# Evaluation of Compressive Strength in Various Timbers for Agricultural Implements in Pantnagar, Uttarakhand, India


## Abstract

This study investigates the compressive strength of various timber types, including Red Cedar, Java Plum, Mango, Yellow Teak, Margosa, Eucalyptus, Teak, North Indian Rose timber, Lebbeck, and Sal. The compressive strengths of these timbers were measured to be 43.79, 50.42, 78.00, 71.16, 68.32, 69.88, 80.78, 85.50, 65.12, and 81.20 MPa, respectively. North Indian Rose timber and Sal exhibited the highest compressive strengths, suggesting their superior suitability for applications requiring high compressive resistance. Conversely, Red Cedar showed the lowest compressive strength among the timbers tested. The standard deviations for these measurements were Java Plum (0.07), Mango (0.28), Yellow Teak (0.36), Teak (0.45), Margosa (0.52), Eucalyptus (6.11), Red Cedar (0.69), North Indian Rose timber (0.79), Lebbeck (0.93), and Sal (0.68), with Mango displaying the lowest variation. The findings indicate that North Indian Rose timber and Sal are particularly robust, while Mango exhibits consistent compressive strength, making these timbers preferable for specific structural applications.



***Keywords:*** Compressive strength, material properties, standard deviation, timber performance, high compressive resistance


## 1. Introduction

"Agriculture in India had developed in remote antiquity, and down to the 18th century, India ranked among a few developed countries of the globe. Indigenous tools were basic but well-designed suit farmer's needs. Traditionally farmers have been using a variety of tools in their everyday life, often for agricultural operations and household purpose. Agricultural implements used in 18th and 19th centuries were mostly hand operated and animal drawn. The fresh development in new designs of implements and tools was noticed around independence. Most of the timber tools, implements use local timber materials – different timbers for particular tools and strings for various uses come from different plants" (Karthikeyan et al 2009). "The present investigation was carried out to determine the Compressive strength of various types of Timbers used for agricultural implements in Pantnagar, Udam Singh Nagar, Uttarakhand"[30-34]. This study provides information for selection criteria of timber to make a different component of agriculture implement and tools.

This study was mainly targeted on utilization of different type of timber for their use to make different components of agricultural implements and tools.

## 2. Experimental Details

### 2.1 Timber

Timber is light weighted, durable and economical. Timber is a natural polymer and its molecular structure is established on the cellulose chain whose cell wall comprises cellulose fibers which were laterally arranged to its axis. The timber is the intermediate and in fact the main zone of the tree. Timber subsists of four main chemical groups represented in Table 1. The cellulose and hemicellulose groups are the carbohydrates (sugar molecules) which make up the majority of the cell wall. Lignin performs as a "glue" to bind the cells together into a stiff/strong material. “The extracts are chemicals that are deposited in the cells and provide unique properties to timber, such as the natural resistance to biological deterioration. Timbers with a high degree of natural resistance have approximately high percentage of biocidal extracts (Author). The total extractive content of few species can be as high as 20 to 30%; these species commonly have a high proportion of biocidal extracts”. [34]

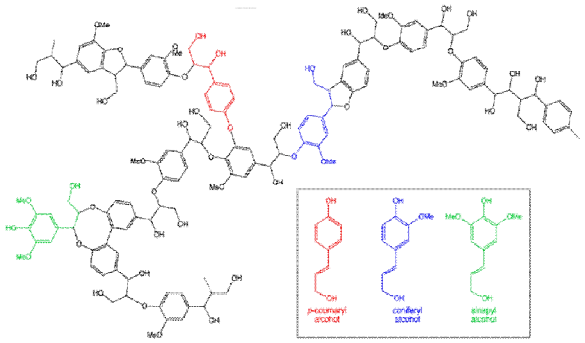


**Figure 1: Chemical structure of lignin, which comprises approximately 30% of timber and is responsible for many of its properties**

Various samples have been prepared in different proportion considering different properties of timber there after tested for Mechanical properties and compare which one has best strength sample among the all sample. The testing was conducted by using Universal Testing Machine

### 2.2 Collection of various types of timber

Destructive method of sampling was adopted to collect the timber samples. The tree of Sheesham, Sal, Yellow Teak, Red cedar, Teak, Margosa, Java plum, Eucalyptus, Lebbeck

and Mango were felled and converted into logs of one meter length which are used for preparation of samples for mechanical property analysis. Mechanical tests were conducted as per the Indian Standard Specification IS 1708 by Universal Testing Machine (AMT-SC, A.S.I make).

