Innovative Systems Design and Engineering
ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online)
Vol 3, No.12, 2012

The Use of Gum Arabic Liquid and Modified Liquid in Concrete Mixes

N.S. Abdeljaleel[1], A. E. Hassaballa[2]*, A.Rahman E. Mohamed[3]

1. Civil Engineer, Dar Consult, Khartoum, Sudan
2. Assistant Professor, School of Civil Engineering, Sudan University of Science and Technology
3. Associate Professor, School of Civil Engineering, Sudan University of Science and Technology

E-mail of the corresponding author: atomha1@yahoo.co.uk

The research is financed by Sudan University of Science and Technology

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 liquid was added to concrete mixes at ratios of 0.1%, 0.2%, 0.4%, 0.6%, 0.8%, 1.0 % and 1.2 % of cement content. Eleven concrete mixes were prepared: One as a control mix, seven with Gum Arabic liquid, and three with Gum Arabic liquid with modified water cement ratios added. This modification was done by reducing water cement ratios in concrete mixes to be 0.4 %, 0.6% and 0.8% of cement content.

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 concrete mixes prepared using modified gum Arabic in its liquid state by reducing (w/c) and adding gum Arabic as a percentage of cement content showed a clear and significant change in the properties of concrete. These ratios resulted in high compressive strength concrete with good workability.

Keywords: Gum Arabic, Hashab, Sudan, compressive strength, workability

1. 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.

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 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.

Afaf Mahgoub Osman (2008) [4], Presented a thesis on high strength concrete by using local materials in Sudan. The objective of this thesis was to obtain a high grade concrete in Sudan by using local available materials and small amount of cement as possible by using cement replacement materials (fly ash), with high workability that is normally required when using pumps to construct structures, high workability was achieved by adding admixture to the concrete mixes to make it workable with low water –cement ratio.

Mahja Mohammed Osman (2010) [5], Presented a thesis on the use of Graygreb's natural Pozzalana in concrete mixes. This research presents an experimental investigation on the use of the natural pozzolanas in concrete mixes. The local natural pozzolanas used in this study were obtained from locations in "Al-Grayegreeb" at central Sudan.

In this study, the natural pozzolanas were used to partially replace Portland cement with 10,20 and 30% by mass of binder . Other mixes of burnt pozzolana with lime was used at 10,20 and 30% by mass . Comparison of the setting time, compressive strength and workability were performed with control mix. With up to 20% pozzolana can increase the initial setting time. Compressive strength depends on pozzolana percentage and curing time. With Burnt Pozzolana and lime high compressive strength and increase in workability and setting time were noticed. Therefore natural pozzolana in Sudan can be used in concrete to replace the cement content.

2. Case Study

In this paper concrete mixes were designed, prepared and tested in the laboratory. At first, tests were carried out on the basic components of concrete mix (cement, coarse aggregate, and fine aggregate). Then several concrete mixes were prepared using 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 liquid to concrete mixes. It was then added to concrete mixes as liquid with modified water-cement ratios by reducing (w/c) from 0.5 to 0.43, 0.45 and 0.48.

3. 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; $Kt = Kc + 1.96\ S$ for 5% defect .

The aggregate dry density used was 1600 kg/m3, 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/m3

Fine aggregate content = 519 kg/m3

Coarse aggregate content = 1401 kg/m^3

Cement content = 320 kg/m3

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

4. Results of Experiments of Fresh and Hardened Concrete

Samples of the results of fresh and hardened concrete tests conducted by adding different ratios of liquid and modified liquid of Gum Arabic are shown in Tables 1 to 5 and in Figures 1 to 5.

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

Age	Areas of cubes (mm^2)	Slump (mm)	Failure Load (KN)	Compressive Strength (N/mm^2)	Average compressive Strength (N/mm^2)
7 days	$(100)^2$	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 slump and compressive strength of the concrete mixes containing 0.8% of G. A. liquid

Age	Areas of cubes (mm^2)	Slump (mm)	Failure Load (KN)	Compressive Strength (N/mm^2)	Average compressive Strength (N/mm^2)
7 days	$(100)^2$	225	270	27	26.0
			240	24	
			270	27	
21 days			320	32	30.0
			300	30	
			280	28	
28 days			300	30	31.5
			330	33	
			315	31.5	

Table 3. Results of slump and compressive strength of the concrete mixes containing 0.6% of G. A. modified liquid

Age	Areas of cubes (mm^2)	Slump (mm)	Failure Load (KN)	Compressive Strength (N/mm^2)	Average compressive Strength (N/mm^2)
7 days	$(100)^2$	12	385	38.5	40.5
			400	40	
			430	43	
21 days			420	42	46.0
			470	47	
			490	49	
28 days			490	49	50.0
			510	51	
			500	50	

Tables 4 and 5 show the average of tests' results shown in Tables 1 to 3.

