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Finite Element Analysis of Human RIB Cage

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ABSTRACT *: This paper of finite element analysis of the rib cage model is applied to recognize stress distributions and to determine the rate of bone fractures(especially for pathologically changed bones). Also to determine the load and stress to occurs on the human rib cage at any accident. Also find the maximum load sustain capacity of human rib cage and according to the load sustain capacity of the human rib cage by finite element analysis and search a material as like a bone cement and it take on a rib fracture and see the result . This paper is only of to nullify the rib fracture as present medical treatment give the elastic belt but due to respiration, the human ribs are contract and relax that's the rib fracture are only minimize not a nullify. The human models are considered in between age 15 to 40 year. The Simulation result shows a good agreement with the cadaver test data.*

Key Word*: Finite element model, thorax, rib cage, bone.*

I. Introduction

It is correctly said by Mr. DEVID STARR JORDAN "Wisdom knows what to do, skill is knowing how to do it and virtue is doing it." Following saying I started my project titled "FINITE ELEMENT ANALYSIS OF HUMAN RIB CAGE."Along with the analysisthis gives a plenty of option to the designers, manufactures and to the businessman. This project consists of some biological relation to understand as to know how wholeanatomy in a mankind can be correlated with machine. Everyone in world in a impression that man is nothing but a machines. So like any part in the machine one can renewed, repaired and replaced in the human anatomy. Along with the analysisthis gives a plenty of option to the designers, manufacturers and to the businessmen.

II. Mechanical Analysis

A mechanical analysis is nothing but making a model of the entity and using different finite element methods find the different properties of that element.Along with the analysisthis gives a plenty of option to the designers, manufacturers and to the businessmen. This project consists of some biological relation to understand as to know how whole anatomy in a mankind can be correlated with machine. Everyone in the world in a impression that man is nothing but a machine. So like any part in the machine one can renew, repaired and replaced in the human anatomy.And for this one must understand the relation between Biology and Mechanical Engineering.

III. Biomechanics

Biomechanics is the theory of how tissue, cells, muscles, bones, organs and the of them and how their form and function are regulated by basic mechanical properties. The purpose of this study is to illustrate the potential that a combination of knowledge fro biology and engineering from biology and engineering can have on the understanding of the development, maintenance and repair of the skeleton and on the clinical management of bone diseases.The mechanical loading of the environment and the circumstances of life have a huge impact on developmentand the evolution of our skeleton and the constituents of our body.

IV. Construction Of Human Rib Cage

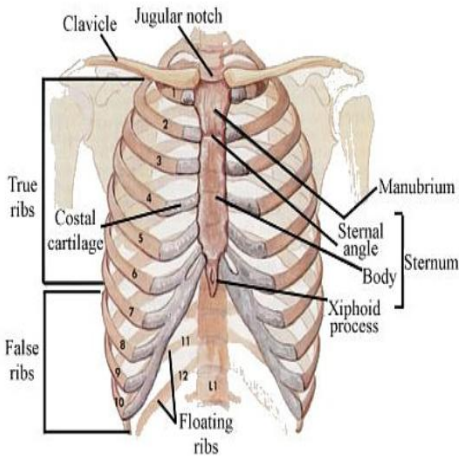

Fig 1: Human Rib Cage

The ribs are thin, flat, curved bones that form a protective cage around the organs in the upper body. They are comprised 24 bones arranged in 12 pairs.

These bones are divided into three categories:

1) The first seven bones are called the true ribs. These bones are connected to the spine (the backbone) in back. In the front, the true ribs are connected directly to the breastbone or sternum by a strips of cartilage called the costal cartilage.
2) The next three pairs of bones are called false ribs. These bones are slightly shorter than the true ribs and are connected to the spine in back. However, instead of being attached directly to the sternum in front, the false ribs are attached to the lowest true rib.
3) The last two sets of rib bones are called floating ribs. Floating ribs are smaller than both the true ribs and the false ribs. They are attached to the spine at the back, but are not connected to anything in the front.

V. Standard Properties of Bone

Human bone should be hard one.

Bone should able to sustain compressive strength between 50 MPato 70 MPa for normal human being.

The bone material should be flexible having a elastic value between 0.008mm to 0.031mm for the rib cage.

VI. Problem & Remedies with the Bone

Problem occurs when any accident is happen and in that accident the fracture or cracks are occurs in rib so due to how much load the rib is fracture is don't know and what is the load sustainable capacity of human rib is also don't know. Therefore, Finite Element Method is to calculate the mechanical properties of Human Ribs i.e. stress, deformation and sustainable capacity of human ribs. Finite Element method calculates the mechanical properties of human rib and that property is beneficial to Biomechanical Engineering to manufacture the artificial bone material.

VII. Boundary & Loading Condition Of Human Rib Cage

We are considering the human rib cage model between the age group 14 to 40.

According to age group,all the conditions are change.

1st boundary condition:-

Normal weight carrying capacity of human body 40kg.

2nd boundary condition:-

Maximum weight carrying capacity of human body = 1.5 times it's own weight

i.e. normal human weight = 60kg, then weight carrying capacity is 90kg.
3rd boundary condition:-
If more than 1000kg then this impact occur is in accidental condition.

