Material

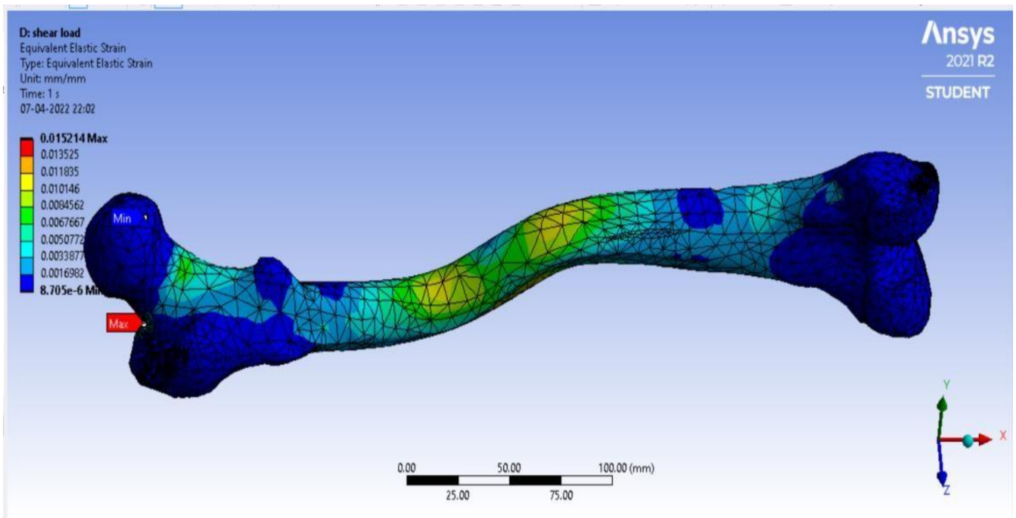


Fig.5.52 Strain of Strontium Material

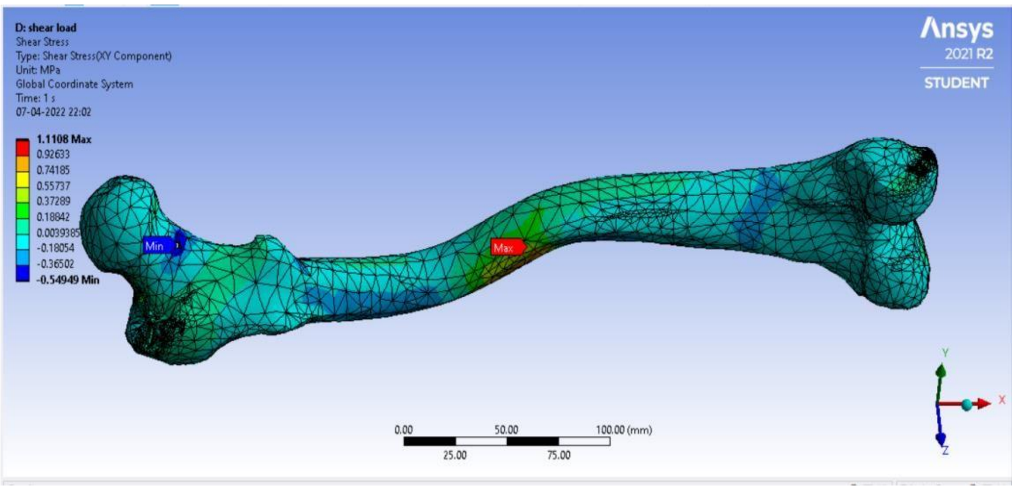


Fig.5.53 Shear stress of Strontium Material

3. Shear Load of Steel 304 Material

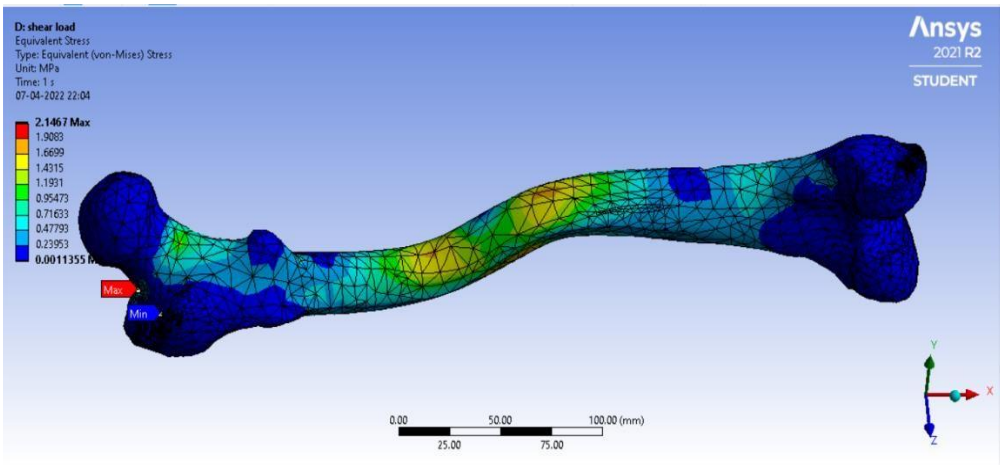


Fig.5.54 Von-misses stress of Steel 304 Material

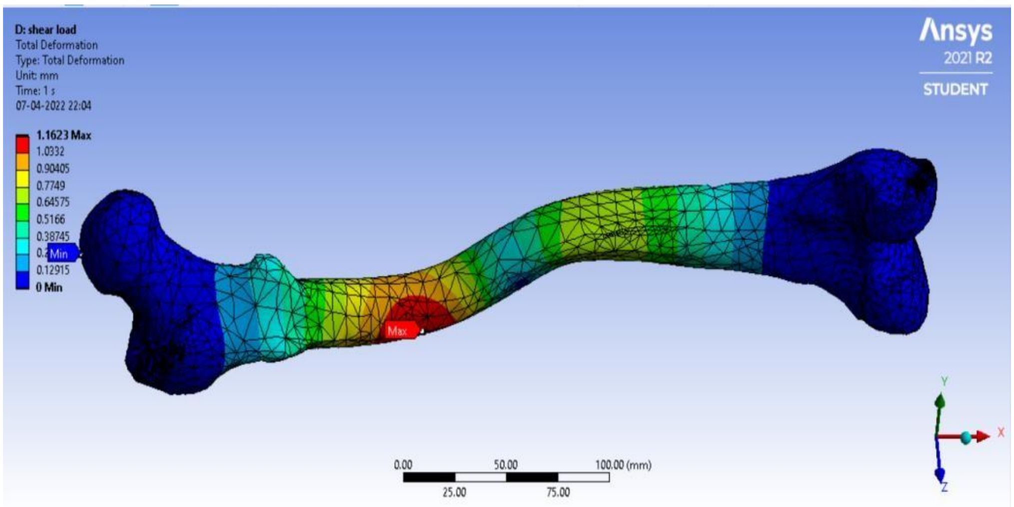


Fig.5.55 Total deformation of Steel 304 Material

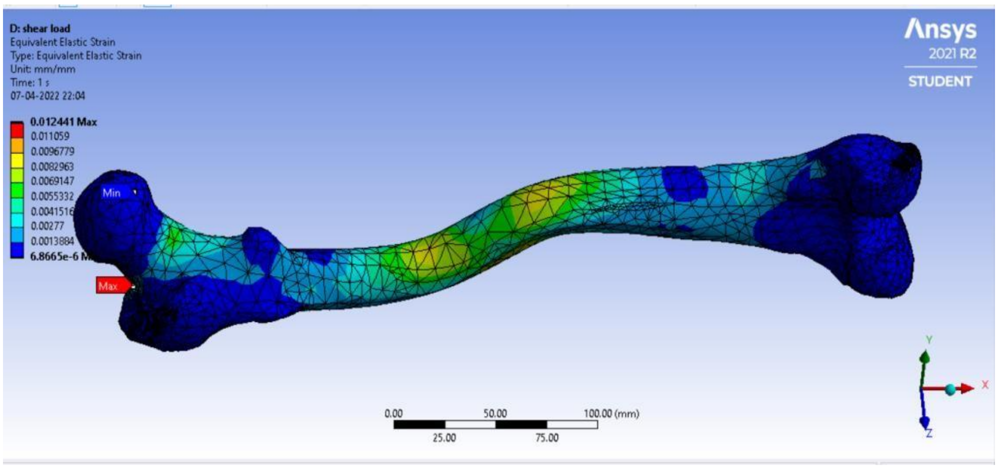


Fig.5.56 Strain of Steel 304 Material

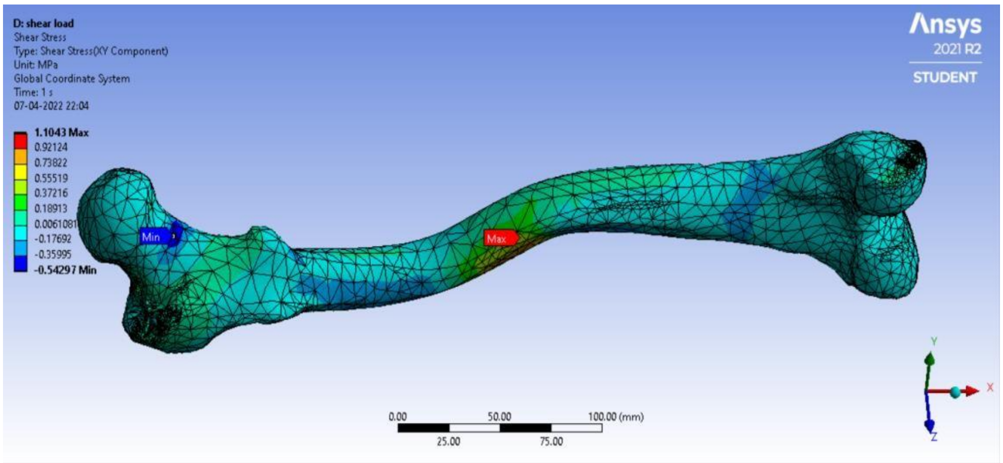


Fig.5.57 Shear stress of Steel 304 Material

4. Shear Load of TI-6AL-4V Material

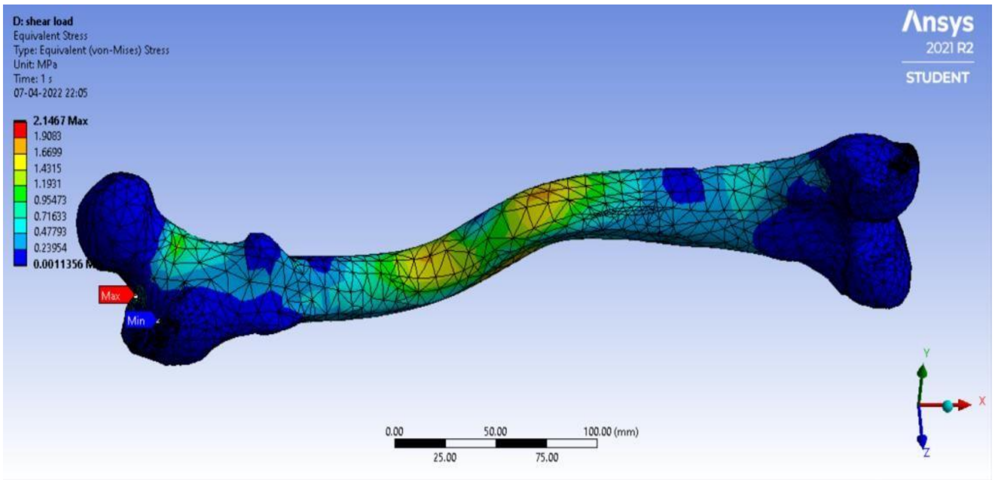


Fig.5.58 Von-misses stress of TI-6AL-4V Material

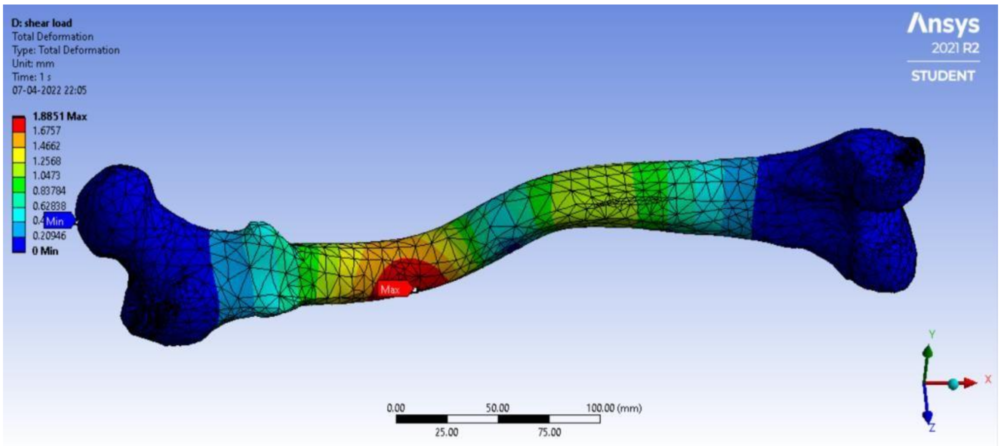


Fig.5.59 Total deformation of TI-6AL-4V Material

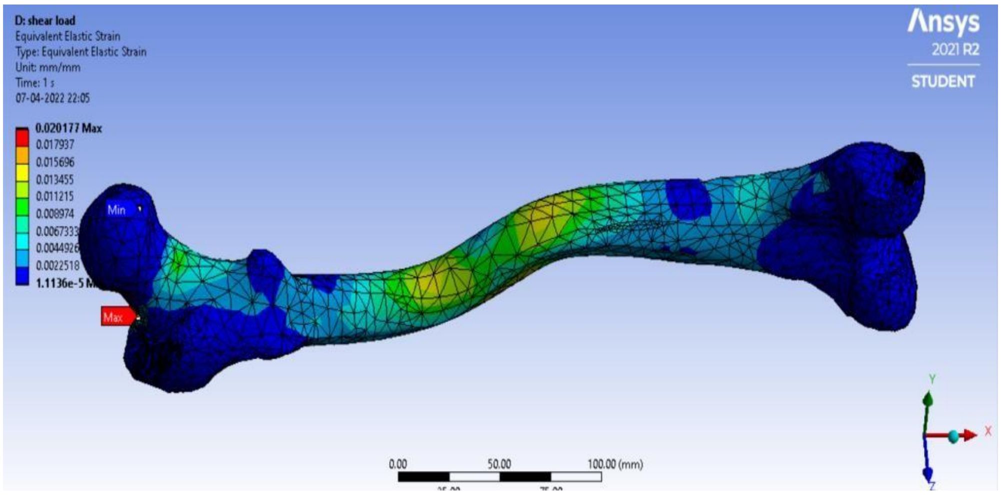


Fig.5.60 Strain of Steel TI-6AL-4V Material

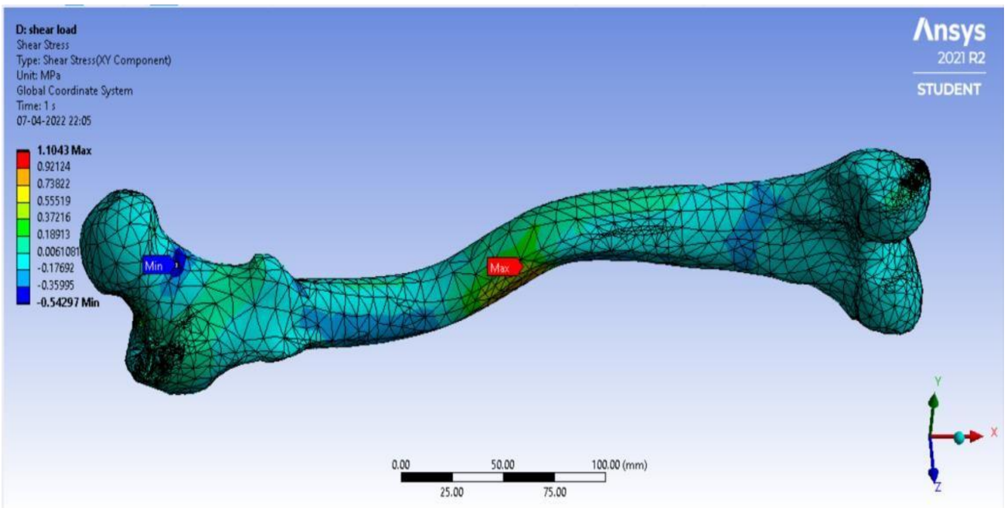


Fig.5.61 Shear stress of TI-6AL-4V Material

5. Shear Load of PLA Material

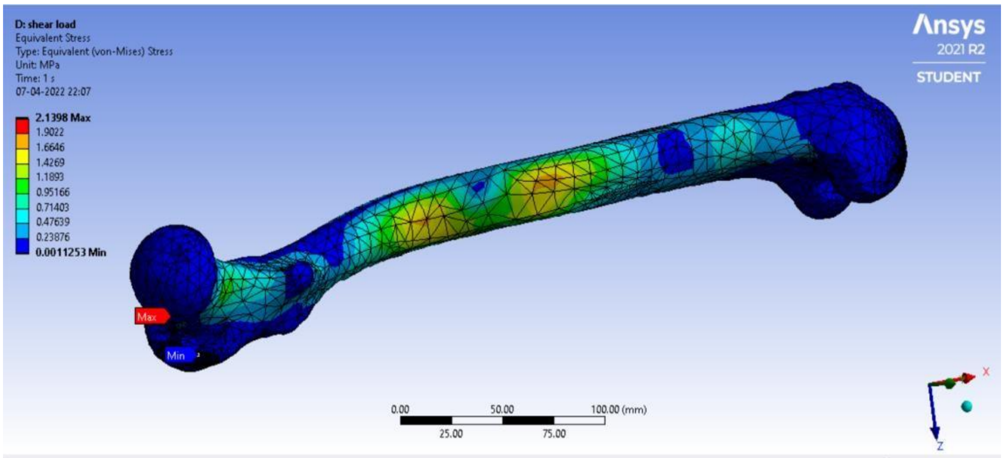


Fig.5.62 Von-misses stress of PLA Material

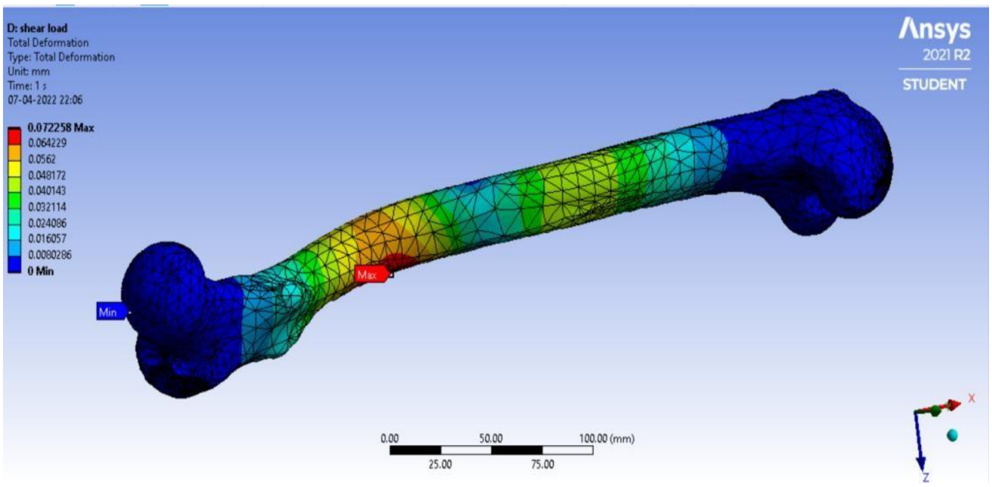


Fig.5.63 Total deformation of PLA Material

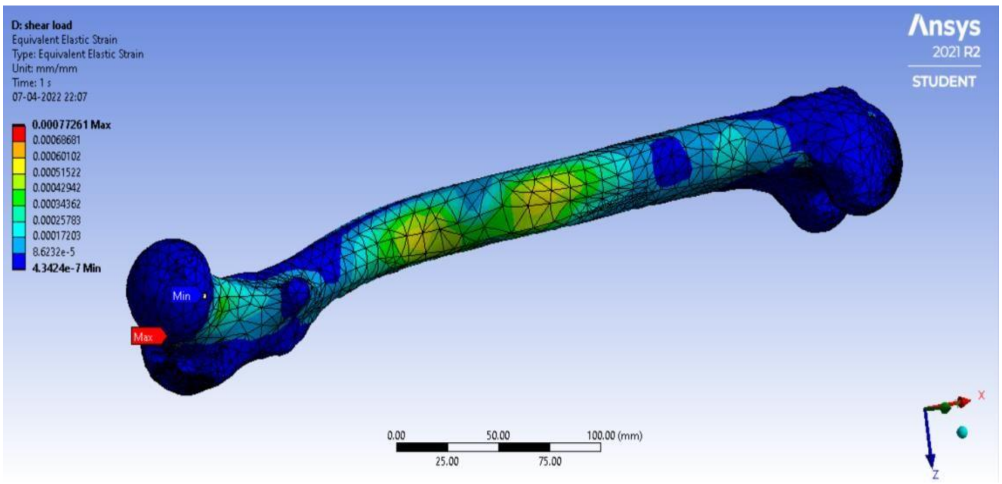


Fig.5.64 Strain of Steel PLA Material

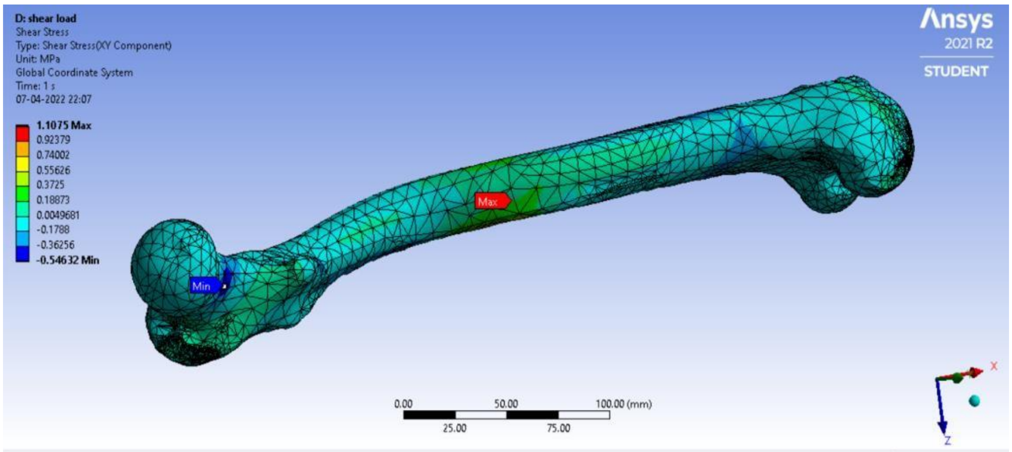


