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Analysis of Coconut Shell Concrete in the Sandwich Beam using ANSYS

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Abstract: SCS consists of a layer of unreinforced concrete core, sandwiched between two relatively thin steel plates with novel enhanced C-channel connectors. Compared to C-channel connectors, ECs directly link the two external steel faceplates. The cost of traditional materials used in the concrete is the major factor which increases the cost of constructions, so it is necessary to research for alternative construction materials. In this project, the concrete core is used as the coconut shell concrete. Coconut Shell is a waste, generated by industrial and agricultural processes, and has created disposal and management problems that pose serious issues of environmental pollution. The first objective is to analyze the composite properties at 0%, 10%, 20% and 30% of coconut shell in the sandwich beam using rules of mixture . The Rules of Mixture is an analytical equations that are used to calculate the composite properties of the material. Then analyze the effect of coconut shell sandwich beam in ANSYS software. Also compare the conventional sandwich beam and coconut shell sandwich beam. Analyze the strength and decaying of coconut shell sandwich beam using ANSYS.
Keywords: Sandwich beam, coconut shell concrete, composite properties, rules of mixture, ANSYS

I. INTRODUCTION

Steel-concrete-steel (SCS) sandwich structures are a new form of construction. Recently, steel-concrete-steel (SCS) sandwich structure (SCSSS) has become popular in both onshore and offshore engineering infrastructures. SCS consists of a layer of unreinforced concrete core, sandwiched between two relatively thin steel plates with novel enhanced C-channel connectors. In steel-concrete-steel sandwich composite structures, the steel and concrete are the main materials that are used to resist tension and compression forces. In this project, the concrete core is used as coconut shell concrete.. Sources of conventional aggregates occupy the major part of the concrete. Extraction and processing of aggregates is also a major concern for environment. Therefore consumption of alternative waste material in place of natural aggregate in concrete production not only protects environment but also makes concrete a sustainable and environment friendly construction material. Coconut shell is categorized as light weight aggregate. The coconut shell when dried contains cellulose, lignin, pentosans and ash in varying percentage. In Asia, the construction industry is yet to realize the advantages of light weight concrete in high rise buildings. Coconut shells are not commonly used in construction industry and are often dumped as agricultural waste, therefore, an economic and interesting option. Therefore coconut shell is utilised as a partial replacement of coarse aggregate and analyse the optimum percentage of coconut shell in the sandwich beam using ANSYS software.

II. EQUATIONS FOR CALCULATING COMPOSITE PROPERTIES OF A MATERIALS BY RULE-OF-MIXTURES

It is great importance to be able to predict the properties of a composite, given the component properties and their geometric arrangement, various micromechanical aspects of composites. A particularly simple case is the rule-of-mixtures, a rough tool that considers the composite properties. It is an analytical equations that are used to calculate the composite properties of the material. In the case of mechanical properties, there are certain restrictions to its applicability. When more precise information is desired, it is better to use more sophisticated approaches based on the theory of elasticity.

A. Young's Modulus

$E1 = Em + Vf(Ef - Em)$

$1/E2 = Vm/EM + Vf/Ef$

Young's modulus of fiber (Ef)
Young's modulus of matrix (Em)
Volume fraction of fiber (Vf)
Volume fraction of matrix (Vm)
Young's modulus of fiber and matrix represent the Young's modulus of coconut shell and concrete.

B. Poisson's Ratio

$$\vartheta_{12} = \vartheta_{13} = \vartheta_{f12} V_f + \vartheta_m V_m$$

$$\vartheta_{23} = \frac{E_{22}}{2G_{23}} - 1$$

Poissons Ratio of fiber (ϑ_f)
Poissons Ratio of matrix (ϑ_m)
Volume fraction of fiber (Vf)
Volume fraction of matrix (Vm)
Here also fiber and matrix represent coconut shell and concrete

C. Shear Modulus

$$G_{12} = G_{12} = \frac{G_m}{1 - \sqrt{V_f (1 - \frac{G_m}{G_{f12}})}}$$

$$G_{23} = \frac{G_m}{1 - \sqrt{V_f (1 - \frac{G_m}{G_{f23}})}}$$

Shear modulus of fiber(Gf)
Shear modulus of matrix(Gm)
Volume fraction of fiber (Vf)
Here fiber and matrix represent coconut shell and concrete

D. Tensile Strength

$$\sigma_{cl} = \sigma_f V_f + \sigma_m V_m$$

Stress in the fiber (σ_f)
Stress in the matrix(σ_m)
Volume fraction of fiber (Vf)
Volume fraction of matrix (Vm)

III. MODELLING

First creating the geometry of beam with the size of 200, 100, and 1900 mm in width, depth, and length is taken for the analysis. Figure 1 shows the model of sandwich beam in Ansys The mesh is for the discretization for the analysis. Figure 2 shows the mesh model of sandwich beam. The material properties of varying percentage of coconut shell in the sandwich beam are calculated using Rules of Mixture. The above equations are used for calculating the composite properties of a material.

