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EVALUATION OF KONKAR NALA GRAVEL AS NATURAL AGGREGATE

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Various physical and chemical tests on the gravel and sand from the bed of Konkar Nala and the chemical analysis of water from the same site were carried out to determine their suitability as natural aggregate for concrete. The study suggests that because of its upredictable silt, bicarbonates and organic matter content, the aggregates should be subjected to washing and that it should be used in well mixed proportions.

INTRODUCTION

Massive construction in Karachi has almost depleted the sand and gravel reserve in the Malir river bed. This has already given rise to two catastrophes, one is the exhaustion of the ground water level in the adjacent vegetable growing area of Memon Goth and the other is the occurrence of flash floods such as the one in 1977. The flood retaining capacity of the river has been lost since excavation of sand and gravel by transporters has already reached the rock bottom thus depriving the river of the natural process of water absorption. After the flash floods in 1977 the environmentally unsound digging and transportation of gravel [1] was debated and discouraged. Excavation from this site has thereafter been stopped.

Several new sites for excavating gravel were opened, one of them being Konkar Nala whose bed has calcareous but irregular shaped sand similar to that of Malir river [2]. The gravel obtained from Konkar has, however, a disadvantage that its bed is not loose and hence separation of silt from gravel during floods has not taken place extensively. Silt beds are distinctly intermeshed with those of gravel. Such beds being unwashed retain soluble salts and organic impurities.

There are very few detailed reports on aggregates and the present one undertaken at the instance of M/s Association of Builders and Developers is the second on sand and gravel being used in Karachi and the first for Konkar Nala.

This study aims at quantifying the defects, if any, in the gravel and sand and a comprehensive analysis of the aggregates by drawing samples from the site.

METHODOLOGY

Six samples were collected, one being from the silt layer which was intermeshed with that of gravel, one representing a mix containing the admixture of silt and gravel while the others were gravel samples. One sample of water was also collected from a pit at the site. The samples collected [3] were marked and numbered as follows:

Sample No.	Type
(1)	Gravel mix
(2)	Gravel
(3)	Gravel
(4)	Silt from silt layer
(5)	Fine sand and silt mix
(6)	Gravel (Konkar II spot)

Sieve analyses of the samples to determine the percentage of stones and pebbles, sand, silt and clay was carried out by using standard sieves. Chemical analyses of the samples for their water solubles, the chemical composition of the mixes and of water from a pit in the immediate neighbourhood of the site were performed by the usual methods [3,4].

RESULTS AND DISCUSSION

Sieve Analysis. It may be observed from sieve analysis presented in Table 1 and 2 that excepting sample No. 1 all the others contain fine sand, silt and clay. Sample No. 4 which was drawn from the silt layer and the mix sample No. 5 contain over 10 % silt which, if used as such, would be injurious for the construction industry. It may also be noted from Table 1 that all the samples contain stones and pebbles. For example in sample Nos. 1, 3 and 6, the quantity of stones and pebbles is almost one third of the total mix. This is highly undesirable because these ingredients provide an inappropriate mix, reduce the percentage of sand and do not add to the strength as such. On an average the sand content of the mix samples is only 71 %

Table 1. Mechanical analysis (separates).

Sample No.	Stones & pebbles	Sand	Silt & clay
(1)	38.6 %	61.3 %	0.1 %
(2)	19.8 %	77.6 %	2.6 %
(3)	34.8 %	63.4 %	1.8 %
(4)	1.5 %	81.4 %	17.1 %
(5)	4.3 %	83.8 %	11.9 %
(6)	34.7 %	63.4 %	1.9 %

and the silt content is 5.7 %. On the contrary the relevant B.S. Specifications do not allow clay, silt and fine sand content to exceed 5 % by weight in natural sands and 10 % by weight in crushed stones [5]. It may be added here that there is no quality control at the site and lifting of sand and gravel is all indiscriminate. Use of the sand and mix is therefore likely to raise problems in making concrete.

