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Studies on Particle Boards made from Sugar Cane Bagasse

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ABSTRACT: Particle boards a part of the engineered wood segment is a very huge segment involving waste recycling. They can be made from chipped wood particles to rice husks and even bagasse(Sugar Cane Waste from factories) particles thus having huge market potential in India having a vast agricultural background and very diverse requirements in day to day life.

KEYWORDS: Particle Boards, Bagasse (Sugar Cane Waste), Plywood, Fibre Board

I. INTRODUCTION

Particle board is fabricated from wooden particles, saw shavings, or sawdust, and a manmade resin or other suitable adhesive, which is compressed and extruded. Particle board is cheaper, denser and even in comparison of a traditional wood and plywood and is used instead of them when cost is significant rather than potency and aesthetics. A major drawback is that it is extremely prone to extension and discoloration due to dampness, particularly when it is not coated with paint or another sealer. The existing particle boards used in the industry have limitations in their mechanical properties as well as their dimensional stability when wet. Introduction of textile materials as reinforcement in these boards might improve these properties thus expanding the applicative region of these boards and may even help to replace costlier engineered wood and composites used in the market presently.

II. RELATED WORK

Engineered wood [1], are fabricated by adhering the strands, particles, fibers, or veneers and boards of wood, together with adhesives, or other methods of adhesion to form composite materials. These merchandise are designed according to certain specifications to satisfy national and international standards. They are used in a variety of applications from domestic to commercial to industrial buildings. They can also be utilized for beams that replace steel in many construction projects. Particle Boards [2] are a relatively novel type of engineered wood product that are made from bonding together small chips and saw-dust and tightly pressing them together to make board or sheet. With particle board furniture more frequently available in the market it is of use to know how it stands with variety of engineered woods such as plywood and with solid wood. Urea Formaldehyde-based resins [3] have been the typical binders used to adhere the particles together in many composite wood products, including particleboard, wheat board, and medium density board (MDF). In recent years, however, concerns have been raising about the risks of cancer and bronchial health impacts from formaldehyde. All of the test methods used for particle boards are as per ASTM D1037-12 [4]. Felix A. Aisien et al. explored the possible use of cassava stalks for the fabrication of bonded particle boards [5]. Particle boards were produced using cassava stalks with urea-formaldehyde as an adhesive. Dimensional stability of the boards was determined with water absorption and thickness swelling tests while mechanical strength was assessed with modulus of rupture and modulus of elasticity tests of the boards. Particle boards produced using an adhesive-cassava stalk ratio of 3:1 gave the best results in terms of the lowest mean values of water absorption and thickness swelling, as well as the highest values of modulus of rupture and modulus of elasticity. Behzad Kord et al. examined possible feasibility of canola straws in the manufacturing of particle board [6].

III. METHODOLOGY

Manufacturing of Particle Boards:

3.3.1 The manufacturing of reinforced particle boards.

The Nonwoven reinforced particle boards were made up on the machine in the industry according to the process discussed earlier in the manufacturing process of the particle boards by heat based compression moulding.

The particle boards with jute fabric reinforcement were prepared on a specially fabricated mould made up of iron on which the pressure was applied using screw loading.

3.3.2: Testing of the Particle Boards:

The tests that were conducted in order to analyse the boards those were formed are as follows:

1. Size: When measurements of particle boards were done, the width of each particle board was garnered by measuring the width at each end & at mid-length to an accuracy of not less than 2mm. Similarly, three measurements of length were made, one near each edge, and one at mid-width with similar accuracy.

2. Thickness :For the determination of variations in thickness, samples at least 6-in. (150- mm) square was used. The thickness of each sample was measured at five different points, near each corner and the center, the average thickness and the variation in it was noted.

3. Static Bending :Static bending tests were made both on samples when conditioned. One half of the test samples were prepared with the long dimension parallel and the other with the long dimension perpendicular to the long dimension of the board.

Each test specimen was 3 inches in width if the nominal thickness was greater than 1/4 inches, and 2 inches in width if the nominal thickness is 1/4 inches or less. The depth was the thickness of the material. The length of each specimen was 2 inches plus 24 times the nominal depth.