Fig.5.65 Shear stress of PLA Material

Static Analysis Results of Point Load

1. Point Load of Calcium Phosphate Material

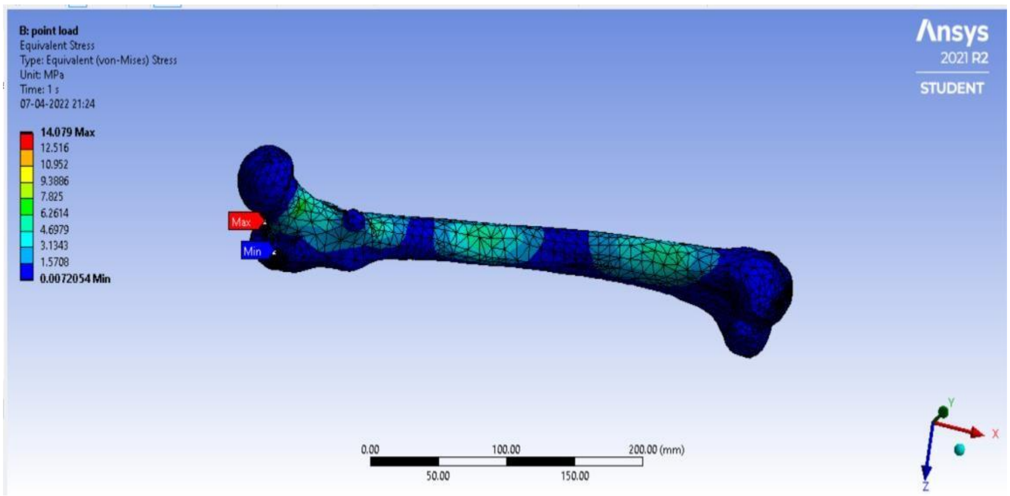


Fig.5.66 Von-misses stress of Calcium Phosphate Material

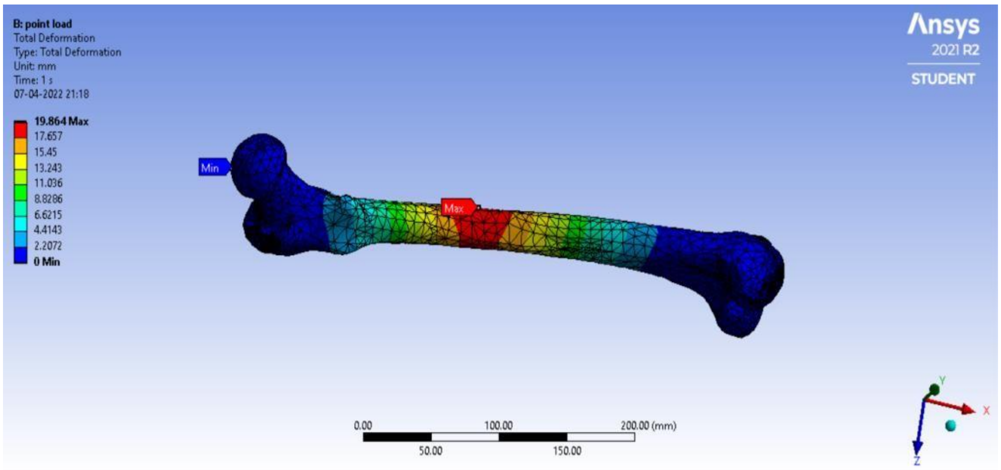


Fig.5.67 Total deformation of Calcium Phosphate Material

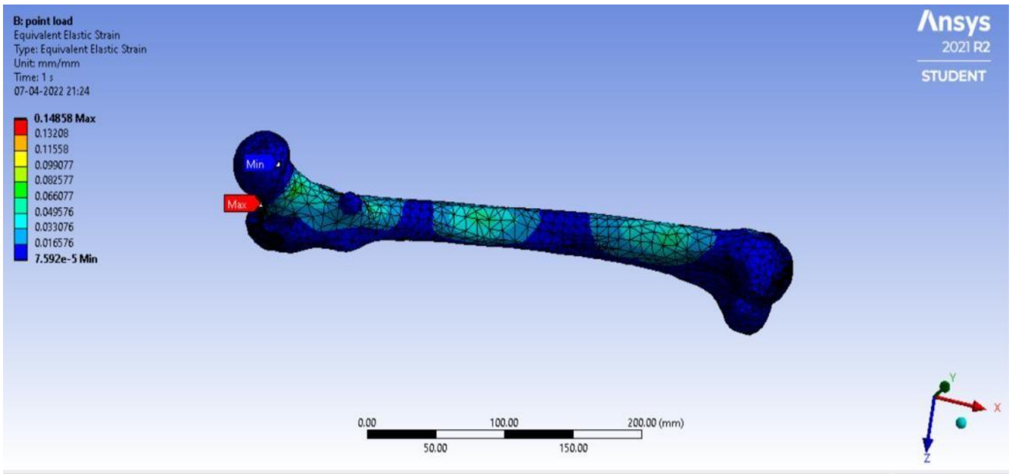


Fig.5.68 Strain of Calcium Phosphate Material

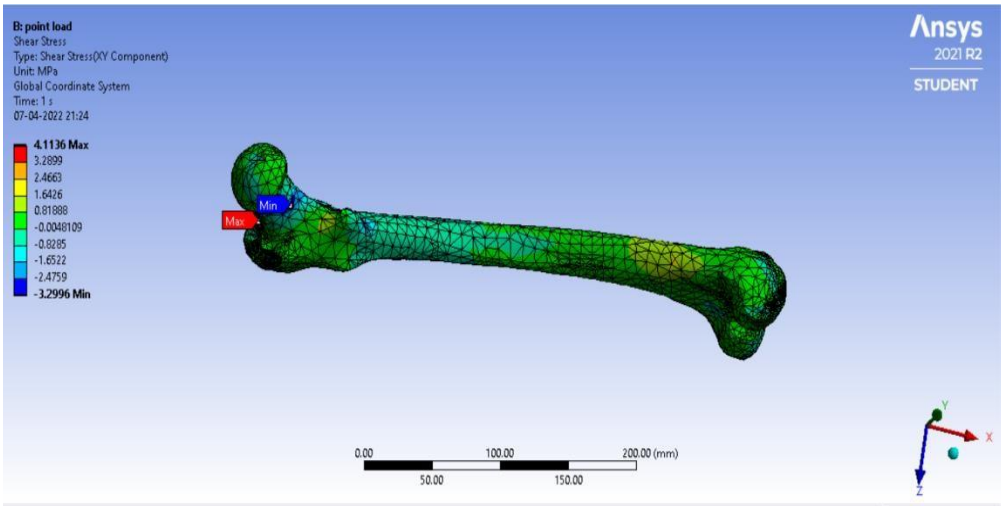


Fig.5.69 Shear stress of Calcium Phosphate Material

2. Point Load of Strontium Material

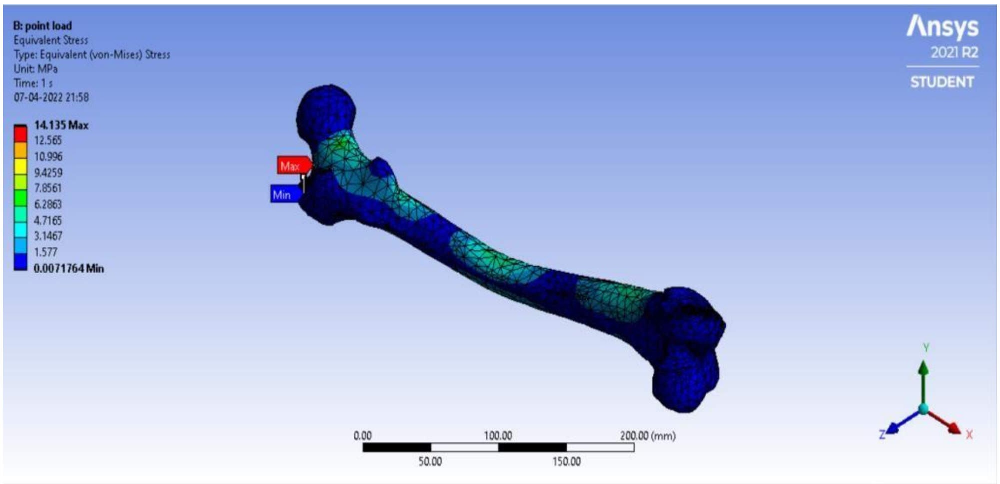


Fig.5.70 Von-misses stress of Strontium Material

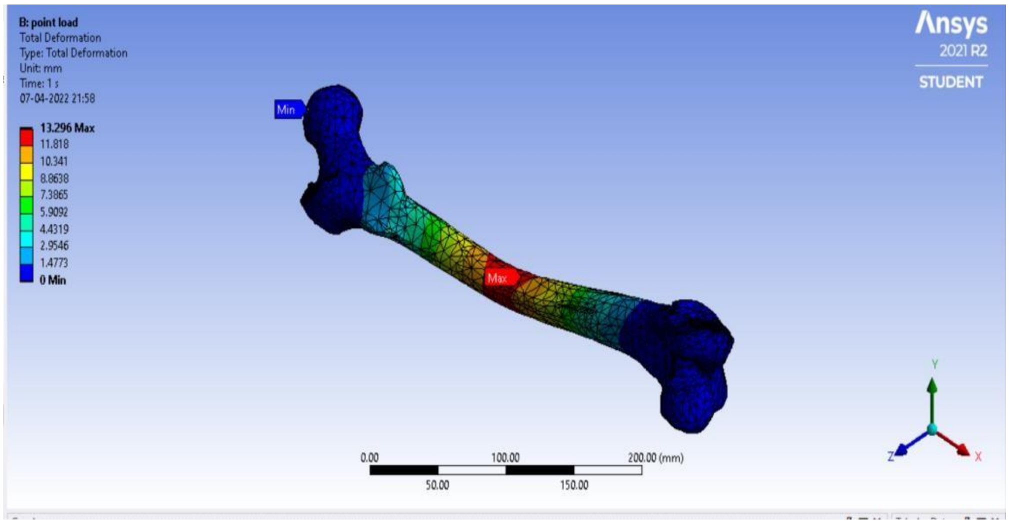


Fig.5.71 Total deformation of Strontium Material

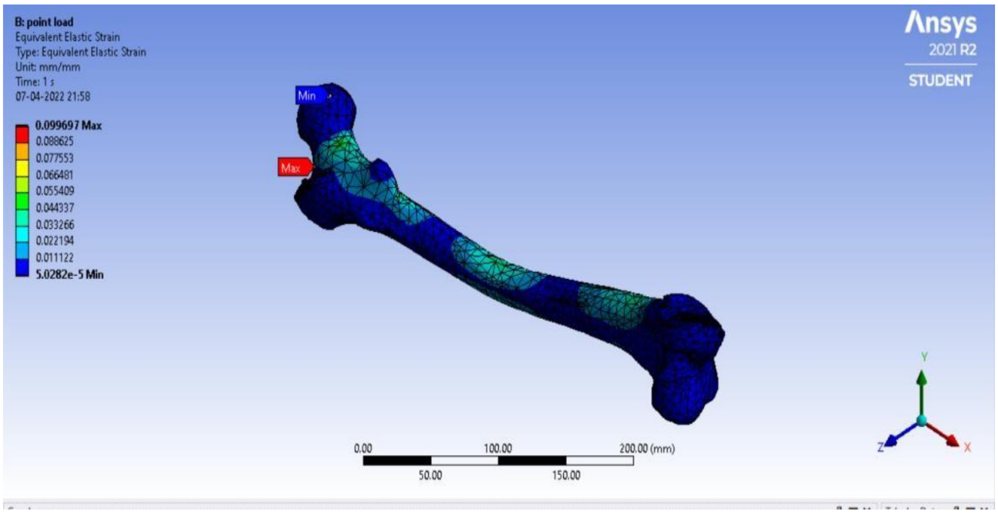


Fig.5.72 Strain of Strontium Material

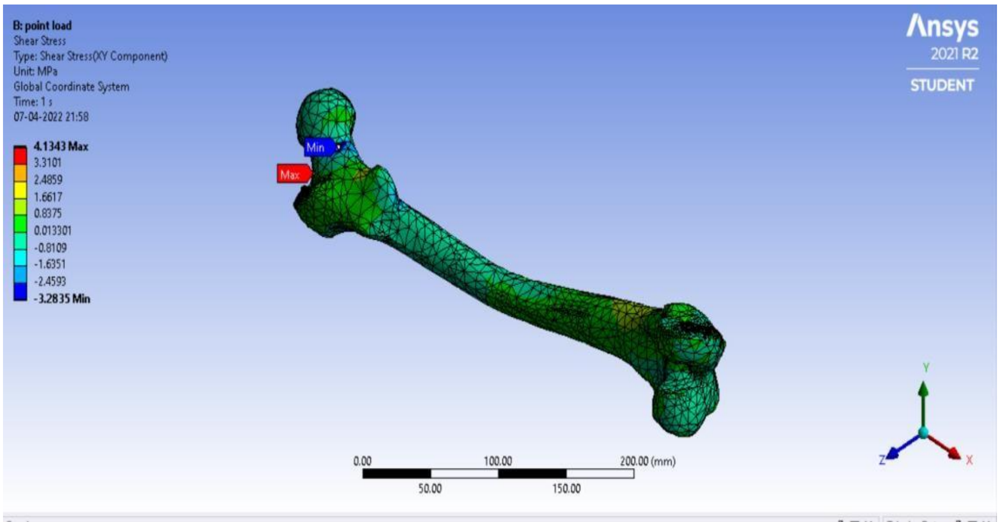


Fig.5.73 Shear stress of Strontium Material

3. Point Load of Steel 304 Material

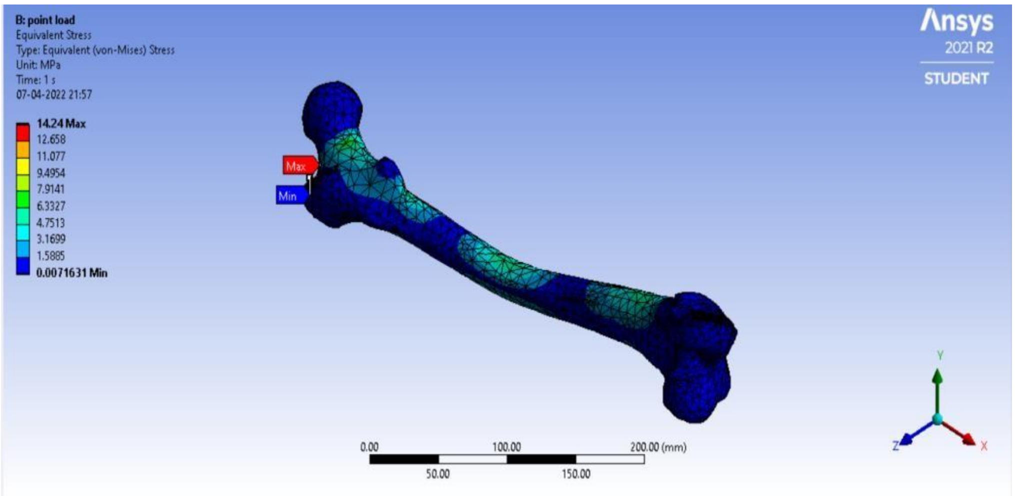


Fig.5.74 Von-misses stress of Steel 304 Material

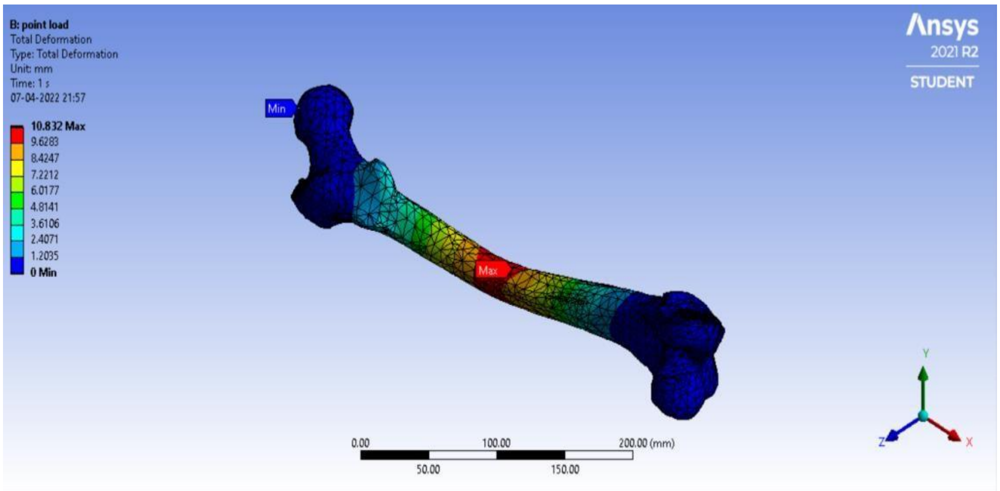


Fig.5.75 Total deformation of Steel 304 Material

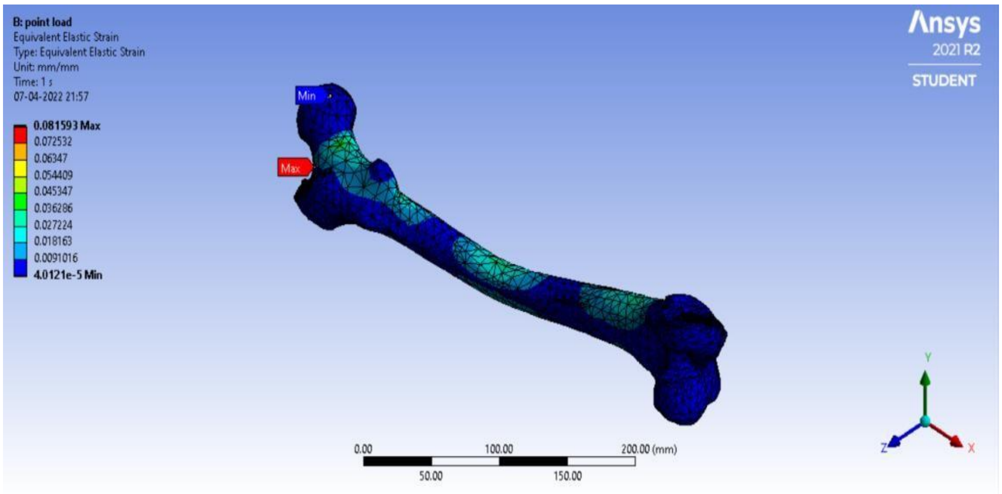


Fig.5.76 Strain of Steel 304 Material

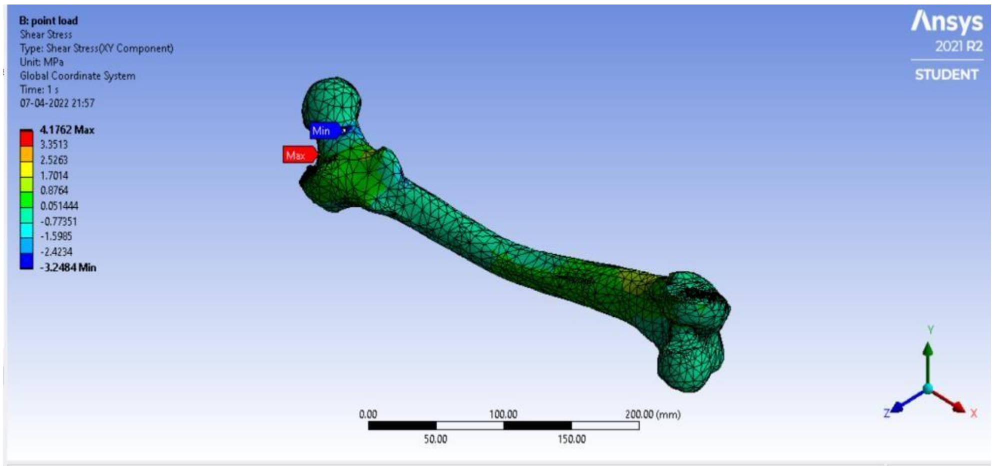