Detailed sieve analysis and a comparison of the analysis curves presented in Figs. 1–6 show that the change between the extreme gradings is not progressive. This happens when a number of intermediate sizes are missing. In such cases there is a danger of segregation. When the curves are superimposed on one another it is found that they intermix and cross over from one to the other and do not run parallel. Under the circumstances i.e. because of the absence of the sizes it would be difficult to obtain an appropriate mix. It may be mentioned here that the use of aggregates with grading similar in type is preferred over totally dissimilar ones.

From the above data it may also be noted that the fineness modulus for sample Nos. 1, 2, 3 and 6 are within reasonable limits. Values of fineness modulus depend on the degree of fineness, higher values are for coarser aggregates and lower ones for fine sand and silt [7]. It is, therefore, possible to say that the materials or the mixes in their present form are not properly graded and one could see that they would be unpredictable in behaviour.

The unpredictable nature just mentioned could mislead the workmen who, in looking for better workability, would use larger quantities of fine sand. Consequently in cases where the concrete is poorly compacted or the joints are not perfectly executed, the voids at the surface of the concrete would lead to efflorescence and would leach out the calcium compounds. The process would be promoted by mixes which contain carbonates and bicarbonates.

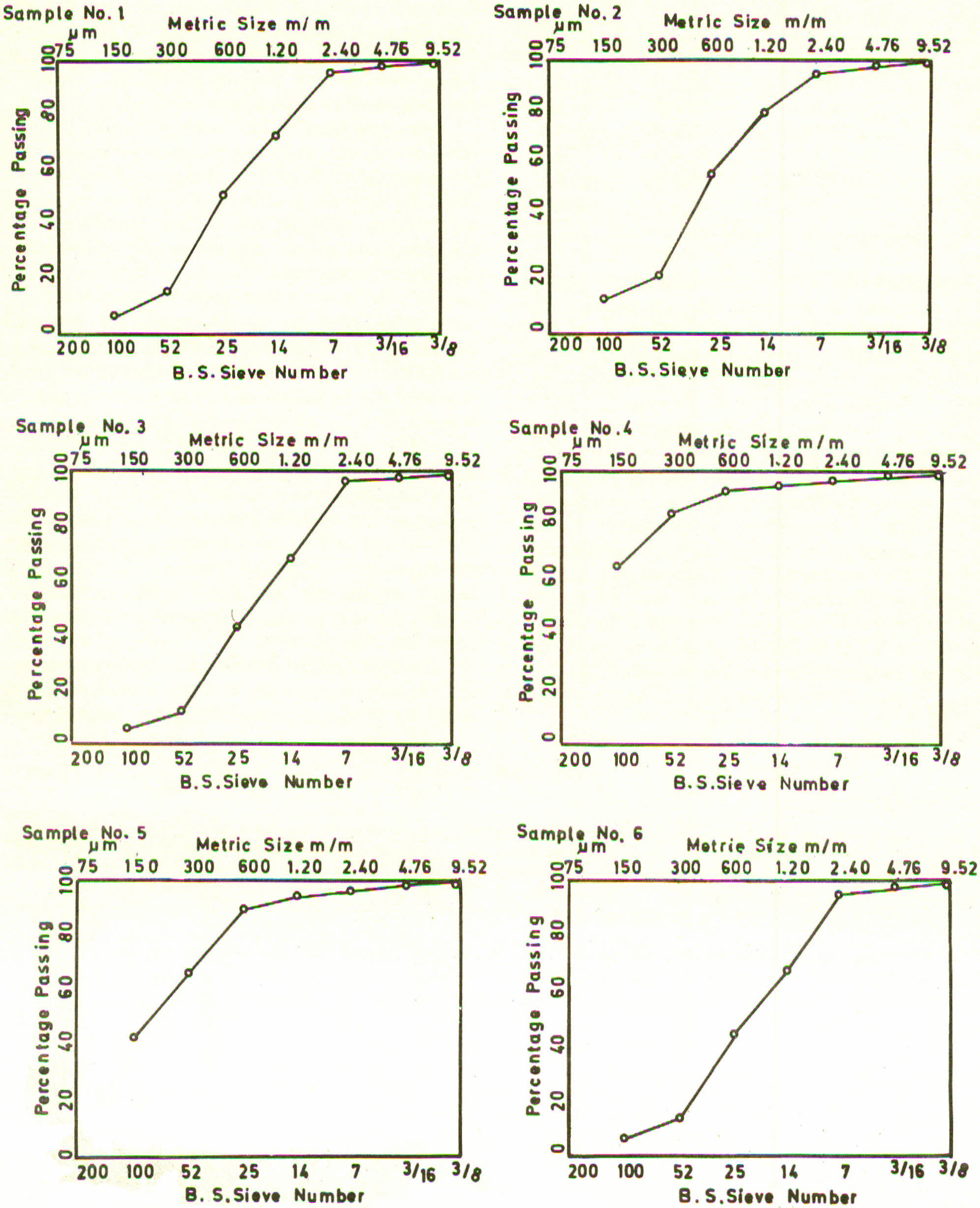
Grading influences the mix proportion for a desired workability of water/cement ratio and hence the coarser the grading the leaner would be the mix which can be used. It should also be mentioned that excess of fine aggregates does not allow full compaction and thus it leads to lowering in strength. Since the Konkar mix is poorly graded, and since the surface texture, shape and allied properties affect the aggregate/cement ratio for a desired workability, it is imperative to know the type of aggregates available. Unfortunately in the case of Konkar aggregates, conditions are extremely variable and therefore one may have to depend entirely on the poorly trained workmen. This suggests the need for strict quality control to be excercised on the site of construction.

