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Research paper

Effect of Using River Sand on The Strength of Normal and High Strength Concrete

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Abstract

The shortage and high cost of quarries sand in some regions around the world has motivated engineers and researchers to investigate the possibility and feasibility of using other materials to be used as a fine aggregate in concrete mixtures. The main objective of this research is to experimentally investigate the effect of using river sand as a partial replacement of the ordinary quarries sand on the mechanical properties of normal and high strength concrete. Nine concrete mixtures were prepared and tested in terms of fresh and hardened properties using different replacement ratios of the required proportion of the normal sand. Four replacement ratios were used for normal strength concrete (NSC) which are: 0%, 25%, 50% and 75%, whereas, five replacement ratios were used for high strength concrete (HSC) namely: 0%, 35%, 60% and 90%. For each strength grade, the test parameters of the prepared mixtures included compressive and tensile strength. The experimental test results have revealed that it is possible to obtain a normal and high strength concrete with acceptable compressive and flexural strengths values by using river sand with replacement ratios up to 25% and 35% for NSC and HSC, respectively. When the replacement ratios were increased to more than the aforementioned ratios, the strength of the concrete decreased accordingly.

Keywords: *Compressive Strength; Flexural Strength; HSC; NSC; Replacement ratio, River sand*

1. Introduction

Aggregates conforming to ASTM specifications are not always economically available for constructional use. In fact, noncomplying materials may satisfy the required performance in some cases, and the commentary of ACI code and ASTM specifications No. C33\03 permitting using nonconforming materials when acceptable evidence of satisfactory performance is provided [1,2]. The declining availability and high cost of normal sand in some regions around the world such as India and Southeast Asian countries has motivated researchers to investigate the feasibility of using other materials to be used as fine aggregate in the concrete production. River sand is one of the economical, sustainable materials that can be used in concrete due to its availability and feasibility. It is mainly obtained by dredging from river beds and since it has been subjected to decades of abrasion and washing, its particle shape is very smooth with very low silt and clay contents. With lower silt and clay contents, the use of river sand helps to improve the quality control of the concrete production because the presence of high contents of silt and clay would adversely affect the workability and strength of the concrete.

Several research studies have been published in the last decade on investigating the use of river sand in normal strength concrete. For example, Jabbar [3] has presented experimental study on the possibility of using river sand in concrete production. Seven different ratios of river sand were used as replacement to the normal sand (from 0% to 50%) with mixing proportions of 1: 2: 4 (cement: sand: gravel) and water to cement ratio of 0.55. Experimental tests results have indicated that the replacement ratio of 35% gives the greatest compressive strength compared to the control mixture with normal sand only. The results have also shown that when using the replacement ratio of 50% with increasing of water/ cement ratio to 0.59, the compressive strength was found to be 19.1 MPa at 28 days which is very close to the compressive strength of the control mixture. Hawi [4] has conducted experimental study to investigate the feasibility of using noncomplying fine aggregate with the Iraqi specification No. 45 - 1984 [9] regarding sieve No.300 in producing concrete. Results have revealed that compressive strength, tensile strength and density of the produced concrete mixture were lower than the corresponding mixture with standard fine aggregate with 9.5% increasing of water absorbing ratio. In addition, the experimental study has shown that using the nonconforming sand with increasing proportion of cement by 10%, the compressive strength, tensile strength and density increased by 8.83%, 11.15%, and 1.01%, respectively with decreasing water absorption ratio by 2.5%. It was further found that when plasticizers were added to the mixture with noncomplying sand using ratio of 1% of the cement content, the compressive strength, tensile strength and the density of the concrete increases by 40.63%, 32.4% 1.98%, respectively with reduction in water absorption by 8% compared with control mixture. Nagpal et al. [5] have presented an experimental study on the possibility of using crushed stone dust as partial or full replacement of fine aggregate to produce different grades of concrete. Two mixtures were firstly prepared using normal sand to achieve M25 and M30 grade of concrete. Other equivalent mixtures were obtained by partially and fully replacing normal sand by crushed stone dust. It has been shown that crushed stone dust waste can be effectively used to replace normal sand in concrete. The concrete with crushed stone dust showed increase in compressive and flexural strength compared to the concrete with normal sand. Hawi [6], has also investigated the effect of using river sand as an alternative to the quarry sand on the mechanical properties of concrete. Three ratios of river sand were used as a replacement to the normal sand which were 25%, 50% and 75% in addition to the control mixture without river sand (i.e. 0%) and using mixing proportions of 1: 2: 4 (cement: sand: aggregate). The experimental test results have indicated that the replacement ratio of 75% gave the highest compressive strength, tensile and flexure strengths compared to the results of the other replacement ratios at 28 day. This conclusion is in contrast with Jabbar's study [3] which has shown that the compressive resistance of the concrete mixture with 35% replacement ratio of river sand was higher than the control mixture with normal sand only. Kumar and Radhakrishna [7] have also presented experimental study on the effect of replacement natural sand by manufactured sand at different ratios on the strength and workability of cement mortar. Cement mortars were prepared using natural sand and manufactured sand as fine aggregate with different replacement ratios. Results have come up with a conclusion that workability of the cement mortar increases with the increase in manufactured sand content up to replacement ratio of 80%. However, the strength of manufactured sand mortar is higher than that of natural sand cement mortar at all replacement ratios. Hence, it was recommended to use the cement mortar with manufactured sand in masonry work.