4. Moisture Content: Composite samples were kept under standard conditions of 24°C and 65% R.H. for about 1 hour. Then the samples were weighed. And then were kept in the hot air oven for 30 minutes to measure its oven dry weight. Now the moisture content is calculated using the formula as shown:

$$\text{Moisture Content} = (\text{original weight} - \text{oven dry weight} / \text{original weight}) * 100$$

5. Statistical Analysis: Analysis Of Variance was applied (ANOVA).

IV. EXPERIMENTAL RESULTS

4.1 Introduction:

The Boards were manufactured as per the plan of work discussed earlier in Chapter 3. Samples were prepared and they were tested for various characteristics. The data obtained from tests is presented in this chapter and discussed with the concepts referred on the basis of technical knowledge & from the literature review.

4.2 Results: The boards were tested for density, moisture content, modulus of rigidity, water absorption, thickness swelling, internal bonding, screw withdrawal. The samples were tested after conditioning in standard atmosphere and the tests were performed as per the standards mentioned in previous chapter 3. The results are as follows:

4.3: Tensile Testing: Tensile strength is one of the most important properties of the reinforcements used in the manufacturing of these particle boards. Tensile testing is hence necessary to be done and analyzed before moving on to the characteristics of the particle boards.

Tensile Testing of nonwovens and jute fabrics used for reinforced particle board was carried out in both machine as well as cross direction for nonwovens. The results of the test are as below figure 2

As it can be seen from the Fig 2 that the two different direction based Nonwoven fabrics were used to produce the reinforced particle boards from the waste collected from the sugar factories otherwise either it goes for feeding the cattle or it goes as a fuel for local sizing units etc. These nonwovens by their natural characteristic were having more prominent strength in the cross direction as they were cross laid material. During reinforcement though the direction was going to have less profoundness as after bagasse composite was formed at the bonding points more prominence was noticed of the entire material as such rather than the individual component's identity. But non the less for academic purpose the tensile property testing was conducted. A The significant ($P=6.8E-09 < 0.05$) increase in the strength of the two nonwovens was noticed. Similarly the tensile strength study was also conducted for Jute fabric the results for that as below in figure 3 The warp way and weft way tensile strength studies were conducted first of all just to have resemblance with the cross laid machine direction and cross directional studies conducted on nonwoven fabrics under observation. Warp way the load bearing capacity of the woven Jute material exhibited significant difference. There was a significant ($P=0.000401 < 0.05$) increase in the tensile strength of the jute fabric.

Similarly the elongation and other property studies were also conducted just to ensure the basic property know how of the materials used for reinforcement

