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ROLE OF ORGANIC GUM ON HYDRATED PHASES OF LIME AND CEMENT MORTAR

S. THIRUMALLINI[a,*], R. RAVI[b], ANIL GIRGOSWAMI[c] and S. KUMARAVADIVEL[c]

[a]SCALE, VIT University, VELLORE (T.N.) INDIA
[b]Department of Civil Engineering, SRM University, KATTANKULATHUR (T.N.) INDIA
[c]Department of Civil Engineering, S. A. Engineering College, CHENNAI (T.N.) INDIA

ABSTRACT

The study was carried out to find the role of organic gums from Drumstick (Moringa Oleifera), Badam (Prunusdulcis), Kikar (Vachellia Karroo) trees on cement and lime paste. Organic tests were conducted on the gum to unearth the amount of proteins, fat and carbohydrate. All gums does not contain fat with around 1% protein. Drumstick contains highest percentage of Carbohydrate while Kikar and badam with around 15%. The Lime and cement were mixed with 8% of of badam gum, 12% of kikar gum and 16% of drumstick gum individually and balls were made based on their binding property. In XRD results, Cement mortar with Kikar is found to have β-Belite (C_2S), which is the strength phase in comparison with Badam and Drumstick. The other hydrated phases in cement mortar are Calcite, Calcium Hydroxide, Calium Aluminate and Triclinic Alite. The principal compounds formed with lime and organic gums are Calcium Aluminate, Calcite, Brucite, β-Belite, Triclinic Alite and Calcium hydroxide. The XRD analysis, the percentage of calcite is very high in Lime mortar with Badam.

Key words: Organic gum, Lime, Cement.

INTRODUCTION

The history of cementing material is old as the history of engineering construction. Various types of cementing materials were used by Egyptians, Romans and Indians in their ancient constructions. The cementing material mostly used by Egyptians is obtained by burning gypsum whereas the early Greeks and Romans used cementing materials, obtained by burning limestone. The Greeks and Romans mixed certain amount of volcanic ash and tuff with lime and sand to yield mortar, that possesses superior strength and better durability

*Author for correspondence; E-mail: p.thirumalini@yahoo.in, ravistrucl@yahoo.co.in

in fresh as well as salt water. The Romans have also added blood, milk and lard to their mortar and concrete to achieve better workability. Haemoglobin is a powerful air-entraining agent and plasticizer, which perhaps is yet another reason for the durability of Roman structure. The cementing material made by Romans using lime and natural or artificial Pozzolana retained its position as the chief building material for all construction works. In about 1800 AD the product thus obtained was called Roman cement. This type of cement was in use till about 1850 AD after which this was outdated by Portland cement, which was invented by Joseph Aspdin.

Literature brings out the usage of natural admixtures such as proteins, polysaccharides and fats, (Vitruvius 1960). Shetty, (2006) has discussed the usage of various natural polymers in different forms of construction around the world. People in different countries used different additive materials to the cement mortar to improve various properties. The use of natural admixtures in concrete was a logical progression. Materials used as admixtures included milk and lard by the Romans; eggs during the middle ages in Europe; polished glutinous rice paste, lacquer, tung oil, blackstrap molasses, and solutions from elm soaked in water and boiled bananas by the Chinese; and in Mesoamerica and Peru, cactus juice and gums from plants were used as admixtures. Chandra et al., (1998) has tested Cactus extract on cement mortar and found increased plasticity, improved water absorption and enhanced freeze salt resistance.

Gums are a group of plant products, formed primarily due to the disintegration of plant cellulose. This process is known as gummosis. Gums are produced by members of a large number of families but commercial exploitation is restricted to a few tree species of Leguminosae, Sterculiaceae and Combretaceae families. The admixtures used in cement mortar are Badam, Kikar (babul), and Drumstick gum.

(a) Kikar (b) Badam (c) Drumstick

Fig. 1: Organic gums

Chemical admixtures are the ingredients in concrete other than Portland cement, water, and aggregate that were added to the mix immediately before or during mixing. The effectiveness of an admixture depends on several factors including: type and amount of cement, water content, mixing time, slump, and the temperature of the concrete and air. Since, it is costly. In this study, various organic gums such as Badam, Kikar and Drumstick (Fig. 1) are used instead of chemical admixture. As the natural organics were used during the ancient times, the chemical reaction of gums with lime is studied first and then it is compared with cement. XRD techniques were used to examine the hydrated phases of hardened cement and lime mortar. Hence the main objective of this study was to characterise the organic additives and to find the hydrated phases responsible for strength and Durability.