Fig.5.77 Shear stress of Steel 304 Material

4.Point Load of TI-6AL-4V Material

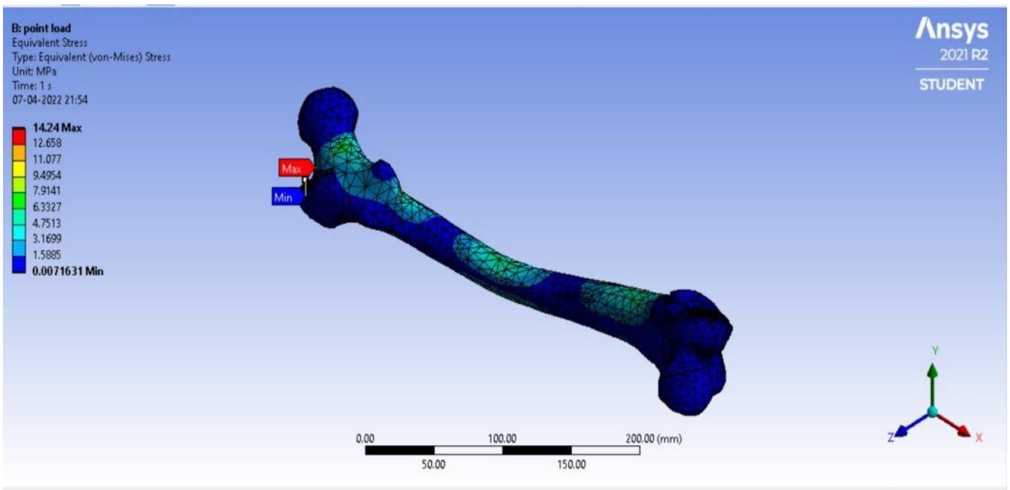


Fig.5.78 Von-misses stress of TI-6AL-4V Material

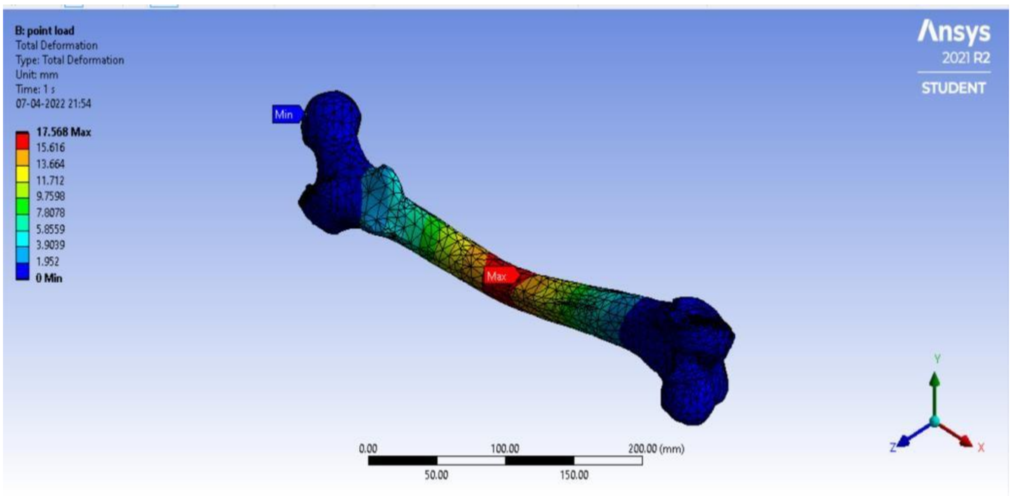


Fig.5.79 Total deformation of TI-6AL-4V Material

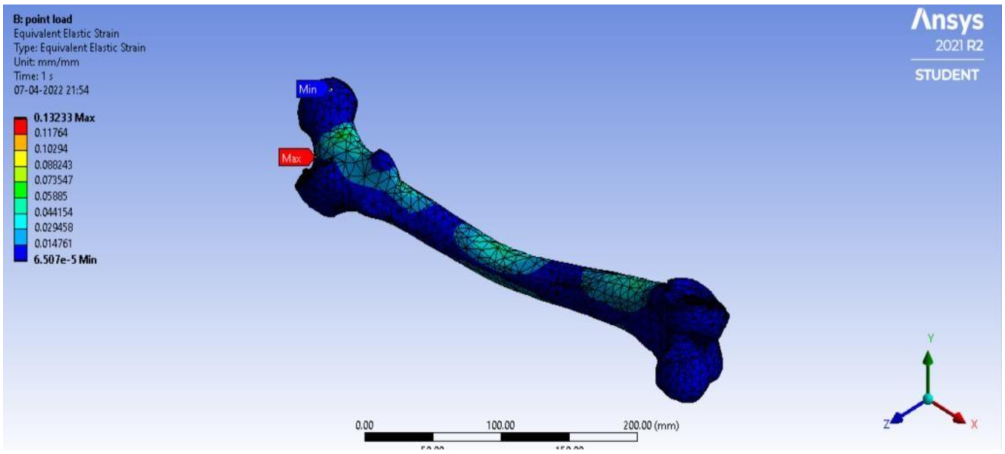


Fig.5.80 Strain of Steel TI-6AL-4V Material

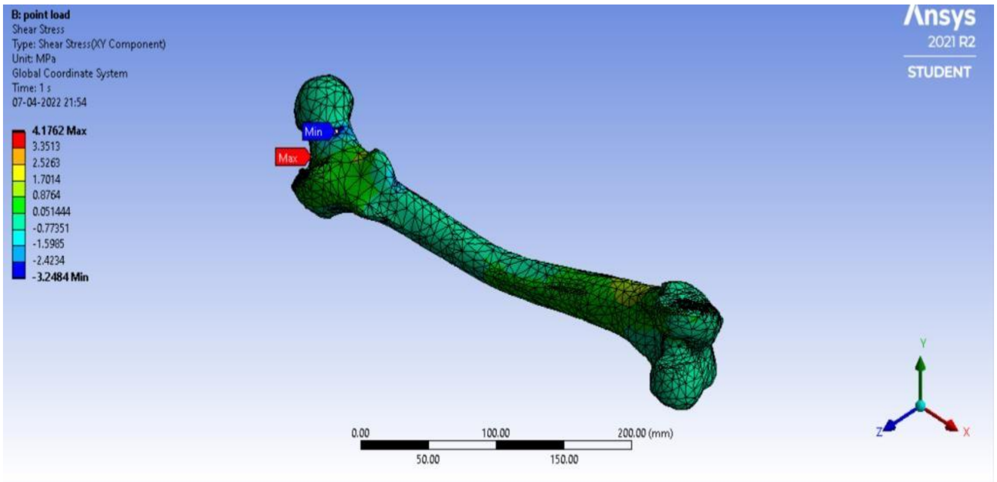


Fig.5.81 Shear stress of TI-6AL-4V Material

5. Point Load of PLA Material

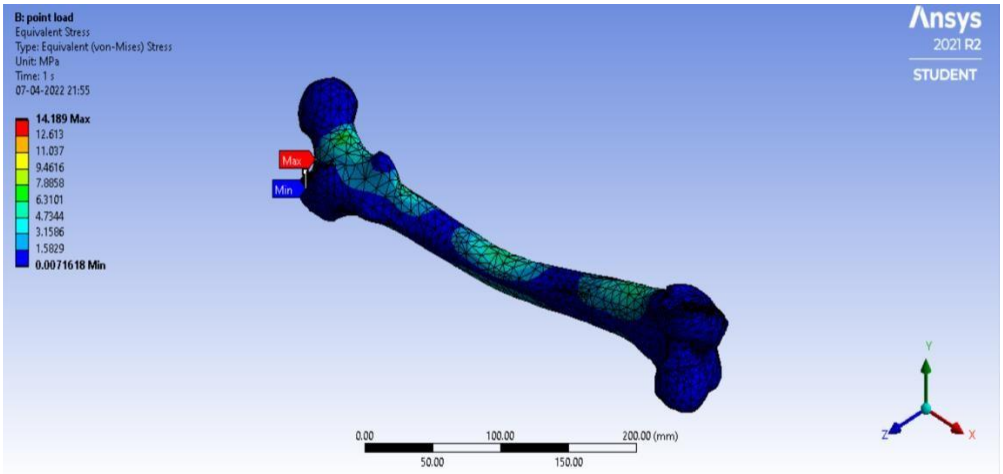


Fig.5.82 Von-misses stress of PLA Material

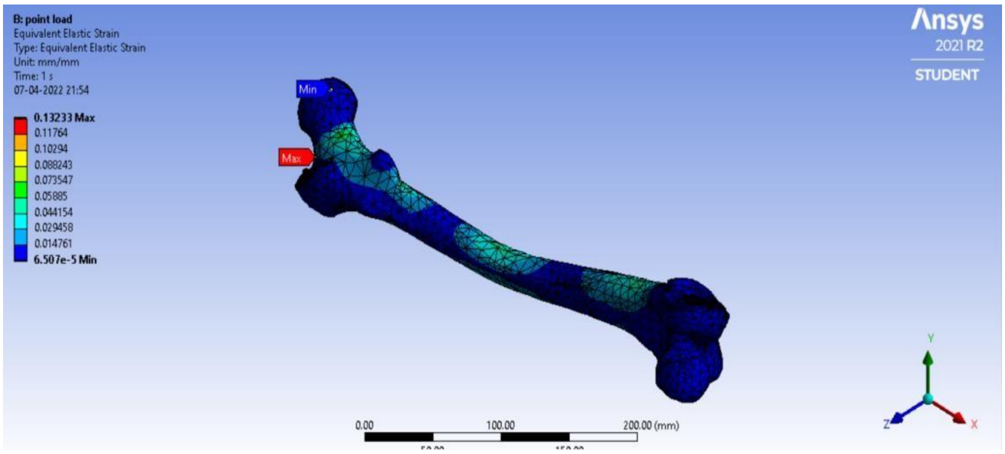


Fig.5.83 Total deformation of PLA Material

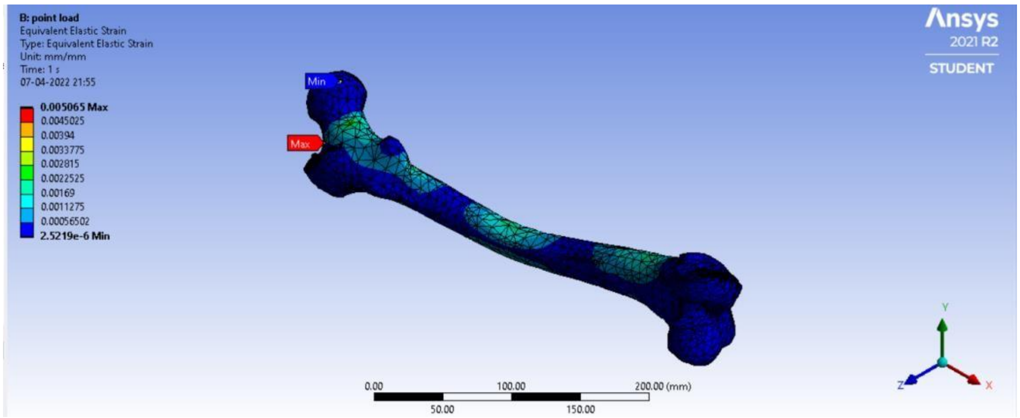


Fig.5.84 Strain of Steel PLA Material

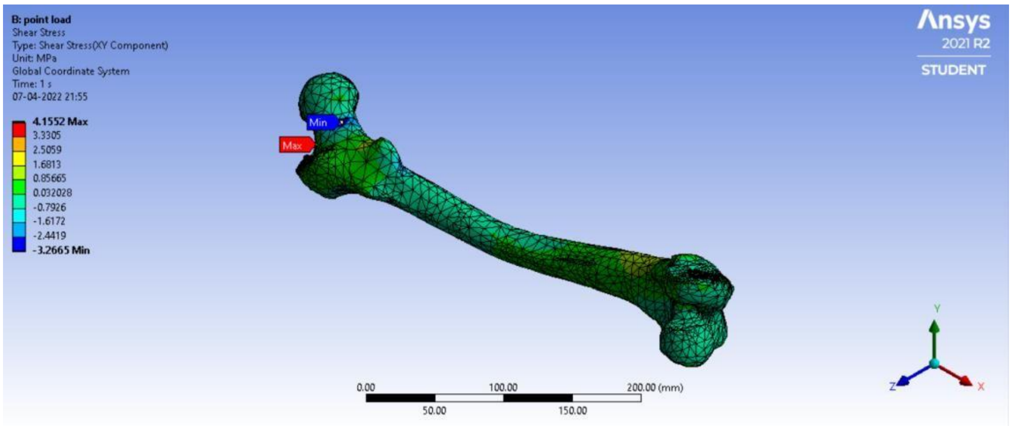


Fig.5.85 Shear stress of PLA Material

MODAL ANALYSIS & RESULTS

Modal analysis is a technique to study the dynamic characteristics of a Humer bone fixed the two ends observe the under vibration excitation. Using various materials (CALCIUM PHOSPHATE, STRONTIUM, STEEL 304, TI-6AL-4V, and PLA) to find out the best material.

Natural frequencies, mode shapes and mode vectors of a structure can be determined using modal analysis. A graphical variation of number of modes vs. the frequency can also be obtained from ANSYS Workbench.

