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Alkaline Treatment Effect on Mechanical Properties *Tectona grandis* wood species

M.vasubabu[1]*, S.Harish Babu[2], T.Narendrudu[3], Ch.Anjaneyulu[1]

[1]Dept of Applied Sciences, St.Ann's College of Engineering and Technology, Chirala, India
[2]Dept of Mechanical Engineering, St.Ann's College of Engineering and Technology, Chirala, India
[3]Department of physics, Aditya Engineering College, Surampalem, A.P., India

Abstract : This present work is concerned with effect of alkaline treatment on the mechanical properties of *Tectona grandis* wood species. Mass loss, Tensile strength, compression strength, elongation and hardness were measured at different alkaline (NaOH) concentrations (5%, 10%, and 15%). The result shows that variation in mechanical properties with alkali treatment on *Tectona grandis* wood species at different concentrations. Optimum mechanical properties were obtained at 10% of alkaline treatment is discussed with its structure critically.
Key*words:* *Tectona grandis* wood species, alkaline treatment, mechanical properties.

Introduction:

Wood is an extremely versatile material with a wide range of physical and mechanical properties among the many species of wood. It is also a renewable resource with an exceptional strength-to-weight ratio. Wood and wood products occupy an important place in engineering Wood is a desirable construction material because the energy requirements of wood for producing a usable end-product are much lower than those of competitive materials, such as steel, concrete, or plastic [1]. For artificial materials like steel, the mechanical properties of numerical values are constant. However, for plant tissues like wood, this parameter is known to vary numerically as a function of tissue moisture content and other external chemical treatment [2-5].

It is well known that hardwoods and agricultural residues such as bagasse or cereal straw are particularly affected by a mild alkaline treatment. This effects primarily on the hemicellulose fraction and brings about the swelling of the cell wall. The increase in wall thickness can reach a high magnitude. A study of the evolution of the poplar fibre wall thickness showed that after one hour alkaline swelling can almost close fibre lumen for conditions such as high alkali concentration (50 gm) and room temperature [6].

The mechanical properties of a hardwood are significantly modified by alkaline treatment [7,10]. To our knowledge, despite its important effects, alkaline treatment has not been extensively studied. Zanuttini et al.[8] 1997 reported on the study of the alkaline swelling of poplar wood meal at low temperature. The alkaline treatment causes a swelling which is related to deacetylation rather than to acid groups content development. The use of wood meal in this study allowed the elimination of the mass and heat transfer resistance that takes place in larger wood particles. It should be mentioned that Beatson et al. [9] found that the operation on milled wood resulted quite representative of the reaction of wood chips evenly impregnated for the study of the sulphate treatment of poplar. The use of wood meal was a useful way to determine the evolution of yield, lignin dissolution and the generation of carboxylic and sulphonic groups.

Tectona grandis wood species is used as construction material for commercial applications in India. This work studies, percentage of mass loss, tensile strength, compression strength, elongation at failure and hardness is measured at different alkaline (NaOH) concentrations (5%, 10%, and 15%) for 1hr at 100^0C on *Tectona grandis* wood species

Material methods:

Different wood logs of *Tectona grandis species* were collected at normal dried condition for present Investigation.

Alkalization treatment involved a procedure of immersing wood logs in NaOH solution with concentration of 5, 10 and 20% at ambient temperature of 100^0C, then test samples are washed with distilled water, dried for one week under sun radiation. Mass loss for different concentration is measured with untreated sample as reference.

A Universal Testing Machine was used to study the tensile strength, compression strength and Percentage of elongation. The UTM is a computerized servo controlled machine with nominal loads from 20 kg to 100 ton. Hardness was also measured for untreated and alkaline treated wood samples with different concentrations by using Rockwell Hardness testing Machine.

Results and discussion:

Wood is a lignocelluloses fibre consists of cellulose, hemicellulose and lignin as the main components. The amorphous hemicellulose and lignin tied up together to encapsulate the cellulose so that the cellulose will be crystallized rigid and packed together [11]. They are generally called as cementing materials and often highly cross-linked to each other that act as a structural rigidity to the fibre cell wall itself [12]. Sodium hydroxide (NaOH) is a suitable alkali to be used in order to eliminate those blockages to provide more hydroxyl groups on the fibre surface. This is because NaOH has a great tendency to degrade the cementing materials and thus will improve the particle dispersion [13]. During the alkali treatment, hydroxyl groups of the cementing materials may interact with the NaOH approached to them [14]. The interaction results in the cellular structure to be destructed and split from each other into filament forms.