It can be noticed that all the above-mentioned studies have only considered normal strength concrete and no study has investigated the effect of river sand on the strength of high strength concrete. However, Suresh and Revathi [8] have experimentally investigated the development of the workability, compressive strength and tensile strength of high strength concrete by replacing natural sand by manufactured sand with adding silica fume and fly ash. Four ratios of silica fume and fly ash were used as a replacement of the fine aggregate which are 0%, 5%, 7.5%, and 10% for silica fume, whereas, three ratios of fly ash were also used as a replacement of the fine aggregate, which are 10%, 20%, and 30%. Results have revealed that the maximum strength was obtained at 5% replacement ratio of the silica fume.

The ultimate aim of the present study is to experimentally investigate the effect of using river sand as a partial replacement of the ordinary quarries sand on the mechanical properties of NSC and HSC. Nine concrete mixes were prepared and tested using four replacement ratios for NSC and five replacement ratios for HSC. For each of the nine concert mixes, three cubes and three prisms were cast, cured and tested to determine the compressive and flexural strengths at 28 days.

2. Experimental program

This section describes in details the experimental program conducted in this study including the preliminary tests of the materials used in the concrete mixtures and the proportions of ingredients used to make normal and high strength concrete including the proportion of the admixtures used to obtain HSC. Also, the section presents and discusses the different replacement ratios of the river sand used for NSC and HSC as well.

2.1. Concrete mixture ingredients

Cement: Locally available ordinary Portland cement type I conforming to Iraqi specification No. 5/1984 [9] was used in all concrete mixtures used in the present study.

Fine aggregate (**ordinary quarries sand**): The natural quarries sand was used in this study. A sample of 500g was collected to carry out sieve and to calculate sulfate and fine material contents and the results are shown in **Error! Reference source not found.** and Figure 1. The table shows that the grain size distribution conforming to the Iraqi specification No.45/1984 [9] along with sulfate and fine materials contents

Table 1: Tests results for the normal sand

Fine minerals				Iraqi Specification No. 45/ 1984 (zone 3)	Sieve size analysis	
Iraqi Specification No. 45/ 1984	(SO3) sulfate contents	Iraqi Specification No. 45/ 1984	materials finer than75µm,		% (accumulative passing)	sieve size (mm)
٪0.5	0.34 %	5%	2.75%	100-90	100	4.75
				100-85	95	2.36
				100-75	83.6	1.18
				79-60	61.3	0.6
				40-12	17.8	0.3
				10-0	3.4	0.15