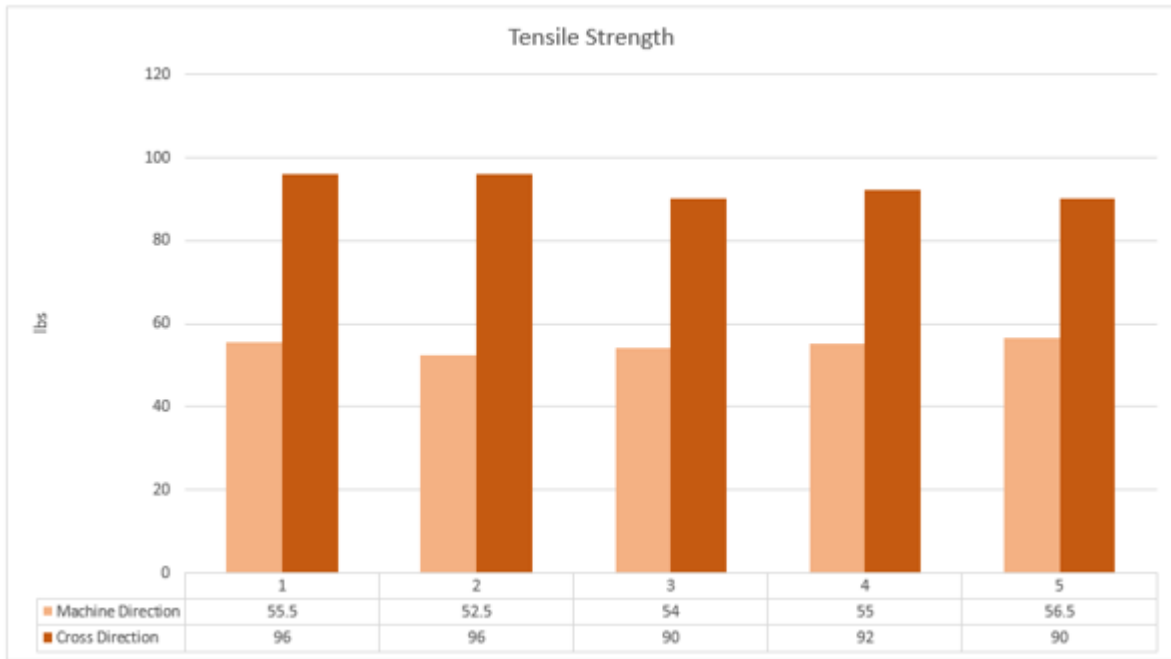


Fig 2. Tensile Strength of Nonwoven Fabrics

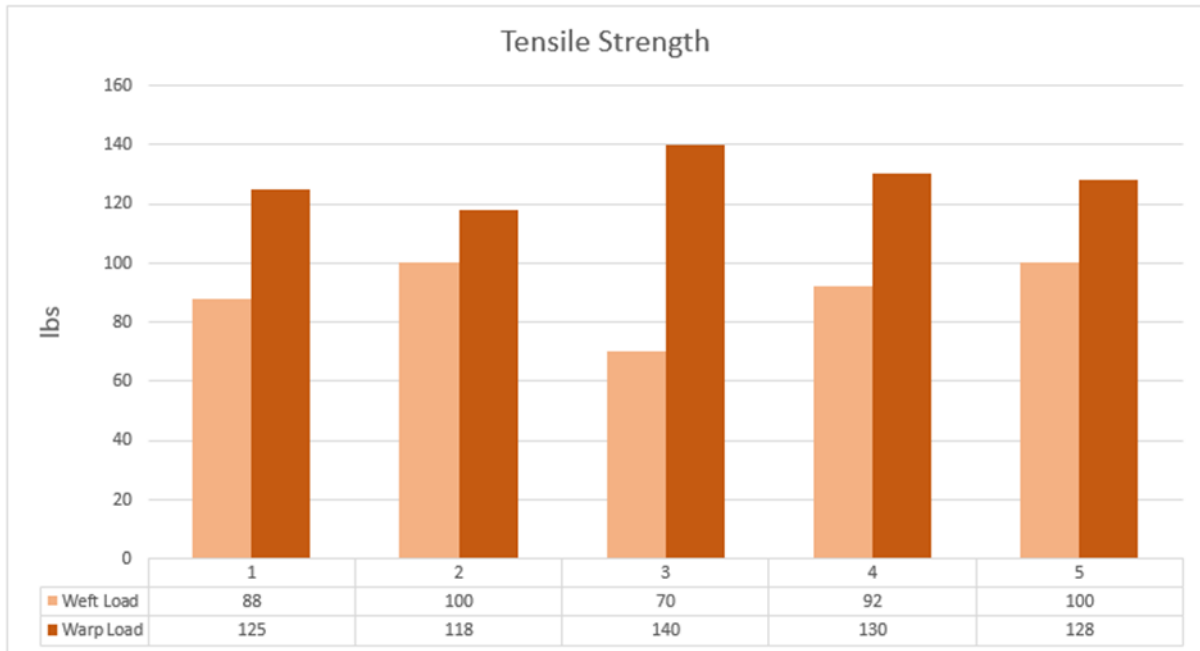


Fig 3. Tensile Strength of Jute Fabrics

4.4 Elongation:

Elongation property of any reinforcement was too very important as it defines how the reinforcement will behave when it is under force when it is installed in a composite.

Elongation property of the nonwoven fabric was also measured in both machine as well as cross direction. The results of which are shown in the Figure 4