The separated fibrils then caused the interfibrillar region to become less dense and less rigid. This situation may contribute in letting the fibrils to be capable enough in rearranging themselves and thereby resulting in better load sharing [15]. As the hemicellulose and lignin are attached with the NaOH, the filaments left have more exposed surface to facilitate the chemical reaction between the cellulose and phenolic resin that later contributing in better stress transference at the interface [16]. In general, dissolving a part of cementing materials may result in possibility of interfacial interaction between fibre and matrix, increment of the effective surface contact with the matrix and also to make the load transfer between the fibre and the matrix to be possible [17].

Effect of Alkali Treatment

Figure 1-5 shows the mean values of percentage of mass loss, tensile strength, elongation at failure, compression strength and Hardness of properties *Tectona grandis L wood species at* different alkaline (NaOH) concentrations (0%,5%, 10%, and 15%) for 1hr at 100^0C.

The variation of mass loss of *Tectona grandis* Wood were probed to reveal that effect of alkali treatment on complex material wood at different concentrations. The mass decreases with minimum value corresponding to maximum concentration at constant temperature. The variation of sodium hydroxide treatment concentration influences the value of residual mass, the residual mass increases from 0% NaOH (untreated) to 10% of NaOH which corresponds minimum loss. However it decreases for15% NaOH. Beyond certain concentration of NaOH, it notes that mass loss increased significantly, this may explained by the fact that the internal structure of wood is quote drops till and starts degrade. Thus the optimal concentration for alkali treatment is order of 10%treatment. Percentage of mass loss on wood at different concentrations shows cleaning impurities and water content relations. This may be attributed to loss in density compared to without alkaline effect.

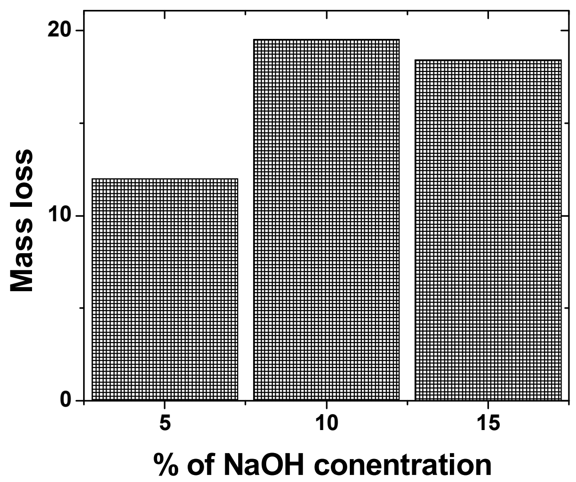
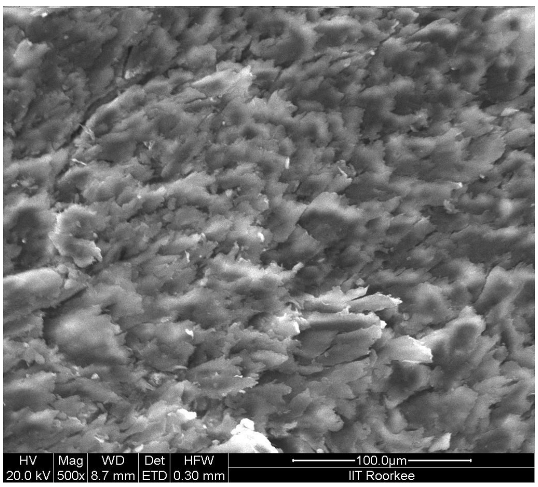


Fig.1.Average Mass loss of *Tectona grandis species* versus alkali concentration (NaOH)

Morphology Analysis

Microscopic examinations were carried out using a scanning electron microscope (SEM) to study wood fibre morphology sample after alkaline treated. The SEM micrographs for alkali treated samples were analyzed; fiber thickness and arrangements for different magnifications are shown in figure (6a& 6b).



