Three Point Bending Analysis of Honeycomb Sandwich Panels: Experimental Approach

Kuldeep P. Toradmal[1] , Shrishail Sollapur[2], Shweta Wange[3], Vikram Pawar[4]
[1, 2, 3, 4] Department of Mechanical Engineering
[1, 2, 3, 4] SAE, Kondhwa, Pune- 411 048.

Abstract- *Recent trends in modern railway industry shows more and more use of composites specially sandwich structures to build the coaches so as to achieve higher speeds, reduced power consumption and increase in pay load carrying capacity. Honeycomb sandwich structures have wide applications as structural and non-structural materials of the coaches in the railway industry. A sandwich construction consists of two thin facing layers separated by a thick core.*

Static three-point bending tests were carried out in order to investigate the failure loads. ASTM C 393 standards are followed for the experimental approach.

Keywords- Pay Load, Honeycomb sandwich structures, Three- point bending test, ASTM C 393.

I. INTRODUCTION

Lighter bodied coaches are advantageous for achieving higher speed in a mass transit system. Honeycomb sandwich construction gives designers many new options. It is technique that can be usefully applied to the structures requiring low weight, high strength and good dynamic properties. A honeycomb sandwich consists essentially of two outer facing layers and honeycomb core. These structures show good structural efficiency. Therefore strength characteristics of these panels are studied by many researchers. The strength characteristics of aluminium honeycomb sandwich panels have been studied by Paik et al. [5] for which they have carried a three-point bending test, lateral crushing test and buckling test. K. Kantha Rao et al. [3] have studied theoretically bending behavior of aluminum rod and aluminium sandwich panel. The theoretical bending strength analysis on honeycomb sandwich panels of different materials has been studied by K. Kanta Rao et al. [4]. The theoretical load and defections in copper honey comb sandwich panel values has been adapted and compared with experimental and simulation results by A.Gpoichand et al. [7].

This study is targeted to arrive at a combination of face sheet and core material that has a high bending strength to weight ratio. Therefore in this study GFRP is selected as a face sheet material along with its metallic counterparts such as stainless steel and an alloy of aluminium. The polypropylene is used as a common core material. The three point bending test is carried for these panels on Universal Testing Machine and results are documented.

II. TYPES OF MATERIALS DISCUSSED

A. Stainless Steel (SS-304)

Characteristics of Stainless Steel (SS-304)

- Good forming and welding properties
- Corrosion resistance
- Excellent hot and cold forming processes and performance
- Excellent toughness even at very low temperatures
- Low temperature properties responding well to hardening by cold working
- Ease of cleaning and aesthetically good appearance.

B. Aluminium (A 3003 H19)

Characteristics of Aluminium (A 3003 H19)

- High stiffness
- Good energy absorbing properties
- Provides geed electrical shielding
- Low cost

C. Glass Fiber Reinforced Polymer (GFRP)

Characteristics of Glass Fiber Reinforced Polymer (GFRP)

- High stiffness
- High impact resistance
- High surface finish
- High corrosion resistance due to its non-metallic structure.
- Flexibility in manufacturing.

D. Polypropylene

Characteristics of Polypropylene

- High tensile strength
- Good sound and vibration damping
- Good energy absorbing capacity
- Thermoformable

- Excellent abrasion resistance
- High corrosion and chemical resistance
- Resistance to moisture absorption
- Excellent thermal insulating properties

III. EXPERIMENTAL PROCEDURE

A. Bending test set-up

Honeycomb sandwich panels are successfully used as structural materials to take tensile, compressive and bending loads. The bending strength of these panels can be determined by conducting a three point bending test experimentally on Universal testing machine. Fig.1. shows three point bending test set-up. The test is carried up to the failure of the panels and failure loads are recorded.

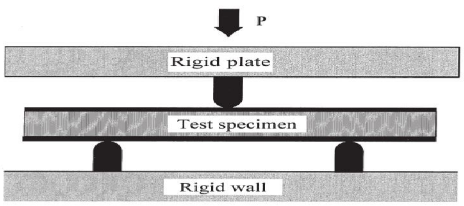

Fig.1. Bending Test Set-up [5]

TABLE I. SPECIFICATIONS OF TESTING MACHINE

Machine Name- Computerized Universal Testing machine	
Model	TUE-C-1000
Measuring Capacity (kN)	0-1000
Least Count (N)	50
Load Range in kN with accuracy of measurement ± 1%	20 to 1000
Resolution of Piston Movement (mm)	0.01
Over all dimension approx. (mm)	2350 x 800 x 2700
Weight approx. (kg.)	4200

B. Test Specimen

As mentioned in ASTM C 393 standard the test specimen are made rectangular in cross section. The thickness of the specimen is selected as 32 mm. The width of the specimen is taken as 100 mm which is maintained as twice the total thickness. The length of the specimen is taken as 300 mm where 60 mm is total unsupported length and span length is 240 mm. Sample size for all three types of panels selected is 3. Each of the specimens for all three types of panels is designated as follows.

