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Replacement of Sand with Stone Crushed Powder in Conventional Concrete

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Abstract: *Since ancient period, river sand has been used in the construction industry as a dominant material from the level of foundation to the end of a project .Today demand for sand continues to increase to meet the needs of growth in population. Excessive instream sand mining causes the degradation of rivers and creating ecological imbalance. Instream mining lowers the stream bottom, which may lead to bank erosion and may lead for river meandering. It is the need of the hour to investigate for a suitable alternative material for sand like stone crusher powder and granite fines etc. which are available abundantly from crusher units and granite industries. Use of stone crusher powder proves to be economical and eco-friendly which generally considered as unused. The investigations indicate that stone crusher powder has the similar characteristics and performances as that of river sand. In this paper an attempt has been made to investigate the replacement of sand with Stone crusher powder. Strength behavior of concrete with the use of stone crusher powder as a replacement of fine aggregates in different proportions is discussed. Test results are also discussed pertaining to strength and values are compared with conventional concrete.*
Keywords: *Degradation of rivers, Environmental impacts, Stone crusher powder, Alternative material.*

I. Introduction

Concrete is the most widely used composite material today. The constituents of concrete are coarse aggregate, fine aggregate, binding material and water. Rapid increase in construction activities leads to acute shortage of conventional construction materials. It is conventional that sand is being used as fine aggregate in concrete. For the past two years, the escalation in cost of sand due to administrative restrictions in India, demands comparatively greater cost at around two to three times the cost for crusher waste even in places where river sand is available nearby.The function of the fine aggregate is to assist in producing workability and uniformity in the mixture. The river deposits are the most common source of fine aggregate. Now-a-days the natural river sand has become scarce and very costly. Hence we are forced to think of alternative materials. The Quarry dust may be used in the place of river sand fully or partly. A comparatively good strength is expected when sand is replaced partially or fully with or without concrete admixtures. It is proposed to study the possibility of replacing sand with locally available crusher waste without sacrificing the strength and workability of concrete.

II. Concrete materials and their properties

Coarse aggregate of 20mm maximum size is used in Reinforced cement concrete work of all types of structures. This is obtained by crushing the stone boulders of size 100 to 150mm in the stone crushers. Then it is sieved and the particles passing through 20 mm and retained on 10mm sieve known as course aggregate. The particles passing through 4.75mm sieve are called as quarry dust. The quarry dust is used to sprinkle over the newly laid bituminous road as filler between the bitumen and coarse aggregate and manufacturing of hollow blocks. Various physical properties of the concrete materials are tabulated in Table 1.

Table 1: Properties of the materials.

Material	Properties
Crushed granite stone	Maximum size : 20 mm Specific gravity : 2.98 Fineness modulus : 6.36 Density : 1.58gm/cc
River sand	Specific gravity : 2.53 Fineness modulus : 3.08 Density : 1.63gm/cc Void ratio : 0.55
Quarry dust	Specific gravity : 2.57 Fineness modulus : 2.41 Density : 1.85gm/cc

	Void ratio : 0.42
Ordinary Portland cement	Specific gravity : 3.05 Initial setting time : 30 min. Final setting time : 220 min Fineness : 8 % residue on IS 90 micron sieve
Water	PH : 7 Density : 1gm/cc

III. Experimental investigation

3.1. Mix proportioning

Two grades of concrete M20 and M25 having nominal mix proportion of 1:1.5:3 and 1:1:2 respectively were used by weight and w/c ratio was fixed according to the slump requirement of 60mm. For this concrete mix, quarry dust was added for replacement of sand from 0% to 100% in step of 10%.

3.2. Casting of specimen

Mould of size 150 x 150 x 150 mm was used to cast specimens for compression test. Aggregate of size less than 20 mm and greater than 12.5 mm were used. The specimens were cast, tested at the age of 7 and 28 days after curing.

IV. Testing procedure

4.1 Fresh concrete workability

To determine consistency of concrete, Slump test was conducted with varying water content and a particular water cement ratio (w/c) which gives the slump of 60mm was selected from graph. The various w/c for different proportions of sand and quarry dust was presented in Table 2.

