IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 17, Issue 4 Ser. I (Jul. – Aug. 2020), PP 17-20
www.iosrjournals.org

Influence of Dracaena Aborea and Carica Papaya Leave Extracts on the Strength and Setting Time of Cement Paste and Mortar

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Abstract:
Background*: One of the emerging trends in achieving sustainable construction is through the application of green materials in construction. Green materials are materials which are environmentally friendly, use less natural resource and energy, and generate less* CO_2 *during production. This study evaluated the effect of Dracaena Arborea (DA) and Carica Papaya (CP) leaves extracts as potential bio-based admixture in cement mortar.*
Materials and Methods*: Dracaena Arborea (DA) and Carica Papaya (CP) leaves extracts were characterized in terms of their phytochemicals and added to ordinary Portland cement/sand mix of 1:3 ratio in dosage of 1, 2, 3 and 4%. Setting time of the cement paste samples were evaluated using a standard vicat apparatus. A total of one hundred and twenty (120) cement/sand mortar samples were produced in a 140mm x 40mm x 40mm mould and tested for compressive strength after curing in water for 7, 28, 56 and 90days.*
Results*: setting time of the paste samples were extended with increase in the dosage of the extracts. At 1% extracts incorporation, the DA sample setting time extended by 15% and 27% while CP sample extended by 6% and 12% for initial and final respectively. At 4% extract incorporation, DA setting time further extended by 91 % and 86%, while CP sample equally extended by 77% and 65% for initial and final setting time respectively. The early compressive strength development decreased gradually with increase in extract percentage. At 4% extracts, the compressive strength decreased by 33% and 13% at 7 and 28 days respectively for DA samples, while CP samples decreased by 31% and 11% at 7 and 28days respectively. After 56 and 90 days curing, the compressive strength increased gradually from 1.5% to 6%, 2.7% to 7% and 1% to 2%, 3% to 5% for 1% and 2% DA and CP respectively.*
Conclusion: *Dracaena Arborea (DA) and Carica Papaya (CP) extracts can be used as retarders in Portland cement with significant benefits for masonry and concreting in tropical conditions*
Key Word*: Dracaena Arborea (DA), Carica papaya (CP), Setting Time, Portland cement, mortar.*

Date of Submission: 30-06-2020 Date of Acceptance: 16-07-2020

I. Introduction

Cement paste/mortar is a composite material which comprises of cement, sand and water in a well defined proportion. Mortar/cement paste is a very important construction material which is used for plastering of concrete surfaces, filling joint between blocks or to achieve pleasing design surfaces. Mortar strength is a function of cohesion between its constituent's material, and the strength of aggregate used[1]. Conventionally, cement paste is made of cement, sand and water. In some cases, admixture may be added to improve specific properties of concrete and cement paste.

One of the emerging concrete technologies for sustainable development is the use of green materials for construction. Green materials are considered as materials that use less natural resource and energy, and generate less CO_2 during production. The demand for sustainable concrete is principally driven by the actual and perceived reliability of the materials to meet strict performance and standards when compared to conventional materials[2]. Sustainable growth in the construction industry can be achieved only if the materials used in the design and construction are eco-friendly, cost-effective, ductile and give durable service performance over their specified design life[3]. One of such materials is agricultural waste or by-product. The use of these materials will not only reduce environmental problems caused by waste disposal but will also encourage eco-friendly structures to be built. Researches into the used of these waste materials as admixture has been carried out in recent years. For instance agricultural waste such as palm kernel shell ash and groundnut shell ash has been used as admixture to improve properties of cement paste or concrete[4, 5, 6, 7] and encouraging result has been achieved.

Admixture are material other than water, aggregates, hydraulic cement, and fibre reinforcement that is used as ingredient of concrete or mortar and is added to the batch immediately before or during mixing[8]. Admixtures are essential components for modern concrete technology considering its enormous potentials. Several admixtures have been used in concrete and cement mortar but most of these admixtures are chemicals and minerals based. To curb the over dependence on conventionally used materials and to make construction sustainable, it becomes necessary to source for other materials which can give comparable level of strength as the conventionally used ones. Natural (bio-based) admixtures are being considered as abundant and environmentally friendly alternative to chemical admixtures in cement matrix.