Samples of stainless steel (SS-304) – Polypropylene panel are designated as SS-I, SS-II and SS-III. Samples of Aluminium (A3003 H19) – Polypropylene panel are designated as AL-I, AL-II and AL-III. GFRP – Polypropylene panels are designated as FR-I, FR-II and FR-III.

C. Results from experimental testing

Fig.2. Specimen SS-I of Stainless Steel – Polypropylene panel after bending

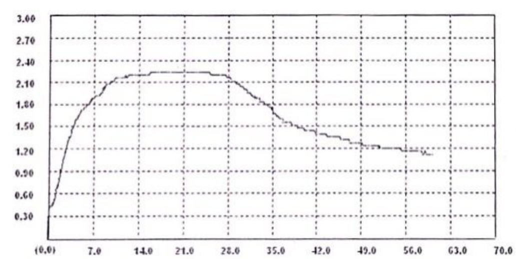

Fig.3. Load Vs Displacement graph for Specimen SS-I

Fig.4. Specimen SS-II of Stainless Steel – Polypropylene panel after bending

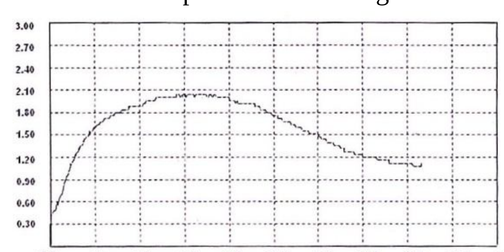

Fig. 5 Load Vs Displacement graph for Specimen SS-II

Fig.6. Specimen SS-III of Stainless Steel – Polypropylene panel after bending

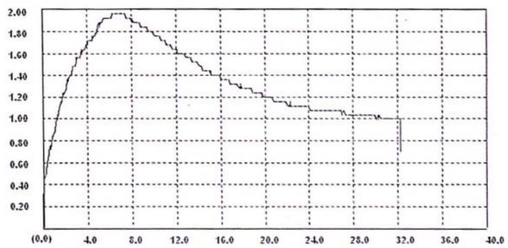

Fig.7. Load Vs Displacement graph for Specimen SS-III

Fig.8. Specimen AL-I of Aluminium (A3003 H19) – Polypropylene panel after bending

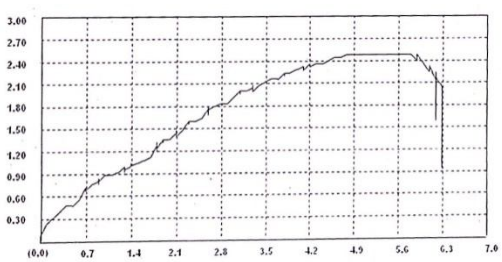

Fig.9. Load Vs Displacement graph for Specimen AL-I

Fig.10. Specimen AL-II of Aluminium (A3003 H19) – Polypropylene panel after bending

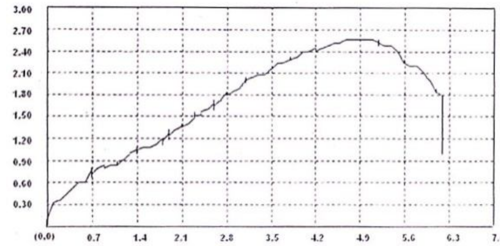

Fig.11. Load Vs Displacement graph for Specimen AL-II

Fig.12. Specimen AL-III of Aluminium (A3003 H19) – Polypropylene panel after bending

