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Experimental analysis of the bending behaviour of woods with kerf-cutting technique

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ABSTRACT: Wood has been recognised for its ecological benefits and lightness throughout history. Its flexibility can be significantly enhanced when processed with proper techniques, inspiring various architectural products and furniture. This study aims to investigate the bending capacity of different natural wood samples made flexible using the kerf-cutting technique and the maximum load they can bear at their maximum bending capacity. Although there are studies on how kerf-cutting techniques can increase the flexibility of various wood products, the relationship between the bending capacity provided by the kerf technique and load-bearing capacity has not been examined, making this study original. The paper first examines the general physical properties and bending capacities of different wood types. Then, a two-stage experimental study is presented. The first step discusses the effects of different kerf-cutting techniques on wood flexibility. The bending and load-bearing capacities of three different types of wood are investigated in the second step. Results indicate that ash has the highest flexibility, while walnut demonstrates greater load-bearing strength than ash, making it suitable for designs requiring higher strength.

Keywords: Wood, kerf-cutting technique, bending, load-bearing capacity

Kerf-kesme tekniği uygulanmış ahşapların eğilme davranışının deneysel analizi

ÖZ: Ahşap, tarih boyunca ekolojik faydaları ve hafifliği ile tanınmıştır. Doğru tekniklerle işlendiğinde esnekliği önemli ölçüde artırılabilir, çeşitli mimari ürünlere ve mobilyalara ilham kaynağı olabilir. Bu çalışmanın amacı, kerf kesim tekniği ile esneklik kazandırılmış farklı doğal ahşap numunelerinin esneklik düzeylerini ve bu düzeylerde taşıyabildikleri azami yükü incelemektir. Kerf kesme tekniklerinin çeşitli ahşap ürünlerin esnekliğini nasıl artırabileceğine dair çalışmalar olmasına rağmen, bu tekniğin sağladığı eğilme kapasitesi ile yük taşıma kapasitesi arasındaki ilişki incelenmemiş olması bu çalışmayı özgün kılmaktadır. Makalede öncelikle farklı ağaç türlerinin genel fiziksel özellikleri ve eğilme kapasiteleri incelenmiştir. Sonrasında ise iki etaplı bir deneysel çalışma ortaya konmuştur. Bu deneysel çalışmanın ilk aşamasında, farklı kerf kesim tekniklerinin ahşabın esnekliğine etkisi, ikinci aşamada ise üç farklı ahşap tipinin esneklik ve taşıma kapasiteleri araştırılmıştır. Sonuçlara göre, dişbudağın en fazla esnekliğe sahip olduğu, cevizin ise yük taşıma kapasitesi olarak dişbudaktan daha yüksek mukavemet gösterdiği, dolayısıyla daha fazla mukavemet gerektiren tasarımlar için uygun olduğu belirlenmiştir.

Anahtar kelimeler: Ahşap, kerf kesim tekniği, eğilme, yük taşıma kapasitesi

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1 Introduction

Wood is one of the most common materials in the architecture and construction industry due to its versatility and availability. It can be utilised in various applications with minimal processing, such as cutting and drying. Furthermore, its unique fibrous composition allows the wood to bend naturally, creating curved and flexible elements. This natural ability to bend can be further enhanced through techniques such as kerf-cutting (Capone & Lanzara, 2019), steam bending (Whinney, 2019), lamination bending (Bianconi & Filippucci, 2020), cold bending (Hao & Chen, 2024), chemical bending (Mao et al., 2024), soaking in water (Shi et al., 2024), heat bending (Kwon et al., 2024), mechanical bending (Florkowsk et al., 2024), microwave heating (Zhang et al., 2020) and vacuum press bending (Lee et. al., 2021).

The production of flexible and curved surfaces has become a prominent area of research in architecture, with many studies focusing on materials and fabrication techniques to achieve curvilinear geometries and freeform surfaces. Among these techniques, kerf-cutting is a subtractive manufacturing method that transforms rigid, planar materials into curved surfaces. It is widely used across various industries, from crafting furniture and decorative structures to producing musical instruments. In architecture and interior design, kerfing is employed not only to create flexible surfaces (Shadid et al., 2022) but also to develop technical components such as façade panels (Teuffel et al., 2009) and acoustic panels (Greenberg & Körner, 2014). For example, complex kerfed surfaces are incorporated into façade designs to mitigate the adverse effects of strong winds (Teuffel et al., 2009), while they are used for acoustic optimisation in interior spaces (Greenberg & Körner, 2014).

