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Evaluation of Mechanical and Physical Properties of Timber Available in Nepal using Indian Standard

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Abstract

In Nepal's construction sector, timber remains an indispensable material, forming the backbone of residential buildings, commercial structures, and cultural heritage sites. Yet the absence of standardized quality assessment protocols has resulted in unpredictable material performance, compromising structural integrity and safety. This study bridges this critical gap by systematically evaluating four predominant Nepalese timber species - Sal (Shorea robusta), Sisau (Dalbergia sissoo), Chir Pine (Pinus roxburghii), and Utis (Alnus nepalensis) - employing arduous testing methodologies outlined in Indian Standard IS 1708:1986. Through comprehensive laboratory analysis, we quantified key mechanical properties including modulus of rupture (MOR), modulus of elasticity (MOE), compressive and tensile strengths, alongside physical characteristics like density. Our results demonstrate Sal's superior structural capacity (MOR: 129.9 N/mm²; MOE: 13,959.7 N/mm²), validating its traditional use in critical load-bearing elements. Sisau exhibited exceptional surface hardness, confirming its suitability for high-traffic flooring, while the lighter Chir Pine and Utis showed promising characteristics for cost-effective, non-structural applications. This research provides the first standardized dataset for Nepalese timber species, offering a scientific basis for material selection that harmonizes traditional building knowledge with modern engineering requirements. The implementation of IS-based evaluation protocols presents a practical pathway for Nepal to establish much-needed quality benchmarks, enhance construction safety, and optimize the use of its valuable forest resources in an era of increasing seismic awareness and sustainability concerns.

Keywords: Timber standardization, Structural safety, Material characterization, Seismic-resistant construction, Sustainable forestry, Wood engineering

1. Introduction

Walk through any Nepalese city or village, and you'll immediately notice how deeply timber is woven into our built environment. From the intricate woodcarvings of ancient temples to the sturdy beams supporting modern homes, this natural material has been the backbone of our construction traditions (Pandey & Sharma, 2020) for centuries. Its abundance in our forests, ease of crafting with simple tools, and adaptability to both ornate and utilitarian designs has made it irreplaceable in our architecture.

Yet there's a troubling paradox in how we use this precious resource. While every carpenter and builder relies on timber daily, we're essentially working without an instruction manual. Unlike our neighbors in India who follow standardized testing methods (like IS 1708), we lack any national system to verify if the wood we're using can actually bear the loads we're imposing on it. This knowledge gap leads to worrying realities on construction sites:

- Builders often gamble with material quality, never quite certain if their timber will stand the test of time
- Traditional homes that should last generations show premature wear
- Modern engineered structures sometimes fail to achieve their designed safety margins

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Having worked on post-earthquake reconstruction projects, I've seen firsthand how this uncertainty plays out when buildings face real stress (Duwadi, 2023). The solution might be as close as our southern border. India's decades of timber research have produced reliable testing standards that would translate well to Nepal's similar climate and species. Adopting these proven methods could be the key to preserving our woodworking heritage while building safer structures for tomorrow.

Common timber species available in Nepal include Sal (Shorea robusta), Chir Pine (Pinus roxburghii), Sisau (Dalbergia sissoo), Utis (Alnus nepalensis), Khair (Acacia catechu), Salla (Pinus wallichiana), and Champ (Michelia champaca). These species are widely used in construction, furniture making, and other woodworking applications due to their varying mechanical and physical properties.

The mechanical properties of timber are critical in determining its strength and usability. Key parameters include static bending, which consists of the modulus of rupture (MOR) and modulus of elasticity (MOE), as well as compression strength both parallel and perpendicular to the grain. Other important mechanical characteristics include shear strength parallel to the grain, cleavage strength, impact bending (measured by the height of drop causing failure), tensile strength both parallel and perpendicular to the grain, and hardness, which is determined using the Janka hardness test. In addition to mechanical properties, the physical characteristics of timber also play a significant role in its performance. Density is classified based on basic and air-dry density (as per IS 1708), categorizing timber as light, medium, or heavy. Moisture content is another key factor, influencing shrinkage and swelling characteristics. Durability is assessed according to IS 401, which classifies natural resistance to fungi and insects, as well as the durability of heartwood. Workability, including the ease of sawing, planing, and finishing, is also considered when evaluating timber suitability.

