Table 8: Post processing results of 3P-bending of sandwich beam model

ρ_o (Kg/m^3)	50	100	150	200
σ_f(MPa)	8.6	6.72	5.73	5.1
τ(MPa)	0.0901	0.073	0.062	0.05
y(mm)	0.444	0.287	0.209	0.167

3. Results and Discussions

The present investigation was mainly focus on the influence of high density polyurethane foam cores on the flexural behavior of sandwich beams made up of polyurethane foams and composite face sheets (Bi-woven E-glass/epoxy resin). To rate the performance of these structures, the most important beam properties i.e. flexural rigidity (D) and Shear stiffness (S) and the engineering parameters such as face sheet stress (σ_f), core shear (τ), beam deflection(y) of the sandwich beam were considered. For the present study, these properties were obtained using all the three methods such as analytical, experimental and numerical using FEM/ANSYS. First of all, the numerical procedure (FEM/ANSYS) was validated using 2D-elasticity solutions. To pursue this task, a sandwich beam model of dimensions 300mmx50mmx14.2mm loaded in three- point bending was chosen as per ASTM standards (C323) [9] with a span length of 150mm as shown in figure-1. Finite element analysis was performed and analyzed under three- point bending with a constant mid span load of 200N. To be more confident on the FE- modeling and its results, analytical verification using 2D-elasticity of sandwich beam were carried out as shown in table-2. A comparison of FE-analysis results and analytical solutions are tabulated in Table-3. The agreements between numerical and theoretical results were generally good.

In order to study the most important mechanical properties of sandwich beams such as flexural rigidity (D) and Shear stiffness (S) experimentally, on the whole six sandwich beam specimens were fabricated as per ASTM (C393) standards and tested under both 3-point & 4 -point bending as shown in figure-4.The results of both 3-Point & 4- point bending were used to evaluate the mechanical properties using the most popular formulae proposed by Kuenzi (ASTM Standards, C393). Furthermore finite element analysis was performed by modeling the sandwich beams that were considered for experimental study using the validated FEM/ANSYS. The theoretical estimates of the mechanical properties were also obtained using analytical equations proposed by Allen H G in his book titled "Analysis and design of structural sandwich panels" Oxford Pergaman Press 1969 as shown in table-5. Finally the results so obtained using all the three methods were compared as shown in table-7. The agreement between numerical and experimental results was generally good.

In order to study the influence of core density on the flexural behavior of sandwich beams, number of sandwich beam specimens of different core densities (ranged from 50Kg/m^3 to 300Kg/m^3) were fabricated & tested under both 3-Point and 4- point bending. The plot of graphs of load v/s deflection for all the cases studied experimentally is as shown in figure-10. It was observed that as the density of core increases, the stiffness of beam increases, which in turn the load bearing capacity of the beam increases. It was also observed that the increasing of core density in PUF cored sandwich beams is more or less similar to the phenomenon of increasing of carbon content in steel alloy. Furthermore in order to study the influence of high core density on other performance parameters such as face sheet stress (σ_f), core shear (τ) & beam deflection (y), finite element analysis was performed using the validated FEM/ANSYS by modeling the sandwich beams which were considered for experimental study. From the present investigation it is evident that the performance of high density foams in PUF cored sandwich beams are better than the conventional low density foams, because remarkable improvements was observed on the most important beam properties i.e. flexural rigidity (D) and shear stiffness (S) of sandwich beams with the use of higher density foams as shown in figure-12. Influence of core density on three important parameters of sandwich beams such as (σ_f, τ, y) were observed during FE-analysis as shown in figure-13. From the results so obtained, it was observed that all the three engineering parameters such as face sheet stress (σ_f) transverse shear stress (τ), as well as resultant beam deflection (y) decreases drastically as core density increases to certain limit (ρ=300Kg/m^3) and attains to nearly asymptotic for further increase in core density thereafter.

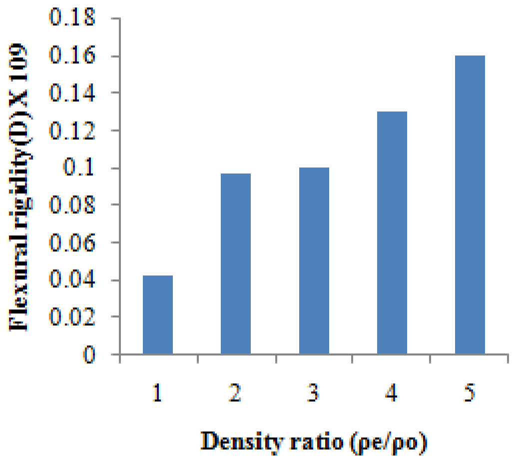

Figure 12(a): Graph of D v/s (ρ_e/ρ_o)