**Table 1: Chemical Constituents of Timber**

| **Compound** | **Description** | **Amount (Percent of total mass)** |
|---|---|---|
| Cellulose | Long chain of glucose molecules | 40-50 |
| Hemicellulose | Long chains of sugar molecules other than glucose | 25-30 |
| Lignin | Complex organic compounds that help bond cells together | 15-20 |
| Extracts | Compounds that are not an integral part of the cell wall | < 15 |
| Ash | Inorganic elements in timber | < 1 |

### 2.3 Compression testing

The Compression test is simply the opposite of the tension test with respect to the direction of loading. In any materials like brittle and fibrous ones, the tensile strength is appreciably contrasting from compressive strength. Therefore, it is necessary to test them under tension and compression separately. Compression tests results in mechanical properties that consist of the compressive yield strength, compressive ultimate strength, and compressive modulus of elasticity in compression, The percentage reduction in length etc. All the compression tests of different woods are conducted on 25kN servo hydraulic UTM machine (AMT-SC, A.S.I make). Specimen configuration is shown in Figure 3

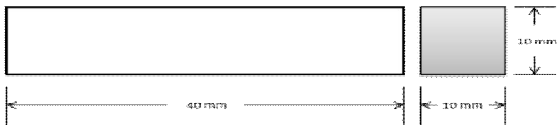



**Figure 2: Specimen geometry of Compression test (IS 1708 (part - 9:1986))**

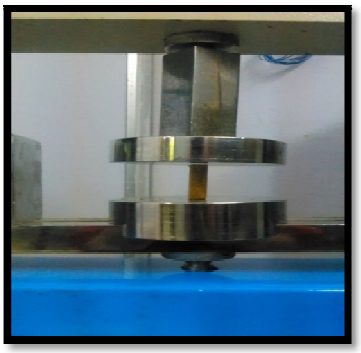


**Figure 3: Test setup for Compressive strength**

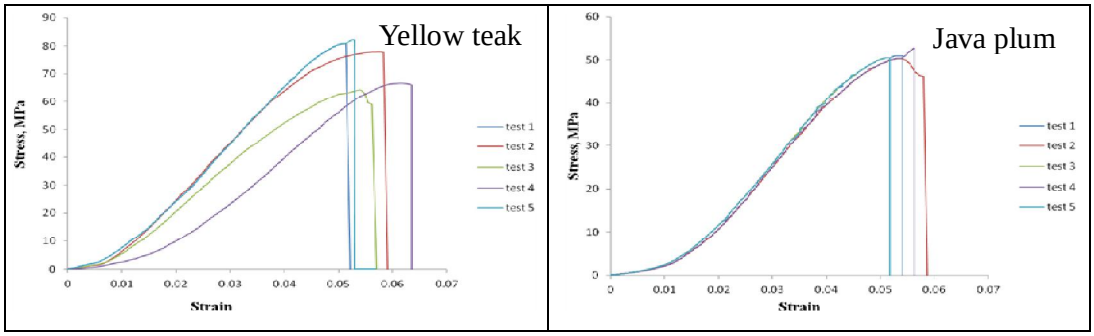
## 3. Results & discussion:

The results of the compressive test are discussed in this section. The compressive tests were carried out using controlled Universal Testing Machine (AMT-SC, A.S.I make). Compressive strength plays an important role to provide good strength for agricultural implements. Compressive strength was tested at different types of timber Ultimate compressive strength found from the stress- strain curve. The stress-strain curves of timber were presented in Fig 4.

