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STUDIES ON PORTLAND POZZOLANA CEMENTS CONTAINING ENDOD, A SOAP BERRY PLANT

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ABSTRACT

Water extract from Endod retards both the initial and final setting times of portland pozzolana cement paste. For a given water/cement ratio (0.66) the slump of the concrete mix containing 0.00, 0.02,0.05,and 0.08% of Endod increases from 2 to 9 mm and 3 to 11% sand and cement mixture was retrieved from the mould of concrete cubes. The average unit weight of the concrete cubes prepared with 0.00, 0.02, 0.05, 0.08% of Endod were 2.13, 2.04, 1.92, and 1.78 (for 28 days old) kg/L respectively.

Introduction

Endod is the Ethiopian name for the soap berry plant phytolacea dodecandra, a member of the phytolaccacaea family. Endod has small berries which when dried, ground and mixed with water yield a foaming detergent solution that has been traditionally used in Ethiopia and elsewhere as cleansing agent for washing clothes.

Endod has long been recognized for its varied medicinal and other uses[1]. We have reported that Endod modifies the properties of concrete or mortar and retards both initial and final setting times of the paste of portland cement[1]. As part of a continuous project we would like to report here the contribution of pozzolana (such as pumice) to the performance of the cement containing Endod with respect to strength development, setting time retardation and unit weight reduction.

General

The foaming agent extracted from dried Endod berries by using distilled water was dried and mixed as solid with the cement mix. For the preparation of mortar cubes British standard sands and portland pozzolana cement obtained from the Addis Ababa Cement Factory were used. As soon as all the specimens were demolded they were put in water at 20° $\pm$ 2 °C for 28 days and afterwards kept in a moisture room at 20$\pm$2°C and 95% humidity until they were tested. For each test three specimens from each mix were prepared and the average results were taken.

Compressive strengths of mortar (BS 12, part 1, 1958) and concrete [ASTM C330-68T(12)] cubes were determined using ELE serial No. 300 C.001 machine, with loading speed 15 seconds used for 1.0 -5.5 tons. Consistency, initial and final setting times of cement were measured using Vicat Plunger in accordance with BS 12, part 1, 1958. The modules of rapture test of concrete beams was carried out according to ASTM C 683, part 14, 1978 and with center-point loading. The machine used was Los-universal Testing UHP-100 19515/1967.

The best workability and required consistency together with an optimum yield of the fresh concrete obtained were found by preparing trial mixes.

Final trial	quantities
Cement content	= 420 kg/m_3
River sand	= 805 kg
Scoria	= 527 kg
Added water	= 280 L
W/C ratio	= 0.66
workability	= good

Materials, Testing procedures and Test Results

All physical tests on the aggregates, cements, mortars and concrete cubes were made at the Materials Research and Testing Department, College of Technology, Addis Ababa University. Chemical Analysis on cement was carried out at the Ethiopian Standard Institute.

Table 1
Sieve analysis and other physical tests of natural sand and scoria.

Sieve size (ASTM)	Scoria, percent passing	Natural sand,percent passing
3/4" (16mm)	100	-
1/2" (12.5mm)	99	-
3/8" (8mm)	96	100
No. 4 (4mm)	79	96
No. 8 (2mm)	48	88
No. 16(1mm)	25	72
No. 30(.5mm)	16	39
No. 50 (.25mm)	9	5
No. 100 (.125mm)	5	1
No. 200 (.074mm)	2	0

Aggregates

Scoria as well as river sands used in the project were obtained locally in Addis Ababa. The method adopted for sieve analysis was ASTM C136-76 part 14, 1978, Scoria and natural sand whose analyses are given in Table 1 were used in all concrete mixes. The grading curves for both aggregates are well within the standard ranges.

Table 1B
Physical Tests of Natural Sand and Scoria

	Scoria	Natural Sand
specific gravity	2.14	2.45 (SSD)
absorption	8.7%	3.8%
unit weight(loosely filled)		
unit weight(compacted)	$1130 Kg/M^3$	$1360\ Kg/M^3$
clay content		
organic impurity no	$1210 Kg/M^3$	$1440\ Kg/M^3$
	-	1.9%
	-	1

SSD - surface drying

Table 2
Chemical Composition and Physical properties of Cement and Scoria.

