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The Effect of Gum Arabic Powder and Liquid on the Properties of Fresh and Hardened Concrete

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Abstract:–In this paper, the purest kind of Gum Arabic, extracted from (Hashab) trees (in western Sudan), is used in concrete mixes after crushing to be in a form of powder which was dissolved in water to get the liquid of this additive. In this study, Gum Arabic (G.A.) powder and liquid was added to concrete mixes at ratios 0.1%, 0.2%, 0.4%, 0.6%, 0.8%, 1.0 % and 1.2 % of cement content. Fifteen concrete mixes were prepared: One as a control mix, seven with Gum Arabic powder, and seven with Gum Arabic liquid. The study showed that the addition of Gum Arabic to the concrete mixes has a clear effect when equal to 0.4% of cement content. The compressive strength was measured at ages of 7, 21, and 28 days and it was found that it decreases slightly with increase in the proportion of Gum Arabic in concrete mixes. The paper shows that good results of compressive strength and workability of concrete were obtained when using the Gum Arabic liquid.

Key Words:–Gum Arabic, Hashab, Sudan, strength, workability

I. INTRODUCTION

The objective of this research is to study the behavior of Gum Arabic as a local additive and to detect its effect on the properties of concrete mixes. This was achieved by designing and preparing mixes by adding different ratios of Gum Arabic liquid as percentages of cement content. of mechanical properties, economy, and non-mechanical properties, such as, permeability and durability. Concrete has been extensively used in construction industry since the beginning of the 20th century. Concrete in a wide range of proprieties can be obtained by appropriate selection of the constituent materials and adjustment of their proportions. These properties depend on proper proportioning of the mix components, the thoroughness with which the various components are intermixed, and on the conditions of humidity and temperature in which concrete is maintained until it is fully hardened. One of the main areas of research being investigated is the improvement of concrete performance in terms of mechanical properties, economy, and non-mechanical properties, such as, permeability and durability. Chemicals additives, added to concrete, mortar or grout at the time of mixing, to modify the properties of fresh and hardened concrete. Gum Arabic, also known as gum acacia, chaar gund, char goond or meska, is a natural gum made from the sap taken including two types of acacia trees; Acacia Senegal and Acacia Senegal. Gum Arabic and harvested on a commercial scale from wild trees in the Sahel from Senegal to Somalia and Sudan, although it was there in earlier times in some areas of the Arabian Peninsula in the west of Asia [1].

Sudan is the largest producer of Gum Arabic in the world which produces 70-85% of world production, and produces most of Gum Arabic in Sudan from the tree Acacia Senegal (in Arabic: Hashab) is the tree found naturally in the semi-desert in Africa and some areas of Asia and the Sudan is characterized by the presence of the largest belt of Acacia Senegal in the west. This paper studies the possibility of using Gum Arabic, as local additives, in concrete mixes [2]. In general, local additives have been studied by many researchers such as **Ashraf Mahmoud Saleh (2001)** [3], investigated the effect of Gum Arabic liquid in concrete mixes to obtain high compressive strength concrete and good workability. This was achieved by preparing concrete mixes using Gum Arabic liquid at ratios between 0.2% to 0.8% of cement content. The research concluded that Gum Arabic liquid ratios of 0.6% & 0.8% resulted in high compressive strength and good workability.

Ahmed Abdalla Dafalla (2006) [4], Present a thesis on effect of PFA on fresh & hardened concrete. Mass concrete structures, such as dams, always require special measures to be taken to produce a qualified concrete. The use of PFA in concrete has become an accepted practice partly due to the large body of research work conducted in the area of blended cement to have a consistent concrete and to eliminate heat of hydration as well as to improve the quality of concrete .

This research was formulated to evaluate the performance of concrete when PFA was used at Merowe Dam project, as a replacement of cement in the range 0% to 35% and changing the water –cement ratio from 0.45 to 0.65 adding 0.05.
In trail mix stage, samples of 180 cubes, and 180 cylinders were taken and tested for 3,7,and 28 days.
After full curing a compressive strength tests were performed .The results showed low strength recorded in the early age with the increment of PFA dosage and qualified strength at 28 days.