Table 4: Average results of slump and compressive strength tests of 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)
0.0%	30.50	34.70	36.80	15
0.1%	30.50	34.50	36.50	15
0.2%	30.20	34.20	36.00	25
0.4%	27.50	32.00	34.00	70
0.6%	27.00	31.00	33.00	150
0.8%	26.00	30.00	31.50	225
1.0%	22.13	26.00	28.00	230
1.2%	17.30	24.00	26.00	240

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

G.A. modified Liquid (%)	Average Compressive Strength (N/mm2) 7 days	Average Compressive Strength (N/mm^2) 21 days	Average Compressive Strength (N/mm^2) 28 days	Slump (mm)
0.40%	36.50	41.70	45.60	10
0.60%	40.50	46.00	50.00	12
0.80%	38.38	43.50	47.50	15

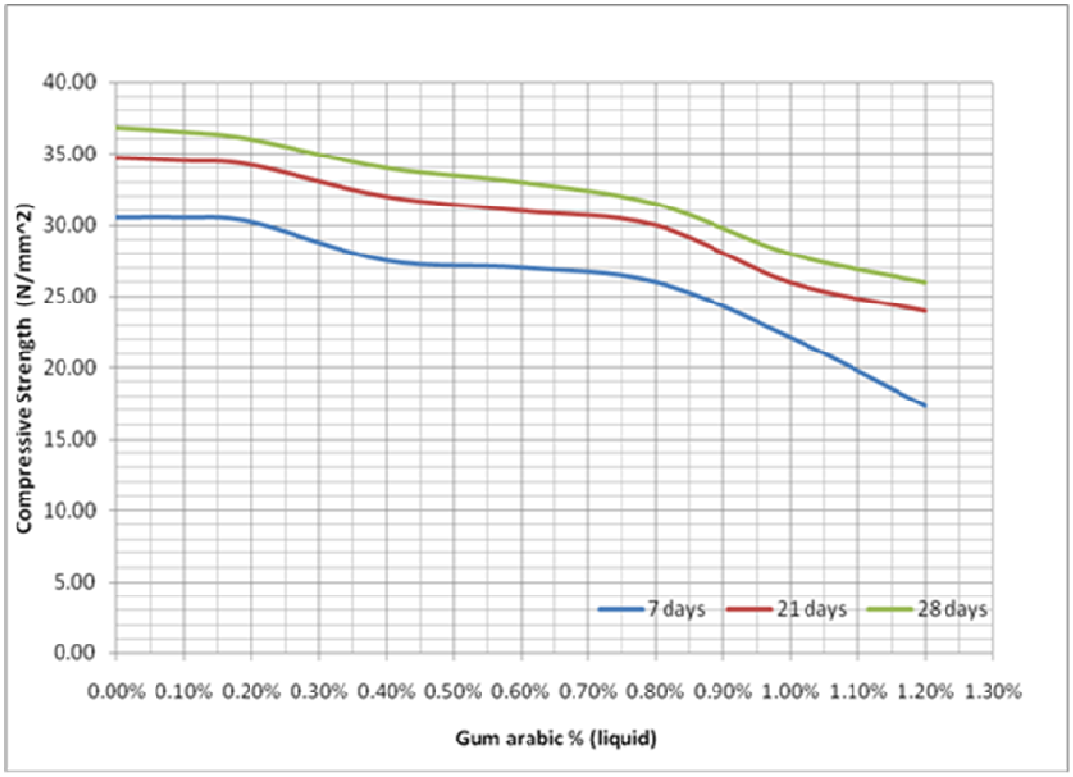

Figure 1. Relation between G.A. liquid ratios and compressive strength of concrete at ages of 7, 21, and 28 days