River sand

The British standard BS 882: 1992 [10] defines sand as the aggregate passing the 5mm size of BS410 test sieve and containing no more coarse aggregate than allowed by this standard. According to this standard, the crushed rock sand is considered as one type of the sand that is resulted from crushing rocks in manufactures. The British standard limits fine contents in crushed rock sand to 16% for general use. One the other hand, for the fine aggregate used in construction, the Iraqi Specification No. 45/ 1984), ASTM specifications No. C33\03 and BS standard 882: 1992 limit the ratio of the material passing through the sieve of size 150 micron to 10%, 10% and 15% respectively. However, till now, the Iraqi standards do not consider the river sand for constructional use. Nevertheless, the ASTM specifications No. C33\03 suggests using nonconforming fine aggregate in concrete mixtures provided that the produced concrete satisfies all specified requirements [2]. in this study, the sieve size analysis and sulfate and fine mineral contents tests were conducted on 500g of the river sand used in this experimental study to determine how the river sand is diverted form the Iraqi specification and the results are shown in Table 2 and Figure 1.

Table 2: Tests results for the river sand

Fine minerals				Iraqi Specification for fine aggregate No. 45/ 1984 (zone 3)	Sieve size analysis	
Iraqi Specification No. 45/ 1984	% (SO3) sulfate contents	Iraqi Specification No. 45/ 1984	materials finer than75µm, %		% (accumulative passing)	sieve size (mm)
٪0.5	0.054	5%	3.75	100-90	100	4.75
				100-85	98.2	2.36
				100-75	94.8	1.18
				79-60	91.4	0.6
				40-12	88.4	0.3
				10-0	41	0.15

Figure 1 shows a comparison of the grain size distribution between normal and river sands. As we can see from this figure, the percentages of materials passing through sieve No. 2.36 mm or less is larger in the river sand than that in normal sand. It can also be noticed that the river sand does not meet the requirements of the Iraqi specification No.45/1984 [9] of the gradient of the sand used in the concrete mixtures. On the other hand, Table 2 shows that the sulfate contents of the river sand is much lower than that in normal sand and both conforming to Iraq standards. However, the objective of the present research is to investigate the possibility of using river sand that does not conforming to the standard specifications in grain size distribution in concrete for constructional use. In addition this research aims to investigate the possibility of improving the mechanical properties of concrete containing this noncomplying sand.

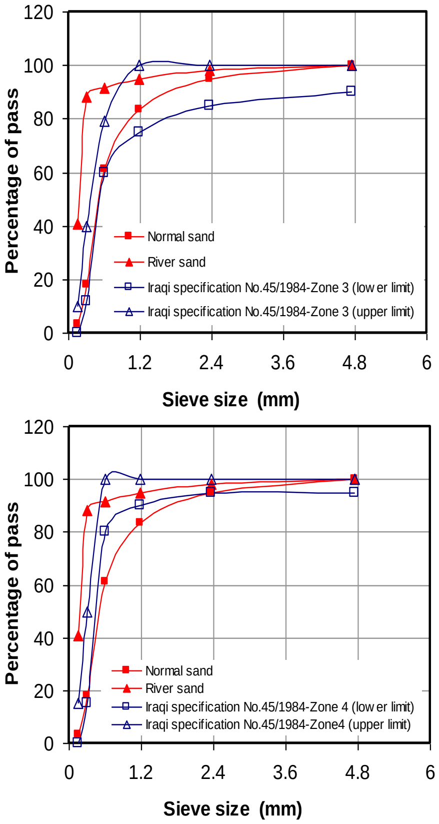

Figure 1: The grain size distribution of normal sand versus river sand with a comparison with of Iraqi Specification.

Coarse aggregate (gravel): Natural coarse aggregate with maximum size of 20 mm was used in this study. A sample of 2000g was used to carry out sieve analysis and to calculate sulfate and fine material contents and the results are shown in Table 3. Test results indicate that the grain size distribution conforming to the Iraqi specification No.45/1984. In addition, sulfate and fine materials contents are also comply with the requirements of the Iraqi specification No.45/1984 [9].