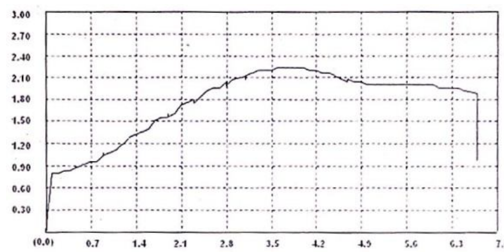

Fig.13. Load Vs Displacement graph for Specimen AL-III

Fig.14. Specimen FR-I of GFRP – Polypropylene panel after bending

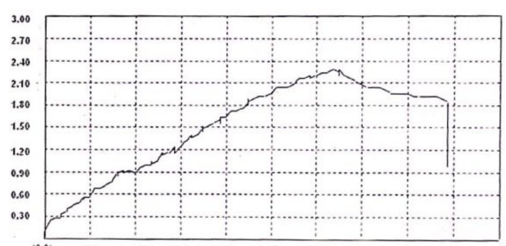

Fig.15. Load Vs Displacement graph for Specimen FR-I

Fig.16. Specimen FR-II of GFRP – Polypropylene panel after bending

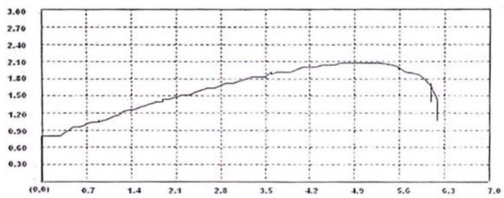

Fig.17. Load Vs Displacement graph for Specimen FR-II

Fig.18. Specimen FR-III of GFRP – Polypropylene panel after bending

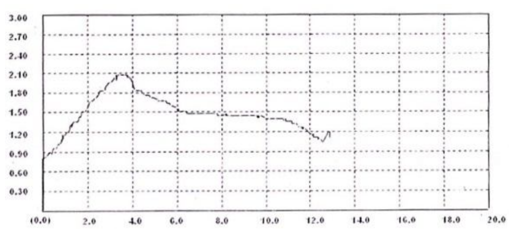

Fig.19. Load Vs Displacement graph for Specimen FR-III

TABLE II TEST RESULTS

Panel	Ultimate Load (N)	Average Ultimate Load (N)
SS-I	2240	
SS-II	2040	2080
SS-III	1960	
AL-I	2480	
AL-II	2560	2427
AL-III	2240	
FR-I	2280	
FR-II	2080	2147
FR-III	2080	

IV. CONCLUSION

Three point bending test is performed experimentally on honeycomb sandwich panels. Three different types of facing material are used which are Glass fiber reinforced polymer (GFRP), aluminium (A3003 H19) and stainless steel (SS-304). The Polypropylene is used as a core material for all the three samples. The results of the test show lowest value of ultimate load for stainless steel (SS-304) - Polypropylene panel among all the three samples whereas GFRP – Polypropylene and aluminium (A3003 H19) – Polypropylene honeycomb panels have comparable values of ultimate load. Comparing weights of Aluminium (A3003 H19) - Polypropylene panel and GFRP- Polypropylene panel the percentage weight reduction amounts to 14.28%.

REFERENCES

[1] Jim Kidinger, “Lightweight Structural Cores”, Hexcel Composites.

[2] HexWeb™ Honeycomb Sandwich Design Technology, Publication No. AGU 223, Hexcel Co., Ltd., Duxford (UK), 1995.

[3] K.Kantha Rao, K. Jayathirtha Rao, A.G.Sarwade, B.Madhava Varma, “Bending Behavior of Aluminum Honey Comb Sandwich Panels”, ISSN: 2249 – 8958, Volume-1, Issue-4, April 2012.

[4] K.Kantha Rao, K. Jayathirtha Rao, A.G.Sarwade, M.Sarath Chandra “Strength Analysis on Honeycomb Sandwich Panels of different Materials”, ISSN: 2248-9622, Vol. 2, Issue 3, May-Jun 2012, pp. 365-374.

[5] Jeom Kee Paik et al., "The strength characteristics of aluminum honeycomb sandwich panels”, Thin-Walled Structures 35 (1999) 205–231.

[6] A. Petras, “Design of sandwich structures”.

[7] A. Gpoichand, R.Mohanrao, N.V.S Sankar, G.Rama Balaji, P.Sandeep Kumar, “Design and Analysis of Copper Honeycomb Sandwich Structure”, ISSN: 2249 – 8958, Volume-2, Issue-4, April 2013.

[8] Dipak G. Vamja, G. G. Tejani, “Experimental Test on Sandwich Panel Composite Material”, ISSN: 2319-8753, Vol. 2, Issue 7, July 2013.

[9] M K Khan, “Compressive and lamination strength of honeycomb sandwich panels with strain energy calculation from ASTM standards”, DOI: 10.1243/09544100JAERO76.