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***Journal of Scientific and Engineering Research*, 2020, 7(4):177-182**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Partial Replacement of Fine Aggregates with Wood Dust in Concrete (Compressive Strength Test)

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Abstract The purpose of this study is to provide a self-curing concrete using locally available wood powder as water reservoir to produce a water entraining concrete. This supplement shall be added into concrete during mixing, to find out if that concrete can be self-cured after placing without the need of any external curing. A total of 72 cubes were cast. This was done in two phases. Two sets of control cubes were casted consisting of 12 cubes each, one set was cured internally (Self-curing) while the other was cured externally (In a curing tank). For the batch of specimens which contained wood powder, a total of 48 cubes were casted at varying percentages of 5%, 10%, 15% and 20% by weight of fine aggregate. The concrete mix ingredients namely cement, coarse aggregate, fine aggregate with 5%, 10%, 15% and 20% replacements with wood powder were first mixed in dry state, then the calculated amount of water was added and mixed thoroughly to get a homogeneous concrete mix to produce a uniform mixture. Superplasticizer was added at 0.4% by weight of cement. The cubes were tested for compressive strength at 7, 14 and 28 days. Among the specimens subjected to partial percentile replacement of fine aggregate with wood powder, only the 5% samples met the stipulated characteristic strength of 30 N/mm^2 at 28 days. It was thus concluded that the locally available wood powder can be used to produce internally/self-curing concrete by using 5% of it in place of the specified quantity of fine aggregate.

Keywords Fine Aggregates, Wood Dust, Concrete, Compressive Strength Test

Introduction

The overall relevance of concrete in virtually all civil engineering practice and building construction works cannot be overemphasized [1]. Concrete is a non-homogeneous material consisting of aggregate in a cement paste matrix. While the cement paste is initially a fluid suspension, it reacts (hydrates) over time causing it to solidify, thus binding (gluing) the aggregates together. If water is lost from the paste due to evaporation at early ages, there are two main consequences. First, the hydration reaction will slow and ultimately stop, which limits strength development and produces a more permeable material when compared with a sample that did not lose water. Secondly, the loss of water causes concrete to shrink and, if restrained, the concrete develops stresses that may lead to cracking. Conventional concrete construction relies on external curing to reduce the potential for water loss. Some conventional approaches add water to the concrete surface (i.e., water ponding or misting) which can be absorbed, while other approaches focus on minimizing moisture loss by the use of evaporation retarders, curing compounds, or plastic sheeting [2].

Evangeline [3] noted that proper curing of concrete structures is important to meet performance and durability requirements. The use of self-curing admixtures is very important from the point of view that water resources are getting valuable every day (i.e. each $1m^3$ of concrete requires about $3m^3$ of water for construction most of which is for curing).

Kumbhar et al [4], observed that the behaviour of the design concrete mix is significantly affected by variation in humidity and temperature both in fresh and hardened state. The strength of concrete is affected by a number of factors, one of which is the length of time for which it is kept moist, i.e. cured, another being the method of curing. Inadequate or insufficient curing is one of main factors contributing to weak, powdery surfaces with low abrasion resistance and durability.

Abubakar & Afolayan [5] in their research on the partial replacement of sand with sawdust in concrete production came to the conclusion that the optimum replacement of sand with sawdust is 10%. Beyond this limit, the concrete produced did not meet code requirements for strength as per BS 8110 (1997) [6]. Olugbenga [7] also noted that concrete produced using sawdust as partial replacement of sand has influence on the properties of the concrete. The result of the analysis carried out shows that the workability of concrete with partial replacement of sand with sawdust reduces at constant water-cement ratio; while the use of sawdust in concrete at high percentage of sawdust replacement of sand affected the strength of the concrete as there was a decrease in the strength value, and the density requirement of 1480 to 1840 kg/m^3 was not meet. However, use of sawdust as partial replacement of sand at 25 percent by weight gives the same strength requirement when sawdust was not used. Thus, the use of sawdust as partial replacement of sand between 0 to 25% will contributes to reduction in sawdust waste generated in the society without adversely affecting concrete strength.