Table 3: Tests results for coarse aggregate

Fine minerals				Iraqi Specification No. 45/ 1984 (size 5-20mm)	Sieve size analysis	
Iraqi Specification No. 45/ 1984	(SO3) sulfate contents	Iraqi Specification No. 45/ 1984	materials finer than75µ m,		% (accumulative passing)	sieve size (mm)
٪0.1	0.045 %	3%	1%	100	100	37.5
				100-95	95	20
				60-30	30	10
				10-0	44	5
				0	0	2.36

Water: Tap water conforms to ASTM C1602 was used for mixing and curing test specimens.

Silica Fume. The American concrete institute [11] defines silica fume as "very fine non –crystalline silica produced in electric arc furnace as a by-product of the production of elemental silicon or alloys containing silicon [10]. It is usually a grey coloured powder, similar to Portland cement or fly ash as shown in **Error! Reference source not found.**. Silica fume is one of the very important admixtures for producing high strength concrete. In this study, silica fume was used as a replacement of 20% of the required content to produce high strength concrete. This material was obtained from the local market and it conforms to ASTM C1240 specification as shown in Figure 2 [1, 12]

Figure 2: Silica fume (left) and Hyper-plasticiser (right) used in the present study

Hyper plasticizer: Plasticizers are essential components for high strength concrete. In this research study, hyper plasticizer (HP 580) was used in the five concrete mixtures to produce HSC. HP 580 is a highly effective polymer based additive which performs extremely well with various types of Portland cement and specifically designed to produce concrete with low water to cement ratio and excellent workability [12]. HP 580 improves the physical and mechanical performance of concrete as well. It is comply with ASTM C 494 specification and compatible with silica fume and other pozzolanic binders. Hyper-plasticizer was used in this study at 0.5 litres per 100 kg of cement to obtain the desired effect according to the manufacturer [13].

2.2. Mixing, casting and curing of cubes and prisms

This research aims to investigate the effect of using river sand on the mechanical properties of normal and high strength concrete. To achieve this goal, nine concrete mixtures were prepared using four and five replacement ratios of river sand for NSC and HSC, respectively.

2.2.1. Normal strength concrete

Four concrete mixtures were prepared using four replacement ratios of river sand for normal strength concrete which are: 0%, 25%, 50% and 75%. For each mixture, the weights of the ingredients were determined and listed in Table 4. These weights were calculated to satisfy the volumetric proportions of 1:2:3 (cement: sand: gravel) and water cement ratio of 0.45 according to ACI mix design procedure [14] to give a nominal compressive strength of 30Mpa at 28 days.

Table 4: Weights of mixtures ingredients for normal strength concrete

Item	Quantity			
	Replacement ratio			
	(0%)	(25%)	(50%)	(75%)
Cement (kg/m3)	240	240	240	240
Normal sand (kg/m3)	540	405	270	135
River sand (kg/m3)	0	135	270	405
Gravel (kg/m3)	820	820	820	820
Water (Litre/m3)	130	130	130	130
Slump (mm)	80	75	40	0

2.2.2. High strength concrete

High strength concrete is defined by the American concrete institute as the concrete that has compressive strength not less than 41MPa [15]. In the present study, five concrete mixtures were prepared for high strength concrete using five replacement ratios of river sand namely: 0%, 10%, 35%, 60% and 90% and the corresponding weights of concrete ingredients is presented in Table 5. These weights were determined to satisfy the volumetric proportion of 1:1.5:3 (cement: sand: gravel) and water to cement ratio of 0.45 according to ACI mix design procedure [14, 15] to give a nominal compressive strength of 41Mpa at 28 days.