Modal Analysis of Calcium Phosphate Material

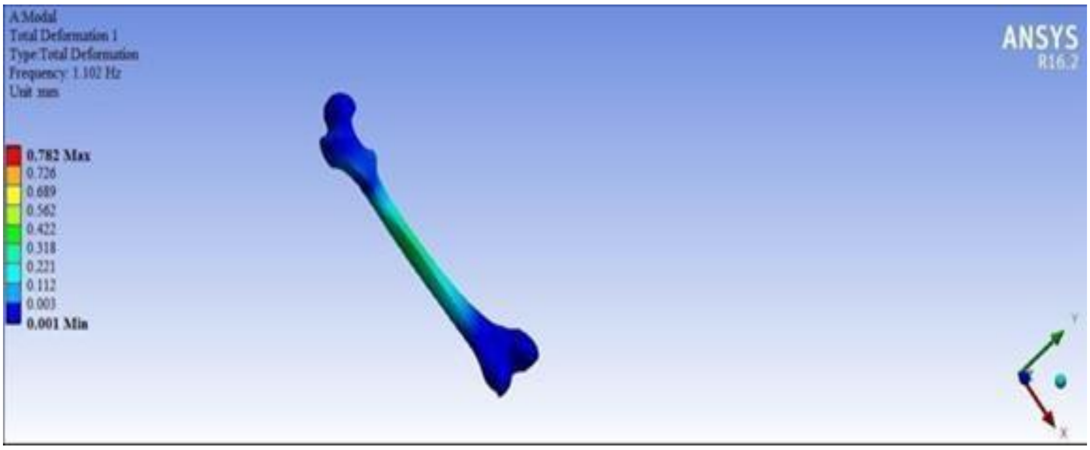


Fig.5.86 Total deformation of Calcium phosphate material at Mode1

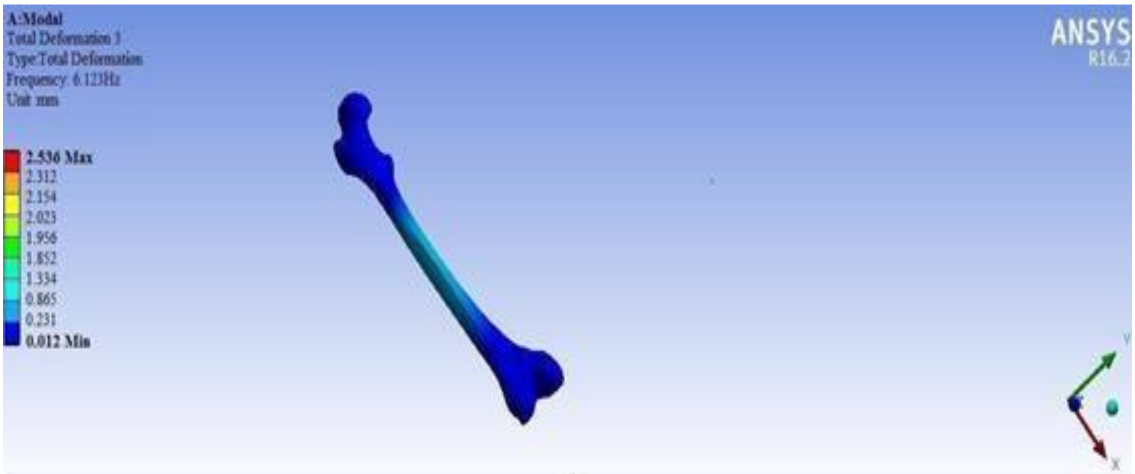


Fig.5.87 Total deformation of Calcium phosphate material at Mode 2

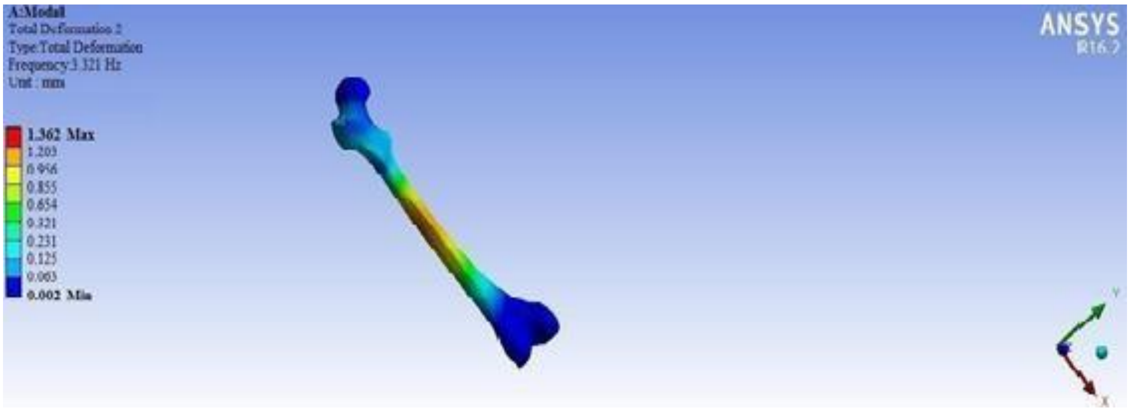


Fig.5.88 Total deformation of Calcium phosphate material at Mode 3

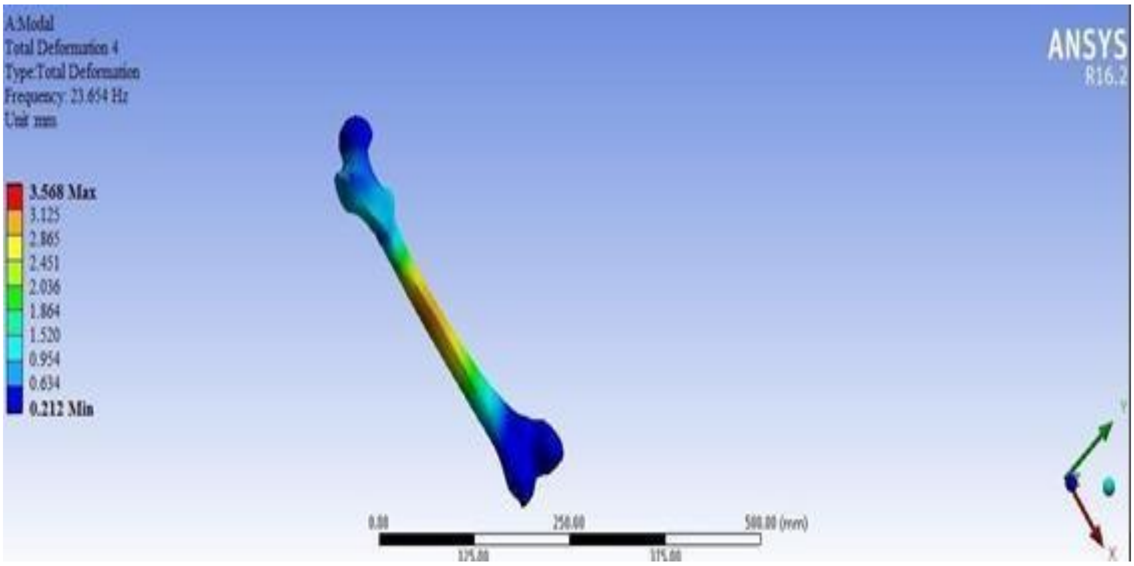


Fig.5.89 Total deformation of Calcium phosphate material at Mode 4

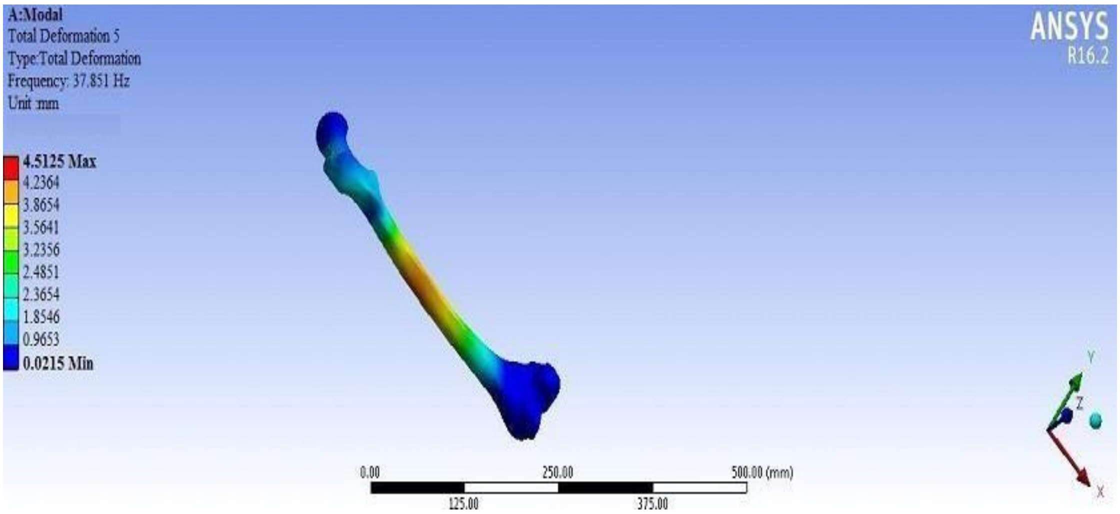


Fig.5.90 Total deformation of Calcium phosphate material at Mode 5

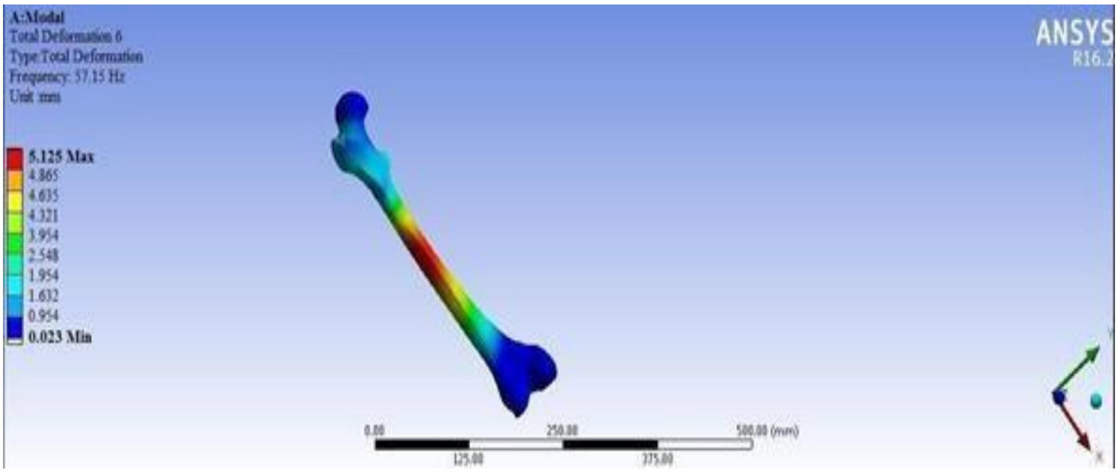


Fig.5.91 Total deformation of Calcium phosphate material at Mode 6

Modal Analysis of Strontium Material

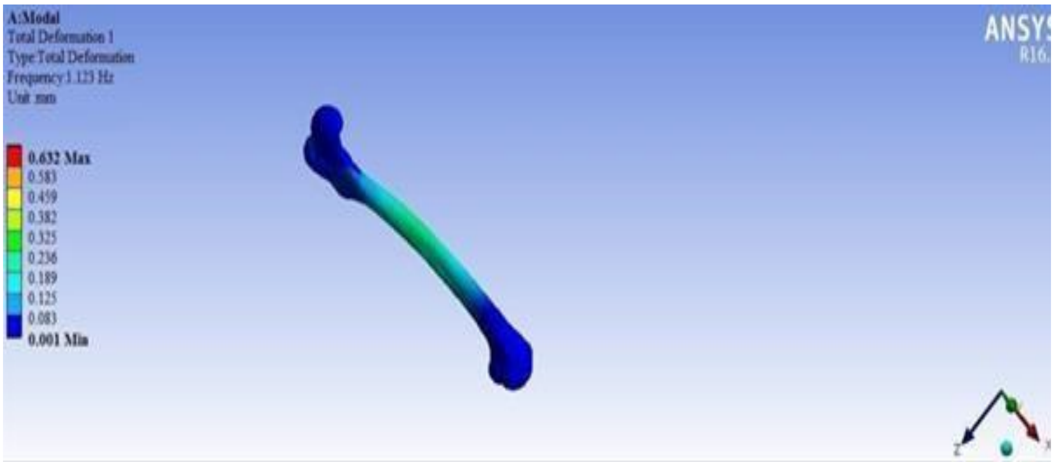


Fig.5.92 Total deformation of Strontium material at Mode1

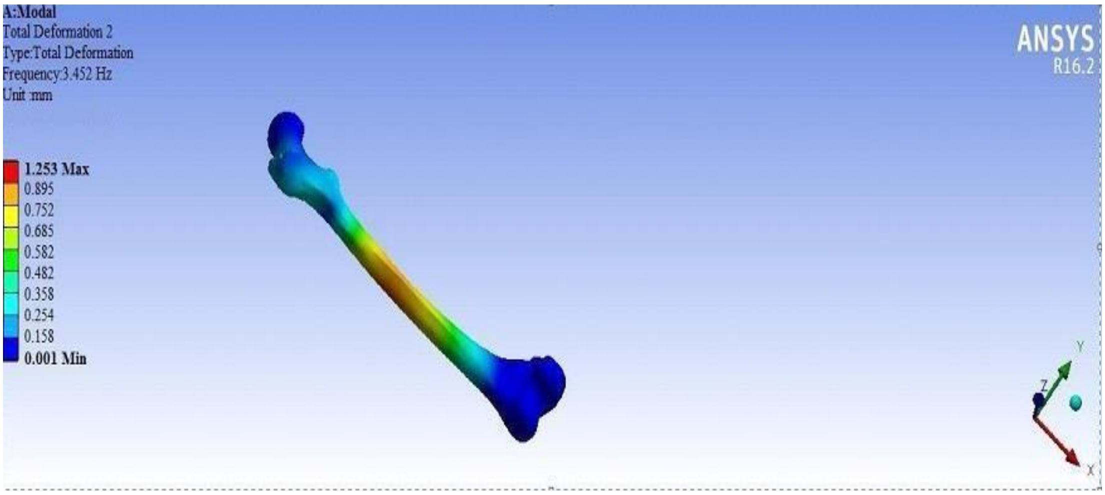


Fig.5.93 Total deformation of Strontium material at Mode 2

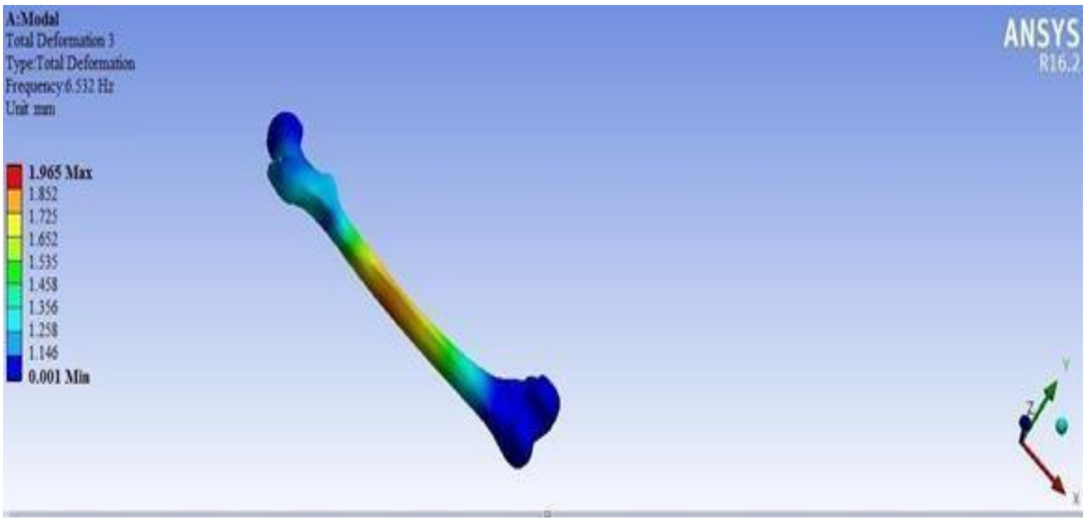


Fig.5.94 Total deformation of Strontium material at Mode 3

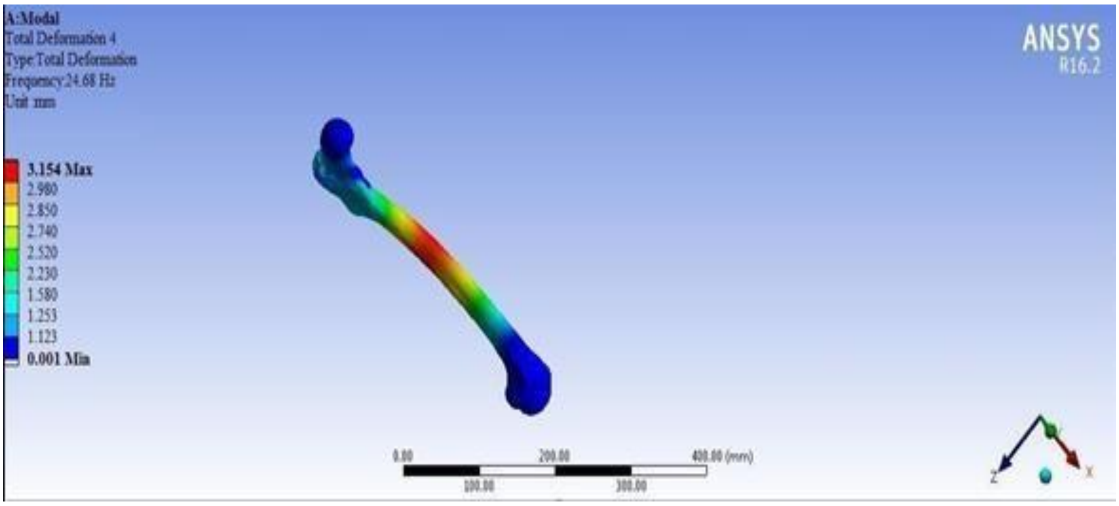


Fig.5.95 Total deformation of Strontium material at Mode 4

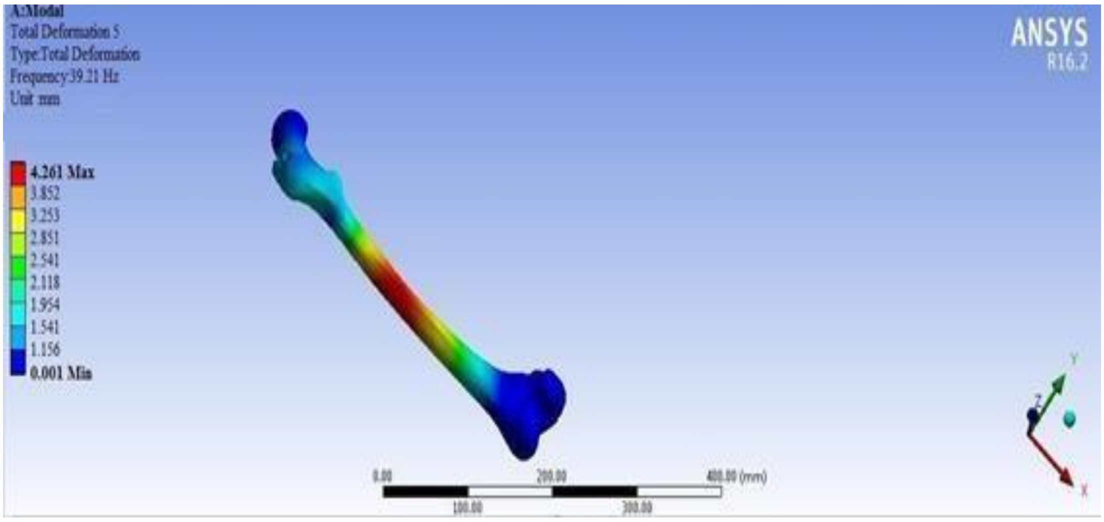


Fig.5.96 Total deformation of Strontium material at Mode 5

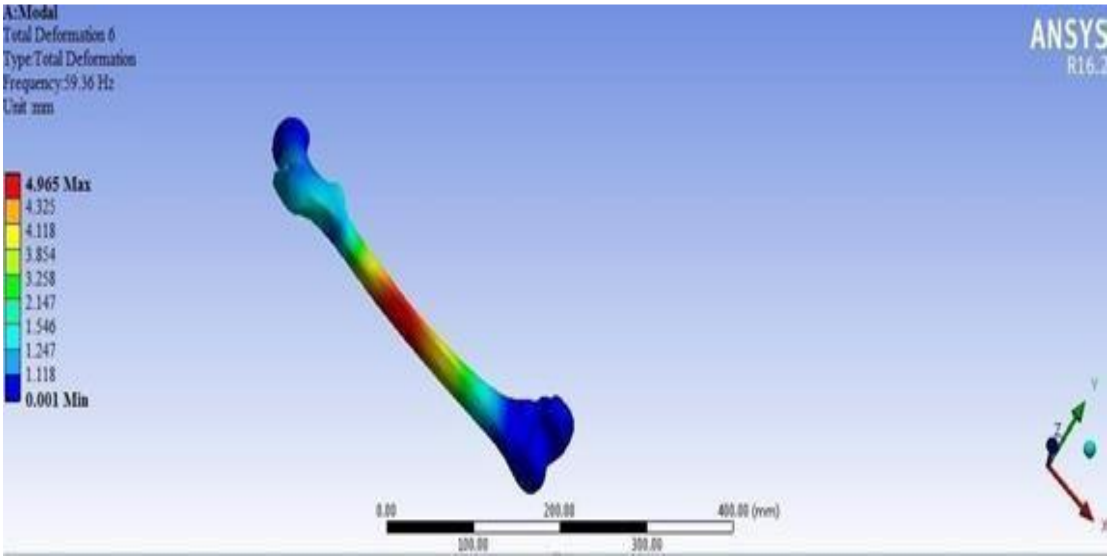


Fig.5.97 Total deformation of Strontium material at Mode 6

Modal Analysis of Steel 304 Material

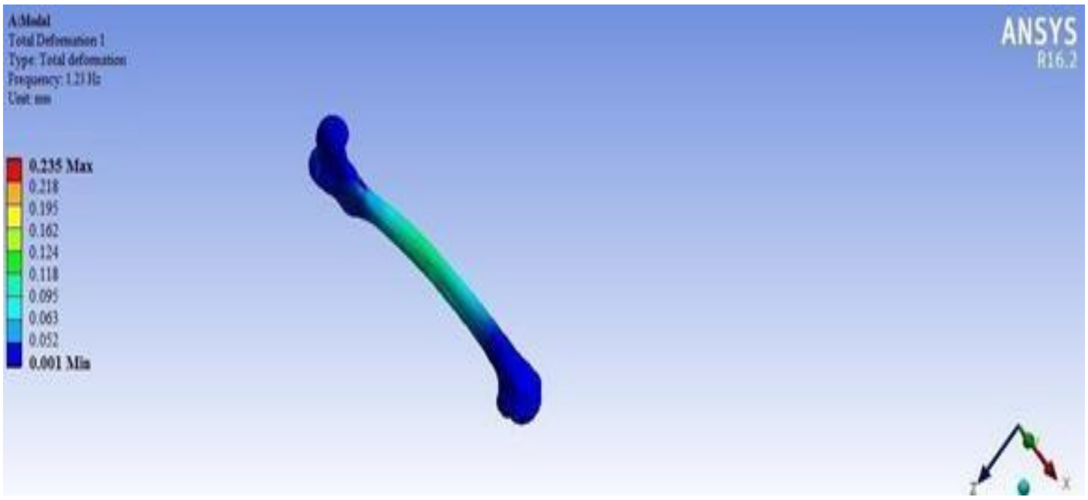


Fig.5.98 Total deformation of Steel 304 material at Mode1

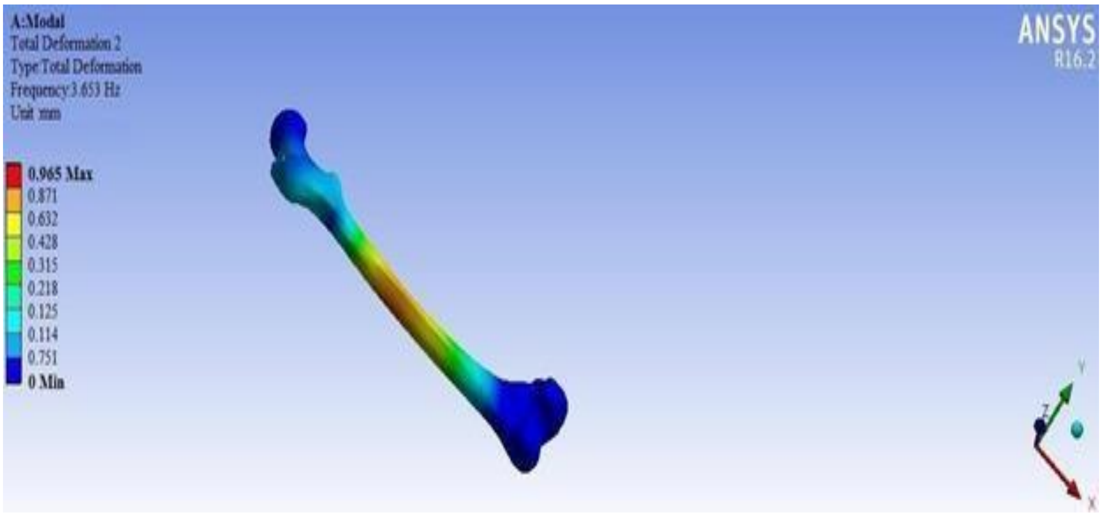


Fig.5.99 Total deformation of Steel 304 material at Mode 2

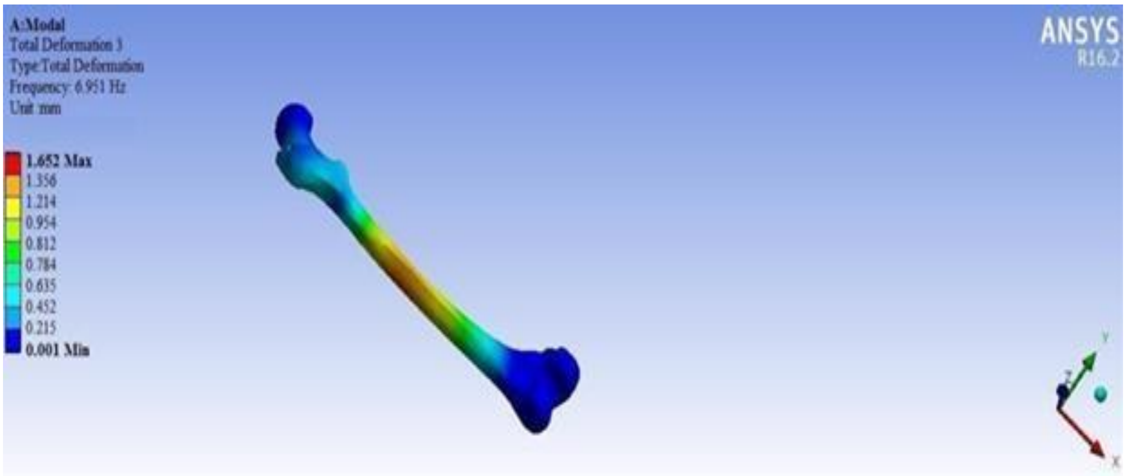