Statement of the Problem

Proper curing of concrete structures is important to meet performance and durability requirements. Enough water needs to be present in a concrete mix for the hydration of cement to take place. However, even if the mix contains enough water, any loss of moisture from the concrete will reduce the initial water cement ratio and result in incomplete hydration of cement especially with the mixes having low water cement ratio; this results in a very poor quality of concrete [8]. The first modern awareness of internal curing dates back to the mid-1950s when Paul Klieger [9] wrote; Lightweight aggregates absorb considerable water during mixing which apparently can transfer to the paste during hydration. In 1991, Philleo [10] suggested incorporating saturated lightweight fine aggregate into the concrete mixture to provide an internal source of water to replace that consumed by chemical shrinkage during hydration of the paste. It was also noted that these suppliers act as internal reservoirs, replacing the water throughout the hydration process. These special materials include saturated lightweight fine aggregates, superabsorbent polymers, and saturated wood fibres. Kamlesh et al [11] in their research came to the conclusion that the replacement of fine aggregates by wooden powder in concrete generally increases the ultimate strength of concrete.

An attempt shall therefore be made in this research to compare the viability of using locally available wood powder as water reservoir for producing a water entraining concrete that is subject to self- curing.

Purpose of the Study

The purpose of this research shall be to provide a self-curing concrete using locally available wood powder as water reservoir to produce a water entraining concrete. This supplement shallbe added into concrete during mixing, to find out if that concrete can be self-cured after placing without the need of any external curing. Thus, Water evaporation after removal of formworks is expected to reduce, and the degree of cement hydration improved without extra standard curing. Furthermore, compressive strength is expected to be enhanced with the reduced shrinkage arising from water evaporation, making it ideal for concrete placing without any external curing.

The objectives of the research are:

1. To find a suitable material for application of internal curing.
2. To study the mechanical property of concrete made using wood powder to that of conventional concrete by varying the percentages in the concrete mix using wood powder as partial replacement of fine aggregate and also as water reservoir to produce a water entraining concrete.

Methodology

Information on this subject was gathered through personal assessment of well-written and recognised documents such as published textbooks, journals and conference papers.A total of 72 cubes were cast. This was done in two phases. Two sets of control cubes were casted consisting of 12 cubes each, one set was cured internally (Self-curing) while the other was cured externally (In a curing tank). For the batch of specimens which contained wood powder, a total of 48 cubes were casted at varying percentages of 5%, 10%, 15% and 20% by weight of fine aggregate. The concrete mix ingredients namely cement, coarse aggregate, fine aggregate with 5%, 10%, 15% and 20% replacements with wood powder were first mixed in dry state, then the calculated amount of water was added and mixed thoroughly to get a homogeneous concrete mix to produce a uniform mixture. Superplasticizer was added at 0.4% by weight of cement and the cubes were tested for compressive strength at 7, 14 and 28 days.

Results

Sieve Analysis

Fine Aggregates

Table 1: Determination of Grading of Fine Aggregate Sample

Sieve Size (mm)	Weight Retained (g)	Cumm. Weight retained (g)	Cumm. Percentage weight (%)	Weight passing (g)	Cumm. Weight passing (%)
5.00	445	445	1.51	29112	98.49
2.36	1643	2088	7.06	27914	92.94
1.18	9220	11308	38.3	20337	61.7
600u	11263	22571	76.4	18294	23.6
300u	5565	28136	95.2	23992	4.8
100u	15	28151	95.24	29542	4.76
Pan	1406	29557	100	28151	0
	29557				

Determination of Grading of Wood Powder

From the material analysis, a total weight of wood powder needed is
Therefore, 2kg of wood powder was measured and weighed.
The following results were obtained.

i. 1.35 kg of wood powder passed through 0.43mm sieve.
ii. 1.18 kg of wood powder was retained on 0.15mm sieve.
iii. 0.155kg of wood powder passed through 0.15mm sieve.

This means that the size of wood powder used was between 0.43mm to 0.15mm and below.

Slump test

The types of slump obtained from the experiments were true slumps that ranged between 0-10mm.