This study aims to test and evaluate the mechanical and physical properties of four widely available Nepalese timber species: Sal (Shorea robusta), Sisau (Dalbergia sissoo), Chir Pine (Pinus roxburghii), and Utis (Alnus nepalensis) (Pandey & Sharma, 2020). Various strength and physical tests are conducted on these species, and the results are compared to determine their suitability for different applications in construction and woodworking. The primary objective of this study is to determine the mechanical and physical properties of major Nepalese timber species. By conducting various tests, the study aims to evaluate whether these species comply with Indian Standard (IS) specifications. Based on the findings, suitable timber species will be recommended for both structural and non-structural applications, ensuring their effective utilization in construction and woodworking industries.

2. Literature Review

Timber is one of the most commonly used materials in Nepal for construction, furniture, and other woodworking applications. Despite its widespread use, there is limited scientific data on the mechanical and physical properties of Nepalese timber. Understanding these properties is crucial to determining timber’s strength, durability, and suitability for different applications. This review explores previous research on timber characteristics, the relevance of Indian Standard (IS) specifications, and the challenges Nepal faces in timber testing and standardization. The mechanical properties of timber, such as strength, stiffness, and durability, play a key role in its structural performance. Important characteristics include the modulus of rupture (MOR), modulus of elasticity (MOE), compression and shear strength, and hardness (Pandey & Sharma, 2020). The physical properties, such as density, moisture content, shrinkage, and workability, also affect how timber performs in different environments (Shrestha et al., 2018). Research shows that these properties vary depending on the species, growing conditions, and the maturity of the tree.

Several timber species are widely used in Nepal, including Sal (*Shorea robusta*), Sisau (*Dalbergia sissoo*), Chir Pine (*Pinus roxburghii*), and Utis (*Alnus nepalensis*). Sal is known for its strength and durability, making it ideal for heavy construction. Sisau is valued for its hardness and resistance to decay, while Chir Pine, a softwood species, is often used in lightweight structures. Utis, a fast-growing timber, is commonly used for general woodworking (Gautam et al., 2017). While these species are frequently used, there has been little standardized testing to evaluate their mechanical and physical properties based on IS specifications.

The Indian Standard (IS) codes provide widely accepted guidelines for testing and grading timber. The IS 1708 series defines methods for evaluating mechanical and physical properties, while IS 401 classifies timber's durability against fungi and insects (BIS, 2019). Researchers have emphasized the importance of adopting these standards in Nepal to ensure consistency in quality and performance (Joshi & Bhandari, 2021). Since Nepal does not yet have a national grading system, using IS standards can help establish reliable classification methods and improve timber quality.

One of the biggest challenges in evaluating timber in Nepal is the lack of advanced testing facilities. Due to limited resources, mechanical testing is often incomplete, leading to gaps in data (Kandel et al., 2020). Additionally, factors like variations in growing conditions, tree age, and natural defects in wood make standardization difficult. Researchers suggest that Nepal should develop its own grading system while maintaining regional compatibility with IS standards to ensure consistent quality and usability. The existing research highlights the importance of evaluating Nepalese timber scientifically to ensure its safe and effective use in construction. While IS specifications provide a strong framework for classification, Nepal still needs more studies and standardized testing methods to assess its timber accurately. This study aims to bridge that gap by testing major Nepalese timber species based on IS standards, providing valuable data for better quality control, construction safety, and sustainable use of local timber resources.