Oxides	Portland Cement, percent	Portland, pozzolana, percent	Pumice, percent	Scoria*, percent
SiO_3	20.14	24.4	65.72	42.7
$Al_2 0_3$	5.68	7.0	14.33	15.4
$Fe_2 0_3$	4.08	2.1	3.79	11.1
CaO	63.04	57.4	1.82	12.8
MgO	-	1.5	0.82	9.7
SO_3	2.62	-	0.40	-
ignition				
loss(1000°c)	1.15	3.0	6.70	2.54
Color				
	Grey	Grey	white	brown-red

* Ref.3

Table 3
Effect of Endod on Setting time of Cement paste

Endod (%)	Portland pozzolana cement		Portland cement		water (%)
	Initial (hrs)	Final (hrs)	Initial (hrs)	Final (hrs)	
0.00	3.50	5.55	3.30	8.15	$27^+(28)^*$
0.02	4.10	6.23	4.20	8.30	27 (27)
0.05	4.15	7.15	4.30	11.20	27 (26)
0.08	4.45	7.23	5.00	12.50	26.5(24)

Physical test of cement

Specific Surface 4416 cm^2/g
Soundness(Le Chatelier test) 1.2 mm

Table 4
Relation between percent Endod content and change in quantity of Entrained Air in Portland Pozzolanic Cement mixes.

Quantity of Entrained Air, Percent				
Endod, percent	Portland cement		Portland pozzolana cement	
	Mortar	concrete	Mortar	Concrete
0.00	0.00	0.00	0.00	0.00
0.02	11.30	3.80	3.00	3.40
0.05	19.30	9.50	13.50	4.40
0.08	23.90	11.80	17.40	12.70

Table 5
Relation between endod content and overflow of sand and Cement from mortar mixes.

Composition mix, g	wt. of overflow (sand and cement)	wt of overflow of sand	wt. of overflow of cement	Unit weight (kg/cm^3)
Cement 555 Sand 1665 Water 222 Endod 0.00%	-	-	-	2.30
Cement 555 Sand 1665 Water 222 Endod 0.02%	119	89.1	29.8	2.23
Cement 555 Sand 1665 Water 222 Endod 0.05%	323.5	242.5	82.7	1.99
Cement 555 Sand 1665 Water 222 Endod 0.08%	391	293.2	97.3	1.91

Table 6
Relation between percent of endod and quantity of overflow of sand and cement mixture from concrete mixes.

Composition of mix	wt. of overflow (kg)	% of overflow	Average unit weight (kg/e)
Cement 21.3 Sand 40.9 Scoria 24.3 Water 11.4 Endod 0.00%	-	-	2.04
Cement 21.3 Sand 40.9 Scoria 24.3 Water 11.4 Endod 0.02%	2.8	2.7	1.97
Cement 21.3 Sand 40.9 Scoria 24.3 Water 11.4 Endod 0.05%	9.0	9.2	1.95
Cement 21.3 Sand 40.9 Scoria 24.3 Water 11.4 endod 0.08%	11.2	11.4	1.78

Results and Discussion

Setting Time

In Table 3 the effect of Endod in retarding both the initial and final setting times of the two type of cements is given. Although, as the amount of Endod increases the setting time is considerably retarded in all cases, the effect on the final setting time of the portland cement is even more significant. The mechanisms by which the

percent of water added to portland pozzolana cement (+) and portland cement (*.)

pozzolana reactions contribute to this observation is yet unknown to the author. The pozzolana is siliceous (65.72%) and aluminous (14.33%) material, which in the presence of moisture, even at ordinary temperatures, can react in time to produce calcium aluminate that is responsible for the final setting of the cement paste[2]

Table 7
Average Compressive Strength and flexural strength, unit weight and Slump