Fig.5.100 Total deformation of Steel 304 material at Mode 3

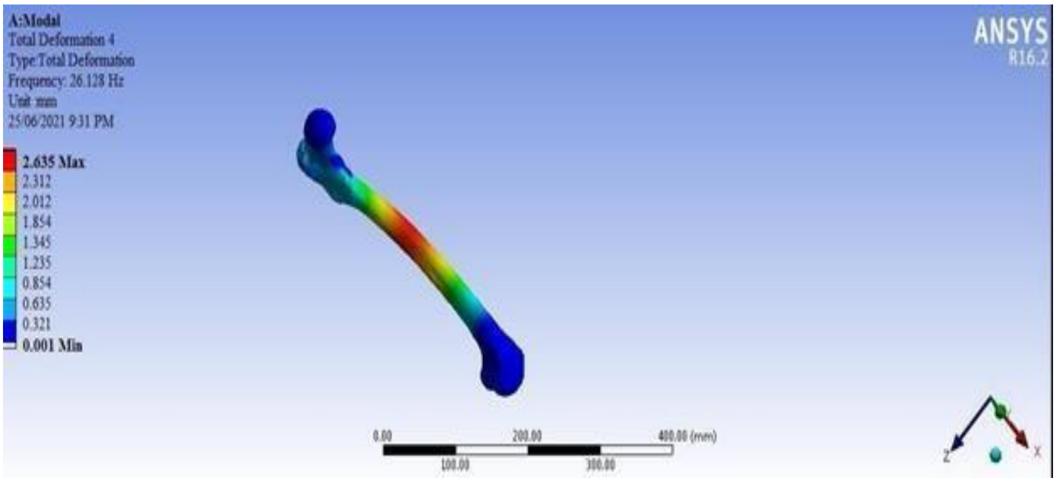


Fig.5.101 Total deformation of Steel 304 material at Mode 4

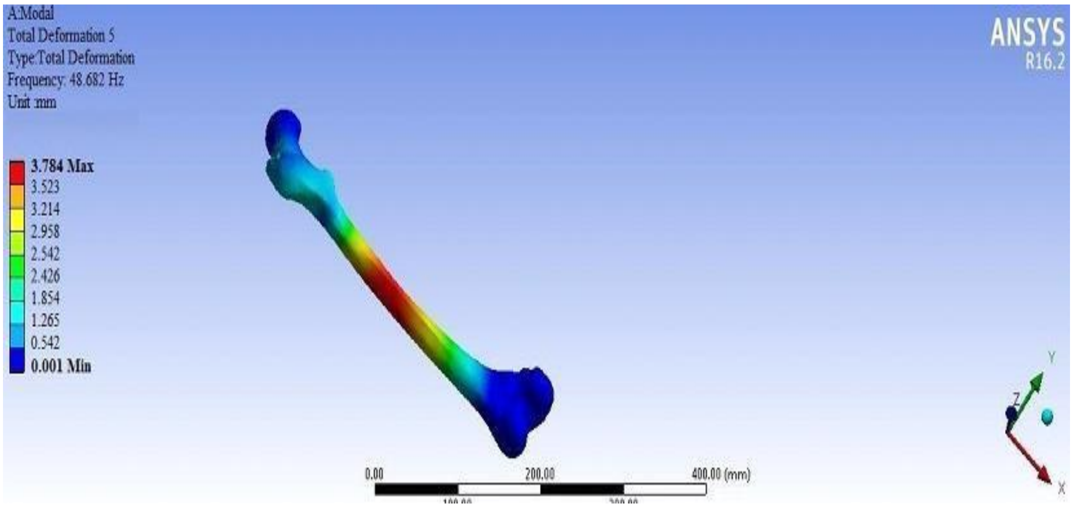


Fig.5.102 Total deformation of Steel 304 material at Mode 5

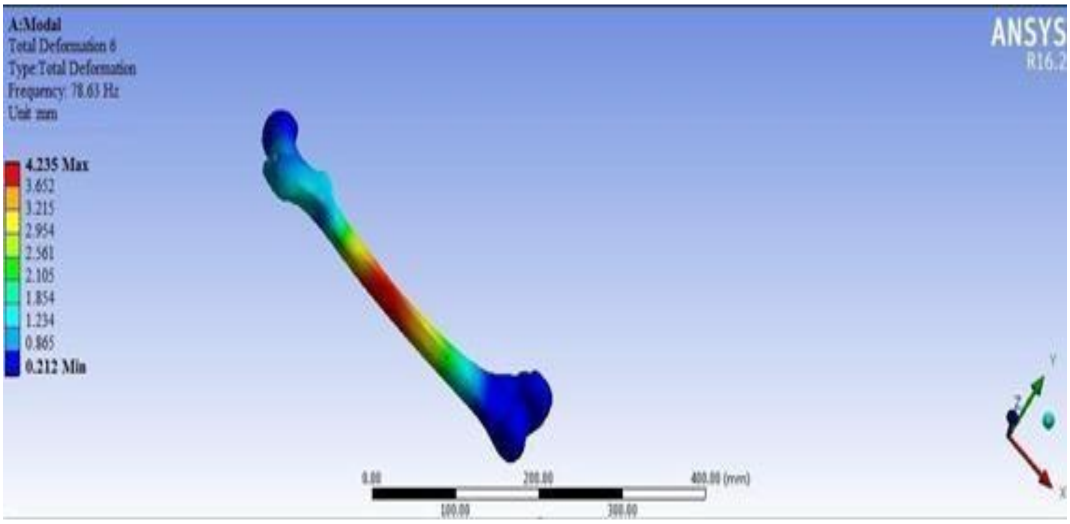


Fig.5.103 Total deformation of Steel 304 material at Mode 6

Modal Analysis of Ti-6AL-4V Material

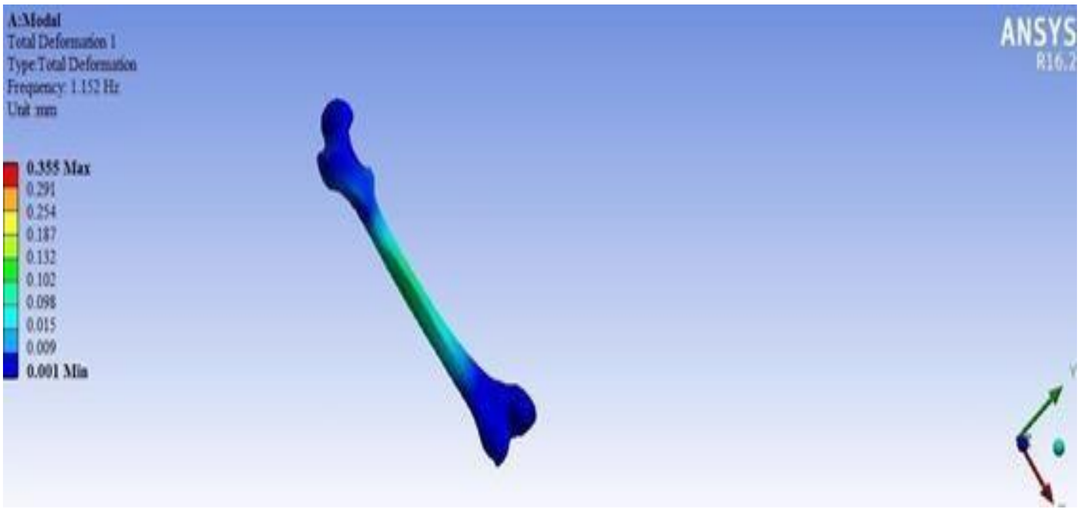


Fig.5.104 Total deformation of TI6AL-4V Material at Mode1

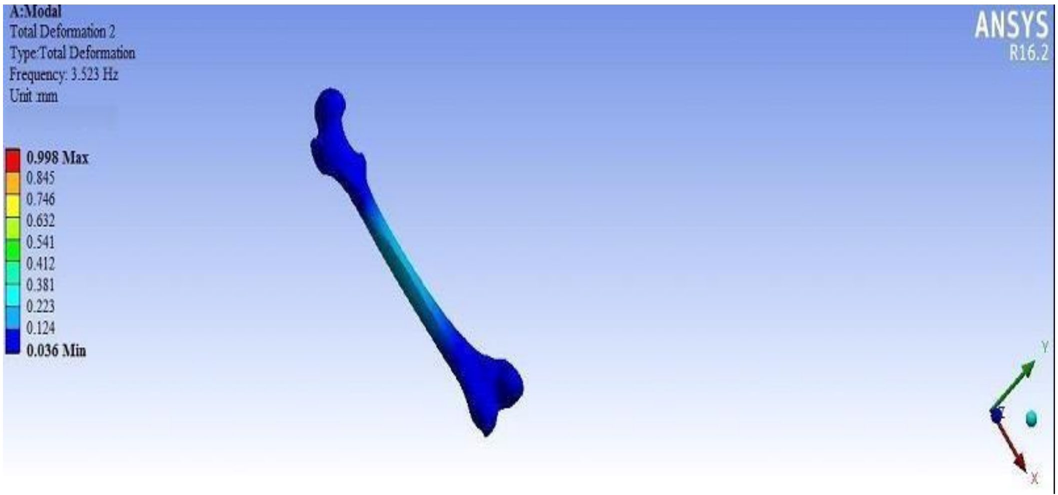


Fig.5.105 Total deformation of TI-6AL-4V Material at Mode 2

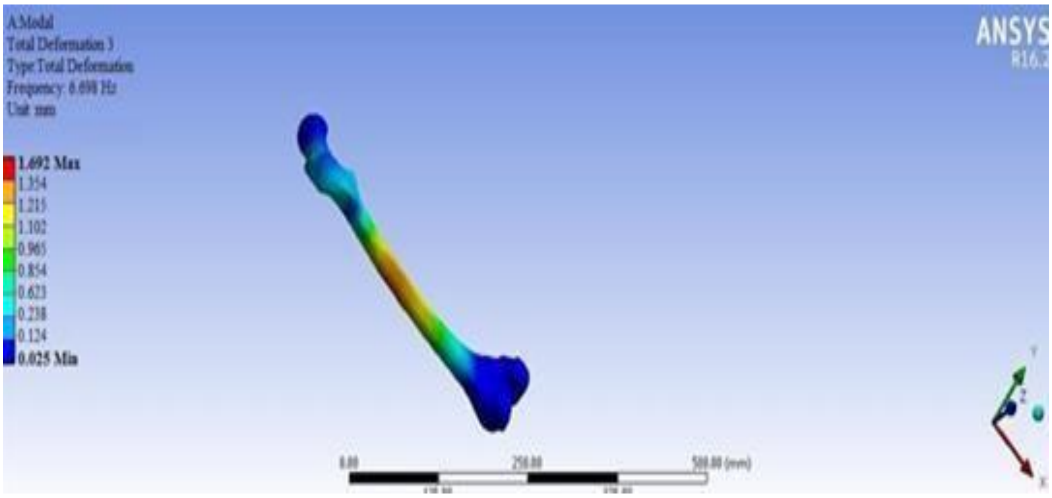


Fig.5.106 Total deformation of TI-6AL-4V Material at Mode 3

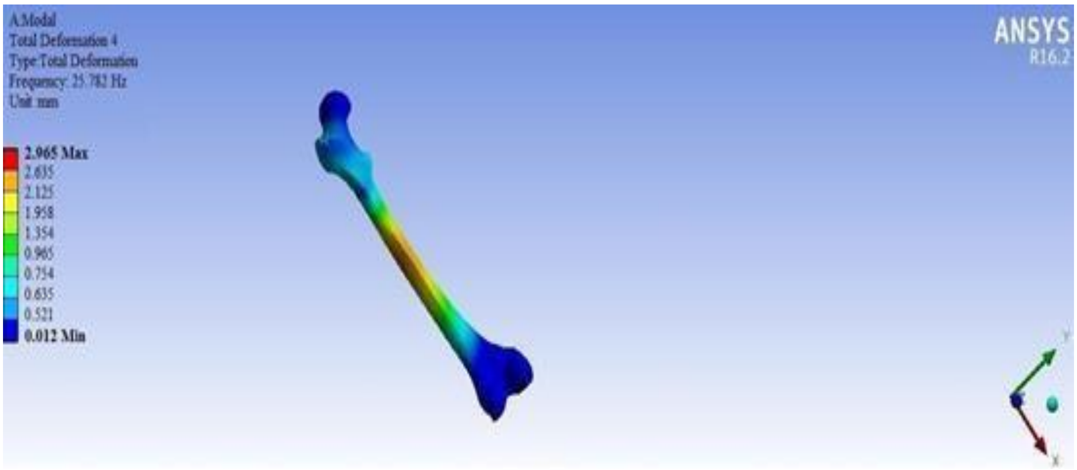


Fig.5.107 Total deformation of TI-6AL-4V Material at Mode 4

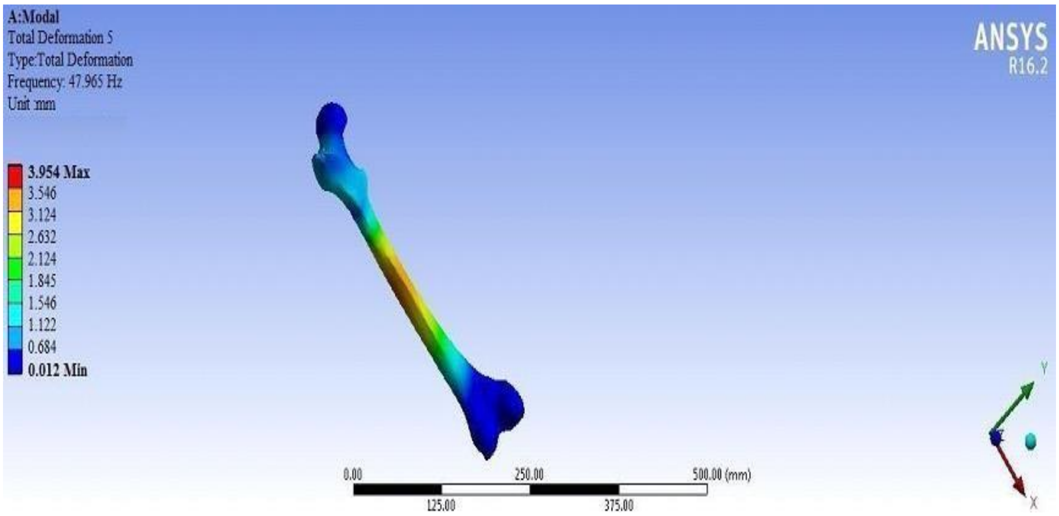


Fig.5.108 Total deformation of TI-6AL-4V Material at Mode 5

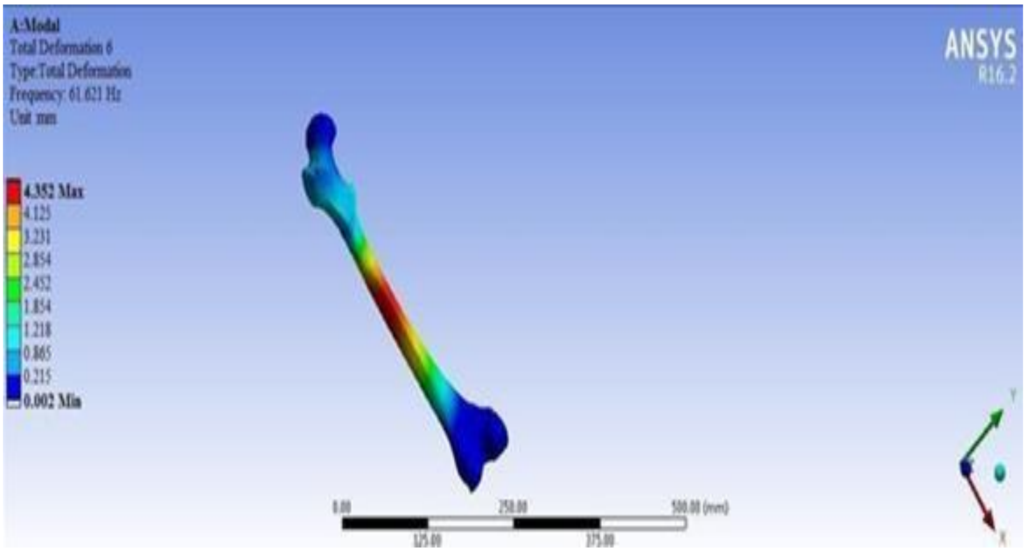


Fig.5.109 Total deformation of TI-6AL-4V Material at Mode 6

Modal Analysis of PLA Material

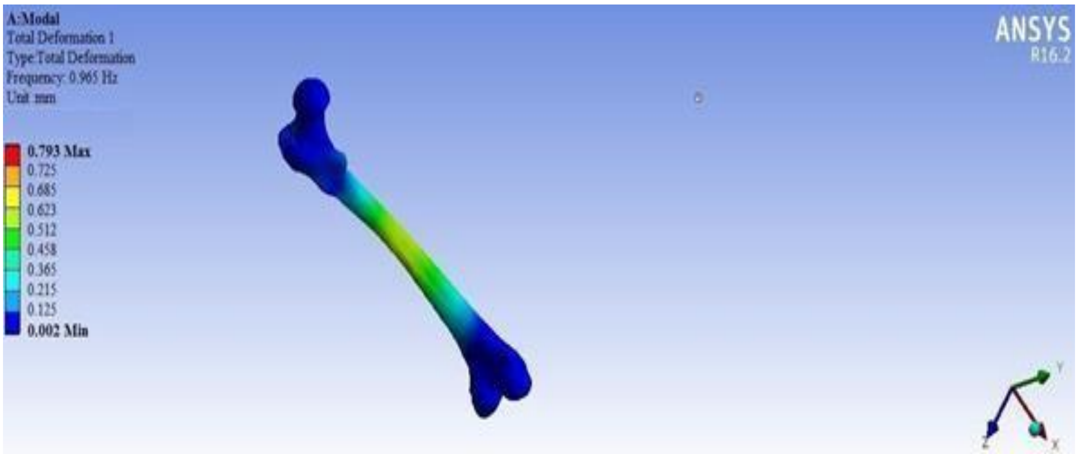


Fig.5.110 Total deformation of PLA Material at Mode1

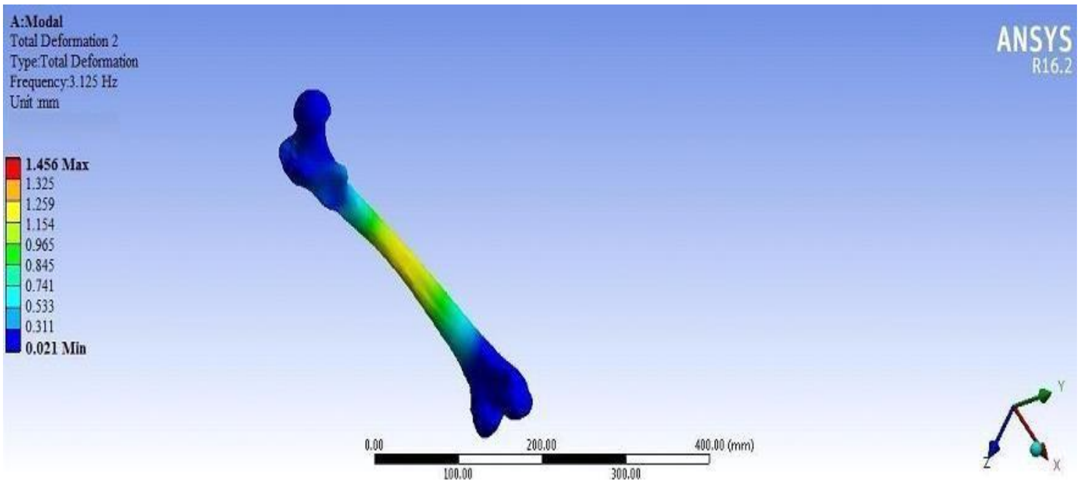


Fig.5.111 Total deformation of PLA Material at Mode 2

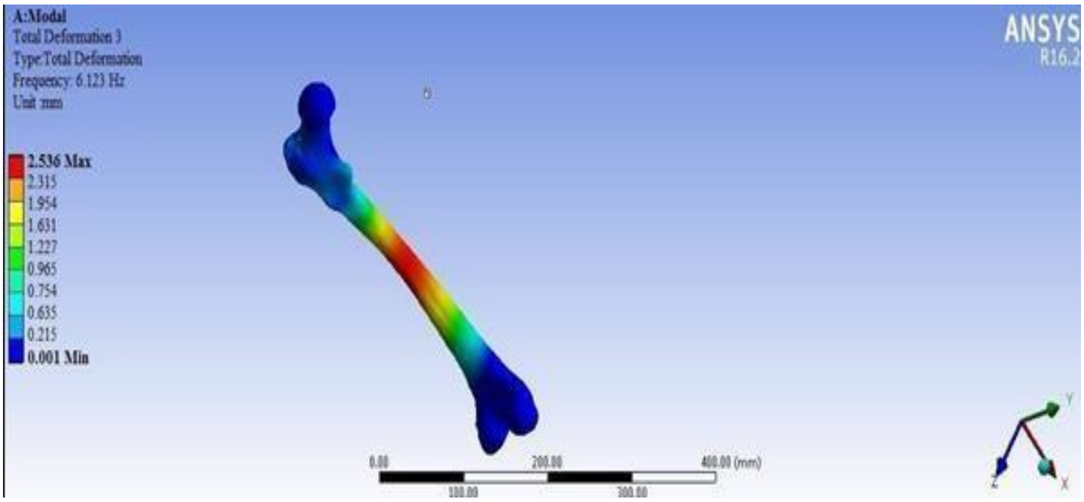


Fig.5.112 Total deformation of PLA Material at Mode 3

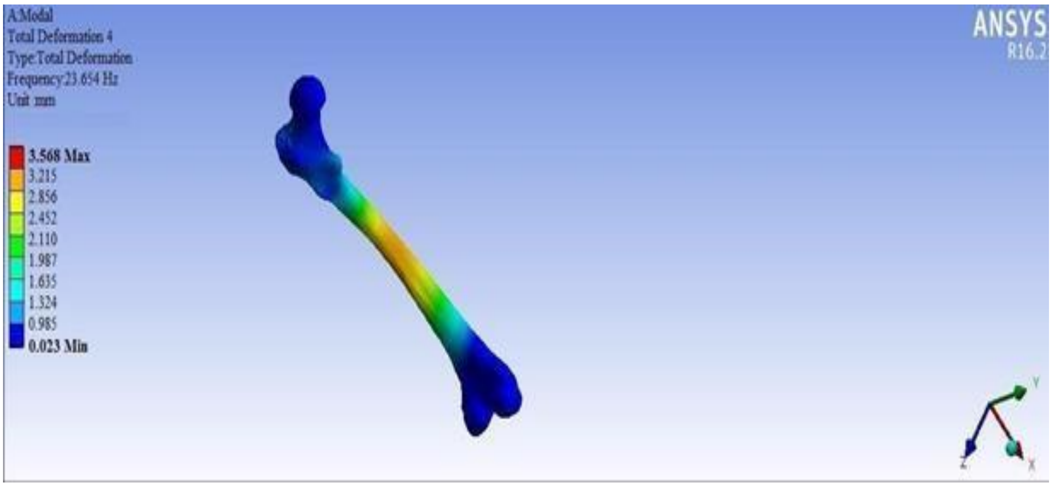


Fig.5.113 Total deformation of PLA Material at Mode 4

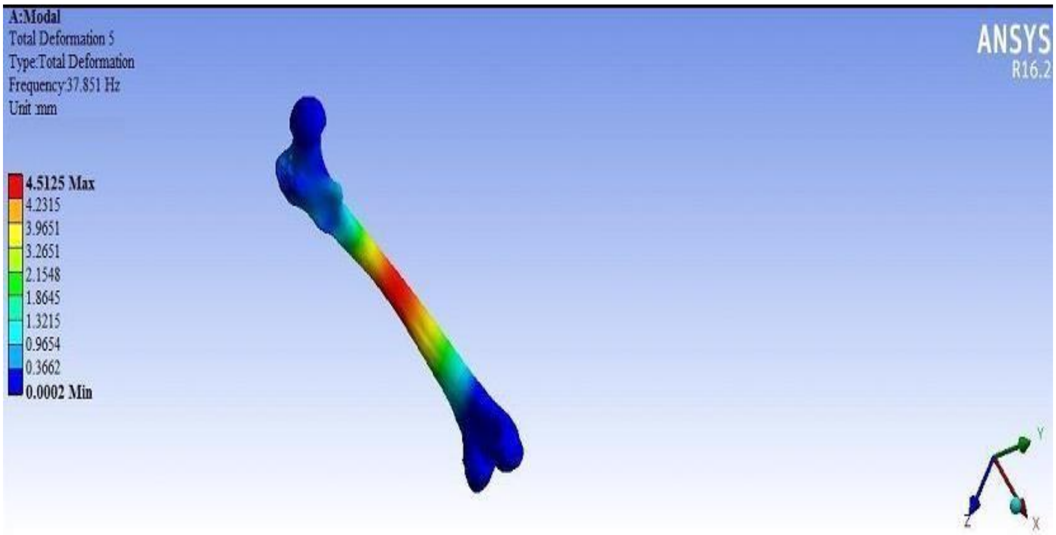


Fig.5.114 Total deformation of PLA Material at Mode 5

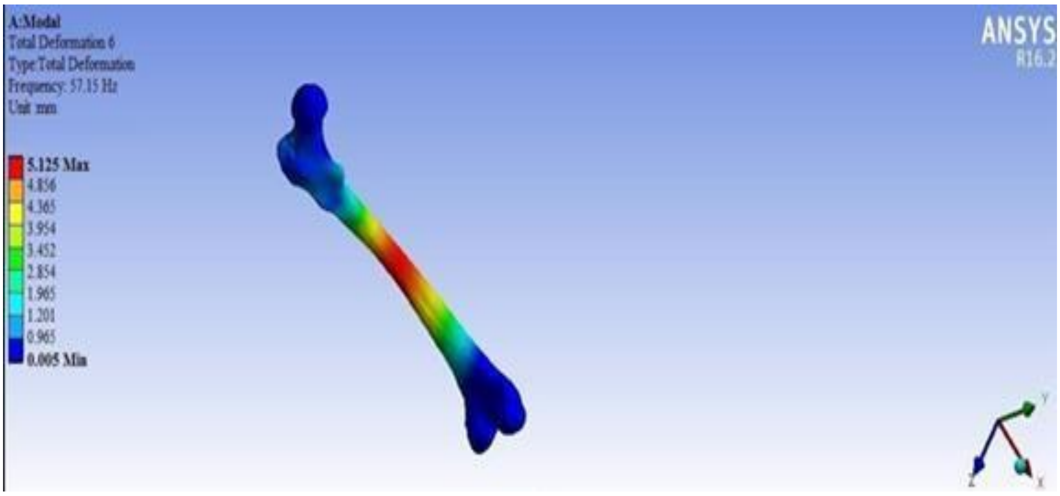


Fig.5.115 Total deformation of PLA Material at Mode

Chapter 6

STATIC ANALYSIS RESULT COMPARISION