Kerf bending involves machining a panel into a specific cutting pattern to design flexible and free-form systems (Zarrinmehr, 2017). Depending on the chosen pattern, a rigid panel can acquire bending capacity in one direction while retaining its strength in the other, thanks to the gaps introduced by the cuts (Capone & Lanzara, 2019). Three primary types of kerf-cutting are single-sided, double-sided, and cuts that penetrate entirely through the panel. Each type produces varying levels of bending capacity, offering a range of possibilities for design and structural performance (See Figure 1).

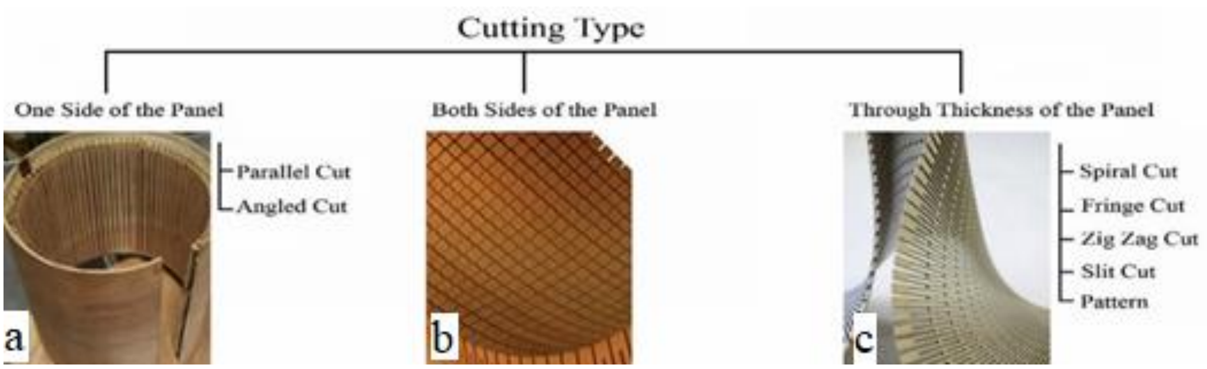

Figure 1. Kerf technical methods (Bianconi & Filippucci, 2020)

The first cutting type is the traditional approach wherein the kerf cut is made on just one side of the panel and examined in two groups: Parallel cutting is when notches are cut parallel to the edges of the panel (see Figure 2a as an example) and Angled Cutting in which notches are made at an angle to the edges of the panel.

The second type involves cutting both sides of the panel following a specific set of rules (see Figure 2b as an example). This process allows for the creation of double-curvature surfaces. The parametric design of the cuts ensures precision in achieving the desired curves (Capone & Lanzara, 2019).

The third type is an advanced technique based on "cutting where needed." In this method, cuts are made crosswise on both sides of the panel using an improved kerf technique. This allows the wood panel to be bent into 3D shapes, creating a double-curvature surface. The blanks must be processed meticulously for the curves to be smooth (Bianconi & Filippucci, 2020) (See Figure 2c as an example).

Many studies in the literature deal with the relationship between kerf-cutting techniques and the form flexibility provided by the kerf technique, as summarised in Kırkpınar et al. (2024). However, no study investigates the relationship between the type of wood, the kerf-cutting technique, and the load-bearing capability of the sample. This study aims to fill this gap in the literature. Experiments were conducted to assess the bending capacity of various wood types and the loads they could endure to achieve this aim. Based on the test results, a comprehensive analysis of the flexural capacity was performed, and valuable information was provided to the literature. The method involved testing samples of materials in a workshop setting. Simple timber beams were subjected to a single-centred load to determine their deformation. The bending radius and the load-bearing capacity at rupture were precisely measured for different kerf patterns and wood types. Finally, the data from these experiments were analysed and optimised through comparative analysis to enhance the performance of flexible prototypes.

1.1 Main Concepts

Wood is widely used in various fields, ranging from solid wood to engineered wood products such as plywood, fibreboard, particleboard, laminated timber, and carpenter board (Kretschmann, 2010). Additionally, it serves as a coating material and functions as a structural element or complement in architectural constructions. The effective use of wood, particularly in bending applications, depends on selecting appropriate wood species and varieties based on their mechanical properties (Doğu, 2016). In this context, wood species are classified according to specific gravity, compressive strength, bending strength, and modulus of elasticity. Since physical characteristics influence the mechanical properties of wood, this classification is presented in two tables for hardwoods and softwoods (See Tables 1 and 2).