Table 5: Weights of mixtures ingredients for high strength concrete

Item	Quantity				
	Replacement ratio				
	(0%)	(10%)	(35%)	(60%)	(90%)
Cement (kg/m3)	221.26	221.26	221.26	221.26	221.26
Normal sand (kg/m3)	400	360	260	160	40
River sand (kg/m3	0	40	140	240	360
Gravel (kg/m3)	800	800	800	800	800
Water (Litre/m3)	108	108	108	108	108
Silica fume (kg/m3)	18.75	18.75	18.75	18.75	18.75
Hyper plasticiser (Litre/m3)	2.4	2.4	2.4	2.4	2.4
Slump (mm)	85	80	60	50	10

According to the instructions of silica fume manufacturer [12], mixing of the ingredients of high strength concrete mixture was conducted using the following steps:
First: Adding the whole weight of coarse aggregate in addition to half of the required quantity of water with the full required weight of silica fume to the mixed drum and mixing all the contents for one and half minutes.
Second: Adding the while required weight of cement and the required quantity of the Hyper-plasticizer and mixing it for one and half minutes.
Third: Adding the required weight of river and sand with the remaining quantity of water and mixing them for a five minutes and then pausing mixing for three minutes and then resuming mixing for another five minutes so that the mixture become homogenous.

As can be seen from Tables 4 and 5 that the slump values decease with increasing of the river sand ratio which indicates the reduction in workability of the fresh concrete.

For each of the nine concert mixes, three concrete cubes with dimensions of (150×150×150) mm and three concrete prisms with dimensions of (100×100×500)mm (height× width× length) were cast, cured and tested to determine the compressive and flexural strengths at 28 days respectively (see Figure 3).

Figure 3: Preparing cubes and prisms for the compressive and flexural strengths tests

2.3. Testing of cubes and prisms

After 28 days of curing, tests were carried out for the concrete cubes and prisms using compressive test and universal test machine available at the concrete laboratory of Engineering College/ University of Al-Qadisiyah (see Figure 4) and following the Iraqi specifications

Cubes: The axial compression tests have been carried out on 12 and 15 concrete cubes to obtain the compressive strength of normal and high strength concrete respectively with river sand. The compression test machine available at concrete laboratory Engineering College / University of Al-Qadisiyah has been used to conduct the tests (see Figure 4- left); Tables 6 and 7 shows the values of compressive strength corresponding to each of the 27 concrete cubes along with the average values used for each group corresponding to each of the nine concrete mixtures.

Figure 4: Compressive (left) and flexural (right) test devices used in the study.

Prisms: One point load flexural tests (see Figure 5) have been carried out on the 12 and concrete prisms to obtain the flexures strength of concrete of normal and high strength concrete respectively containing river sand. The flexural test machine available at concrete laboratory at the Engineering College/ University of Al-Qadisiyah was used to perform the tests; **Error! Reference source not found.** and 9 show the flexural strength corresponding to each of the 27 concrete prisms along with the average values used for each group corresponding to each of the nine concrete mixtures. The flexural strength was calculated form the well-known equation:

$$f_{cr} = \frac{3}{2}\frac{PL}{bh^2} \quad (1)$$

Where P is the applied load; L is the effective length of the prism (see Fig. 5); b and h are width and depth of the prism cross section respectively.

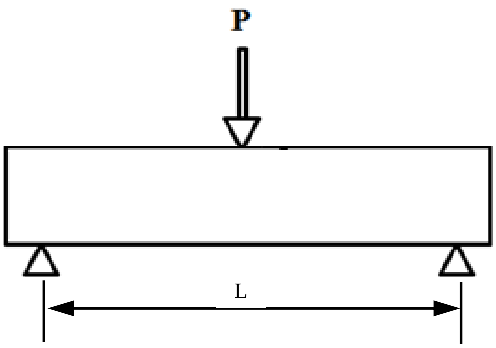

Figure 5: Test set up of the flexural strength

2.4. Results and discussion

This section presents and discusses the experimental tests results of the cubes and prism for normal and high strength concrete.

