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The Effect of Acacia Tortilis Gums on the Properties of Fresh and Hardened Concrete

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Abstract: *In this paper, the Acacia tortilis Gum, extracted from west of Kurdofan (in western Sudan), is used in concrete mixes after crushing to be in a form of powder .In this study , the use of Acacia tortilis Gum after it proved not to fit for use within the food, where it was became a grinding gum in the form of powder and then added in different proportions of the weight of the amount of cement in concrete mixes at ratio 0.25% ,0.5 % and 1.0 % of cement content .Four concrete mixes were prepared: one as a control mix, three with Acacia tortilis Gum. The study showed that the effect of Acacia tortilis began runny in the concrete mix at ratio 0.25 % of cement content, resulted in the segregation. The compressive strength was measured at ages 7 and 28 days and it was found that the resistance decreased when additive increased to ratio over 0.5% Acacia tortilis. In the concrete mix at ratio 0.5% had turned out gave the ratio, which gave good workability and high compressive strength. While in the concrete mix at ratio 1.0 % gave very low resistance with high workability. The paper showed that the workability can be obtained without effecting on the compressive strength of concrete when adding 0.5% of Acacia tortilis Gum from cement content.*

Keywords: *Acacia tortilis Gum, Kurdofan (western Sudan), concrete, compressive strength, workability*

I. Introduction

Concrete is the second largest material consumed by human beings after food and water. It is obtained by mixing cement, fine aggregate, coarse aggregate and water in required proportions. The mixture when placed in forms and allowed to cure becomes hard like stone. The hardening is caused by chemical Action between water and the cement due to which concrete grows stronger with age.[1] Communities around the world rely on concrete as a safe, strong and simple building material. It is used in all types of buildings (from residential to multistory office blocks) and in Infrastructure projects (roads, bridges, etc). Despite its widespread use, many people are unaware of the considerations involved in providing high quality, strong, durable concrete.

The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, proportion of the mix, the method of compaction and other controls during placing, compaction and curing.

The workability of a concrete mix gives a measure of the ease with which fresh concrete can be placed and compacted. The concrete should flow readily into the form and go around and cover the reinforcement, the mix should retain its consistency and the aggregates should not segregate. A mix with high workability is needed where sections are thin and/or reinforcement is complicated and congested.

The main factor affecting workability is the water content of the mix. Admixtures will increase workability but may reduce strength. The size of aggregate, it's grading and shape, the ratio of course to fine aggregate and the aggregate-to-cement ratio also affect workability to some degree.[2].Also the additives are used to enhance the workability of concrete without adversely effectives its strength [3]

Acacia tortilis Gum: Acacia tortilis, often called the "umbrella thorn" for its distinctive spreading crown, is one of the most widespread trees in, seasonally, dry areas of Africa and the Middle East. The umbrella thorn is the dominant tree in many savanna communities and provides an important source of browse for both wild and domesticated animals.

Chemical Composition and Structural features of Acacia Gums: Gums are complex copolymer of polysaccharide obtained as mixed calcium, magnesium and potassium salt, with high molecular mass and a complex structure. However all Acacia gums are Arab inogalactan-proteins (AGP) and it was described as heterogeneous. The heterogeneous nature of the gum has been studied extensively using different techniques: hydrophobic affinity chromatography, anion-exchange chromatography.

Botanical aspects of Acacia tortilis: Acacia tortilis is one of about 135 African Acacia species. Unlike Australian Acacias, African Acacias are armed with thorns and produce highly palatable pods. Acacia tortilis is a variable species, with six intra specific taxa including four recognized subspecies: tortilis, spirocarpa, heteracantha, and raddiana . Although some French and Israeli authors consider ssp. raddiana a separate species, recent revisions treat it as a subspecies. As with other African Acacias, tortilis is a polyploid complex most are tetrapoloids.

Botanical description: Acacia tortilis varies from multi – stemmed shrubs less than 1m umbrella shaped, and trees up to 20m tall with rounded or flat topped and crowns. Bark grey, grayish brown to yellow, smooth or fissured. Young branches are glabrous. Spines mixed, some white, straight, slender, up to 7.5 cm long, and short hooked brown spine 2-6mm they occur on plant. Leaves dark green (0.5 – 3.0 cm) long, (2-5) pairs. Petiole glandular. Pubescent, (0.2 - 3 mm) long. Flower pale yellow cluster in 1cm diameter round heads. Pods flat, coiled or spirally shaped. Seeds olive green to red brown, smooth, elliptic slightly compressed, 6*35 mm areole marginal, U – shaped, and 4-5 mm long, coiled, seeds lie longitudinally in the pod.