Osman Alsir Dabluk (2010) [5], Presented a thesis on use of Pozzalana in concrete: a case study of a Pozzolana excavated from the mountain in Bayoda Desert.
Many materials are used to manufacture concrete to get high strength and to reduce the cost by using locally available materials.
In this research, the study of using Pozzolanas of volcanic ash excavated from the mountains in Bayoda Desert as a partial replacement for cement and in different % ages of cement weight 0%, 10%, 20%, 30% was carried out . The compressive strength of concrete was added to Pozzolanas of volcanic ash in the same previous ratios to study their properties to define the best quantities to be added to the concrete to get sufficient strength and to recognize the compressive strength development with time . The mix design for concrete mixture depends on decreasing the water content whenever the ratio of used Pozzolanas is increased.

II. CASE STUDY

In this paper concrete mixes were designed, prepared and tested in the laboratory. At first tests were carried out on the components of concrete mix (cement, coarse aggregate, and fine aggregate). Then several concrete mixes were prepared using powder and liquid of Gum Arabic at ratios of 0.1%, 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, and 1.2% of the weight of ordinary Portland cement. This was done in order to find out the influence of Gum Arabic on the properties of fresh (slump test) and hardened (compressive strength) concrete Gum Arabic was first added as powder to concrete mixes, then in second part of experiments it was added to concrete mixes as liquid after dissolved in water.
The results of laboratory experiments were analyzed and discussed to investigate the influence of both powder and liquid of this additive on workability of fresh concrete and compressive strength of hardened concrete.

III. MIX DESIGN METHOD

The Department of Environmental UK, (DoE) method was used to design concrete mixes. This method considers statistical element to determine the margin for the target strength [6],[7],[8],[9] and [10].
The target strength is given by:
Target strength = characteristic strength + margin
$Kt = Kc + M$
Where the margin M is:
$M = A \times S$
And A is a constant from normal distribution, i.e. 1.64 for 5% defect and S is the standard deviation, therefore;
$Kt = Kc + 1.96S$ for 5% defect .
The aggregate dry density used was 1600 kg/m^3, and the maximum aggregate size use in all mixes was 20 mm
Using standard Cubes moulds (100 * 100 * 100) mm [11], 9 cubes representing each ratio, were casted and tested at ages of 7,21 and 28 days .
Components of mix materials:
Water content = 160 kg/m^3
Sand content = 519 kg/m^3
Coarse aggregate content = 1401 kg/m^3
Cement content = 320 kg/m^3
Ratios of Gum Arabic liquid = 0.1%, 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, and 1.2 % of cement content.
The results of these experiments have been shown in Tables 1 to 5

IV. RESULTS OF EXPERIMENTS OF FRESH AND HARDENED CONCRETE

The results of fresh and hardened concrete tests conducted by adding different ratios of the powder and liquid of gum Arabic, examples of this results are shown in Tables 1 to 5 and depicted graphically in Figures 1 to 9

Table 1: Results of slump and compressive strength tests of the control mix using (0.0 % of Gum Arabic)

Age	Area (mm^2)	Slump (mm)	eruliaF Load (KN)	evisserpmoC Strength (N/mm^2)	Average compressive Strength (N/ mm^2)
7 days	10000	15	285	28.5	30.5
			310	31	
			320	32	
21 days			340	34	34.7
			340	34	
			360	36	
28 days			355	35.5	36.8
			370	37	
			380	38	

Table 2: Results of compressive strength of concrete mixes containing 0.2% of Gum Arabic powder

Age	Area (mm^2)	Slump (mm)	eruliaF Load (KN)	evisserpmoC Strength (N/mm^2)	Average Compressive Strength (N/ mm^2)
7 days	10000	15	350	35	35.0
			340	34	
			360	36	
21 days			320	32	34.3
			360	36	
			350	35	
28 days			370	37	35.0
			330	33	
			350	35	