COMPRESSIVE LOAD

Von-Misses Stress Graph of Compressive Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti- 6Al-4V, Pla)** are done we are taking Compressive load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Von-misses stress as shown below Graph

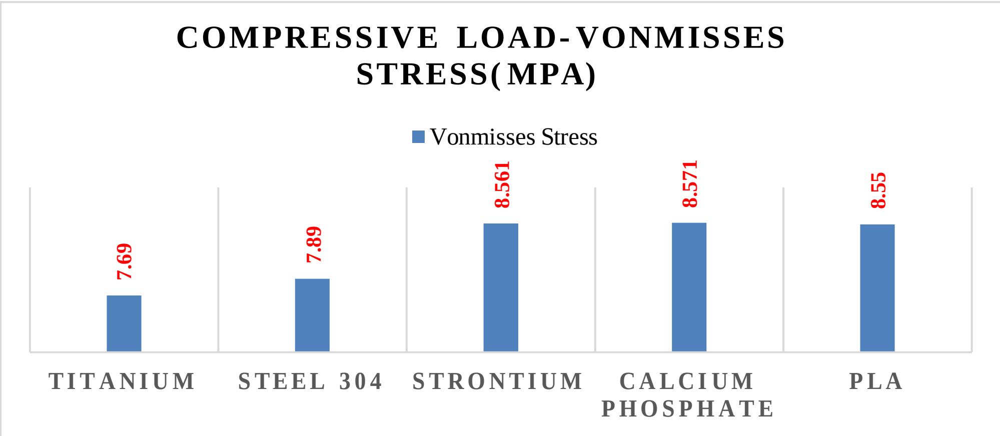


Fig.6.1 Von-misses stress Graph of Compressive load

Total Deformation Graph of Compressive Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti- 6Al-4V, Pla)** Material are done we are taking Compressive load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Total deformation as shown below Graph.

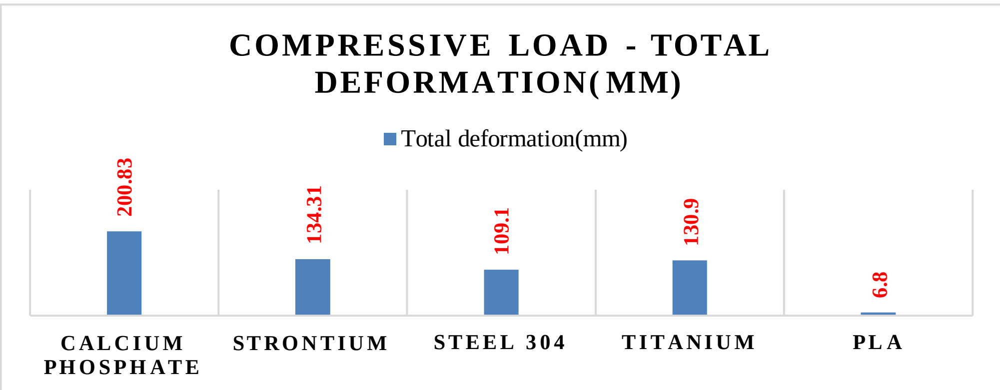


Fig.6.2 Total deformation Graph of Compressive load

CHAPTER-6 STATIC ANALYSIS RESULT COMPARISION

Strain Graph of Compressive Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti- 6Al-4V, Pla)** Materials are done we are taking Compressive load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Strain as shown below Graph

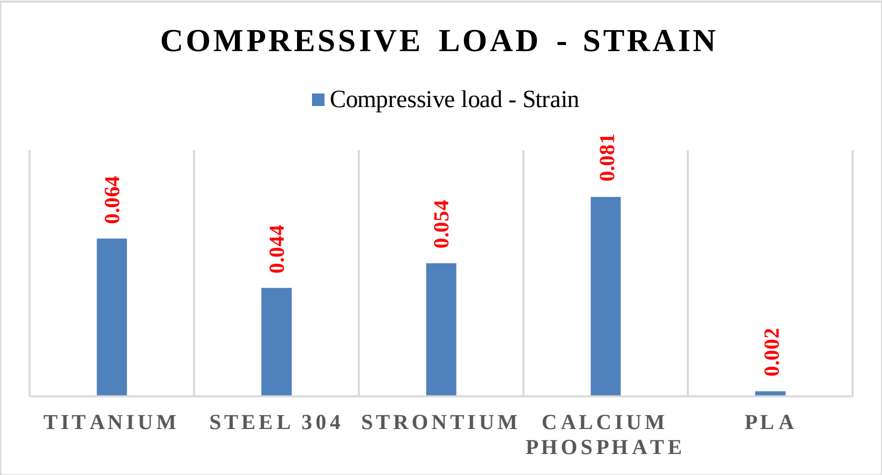


Fig.6.3 Strain Graph of Compressive load

Shear Stress Graph of Compressive Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, Pla)** Materials are done we are taking Compressive load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Shear stress as shown below Graph

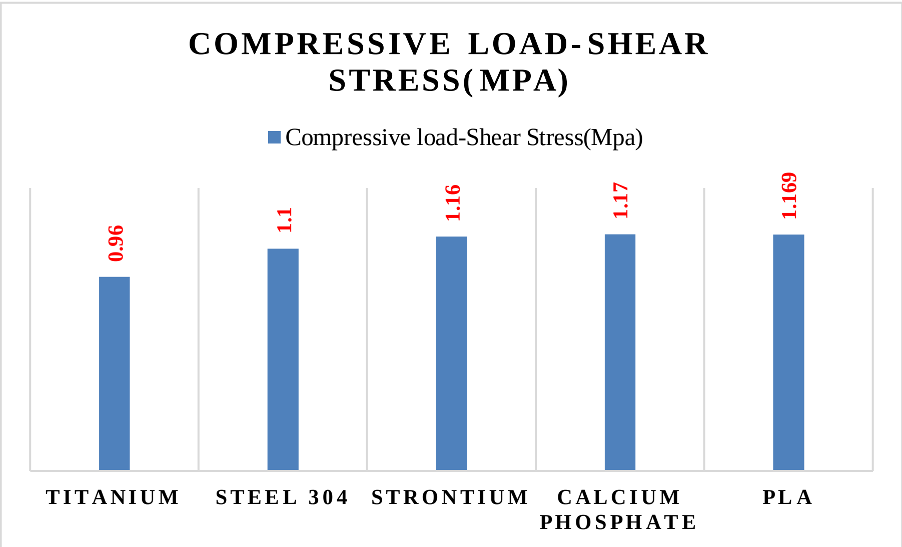


Fig.6.4 Shear stress Graph of Compressive load

CHAPTER-6 STATIC ANALYSIS RESULT COMPARISION

TENSILE LOAD

Von-misses Stress Graph of Tensile Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, Pla)** Materials are done we are taking Tensile Load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Von-misses stress as shown below Graph