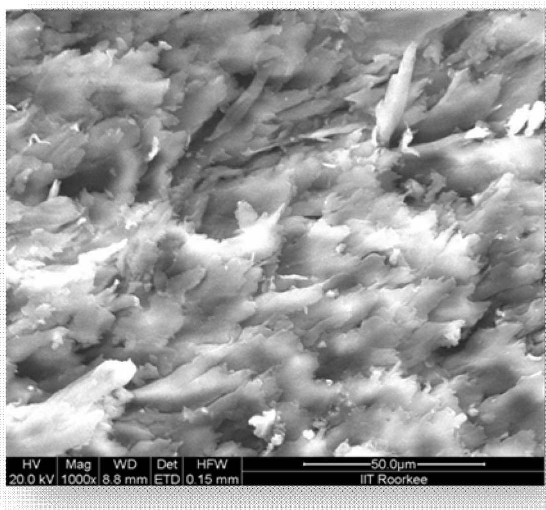


Fig6a **Fig6b**

Figure 6a&6b. Typical SEM images of alkali treated *Tectona grandis* Wood species .

Mechanical properties:

The test results of tensile strength, elongation at failure, compression strength and hardness for *Tectona grandis* wood species were showed consistent in their property, which proved the effectiveness of the treatment.

The maximum tensile strength and compression strength was reported at 10% of NaOH treatment. As soda concentration increases the fibre become cleaner of its impurities and later improves mechanical strength.

However, it is interesting to note that, as soda (NaOH) concentration increases and researches to 15% of NaOH, the solution attacks the main construction components of the fiber and more grooves appear on the surface of the fiber. Improvement in tensile strength of wood was observed when soda treatment was applied. This results in further weakening in fiber strength, so the tensile strength and compression strength start to decrease. As it is known, natural fibers are usually composed of cellulosic materials cemented together with weaker materials. The deterioration mechanism has been explained to be due to the attack of the cementing materials rendering the cellulose chains unconnected and hence unable to carry any load. Eichhorn et al. reported in there review that high concentration of caustic soda results in a decrease of fiber tensile strength due to notched grooves at the plant fibers surface [18]

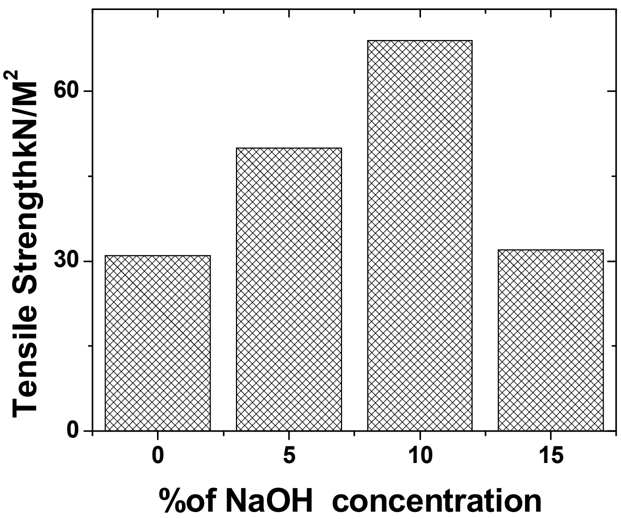


Fig.2.Average tensile strength of *Tectona grandis species* versus alkali concentration (NaOH)

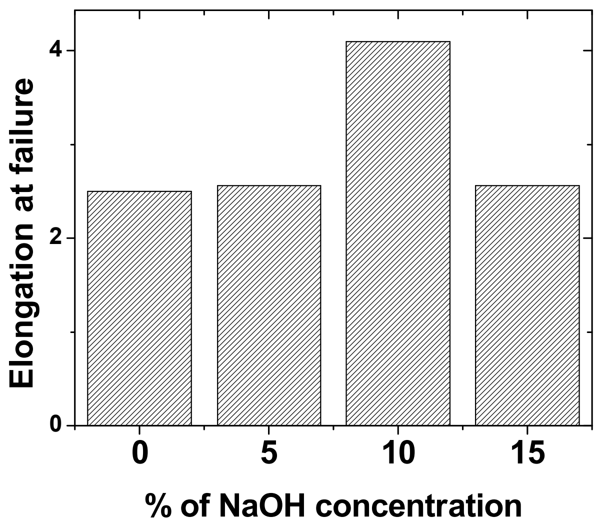


Fig.3.Average Elongation at failure of *Tectona grandis species* versus alkali concentration (NaOH)

Compression strength related to density, wood sample with high density shows high mechanical strength. This may be attributed to the supramolecular architecture of the cell wall with its special chemical composition also here plays an important role. Alkali treatment may affect cell wall thickness. so the variation in compression strength is observed for different concentrations.