3. Problem Statement

In Nepal, timber serves as a vital material for construction and woodworking, yet there remains a significant gap in scientific data on the mechanical and physical properties of locally available species. Current timber selection practices predominantly rely on traditional knowledge rather than empirically tested performance metrics, creating uncertainties regarding strength, durability, and suitability for specific applications. Furthermore, limited research has been conducted to assess whether Nepalese timber aligns with Indian Standard (IS) specifications—established benchmarks for quality and reliability in structural materials. This lack of standardized data hinders informed decision-making, making it challenging to identify optimal species for structural (e.g., beams, columns) or non-structural (e.g., furniture, finishes) uses. Addressing this gap, the present study systematically evaluates key Nepalese timber species through rigorous testing of their mechanical and physical properties. By benchmarking results against IS criteria, the research aims to validate compliance with industry standards and recommend species best suited for diverse applications, thereby enhancing safety, efficiency, and sustainability in Nepal's construction and woodworking sectors.

4. Significance of Study

This study holds critical importance for Nepal as it generates scientifically validated data on the mechanical properties (e.g., strength, hardness), density, durability, and workability of indigenous timber species. By aligning evaluations with Indian Standard (IS) codes, the research not only facilitates the creation of a Nepal-specific timber grading system but also ensures regional interoperability, fostering cross-border trade and standardization. Such data-driven insights empower policymakers to revise national building codes, integrating locally sourced timber into construction guidelines—a step toward cost-efficient, sustainable infrastructure development. Furthermore, the study lays the groundwork for advancing engineered wood technologies like glued laminated timber (glulam) and cross-laminated timber (CLT), positioning Nepal to innovate within its timber sector and access emerging markets. A pivotal outcome of this work is the identification of underutilized Nepalese timber species that rival or surpass the performance of imported Indian hardwoods such as Teak, Sal, and Deodar. Reducing reliance on foreign timber not only bolsters Nepal's self-reliance but also ensures the availability of structurally robust materials for load-bearing elements (beams, columns, trusses) in buildings. Given Nepal's high seismic risk, the study's focus on quantifying timber's mechanical properties—such as modulus of elasticity and impact resistance—directly supports the design of earthquake-resilient structures. Additionally, the discovery of lightweight yet durable species could revolutionize low-cost housing initiatives, enabling safer, affordable homes for vulnerable communities. Beyond technical advancements, this research fosters skill development by advancing education in wood science and quality testing, cultivating a skilled workforce for Nepal's timber industry. It also stimulates economic growth by creating jobs in testing laboratories, certification bodies, and quality assurance sectors, ensuring adherence to national and international standards. By bridging data gaps and promoting evidence-based practices, the study strengthens Nepal's construction safety, enhances industry competitiveness, and drives sustainable resource utilization—key pillars for long-term environmental and economic resilience.

5. Limitation of Study

This study has several limitations that may affect the accuracy and generalizability of the findings. The properties of timber can vary significantly due to factors such as growing conditions, including altitude, soil type, and climate, as well as the age of the tree at the time of harvest. Natural defects in timber, such as knots, cracks, and grain irregularities, are unavoidable and may influence test results. Additionally, the position of the wood within the tree, whether from the heartwood or sapwood, can impact its mechanical and physical properties. Another major limitation is the availability of testing facilities in Nepal. Due to limited resources, a comprehensive evaluation of all relevant timber properties may not be possible, which could affect the depth of analysis. Furthermore, while comparisons with Indian timber species are made for benchmarking purposes, differences in genetic composition, growth conditions, and regional variations may lead to inconsistencies in direct comparisons. Despite these limitations, this study aims to provide valuable insights into the mechanical and physical properties of Nepalese timber, contributing to its better utilization in construction and woodworking.

6. Material, Standard Specimen, and Standard Test

This study focuses on the selection of timber species, preparation of standard test specimens, and Standard test methods as per Indian Standards (IS) to determine the mechanical and physical properties of wood available in Nepal.

6.1. Materials

The study includes following available structural and non-structural timber species in Nepal using the selection criteria of Commercial importance in Nepal's timber market, Structural vs. non-structural applications, and Availability and sustainability.

