International Journal of Advance Research in Science and Engineering
Volume No 06, Special Issue No. (02), September 2017, ICITTESE-17
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

DEVELOPMENT AND ASSESSMENT OF STRUCTURAL EFFICIENCY OF TIE MEMBER BASED ON BIOMIMICS

Neetu Devi Singh

Lecturer, Department of Civil Engineering CSVTU University, Raipur (India)

ABSTRACT

Biomimicry (from bio,meaning ***life*** *and mimics,meaning to* ***imitate****) is the examination of nature,its model,system,process and element and then imitate these is an appropriate manner to solve human problems. Biomechanics is the study of the structure and function of biological systems such as humans, animals, plants, organs, and cells by means of the methods of mechanics. In this paper ,the behaviour of human humerus bone is studied using F.E.A(finite element analysis).Structurally, human body is a stable,vertical, slender element of frameworks using bones.On the skelton system,the human humerus bone is efficient in resisting tensile force. The modelling of real proximal human humerus bone is done using Mimics and is analyzed in Ansys under various boundary conditions.A similar type of tension member is modelled and analyzed. The stress pattern of both the models (Human Bone and Tension member) were compared and studied.*

Keywords: Biomechanics, Boundary condition, C.T Scan, FEA, Humerus bone, Mimics.

I. INTRODUCTION

Biomimicry is the discipline of observing nature and applying nature's lessons to human design and innovation. Nature operates according to the laws of natural selection and survival of the fittest. Nature is the world's largest research and development laboratory. The main objective of this project is to model a tie member similar to human hand bone (humerus) and to evaluate its structural efficiency under uniaxail loading. Antonia Dalla Pria Bankoff (2007) Antonia Dalla studied that the behavior of any material under load conditions is determined by its strength and hardness. By load-deformation curve,the strength may be assessed by checking the relation between the external force and the quantity of deformation (internal reaction) that takes place in the material (Holtrop, 1975). Bone is a material that has properties that respond in both the fragile and the flexible mode. The fragility of bone depends on the mineral constituents that give it the ability to support any type of loads. In this paper FEA is used to find the stress pattern of human bone and similar tie member under tensile loading. The bone between shoulder and elbow is Humerus bone. This Humerus bone is largest bone of human hand arm. The radius of shoulder is bigger than elbow. These both are cylindrical in shape. The joint is the structural weakness and fracture point. Due to complex configuratioin of bone it difficult to perform the complete 3D mechanical analysis of the humerus bone in actual form. For analysis we have considered the simple geometry of tie member and mathematical techniques to get the desired result.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

II. LITERATURE REVIEW

2.1 General

In the past decades, three-dimensional finite element (FE) analyses are performing for the prediction of bone's mechanical response. FE model would be advantageous in experimental works and in overcoming the inherent limitations associated with experimental studies which can provide only limited amount of information. The mechanical response of an individual human bone, and the proximal humerus, are of major clinical importance for orthopaedists.

2.2 Literature Study

Antonia DallaPriaBankoff (2007) AntoniaDalla studied that the behavior of any material under load conditions is determined by its strength and hardness. By load-deformation curve,the strength may be assessed by checking the relation between the external force and the quantity of deformation (internal reaction) that takes place in the material(Holtrop, 1975).The bone is a material that has properties that respond in both the fragile and the flexible mode. The fragility of bone depends on the mineral constituents that give it the ability to support compressive loads.(Ref. 1).

S. Parasuraman, Kee Chew Yee (2009) S.Parasuraman assisted the development of the robot assisted stroke rehabilitation system.robotics principles and anthropometry data are taken in modeling and analysis process.In this literature 7 (DoFs) kinematical model of human arm, and an 11 DoFs human hand kinematical model are taken for analysis.The Mathematical model is done to compensate the dynamic inperfection and distrubance in bone.Physical model is to assit the simulation of mathematical model.(Ref. 5).

