THE PERFORMANCE OF WOOD-CEMENT RATIOS AND CEMENT PARTIAL SUBSTITUTE BY GYPSUM ON THE QUALITY OF PROSOPIS CHILENSISWOOD-COMPOSITES

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Abstract: Portland cement is an inorganic binder that can be used for the production of composite panels. Many studies have focused on understanding the complex behavior of wood-cement water mixture. The experimental part of this study consisted of two main experiments; the promising results obtained in the former experiments wereused in the latter one. All experiments were conducted using Completely Randomized Design (CRD) with three-five replicates.

The first experiment was designed to study the effect of cement- wood ratio namely 2:1; 3:1; 4:1 and 5:1. The studied variables are (density and compressive strength) and the composite produced used the recommended cement wood ratio of 3:1. The second experiment was designed to study the effect of cement partial substitutes by gypsum as 10, 20, 30 and 50 percent based on cement weight using the recommended cement-wood ratio (3:1) that obtained in the first experiment results. The results revealed that, the lower substitute percentages (10, 20%) were found to improve the compressive strength, while increasing the substitute percentages more than 20% caused reduction in the density of the aggregates which negatively affect the compressive strength of the cement composite. Also The investigation implies that 3:1 cement wood ratio is the suitable and recommended ratio to be used for untreated mesquite (Prosopis chilensis) wood.

Keyword: gypsum, water absorption, substitute percentages, compressive strength and Prosopis chilensis.

Introduction: Portland cement is an inorganic binder that can be used for the production of composite panels. Many studies have focused on understanding the complex behavior of wood-cement water mixture.Wood species have been classified as highly suitable, unsuitable and less suitable for the manufacture of wood-cement products, or as having non-inhibitory, moderately inhibitory or highly inhibitory effect on the curing of cement,(Hachemi and Moslemi 1989,Alberto, et al. 2000). The nature and quantity of wood component critically affect the cement hydration and composite strength. The exact cause of cement inhibition by wood components is difficult to ascertain, since a number of complex chemical and physical processes are occurring. Various compounds are thought to be responsible for the inhibitory effect of wood on cement setting including soluble sugars, arabinogalactans, phenolic and other extractives, Geographical location, felling season and storage period also influence cement curing through their effects on the extractive content of wood (Yoshida et al.1992). In addition, the effect of species depends mainly on the extractives present in wood species. (Yashido, et al., (1992), studied the manufacturing conditions of cement bonded wood boards oflarixleptolpis, patula japonica, and petercaryarhoifolia and concluded that the hydration temperature of wood cement mixture attained, varied with the species and between sapwood and hardwood.

In addition, wood and other lignocellulosic materials have been in use for ages in cement matrices for manufacturing construction products (Bentur and Mindess, 1990). Wood particle-cement composites have been produced from a number of materials including sawdust, construction waste, bagasses, coffee husk, maize husk, and rattan furniture waste among others (Kasai, et al., 1998; Olorunnisola and Adefisan, 2002). However, when particles from many woody materials come in contact with cement slurry, their organic compounds, such as carbohydrates, tannins, and flavonoids tend to retard or inhibit cement hydration and bond formation between the cement and wood particles, their effects is the slowing down of the strength development and delay in the demoulding of products (Hachmi and Campbell 1989; Swamy 1990; Miller and Moslemi 1991; Alberto, et al., 2000).

The species Prosopis consists more than 44 types essentially of American and a few of Asian spreading as well as arid and semi-arid zones of Northern and Southern Africa (Elsidig et al., 1998). Prosopis chilensis (Molina) Stuntz was found in Sudan by the government botanist since 1917.the seeds were obtained from South Africa and Egypt and now naturalized to all parts of Sudan (Salah and Yagi, 2011).

In dissimilarity to their adverse effects as warlike weeds in Sudan, many Prosopis species are cherished versatile resources in their natural array, supplying timber, firewood, livestock feed, human food, shade, shelter and soil improvement (Pasiecznik et al., 2001).

In addition Prosopis chilensis fruits (pods) is rich with protein, energy and mineral concentration might give a strong indication that Prosopis chilensis is potentially a suitable fodder tree that can meet the grazing requirements of livestock for the sustainability of animal as well as high capacity to stabilize sand dunes, survive uncongenial environments, and provide fuel, timber, fodder, and edible pods (Mohamed etal., 2014). Therefore, to study wood cement composite is one of attempt that can combat Prosopis chilensis tree through its natural stands for producing wood-cement panels.

Materials And Methods:

Wood and cement: The wood material used in this investigation was obtained from Prosopis chilensis (mesquite). The wood manually was cut into chips, milled using hammer mill and then screened using a set of standard meshes. The parts passed through mesh 2 and 4 mm was used for preparation of the test specimens. Cement which obtained from Atbra cement Corporation, Sudan was usedas binding material for the two experiments. The commercial gypsum used to substitute cement.