Table 3: Results of compressive strength of the concrete mixes containing 0.6% of Gum Arabic liquid

Age	Area (mm^2)	Slump (mm)	eruliaF Load (KN)	evisserpmoC Strength (N/mm^2)	Average Compressive Strength (N/ mm^2)
7 days	10000	150	275	27.5	26.8
			285	28.5	
			245	24.5	
21 days			295	29.5	30.8
			300	30	
			330	33	
28 days			360	36	33.0
			290	29	
			340	34	

Table 4: Average for results of compressive strengths and slump tests (% G.A powder)

% G.A (Powder)	Average. Compressive Strength (N/ mm^2) 7 days	Average. Compressive Strength (N/ mm^2) 21 days	Average. Compressive Strength (N/ mm^2) 28 days	Slump (mm)
0.00%	30.5	34.7	36.8	15
0.10%	30.4	34.3	36.3	15
0.20%	30	34	35	15
0.40%	27	30	33.5	15
0.60%	26.2	28.2	32.5	15
0.80%	25	27.5	30	15
1.00%	20.2	24.3	26.5	15
1.20%	16.2	23.2	25	15

Table 5: Average for results of compressive strengths and slump tests ((% G.A liquid)

% G.A (Liquid)	Average. Compressive Strength (N/ mm^2) 7 days	Average. Compressive Strength (N/ mm^2) 21 days	Average. Compressive Strength (N/ mm^2) 28 days	Slump (mm)
0.00%	30.50	34.70	36.80	15
0.10%	30.50	34.50	36.50	15
0.20%	30.20	34.20	36.00	25
0.40%	27.50	32.00	34.00	70
0.60%	27.00	31.00	33.00	150
0.80%	26.00	30.00	31.50	225
1.00%	22.13	26.00	28.00	230
1.20%	17.30	24.00	26.00	240

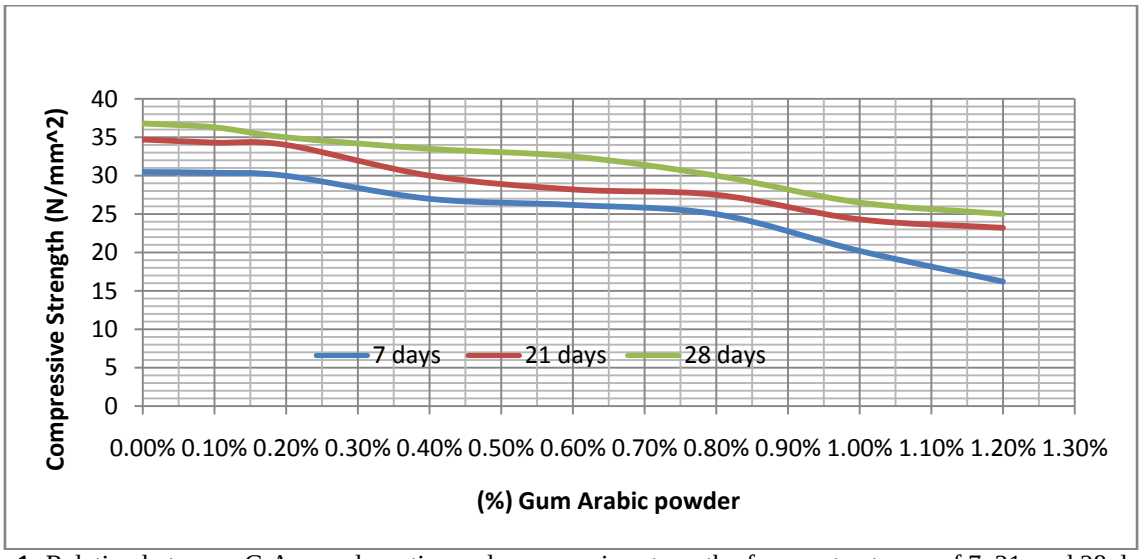

Fig.1: Relation between .G.A. powder ratios and compressive strength of concrete at ages of 7, 21, and 28 days.