Table 2: Workability of concrete (Slump 60mm)

Fine aggregate	Water Cement ratio (w/c)	
Sand: Quarry dust	**M20**	**M25**
100:0	0.420	0.382
90:10	0.435	0.387
80:20	0.450	0.392
70:30	0.460	0.397
60:40	0.480	0.400
50:50	0.490	0.404
40:60	0.500	0.408
30:70	0.510	0.412
20:80	0.525	0.415
10:90	0.530	0.419
0:100	0.540	0.425

4.2. Compression test

The cube specimens were tested for compressive strength at the end of 7 days and 28 days. The specimens were tested after surface of the specimen dried. The load was applied on the smooth sides without shock and increased continuously until the failure of the specimen. The maximum load withstand by the specimens is noted, mean compressive strength is determined and presented in Table 3.

Table 3: Mean Compressive strength of concrete (in MPa) Fine aggregate

Sand: Quarry dust	M20		M25	
	7 days	**28 days**	**7 days**	**28 days**
100:0	19.25	22.22	23.21	31.03
90:10	19.67	22.67	23.54	31.19
80:20	20.35	24.00	23.97	31.52
70:30	20.89	25.33	24.12	31.75
60:40	21.33	25.77	24.29	32.54
50:50	22.67	27.56	24.59	32.92
40:60	20.44	26.22	23.60	31.33
30:70	19.25	23.56	23.37	30.87
20:80	18.15	22.22	20.58	30.24
10:90	17.70	20.89	20.35	29.33
0:100	15.85	20.44	19.67	28.33

4.3. Temperature effect on concrete

Due to increase in temperature the strength of concrete was affected. To find the loss in strength the concrete cubes were kept at 100^0C at an age of 28 days for 24 hrs in an oven and then tested in CTM. The strength obtained is presented in Table 4.

Table 4: Mean Compressive strength of concrete at 100^0C

Fine aggregate	28 days Compressive strength (in MPa)	
Sand: Quarry dust	**M20**	**M25**
100:0	17.63	24.37
90:10	18.29	24.50
80:20	18.52	25.15
70:30	18.59	25.39
60:40	19.11	25.41
50:50	20.74	26.75
40:60	19.85	26.30
30:70	19.48	25.15
20:80	19.33	23.87
10:90	17.77	22.77
0:100	16.96	19.90

Due to sudden cooling (thermo shock) the strength of concrete was affected. To find the loss in strength the concrete cubes were kept at 100^0C at an age of 28 days for 24 hrs in an oven and then immersed in water for few minutes and then tested in CTM. The strength obtained is presented in Table 5.

Table 5: Mean Compressive strength of concrete due to thermo shock

Fine aggregate	28 days Compressive strength (in MPa)	
Sand: Quarry dust	**M20**	**M25**
100:0	16.96	22.22
90:10	17.50	22.67
80:20	17.63	23.56
70:30	17.77	24.00
60:40	18.29	24.37
50:50	19.33	26.00
40:60	18.60	25.33
30:70	18.52	24.00
20:80	18.29	22.22
10:90	17.50	21.33
0:100	16.00	18.29

V. Analysis of test results

5.1. Compressive strength

From the Table 3, it is observed that both the 7 days and 28 days compressive strength is increased for the 50% replacement of sand at considerable level. The variation in compressive strength is represented in Fig 1 and 2.