Bio-substances (solid or liquid) are obtained from plants or animals. Bio-substances (solid or liquid) have been used for various purposes such as; medicinal, admixture in cement mortar, concrete and also as additives in production of various binding materials. Bio-resins (polyfurfuryl alcohol) produced from agricultural wastes used in concrete has yielded interesting mechanical property for concrete structures[9]. Investigations on the use of biopolymers on Ordinary Portland Cement (OPC) are still not saturated[10]. More so, limited information exist on the influence of bio-based admixtures in cement mortar.

This study investigated the effect of two bio-substances; Carica Papaya and Dracaena Arborea on the strength and setting time of cement paste. Carica Papaya (paw paw) is a tropical fruit trees with broad star shaped leaves, belonging to the genus Asimina family (see Figure 1a.) while Dracaena Arborea (DA) tree is a small perennial, palm-like plant with lance-shaped, dark green long leaves, smooth trunk and grows atop a woody, belonging to the Asparagaceae family (see Figure 1b). Carica Papaya (CP) and Dracaena Arborea (DA) can be harnessed as potential bio admixture in cement mortar. Nigeria is a tropical country that has abundance of wide diversities of tree plants and vegetation which includes Dracaena Arborea (DA) and Carica papaya (CP) trees. For these substances to be used as admixture its effect on the setting time and strength of cement mortar most be fully understood.

Figure 1: (a) Carica Papaya (paw paw) (b) Dracaena Aborea Tree

Setting time is one of the essential standard consistency tests for cement paste, which indicates whether or not cement is undergoing hydration[11]. The initial setting time is the time elapsed between the moment water is added to the cement and the time the paste starts losing its plasticity while the final setting time is the time elapsed between the moment water is added to the cement and the time, the paste completely lost it plasticity and attained sufficient firmness to resist definite pressure[12]. Using the vicat apparatus, initial setting time measures the time taken by the paste to stiffer such that the vicat needle is not permitted to move down through the paste within 5 mm from bottom of the mould, while the final setting time is the time from when water is added to the cement paste to the time when the paste becomes hard that the annular attachment to the needle under standard weight fails to leave any mark on the hardened paste[13].

II. Material And Methods

Materials: Ordinary Portland cement (Dangote brand) conforming to BS 12[14] specification was used; fine aggregate (natural sand) was used after preliminary investigations were conducted in accordance with BS EN 12620[15]to ascertain their suitability for the experiment. The water used for mixing was portable water obtained from a borehole conforming to BS EN 1008[16]and extracts obtained from Dracaena and Carica Papaya leaves.

Sample Preparation: samples Dracaena and Carica Papaya leaves were collected from a farm located at Ekpri Nsukara, Uyo in Akwa Ibom State, Nigeria. The leaves collected were thoroughly washed in clean water to get rid of muddy debris and impurities and dried by spreading the samples on polythene in a well ventilated room for about 1 hour 30 minutes. The samples were uniformly cut into pieces using a table knife, the extracts from the Dracaena and Carica Papaya were obtained by mechanical squeezing the leaves and filtered into two containers to avoid filtrates. The cement pastes were prepared with a mixture of cement and sand using mix ratio of 1:3. The contents of Dracaena and Carica Papaya leaves extracts were varied at 0%, 1%, 2%, 3% and 4% dosages of water. The mixing of cement and sand was manually achieved with water and extracts added gradually till homogeneity and consistency attained before feeding into 140mm x 40mm x 40mm moulds. For each dosage of Carica and Dracaena considered, twelve (12) samples were prepared which represented three samples each for 7, 28, 56 and 90 days. A total of one hundred and twenty (120) test samples cast and cured in water tank for the respective number of days.

Testing Method

Determination of Phytochemical compositions of Dracaena Aborea and Carica Papaya Leaves.

Spectroscopic and titrametric methods were used to determine the levels of phytochemicals in the Dracaena and Carica Papaya extracts in accordance with AOAC in the Botany and Ecological study laboratory, University of Uyo, Nigeria.

Determination of Initial and Final Setting Time.

The penetration test which measures the time taken for a variety of plungers to penetrate a cement paste for standard consistency was conducted for the initial and final setting time with Vicat apparatus setup, ring mould in accordance with Nigerian Industrial Standard (NIS) 447 and BS EN 197.

Determination of Compressive Strength.

The compressive strength of the 140 x 40 x 40mm mortar cubes were obtained from a compression testing machine mould in accordance with BS EN 206 (2013)[17] after curing for 7, 28, 56 and 90days.