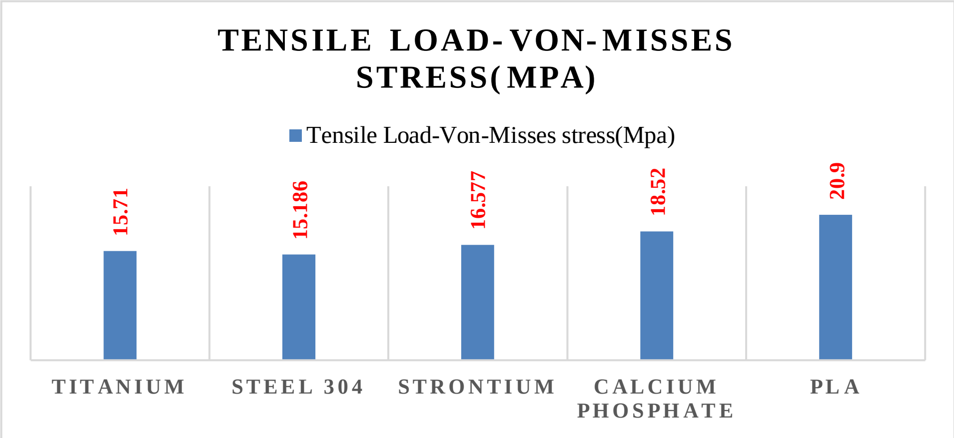


Fig.6.5 Von-misses stress Graph of Tensile load

Total Deformation Graph of Tensile Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, Pla)** Materials are done we are taking Tensile Load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Total deformation as shown below Graph

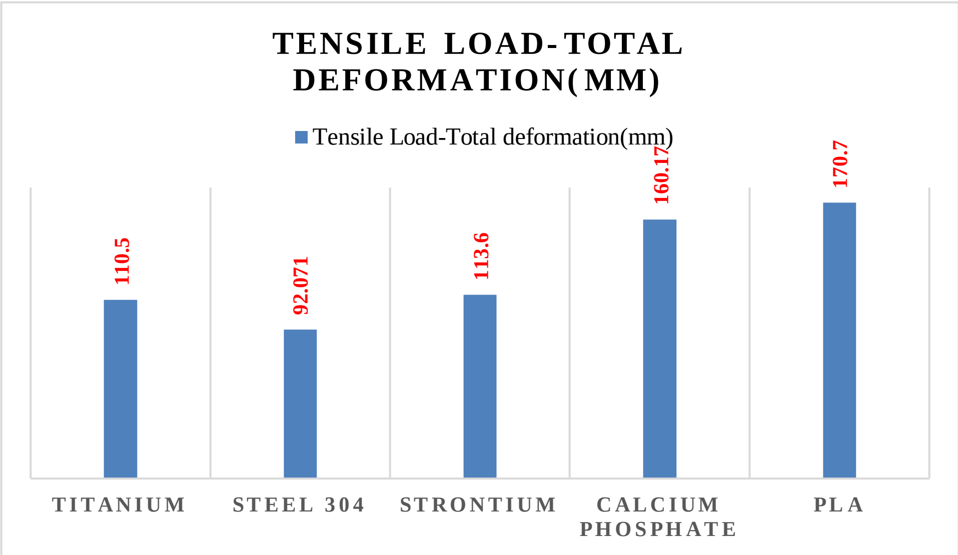


Fig.6.6 Total deformation Graph of Tensile load

CHAPTER-6 STATIC ANALYSIS RESULT COMPARISION

Strain Graph of Tensile Load

The static structural analysis of **(Calcium Phosphate, Strontium, Steel 304, Ti- 6Al-4V, Pla)** Materials are done we are taking Tensile Load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained strain as shown below Graph.

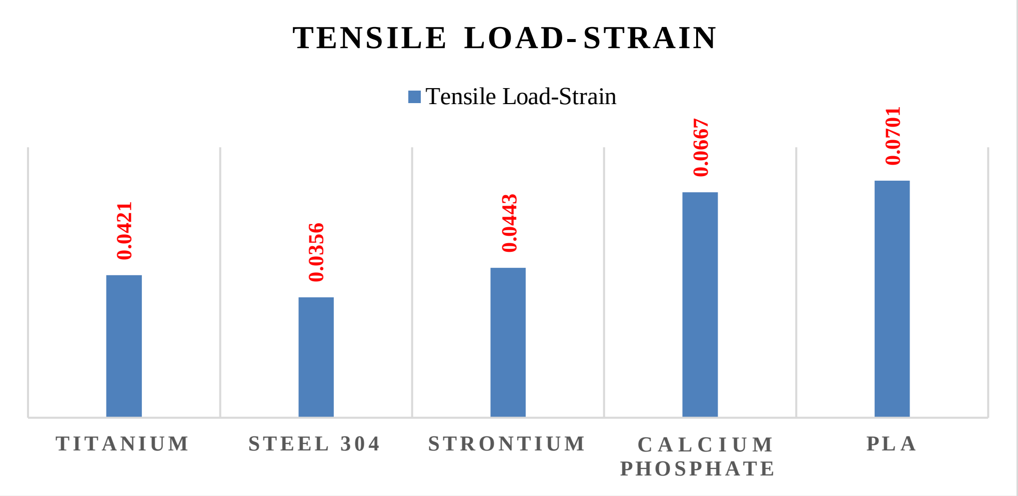


Fig.6.7Strain Graph of Tensile load

Shear Stress Graph of Tensile Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti- 6Al-4V, Pla)** Materials are done we are taking Tensile Load conditions 390N are Fixed at Knee area and apply load at Humer Ball and results are obtained Shear stress as shown below Graph

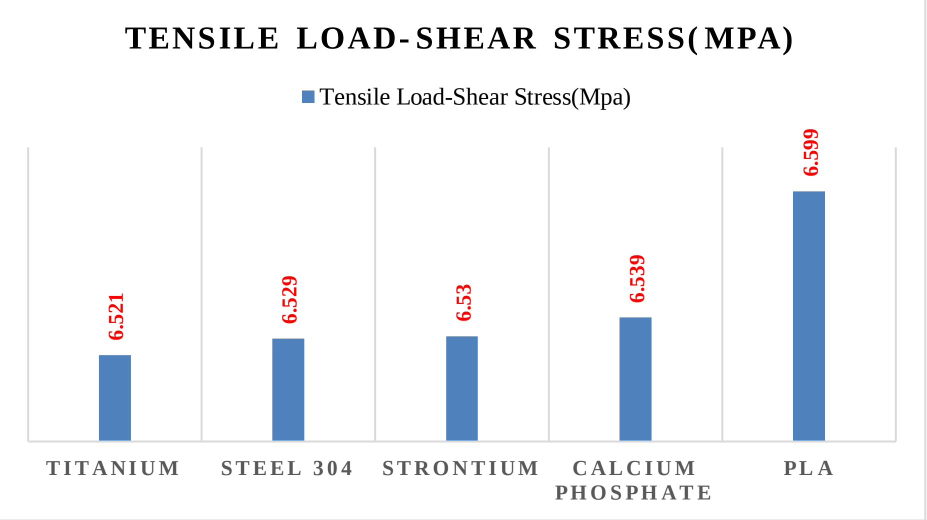


Fig.6.8 Shear stress Graph of Tensile load

CHAPTER-6 STATIC ANALYSIS RESULT COMPARISION

SHEARLOAD

Von-Misses Stress Graph of Shear Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti- 6Al-4V, Pla)** Materials are done we are taking shear load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Von-misses stress as shown below Graph

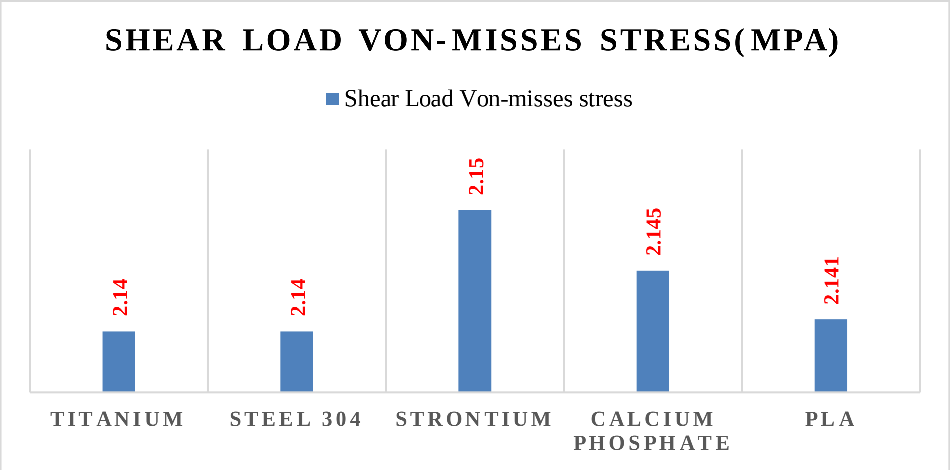


Fig.6.9 Von-misses stress Graph of Shear load

Total Deformation Graph of Shear Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, Pla)** Materials are done we are taking shear load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Total deformation as shown below Graph

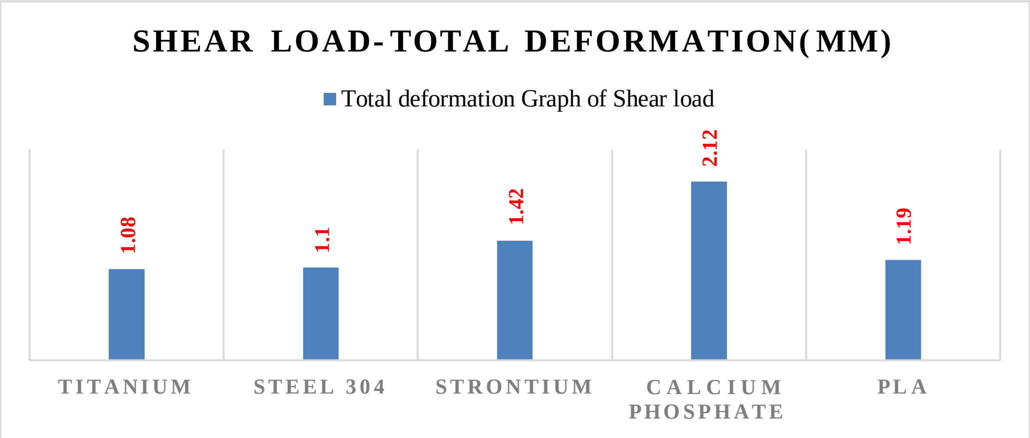


Fig.6.10 Total deformation Graph of Shear load

6.3.2 Strain Graph of Shear Load

The static structural analysis of **(Calcium Phosphate, Strontium, Steel 304, Ti- 6Al-4V, Pla)** Materials are done we are taking shear load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained strain as shown below Graph.

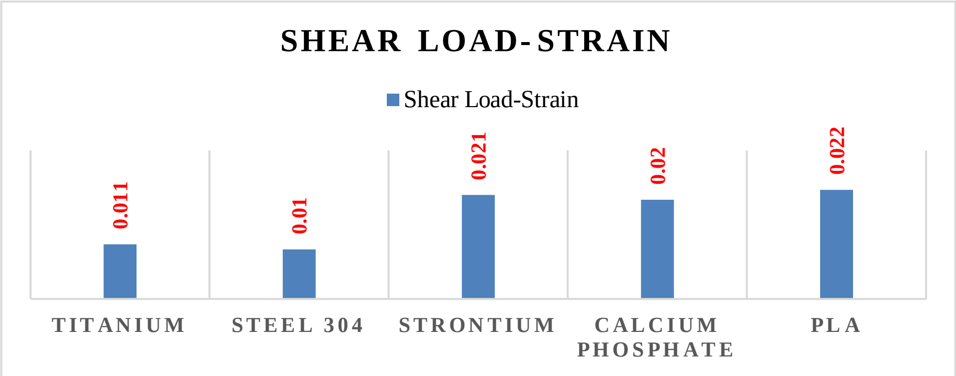


Fig.6.11 Strain Graph of Shear load

6.3.4 Shear Stress Graph of Shear Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, Pla)** Materials are done we are taking shear load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained shear stress as shown below Graph

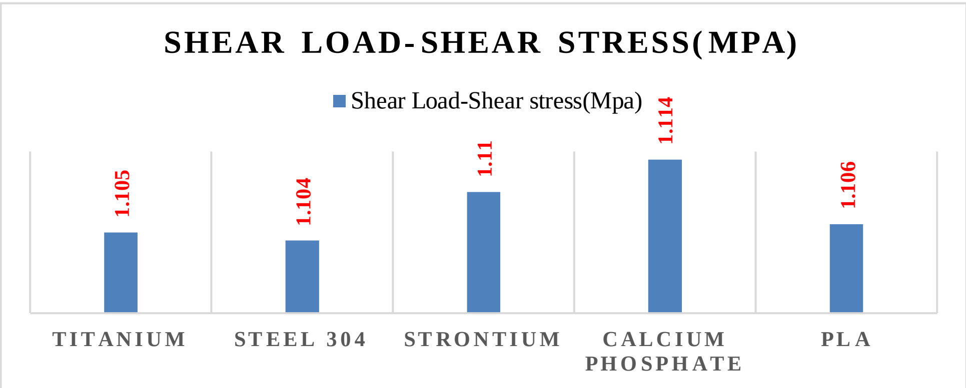


Fig.6.12 Shear stress Graph of Shear load

POINT LOAD

Von-Misses Stress Graph of Point Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, Pla)** Materials are done we are taking Point load conditions 390N are

CHAPTER-6 STATIC ANALYSIS RESULT COMPARISION

Fixed at Shoulder area and apply load at Humer Ball and results are obtained von-misses stress as shown below Graph.

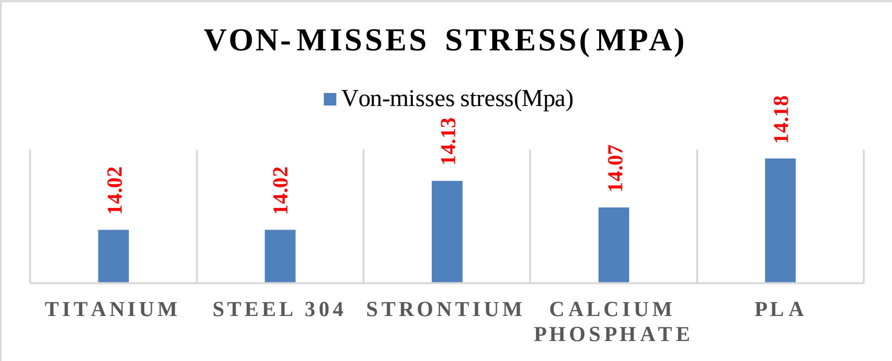


Fig.6.13 Von-misses stress Graph of Point load

Total Deformation Graph of Point Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, Pla)** Materials are done we are taking Point load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Total deformation as shown below Graph

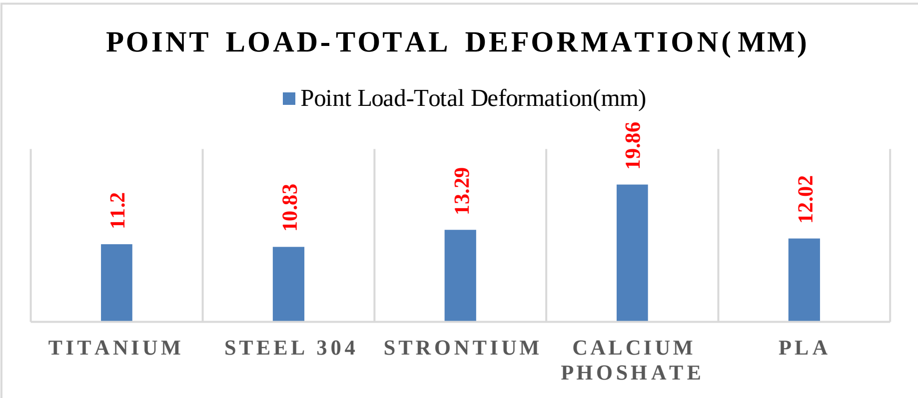


Fig.6.14 Total deformation Graph of Point load

Strain Graph of Point Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, Pla)** Materials are done we are taking Point load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Strain as shown below Graph

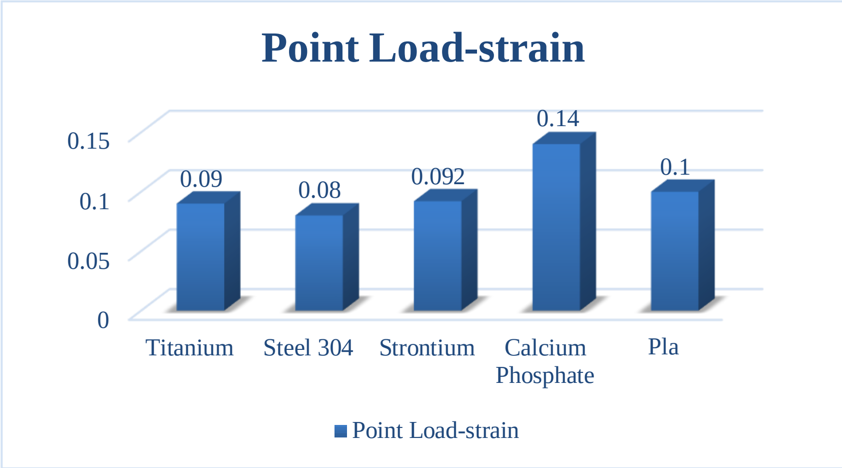


Fig.6.15 Strain Graph of Point load

Shear Stress Graph of Point Load

The static structural analysis of (**Calcium Phosphate, Strontium, Steel 304, Ti-6Al-4V, Pla)** Materials are done we are taking Point load conditions 390N are Fixed at Shoulder area and apply load at Humer Ball and results are obtained Shear stress as shown below Graph

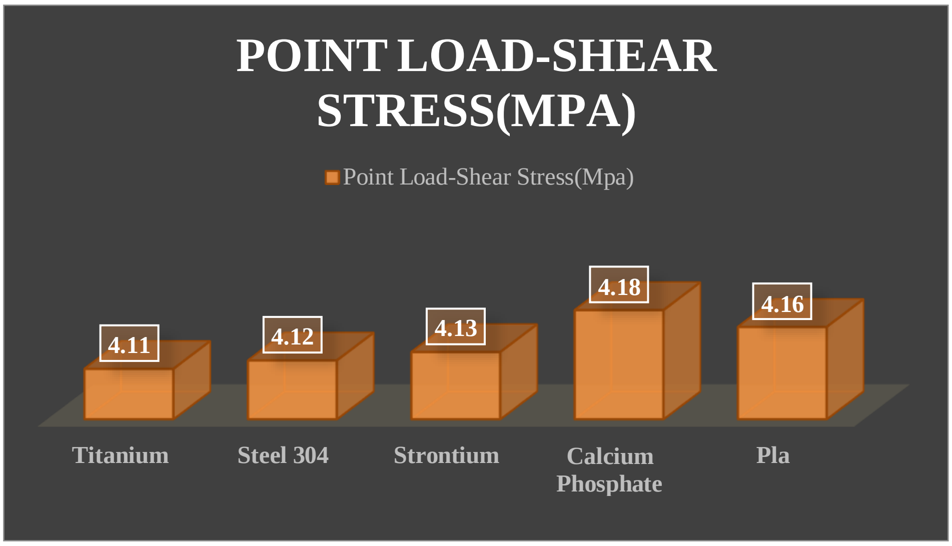


Fig.6.16 Shear stress Graph of Point load

Chapter 7

MODAL ANALYSIS RESULT COMPARISON

MODAL ANALYSIS RESULT COMPARISON

Modal analysis is a technique to study the dynamic characteristics of a Humer bone fixed the two ends observe the under vibration excitation. Natural frequencies, mode shapes and mode vectors of a structure can be determined using modal analysis with various materials (**Calcium Phosphate, Strontium, STEEL 304, TI-6AL-4V, and PLA**. A graphical variation of number of modes vs. the frequency can also be obtained from ANSYS Workbench.