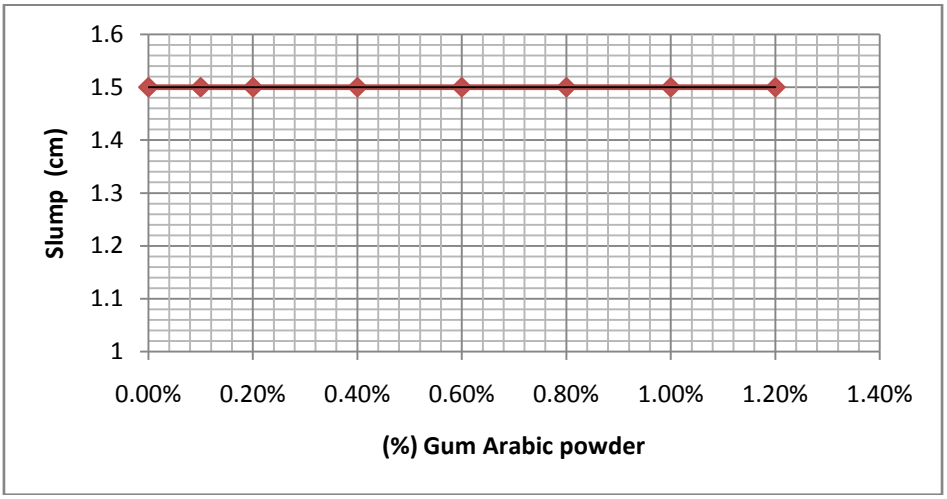

Fig. 2: Relation between powder of .G.A. ratios and slump tests of fresh concrete

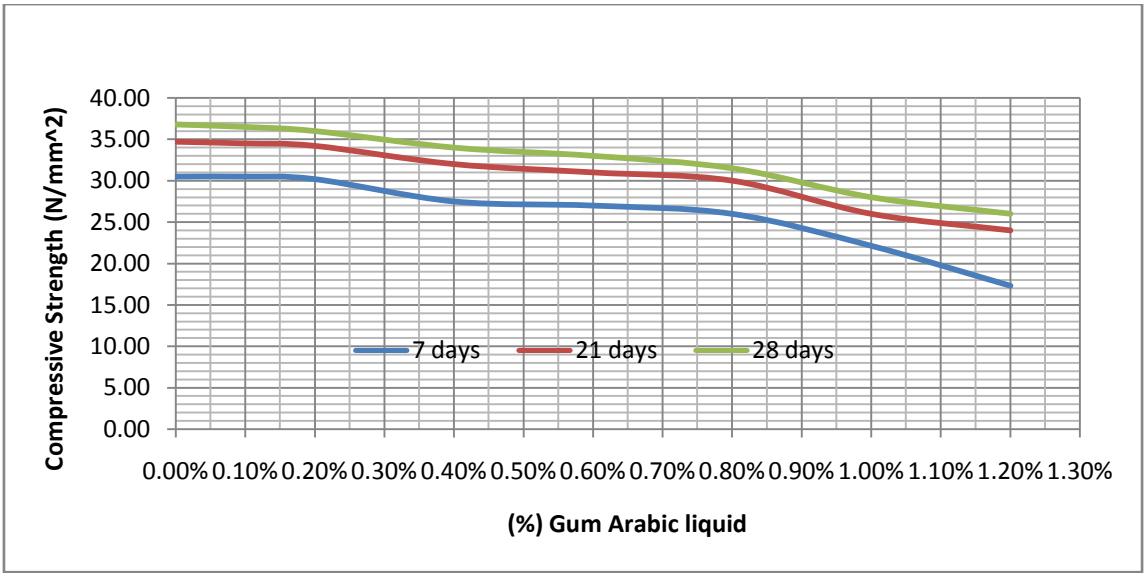

Fig. 3: Relation between G.A liquid ratios and compressive strength of concrete at ages of 7, 21, and 28 days