Hardwoods, classified as angiosperms with anatomically porous structures, are distinguished by their broad leaves. They are widely used in construction, architecture, and interior woodworking. Common broad-leaved tree species with similar anatomical characteristics include maple, chestnut, alder, birch, hornbeam, beech, ash, walnut, plane, poplar, oak, willow, elm, olive, and ebony (Farmer, 1972). Most tropical trees, particularly teak and iroko, are also classified as hardwoods (Kukachka, 1970) (see Table 1).

Softwoods, botanically classified as gymnosperms and conifers, are characterised by their non-porous anatomical structure. They typically have needle- or scale-like leaves that remain evergreen. Softwoods are widely used in construction for various applications, including scaffolding, cabinetry, framing, veneering, flooring, and panelling. Notable coniferous species include fir, cedar, cypress, juniper, spruce, pine, larch, linden, mahogany, and ayous (Alden, 1997) (see Table 2).

Table 1. Properties of Hardwoods (reproduced from Timberpolis, 2003)

Type	Origin	Body/ Diameter	Tree Size / Height	Specific Weight	Bending Strength	Modulus of Elasticity	Compressive Strength	Use Area
Maple	North America	0,6 - 1,0 m	25 - 30 m	0.44	73,8 MPa	10,00 GPa	41,0 MPa	Solid and veneered furniture, musical instruments, kitchen appliances, shoe molds, carving, marquetry, finishing works, parquet, toys, plywood, tool handles,
Cherry	North America	1,0 - 1,5 m	15 - 30 m	0.59	84,8 MPa	10,30 GPa	49,0 MPa	window frames, exterior cladding, parquet, pergola, furniture
Mulberry	China	0,3 – 0,5 m	10 - 15 m	0.69	80,6 MPa	9,32 GPa	48,2 MPa	solid and veneered furniture, turning, plywood tool
Chestnut	Europe, Asia	1,5 - 2,0 m	30 - 37 m	0.44	71,4 MPa	8,61 GPa	43,8 MPa	window frames, exterior cladding, parquet, pergola, furniture
Alder	Europe, Asia, North America	0,6 - 1,0 m	15 - 24 m	0.58	71,7 MPa	8,48 GPa	47,4 MPa	Solid wood, plywood, veneer, modelling, clogs, toys, cigarette boxes, carved and turned works
Birch	North America	0,6 - 1,0 m	20 - 30 m	0.55	114,5 MPa	13,86 GPa	56,3 MPa	furniture, carved works, musical instruments, sled and ski, plywood production, barrel, reel, shuttle, shoe mold
Hornbeam	Europe, Asia	0,6 - 1,0 m	15 - 20 m	0.598	110,4 MPa	12,10 GPa	50,5 MPa	small-sized products, kitchen appliances, shoe mold, measurement tools
Beech	United Nations, North America, Europe	1 - 1,5 m	30 - 40 m	0.55	110,1 MPa	14,31 GPa	57,0 MPa	furniture, plywood, cars, parquet, shoe molds, packing crates, toys, boat and oven shovels, tool handles,
Ash	North America	0,6 - 1,5 m	20 - 30 m	0.54	103,5 MPa	12,00 GPa	51,1 MPa	solid and veneered furniture, turning, plywood tool making, sports tools
Walnut	United Nations	1 m	30 m	0.36	55,9 MPa	8,14 GPa	35,2 MPa	furniture, solid and veneered, carved and turned works, musical instruments
Plane	Europe	1 - 1,5 m	20 - 35 m	0.52	74,7 MPa	8,90 GPa	40,8 MPa	kitchenware making, packaging industry turned and inlaid works
Popular	North America	1 - 1,5 m	25 - 30 m	0.31	46,9 MPa	7,59 GPa	27,7 MPa	match production veneer and plywood
Oak	Turkey, Europe	1,2 - 2,0 m	25 - 37 m	0.62	114,3 MPa	10,81 GPa	56,4 MPa	doors, windows, stairs, flooring, parquet, barrel, wagon, car, ship, boat, bridge, and pier, furniture
Willow	Europe, Asia	1 - 1,2 m	20 - 30 m	0.34	56,2 MPa	7,76 GPa	26,9 MPa	cosmetics, medical
Elm	Europe	1 - 1,5 m	25 - 35 m	0.43	68,7 MPa	7,52 GPa	32,0 MPa	furniture, solid and veneer, turning, parquet, boating, bridge, and pier
Olive	Mediterranean, Europe, Asia and Africa	0,3	8 - 15 m	0.94	64.39 MPa	4,44 GPa	53.17 MPa	coating in furniture production, brush handle, trinket making
Teak	Asia	1 - 1,5 m	30 - 40 m	0.55	96,1 MPa	10,83 GPa	53,6 MPa	yachts, garden furniture
Iroko	Africa	1 - 1,5 m	30 - 40 m	0.55	87,6 MPa	9,38 GPa	54,0 MPa	indoor and outdoor furniture, flooring, exterior, stairs
Ebony	Africa	0,6 m	15 - 18 m	0.90	167,6 MPa	17,20 GPa	89,5 MPa	valuable and expensive furniture, turned, inlaid, and carved works, musical instruments, furniture, door handles, and knife handles