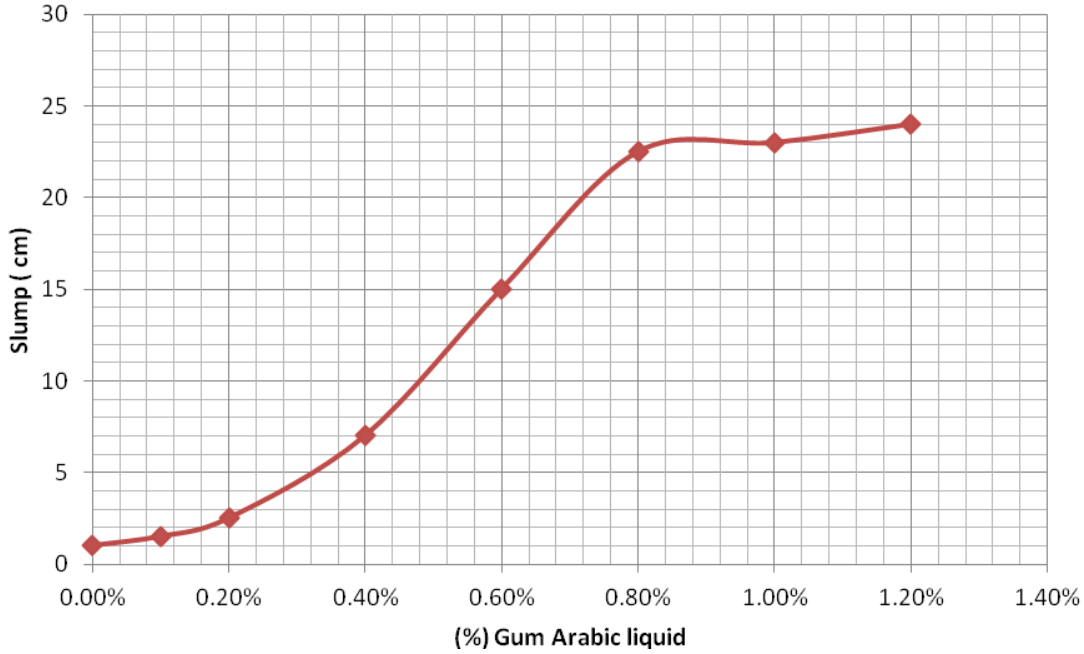

Figure 2. Relation between G.A. liquid ratios and slump tests of concrete mixes

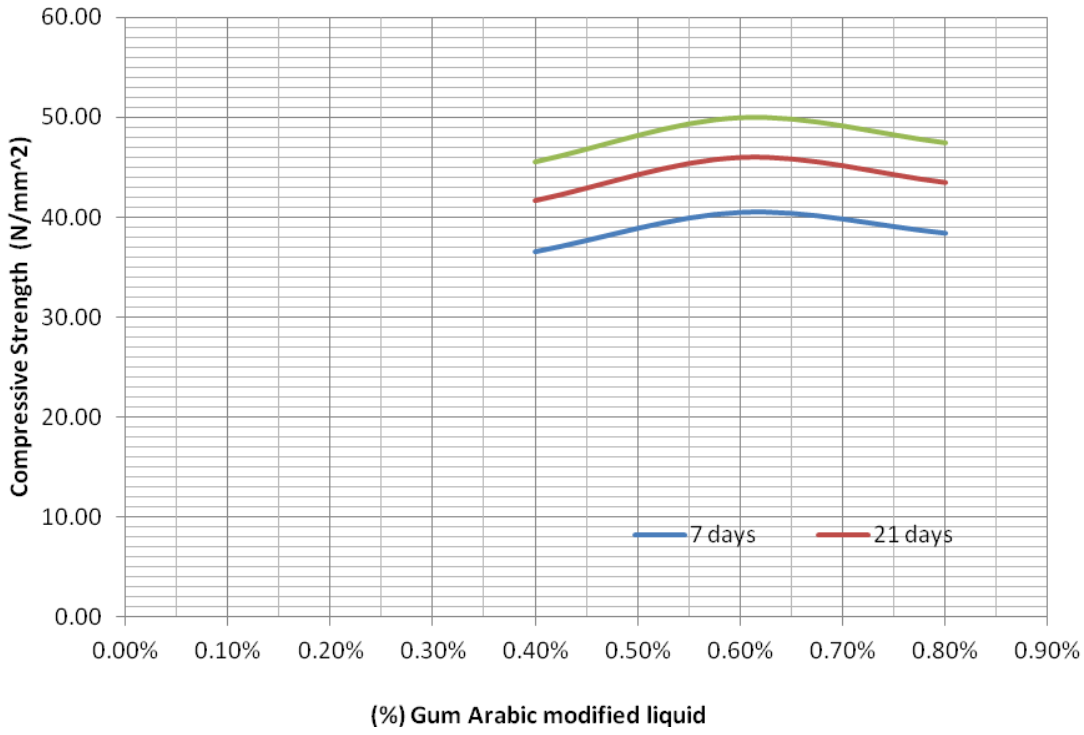

Figure 3. Relation between G.A. modified liquid