Table 1. Most Common species of timber used in Nepal

S.N.	Species(local Name)	Scientific Name	Common Use
1	Sal (Sakhuwa)	*Shorea robusta*	Beams, columns, furniture
2	Sisau (Sisau)	*Dalbergia sissoo*	Flooring, furniture, construction
3	Chir Pine (Rani Salla)	*Pinus roxburghii*	Light construction, plywood
4	Utis (Utis)	*Alnus nepalensis*	Temporary structures, packing

6.2. Standard Size of Specimen and Preparation:

The Indian Standard IS 1708:1986 defines the dimensions and preparation process of test samples. For the testing specimens; specimens should be air-dried to 12% moisture content (IS 1708, BIS, 1986), Defect-Free (Chudnoff, 1984) Samples, Avoid knots, cracks, or grain distortions, Cut using precision saws to ensure dimensional accuracy, and Follow IS 1708 for longitudinal, radial, and tangential testing directions. Sizes of Specimens are

Table 2. Standard size of test specimen based on IS standard

S.N.	Property Tested	Specimen Size (mm)	IS Standard Reference
1	Static Bending (MOR, MOE)	300 (L) × 20 (W) × 20 (T)	IS 1708 (Part 1)
2	Compression (Parallel)	60 (L) × 20 (W) × 20 (T)	IS 1708 (Part 2)

3	Compression (Perpendicular)	50 (L) × 50 (W) × 50 (T)	IS 1708 (Part 3)
4	Tensile Strength	300 (L) × 20 (W) × 5 (T)	IS 1708 (Part 7)

6.3. Standard Test

For the determination of the physical and mechanical properties of timber, following standard process is used;

6.3.1. The density is the ratio between the mass of the porous solid and its apparent volume
Density = Dry weight of specimen/Volume of specimen (IS 1708, Part 1)

6.3.2. Static Bending Test; Using universal testing machine (UTM) with center point loading on static bending test, Modulus of Rupture (MOR) & Modulus of Elasticity (MOE) are calculated using; $MOR = 3PL/2bd^2$, $MOE = PL^3/4bd^3\delta$
Where: P = Load at failure, L= Span length, b= Width, d= Depth, δ= Deflection.

6.3.3. Compressive and Tensile strength Test: UTM is used for compressive strength of timber along the grain and perpendicular to grain.
Compressive/Tensile strength= P/A, where, P= load at failure, and A=contact surface area (BIS, 1986).

7. Result & Discussion

In this study, the mechanical properties of four timber species from the Middle Terai region were investigated. Five standard-sized specimens for each species were prepared, assuming all samples were well-seasoned with moisture content below 12%. The specimens were tested using a Universal Testing Machine (UTM) to determine key mechanical and physical properties, including modulus of rupture, modulus of elasticity, compressive strength, tensile strength, and density. The experimental data were analyzed to calculate average values for each property, which are summarized in the accompanying table. The results highlight the relationship between density and mechanical performance across the selected timber species, providing insights into their structural suitability for engineering applications.

Table 3. Laboratory test result of most common species of timber available in Nepal

S.N	Name	Density (kg/mm3)	Modulus of Rupture (MOR) (N/mm2)	Modulus of Elasticity (MOE) (N/mm2)	Compressive Strength(N/mm2)		Tensile Strength (N/mm2)
					Parallel to grain	Perpendicular to grain	
1	Sal	816.7	129.9	13959.7	37.45	3.2	20
2	Sisau	758.3	115.9	11118.8	30.1	2.832	15.1
3	Chir Pine	450.0	84.9	8276.0	25.25	2.536	14.8
4	Utis	583.3	96.2	9889.9	27.25	2.464	13.7

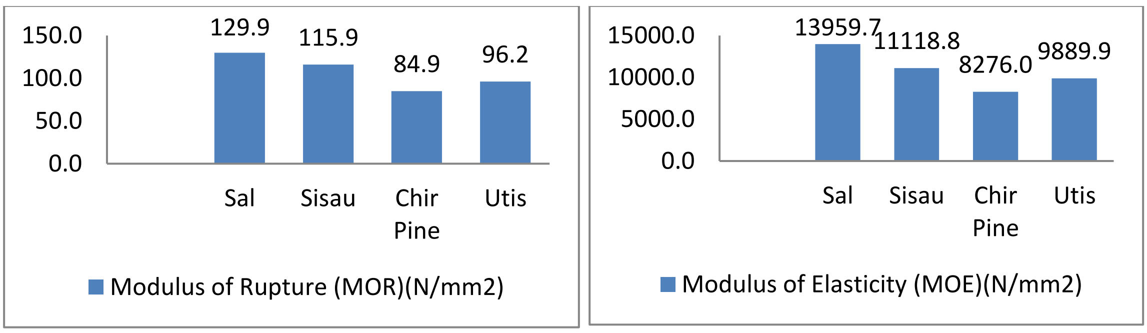

Figure 1. Graphical representation of Modulus of rupture (MOR) and Modulus of Elasticity (MOE)