**Table 2:Compressive strength and Parentage reduction in Compressive test**

| S.No | Types of timber | Compressive ultimate strength (MPa) | | (%) Reduction | |
|---|---|---|---|---|---|
| | | Mean | S.D. | Mean | S.D. |
| 1. | Yellow teak | 71.16 | 0.36 | 7.05 | 0.10 |
| 2. | Red cedar | 43.79 | 0.69 | 11.77 | 0.56 |
| 3. | North Indian rose timber | 85.50 | 0.79 | 7.83 | 0.92 |
| 4. | Teak | 80.78 | 0.45 | 8.41 | 0.81 |
| 5. | Lebbeck | 65.12 | 0.93 | 9.15 | 0.60 |
| 6. | Java plum | 50.42 | 0.07 | 6.67 | 0.45 |
| 7. | Eucalyptus | 69.88 | 6.11 | 9.33 | 0.47 |
| 8. | Margosa | 68.32 | 0.52 | 7.63 | 0.15 |
| 9. | Mango | 78.0 | 0.28 | 6.32 | 0.38 |
| 10. | Sal | 81.20 | 0.68 | 6.46 | 0.33 |

It was concluded from table 2 that the Compressive strength of different types of timber red cedar, Java plum, Mango, Yellow teak, Margosa, Eucalyptus, Teak, North Indian Rose timber, Lebbeck and Sal were 43.79, 50.42, 78, 71.16, 68.32, 69.88, 80.78, 85.50, 65.12 and 81.20 MPa. Similar patterns of compressive strength were observed in the research findings of **Izekor D. N.** and **Fuwape J. A. (2010)**.