Methods:

The effect of cement/wood ratios on the properties of mesquite wood composite: The experiment was conducted under laboratory environment using Completely Randomized Design (CRD) with five replicates. Four cement wood ratios namely 2:1, 3:1, 4:1 and 5:1 were used. Wood particles were mixed with Portland cement without any treatment or additives, the required amount of water (according to Basheir 2005) was added, then the mixture was molded into testing metallic mold of (7×7×7 cm) and left for 24 hours for setting. Then the resulting composites were soaked in water for four weeks for complete cement curing. Thereafter, all the specimens were tested for water absorption for 2 and 24 hour, density and compressive strength.

The effect of cement partial replacement by gypsum on the properties of Mesquite wood composite: Under completely randomized design with five replicates using a fixed cement wood ratio of 3:1, four levels of cement substitute by gypsum were done. The selected percentage of substitution was 10, 20, 30 and 50% based on cement weight. Wood particles were mixed with Portland cement, and the gypsum according to each level of substitution, and then required amount of water according to (Basheir, 2005) was added. The mixture was molded into testing metallic mold of (7×7×7cm) and left for 24 hours for consolidation and primary curing of cement. Then the experiment proceeded as in the effect of cement wood ratio. Another replicate was molded without any gypsum to serve as control.

Property measurement:

Determination of density: Density (g/cm³) for each specimen (7×7×7cm) was calculated by dividing weight (air dry weight) by volume of the specimen.

Determination of compressive strength: The specimens prepared in each of the above-mentioned experiments were tested for compressive strength using a universal testing machine. The compressive strength was calculated by dividing the maximum load over the cross sectional area of the cube sample. Maximum load in kilogram was recorded and compressive strength (kg/cm²⁾ was worked out.

Results And Disscussions:

Effect of cement/wood ratios on the density of mesquite wood composites: The results for the effect of cement wood ratio on mesquite wood-composite airdry density were presented in Table 1. The mean separation test shows that, no significant differences were observed between ratios 4:1 and 5:1which gave the highest value. But there were significant differences between the other ratios. The same conclusion was found by (Zhou and Kamdem, 2002). Also (Oyagade et al., 1995) reported that veneer laminated cement-bonded particleboard were stronger and stiffer with increased cement/wood ratio due to increased density.Also (Lee ,1984) stated that if a lower cement/wood ratio is used, wood excelsior will not receive adequate cement coating, which results in poor bonding.

Table.1. Effect of cement/wood ratios on the density of mesquite wood composite

Cement /wood ratio	Density (g/cm³)
5:1	1.488 a
4:1	1.398 a
3:1	1.153 b
2:1	0.818 c

In the same columns, means with the same letter/s were not significantly different at P= 0.05.

Effect of cement /wood ratios on compressive strength of mesquite wood composite. The results for the effect of cement/wood ratio on mesquite wood-composite compressive strength were shown in Table 2. Significant differences were found between the four studied ratios. As observed from the Table 1 increasing cement:wood ratio resulted in increasing compressive strength. This can be attributed to the increased air dry density. This goes in total agreement with the finding of (Abdelgadir and Ibrahim, 2003).

Table.2. Effect of cement/wood ratios on the compressive strength of mesquite wood composite

Cement/wood ratios	Compressive strength (Kg/cm²)
5:1	109.72 a
4:1	89.91 b
3:1	38.04 c
2:1	15.69 d

In the same columns, means with the same letter/s were not significantly different at P=0.05.

Effect of cement partial substitute by gypsum on the air density of mesquite wood composite: The results for the effect of cement partial substitute with gypsum on the air dry density of mesquite composite, there was a highly significant differences between the different ratios (P=.0001). The results of the mean separation test for the effect of cement partial substitute by gypsum on mesquite compositeair dry density were presented in Table 3. The mean separation test shows that, no significant differences were found between the different percentages of the substitute (10, 20, 30 and 50%, based on cement weight). But there is a trend of reducing density by increasing the gypsum replacement percentage and statistically appear to be significant.

Table.3. Effect of cement partial substitute by gypsum on the density of mesquite wood composite

Gypsum percentage	Density (g/cm³)
Control (0)	1.248 a
10	1.008 b
20	1.067 b
30	1.044 b
50	1.016 b

In the same columns, means with the same letter/s were not significantly different at P=0.05

Effect of cement partial substitute by gypsum on the compressive strength of mesquite wood composites: The results of mean separation test for the effect of cement partial substitute by gypsum on mesquite wood-cement bonded aggregates compressive strength were shown in Table 4. Significant differences were found between replacement percentage of 10, 20, 30 and 50%. The highest compressive strength was associated with 10% substitute which was significant differences from all other substitute levels. This was followed by 20%. However no significant differences were observed between 30 and 50% substitute. When comparing this result with control, the control compressive strength showed no significant difference from that of 20% substitute, while 10% replacement improved the compressive strength significantly over that of the control. The gypsum partial replacement of 10% increased the compressive strength more than 100 percent when compared with the percentage 30 and 50. This indicated that the partial replacement of cement by gypsum in fewer amount is sufficient to improve the aggregates compressive strength. While increasing the percentage more than 20% causes reduction on compressive strength of the aggregate. According to Sudanese Standard (1974), the minimum requirement of compressive strength for burnt clay bricks, should not be less than 20 Kg/cm²,referring to the result of this experiment, the worst mesquite wood cement aggregates showed compressive strength of 24.8 Kg/cm² which exceeds the required compressive strength by the standard.