Age (days)	endod, percent	Compressive* strength (kg/cm²)	flexural strength (kg/cm²)	Unit wt*. (kg/l)	Slump (cm)	Compressive Strength of mortar	Unit weight of mortar (kg/l)
3	0.00					206	2.25
	0.02					197	2.21
	0.05					115	1.96
	0.08					87	1.94
7	0.00	139		2.14	2	295	2.28
	0.02	117		2.04	3	269	2.19
	0.05	92		1.94	4	171	1.97
	0.08	59		1.74	9	122	1.94
28	0.00	244	53.1	2.13	2		
	0.02	199	39.3	2.04	3		
	0.05	150	36.2	1.92	4		
	0.08	87	33.2	1.78	9		
180	0.00	391		2.12	2		
	0.02	345		2.04	3		
	0.05	250		1.92	4		
	0.08	152		1.78	9		
360	0.00	400		2.19	2		
	0.02	364		2.12	3		
	0.05	271		1.99	4		
	0.08	151		1.85	9		

* of concrete

Air Content

The air content (relative to the Endod free concrete) was determined by the gravimetric method in accordance with ASTM C138-71(10).

The estimated air content increased with the increase of Endod concentration. It is also clear that the air content in mortar mixes is greater than concrete mix.

As expected, the workability was very much improved in those mixes containing Endod. While preparing the cubes, an overflow of the mix containing Endod from the mould was observed after compaction with the vibrator. However, this was much less than the mix made of basalt stones and portland cement. The pores in the scoria probabily behaves as trapping media for the cementitious hydrates[2].

This is further verified from the relative unit weight reduction which is higher in the mix containing basaltic stone and portland cement[1]. However, the unit weight in both mortar (Table 5) and concrete (Table 6) mixes decreases as the percent of Endod increases which is also directly proportional to the amount of air entrained.

Compressive strength

A total of three mortar and concrete cubes were prepared for each test and they were tested for compressive strength after 7,28,180 and 360 days. The average results are given in Table 7. It is evident that the strength of mortar and concrete cubes containing Endod was reduced when compared with cubes containing no Endod. The presence of air bubbles or voids in the cubes is probably responsible for such decrease.

The data of the compressive strength test at 7,28,180 and 360 days was approximately proportional to the amount of Endod in the mixes.

The presence of pumice in portland cement in general significantly improved the compressive strength. For the specimen of age 180 days, however, the strength of the mix containing 0.02% Endod was found to be 11% less than that of the Control and the unit weight is 4% less. For the specimen containing 0.05% Endod, the strength was lowered by 29%, compared with the sample made of portland cement and containing 0.05% Endod which is 46% less[1]. The unit weight is also less by 10%. Concrete mix of lower unit weight and an acceptable strength with overall low cost can be obtained by using Endod of concentration between 0.02 and 0.05%. Thus from the strength data, it can be concluded that some pozzolanic reactions must have taken place during the hydration period.

The relative rate of development of strength of both concrete and mortar cubes stored in water at 20°C can be seen in Table 7.

The compressive strength of both concrete and mortar cubes made of portland pozzolanic cement containing Endod in general increased with age. This rate of increase of strength is more significant than in yhe cubes made of portland cement containing the same quantity of Endod[1], suggesting a high level of pozzolanic activities in enhancing the strength.

Flexural Test

The result of the tensile strength of the concrete beams given in Table 7 indicates that the modules of rapture also decreases as % of Endod increases but less marked in the portland pozzolanic cement cases. The reduction in strength for the case of 0.02% Endod is 26% as compared to 42% in the case of beams made of portland cement. The unit weight is also lowered significantly.

Conclusion

On the basis of strength development data, it seems that the contribution from the pozzolanic reaction is marked after 7 days of hydration and is more pronounced than when using portland cement.

Endod extends the setting time of the cement paste, a property that is useful in hot weather and low humid regions. An increase in the volume of the mix produced by entrained air further leads to a reduction in the amount of cement and sand in order to obtain the necessary slump and workability of the mix. A good part of Ethiopia is covered with scoria which can be used as obtained without any processing (contrary to basaltic which requires crushing) and is very cheap to buy. It is also light weight which will have a reduction in the overall dead weight of the concrete. This will make possible a significant reduction in the cost of building.

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