EVOLVING AN EFFICIENT STRUCTURAL COLUMN THROUGH BIOMIMICS

LUCKY REBECCA JOSEPH, SATYANARAYANAN K. S

Abstract: Biomimicry is the discipline of science that studies models of nature and then imitates or inspiration of those designs, processes to solve human problems. Many engineering and architectural applications have learned from these natural processes to create buildings that are models of resource efficiency. Although present construction has included all requirements in seismic codes, there are still some design-construction principles that have to be optimized in order to improve building adaptation seismic events. Structures need to modify concurrently with ecological trends for reducing pollution associated with production. For this paper, such kind of resiliency standard is achieved focusing on structural design concept inspired by the performance and geometry efficiency of a static model bio-structure - human skeleton precisely femur, tibia and produce structural elements driven by the natural flow of force generated by an earthquake. Such kind of desired "force-driven form" found resemblance with bones. Human skeleton adapts according to function and loads that are normally encountered. This key idea of nature is mimicking to composite columns of framed structures, which should withstand both gravity and transverse loading of structural system. This paper is an initial part of ongoing research work and presents the results of analysis on femur and tibia.

Keywords: *Biomimicry, structural system, CT scan, femur bone, tibia bone, mimics, column.*

Introduction

Nature as an inspiring model: Nature operates according to the laws of natural selection and survival of the fittest. To survive and reproduce, organisms need to be resilient to unforeseeable changes to the environment. They use local natural resources and energy that are constantly cycled, reused and renewed. They don't produce permanent garbage and they aren't toxic to their living environment. They don't require an energy grid or equipment to operate. Essentially, they've done everything human beings want to do, but without destroying the biosphere or mortgaging our future. Nature has always served as a model for mimicking and inspiration to humans in their desire to improve their life last.

Nature as a structural system: Human Being is a highly evolved species in nature in the present era. Structurally speaking, Human body is a stable vertical slender element of six feet height in which due to the specific arrangements of frameworks using bones, slender structure can move and jump without falling and failing. Each element in the frame i.e. skeleton system has its own significant and specifications in shape, size, structure, strength etc; which made entire structural system to be stable. On to the skeleton system, Tibia and fibula are the leg bones which have the function of supporting gravity loading and transverse loading of the structural system. This key idea of nature is mimicking to the Reinforced columns of the framed structures, which should withstand both vertical and horizontal loading of structure.

Methodology: For finite element analysis of tibia bone, firstly the three dimensional model of tibia is developed.

i. The geometrical data of real proximal human tibia, and tibia bone in the form of DICOM image format from CT scan, of 24 years old male, whose weight is 75 kg, is used.
ii. Digital Imaging and Communications in Medicine (DICOM) contains binary data elements.
iii. CT scan data in the form of DICOM consist of two dimensional gray scaled images of a human male. The images are converted into three dimensional models using an interpolation algorithm embedded in medical imaging software called MIMICS 10.01 by materialize.
iv. The gray-scaled values of the images represent the density of scanned bone.
v. DICOM files are 2D, but they retained data for 3D as well. The CT scan data set is processed in MIMICS 10.01 and creates three dimensional model of tibia.
vi. This CT scan 3D images are exported in IGES file
vii. IGES file is imported to ANSYS 13, elements type of solid 65, material as M30 grade concrete.
viii. Remaining models are created from SOLIDWORK and export to ANSYS
ix. Figure 1 is the model of the real bone

Modelling: In this study, materials is assign in two ways, either in MIMICS or in Finite element module and material properties are directly assigned in ANSYS. The following properties of Young's Modulus, Poisson's ratio and Density are used as 2.5GPa, 0.3, 2400Kg/m^3. The three dimensional finite element models of different models of columns are of volumetric mesh. Four node linear tetrahedron elements are used to create volumetric mesh in ANSYS 13. A concentrated pressure load of 1000N

applied at the top face of columns and fixed support at bottom face of the models. The different models of columns done in SOLIDWORK are shown in figure 2.

Figure 1 is the model of the real bone.

Fig.2 shows the different models of columns in solid work

Results and Discussion:

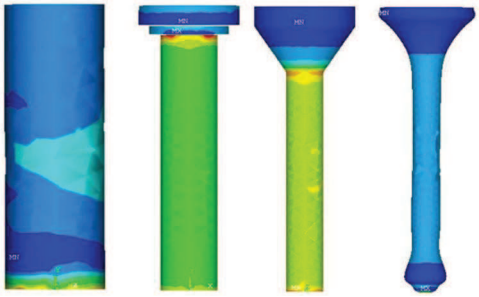

Fig.3 shows the principal stress of different columns

The static stress analyses of different columns are shown in figure 3 in a pictorial manner. Among the columns tibia mimicked column that is at the right end of figure is having minimal uniform stress flow. This shows that bio-mimicked column is more structural efficient than the conventional columns of any dimensions and types. Due to this shape, material conceptions are far less than the conventional columns and thus bio-mimicked columns are safe, eco-friendly.

Conclusions: According to computational analysis, tibia shaped column becomes highly efficient for both transverse and axial loads because the principal stresses were reduced due to the effect of shape of column. Furthermore, the proposed architecture implies a reduction of concrete use for structures which also means a reduction of CO_2 emissions. This fact becomes very important considering that concrete is responsible for about 10 percent of global carbon dioxide emissions, making it the third largest contributor to global warming after transportation and power generation. Current trends indicate that the future of the building industry would be greatly associated to Nature and the living technologies. Structural biomimicry is an effort to provide the building's structures with the capacity to be responsive to environment in real time such as the living structures are and reduction usage of construction materials from its surroundings in order to improve the built environmental resiliency.

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P.G student Structural Engineering, luckyrebeccajoseph2008@gmail.com
Professor, srm.kssn@gmail.com
Department of Civil Engineering, SRM University,