Methodology

Chemical analysis of cement and lime

Ordinary Portland Cement of 53 grade and shell lime from Chunnabukulam were used in the study. The chemical composition of lime determined by atomic absorption spectroscopy (Callebaut et al. 2001) and following as per IS: 6932 (Part V) – 1973.

(a) Drumstick (b) Badam (c) Kikar

Fig. 2: Cement balls containing organic gums

(a) Drumstick (b) Badam (c) Kikar

Fig. 3: Lime balls containing organic gums

Preparation of cement and lime balls

Cement and Lime powder was mixed with sufficient gum water to get a stiff paste to make a ball of 50 mm diameter. It is dried for 24 hrs and left undisturbed for a period of six hrs in a basin of water. 20 gms of badam and drumstick, 10 g of kikar was required in 50 g of lime/ cement to make the balls.

Organic Tests on Gums

The 100 g of gums are soaked in the one litre water (Fig. 4) for 24 hrs. The gums were tested for the presence of organics and they are broadly classified as carbohydrate, fat and protein. The presence of fat and protein in the samples were analysed by crude fat method and kjeldhal method. The percentage of carbohydrate present in herbs is calculated.

(a) Badam (b) Kikar (c) Drumstick

Fig. 4: Soaked gums in water

Determination of protein

Proteins are polymers of amino acids. Kjeldahl method is usually considered to be the standard method of determining protein concentration in the form of nitrogen concentration. The kjeldahl method can conveniently be divided into three steps: digestion, neutralization and titration. The sample is first digested in strong sulfuric acid in the presence of a catalyst, which helps in the conversion of the amine nitrogen to ammonium ions. In neutralization, the ammonium ions are then converted into ammonia gas, when heated and distilled. The ammonia gas was led into a trapping solution where it dissolves and becomes an ammonium ion once again. Finally the amount of the ammonia that has been trapped is determined by titration with a standard solution. As the number of moles of ammonia is same as number of nitrogen, the amount of crude protein is given by % Nitrogen x 6.25 [(Cultrone, 2005).

Determination of fat

The determination of fat in mortars are determined by crude fat conforming to IS 7874-1975. The powder sample (5 g) heated at 105 ± 2°C for at least 2 hr was extracted with petroleum ether in a Soxhlet extractor. Extraction was done at a condensation rate of 5 to 6 drops per second for 4 hr initially, and then 2 to 3 drops per seconds for 16 hr. The extract was dried on a steam-bath for 30 min, cooled in a desiccator and weighed as M_1. Alternate drying and weighing were done at 30 min intervals until the difference between two successive weighing was less than 1 mg and the lowest mass was noted as M_2. The mass of dried sample is taken as m. The percent of crude fat content in the plant sample was calculated as follows: $100 \times (M_1 - M_2)/m$.

Calculation of carbohydrate

The percentage of carbohydrate present in herbs was calculated using Eqn. 1.

Total carbohydrate percentage = (100 – (A + B + C + D) Eqn. 3

Where A is percentage by mass of moisture

B is percentage by mass of total protein

C is percentage by mass of fat

D is percentage by mass of total ash.

XRD Analysis

The soaked gums are mixed with cement and lime separately to evaluate the percentage of gum required for formation of ball. This was done to find the binding property of binder with gums. Then XRD was carried out on the powder samples of balls. X-ray diffraction (XRD) analysis of fine samples were carried out by using Bruker Desktop-Diffracometer working with the Cu K-alpha radiation (k = 1.54182), and graphite monochromator in the diffracted beam, at 1.5 kW and interpretation by Bruker DIFFRAC. SUITEEVA Software. It gives qualitative result on the possible presence of minerals in the mortar samples. The chemical reaction of gums with Cement and Lime is studied.

RESULTS AND DISCUSSION

Chemical composition of cement and lime

The results of chemical composition of Cement and Lime are presented in Table 1.

The presence of impurities like alumina, silica and ferric oxide in both lime samples indicates the lime is hydraulic in nature.