If more than Normal & maximum weight carrying capacity of human body then this impact is of accidental condition so 3rd boundary condition is 100kg
1stBoundary condition:- 40kg(normal condition)
2ndBoundary condition:- 60kg(1.5times its own weight)
3rdBoundary condition:- 100kg(accidental condition).

VIII. Static Analysis

In static analysis the moment is applied at the rib cage as the rib cage bone are fixed at the backside of rib cage (nearer to backbone). The result obtained as maximum stress and deformation of rib cage. FE analysis shows the maximum stress and deformation occurred at the red zone.

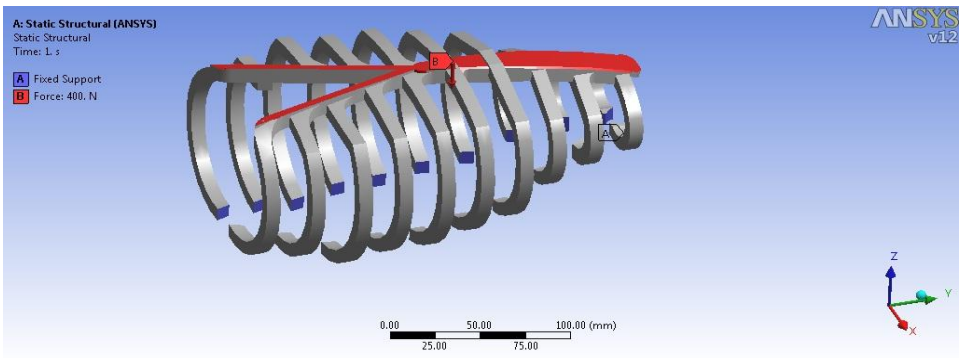

Fig 2A: Boundary condition by applying tangential load & axial load on human rib cage

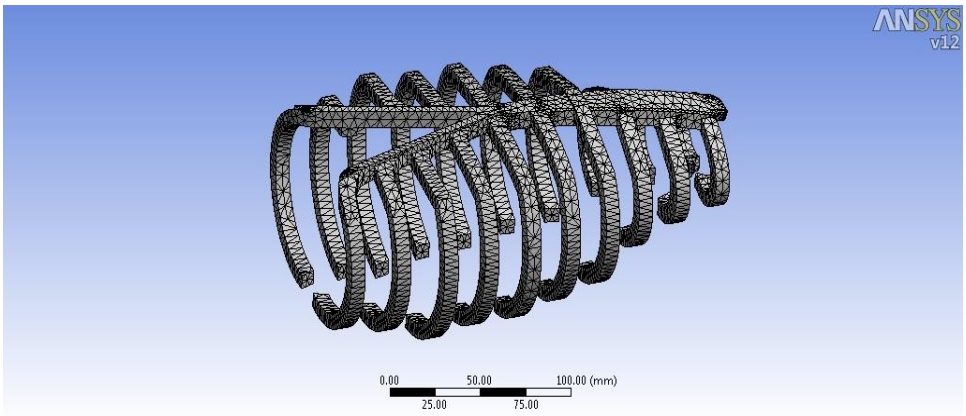

Fig 2B: Meshing of Human Rib cage assembly Fig 2C: Equivalent Stress σ = 10.338MPa

Fig 2D: Max deformation of Human Rib CageTable 1:FEM Results of Human Rib Cage

Loading	Ribs	Stresses(Mpa)	Deformation(mm)
400N	1-3	17.081	0.011
	4-6	21.644	0.047
	7-10	26.143	0.102
	Combine	10.338	0.034
600N	1-3	23.51	0.0144
	4-6	32.46	0.0711
	7-10	39.214	0.1541
	Combine	15.537	0.0515
1000N	1-3	39.183	0.024
	4-6	54.109	0.118
	7-10	65.35	0.2576

	Combine	25.895	0.086

IX. Result & Discussion

The FEA and Analytical result shows the stress is increasing when load goes on increase and deformation are varying when load goes on increasing. As this FEA and Analytical result is compare to allowable limit of stress and deformation, if given result is within allowable limit of stress and deformation then rib cage can sustain this load. If stress and deformation value goes on increase over the allowable limit then rib cage can break or fracture in any accidental condition.

The following table shows FEA and analytical result of stress and deformation when load are apply on the human rib cage.

Table 2: Stresses& Deformation obtain by FEA & Analytical method

Sr No	Loading Condition	FEA Result		Analytically Result		Allowable Limit	
		Stress(Mpa)	Deformation(mm)	Stress(Mpa)	Deformation(mm)	Stress(Mpa)	Deformation(mm)
1	400N	10.338	0.034	0.8	-3.409	50-70	0.5-5.44
2	600N	15.537	0.0575	12	-5.11		
3	1000N	39.183	0.024	2	8.522		

X. Conclusion

It is observed that the experimental analysis carried out in a forensic lab and FEA analysis value are very different. Still we can consider FEA analysis is a good tool for find out the mechanical properties of Bone material. With reference to the discussion with orthopedic surgeons this study can be helpful for them while inserting any kind of artificial bone material in human rib in case of accidents. Further one can make the study of bio-chemical of bone material and use this data for the medical research.

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