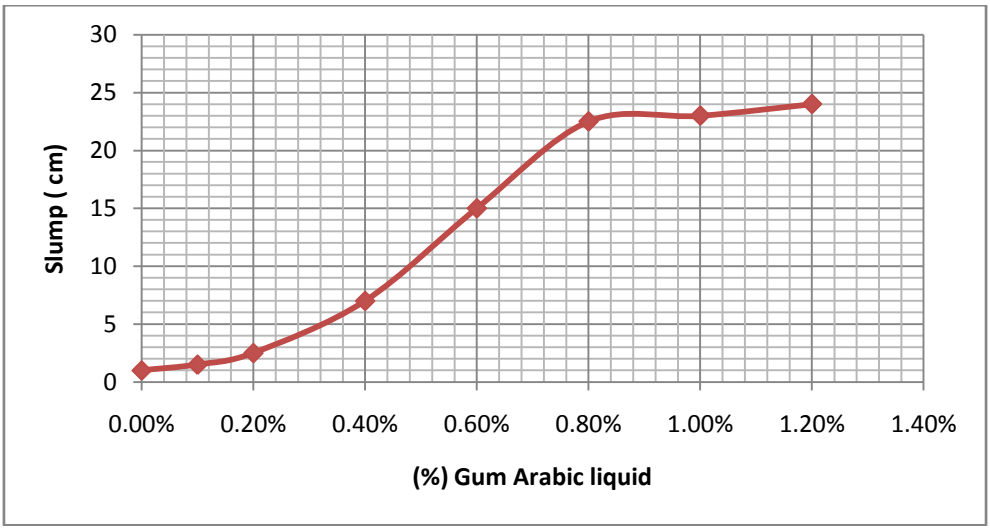

Fig. 4: Relation between liquid of G.A. ratios and slump tests of fresh concrete

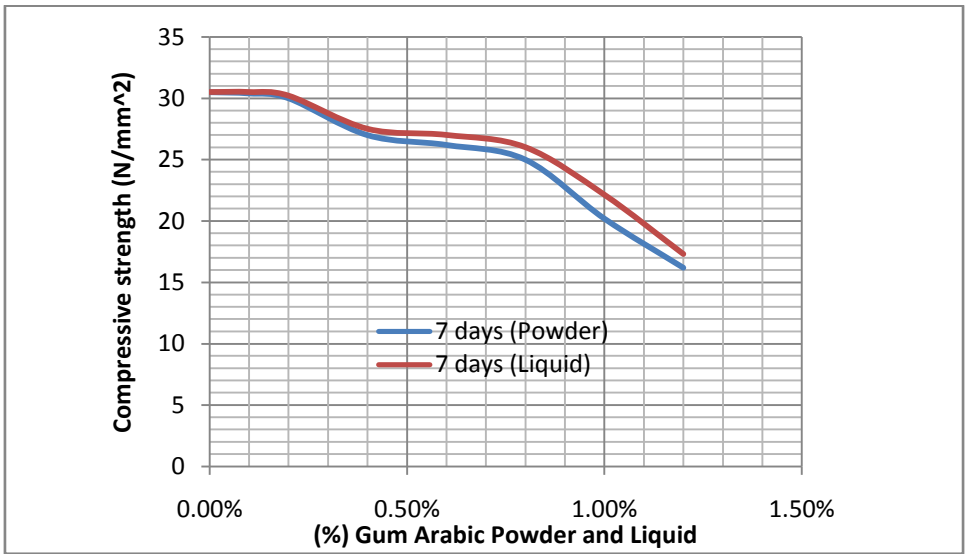

Fig. 5: Relation between liquid and powder of G.A. ratios and compressive strength of concrete at age of 7 days