JacekKruczynski,TomaszTopolinski (2012) JacekKruczynski studied to find the force act during arm wrestling as well as to explain mechanism ofoccurrence.To analyze the types and locations of fractures, computer programs were used (Adobe Photoshop and Paint Microsoft Office) to identify the fracture line.Transmission of the stress through the distal part of the arm resulting in shifting the maximum force on the humeral bone and its fracture.The Strength Analysis carried out during arm wrestlingrevealed that the force of the acting muscles significantly exert stress within the distal third of the humeral.(Ref. 2).

S.Lokanadham,N.Khaleel,P.Arun Raj (2013)S.Lokanadham, N.Khaleel,PArun studied the statistical and morphometric analysis of humerus bone is done for the purpose of determination of sex.In this 100 adult humerus bones were taken and measured 14 different parameters by using Metal sliding caliper, Osteometric board, and Tape. Out of 100,71 male and 29 female bones are measured and found the mean maximum length in male was: 31.97±0.155;female it was: 28.65±0.153. The mean maximum diameter in middlein male was: 1.953±0.027, in female was: 1.75±0.030.The mean minimum diameter in middle in male was:1.657±0.0211, in female was: 1.485±0.026.(Ref. 3).

Neelesh Sharma, BrijeshYadav (2014) Neelesh Sharma and BrijeshYadavstudiedthe natural frequencies and mode shapes of hand bone during vibration.Finite Element Analysis is a mathematical technique used for the analysis of complex objects and geometries.Analysis is done with two boundary condition, free-free(fixed in centre) and fixed-fixed boundary condition.All degree of freedom of boundaries are subjected to variations in free-free, and constraints in boundaries in fixed-fixed.Fixed-fixed boundary condition is more appropriate and it describe biodynamic behavior.(Ref. 4).

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Somesh M. S.; Latha V. Prabhu; ShilpaK(2011) Somesh and latha studied to obtain the measurements of the different humerus segments and to estimate thelength of humeri from them, in the present study we made an attemptto determine the mean values of humerus segments in our population and compare with other populations and also to correlate measurements of some of the fragments of the humerus with its total length in the attempt of obtaining. Dry humerus bones of both the sides were obtainedfrom the Bone bank of anatomy department, Kasturba Medical College, Manipal University Karnataka state, India. Morphometric measurements were done from 100 (49 right and 51 left) adult dry humerus. Measurements were obtained in millimeters (mm). Measurements were taken in longitudinal axis and Mean (M) and standard deviations (S.D) were calculated regression equations that allow us to estimate the humeral length from these fragments, which would assist in various medico legal and archaeological studies.

III. METHODOLOGY

The geometrical data of real proximal human humerus bone of 24 years old male, whose weight is 74 kg is obtained in the form of DICOM image format from C.T scan. The C.T scan data is processed in Mimics 10.0.1 and 3D model of humerus bone is created and represented as H1.The surface mesh is generated for further analysis as shown in Fig.1. The three dimensional finite element model of humerus bone consists of 31996 number of triangles, 200663.80 mm^3 volume and 45870.71 mm^2 surface area after meshing. The model is then analyzed using Ansys 12.Similar type of tie member with same dimension of bone is modeled in Auto Cad 3D and analyzed and is denoted as T1.

