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Review of Comparison of Finger joint Efficiencies of Wood Species

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Abstract* – This paper presents the finger joint efficiencies of different wood species. The technique of finger joining is used to strengthen the wood also make full use of wood. This paper gives comparison study of finger joint efficiencies of wood species by considering the finger joints of different wood species such as Burma teak wood, Poplar wood, Oak wood like turkey oaks, Hungarian oak and Holm oak, African woods like Moabi, Obeche, Makore. Burma teak wood and oak woods are tested under three point bending and African woods, poplar wood are tested under four point bending. Different finger configurations and adhesives are used to test these wood species. It is found that the joint configuration and the type of adhesive used have the effect on joint efficiency. From this study it is recommended to use the joint configuration of finger length 18 mm and use the resorcinol formaldehyde adhesive for higher joint efficiency.

***Keywords* - Burma teak wood, oak wood, African wood, poplar wood, joint efficiency.**

I. Introduction

Wood is oldest, widely and commonly used material in structural and building applications in the world because of its low cost, high specific strength, high stiffness and high toughness. Wood is fibre-composite material with complex overall structure. Also it is a renewable resource, and its production requires low energy input [1].

Teakwood structures have played an important role in construction. It is most valuable and highly valued for use in outdoor equipment, ship building, furniture, rural housing and general carpentry. It possesses high dimensional stability. Teakwood exhibits good machining properties and is moderately hard and heavy [2].

In a study to examine the bending strength (MOE and MOR) of finger jointed specimens of turkey oak, Hungarian oak and Holm oak with three different finger lengths (4mm, 10mm 15mm), two finger orientations (horizontal and vertical) and three glues of polyvinyl-acetate were investigated. It is concluded that MOR values of the finger jointed Hungarian oak fluctuated from 52.9 up to 112.1 N/mm^2, which corresponds percentage level of 40.8 up to 86.6% mean values of the solid woods. The higher MOR values of the finger jointed turkey and Holm oak specimen corresponds in a percentage level of 77.3 and 75.8% compared with mean values of the solid woods. MOR values affected partly by finger orientation but MOE of all joints was not affected by finger jointing [3].

In a study Flexural properties and joint efficiencies of Finger joints from three tropical African hardwoods such as Obeche, Makore and Moabi were prepared using three finger profiles,three end pressures and resorcinol formaldehyde adhesive, to assess the effect of the study variables on the performance of the joints. Finger profile geometry was found to have a statistically significant influence on Modulus of Elasticity and Modulus of Rupture of Finger joints from the three tropical African hardwoods. Finger joints from the low density Obeche exhibits highest joint efficiency, high flexural performance and wood failure followed by that from the medium density Makore. Finger joints from the high density Moabi exhibited the lowest joint efficiency and wood failure [4].

In a investigation the series of tests were conducted on finger jointed poplar wood to find the mechanical performances of end finger-joints having different lengths 7.5 mm, 15 mm and 20 mm, in order to determine the influence of parameters such as wood density, joint geometry and amount and time of pressure application. The combinations of parameters which resulted in best joint performances were identified [5].

In a recent study effect of finger joint on flexural strength of teak wood considers the finger joint as defined defect and effect on the flexural strength is determined. Both edge wise and flat wise tests were carried out for teak wood without finger joint and with finger joint under three point bending. It is observed that teak wood without joint is stronger than finger jointed teak wood beam. It is concluded that strength loss can be improved by selecting suitable adhesive and selecting suitable finger joint geometry [6].

II. MATERIALS AND SPECIMENS

A.Oak wood

Experiments were carried out on oak wood species like turkey oak, Hungarian oak and Holm oak with final dimensions 20X20X360 mm. Three finger joints were performed with joint profiles i. 4 mm finger length, 0.4 mm tip, 1.6 mm pitch and 12^o angle, ii. 10 mm finger length, 0.16 mm tip, 3.8 mm pitch and 11^o angle, and iii. 15 mm finger length, 0.11 mm tip, 3.8 mm pitch and 7.5^o angle. Three types of polyvinyl-acetate based adhesives used to make joint. Both edge wise and flat wise specimens are examined [3].