ratios and compressive strength of concrete at ages of 7, 21, and 28 days

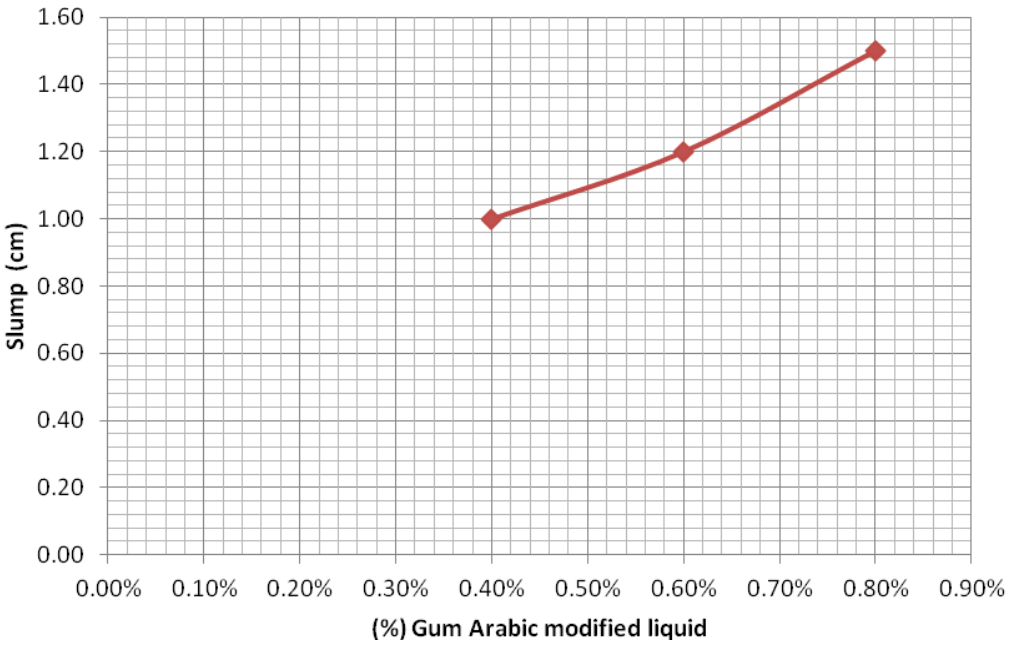

Figure 4. Relation between G.A. modified liquid ratios and slump tests of concrete mixes