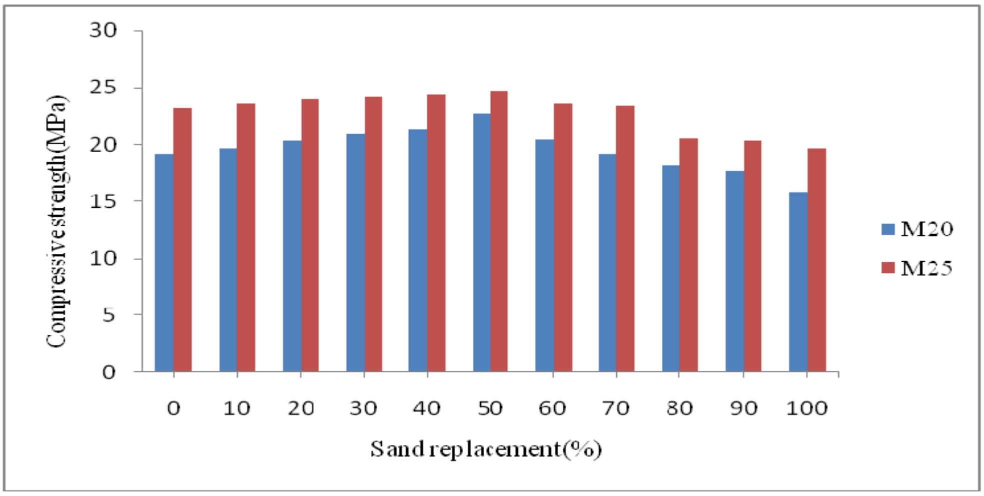

Figure 1: Compressive strength of concrete in 7 days

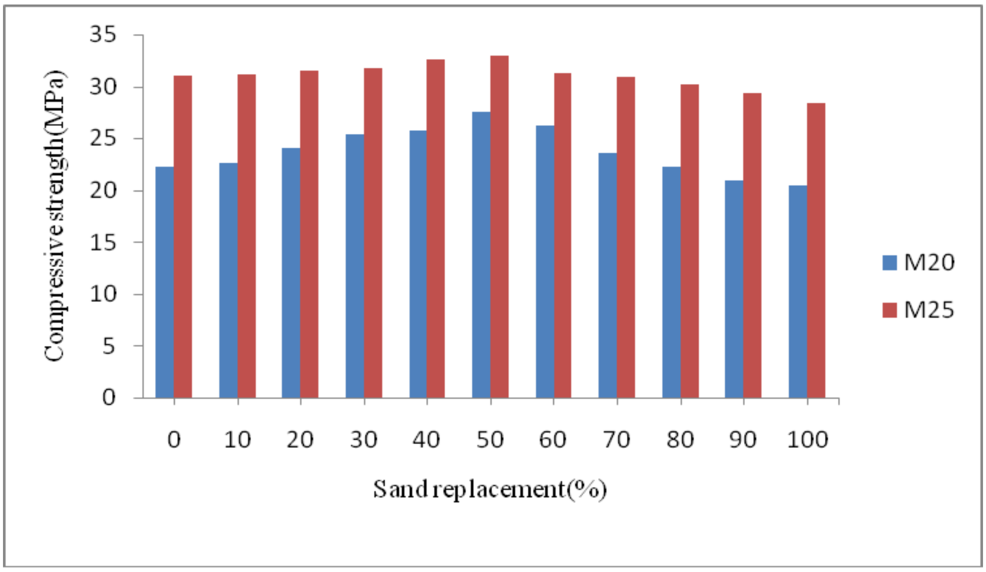

Figure 2: Compressive strength of concrete in 28 days

Due to increase in temperature the strength of concrete was affected. The reduction in strength due to increase in temperature is presented in Table 6 and 7. From those Tables, it is observed that the percentage of reduction in strength compared with control concrete is very less in 50% sand replacement.

Table 6: Compressive strength of M20 concrete in 28 Days due to temperature effect

Fine aggregate Sand: Quarry dust	Compressive strength (MPa)		% of reduction in strength compared with control concrete
	Normal temperature	After heated to 100°C	
100:0	22.22	17.63	20.66
90:10	22.67	18.29	17.69
80:20	24.00	18.52	16.66
70:30	25.33	18.59	16.34
60:40	25.77	19.11	14.00
50:50	**27.56**	**20.74**	**6.67**
40:60	26.22	19.85	10.67
30:70	23.56	19.48	12.34
20:80	22.22	19.33	13.01
10:90	20.89	17.77	20.03
0:100	20.44	16.96	23.68

Table 7: Compressive strength of M25 concrete in 28 days due to temperature effect

Fine aggregate Sand: Quarry dust	Compressive strength (MPa)		% of reduction in strength compared with control concrete
	Normal temperature	After heated to 100°C	
100:0	31.03	24.37	21.47
90:10	31.19	24.50	21.05
80:20	31.52	25.15	18.95
70:30	31.75	25.39	18.18
60:40	32.54	25.41	18.12
50:50	32.92	26.75	13.80
40:60	31.33	26.30	15.25
30:70	30.87	25.15	18.95
20:80	30.24	23.87	23.08
10:90	29.33	22.77	26.62
0:100	28.33	19.90	35.87

Due to sudden cooling (thermo shock) the strength of concrete was affected. The reduction in strength due to thermo shock is presented in Table 8 and 9. From those Tables, it is observed that the percentage of reduction in strength compared with control concrete is very less in 50% sand replacement.