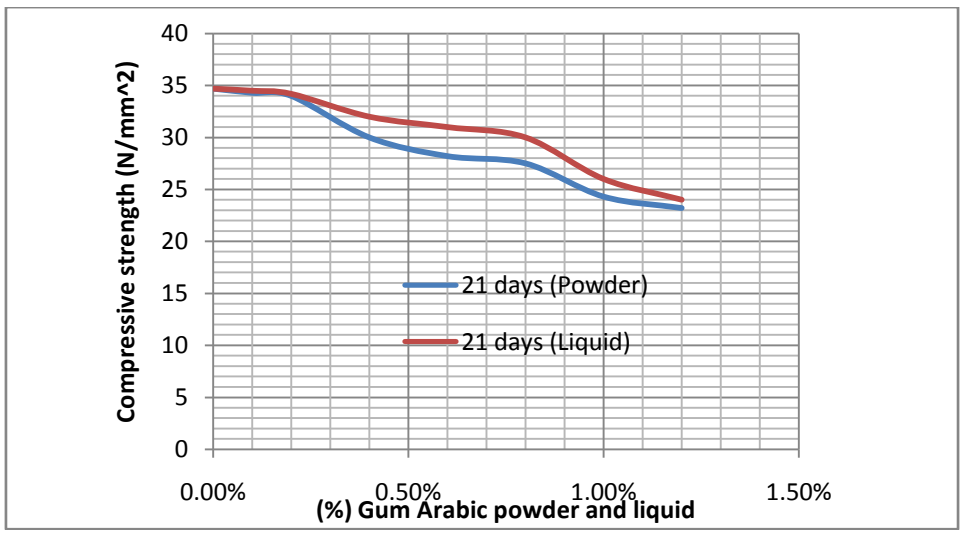

Fig. 6: Relation between liquid and powder of G.A. ratios and compressive strength of concrete at age of 21 days

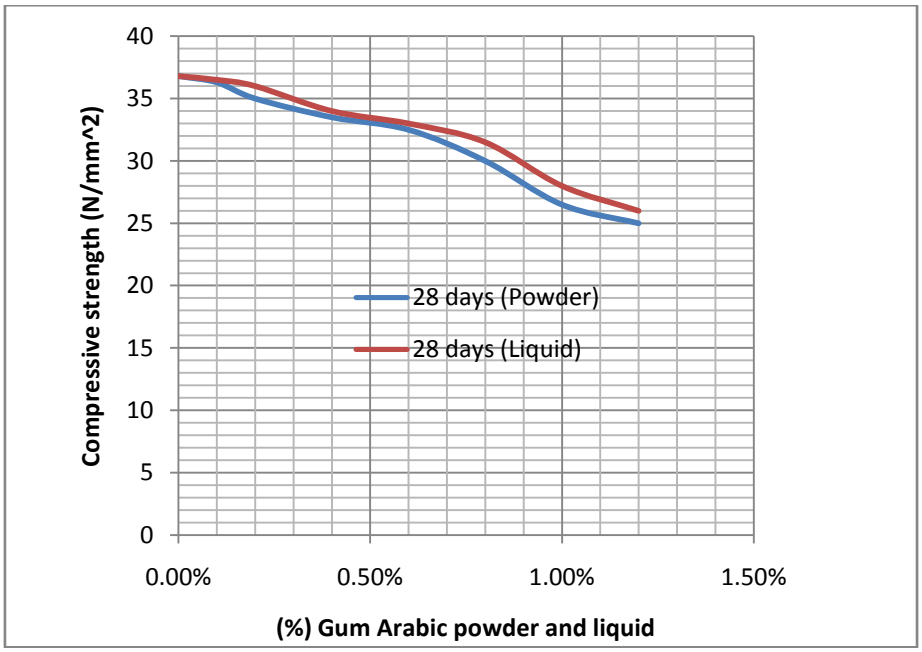

Fig. 7: Relation between liquid and powder of G.A. ratios and compressive strength of concrete at age of 28 days