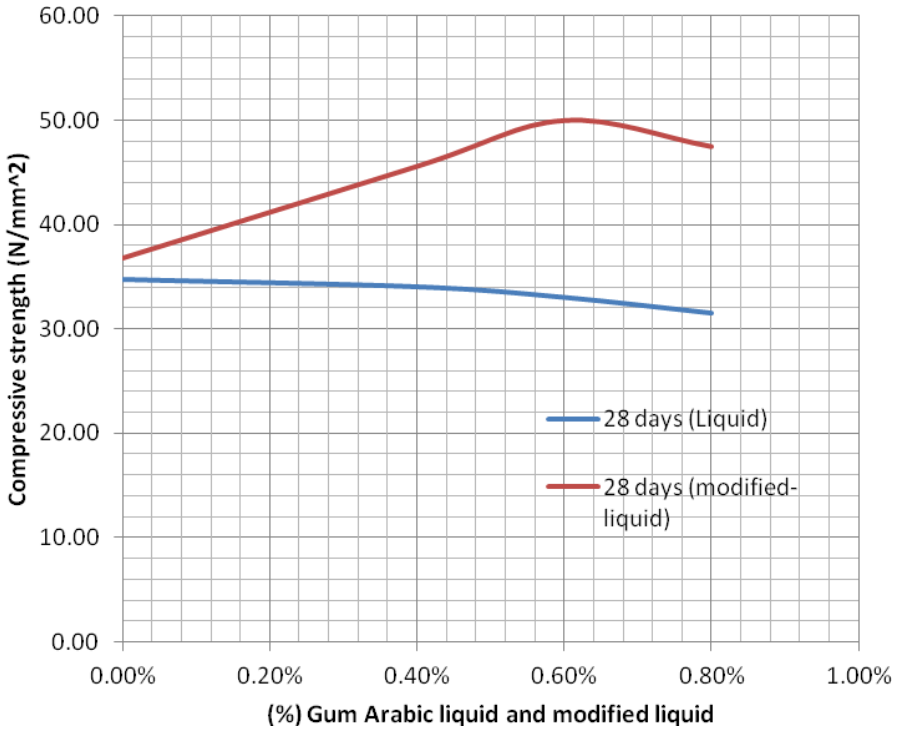

Figure 5. Relation between G.A. modified liquid ratios (0.4, 0.6 and 0.8) and compressive strength of hardened concrete at 28 days.

5. Discussion of the Effect of Gum Arabic Liquid

Tables 2 & 4 and Figures 1&2, show the results of compressive strength and slump, from which it was found that there was significant change in the properties of fresh and hardened concrete when adding all ratios of Gum Arabic liquid, during all ages, the compressive strength values decrease and slump values increase, in all mixes at all ages,

with the increase in Gum Arabic liquid

6. Discussion of the Effect of Gum Arabic Modified Liquid

Tables 3 & 5 and Figures 3 & 4 , show that the compressive strength and slump values increase with the increase in the ratios of Gum Arabic modified liquid, from which it was found that there was significant change in the properties of fresh and hardened concrete when adding ratios (0.4 , 0.6 , and 0.8) of Gum Arabic modified- liquid , and reducing water cement ratio during all ages .

From Figure 5, Gum Arabic modified liquid ratios (0.4, 0.6, and 0.8) resulted in higher compressive strengths than those obtained when adding Gum Arabic liquid to concrete mixes at age of 28 days.

7- 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:

The significant effect of the Gum Arabic liquid occurred at a ratio of 0.4% of the additive.

The compressive strength of concrete decreased with the increase of Gum Arabic liquid.

The compressive strength and slump tests increase with the increase in the ratios of Gum Arabic modified liquid.

From this study it can be recommended that the modified of Gum Arabic liquid ratios 0.6% & 0.8% must be adopted in normal concrete mixes since they obtained the highest values of compressive strength of the hardened concrete.

References

Karamalla, K. A, Siddig. N. E, Osman, M.E. (1998). Analytical data for Acacia Senegal var. Senegal gum samples collected between 1993 and 1995 from Sudan. Food Hydrocolloids, 12: 373-378.

Rahim, A.H. (2006). Economic Analysis of Deforestation: the Case of the Gum Arabic Belt in Sudan, PhD thesis, Wageningen University.

Ashraf Mahmoud Saleh, (2001). High-Strength Concrete and the Resistance through the Improvement of Natural Additions", Ph.D. Thesis, International University of Civil Engineering, Moscow.

Afaf Mahgoub Osman, (2008). High Strength Concrete by Using Local Materials in Sudan, M.Sc. Thesis, Khartoum University, Faculty of Engineering.

Mohja Mohammed Osman (2010). Use of Graygreb's Natural Pozzalana in Concrete Mixes, M.Sc. Thesis, Sudan University of Science & Technology, Faculty of Engineering.

Neville, A.M. & Brooks J.J. (1990). Concrete Technology, Chetek Ulna. Singapore: Longman Singapore Publishers (Pte.) Ltd.

John Newman & Ban Seng Choo. (2003). Advanced Concrete Technology Concrete Properties. Elsevier Ltd.

Ken, W. Day. (1995). Concrete Mix Design, Quality Control and Specifications. Chapman & Hall, London. UK.

Krishna, Raju N. (1994). Design of Concrete Mixes. CBS Publishers & Distributors, Delhi, India.

B.S 1881: Part 125:1986. Method for Mixing and Sampling Fresh Concrete in Laboratory. 389 Cheswick High Road, London, British Standard Institute.

Ziad al-Dairi, (1995). Tests of construction materials. University of Aden, Sana'.