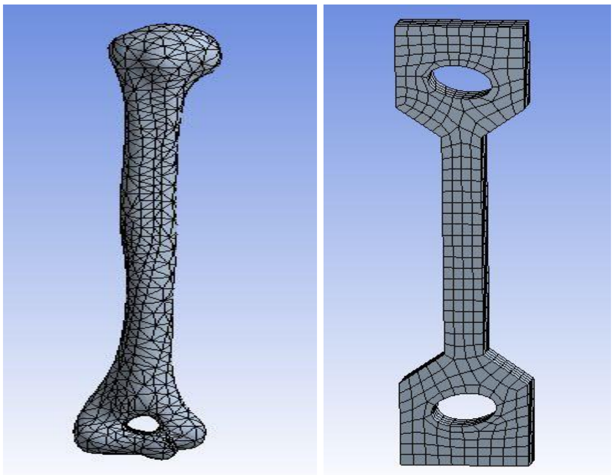


Figure 1 surface mesh H1 and T1

IV. MATERIAL ASSIGNMENTS

Human bone is highly heterogeneous and nonlinear in nature, so it is difficult to assign material properties along each direction of bone model. In biomechanics study, material can be assign in two ways, either in mimics or in finite element module. Here material properties are directly assigned in Ansys for H1 and T1. The following mechanical properties are density 1900 kg/m^3, Young's modulus(E) 17.2 GPa and Poisson's ratio 0.3.[2]

V. BOUNDARY CONDITION

The model H1 and T1 is subjected to a concentrated load of 1000 N at both the ends considering the supports as hinged as shown in Fig 2.

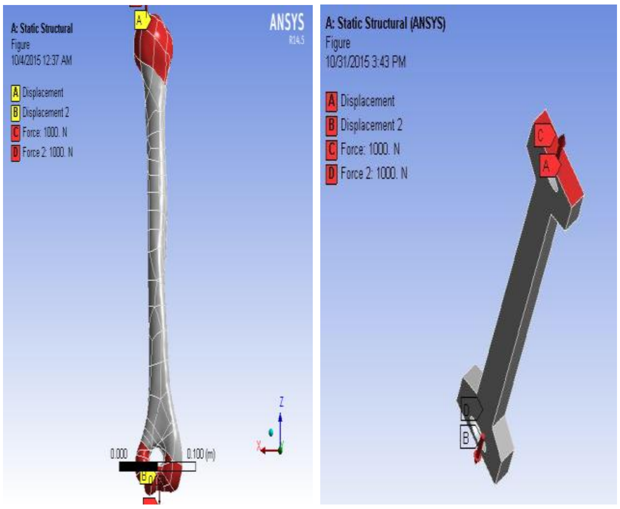


Figure 2 Boundary Condition and Loading H1 and T1

VI. RESULTS AND DISCUSSIONS

In our study the stress distribution of both H1 and T1 were investigated and compared.

(i) TheVon.Mises stress,Maximum Principal stress and Minimum Principal Stress for model H1 is 6.97 Pa, 8.27 Pa, -1.77 Pa respectively as shown in Fig 3.

(ii) TheVon.Mises stress,Maximum Principal stress and Minimum Principal Stress for model T1 is 8.75 Pa, 1.298 Pa, -4.11 Pa respectively as shown in Fig 4.

Equivalent (von-mises) Stress in modelled tension member is slightly more than 1.25 times actual humerus hand bone. Maximum Principal Stress in tension member is less as compare to actual humerus hand bone. Minimum Principal Stress in tension member is three times more than actual humerus hand bone.

