Arid Zone Journal of Engineering, Technology and Environment. October, 2003; Vol.3, 44-48

THE EFFECT OF VARIED MIX PROPORTION AND WATER – CEMENT RATIO ON THE COMPRESSIVE STRENGTH OF MEDIUM GRADE CONCRETE PRODUCED FROM *BAMA GRAVEL*

Onundi, L.O.[1], S.G. Yadima[1] and B.O. Sanyaolu[1]

Abstract

Concrete cubes produced from *Bama gravel* (Category B) using varied mix proportions and water – cement ratios were subjected to compressive strength and density tests at the curing ages of 7, 14 and 28 days. The results indicated that the strength of the concrete is inversely proportional to the water – cement ratio. A maximum compressive strength of 28.00 Nmm^{-2} was recorded from the mix proportion of 1: ½: 4 and water – cement ratio of 0.55, which corresponds to a density of 2495 kgm^{-3}. A careful inspection of the results obtained generally shows that the strengths are inversely proportional to the fine aggregate content and water – cement ratios. It is recommended that great care should be taken while mixing the aggregate proportions of the *Bama gravel* in order to obtain high quality medium grade concrete for construction purposes.

1. Introduction

A popular aggregate called *Bama gravel* exists in Borno and some states in the north eastern part of Nigeria and has been in intensive use as coarse aggregate for concrete production. In some cases this is the only locally available natural coarse aggregate popularly used, because chippings (artificially crushed stones) or other coarser aggregates with higher diameter are very scarce and costly. The location or source of these chippings or coarser aggregate is far from major cities where most of the projects are prevalent within the sub-region. Also, chippings are imported as substitute aggregate materials in order to meet the demand of both private and public developers of civil engineering projects in the north eastern part of Nigeria.

The name "Bama" is prefixed to the gravel because it is found in abundance around Bama town located about 75 km south east of Maiduguri the Borno State capital. Water – cement ratio is the most important factor that influences the properties of fresh and hardened concrete produced from *Bama gravel* (Onundi, *et al.*, 1999). Also, properties of aggregate particles such as chemical and mineralogical composition, specific gravity, hardness, colour, pore structure, size and shape have considerable influence on the quality of either fresh or hardened concrete. Aggregates that comply with BS882 (1975) Standards would usually produce good quality concrete. However, some aggregates may have satisfactory properties but may likely produce poor quality concrete if the correct mix proportions and water – cement ratios are not used.

Onundi *et al.* (1999) reported that *Bama gravel* consists of particle size distribution with diverse range of gradation which varies from very fine to fairly coarse particles. This varied level of particle distribution has implications on the surface area termed specific surface. The higher the specific surface, the higher the required quantity of water and cement in a batch.

[1]Civil and Water Resources Engineering Department University of Maiduguri, Maiduguri

The ogive curves of the *Bama gravel* aggregates commonly available have been categorized into classes *A*, *B* and *C* in accordance with their implications on the specific surface. There is the need to investigate the aggregate mix proportions of the *Bama gravel* classes with a view to producing concrete of satisfactory quality. The aim of this study was to find the correct mix proportion and water – cement ratio for the production of medium grade concrete from class *B* *Bama gravel*.

2. Materials and methods

Samples of the class B *Bama gravel* were obtained from local building sites and vendors in Maiduguri. The samples were collected at two sites in Madube, three sites in Bama, Gudu Kurmi, Firgi and Kawuri. Manually mixed but mechanically compacted concrete cube specimens (150 x 150 x 150 mm) of the gravel with varied prescribed mix proportions (1:½: 4, 1: 1½: 4, 1:2:4, 1:2½: 4 and 1:3:4) and water – cement ratios (0.45, 0.55, 0.65, 0.70 and 0.85) were subjected to compressive strength tests at the ages of 7, 14 and 28 days (Tong *et al.*, 1993). Slump tests were carried out in accordance with BS1881 (1970) guidelines. Densities of the specimens at the specified ages were also determined. The sand used for fine aggregate was obtained from Lake Alau area south east of Maiduguri. Locally sourced Portland cement was used in preparing the samples. The physical characteristics of the mixes as determined by Onundi *et al.* (1999) are shown in Table 1.

Table 1: Physical characteristics of *Bama gravel* collected from various sites

Sample	* Characteristics			
	S.G	S.C (%)	A.I.V (%)	A. C. V (%)
Madube 1	2.76	2.3	22	22
Madube 2	2.59	2.3	23	26
Gudu Kurmi	2.57	2.3	28	26
Bama 1 **	2.64	2.2	23	25
Bakin Gada Bama **	2.58	2.4	25	26
Bama 3 **	2.56	2.6	27	21
Firgi	2.56	2.3	28	27
Kawuri	2.59	2.6	28	26
Mean Value	2.61	2.34%	25.50%	25.11%

* Average of three test results
** Category B of *Bama gravel*
S.G (Specific gravity)
S.C (Silt Content)
A.I.V (Aggregate Impact Value)
A.C.V (Aggregate Crushing Value)

3. Results and discussion

Table 2 presents the results obtained from this study. Out of the prescribed mix proportions (1: ½: 4, 1: 1½: 4, 1:2:4, 1:2½: 4 and 1:3:4) and water – cement ratios (0.45, 0.55, 0.65, 0.70 and 0.85), the mix ratio of 1: ½: 4 and water – cement ratio of 0.55 produced the maximum compressive strength of 28.00 Nmm^{-2} at 28 days, which compares favourably with results expected of grade 25 concrete. It is likely that, aggregate mixes and water – cement ratios higher than 1:3:4 and 0.85 respectively, are likely to produce weaker concrete because of the expected increase in the specific surface in the batch. The results show that the strength is inversely proportional to the fine aggregate content and water – cement ratio (Neville, 1981).