B. African hard wood

Three different African hardwood samples Obeche, Makore and Moabi of different finger joint configuration are selected to investigate the effect of finger profile geometry and end pressure on the performance of finger joints. Three finger joints were performed with joint profiles i. 10 mm finger length, 0.6 mm tip, 3.7 mm pitch and slope 1in 6, ii.18 mm finger length, 0.6 mm tip, 3.7 mm pitch and slope 1 in 12 and iii. 20 mm finger length, 0.6 mm tip, 6 mm pitch and slope 3 in 20. The final dimensions of specimens are 21X70X2000 mm for Makore and Moabi and 21X58X2000 mm for Obeche. Resorcinol-formaldehyde adhesive is used to join the fingers [4].

C. Poplar wood

The poplar laminated wood used for structural purposes in European countries. Two 4 m long logs from each from a timber selected from total 16 trees were used. Then these logs were later turned into sawn boards. Each single board was checked and those boards having important physical defects such as big knots, excessive slope of grain, bark inclusions, pitch presence and exaggerated shrinkage deformations were excluded. Then the material for the preparation of finger-jointed specimens and solid specimens were selected from each board, for the direct verification of the joint efficiency for each single portion of material. Three finger joints were performed with joint profiles i. 7.5 mm finger length, 0.2 mm tip, 2.5 mm pitch, ii. 15 mm finger length, 0.6 mm tip, 3.8 mm pitch, iii. 20 mm finger length, 1.0 mm tip, 6.2 mm pitch, were used with final dimension of specimens are 50 mm in width and 23 mm in thickness. Resorcinol base adhesive is used to produce joints [5].

D.Burma Teak wood

Commercially available finger jointed Burma teak wood material of rectangular shaped was selected for testing. Two types of specimens were considered i. Teakwood without finger joint and ii.Teak wood with finger joint of geometrical dimension 22.5 X 12.2 X 414 mm. Both edge wise and flat wise specimens are tested. Desirable material properties were obtained by simple bending tests as per American Society for Testing and Materials Standard. The geometry used for finger joint consist of finger length=14.8 mm, pitch=4.17 mm, tip width=1.12 mm and gap=2 mm [6].

III.METHODOLOGY

Oak wood specimens are tested under 3-point bending using Shimatzu testing machine. Both horizontal and vertical finger orientation oak wood specimens were tested. Modulus of rupture and modulus of elasticity were measured according to ISO 10983:1999 and DIN 52186:1978 standards [3].

African hardwood specimens of both finger jointed and solid woods were tested under four point bending using INSTRON TCM 10000 test machine with loading capacity of ± 100 KN. For Makore and Moabi wood specimens 20 mm/min cross-head speed is set and 5 mm/min for obeche wood specimens [4].

A 250 KN Instron universal testing machine was used to carry out the tests for poplar wood. Setup consists of testing the specimen under four point bending. Loading application is according to standard prEN 386. The poplar wood flat wise specimens were tested, with the finger joint profile visible on the width. The displacement rate of the loading head was 2 mm/min, and test duration is up to the ultimate load of 300 ± 120 [5].The teakwood specimens of without Finger joint, and with Finger joint were tested under 3-point bending. Edgewise and flat wise bending was carried out for three-three specimens of each type and was tested by loading at the centre with the span of 368 mm. The beams were tested using universal testing machine under the three point arrangement. The universal testing machine consists of a setup for testing the specimen under three point bending along with the digital data acquisition system. Load was applied at slow rate using hydraulic cylinder the values of load applied, deflection are digitally recorded directly onto the data acquisition system. Further the load data was connected with the computer and a plot of load vs. deflection was directly generated by computer which was taken as the output. The applied load increased up to the breaking point or the failure of the material [6].