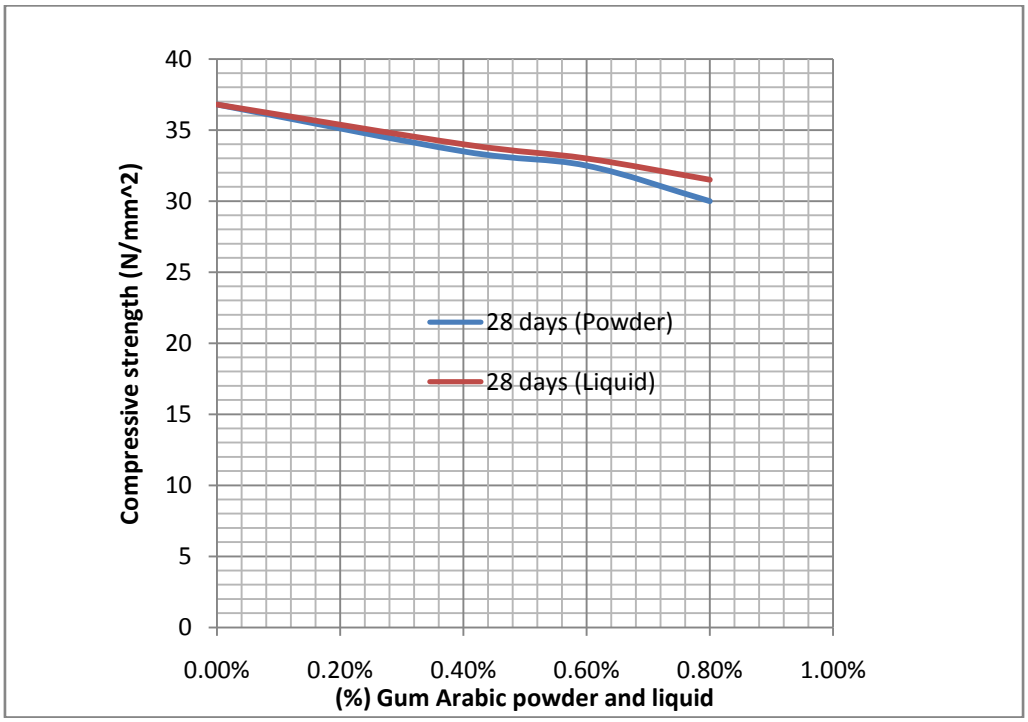

Fig. 8: Relation between liquid and powder of G.A. ratios (0.4%, 0.6% and 0.8 %) and compressive strength of concrete at age of 28 days