Table 2. Properties of Softwoods (reproduced from Timberpolis, 2003)

Type	Origin	Body/ Diameter	Tree Size / Height	Specific Weight	Bending Strength	Modulus of Elasticity	Compressive Strength	Use Area
Fir	Germany, France, Asia	1 - 1,5 m	30-46 m	0.353	66,1 MPa	8,28 GPa	41,0 MPa	paper factories, mold, medical, wool dyeing with shells
Cedar	Israel, Lebanon, Turkey	1,5 - 2,1 m	30-40 m	0.41	82,0 MPa	10,10 GPa	42,0 MPa	flooring, panelling, wooden camellia, and pergola
Cypress	North America	1,2 - 1,8 m	30 - 37 m	0.42	76,6 MPa	9,79 GPa	43,5 MPa	Interior and exterior parts of buildings, ships, bridges, and piers, furniture, turned works,
Juniper	North America	1 - 1,2 m	30 - 35 m	0.44	60,7 MPa	6,07 GPa	41,5 MPa	pencil, lumber
Spruce	Europe	1 - 1,5 m	35 - 55 m	0.38	63,0 MPa	9,70 GPa	35,5 MPa	lumber, furniture, paper factories
Pine	United Nations	0,6 - 1 m	18 - 30 m	0.54	112,4 MPa	13,70 GPa	56,1 MPa	medicinal, perfume essence, timber, pulp
Larch	Europe, Africa, Asia	0,6 - 1 m	20 - 35 m	0.41	64,4 MPa	10,81 GPa	38,4 MPa	construction work, carpentry, various household items, packing cases, bridge, and ship
Linden	Europe	1,5 - 2 m	20 - 40 m	0.42	85,4 MPa	11,71 GPa	44,8 MPa	match production, shoe molds, duralite production, carving arts
Mahogany	Africa	0,7 - 1,2 m	30 - 50 m	0.65	103,0 MPa	9,40 GPa	53,2 MPa	in shipping, musical instruments, frames, parquet, stair making, lathe, carved and inlaid works, solid and veneered furniture
Ayous	Africa	0,7-1.5 m	30 - 50 m	0.38	110,0 MPa	.	30,87 MPa	sauna, sauna accessories, and furniture

A detailed analysis of the hardwood and softwood properties reveals that species such as birch (13.86 GPa), hornbeam (12.10 GPa), beech (14.31 GPa), ash (12.00 GPa), oak (10.81 GPa), teak (10.83 GPa), and ebony (17.20 GPa) among hardwoods, as well as cedar (10.10 GPa), pine (13.70 GPa), larch (10.81 GPa), and linden (11.71 GPa) among softwoods, exhibit relatively high modulus of elasticity. Furthermore, findings by As and Büyüksarı (2010) indicate that certain species, such as alder, beech, birch, fir, hornbeam, spruce, and teak, demonstrate high minimum bending radii both with and without support, making them particularly suitable for bending applications. These insights guided the selection and testing of species in our study, focusing on those with promising mechanical properties for kerf-cutting and bending performance.

1.2 Preliminary experiments

To evaluate the potential of different wood types and kerf patterns for bending applications, several wood species (mulberry, linden, cherry, walnut, chestnut, mahogany, and oak) were cut using two distinct patterns: slit kerf cutting and fringe kerf cutting. The experimental results (Tables 3 and 4) indicate that cherry, walnut, and chestnut exhibited higher flexibility, whereas mahogany proved challenging to bend. Oak samples experienced breaks and cracks during cutting and could not be tested as a result (Kırkpınar, 2024).

Table 3. Classification of Wood Species' Flexibility

Flexibility Based on the Kerf Technique Depending on Wood Species		
Wood Type	Mulberry 	Linden 
Cutting Type	Slit kerf 	Slit kerf 
Flexibility	Result 	Result 

Table 4. Classification of Wood Species Flexibility

Flexibility Based on the Kerf Technique Depending on Wood Species					
Wood Type	Cherry 	Walnut 	Chestnut 	Mahagony 	Oak 
Cutting Type	Fringe kerf 	Fringe kerf 	Fringe kerf 	Fringe kerf 	Fringe kerf 
Flexibility	Flexible 	Flexible 	Flexible 	Flexible 	Less flexible 

2 Materials and Methods

This study investigated the flexibility achieved through kerf-cutting across various tree species, focusing on the extent of flexibility attainable with this technique as the primary research objective. A detailed evaluation assessed the flexibility of different tree species subjected to kerf cutting. The initial analyses were preliminary and aimed at preparing the experimental setup.