Chemical Analysis. Table 3 shows that although the pH and chemical composition of water solubles in sand and gravel are within reasonable limits, the concentration of

Table 2. Sieve analysis.

B.S. Sieve size	Weight retained						Percentage retained						Cumulative percentage passing						Cumulative percentage retained					
Sample Nos.	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
9.5 mm 3/8"	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	100	100	100	100	100	0.0	0.0	0.0	0.0	0.0	0.0
4.76 mm 3/16"	5.0	3.0	5.0	5.0	2.0	3.0	0.6	0.42	0.45	0.59	0.4	0.52	99	99	99	99	99	99	1	1	1	1	1	1
2.40 mm 7	23	13	11	3	5	16	2.9	1.82	1.0	0.35	1.06	2.8	96	97	98	98	98	96	4	3	2	2	2	4
1.20 mm (14)	192	121	315	10	15	168	22.8	17.0	28.9	1.18	3.19	29.4	73	80	69	97	95	67	27	20	31	3	5	33
600 μm (25)	193	150	265	16	22	128	22.8	21.0	24.3	1.88	4.68	22.6	50	59	45	95	90	44	50	41	55	5	10	56
300 μm (52)	288	281	357	85	111	168	34.2	39.5	32.8	10.0	23.6	29.4	16	20	12	85	66	15	84	80	88	15	34	85
150 μm (100)	85	61	81	183	108	43	10.0	8.6	7.4	21.6	22.9	7.5	6	11	5	64	43	8	94	89	95	36	57	92
< 150 μm (100)	57	82	53	545	207	45	6.7	11.5	4.8	64.3	44.0	7.8	–	–	–	–	–	–	–	–	–	–	–	–
Total cumulative percentage retained =																			260	234	272	62	109	271
Fineness modulus =																			2.6	2.34	2.72	0.62	1.09	2.71

Grading Curves



Figs. 1–6

Table 3. Chemical composition of water solubles (Percentage by weight)

Sample No.	(1)	(2)	(3)	(4)	(5)	(6)
pH	6.9	7.35	7.5	6.7	7.85	7.45
Total dissolved solids (TDS)	0.044	0.089	0.082	0.077	0.07	0.051
Sulphates	0.00199	0.012	0.0075	0.01	0.01	0.0015
Chlorides	0.0066	0.012	0.0096	0.013	0.01	0.0065
Bicarbonates	0.026	0.043	0.047	0.034	0.035	0.0292
Magnesium	0.00048	0.0009	0.0019	0.0014	0.00093	0.0014
Calcium	0.0085	0.0140	0.0125	0.011	0.0053	0.0077
Sodium	0.001	0.003	0.002	0.006	0.01	0.002
Potassium	0.0005	0.0012	0.0005	0.0015	0.0015	0.0003

sulphate, chloride and bicarbonates is proportionately quite high. It may be noted that sample No. 2 has a high total dissolved solids (TDS) content, but is well within the 0.15 % limit set for the water soluble impurities in sand by the B.S. specifications for inorganic aggregates. Other samples including the silt sample have total soluble impurities ranging between 0.044 and 0.089 %. Since sample No. 2 is the mix which is accepted by the construction industry and since it contains quite high total dissolved solids (TDS) it is suggested that one must use caution in utilizing this type of mix.