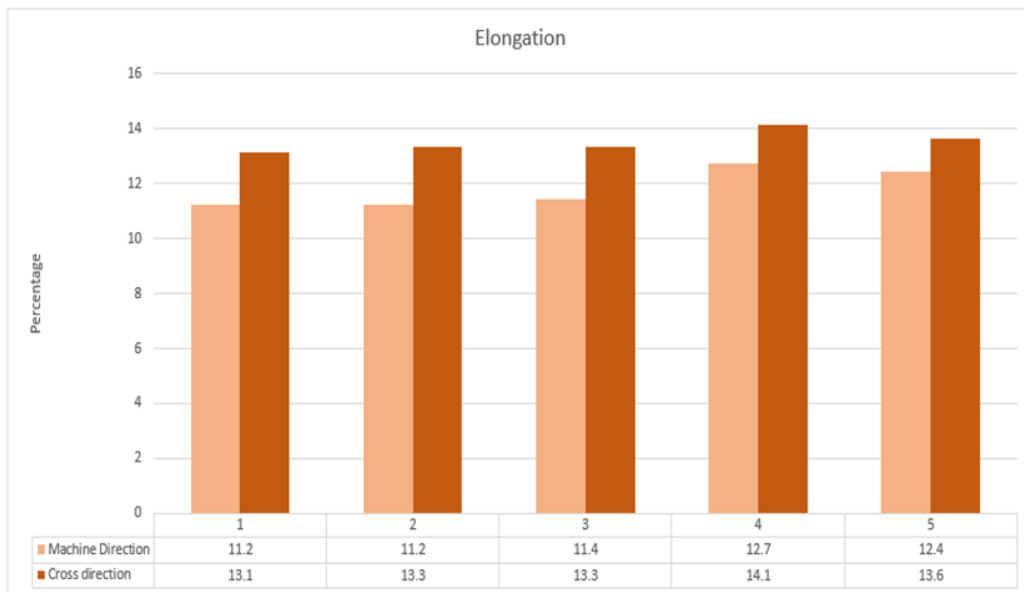


Fig 4. Elongation Of Nonwovens

The elongation property owing to the cross laid fabric may have shown the significant ($P=0.001613 < 0.05$) increase in the cross direction. Again as described in earlier tensile strength related aspect for both nonwovens as well as the Jute fabrics that the inherent characteristic would be nullified as the composite was formed despite this the assessment on elongation reveals that there was a significant difference in elongation behavior owing to the structural aspects.

Similarly the elongation of the Jute fabrics were measured which are indicated in the following Figure 5. Elongation property of jute fabric in both warp and weft direction was measured for this reinforcement. The results for this test are indicated below and shown using a graph given below. Elongation in the weft direction is significantly ($P=1.85E-05 < 0.05$) more than that of the warp direction this could be due to the fact that the warp might be having a pre stretched state during weaving and hence weft shows higher elongation in fabric form.

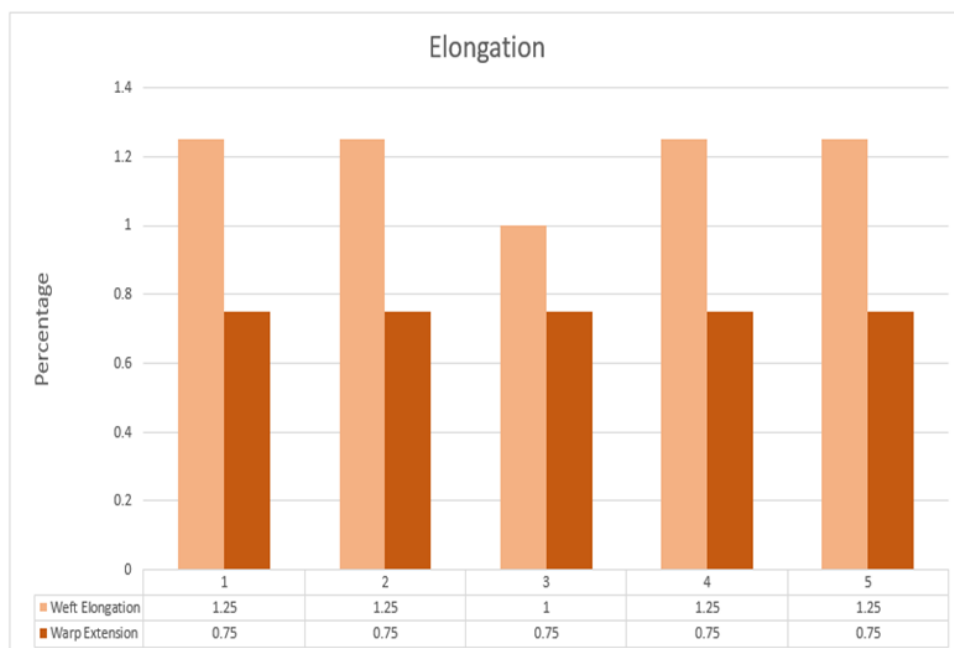


Fig 5. Elongation pattern of Jute Fabrics

4.5 Density: Density is nothing but mass per unit volume. According to IS 3087 standard, three test specimens from each sample, in full thickness of material, 75 mm wide and 150 mm long.

Density for the particle boards made with nonwoven fabric as reinforcement and the boards without reinforcement but fabricated with the same process are tabulated and analyzed in the figure 6 below.