Table 1: Percentage minerals in cement and lime samples

S. No.	Minerals	Cement (Range in %)	Shell lime
1	Calcium oxide	60 - 65	62.10
2	Silica	20 - 25	19.5
3	Aluminium oxide	4 - 8	0.63
4	Ferrous oxide	2 - 4	0.27
5	Magnesium oxide	1 - 3	0.543
6	Sulphur trioxide	0.5 - 3	0.5

Properties of fine aggregates

Grain size distribution of sand have been determined as per IS: 2386 (Part 1) - 1963 on mechanical sieve shaker with sieve series (square mesh) of size 2.36 mm, 1.18 mm, 0.6 mm, 0.3 mm, 0.15 mm and 0.075 mm, with sieving time of 10 min. Individual fractions were weighed, and the results were plotted. The properties of sand used as a fine aggregate in the study has been subjected to particle size analysis and the gradation of sand is presented in Table 2.

Table 2: Sieve analysis of fine aggregate

S. No.	Sieve size (mm)	Weight of soil retained (g)	Cumulative mass of soil retained (g)	Cumulative mass of soil passing each sieve (g)	% Finer
1	4.75	35	35	965	96.5
2	2.36	26	61	939	93.9
3	1.18	459	520	980	98
4	0.60	342	862	138	13.8
5	0.30	112	974	26	2.6
6	0.15	14	988	12	1.2
7	0.075	12	1000	0	0

Uniform co-efficient $Cu = \frac{D_{60}}{D_{10}} = 5$ (from graph)

Thus the given type of sand is well-graded.

The graph of sieve analysis is shown below in Fig. 3.

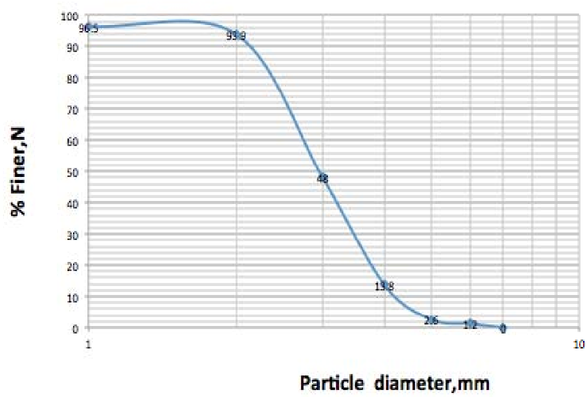

Fig. 5: Particle size distribution of fine aggregates

The results tabulated in Table 3 gives the organic contents of all the three gums. Badam and Kikar gums contained very little quantity of fat while the Drumstick Gum does not contain any fats. The protein content in the gums are around 1%. Drumstick with highest percentage of Carbohydrate (26.74%) while Kikar and badam around 15%.

Table 3: Organic test

Description	Carbohydrates (%)	Fats (%)	Protein (%)
Badam gum	14.90	0.01	0.86
Kikar gum	15.11	0.65	0.58
Drumstick gum	26.74	Nil	1.26

XRD Analysis

The XRD analysis of lime mortarand cement mortar with gums were done to find the mineralogical changes. The principal compounds formed with cement containing organic gum includes Calcite, Cubic aluminate, Alite, Belite and Calcium hydroxide whereas Belite, Calcite, Calcium hydroxide, are the principal compounds formed with lime containing organic gum.

XRD interperatation of lime with drumstick gum

Fig. 6 represents the XRD of lime with drumstick gum which shows the high intense peaks of calcium carbonates and magnesium carbonate peaks at moderate levels.

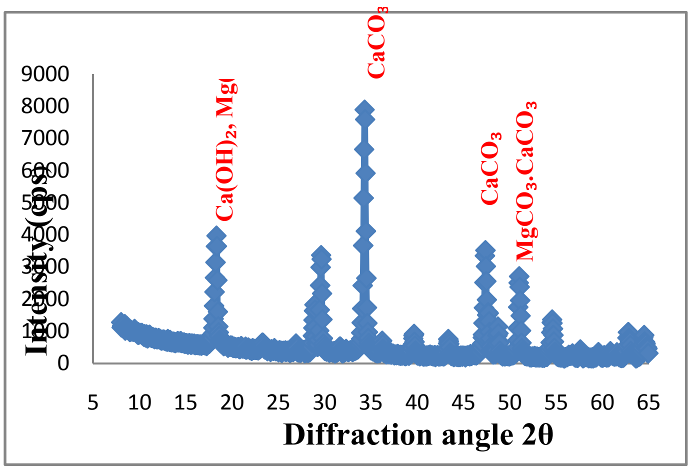

Fig. 6: XRD of lime with drumstick gum

Also the peaks of unreacted lime at moderate intensities has been noticed which represents the possible strength gain as the age progresses. This is an indiction that the gum has provided the carbon source and enhanced the formation of more calcium carbonate in the lime. Also it is well-known fact that carbonation makes the structure harder and more durable (Lanas and Alvarez, 2003). Carbonation plays a vital role in producing stronger and more durable mortars. Carbonation depends on relative humidity, temperature and carbon dioxide (CO_2) concentration (Cowper 2000, Moorehead 1986 and Martínez et al., 2003).