Table 4 lists the analysis of a water sample collected from a nearby pit and indicates a high TDS content of 1,176 ppm which is not acceptable for construction purposes mainly because of the high sulphate and chloride contents. It was observed at the time of collection of the sample that the gravel being lifted from this site was wet with the water having the above noted analysis. As such a proportionate quantity of the salt was being loaded along with gravel thus increasing the salt content beyond acceptable limits.

A comparison of the water analysis with solubles of the sand sample in the vicinity viz. sample No. 3 suggests a correlation and it may be pointed out that although the concentration is not high it would assume serious proportions if several tons of the material is used, because each ton of material would then contribute approximately 1–1.5 kg of dissolved solids. The latter on leaching with water would accumulate at the bottom and could damage the construction undertaken.

Table 4. Comparison of water sample and water solubles of sample No. 3.

	Contents	Water sample	Water solubles of sample No. 3
1.	Sodium	260 ppm	20 ppm
2.	Potassium	10 ppm	5 ppm
3.	Chloride	435 ppm	96 ppm
4.	Sulphate	200 ppm	76 ppm
5.	Calcium	84 ppm	125 ppm
6.	Magnesium	33 ppm	19 ppm
7.	Bicarbonates	110 ppm	42 ppm
8.	Total dissolved solids (TDS)	1,176 ppm	425 ppm

It may also be noted from the analysis in Table 3 that the major constituent of the water solubles is bicarbonates. The latter have a tendency to react with lime formed during hydrolysis of cement paste. This would contribute to efflorescene and hence these aggregates should be used with less intensive leaching.

Concrete is attacked by water containing carbon dioxide. The water even otherwise dissolves calcium hydroxide even if it contains small quantities of carbon dioxide and thus it affects surface erosion. With successive attack of water containing bicarbonates and dissolved carbon dioxide there is a general weakening at the surface. Since the

Table 5. Chemical analysis of the samples of gravel and sand from Konkar

Sample No.	Silica (SiO_2) (%)	R_2O_3 (Al_2O_3+Fe_2O_3) (%)	Calcium oxide+ Magnesium oxide (%)	Loss on ignition (%)	Organic matter (%)
(1)	25.1	2.1	40.6	32.1	0.1
(2)	21.45	2.6	42.1	33.39	0.19
(3)	18.6	1.4	43.2	35.96	1.92
(4)	63.17	4.1	18.3	14.3	0.76
(5)	56.97	4.59	21.4	16.8	0.58
(6)	20.07	2.15	42.3	34.9	0.6

aggregates also contain carbonates and bicarbonates an attack of the calcareous aggregate–concrete mix by the above type of water is quite imminent. Moreover, at a number of places it has been found that well water having bicarbonates ranging upto 400 ppm is being used. This would have a deliterious effect on the strength of the concrete mix which is calcareous by nature.

The detailed chemical analysis [8] presented in Table 5 shows that the aggregate is calcareous in nature. By definition aggregates should be siliceous so as to impart good hardening properties to Portland Cement. The extensive use of calcareous aggregates in a bicarbonate environment is likely to lead to formation of calcium carbonate much earlier than curing would demand and hence the ultimate strength might be affected due to use of non-siliceous aggregates.

The dissolved organic impurities in sample No. 3 is quite high. No upper limit is set for the organic impurities but it appears quite high and seems undesirable since they adversely affect the hardening process, strength and durability of the final concrete.

CONCLUSION

The aggregates from Konkar Nala should be used in well mixed proportions because of the unpredictable silt, bicarbonates and organic matter content. Wet gravel from this area should not be used because it contains soluble salts in larger quantities than the dry ones. If gravel from this area must be used, it should be first subjected to washing so as to remove as much of the salts and silt as is possible.

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