Steel 304 Material

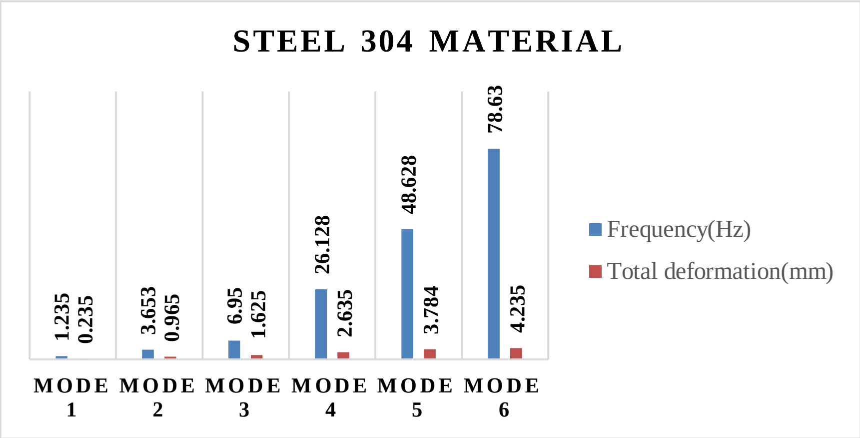


Fig.7.1 Modal analysis of Steel 304 Material

TI-6AL-4V Material

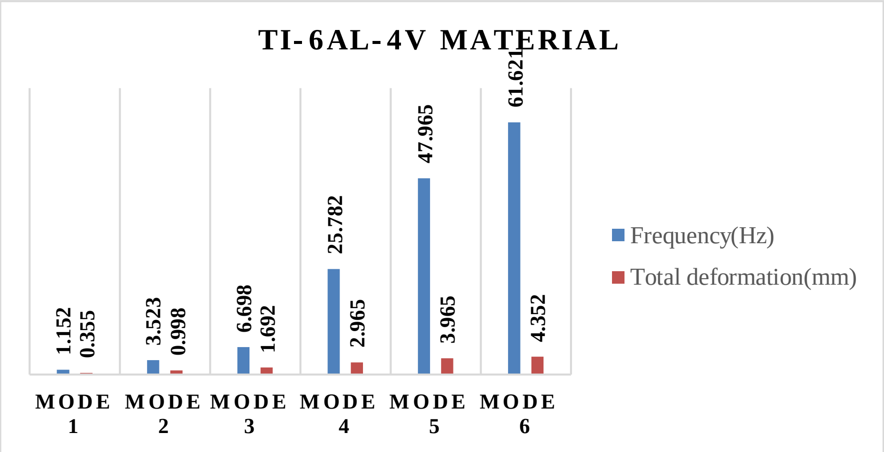


Fig.7.2 Modal analysis of Ti-6AL-4V Material

Strontium Material

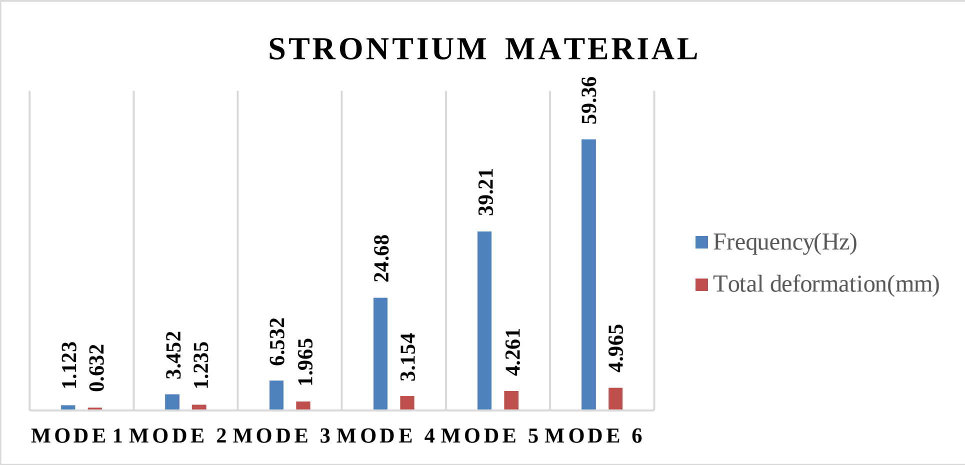


Fig.7.3 Modal analysis of Strontium Material

Calcium Phosphate Material

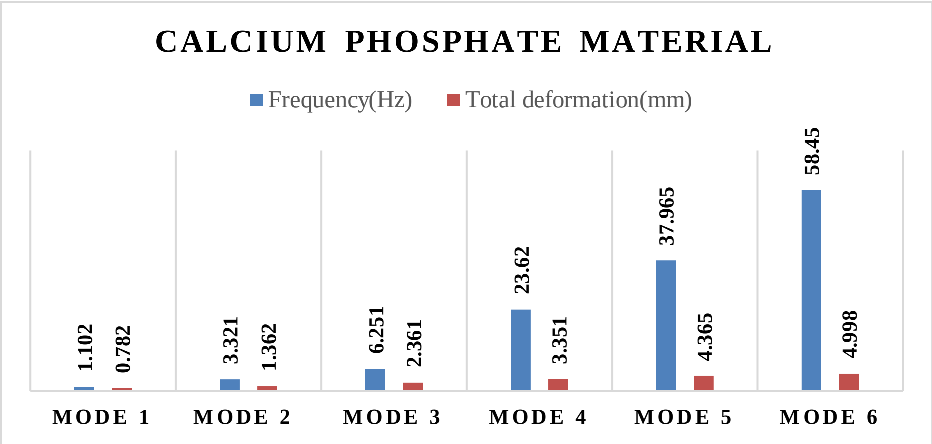


Fig.7.4 Modal analysis of Calcium Phosphate Material

PLA Material

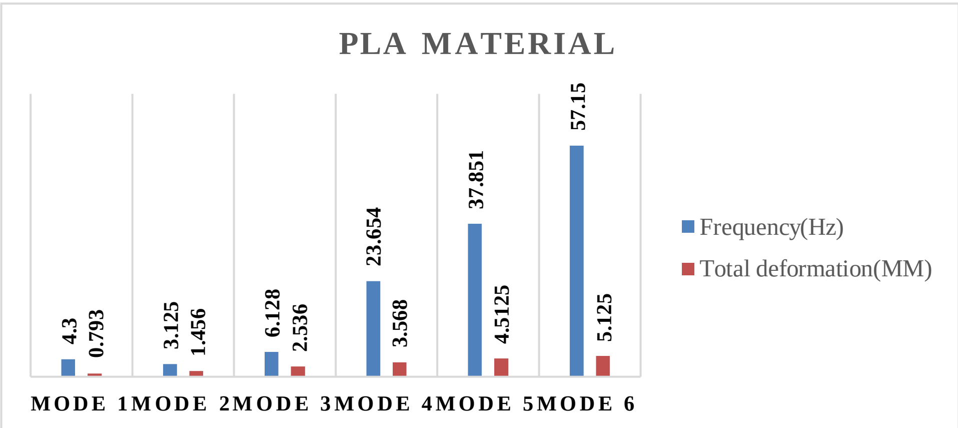


Fig.7.5 Modal analysis of Ti-6AL-4V Material

CHAPTER 8

RAPID PROTOTYPING

INTRODUCTION

Rapid prototyping is the fast fabrication of a physical part, model or assembly using 3D computer aided design (CAD). The creation of the part, model or assembly is usually completed using additive manufacturing, or more commonly known as 3D printing.

TYPES

Rapid prototyping is usually achieved by additive manufacturing process.

1. Selective laser sintering (SLS)
2. Direct metal laser sintering (DMLS)
3. Fused Deposition Modelling (FDM)
4. Binder jetting
5. Poly jetting

FUSED DEPOSITION MODELING (FDM)

Fused deposition modeling is the second most commonly used process after Stereo Lithography Plastic filament supply coil is the filler coil which continuously supply filament to nozzle.

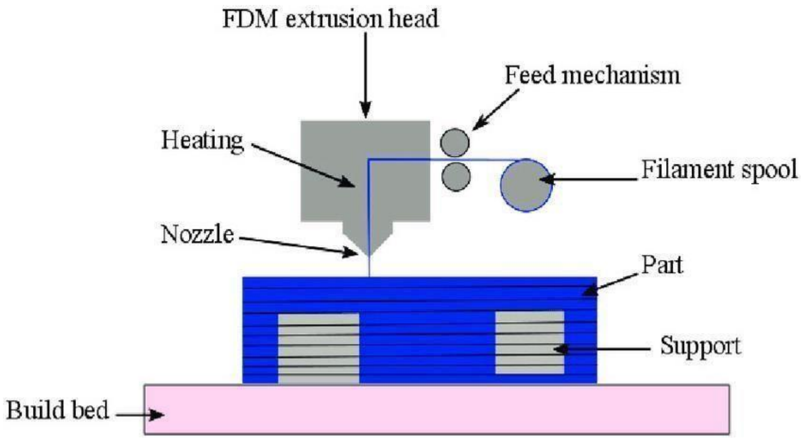


Fig.8.1 FDM Working Model

PLA material is used as filament for common purpose. Extrusion nozzle is having motion in all three directions. At one end filament supply coil is attached and in opposite end heater is attached. Heater heat the filament up to semi molten state. At the tip of nozzle hopper is there for filtering extrusion. Some lower cost configurations of the machinery use plastic pellets fed from a hopper rather than a filament. Table is used for supporting the object which is to be manufacturing. Input to the FDM machine is given in the .stl file format because only STL file is readable to FDM machine. After giving input to the FDM machine start their working. Filament drum continuously start supplying filament to nozzle. After coming filament in nozzle it heated up to semi molten state to pass through nozzle. Nozzle start moving in programmed manner and filament is continuously coming out from nozzle and for a layer on top of another. Humer bone is prepared after number of slices one over another prepares in programmed manner. If supports are required to any part due to cantilever shape, then supporting structure is prepared. After completing the object supporting structure is removed.

The obtained model has a rough surface finish so to achieve smooth finished model smoothening option is used from object modifiers. After applying the smoothening option, the final 3D CAD model of the Humer with the good surface finish is shown in below figure

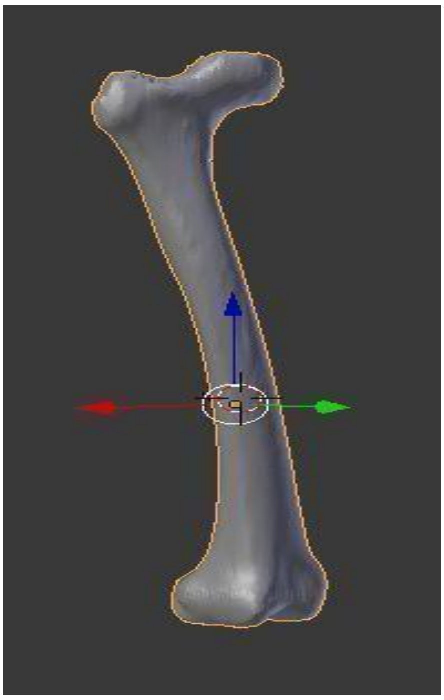


Fig.8.2 Humer with good surface finish.

The obtained model is exported in STL file format which can be later used for otherapplications.

SPECIFICATIONS Model:

Aion 500 FDM printer

Material: ABS, PLA

Filament Thickness: 1.75mm

Base Temperature: 75°C

Extruder Temperature: 230°C

Printable Volume: 500mm³

Price: Approx 10-15 Lakhs

Fig.8.3 Aion 500 FDM printer

HUMER BONE USING FDM

Fig.8.4 R.P Stage 1 Humer

Fig.8.5 R.P Stage 2 Humer

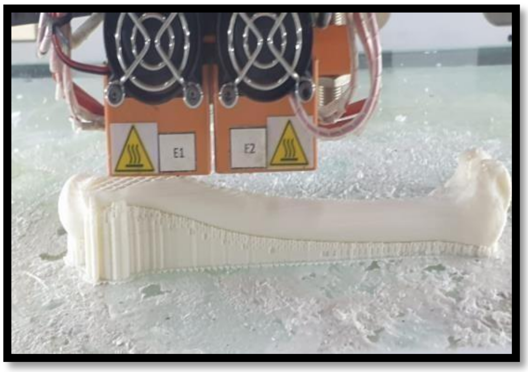


Fig.8.6 R.P Stage 3 Humer

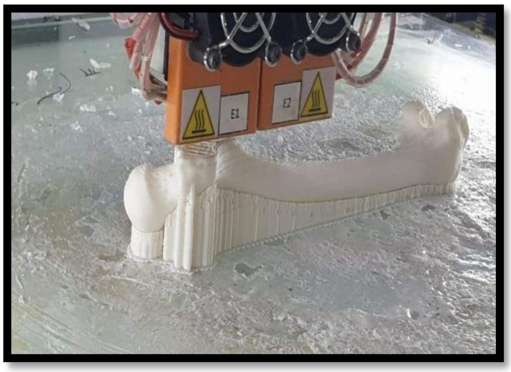


Fig.8.7 R.P Stage 4 Humer

Fig.8.8 R.P Humer Bone

CHAPTER 9

CONCLUSION

CONCLUSION:

1. To conclude, our project describes the three different materials TI-6AL-4V, Steel 304, Strontium that can be used for Bone Transplantation.
2. In the case of Humer Bone Implant, TI-6AL-4V will be the best material. Because, For Compressive Load TI-6AL-4V Vom-misses stress is 7.69 Mpa, Total Deformation is 130.9mm, Strain is 0.064, and Shear Stress is 0.96 Mpa.
3. As, TI-6AL-4V metal is very expensive we can replace it with Stainless steel 304. Because, the result identified in this project for TI-6AL-4V and Stainless steel are almost near.
4. By, Using Rapid Prototyping Technique Prototype Bone is manufactured using PLA.

FUTURE SCOPE

1. With the help of Selective Laser Sintering Process TI-6AL-4V metal Humer bone can beproduced.
2. The Human Bone Transplantation becomes easy.

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Appendix A

S. No	Duration	Expected time	Topic		Project Associates 19K65 A0347	19K65 A0364	19K65 A0378
1	3 weeks	8th Mar2022 to 28thMar2022	Literature survey		√	√	√
2	2 week	29thMar2022 to 11thApril2022	Problem identification & solution		√	√	√
3	3 weeks	12th April2022 to 1th May 2022	Selection of suitable materials and modeling process	a) Selection of materials	√	√	√
				a) Selection of input parameters		√	
				b) Selection of output parameters			√
				d) Selection of the modeling process	√		
				a) Calculating the von misses stress and deformation.		√	
				c) Verifying the design safety			√
5	1 week	2nd May2022 to 7th May 2022	Analysis of Humer Bone using ANSYS software		√	√	
6	3 weeks	8th May2022 To 28th may 2022	Calculations and Results		√	√	
7	1 weeks	29th May2022 to 2ndJune 2022	Documentation		√	√	√

Guide Signature

Appendix B

PO's and PSO's relevance with Project Work

	Program Outcomes	Relevance
PO1.	**Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	Engineering knowledge of DMM, Heat Transfer, Material Science, CAED, Strength of Materials is applied.
PO2.	**Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	Recent research literature was collected for a better understanding of the causes of leaf spring deformation and the different materials which can be used to overcome the deformation.
PO3.	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.	Designed and modeling of leaf spring using FGM method. The geometrical model is designed in CATIA software and by using the Ansys software the leaf spring is studied under different load conditions.
PO4.	**Conduct investigations of complex problems:** Research-based knowledge and research methods including design of experiments, analysis, and interpretation of data, and synthesis of the information to provide valid conclusions.	Collected data regarding the most common cause for failure of layers of the leaf spring and studied the materialistic properties of different materials used for manufacturing of leaf spring.
PO5.	**Modern tool usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	Used CATIA V5 for Geometrical modeling and ANSYS Workbench for simulation of the created 3D model.
PO6.	**The engineer and society:** Apply to reason informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.	----------------
PO7.	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.	-----------------

PO8	**Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams and multidisciplinary settings.	Individually collected different research papers and studied the behavior of layers of leaf spring together and as a team selected the best four materials for testing.
PO9	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.	Effective participated in the team PPT presentation and the college reviews and presented the PPT which was made by taking inputs from the whole project team.
PO10	**Project management and finance:** Demonstrate knowledge and understanding of engineering and management principles and apply these to one's work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	----------------
PO11	**Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	Learned and applied different possible ways for creating the 3D solid model and analyzing it using simulation software.
PSO1	**Thermal and Production Engineering Practice:** Ability to specify, fabricate, test, operate, and document the thermal and production systems or processes.	Studied the behavior of leaf spring under varying loads in trucks and rail roads.
PSO2	**Use of AutoCAD, SOLIDWORKS, and ANSYS:** Ability to design, analyze and develop machine components.	Used CATIA V5 for drafting the 3D model for the project and used ANSYS Workbench for conducting modeling and static analysis.

CO1	To develop student's knowledge for solving technical problems through structured project research study to produce competent and sound engineers.	Studied a good number of journals and books and understood the input parameters for better life of the leaf spring.
CO2	To provide the students with the opportunity to design, undertake or conduct research or study related to their degree course as a team.	Together worked on a selection of the materials for the leaf spring and concluded the best after experimentation.
CO3	To Identify and describe the problem and scope of the project clearly, collect, analyze and present data into meaningful information using relevant tools.	Clearly described the failures of leaf spring under different conditions and finally, in conclusion, we compared the bar graphs produced from the obtained results.
CO4	To select, plan and execute a proper methodology in problem-solving, work independently and ethically, present the results in written and oral format effectively and identify basic entrepreneurship skills in project management.	Proper scheduling, doing the research work effectively, creating the models and analyzing them and together concluded the best material after keen study of different materials selected.
CO5	To allow students to develop, synthesis and evaluation skills.	Developed core designing and modeling skills through this project work. Also able to write the content for research individually.
CO6	To encourage multidisciplinary research through the integration of material learned in several courses.	----------------------

Appendix C

Project Expenditure

S. No.	Material/Equipment/Work	Cost (Rs)
1.	3D Printer Machine Rent	4600
2.	Other expenses	1500
Total		6100

Appendix D

Project – PO mapping

Project Title:	ANALYSIS & RAPID PROTOTYPING OF HUMAN HUMER BONE	
Guide:	Mr. T N V Ashok Kumar	
Student Name(s):	N. Chandra Sekhar	(19K65A0347)
	S. Jai kanth	(19K65A0364)
	M. Gowtham	(19K65A0378)
A.Y.	2021-2022	

Name of Course from which Principles are applied in this project	Related Course Outcome Number	Description of the Activity	Page No.	Attained PO
Advanced Materials	C416.1	Student studied about different compositematerials that can be used for bone implants.	19-11	PO1
Additive Manufacturing	C415.2	Student studied about different types ofrapid prototyping methods.	71	PO1
Additive Manufacturing	C415.3	Student manufactured the artificial Boneusing 3D printer.	72, 73	PO1
Mechanics of Solids	C212.3	Student studied about different types of loads acting & various failures occurs onbone.	1-5	PO1
Advanced Materials, Metallurgy& Materials Science	C416.1 C211.2	Student collected in formation of projectfrom various articles and Journals. Students explained about the five materials and their properties and applications	10, 11	PO1PO2 PO7
FEM	C413.5	The student provided information regarding ANSYS Software and regarding.	19, 20	PO5
CAD/CAM	C417.3 C417.3	Students used CAD software to obtain STL File.	12-59	PO3PO5
Project	C426.2	Students concluded & summaries the project	74	PO9PO2 PO4
Project	C426.2	References: Student able to gather information from various sources required for the given project as	6-8	PO8 PO9 PO11 PO12

		latest as the 2022 year		
Project	C426.2	Student able to write these and present toa panel of experts/examiners	--	PO10

	PO1	PO2	PO3	PO4	PO5	PO7	PO8	PO9	PO10	PO11	PO12
Overall project mapping	5	2	1	1	2	1	1	2	1	1	1

Guide Signature