TABLE I
Material properties of varying percentage of coconut shell in the sandwich beam

Material Properties	0% coconut shell	10% coconut shell	20% coconut shell	30% coconut shell
Young's modulus	3.00×10^{10} N/m^2	2.76×10^{10} N/m^2	2.53×10^{10} N/m^2	2.29×10^{10} N/m^2
Shear Modulus	1.27×10^{10} N/m^2	0.588×10^{10} N/m^2	0.453×10^{10} N/m^2	0.396×10^{10} N/m^2
Poisson's Ratio	0.18	0.186	0.192	0.198
Tensile Strength	4.00×10^7 N/m^2	4.29×10^7 N/m^2	4.58×10^7 N/m^2	4.87×10^7 N/m^2

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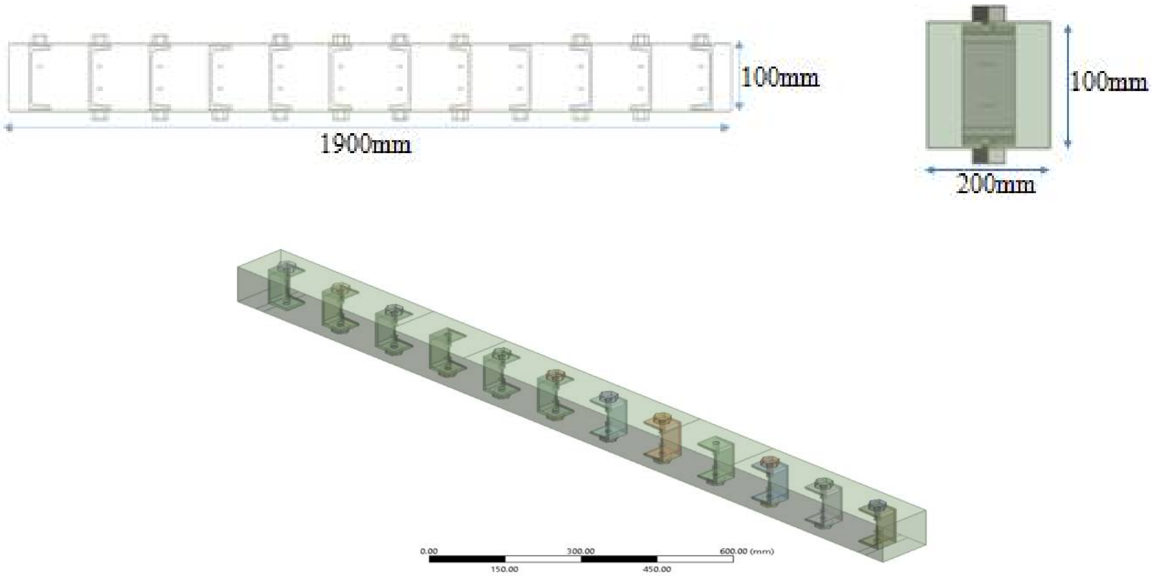

Fig. 1 Model of sandwich beam

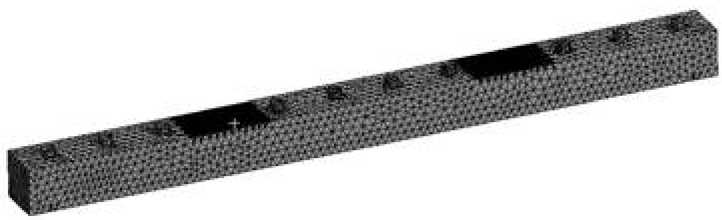

Fig 2 Mesh model of sandwich beam

IV. ANALYSIS

Ansys finite element analysis software is used to analyse the coconut shell sandwich beam. The beam is simply-supported at their left and right ends. The loading was applied firstly as the displacement of -50 mm pushing downward. In addition, the displacements, strains, and reaction forces are also measured. The figure 3 shows the Loading and Support condition in the sandwich beam. Finally the deformation pattern is analysed and finding out the optimum percentage of coconut shell is added.