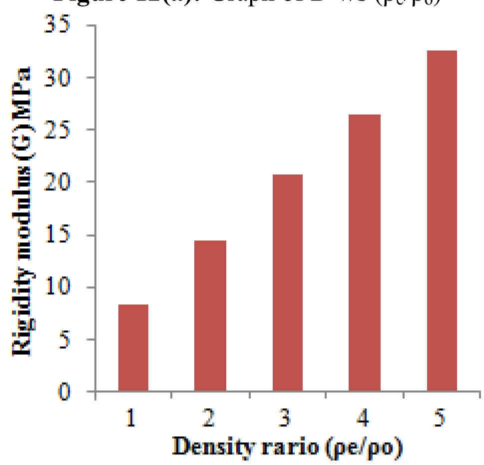

Figure 12(b): Graph of G v/s (ρ_e/ρ_o)

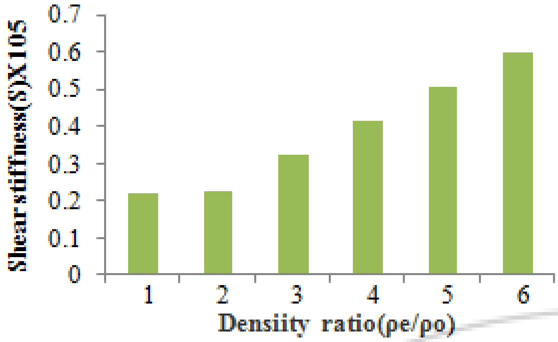

Figure 12(c): Graph of S v/s (ρ_e/ρ_o)

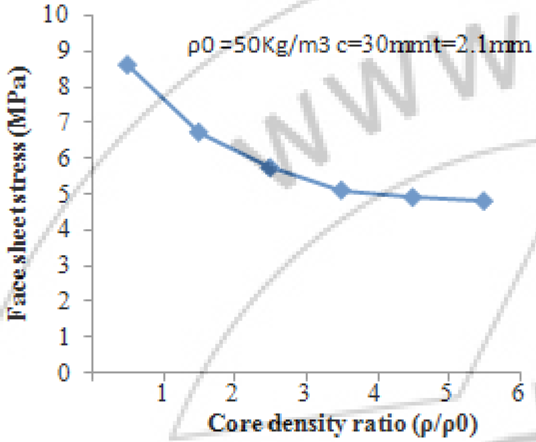

Figure 13(a): Graph D v/s (ρ_e/ρ_o)

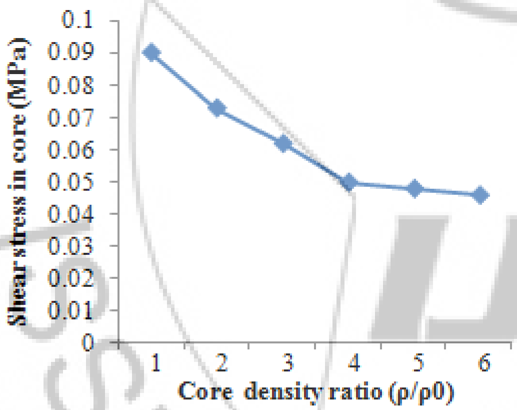

Figure 13(b): Graph G v/s (ρ_e/ρ_o)

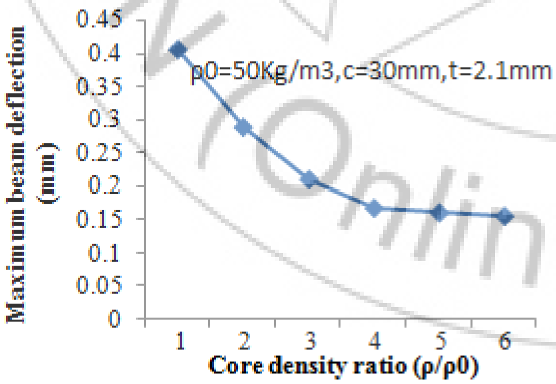

Figure 13(c): Graph S v/s (ρ_e/ρ_o)

Figure 13: Effect of core density on Engineering parameters (σ_f,τ,y)

4. Conclusions

To rate the peformance of high density PUF cored sandwich beams, number of sandwich beam specimens of different core densities (ranged from 50Kg/m^3 to 300Kg/m^3) were fabricated & tested under both 3-Point and 4- point bending experimentally. Effect of core density on most important beam properties i.e. flexural rigidity (D) and Shear stiffness (S) were studied experimentally as well as numerically. Experimental studies on the engineering parameters such as face sheet stress (σ_f), core shear (τ) of sandwich beams under flexural load is quite expensive and time consuming. Instead a prior validated most versatile numerical tool i.e. FEM/ANSYS, was successfully used for the purpose. From the present investigation it is evident that use of high density foams (ranged from 200Kg/m^3 to 250Kg/m^3) for cores has tremendous improvements on complete sandwich construction, However the density higher than 300K/m^3 are unsuitable for cores because the results are nearly asymptote for all densities higher than 300K/m^3.

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