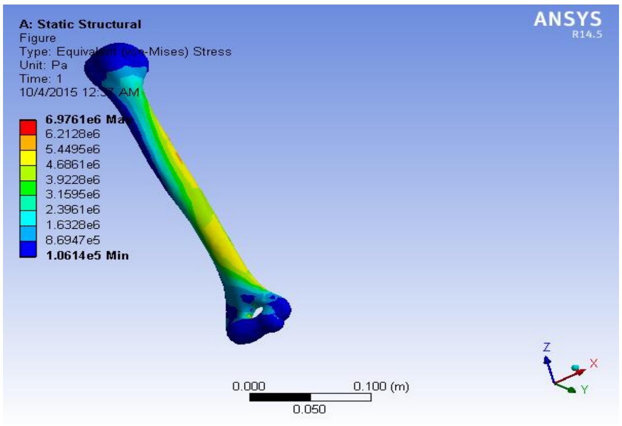


Figure 3 (a) Von-mises Stress in H1

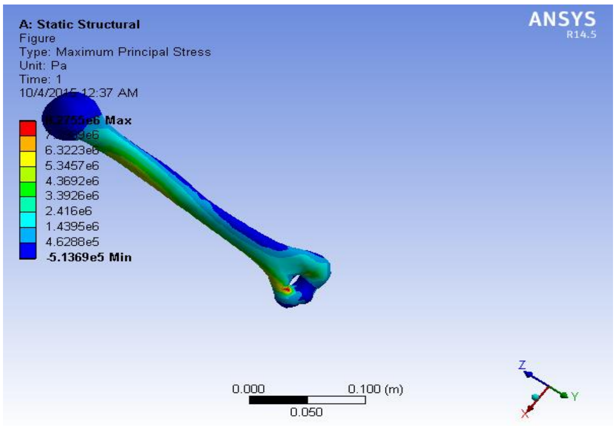
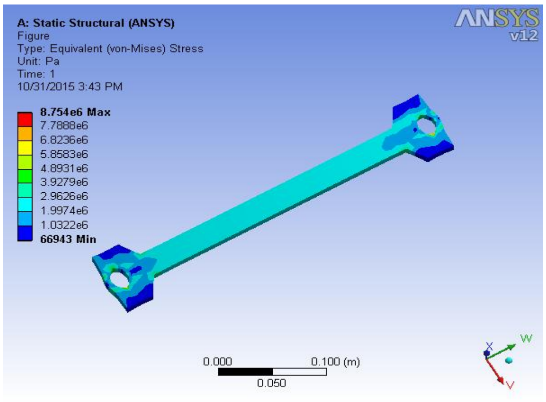


Figure 3 (b) Maximim Principal Stress in H1

International Journal of Advance Research in Science and Engineering
Volume No 06, Special Issue No. (02), September 2017, ICITTESE-17
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346



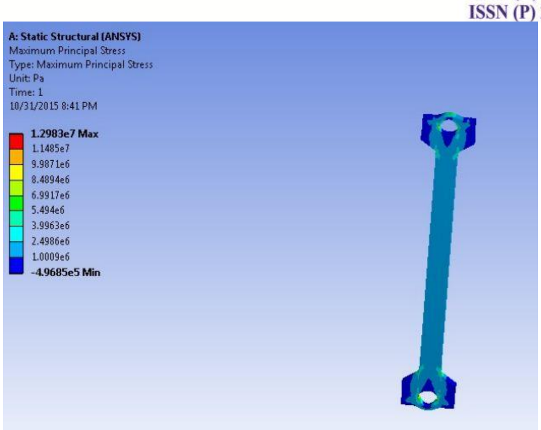


Figure 4 (a) Von-Mises Stress in T1 **Figure 4(b) Minimum Principal Stress in T1**

VII. CONCLUSIONS

This present work aims to produce a steel structure driven by the natural flow of the force generated by an tensile load within the material.Such kind of desired "force-driven form" founds great resemblance with organic bones. The human body and its skelton adapts according to function and loads that are normally encountered.

REFERENCES

[1.] Antonia DallaPriaBankoff, A.D.P. (2007). "Biomechanical Characteristics of the Bone".Brasil.

[2.] Zadpoor A.A, "Finite Element Method Analysis of Human Hand Arm Vibrations".Vol.16 (2006),pp.391-395

[3.] JacekKruczynski,TomaszTopolinski (2012) Radiological and biomechanical analysis of humeral fractures occurring during arm wrestling. Med SciMonit. 2012; 18(5): CR303–CR307.

[4.] Lokanadham S, Khaleel N , Arun Raj P, (2013) Morphometric analysis of Humerus bone in Indian population.Scholars Journal of Applied Medical Sciences (SJAMS) ISSN 2320-6691Sch. J. App. Med. Sci., 2013; 1(4):288-290,page 288.

[5.] Neelesh Sharma, BrijeshYadav (2014) Free vibration analysis of humerusbone fracture with varying boundary condition based on FEA.1st International Conference on Research in Science, Engineering & Management (IOCRSEM 2014).page 201-202.

[6.] Parasuraman.S and Kee Chew Yee(2009), International Conference on Computer and Automation Engineering, ,DOI 10.1109/ICCAE,page 93.