Physical properties of Acacia tortilis gum:Color: The color of the gum nodules is pale yellow to brown.
Shape: The shapes of the gum nodules, as exuded naturally, are irregular or tear shaped.

Solubility: Acacia tortilis gum is highly soluble in water forming transparent solution, and classified as a soluble gum.

Experimental study

In order to achieve the stated objectives , this study was carried out in few stage .on the initial stage ,all the material and equipments needed must be gathered or check for availability. Then the concrete mixes according to the predefined proportions. Concrete samples were tested through concrete tests such as cube test. Finally the results obtained were analyzed to draw out conclusion.

High performance concrete was designed by using ACI curing method. Trail control mixes (M_1)for 7 and 28 days with replacement of cement by Acacia tortilis Gum Additive in concrete with different dosages M_2 0.25%, M_3 0.5%, M_4 1.0 % .

The results of laboratory experiments were analyzed and discussed to investigate the effect of Acacia tortilis Gum additive on workability of fresh concrete and compressive strength of hardened concrete.

Mix Design Method

ACI curing method of mix design was used for mix design for concrete cubes test .concrete specimens with various percentages of Acacia tortilis Gum were prepared .the details of various mix proportions for different replacement levels of cement by Acacia tortilis Gum at 7 and 28 days.

The aggregate dry density used was 1600kg/m^3 ,and the maximum aggregate size use in all mixes was 20mm .using standard cubes moulds (150*150*150) mm, **6** cubes representing each ratio, were casted and tested at age 7 and 28 days.

Components of mix materials:

Water content=170 kg/m^3
Sand content =580kg/m^3
Coarse aggregate content=1380 kg/m^3
Cement content = 395 kg/m^3
Ratios of Acacia tortilis Gum = 0.25%, 0, 5 % and 1 % of cement content.
Cube Area = 150×150 = 22.5 ×103 mm^2
Cube Volume = 150×150×150 =3.375 ×106 mm^3.

The following equations were used to obtain the properties of concrete that was tested.

Poisson's ratio *(v)* = 0.14 (assumed)

$f_c = 0.81\ Fcu$

$E_c = 43\ \gamma^{1.5}\sqrt{f_c} \times 10^{-6,}$ $G = 0.44\ E_c$, $K = \frac{Ec}{3(1-2v)}$ (1)

The result of these experiments have been shown in tables 1 to 5

Results of Experiments of Fresh and Hardened Concrete

The results of fresh and hardened concrete tests conducted by adding different ratios of the Acacia tortilis Gum, examples of this result are shown in tables 1 to 5 and depicted graphically in Figures 1to 5.

Table 1 Results of Slump and Compressive Strength Tests of the Control Mix Using (0.0 % of Acacia Tortilis Gum)

Age	Area (mm^2)	Slump(mm)	Failure Load KN	$\boldsymbol{Fcu}$ N /mm^2	Average F_{cu}	$\boldsymbol{f_c}$ N /mm^2	E_c KN/mm^2	G N/mm^2	K N/mm^2
7 Days	22,500	12	386	17.1					
			371	16.4	16.8	13.6	18.6	8.2	8.6
			380	16.8					
28 Days			583	25.9					
			623	27.7	26.2	21.2	23.3	10.3	10.8
			565	25.1					

Table 2 Results of Slump and Compressive Strength Tests of the Control Mix Using (0.25 % of Acacia Tortilis Gum)

Age	Area (mm^2)	Slump(mm)	Failure Load KN	$\boldsymbol{Fcu}$ N /mm^2	Average F_{cu}	$\boldsymbol{f_c}$ N /mm^2	E_c KN/mm^2	G N/mm^2	K N/mm^2
7 Days	22,500	17	389	17.3					
			397	17.6	17.1	13.9	18.8	8.3	8.7
			370	16.4					
28 Days			532	23.6					
			500	22.2	23.1	18.7	21.9	9.6	10.1
			526	23.4					

Table 3 Results of Slump and Compressive Strength Tests of the Control Mix Using (0.5 % of Acacia Tortilis Gum)

Age	Area (mm^2)	Slump(mm)	Failure Load KN	$\boldsymbol{Fcu}$ N /mm^2	Average F_{cu}	$\boldsymbol{f_c}$ N /mm^2	E_c KN/mm^2	G N/mm^2	K N/mm^2
7 Days	22,500	20	453	20.1					
			444	19.7	20.2	16.4	20.5	9.0	9.50
			480	21.3					
28 Days			587	26.1					
			600	26.7	26.4	21.4	23.4	10.4	10.8
			594	26.4					