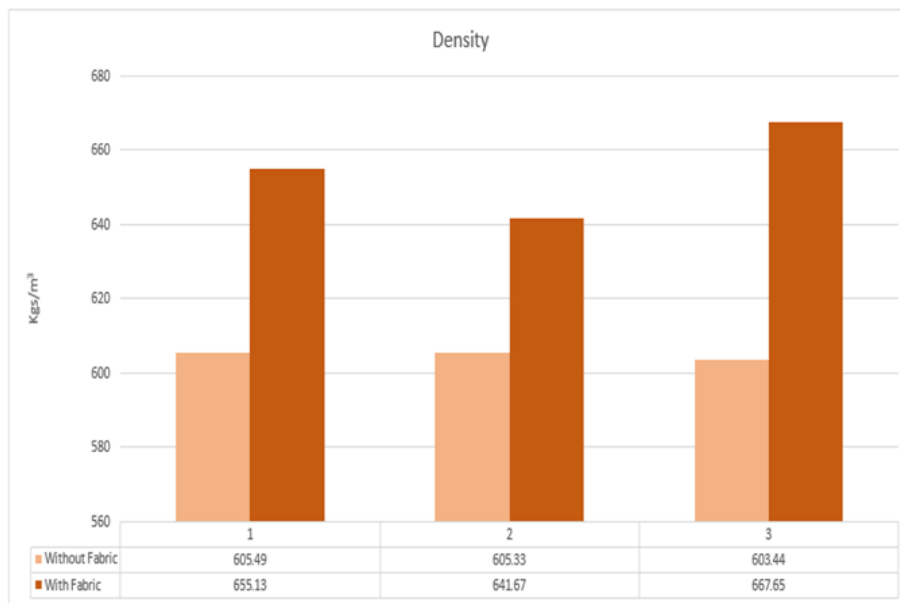


Fig 6. Density of Nonwoven Boards

The density of the boards increased when the fabric is introduced in them as a reinforcement. This was also shown by the significant ($P=0.002658 < 0.05$) increase in the density of the boards as also in the ANOVA table. Not Just the fabric but also with the resin used compared to that of particles absorbed by the fabric, contributed towards the increased density of the particle boards which were reinforced.

Similarly to assess the impact of reinforcement with the Jute fabrics in the particle boards the density studies were done both in warp way direction as well as weft way direction of the fabric the results are indicated in figure 7.

In both the Nonwoven based reinforcement and Jute fabric based reinforcement the rise in density of the boards was noticeably higher owing to the adhesive added for creation of the final board. This rise in density was much desirable because the different functions for which the boards might be used this would provide an added stability as well for a specific duration for which the board has to deliver its function. Here the most noticeable point is though the tensile strength might satisfy one attribute of utility but, on the other hand the performance standing at the specific given end use could be long lasting of a material as it might have gone as waste.

4.6 Modulus of Rupture (MOR):

Modulus of rupture or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. Sampling of this was also done in accordance to IS 3087 standard, three test specimens of each sample with dimensions of 460mm*75mm.

One of the most important property being studied in this research work was MOR. MOR of the particle boards if achieved with a significant improvement in these particle boards can open all new dimensions for its applications. This was one property along with water absorption which limits its applicative scope. But since this study works on its strength this is the property it concentrates upon. Here, in this case, two cases of particle board reinforcement placement are shown, as the reinforcement was off the center of the board. The placement in which the reinforcement was nearer to the point of load in three point load test the strength was similar to that of the non-reinforced particle board. Thus indicating that the reinforcement has not contributed towards the MOR of the board. This in fact has caused a decrease in the strength of the board, this may be due to the fact that the board below the fabric and above the fabric may have acted like two different entities owing to complete separation of these due to the nonwoven fabric. In the other case, when the reinforcement is farther from the particle board it has shown greater performance, this could have been because when the fabric was away from the point of load it borne a part of that load along with a majority of the particle board, thus proving that it had contributed in the strength of the particle board as indicated in Figure 8



In similar testing conditions with jute fabric used as reinforcement the test results showed an improvement in the maximum force endured by the samples. Both single layer as well as double layer reinforcements indicated there was an improvement in the maximum force endured by these samples. But double layer reinforced sample showed statistically significant ($P=0.0012 < 0.05$) increase in its results than without any reinforcements. When both of these facts were analyzed together, it can be seen that though in case of double layer reinforced board, there was statistically significant increase with comparison to non-reinforced sample, but the results in comparison with single layer reinforcement was too small to be considered, this shows that the improvement in strength of the board was achieved in the first case itself i.e. single layer reinforcement, hence the double layer reinforcement may even be redundant when one considers techno-economic feasibility in comparison with single layer reinforced sample. The results for which are shown in Figure 9.