2.1 Materials

After analysing the literature and the preliminary experiments, five different hardwood types (walnut, ash, iroko, cherry, and chestnut) with different bending strengths and modulus of elasticity were chosen among species broadly available for developing industrial products. Due to the unavailability of cherry and chestnut samples with equivalent quality and dryness levels, they were excluded from the testing phase despite promising results in the preliminary experiments. The details of the three selected species (walnut, ash, and iroko) are shown in Figure 2. Walnut was selected for its flexibility as demonstrated in the preliminary tests, while ash wood was chosen based on literature findings indicating its common use in prototyping furniture made with kerf techniques. Iroko was selected for its aesthetic properties and durability. All selected woods were commercially sourced from furniture production suppliers and dried to a moisture content below 17%.

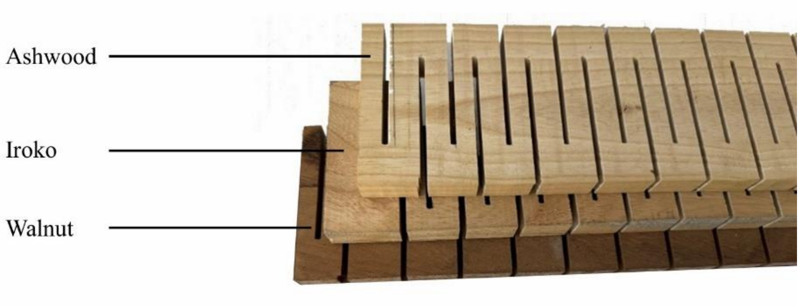

Figure 2. Wood samples used in the test

2.2 Samples' Preparation

The selected materials were prepared and cut to fit experimental conditions and testing devices. The test samples were prepared with a length of 500 mm in accordance with the standard seat width in furniture design. They had a width of 80 mm suitable for the saw blade used in cutting and testing, and a thickness of 20 mm consistent with typical material thickness in furniture production (see Figure 3).

Fringe kerf, which is one of the most commonly used cutting methods, was selected for testing due to its relatively simple cutting process compared to other kerf types, referring to the table on kerf-cutting techniques and corresponding examples examined in Kırkpınar et al. (2024). Preliminary experiments determined the optimal kerf spacing: 4 cm intervals were insufficient for elasticity distribution, while intervals less than 2 cm compromised cutting quality and caused breaks due to blade thickness. Consequently, the kerf interval was set to 2 cm. Samples made with 2 cm intervals were called Wa2 (walnut wood), As2 (ash wood), and Ir2 (iroko wood). Three beams were cut for each type of wood.

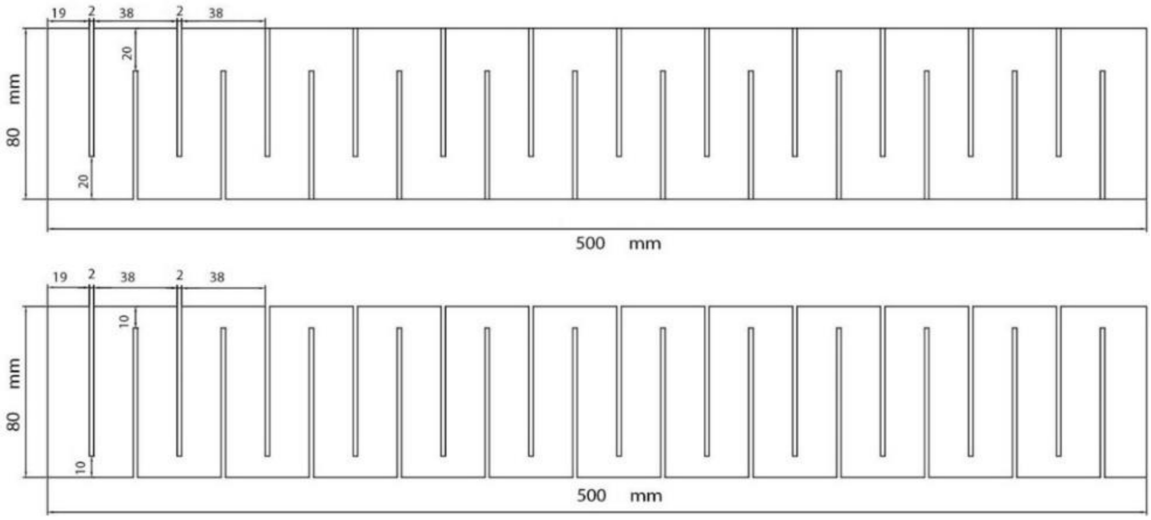

Figure 3. Dimension of the Samples

1 cm kerf depth samples of ash wood were also prepared, owing to the wood's higher bending strength, to understand the impact of the cutting intervals (Timberpolis, 2003). Samples with a 1 cm kerf depth are called As1 (Table 5).