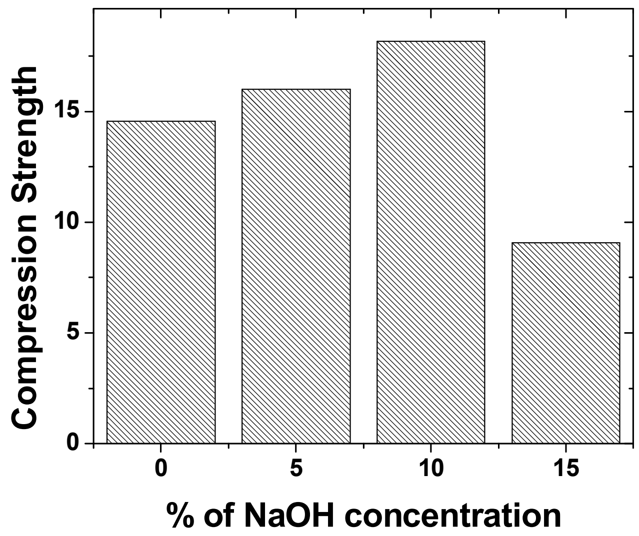


Fig.4.Average compression strength of *Tectona grandis species* versus alkali concentration (NaOH)

The variation of the hardness of material is a function of fibre content is presented in wood Figure.5. In this study, hardness was a measure of resistance to indentation and the values got were used to estimate the mechanical strength of each wood specimen. This shows that fibres that increase the modulus of wood samples are expected to increase the hardness, because hardness is a function of the relative fibre volume and modulus.

The hardness of both untreated and treated wood samples was found to increase progressively with increase in the fibre content. It is observed that the treated fibres of wood showed better hardness properties than the untreated ones at all conditions investigated. The highest value of hardness is observed for 10% of NaOH concentration. This scenario could be linked to the better adhesion of the matrix to the fibre brought about by the fibre treatment with NaOH. The decreases of hardness for15% of soda concentration may attributes fibres strength and reduce flexibility of matrix component in the lignin and hemicelluloses.

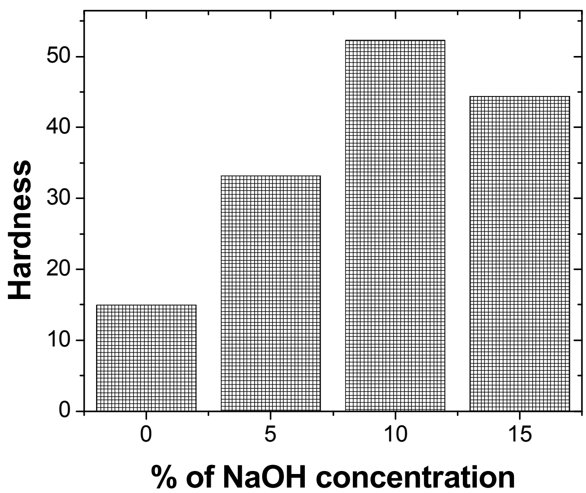


Fig.5.Average Hardness of *Tectona grandis species* versus alkali concentration (NaOH)

Conclusion:

From this study, we conclude that the alkaline treatment has significantly improved the mechanical properties of *Tectona grandis* Wood. The enhancement in mass loss, tensile strength, elongation failure, compression strength and hardness is attributed to the improved wetting of alkali treated fiber by removal of impurities and waxy substances from the fiber surface and the creation of a rougher topography after alkalization, thus the mechanical interlocking and the interface quality will be promoted. The hydrophilic nature of wood palm fiber has been reduced due to this treatment, the content of hemicellulose and lignin decreased, thereby an increase on the effectiveness of the orientated cellulose fibers, the tensile strength and a considerable improvement in surface morphology were observed. The result indicates that the treatment at the condition of 10% NaOH is the optimum treatment which gives the maximum mass loss, mechanical properties such that tensile strength, elongation failure, compression strength and hardness and the better surface morphology of the wood fiber. Thermal analysis of wood shows that soda treated fibers have better thermal resistance compared to raw fibers which due to the repellent action of the treatment of the sample to the phenomenon of water absorption. However, at higher alkaline concentrations 15% NaOH, the effect of these parameters on mass loss and mechanical properties is so pronounced because at this condition, fiber damages may have been dominant. The results obtained in this study encourage us to integrate wood fiber as reinforcement in a given matrix by a prior chemical treatment at 10% NaOH that we can remedy to its reliable mechanical performance before its integration.

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