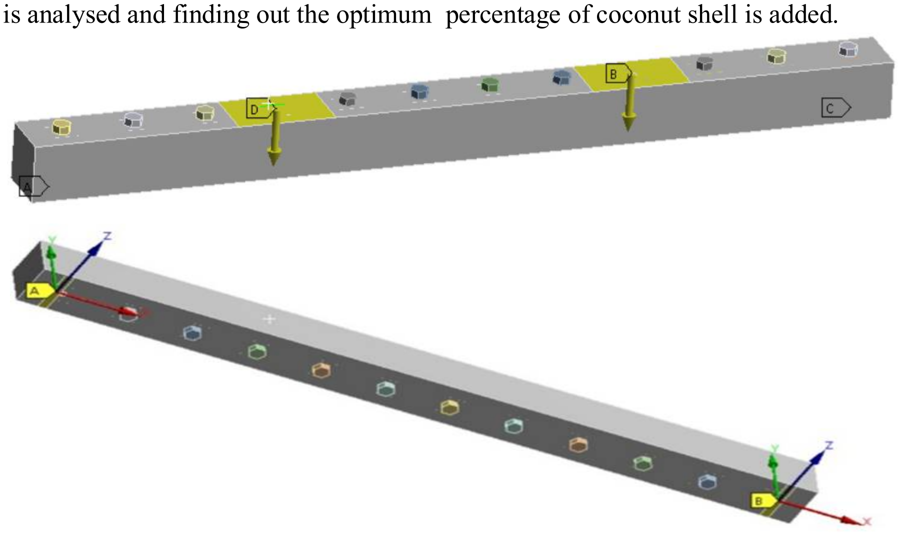

Fig. 3 Loading and Support condition of sandwich beam

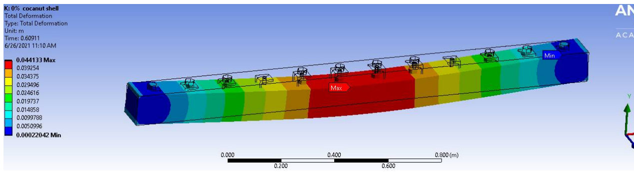

Fig 4:Deformation in 0% coconut shell sandwich beam

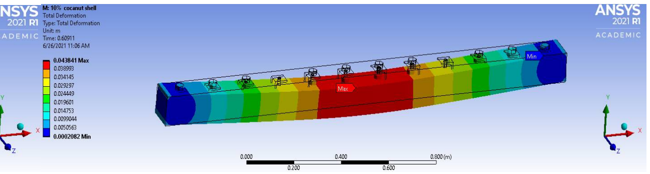

Fig.5 Deformation in 10% coconut shell sandwich beam

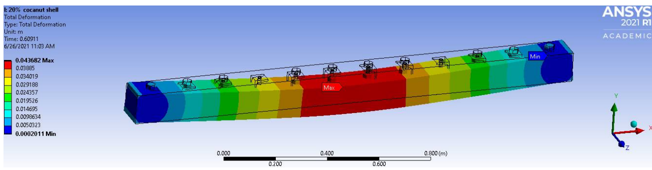

Fig.6:Deformation in 20% coconut shell sandwich beam

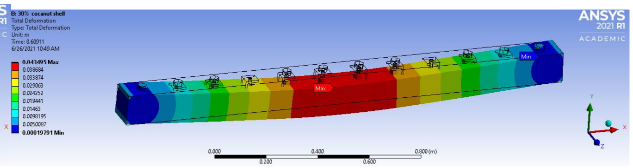

Fig.7Deformation in 30% coconut shell sandwich beam

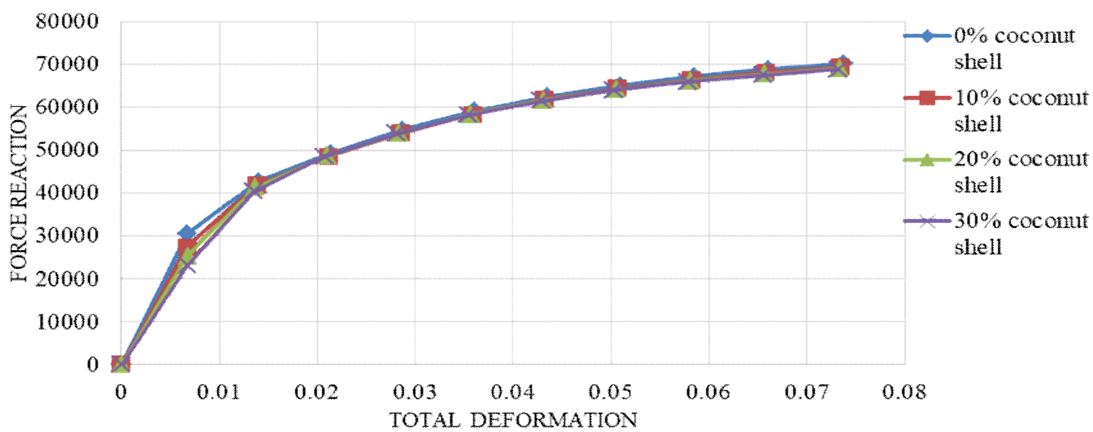

Fig 8. Load deformation graph of sandwich beam

From the result the load deformation cure, the failure load in conventional sandwich beam and the 10% replaced coconut shell sandwich beam is almost same ,that is the failure load at conventional sandwich beam is 30555N and 10% coconut shell sandwich beam is 27551 N. If further increase in the percentage of coconut shell the failure load will reduces. Therefore, we can replace coarse aggregate with 10% coconut shell in the sandwich beam, without any significant reduction in any of the property of the sandwich beam.

V. DEGRADATION ANALYSIS