Table 5. Classification of Samples

Sample name	Wood type	Kerf depth	Number of samples
Walnut2 (Wa2)	walnut	2 cm	3
Ash 1 (As1)	ash	1 cm	3
Ash 2 (As2)	ash	2 cm	3
Iroko 2 (Ir2)	iroko	2 cm	3

2.3 Experimental Method

This section presents the methodology used to determine the bending properties of the selected wood species. The methodology aims to identify the maximum deformation at failure and the minimum bending radius of the selected samples. Determining the load at failure and the corresponding maximum deformation is crucial, as it indicates the maximum load the samples can bear. Additionally, the minimum bending radius provides insight into the material's flexibility.

A simple experimental testing method was used to determine the bending properties of wooden beams. A wood beam was placed on two supports spaced 460 mm apart and loosely fixed with nails to allow rotation without sliding, as seen in Figure 4.

The beam was loaded first with 7900 grams and then by increments of 100 grams until it ruptured. The maximum bending radius was determined at rupture. The experiment was repeated on three identical samples for each wood type.

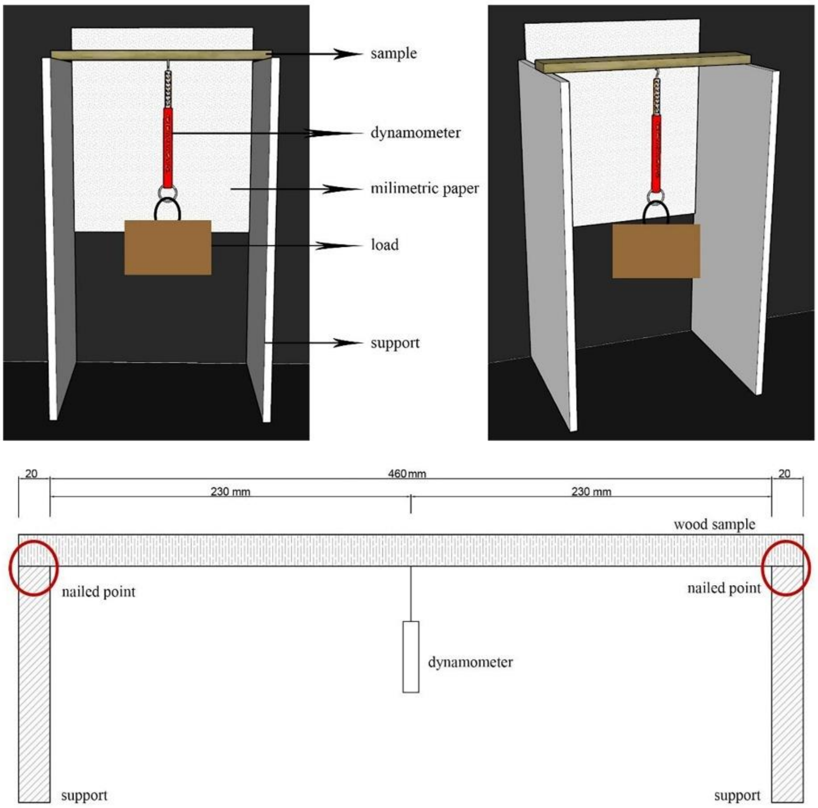

Figure 4. Testing Setup

Simple devices were used to collect relevant data to determine the bending radius and maximum load at rupture.

- A dynamometer was used to determine the load applied to the beam, as all loads were suspended. The maximum load supported at the centre point of the sample when the fracture occurred was recorded by reading it from the dynamometer.
- A millimetric paper was placed behind the setup to measure the deformation of the beam at each step of the experiment, and a high-definition video camera placed perpendicularly in front of the setup was used to record the results.
- Using the camera allowed the exact bending radius at the first visible rupture to be determined. The visible rupture was determined by hearing a cracking sound from the beam.