The XRD analysis of lime with badam gum is shown in Fig 7. High intense peaks of portlandite and Magnesium hydroxides have been recorded which is an indication of providing high strength gain to the lime mortar mix in the future. However calcium carbonate peaks at moderate levels have been recorded. Very few traces of unreacted Calcium oxides have also been identified.

Similar to the other two gums under investigation, Calcium carbonate, calcium hydroxide, portlandite and calcium oxide peaks have been identified in the XRD analysis of kikar gum (Fig. 8). Portlandite peaks at higher levels and all other peaks at moderate levels have been noticed.

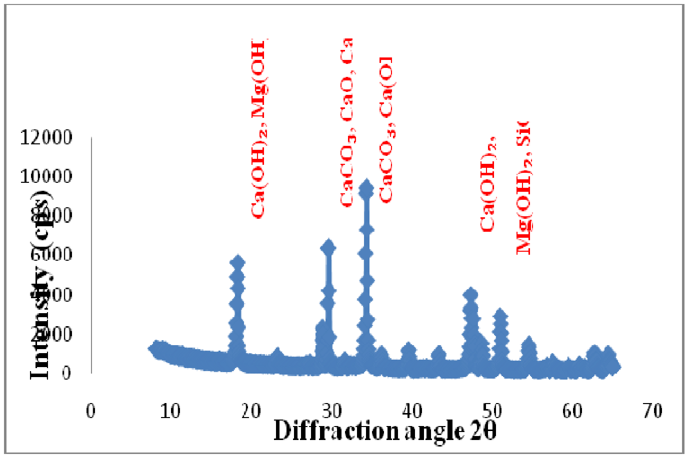

Fig. 7: XRD of lime with badam gum

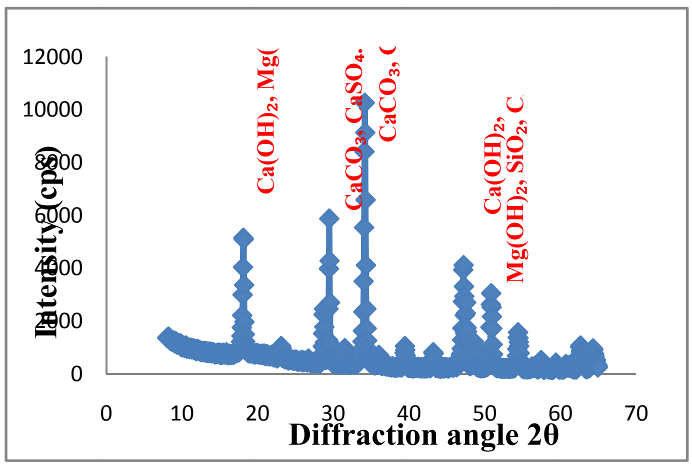

Fig. 8 XRD of lime with kikar gum

Drum stick gum has performed better with lime mortar. The calcite peaks are found at higher intensities which is an indication of higher mechanical properties and also provides better durability to the mortar. Since the portlanite peaks are also identified at moderate levels, there is also wide scope for further strength gain in the lime mortar containing drumstick gum

XRD interperatation for cement with gums

Fig.9 represents the XRD of cement with badam gum. The hydrated phases of C_3S and C_2S have been identified in abundance. Also moderate intensities of aluminium hydroxide peaks have been found. The peaks of calcium carbonate and calcium sulphate have also been recorded at higher levels.