Degradation analysis is done in the 10% coconut shell sandwich beam by using the equation for calculating the composite property of a material by Rules of Mixture. The above same equation that used for finding out the composite property of a material for the degradation analysis. But the volume ratio is calculated as,

$$\text{Volume Ratio} = \frac{\text{Volume of reinforcement} - \text{Void Volume}}{\text{Total Volume}}$$

TABLE II

Material properties of degradation in 10% coconut shell sandwich beam

Material Properties	Values
Young's modulus	2.45×10^{10} N/m^2
Shear Modulus	0.602×10^{10} N/m^2
Poisson's Ratio	0.15428

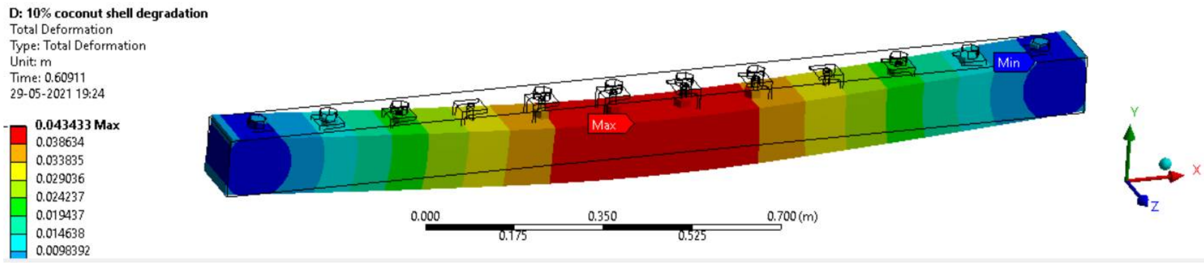

Fig 9: 10% coconut shell degradation in the sandwich beam

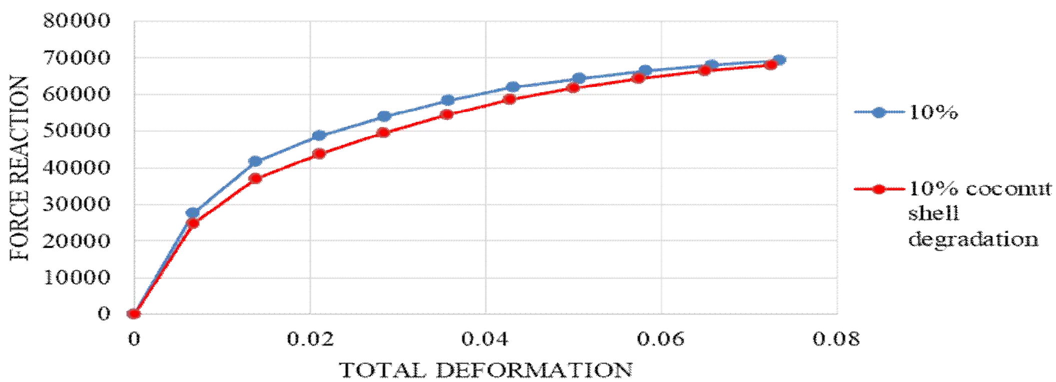

Fig 8. Load deformation graph of degradation analysis

From the load deformation cure, the failure load in 10% coconut shell sandwich beam and 10% coconut shell degradation in the sandwich beam is almost same ,that is the failure load at 10% coconut shell sandwich beam is 27551N and 10% coconut shell degradation sandwich beam is 24787 N. Therefore, even if degradation happened there is no much variation in any of the property of the sandwich beam.

