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Origin and Development of Shell Structure

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Abstract
This paper discuss the origin of shell structure and there development in present era. The present study highlights the origin and generation of idea of shell structure engineering from sea shells available in nature. Further the macroscopic structure and microscopic structure of sea shells is seen and its advantages have been studied to make shell structure. The shell texture and shape present in natural sea shells helps to give shapes of various shell structure. This paper also discusses the advantages of shell structure engineering and various application of structure in current period of time from the beginning of this concept.

Keywords: *Shell structure, Tailoring, Matrix.*

1. INTRODUCTION

The origin of shell structure ideas comes through nature because shell structures resembles to sea shells which are present in nature through natural phenomena. Nature's evolutionary process has created lightweight structures of astonish-ing diversity and beauty such as seashells.

a) Idea Generation

when Ed Clark and Alex Reddihough at Arup[1], exploring a cost-effective method in mid of 18th century of making strong three-dimensional forms for an RIBA competition for Seaside pavilions at Bexhill, they realized that they'd invented something by chance. Subsequent projects using the Shell Lace Structure have brought together story-telling and technical experiments in a single co-hesive process. The discovery has given us a new focus to one aspect of our work, one that takes on a specifically biomimetic approach. Shell Lace Structure is a single surface structural technique inspired by the evolution of seashells and the ancient art of tailoring. The exploration has been made possible through the contem-porary production techniques of computer-aided design and fabrication.

b) Macroscopic Structure

The shell are biological controlled mineralized structure. The mineralized structure may be a rigid skeleton or a nonskeletal mineralization (Lowenstam and Weiner, 1989)[2]. In living systems, biominerals display a broad scale of functions: tissues support, UV protection, shelter against predation, nutrition, reproduction, gravity, light or magnetic field perceptions, storage of mineral ions (Simkiss and Wilbur, 1989). In the metazoan world, calciumcarbonate skeletons are the most commonly found biomineralizations, and the most abundant, from diploblastic animals, sponges, and corals to deuterostomes, echinoderms, and chordates.

The molluscan shell is closely related to an organic matrix, which consists only 0.12–5.1% of the shell weight. The matrix represents amalgamate of proteins, glycoproteins, chitin and acidic polysaccharides, secreted by the calcifying tissues during skeletogenesis. This mixture is simultaneously sealed within the skeleton during its growth. At macroscopic level, the adjunction of organic components to a mineralized structure starting the mechanical properties to the whole organomineral assembly.

c) Microscopic Structure

At molecular level, the matrix plays a important role in the mineralization process. TEMstudies have shown that a thin layer of organic matrix, the interlamellar matrix, delimitates the lower and upper tablet surfaces (Fig.). The thickness of this matrix is about 20 nm. Within a same lamella, an organic matrix [the intercrystalline matrix of Bevelander and Nakahara (1969)] separates continous closing tablets.

(A and B) SEM pictures of the nacre of the freshwater bivalve U. pictorum. (C and D) SEM pictures of the nacre of the gastropod Haliotis tuberculata (bar scales ¼ 10 mm). (E) The ''brick-wall'' model of bivalvian nacre. (F) The ''columnar'' model of gastropod nacre. These identified models do not take the existence of pores in the interlamellar organic matrix, the prototype of nacre tablets, and the existence of a thin ACC layer around the tablets. The composition elements are: E, the secreting mantle epithelium; S, the organic sheets; SS, the newly formed surface sheets; Cr, the aragonite crystals; T, the upper most layer of the newly formed crystals.

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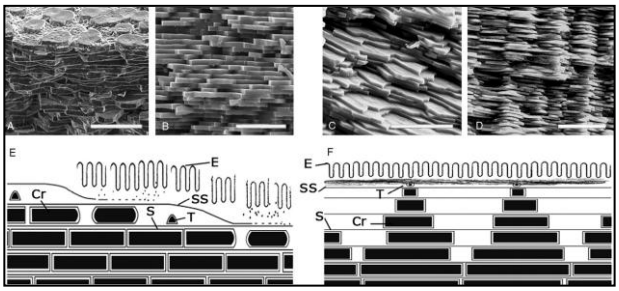
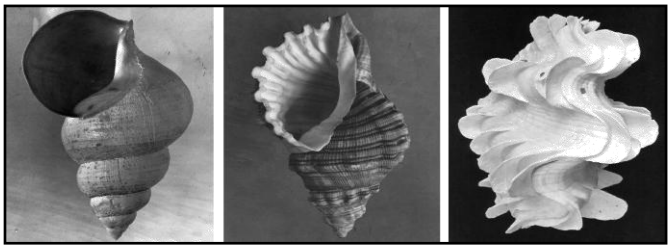


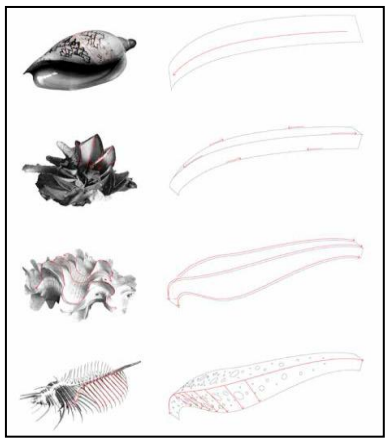
Figure : Micro Structure of the two main molluscan nacre textures

d) Texture and Shape

Shell lace structure is a single surface structural technique coruscating by evolution of sea shell and the ancient art of dressing and exploration of this is made easy by computer aided design and fabrication . Structural principle learned from sea shell such as curvature , corrugation and distortion all contribute in strength and stiffness, allowing the plate thickness to be reduced to minimum. With these principle of dressing and joining of finished and shaped cut thin sheets when joined and shaping together, create incredibly strong and thin structure and also the dead weight of the structure is less due to thin cut slices.