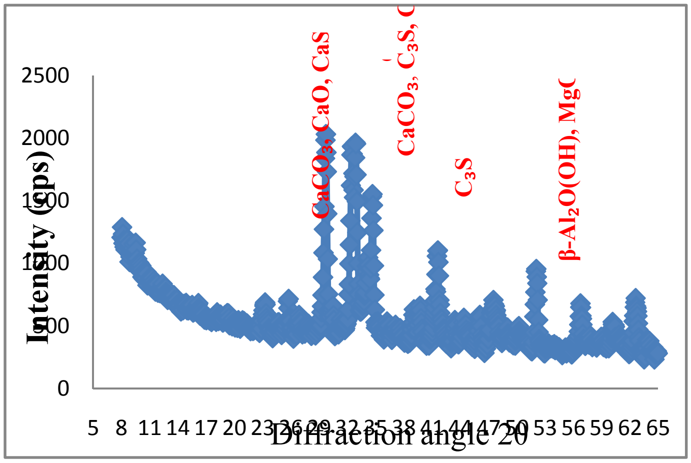

Fig. 9: XRD of cement with badam gum

Similar to the effect of badam gum on cement. The hydrated phases of C_3S and C_2S have been identified in abundance in kikar gum with cement also as seen in Fig. 10. Moderate intensities of magnesium carbonate peaks have been found. High intense peaks of calcium carbonate have also been recorded

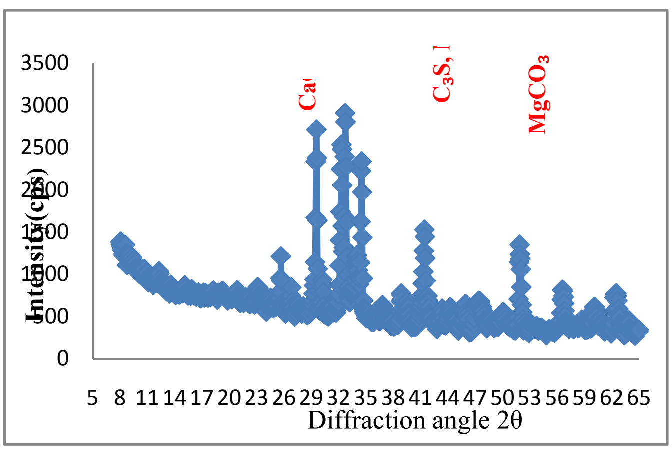

Fig. 10: XRD of cement with kikar gum

In the XRD for cement with drumstick gum shown in Fig. 11 high intense peaks of calcium carbonate with moderate intensities of portlandite, magnesium carbonate and calcium oxide have been obtained.

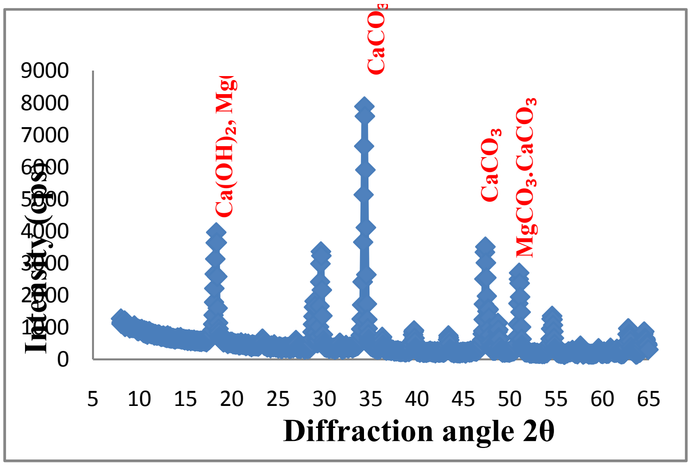

Fig. 11: XRD of cement with drumstick gum

Of all the three natural organics, Kikar gum has a more pronounced effect on the cement which is evident from the identification of C_3S phases in abundance also the portlandite, magnesium hydroxide phases have also been identified in abundance which is good indication of providing high strength and durability to the cement mortar

CONCLUSION

The experimental investigation has been carried out to investigate the possible reaction of three natural organic gums namely Drumstick. Kikar and Badam on the hydrated phases of Lime as well as cement The percentage of gum added.

All the three organic gums have shown indication of better performance to lime mortar Drum stick gum has performed better of all the organics in reacting with lime mortar. The calcite peaks are found at higher intensities that replicates higher mechanical properties and durability to the lime mortar.

Similarly the three organics have provided a pronounced effect on cement mortar also showing signs of strength enhancement and subsequent durability against deteriaration. Kikar gum have shown more reactive hydrated phases of C_3S that could result in higher mechanical resistance.

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