2.4.1. Compressive strength

Tables 6-7 and Figure 6 below show the compressive strength test results of normal and high concrete cubes at 28 days. It can be noticed from Table 6 that the compressive strength of normal strength concrete has increased with increasing of the river sand ratio to 25% of the required normal sand in the control mixture (i.e. river sands ratio =0%). However, Table 6 and Figure 6 show that the compression strength was decreased at river sand replacement ratios of 50% and 75% and their values are of very limited use in practice. On the other hand, Table 7 shows that the compressive strength of high strength concrete has increased with increasing of the river sand replacement ratio to 35% of the required quantity of normal sand in the control mixture (0%). However, Table 7 and Figure 6 also show that the compression strength decreased at river sand replacement ratios of 60%, and 90% but their values are still within the practical range of constructional use (34.7MPa and 28.23MPa, respectively). This behaviour can be attributed to the fact that river sand has positive and negative effects on the concrete mixture. In the positive effect the small particles of the river sand can fill the voids in the concrete mixture when mixed with coarse aggregates, which means increasing the density of the concrete and increasing the compressive strength accordingly. One the other hand, the low sulphate content (SO3) of the river sand which is about one sixth than the sulphate content in the normal sand in this study has also a considerable effect on optimum gypsum content which, in turn, has significant effect on increasing the compressive strength of the river sand [16]. In the negative effect, the surface area of the sand increases when the ratio of river sand increases due to the small size of river sand particles which leads to the rapid absorption of the water in the concrete mixture by the river sand resulting shortage of water in the mixture. Reduction of the water of the mixture affects the cement hydration process and causes low compression strength on the one hand, and causes low workability of the mixture, on the other hand, as can be noticed form the slump values (Tables 4 and 5). The positive effect of river sand predominate over the negative effect at low ratios of river sand such as the ratio of 25% in normal strength concrete and the ratio of 35% in high strength concrete used in the present study. Also, Figure 6 compares the compressive strength of the concrete mixtures for NSC at different river sand replacement ratios obtained from this study with that recoded in the experimental tests obtained from the available literatures which have used different mix proportions [2,5]. Almost similar trend of the relationship can be seen but with different values of river sand replacement ratios at which maximum and minimum values compressive strength were obtained. This comparison demonstrates the effect of the mix proportions on the value river sand replacement ratio at which the maximum compressive strength of NSC may be obtained.

Table 6: Compressive strength results of cubes for NSC with different replacement ratios of river sand

RS Replacement ratio	Average of compressive strength of three cubes at 28 days (MPa)	Coefficient of variation (C.O.V.) of the compressive strength of three cubes at 28 days
0%	26	0.0225
25%	30.34	0.0190
50%	22.67	0.0255
75%	20.67	0.0280

Table 7: Compressive strength results of cubes for HSC with different replacement ratios of river sand

RS Replacement ratio	Average of compressive strength three cubes at 28 days (MPa)	Coefficient of variation (C.O.V.) of the compressive strength of three cubes at 28 days
0%	44.53	0.0337
10%	40.13	0.1099
35%	45.33	0.0775
60%	34.7	0.0496
90%	28.23	0.0516

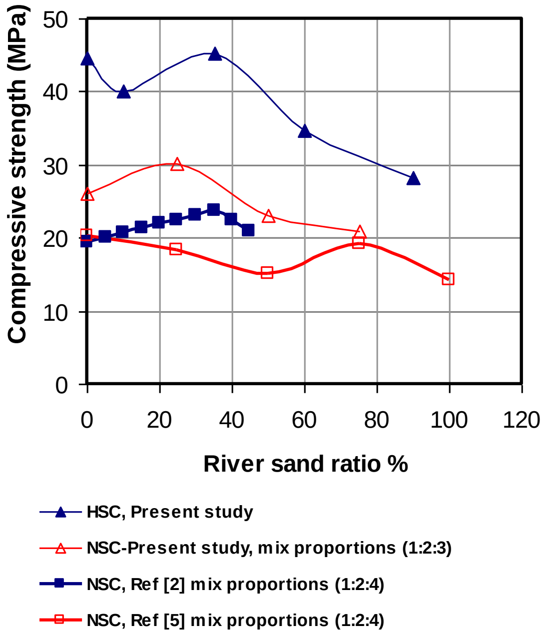

Figure 6: Relationship between compressive strength and river sand replacement ratio