IV.RESULTS AND DISCUSSION

Different wood species and their joint configuration, type of adhesive used, and their joint efficiency shown in Table I all the oak woods species considers the finger length of 15 mm and adhesive used is Poly vinyl acetate, African woods considers 18 mm finger length and adhesive used is Resorcinol-formaldehyde, poplar wood considers finger length of 15 mm and adhesive used is Resorcinol base adhesive (Aerodux 185 resin + HRP 150 hardener) and Burma teak wood considers finger length of 14.8 mm and adhesive used is unknown.

Table I
Wood Species, Joint Configuration, Adhesive used and Finger Joint Efficiency

Wood species	Joint configuration	Adhesive	Finger joint efficiency (%)	Reference
Turkey oak	15 mm finger length, 0.11 mm tip, 3.8 mm pitch and 7.5° angle	Polyvinyl acetate	77.24	[3]
Hungarian oak	15 mm finger length, 0.11 mm tip, 3.8 mm pitch and 7.5° angle	Polyvinyl acetate	85.40	
Holm oak	15 mm finger length, 0.11 mm tip, 3.8 mm pitch and 7.5° angle	Polyvinyl acetate	74.89	
Makore	18 mm finger length, 0.6 mm tip, 3.7 mm pitch and slope 1 in 12	Resorcinol-formaldehyde	94.06	[4]
Mosbi	18 mm finger length, 0.6 mm tip, 3.7 mm pitch and slope 1 in 12	Resorcinol-formaldehyde	72.60	
Obeche	18 mm finger length, 0.6 mm tip, 3.7 mm pitch and slope 1 in 12	Resorcinol-formaldehyde	92.65	
Poplar	15 mm finger length, 0.6 mm tip, 3.8 mm pitch	Resorcinol base adhesive (Aerodux 185 resin + HRP 150 hardener)	74.00	[5]
Burma teak	Finger length=14.8 mm, pitch=4.17 mm, tip width=1.12 mm and gap=2 mm	Polyvinyl acetate	65.71	[6]

Comparison of finger joint efficiencies of different wood species with different joint configurations is shown in Fig. 1.

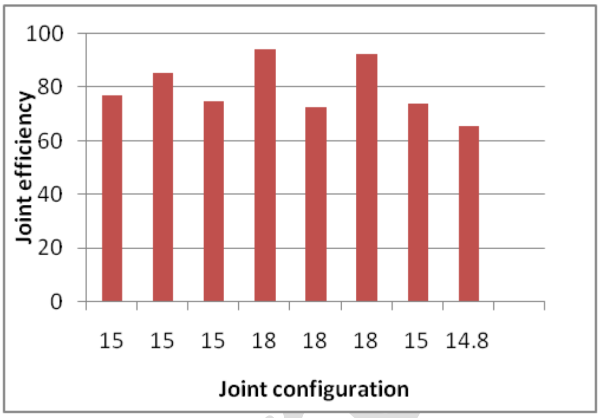

Fig. 1 Comparison of finger joint efficiencies of different wood species for different joint configurations

Comparison of finger joint efficiencies of different wood species with types of wood species is shown in Fig. 2.

Fig. 2 Comparison of finger joint efficiencies of different wood species with types of wood species

V.CONCLUSOIN

From the above study we observed African woods Makore has 94.06 % joint efficiency and obeche has 92.65 % joint efficiency it can be concluded that joint configuration and adhesive used to join the fingers has the effect on the joint efficiency. Therefore it is recommended that to use the joint configuration of finger length of 18 mm, 0.6 mm tip, 3.7 mm pitch and slope 1 in 12 as used for the wood species like Makore and obeche. Resorcinol-formaldehyde adhesive gives the highest efficiency than the other adhesives therefore it is recommended to use the Resorcinol-formaldehyde adhesive to join the fingers. Also it is concluded that selection of combination of wood and adhesive that is suitable adhesive for specific wood species needs to be selected. Burma teak wood has lowest joint efficiency. Suggestion will be given to the supplier to give an adhesive detail which is used to join the fingers of Burma teak wood species.

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