Table 4 Results of Slump and Compressive Strength Tests of the Control Mix Using (1.0 % of Acacia Tortilis Gum)

Age	Area (mm^2)	Slump(mm)	Failure Load KN	$\boldsymbol{Fcu}$ N /mm^2	Average F_{cu}	$\boldsymbol{f_c}$ N /mm^2	E_c KN/mm^2	G N/mm^2	K N/mm^2
7 Days	22,500	23	361	16.0					
			355	15.8	16.2	13.1	18.3	8.1	8.5
			376	16.7					
28 Days			515	22.9					
			520	23.1	23.3	18.9	22	9.7	10.2
			536	23.8					

Table 5 Average for Results of Compressive Strength and Slump Tests using (% of Acacia Tortilis Gum)

Acacia tortilis Gum Additive (%)	Compressive strength (N/mm^2)		Slump (mm)
	7days	28 days	
0.0	16.8	26.2	12
0.25	17.1	23.1	17
0.5	20.2	26.4	20
1	16.2	23.3	23

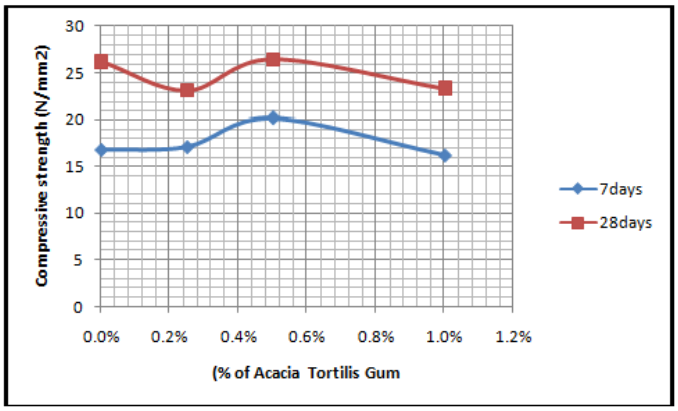

Fig.1 Relation between % of Acacia Tortilis Gum and compressive strength of concrete at ages of 7 and 28 days

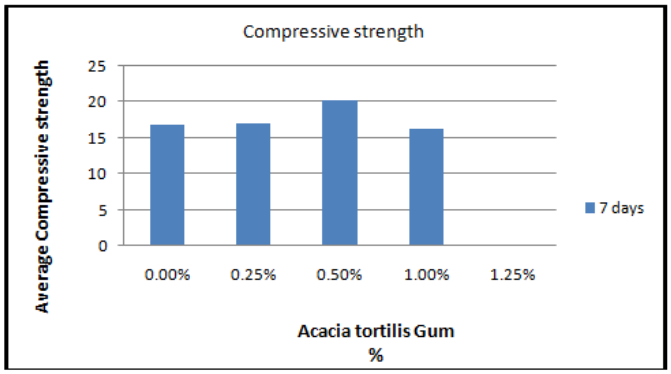

Figure 2 Relation between ratio of Acacia tortilis Gum and compressive strength of concrete at ages of 7days

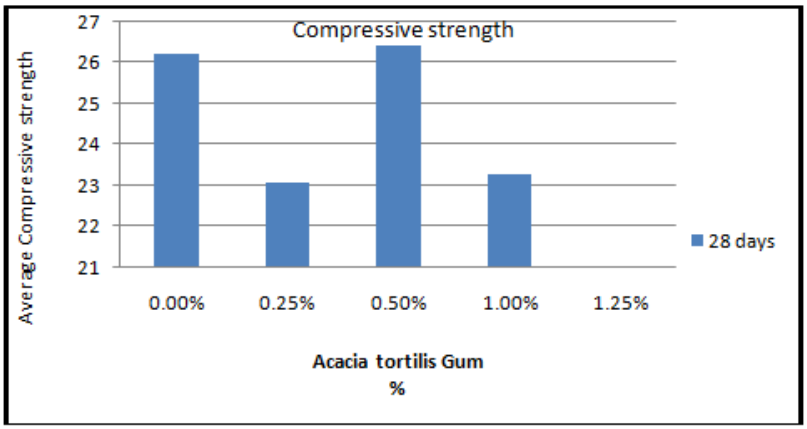

Figure 3 Relation between ratio of Acacia tortilis Gum and compressive strength of concrete at ages of 28 days.