2.4.2. Flexural strength

Tables 8, 9 and Figure 7 below show the flexural strength test results of normal and high concrete prisms at 28-days. It can be noticed from Table 7 that the flexural strength of normal strength concrete has increased with increasing of the river sand replacement ratio to 25% of the required quantity of normal sand in the control mixture. However, Table 7 and Figure 7 show that the flexural strength decreased at river sand replacement ratios of 50% and 75%. Besides, Table 9 shows that the flexural strength of high strength concrete has increased with increasing the river sand replacement ratio by 35% of the required quantity of normal sand in the control mixture. However, Table 9 and Figure 7 show that the flexural strength has decreased at river sand replacement ratios of 60%, and 95%. This behaviour can be attributed to the same effects discussed in the previous sub-section for the compressive strength results. These effects are represented by positive effects of the small particles of the river sand which means increasing the density of the concrete and the low sulphate content (SO3) of the river sand. Whereas the negative effects are represented by the increasing the surface area of the river sand which leads to the rapid absorption of the water in the concrete mixture.

Table 8: Flexural strength results of prism for NSC with different replacement ratios of river sand

(RS) Replacement ratio	Average of flexural strength of three prisms at 28 days (MPa)	Coefficient of variation (C.O.V.) of the flexural strength of three cubes at 28 days
0%	3.75	0.1442
25%	4.35	0.1469
50%	3.6	0.0695
75%	3.0	0.1662

Table 9: Flexural strength results of cubes for HSC with different replacement ratios of river sand

(RS) Replacement ratio	Average of flexural strength of three prisms at 28 days (MPa)	Coefficient of variation (C.O.V.) of the flexural strength of three cubes at 28 days
0%	4.165	0.0136
10%	3.299	0.0239
35%	3.651	0.0401
60%	3.069	0.0665
90%	2.926	0.1709

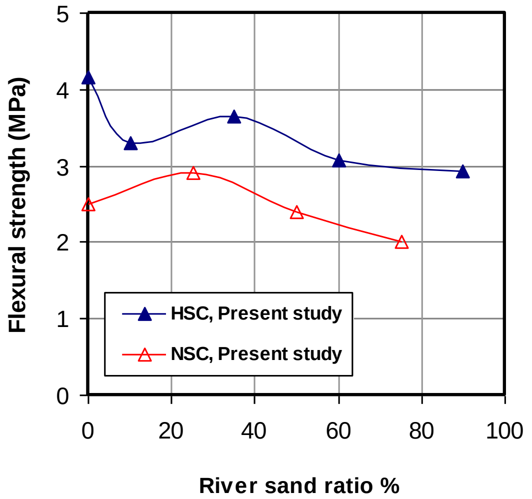

Figure 7: Relationship between flexural strength and river sand ratio

3. Improving the mechanical properties of normal strength concrete with high replacement ratios of river sand.

The experimental tests results have revealed that the mechanical properties of normal strength concrete are adversely affected by increasing of the river sand ratio, particularly at the replacement ratio of 50% and 75%. This section explains and discusses the methods that can be used to improve the compressive and flexural strengths of concrete mixture containing high proportions of river sand.

As discussed in the previous section, the negative effect of the river sand in concrete mixture is the increasing in the surface area of fine aggregate due to the small particle size of the river sand, which leads to the rapid absorption of water mixture by the river sand and shortage in water needed by cement to complete the hydration process. This can be clearly noticed from the values of the slump of mixtures with river sand.
To reduce the effect of the presence of the river sand in concrete mixture and improve the mechanical properties of the normal strength concrete, the negative effect of the river sand may be mitigated by increasing of the proportion of coarse aggregate (gravel) in the mixture and using plasticizers to increase the workability of the mixture.

3.1. Increasing the proportion of coarse aggregate (gravel) in the mixture

Increasing the proportion of coarse aggregate in the concrete mixture containing river sand leads to reduce the surface area of the filler which causes reducing the absorption of the water at early stages of hydration. In this study the proportion of coarse aggregate was increased by replacing 50% of the fine aggregate in the concrete mixture with river sand replacement ratio of 50% which has shown reducing of the compressive strength compared to the reference mixture and using the proportions of 1: 2: 4 (cement: sand: gravel). Three standard cubes and three standard prisms were cast and cured for 28days and the results of compressive and flexural strengths are shown in Table 10.