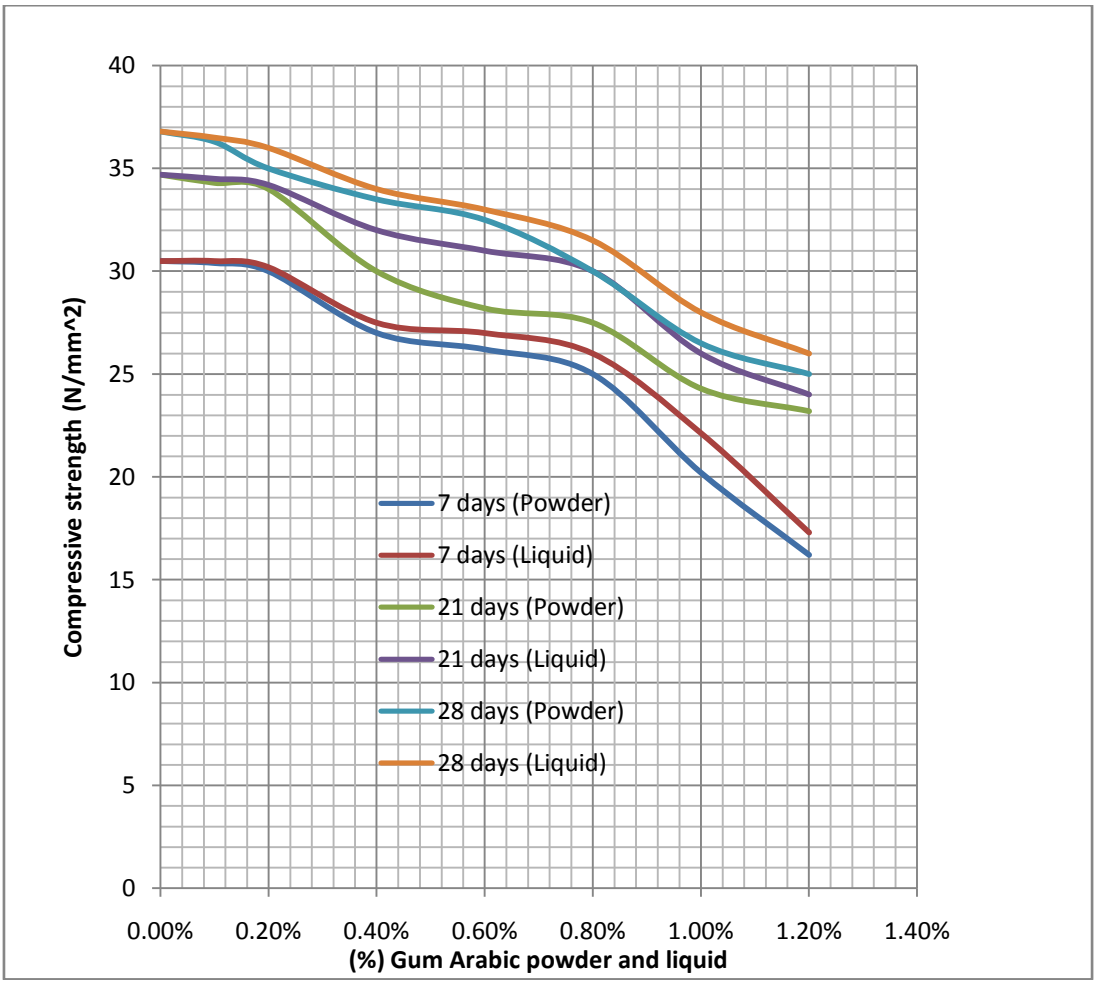

Fig. 9: Relation between powder and liquid of G.A. ratios and compressive strength of concrete at ages of 7, 21, and 28 days

V. DISCUSSIONS OF THE EFFECT OF GUM ARABIC POWDER

1- Tables (2) and Figures (2) show the results of compressive strength and slump test , from which it is found that there was no significant change in the properties of fresh and hardened concrete when adding 0.2% of G.A. powder , during all ages .

2- From Tables (2) and Figures (1&2), the compressive strength values decrease with the increase of the Gum Arabic powder and slump values remain constant in all mixes when adding different ratios of Gum Arabic powder , during all ages, and is thought to be due to the adhesive and bonding properties of this product.

VI. DISCUSSIONS OF THE EFFECT OF GUM ARABIC LIQUID

1- Tables (3&5) and Figures (3&4) , show the results of compressive strength and slump , from which it is found that there was significant change in the properties of fresh and hardened concrete when adding all ratios of G.A. liquid , during all ages, the compressive strength values decrease with the increase of the G.A . Liquid and slump values increase in all mixes at all ages.

2- Figures (5 to 9), show relation between liquid & powder of .G.A. ratios and compressive strength of concrete at different ages.

VII. CONCLUSIONS AND RECOMMENDATIONS

In this study the Gum Arabic extract from (Hashab tree) was used as a local additive to investigate its impact on the fresh and hardened concrete through the measure of workability for fresh concrete and compressive strength for hardened concrete in different ages. From the results obtained it can be concluded that:

1- The significant effect of the G.A. powder and liquid occurred at a ratio of 0.4% of the additive.

2- The compressive strength of concrete decreases in the increase of G.A .powder and liquid.

3- The slump values of all mixes, when adding G.A. powder remained fixed, and the best result of slump was obtained when adding G.A. as liquid additive.

From this study it can be recommended that Gum Arabic liquid or powder should be used as an alternative to chemical additives in concrete mixes.

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