III. Result and Discussion

Phytochemical constituents of Dracaena Arborea (DA) and Carica Papaya (CP) leaves extracts.

The phytochemical test results indicated that Draceana Aborea (DA) contains alkanoids, cyanides, flavanoids, oxalates, phytates and saponins while Carica Papaya (CP) contains alkanoids, flavanoids, glycosides, saponins, steroids and tannins as shown in Table 1.

Table 1: Phytochemical constituents of Dracaena Arborea and Carica Papaya Leaves Extracts

Phytochemical	Dracaena Arborea extract(mg/100) (DA)	Carica Papaya extract(mg/100) (CA)
Alkanoids	0.48 ± 0.14	1.18 ±0.40
Cyanides	0.11 ± 0.10	-
Flavanoids	2.84 ± 0.12	1.90 ± 0.50
Glycosides	-	0.48 ± 0.10
Oxalates	4.94 ± 0.24	-
Phytates	15.30 ±0.53	-
Saponins	1.48 ± 0.10	3. 70 ± 0.27
Steroids	-	7.57 ± 0.52
Tanins	-	4.50 ± 0.20

Initial and Final Setting Time.

The results of the setting time is presented in Table 2. As observed, at 1% extracts incorporation, the DA sample initial and final setting time extended by 15% and 27% while CP sample extended by 6% and 12% respectively. At 4% extract incorporation, DA setting time further extended by 91% and 86%, while CP sample equally extended by 77% and 65% for initial and final setting time respectively, an indication that these extracts are setting time retarders attributed to the organic alkalis and salts present in the extracts in Table.1. This setting time pattern could be quite advantageous in tropical climatic conditions. In general, the setting time were all within the acceptable standard recommendations of a minimum of 45 minutes for initial setting time and 600minutes (10hours) for final setting time (NIS-447 and BS EN 197).

Table 2: **Setting Time of cement paste at varying percentages of extracts**

Extract Percentage (%)	DA Initial setting time (Min)	DA Final setting time (Min)	CP Initial setting time (Min)	CP Final setting time (Min)
0	95	305	95	305
1	109	386	101	342
2	124	442	119	395
3	158	491	134	457
4	183	567	168	503

Compressive Strength

The results of the compressive strength of 140 x 40 x 40mm mortar samples after curing for 7, 28, 56 and 90 days are presented in Table 3. It is observed that the compressive strength decreased gradually with increase in extract percentage considered. At 4% extracts, the compressive strength decreased by 33% and 13% at 7 and 28 days respectively for DA samples, while CP samples decreased by 31% and 10.7% at 7 and 28 days respectively. Early age compressive strength reduction reflects the compressive strength development pattern of most setting time retarders. After 56 and 90 days curing, the compressive strength increased gradually from 1.5% to 6%, 2.7% to 7% and 1% to 2%, 3% to 5% for 1% and 2% DA and CP respectively. It is further observed that at further curing ages the compressive strength improved significantly at 1% to 2% increases in extracts before decreasing at 3% to 4% increase in extracts.

Table 3: Compressive strength at varying percentage of extracts at 7,28,56 and 90 days

Extract Percentage (%)	DA compressive strength (N/mm^2)				CP Compressive strength (N/mm^2)			
	7 days	**28 days**	**56 days**	**90 days**	**7 days**	**28 days**	**56 days**	**90 days**
0	10.3	17.7	27.56	39.54	10.3	17.7	27.56	39.54
1	8.2	16.8	27.97	41.89	8.9	17.1	27.82	40.73
2	7.8	16.2	28.31	42.26	8.3	16.7	28.03	41.51
3	7.3	15.9	28.14	41.17	7.8	16.2	27.91	41.02
4	6.9	15.4	27.74	40.51	7.1	15.8	27.61	40.39

IV. Conclusion

The study investigated the use of Dracaena Arborea (DA) and Carica Papaya (CP) as admixtures in cements paste. The following conclusion can are made

- Dracaena Arborea (DA) is rich in phytates and oxalates while Carica papaya (CP) is rich steroids and glycosides which are responsible for delay in the setting time.
- DA samples exhibited extended setting time than the CP samples.
- Compressive strengths were lower in the DA samples that the CP, in both samples, the compressive strength showed significant improvement at further curing ages.
- Dracaena Arborea (DA) and Carica Papaya (CP) extracts could be used as setting time retarder in Portland cement especially in tropical climatic conditions.

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