Table.4. Effect of cement partial substitute by gypsum on the compressive strength of mesquite wood composites

Percentage of gypsum replacement (%)	Compressive strength (Kg/cm²)
10	55.99 a
20	38.68 b
Control	37.88 b
30	25.89 c
50	24.98 c

In the same columns, means with the same letter/s were not significantly different at P =0.05.

Conclusions: Based on the finding the investigation concluded that,the lower substitute percentages (10, 20%) were found to improve the compressive strength, while increasing the substitute percentages more than 20% caused reduction in the density of the aggregates which negatively affect the compressive strength of the cement composite. Also The investigation implies that 3:1 cement wood ratio is the suitable and recommended ratio to be used for untreated mesquite (Prosopis chilensis) wood.

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References:

1. Abdalla, M., M Abdalla. M, Izeldin .B, Jehan.A. , Afrah. M, El-Kordufani. M Mudawi.
2. (2014).POTENTIAL OF PROSOPIS CHILENSIS (MOLINA) STUNTZ AS A NON-CONVENTIONAL ANIMAL FEED IN DRY LANDS OF SUDAN." IJPAES**4**(2): 674-676.
3. Abdelgadir, A.Y. and M.F.S. Ibrahim 2003.Effect of pretreatments and cement/wood ratio on compatibility of wood with Portland cement.Sudan Silva 9(2): 77-85.
4. Alberto, M.M; E. Mougel and A. Zoulalian 2000. Compatibility of some tropical hardwood species with Portland cement using isothermal calorimetry.Forest product Journal. 50(9): 83-88.
5. Basher, A.B.A. 2005.Effect of some technological factors on some properties of Acacia seyal (Talh) wood-cement aggregates.M.Sc. Thesis Submitted to the University of Khartoum.
6. Bentur, A. and Mindess, S. 1990. Fibre Reinforced Cementitious Composites Elsevier Science Publishers Limited, Essex, England 449 pp.
7. Elsidig EA, Abdelsalam A.A, Abdelmagid TD (1998). Socio-Economic environmental and management aspects of mesquite in Kassala state - Sudan, Institute of environmental studies and ford foundation, SSFS.
8. Hachemi.M. and A.A. Moslemi. 1989. Correlation between wood-cement compatibility and wood extractives. Forest Product Journal. 39(6):55-58.
9. Kasai, Y.; Kawamura, M. and Zhou, J.D., 1998. Study on Wood Chip Concrete with Timber. In: V.M. Malhotra (Ed.). Recent Advances in

Concrete Technology: Proceedings: 4th CANMET/ACI/JCI International Conference, SP 179, Tokushima, Japan, Pp. 905-928.

10. Olorunnisola A.O. Pitman, A. and Mansfield-William, H. 2005a.Strength Properties and Potential Uses of Rattan-Cement Composites.Journal of Bamboo & Rattan 4(4): 343-352.
11. Oyagade, A.O.; S.O.O. Badejo, and O. A. Omole 1995. A preliminary evaluation of flexural properties of wood-veneer laminated cement-bonded particleboard from tropical hardwood species. Journal of tropical forestry and wood technology of the timber Development association of India 41 (3): 25-29.
12. Pasiecznik NM, Felker P, Harris PJC, Harsh LW, Cruz G, Tewari JC, Cadoret K, Maldonado LJ (2001). The Prosopis juliflora – Prosopis pallida Complex: A Monograph. HDRA, Coventry, UK.
13. Salah, O. and S. Yagi (2011). "Nutritional composition of Prosopis chilensis (Molina) Stuntz leaves and pods from Sudan." African Journal of Food Science and Technology 2(4): 079-082.
14. Swamy, R.N. 1990. Vegetable Fibre Reinforced Cement Composites –A False Dream or a Potential Reality? In H.S. Sobral (Ed.), Vegetable Plants and their Fibres as Building Materials. Proceedings of the 2nd the Timber Development Association of India, 35, 19–32.
15. Yoshida, Y., Iwase, Y., Seguchi, Y., Takemura, T. and Matsushita, Y. 1992. Manufacture of wood–cement boards V. Cement hardening inhibitory components of sugi heartwood and behavior of catechol as a simple Inhibitor model with vicinal phenolic hydroxyl groups in cement paste. MokuzaiGakkaishi, 38, 52–58.
16. Zhou, Y.; Kamdem, D.P. 2002. Effect of cement/wood ratio on the properties of cement-bonded particleboard using CCA-treated wood removed from service. Forest Products Journal 52 (2): 73-81.

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