3 Findings and Discussion

This study sequentially tested nine samples from three different wood types under the same experimental setup in a workshop environment. Three samples of each material were recorded for deformation under a constant load (7900 grams) and deformation at failure. The maximum bending was calculated from the deformation at failure. The results are summarised in Tables 6 and 7 and Figure 5. The deformation for ash wood (As2, 75 mm) and walnut wood (Wa2, 66 mm) under the same load shows that ash wood allows for much more deformation than walnut, which has a smaller resistance to bending. Moreover, no results could be obtained for iroko wood (Ir2) as 7900 grams was above the material's limit.

The failure load and deformation of samples are consistent with the behaviour under a 7900-gram load. Ir2 failed with the smallest load (6200 grams and 71 mm deformation), while As2 failed with a 15400-gram load and 112 mm deformation. Wa2 failed under an 8050-gram load (higher than Ir2) but presented only 70 mm of deformation (less than Ir2).

These results show the impact of the kerf cutting on the deformation and resistance of samples. While ash wood has the highest modulus of elasticity among the three chosen wood types (ref above) and should present a higher rigidity for the same load, As2 samples present more deformation than Wa2 under the same load. Similarly, iroko has higher bending strength and modulus of elasticity than walnut, but Ir2 samples were broken under a smaller load and larger deformation than Wa2 samples (Table 7). This data shows that walnuts seem to have better resistance to deformation, while kerf cuts are better than other wood types despite a lower modulus of elasticity and bending strength. The failure patterns of As2 and Wa2 corroborate this behaviour. Figure 6 shows the failure patterns of As2 and Wa2. As expected, the As2 samples break in the middle at the load's application point. In contrast, Wa2 samples break at the support interface, showing that the failure is due to the weakened connection point obtained by nailing the samples to the support.

In contrast, ash wood allows large deformation before breaking (112 mm and 85 mm, respectively, for As2 and As1) while supporting higher loads than other samples. These results are consistent with ash wood's higher bending strength and modulus of elasticity compared to walnut and iroko wood (Timberpolis, 2003).

The comparison between As1 and As2 samples shows the impact of the cutting intervals on the samples' bending strength. Despite As1 samples having higher flexibility due to the smaller interval between cuts according to the literature, their bending strength and deformation at failure are much lower than those of the As2 samples. However, their breaking patterns are similar to a failure of the timber in the middle of the sample, where the width of the wood is the smallest (see Figure 6). This fact is probably due to the lower amount of material left to support the load, and the only 1 cm width of timber between the cut and the side of the beam, leading to an early failure despite lower deformation.

Table 6. Deformation of samples under a 7900-gram load

	Deformation under 7900-gram load		
sample	**Average deformation (mm)**	**Minimum deformation (mm)**	**Maximum deformation (mm)**
Ir2	Failed	Failed	Failed
Wa2	66	63	68
As2	75	72	79

Table 7. Deformation, maximum load, and bending radius at failure

	Deformation and load at failure		Maximum bending radius (mm)
sample	**Average deformation (mm)**	**Average load (g)**	**(average radius at failure)**
Ir2	71	6200	408
Wa2	70	8050	413
As2	112	15400	292
As1	85	8700	354

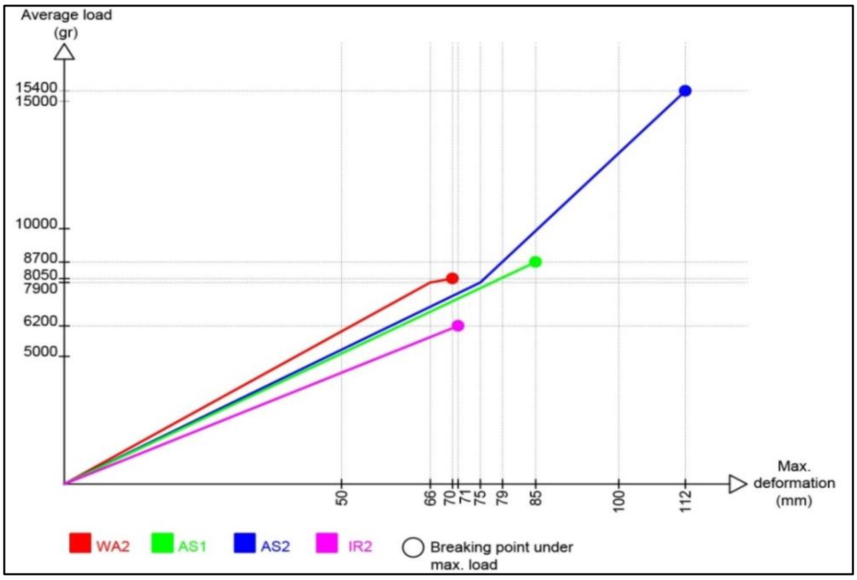

Figure 5. The relationship between average loads and maximum deformation for each sample

It should be noted that the scale of the samples tested influences their load-deformation behaviour. Larger components may experience greater internal stress variations, and the effects of kerf spacing and depth may become nonlinear at increased dimensions. While this study uses a standardised sample size suitable for furniture components, future research should address scalability and its effects on kerf-induced flexibility and strength.