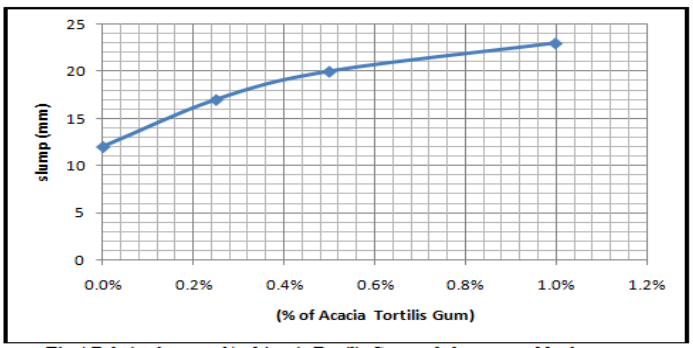

Fig.4 Relation between % of Acacia Tortilis Gum and slump test of fresh concrete

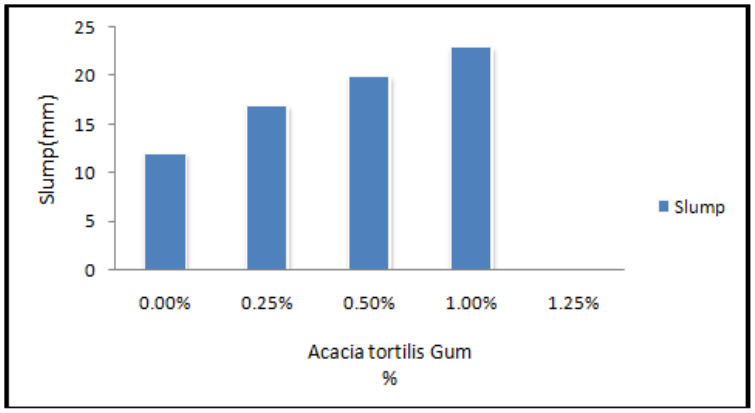

Fig.5 Relation between ratio of Acacia tortilis Gum and slump test of fresh concrete

II. Discussion Of The Results

The results obtained from the different tests are summarized as following:

1. Compressive strength of concrete at the age of 7 days increased with increasing amounts of Acacia tortilis to the ratio of 0.5% Acacia tortilis which gave 20.2 MPa. After it clear there is an effect on the compressive strength of concrete as shown in table 5 and Fig. 1&2.
2. Compressive strength of concrete at the age of 28 days as shown in table 1 and Fig.1&3 noted that:
3. With no additive the value of compressive strength was 26.2MPa.
4. Addition of 0.25% Acacia tortilis, while increasing workability resulted in the reduction of the strength from 26.2MPa (%increase) to 23.1MPa (% redactor).
5. The strength resulted 25MPa(%redact)When 0.5% Acacia tortilis was added with an increase in workability.[10]
6. Addition of 1.0% Acacia tortilis resulted in the reduced of strength to 23.3MPa (%reduction),while the workability increased by amounts of gum to the ratio of 0.5% Acacia tortilis which gave 26.4 MPa greater than 25MPa (specified strength at 28days) and that means effect of Acacia tortilis on compressive strength had been constant as no additive
7. Increased value of slump with increased amounts of Acacia tortilis which give high workability as shown in Fig.5.

III. Conclusions

In this study the Acacia tortilis Gum was used as local additive to investigate its effect on fresh and hardened concrete through the measure of workability for fresh concrete and compressive strength for fresh and hardened concrete in 7 & 28 days. Based on the results it can be concluded that:

1. For fresh concrete the value of slump increased with increased amounts of Acacia tortilis up to1.0 % which give high workability.
2. Addition of 0.25% resulted in segregation showing that the cohesion between the components of the mixture is very little.
3. Thus, it while increasing workability resulted is very little redaction in strength at seven days and a slight increase at 28days.had turned out to be the ratio, which give good workability and high compressive strength.
4. The sample with a ratio of (1.0% Acacia tortilis) with high workability, while resulted in a reduced of strength of % thus leading them very little resistance with high workability.[12]

IV. Recommendations

Based on the result of the study performed in this research, two types of the following recommendations are made:

1. Very low amounts of Acacia tortlilis should not be used as thus result in segregate.
2. 0.5% Acacia tortlilis additive could be used to obtain concrete mixtures with good workability and reasonable strength.
3. An optimization study (in the 0.5 %± range) is required to determine the optimum quality or Acacia tortlilis Gum additive.

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