Compacting factor test

Assessment of workability of concrete mix by compacting factor method

i. Weight of empty cylinder = 3.19kg
ii. Weight of partially compacted concrete = 13.42kg
iii. Weight of fully compacted concrete = 13.84kg

$$\text{Compaction factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

Weight of partially compacted concrete = 13.42-3.19
= 10.23

Weight of fully compacted concrete = 13.84-3.19 = 10.65

Therefore, compaction factor = 10.23kg/10.66kg = 0.96

Compressive Strength Test

Table 2: Compressive strength test result for control cubes

Method of Curing	Curing Age (Days)	Surface Area (mm^2)	Crushing Load (N)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
Internal/Self Curing	7	10,000	149,400	14.94	15.27
		10,000	160,400	16.04	
		10,000	148,300	14.83	
	14	10,000	171,400	17.14	16.49
		10,000	162,200	16.22	
		10,000	161,100	16.11	
	28	10,000	220,400	22.04	21.36
		10,000	201,900	20.19	
		10,000	218,500	21.85	
External/Tank Curing	7	10,000	238,800	23.88	24.06
		10,000	259,200	25.92	
		10,000	223,800	22.38	
	14	10,000	272,100	27.21	26.66
		10,000	259,400	25.94	
		10,000	268,300	26.83	
	28	10,000	314,200	31.42	32.39
		10,000	343.800	34.38	
		10,000	313,700	31.37	

Compressive Strength Test Results for Wood Powder Cubes

Table 3: Compressive strength test results for wood powder cubes

Wood Powder Content (%)	Curing Age (Days)	Surface Area (mm^2)	Crushing Load (N)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
5	7	10,000	222,500	22.25	23.15
		10,000	238,700	23.87	
		10,000	233,300	23.33	
	14	10,000	249,400	24.94	25.92
		10,000	261,400	26.14	
		10,000	266,800	26.68	
	28	10,000	299,400	29.94	30.86
		10,000	312,200	31.22	
		10,000	314,200	31.42	
10	**7**	10,000	109,400	10.94	11.16
		10,000	114,200	11.42	
		10,000	111,200	11.12	
	14	10,000	120,200	12.02	12.41
		10,000	119,900	11.99	
		10,000	132,200	13.22	
	28	10,000	160,200	16.02	16.55
		10,000	166,400	16.64	
		10,000	169,900	16.99	
15	**7**	10,000	19,400	1.94	2.06
		10,000	21,400	2.14	
		10,000	21,000	2.10	

	14	10,000	21,900	2.19	2.28
		10,000	24,200	2.42	
		10,000	22,300	2.23	
	28	10,000	28,000	2.80	2.76
		10,000	27,300	2.73	
		10,000	27,500	2.75	
20	**7**	10,000	5,500	0.55	0.61
		10,000	6,300	0.63	
		10,000	6,500	0.65	
	14	10,000	7,500	0.75	0.74
		10,000	6,900	0.69	
		10,000	7,800	0.78	
	28	10,000	10,400	1.04	0.92
		10,000	8,400	0.84	
		10,000	8,800	0.88	

Findings of the Study

This research work brought about the following findings:

i. The aggregate impact value was found to be 0.96 which is within the range for acceptable standard for the aggregate impact value.

ii. Among the specimens subjected to partial percentile replacement of fine aggregate with wood powder, only the 5% samples met the stipulated characteristic strength of 30N/mm^2 at 28days.

iii. The partial replacement of fine aggregate with wood powder at 5% and subjecting it to self/internal curing produced concrete that exhibited compressive strengths that were higher than the control specimens subject to self/internal curing by 34.04%, 36.38% and 30.78% at 7, 14 and 28 days, respectively.

Conclusion

The locally available wood powder can be used to produce internally/self-curing concrete by using 5% of it in place of the specified quantity of fine aggregate. The use wood powder for producing self-curing concrete provides a sustainable concrete by making use of locally available material.

Recommendation

Based on the findings of this study, the optimum dosage of wood powder to be used in producing self-curing concrete is 5% of the stipulated weight of fine aggregate.

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