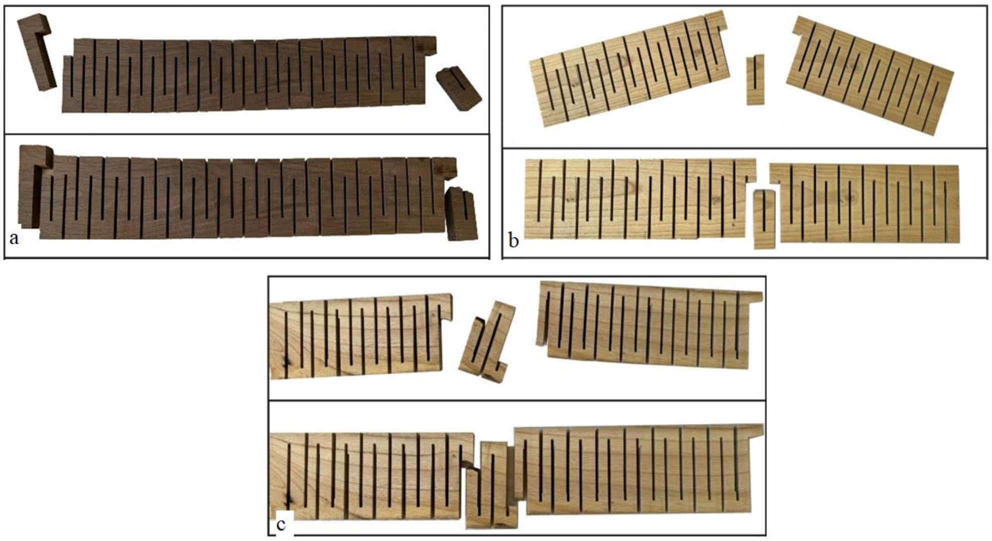

Figure 6. Failure pattern of samples Wa2 (a), As2 (b) and AS1 (c)

4 Conclusion

The literature review reveals limited research on wood processing using the kerf-cutting technique. While this method has been explored in various applications, comprehensive studies on its effects on elasticity and structural performance are scarce. To address this gap, an experimental setup was designed to evaluate the bending capacity of wooden pieces processed using the kerf technique.

- The results of the experiments indicate that iroko is not well-suited for kerf cutting as the process significantly reduces its strength and allows only minimal deformation. Among the three wood species tested for wooden furniture prototypes, ash exhibited the highest deformation and bending strength, making it the most flexible option. Walnut, on the other hand, demonstrated lower deformation under load compared to ash. Due to its reduced flexibility, walnut is preferable for designs that require greater stiffness and higher structural strength.
- The findings also emphasise the importance of testing different kerf patterns to determine the most suitable design for specific applications. The kerf-cutting technique considerably reduces the material's strength under load, making it essential to select an appropriate pattern to achieve the desired balance between flexibility and structural integrity.
- Based on the deformation and stress results, walnut appears suitable for semi-structural elements where strength is critical. In contrast, with higher deformation before failure, ash could be advantageous for kinetic elements such as acoustic panels, flexible screens, or ergonomic furniture components requiring adaptable curvature.
- The kerf-cutting technique remains underrepresented in existing research despite its potential. Further studies are needed to identify the most suitable wood species for kerf applications and assess the impact of kerf patterns on both strength and bending performance. Additionally, although visual observations suggest that the technique may be effective for kinetic panel applications, the long-term impact of repeated loading and unloading cycles has not been examined. A comparative study of different timber species under cyclic loading conditions would provide valuable insights for optimising the use of kerf-cut wood in structural and design applications.

Authors' Contribution

Gökçe Kırkpınar: Conceptualisation (development of research idea and aims), conducting research, conducting analyses, resources, visualization, drafting an article, writing an article **Yenal Akgün:** Conceptualisation (development of research idea and aims), project management, determination of methodology, conducting research, conducting analyses, data curation, resources, visualization, writing article, reviewing and editing. **Matthieu Joseph Pedergnana**: Conceptualisation (development of research idea and objectives), conducting research, Data curation, review, and editing.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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