Table 10: Effect of improving methods on mechanical properties of normal strength concrete

Method of improving	Ratio of river sand replacement	Average compressive strength of three cubes at 28-day (MPa)	Average flexural strength of three prisms at 28-day (MPa)
Section 3.1.1	50%	23	3.3
Section 3.1.2	75%	28	3.43

Table 10 shows that average compressive strength of the improved mixture was 23MPa which is almost the same as the compressive strength of the original mixture with replacement ratio of river sand of 50%. That means no improvement occurred when the ratio of coarse aggregate was increased. It can also be seen from Table 10 that flexural strength was 3,3MPa which is less than the original mixture with replacement ratio of river sand of 50% which was 3.6MPa. This confirms that increasing the ratio of coarse aggregate does not help to improve the mechanical properties of concrete mixture with river sand.

3.2. Using plasticizers to increase the workability of the mixture

In this method, hyper super plasticizer was used to improve the mechanical properties of the mixture with a replacement ratio of river sand of 75% of the normal sand using same water to cement ration of the reference mixture. Using hyper super plasticizer in the concrete mixture increases the workability by slowing up the hydration process and reducing the consumption of water at the early stages of hydration. A 0.5 litre of hyper super plasticizer was used in this study per 100kg of cement. Three standard cubes and three standard prisms were cast and cured for 28 days and the results of compressive and flexural strengths are shown in Table 10. It is shown from Table 10 that average compressive strength of the mixture with hyper plasticiser was 28MPa which is considerably greater than compressive strength of the original mixture with replacement ratio of river sand of 75% which is 21MPa and even greater than the compressive strength of the reference mixture without river sand which is 26MPa. On the other hand, Table 10 demonstrates that flexural strength of the improved mixture was 3.43MPa which is greater than the mixture with 75% replacement ratio of river sand which was 3.0MPa. These results confirm that using hyper plasticizer helps to impose the mechanical properties of concrete mixture with high replacement ratios of river sand such as 75% used in this study.

4. Conclusions

The present study has experimental investigated the effect of using river sand as a partial replacement of the ordinary quarries sand, on the mechanical properties of normal and high strength concrete. Nine concrete mixtures were prepared and tested using four replacement ratios for NSC and five replacement ratios for HSC. For each of the nine concert mixes, three concrete cubes and three concrete prisms were cast and tested to determine the compressive and flexural strengths at 28 days respectively. The following conclusion can be extracted from the experimental results of this study:
1. Using low ratios of river sand in the concrete mixture increases the mechanical properties of the concrete as far as the compressive and flexural strengths are concerned. Using river sand at replacement level of 25% for normal strength concrete and 35% for high strength concrete increased the compressive strength by 16% and 2%, respectively compared to the reference concrete mixture with not river sand.
2. Increasing the replacement ratio of river sand in concrete mixture to more than 25% and 35% for normal and high strength concrete, respectively, leads to decrease in the mechanical properties of concrete. The reduction in the concrete strength increases with increasing of the proportion of river sand in the mixture due to increased surface area of the river sand which causes rapid absorption of the water in the mixture and the decrease in the water in the mixture needed to perform the hydration process.
3. This study has shown that it is possible to improve the compressive strength of the normal concrete with high proportion of river sand (up to 75%) of the normal sand used in the mix by using plasticizers such as super or hyper plasticizer. However, increas-

ing the proportion of coarse aggregate in concrete mixture does not improve the properties of the concrete containing river sand. On the contrary, the experimental tests results have shown a reduction in both compressive and flexural strengths when increasing the proportion of coarse aggregate in the concrete mixture with river sand replacement proportion of 50%

4. It was found that using both hyper plasticizer and silica fume have helped in improving the mechanical properties of concrete with high replacement ratios of river sand (greater that 35%). Such concrete could be used in many structural purposes with acceptable values of compressive and flexural strengths.

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