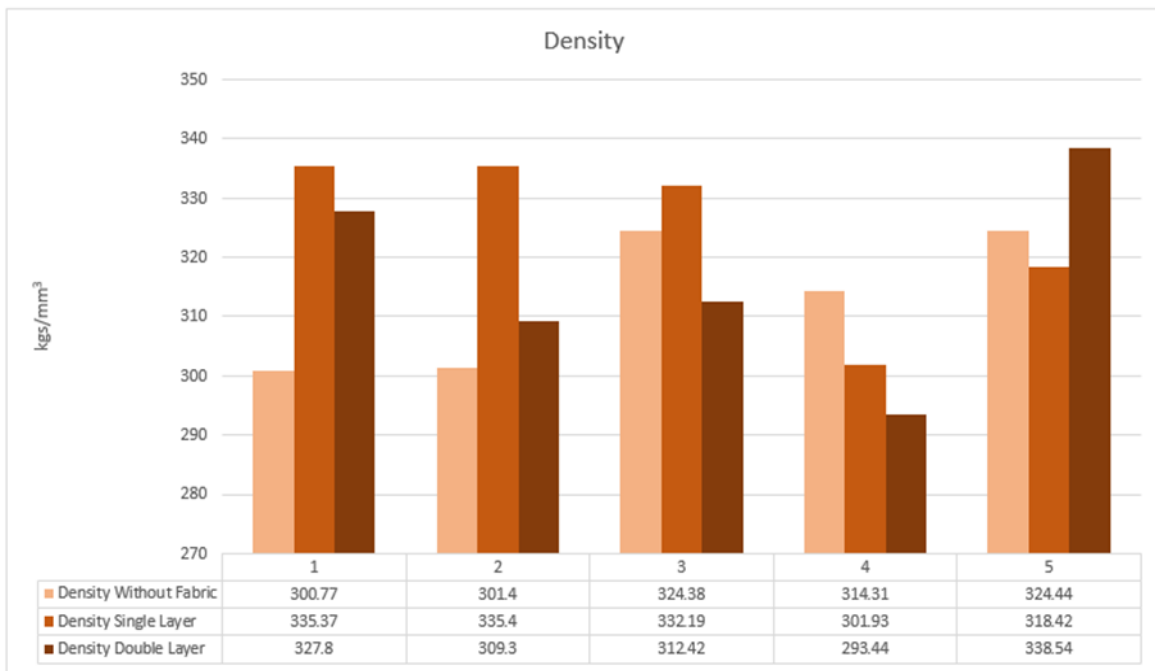


Fig 7. Density of Jute reinforced boards

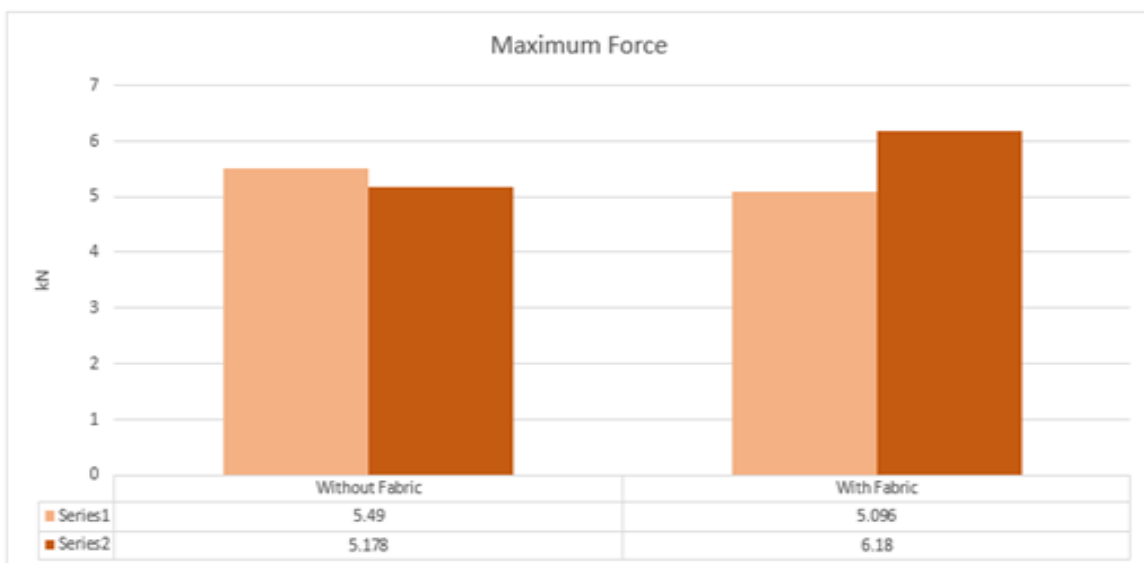


Fig 8. Maximum Force In Nonwoven reinforced boards

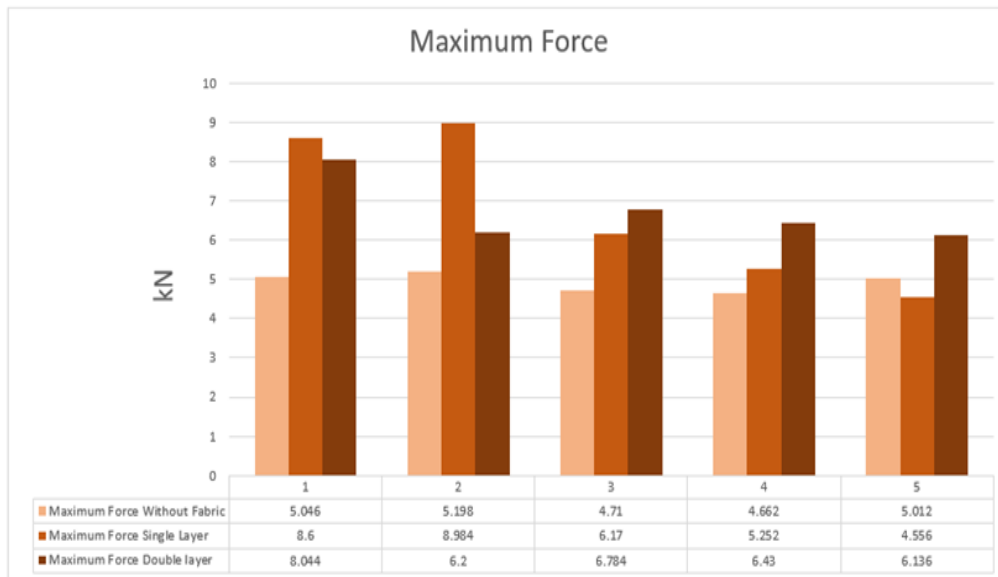


Fig 9 : Maximum Force in multilayer Jute Boards

4.7 Bending Strength:

The bending strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress. Bending Strength was another way of looking at the Modulus of Rupture of the board.

The Bending strength of the Nonwoven reinforced sample is given as follows in the figure 10 below. Also The trends of bending strength were similar to that of the maximum force endured by the particle boards. The bending strength of the board in which the fabric was away from the point of load showed better results and the board where it was nearer it showed lower strength. Bending Strength of the particle boards reinforced using jute fabric were also noted and are shown in the figure 11 given below. The bending strength of the particle boards reinforced using jute fabric showed a trend as above. The single layer reinforced board showed a better result than both the other trials. This may be due to the increased density of these boards. This also prompts to one other reasoning for the above results and that is, the lower results of the double layer reinforced board might be due to the fact that it got fragmented into three parts unlike a more integrated single layer reinforced board, reinforcement increases integrity.