Curvature Corrugation Distortion



Curving a flat sheet increases strength

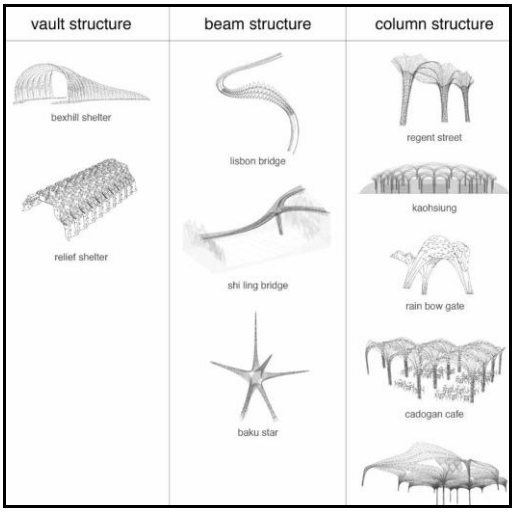
Corrugation increases structural depth

Distortion in plan locks in stiffness

Perforation maximizes lightness

e) Main Structural Element of Shells

On based research data the Shell Lace Structure technique to design several projects in 3 structural typologies that of the vault, the beam, and the column. These range from a shelter built of 3mm thick stainless steel spanning 7 meters, to a competition entry for a Ferry Terminal with 18 meter tall columns made in 10mm thick steel plates, to a bridge proposal for China spanning 75 meters using 16mm thick steel plates.

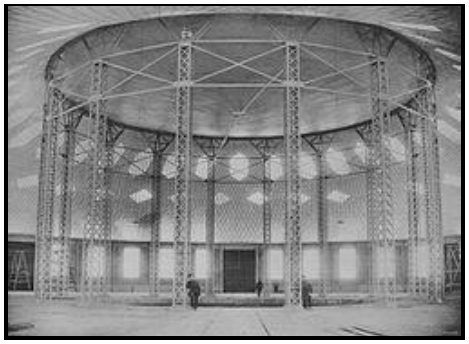


II. DEVELOPMENT OF SHELLS

a) Outside India

By various scientists and researchers various type of shell structure are found. These shell structure based on construction materials and thickness of plates likes concrete shell structure ,steel shell structure combination of these, lattice shell structure ,many more were developed .many shell structure developed based on thickness, like thin shell, or thick shell structure , many shell structure developed on based on curvature, single curvature or double curvature shell structure

The world's first shell structure(hyperbolied) was constructed in center of Rotunda in Russia in 1896 and its design is created in 1895 by Vladimir shukhov .



During the 1990's the Queen Elizabeth II Great Court in London was re-developed by a quadrangle roof shell structure and now known as a Great Court. This is multipurpose building in which various seminar rooms, lecture halls, theaters, gathering halls etc are available.

In 20'th century designer Gerry Judan created a race track in form of a lotus sculpture in 2012 made by 60 tonne steel sheets of 150 meter long track form.

b) **In India**

In India shell structure engineering come across around mid 19th century. The commencement of shell structure is created by architect R. Sundaram. He constructed many projects regarding this. He started in 1961 with his first project of erection of precast concrete folded plate of ITC in sharapur new Delhi. This unique structure won the ACCE-Bhagawati National Award 1998 for Excellence in Design of Industrial Plant. He design the architecture of kanteerave Indoor stadium Banglore in 1995 at Bangalore, it is a sports complex its shape is an eleptical dome which consist of 120 folded plates.

His next project was Dr. T.A. Pai international conventional centre manglore. It is constructed in 2005 , this structure is an octagonal shape having a roof in form of a circular shell with a bottom diameter of 54 meter and top diameter of 10 meter. It is used as an auditorium.

Lotus temple is a great example of combination of civil engg and architecture in development of shell structure . it is constructed in 1986 at shampur daya bagh , bhapur , New Delhi . its in form of a lotus flower , which is main cause of center of attraction to tourists. Its height is about 34 metre and its function as a place of worship. Its design is created by fariborz sahba.

Conclusion

In this paper a study of origin and various developed structure in world have been congregated. The shell structure development is increasing day by day, due to its appealing shape and design, as it is developed in al around world . on other hand in India its physical application have been explored in little extent but it gradually increasing. As Beauty in nature is closly aligned to effectiveness and economy, to use the least material to make the most efficient form, fulfilling the desired fitness for purpose, the shell lace structure may be just from one of those . And the some of those are mentioned above

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