A maximum density of 2495 kgm^{-3} is obtained for the same mix proportion (1: ½: 4) at a water – cement ratio of 0.55. The general trend of the workability in all the mix proportions can be described as " true" for water – cement ratio of 0.45 and 0.55, "Shear" for water – cement ratio of 0.65 and " collapse" for water – cement ratio at 0.70 and 0.85. It was observed that the compressive strength does not necessarily increase as the density when the aggregate material increases disproportionately.

Table 2: Workability, density and crushing strengths of concrete produced from category B *Bama gravel*

Mix	Water-cement ratio	Workability (slump)	*Density (kgm^{-3})			*Strength (Nmm^{-2})		
			Days					
			7	14	28	7	14	28
	0.45	True	2297	2336	2408	17.18	20.00	24.22
	0.55	True	2235	2347	2495	18.00	24.00	28.00
1:½:4	0.65	Shear	2235	2248	2356	18.00	23.00	26.00
	0.70	Collapse	2299	2292	2372	10.38	11.11	15.20
	0.85	Collapse	2179	2196	2185	10.00	11.00	14.00
	0.45	True	2225	2306	2325	18.03	18.75	27.00
	0.55	True	2304	2324	2324	17.00	20.00	26.00
	0.65	Shear	2270	2289	2225	16.00	18.00	25.00
	0.70	Collapse	2205	2237	2285	15.00	17.00	21.00
1:1:4	0.85	Collapse	2203	2214	2233	13.00	14.00	15.00
	0.45	True	2438	2418	2414	15.00	15.78	17.33
	0.55	True	2208	2304	2324	14.00	17.00	23.00
1:1½:4	0.65	Shear	2362	2259	2274	15.00	18.00	22.00
	0.70	Collapse	2230	2275	2300	14.00	17.03	18.00
	0.85	Collapse	2227	2222	2222	12.00	13.00	14.00
	0.45	True	2340	2276	2426	13.80	16.22	20.89
	0.55	True	2191	2170	2261	11.00	13.00	26.00
1:2: 4	0.65	Shear	2210	2190	2240	20.00	22.00	27.00
	0.70	Collapse	2273	2269	2283	9.89	11.42	16.00
	0.85	Collapse	2121	2131	2197	11.00	13.00	16.00
	0.45	True	2313	2249	2412	18.61	10.56	14.29
	0.55	True	2313	2249	2412	8.50	10.40	14.19
1:2½:4	0.65	Shear	2318	2368	2394	10.04	12.00	15.04
	0.70	Collapse	2317	2340	2338	10.00	10.44	15.85
	0.85	Collapse	2356	2306	2420	13.16	14.88	20.34
	0.45	True	2319	2295	2341	7.00	10.02	13.29
	0.55	True	2283	2222	2283	11.00	14.00	25.00
1:3: 4	0.65	Shear	2200	2190	2240	11.00	14.00	24.00
	0.70	Collapse	2237	2365	2423	11.67	11.27	15.98
	0.85	Collapse	2225	2235	2166	11.00	13.00	15.00

* Average of three test results

4. Conclusion

The effects of varied mix proportions and water – cement ratios on the compressive strength of medium grade concrete produced from *Bama gravel* were studied. The results show that the concrete produced met the minimum requirement specified in CP110 (1972) and BS8110 (1985). The mix proportion of 1: ½: 4 and water – cement ratio of 0.55 produced the maximum compressive strength of 28.00 Nmm^{-2} at 28 days. It can be concluded that since the particle size distribution is not uniform within the batch, this will lead to higher water and cement contents in order to satisfy the specific surface requirement.

It is recommended that mechanical method of mixing and compaction should be adopted in order to produce high quality concrete.

5. Acknowledgement

We acknowledge the contributions of Ibrahim, R.D., Tong, H.Y. and the University of Maiduguri Research Committee.

References

BS1881(1970). *Methods of testing concrete*. Publication of the British Standard Institute, Part2.

BS882 (1975). *Specification for aggregate from natural sources for concrete*. Publication of the British Standard Institute.

BS8110 (1985). *Structural use of concrete* . Publication of the British Standard Institute.

CP110 (1972). *Structural use of concrete*. Publication of the British Standard Institute.

Ibrahim, R.D. (1986). Geology of Bama ridge near Maiduguri. Unpublished final year project, Department of Geology, University of Maiduguri.

Neville, A.M. (1981). *Properties of concrete*. London ELDS / Longman.

Onundi, L.O., Y.D. Izam and S.G. Umar, (1999). The categorization and assessment of a local aggregate, *Bama gravel* for the production of a medium grade concrete. *Nigerian Journal of Tropical Engineering*. pp 22-32

Tong, H.Y, A.J. Wakawa and A.B. Maina (1993). Effect of varied mix proportion on the compressive strength of manually mix and compacted concrete made with *Bama gravel* using 0.60 and 0.70 water – cement ratio Unpublished B.Engg project, University of Maiduguri, Department of Civil and Water Resource Engineering.