VI. CONCLUSION

The conclusions derived from the effect of coconut shell content on the in the sandwich beam as follows,

A. Coconut shells are waste materials that causing pollution. Using coconut shell will help to reduce environmental problem which is a big concern for the whole world.
B. Using coconut shell can also achieve a light weight sandwich beam.
C. From the strength analysis, we can we can replace coarse aggregate with 10% coconut shell in the sandwich beam, without any significant reduction in any of the property of the sandwich beam.
D. From the degradation analysis, even if degradation happened there is no much variation in any of the property of the sandwich beam.

VII. ACKNOWLEDGMENT

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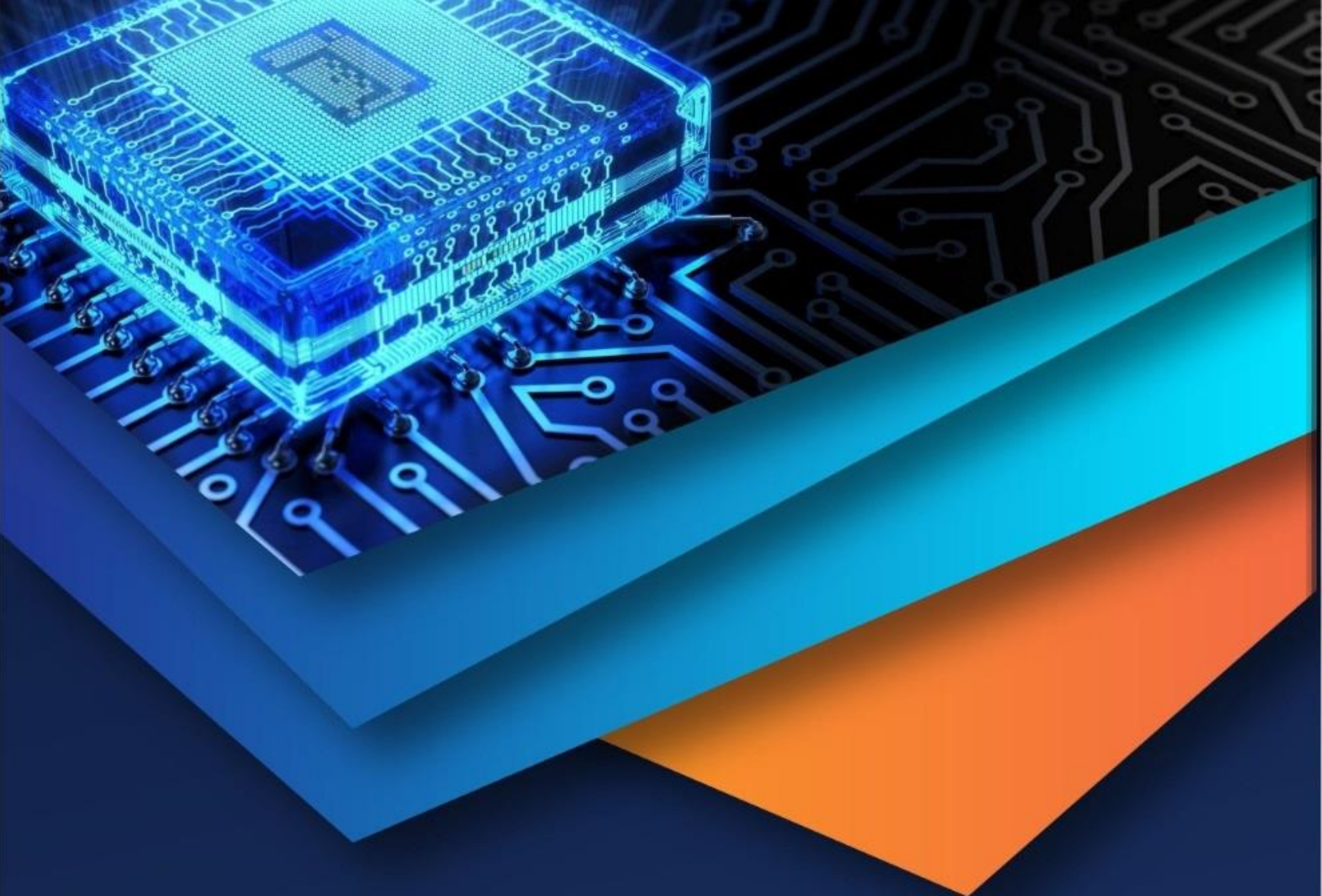

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