The test results clearly indicate a ranking among the four timber species based on their mechanical properties. Sal stands out as the strongest structural material, thanks to its high density (816.7 kg/m³), exceptional bending strength (MOR 129.9 N/mm²), and stiffness (MOE 13,959.7 N/mm²). These properties make it ideal for critical load-bearing applications such as beams and columns in construction. Following closely behind, Sisau offers a well-balanced combination of strength and durability with a density of 758.3 kg/m³ and MOR of 115.9 N/mm². It performs particularly well in wear resistance, making it a preferred choice for flooring and furniture. Utis, despite being a lighter wood (583.3 kg/m³), performs surprisingly well, with a MOR of 96.2 N/mm², proving to be a strong contender for medium-duty construction (Chudnoff, 1984). This challenges previous assumptions about its strength-to-weight ratio, suggesting its potential as an alternative material in structural applications where weight is a limiting factor. On the other hand, Chir Pine, the lightest of the four species (450 kg/m³), has the lowest strength (MOR 84.9 N/mm²). While it may not be suitable for heavy-duty load-bearing applications, it remains a practical choice for non-structural elements, temporary structures, and lightweight construction (Pandey & Sharma, 2020). Additionally, the findings highlight a consistent positive correlation between density and mechanical strength across all species. However, the results also underscore the anisotropic nature of wood, showing a significant strength reduction (approximately 90%) when loaded perpendicular to the grain. This characteristic is particularly important in structural design and traditional joinery techniques used in Nepalese construction, emphasizing the need for careful orientation and reinforcement of timber elements in structural applications.

8. Conclusion

This study reveals significant differences in the mechanical and physical properties of Nepalese timber species, highlighting their suitability for various construction purposes. Sal and Sisau stand out as the most reliable choices for structural applications, thanks to their exceptional strength, durability, and resistance to wear. Their high bending and compressive strength make them ideal for critical load-bearing elements like beams, columns, and heavy-duty furniture. In contrast, Chir Pine and Utis, being lighter and less dense, are more appropriate for non-structural and temporary uses. While they may not be suitable for high-stress applications, their workability and moderate strength make them good choices for furniture, interior paneling, and temporary structures. The findings also highlight the urgent need for Nepal to adopt a standardized timber grading system. By implementing Indian Standard (IS)-based classification and testing methods, Nepal can improve timber quality control, enhance construction safety, and promote better industry practices. Standardized grading would not only ensure consistency in local construction but also help Nepal's timber industry expand into export markets, ultimately contributing to economic growth and sustainable forestry practices.

9. Recommendations

- Nepal has a diverse range of timber species, each with unique mechanical and physical properties. However, standardized data on these species is limited. Creating a comprehensive database that includes information on strength, durability, density, moisture content, and workability for each species will help in better selection and classification. This database can serve as a reference for engineers, architects, and policymakers to choose the most suitable timber for specific applications.
- Since Nepal does not yet have its own standardized timber grading system, aligning it with the Indian grading system can help ensure compatibility for regional trade and construction. Conducting correlation studies between Nepalese and Indian grading methods will help determine whether Nepalese timber meets the required IS standards.
- Proper grading of timber is essential to maintain quality and ensure its suitability for different structural and non-structural applications.
- Nepal currently lacks well-equipped laboratories capable of conducting comprehensive mechanical and physical tests on timber as per Indian Standard (IS) specifications. Setting up advanced testing facilities with modern equipment, such as universal testing machines (UTM), moisture meters, and Janka hardness testers, will improve accuracy in timber classification.

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