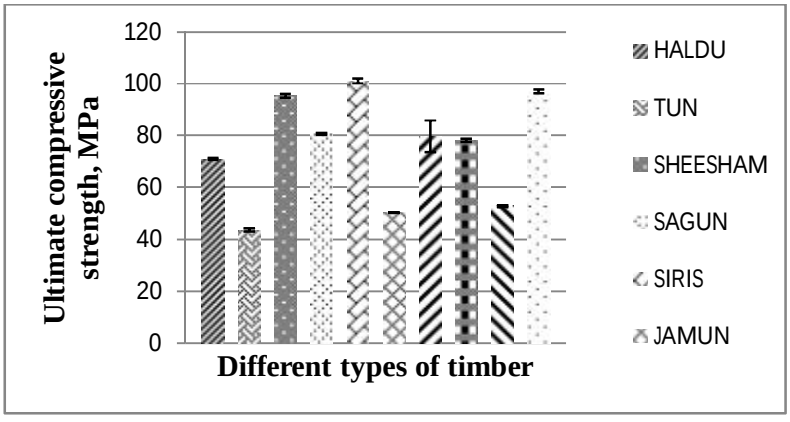




**Figure 4: Ultimate Compressive strength with different types of timber**

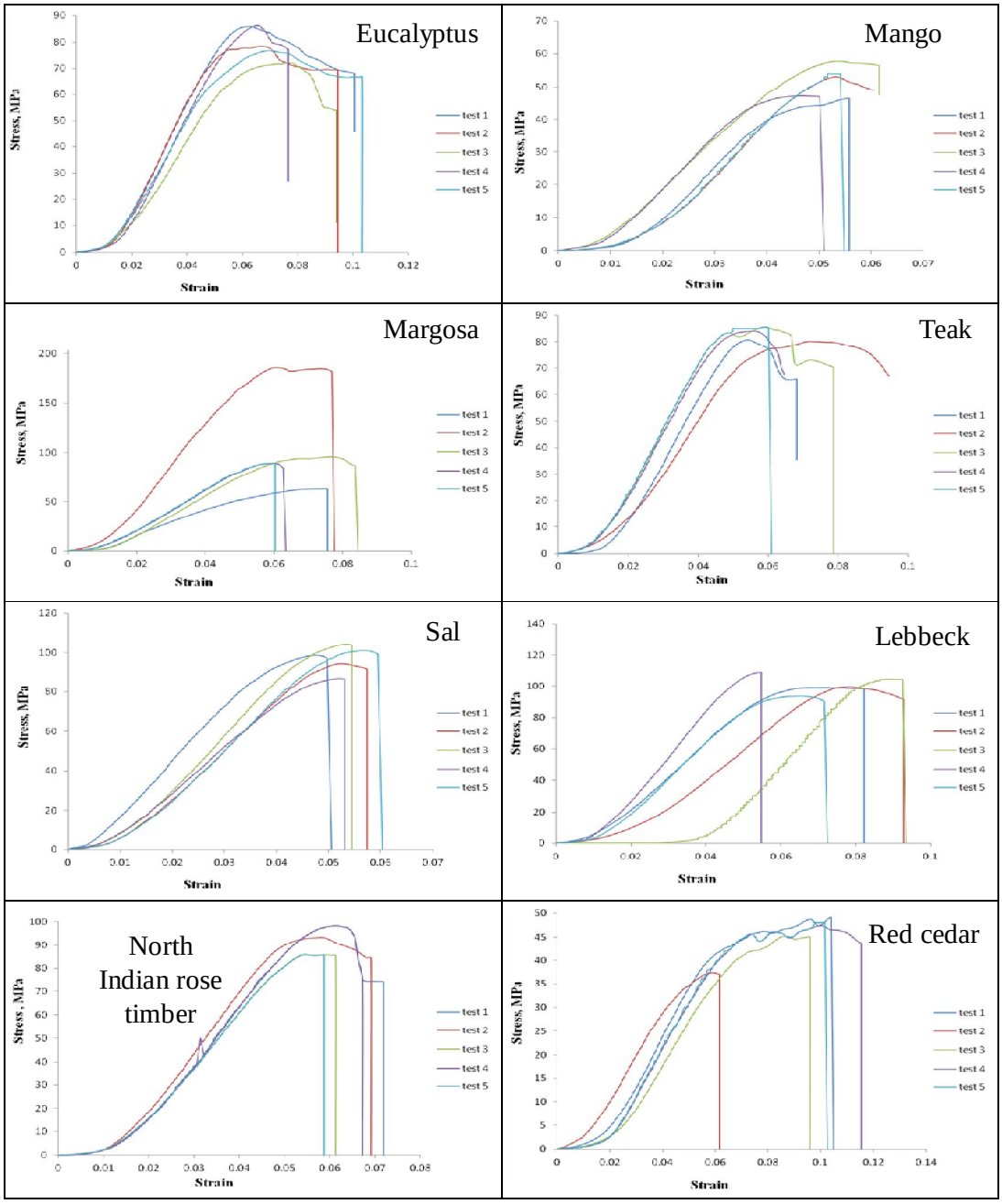



**Figure 5: The engineering stress-strain curve for different types of timber and strains from zero up to the specimen fracture.**

North Indian rose timber and Sal had a good compressive strength over all types of timber, but red cedar has lower compressive ultimate strength as compared to other types of timbers. Hence North Indian rose timber proved itself more suitable timber rest of the other types of timber. And their standard deviations were as follows Java plum (0.07), Mango (0.28), Yellow teak (0.36), Teak (0.45), Margosa (0.52), Eucalyptus (6.11), Red cedar (0.69),

North Indian Rose timber (0.79), Lebbeck (0.93) and Sal (0.68) respectively. Mango has less standard deviation compared to other types of timber.

**Table 3: Analysis of variance**

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| *Factor* | *8267.1* | *9* | *918.56* | *12375.9* | *0.001* | *2.124* |
| *Error* | *2.97* | *40* | *0.074* | | | |
| Total | 8270.02 | 49 | | | | |

The ANOVA results shown in table 3 which indicate that there are statistically significant differences among the means of the groups for the factor being tested, as evidenced by the large F-value (12375.9) and the p-value (0.001), which is much less than the significance level of 0.05. The factor has a significant effect on the dependent variable, and the null hypothesis (that there are no differences among group means) is rejected.

## 4. Conclusion

The molecular structure of timber, primarily composed of cellulose, hemicellulose, lignin, and extracts, plays a crucial role in its strength and durability. The selected timber species—Sheesham, Sal, Yellow Teak, Red Cedar, Teak, Margosa, Java Plum, Eucalyptus, Lebbeck, and Mango—were analyzed to determine their compressive strength, an essential factor for their application in agricultural implements. The results revealed significant variations in the compressive strength of different timber types, with North Indian Rose timber and Sal demonstrating the highest compressive strength, making them more suitable for agricultural tools requiring high strength. In contrast, Red Cedar exhibited the lowest compressive strength among the tested timbers. Furthermore, the study highlighted the importance of standard deviation in evaluating the consistency of the timber's mechanical properties. Mango timber showed the least variation in compressive strength, indicating its reliability. These findings align with previous research by **Izekor D. N. and Fuwape J. A. (2010),** supporting the consistency and reliability of the data. In conclusion, the study provides essential data for selecting appropriate timber for agricultural implements, with North Indian Rose timber and Sal being the top choices due to their superior compressive strength. This research contributes to the efficient and effective use of natural resources in agricultural applications, promoting the use of durable and strong timber materials for enhanced performance and longevity of agricultural tools.

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