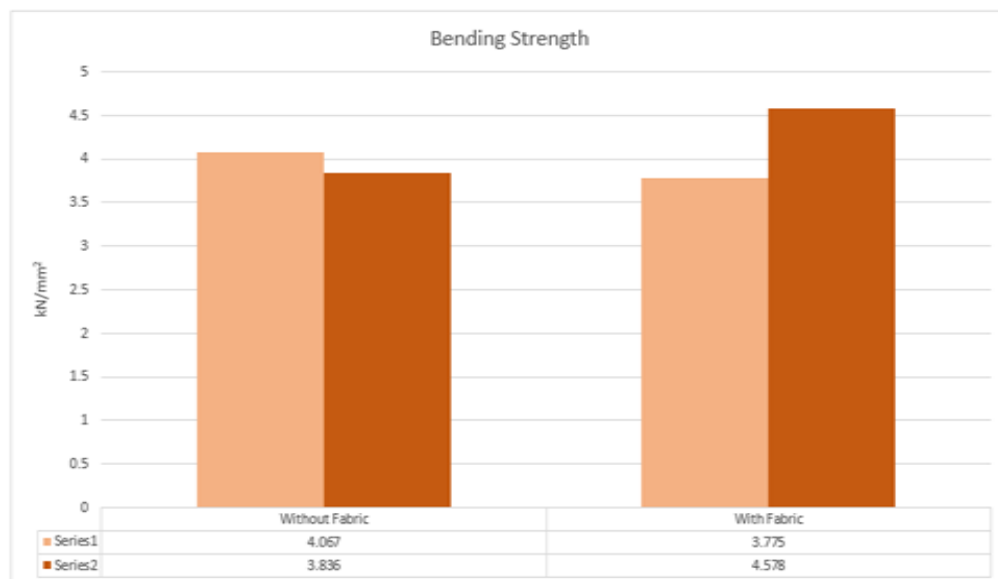


Fig 10. Bending Strength Of Nonwoven reinforced boards

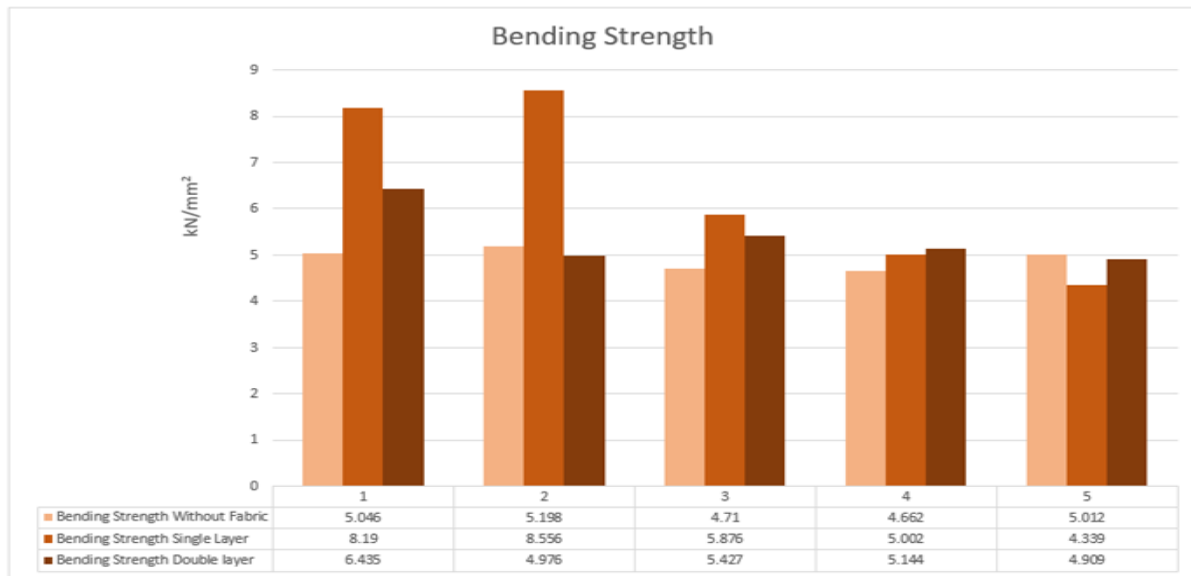


Fig 11 :Bending Strength Of Multilayred Jute Boards

The bending strength of the particle boards reinforced using jute fabric showed a trend as above. The single layer reinforced board showed a better result than both the other trials. This may be due to the increased density of these boards. This also prompts to one other reasoning for the above results and that is, the lower results of the double layer reinforced board might be due to the fact that it got fragmented into three parts unlike a more integrated single layer reinforced board, reinforcement increases integrity.

V. CONCLUSION

1. Density, Dimensional retention, Bendability in such many areas the Nonwoven reinforced boards showed significant and encouraging change as compared to that of non-reinforced boards.
2. There was a significant improvement of maximum force endured by the double layer jute fabric reinforced board as compared to the non-reinforced board.
3. Bending Strength of the single layer jute fabric reinforced board is the maximum.
4. There is a noteworthy increase in the Maximum force as well as Bending Strength from non-reinforced to single layer reinforcement but there is no such great improvement in double layer from single layer, indicating that there is no substantial utilization of the second layer of jute fabric reinforcement.

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