Table 8: Compressive strength of M20 concrete in 28 days due to thermo shock

Fine aggregate Sand: Quarry dust	Compressive strength (MPa)		% of reduction in strength compared with control concrete
	Normal temperature	After thermo shock	
100:0	22.22	16.96	23.68
90:10	22.67	17.50	21.25
80:20	24.00	17.63	20.66
70:30	25.33	17.77	20.03
60:40	25.77	18.29	17.69
50:50	**27.56**	**19.33**	**13.01**
40:60	26.22	18.60	16.30
30:70	23.56	18.52	16.66
20:80	22.22	18.29	17.69
10:90	20.89	17.50	21.25
0:100	20.44	16.00	28.00

Fig 3 and 4 represent the temperature effect on compressive strength of concrete. From the figures it is clear that if the concrete was exposed to high temperature and subjected to sudden cooling then the loss in compressive strength is more than loss due to temperature effect when compared with strength of concrete at normal temperature.

Table 9: Compressive strength of M25 concrete in 28 days due to thermo shock

Fine aggregate Sand: Quarry dust	Compressive strength (MPa)		% of reduction in strength compared with control concrete
	Normal temperature	After thermo shock	
100:0	31.03	22.22	28.40
90:10	31.19	22.67	26.95
80:20	31.52	23.56	24.08
70:30	31.75	24.00	22.66
60:40	32.54	24.37	21.47
50:50	**32.92**	**26.00**	**16.22**
40:60	31.33	25.33	18.37
30:70	30.87	24.00	22.66
20:80	30.24	22.22	28.40
10:90	29.33	21.33	31.27
0:100	28.33	18.29	41.06

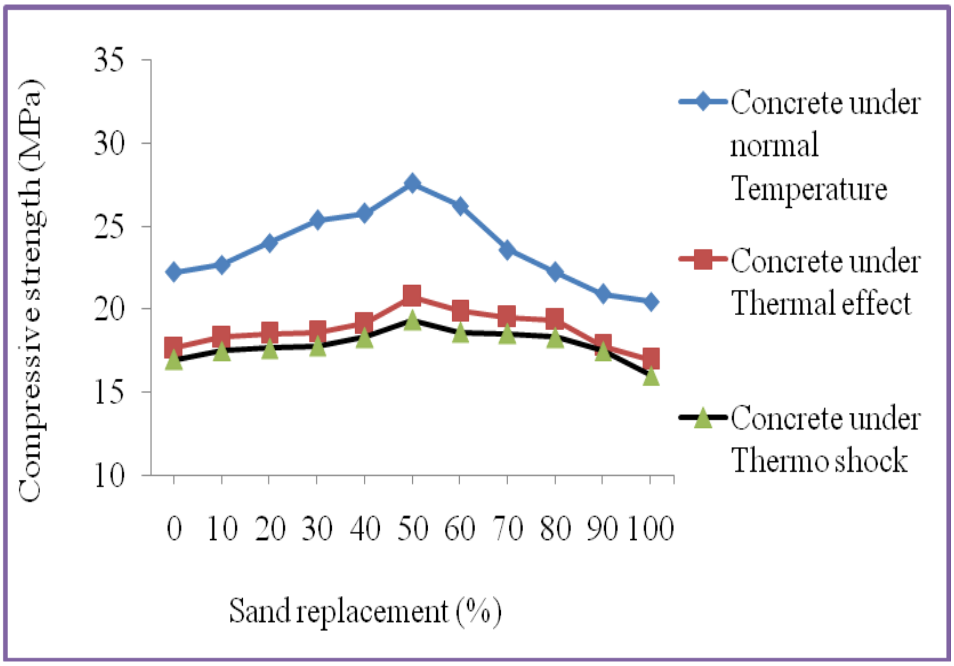

Figure 3: Temperature effect on compressive strength of M20 concrete

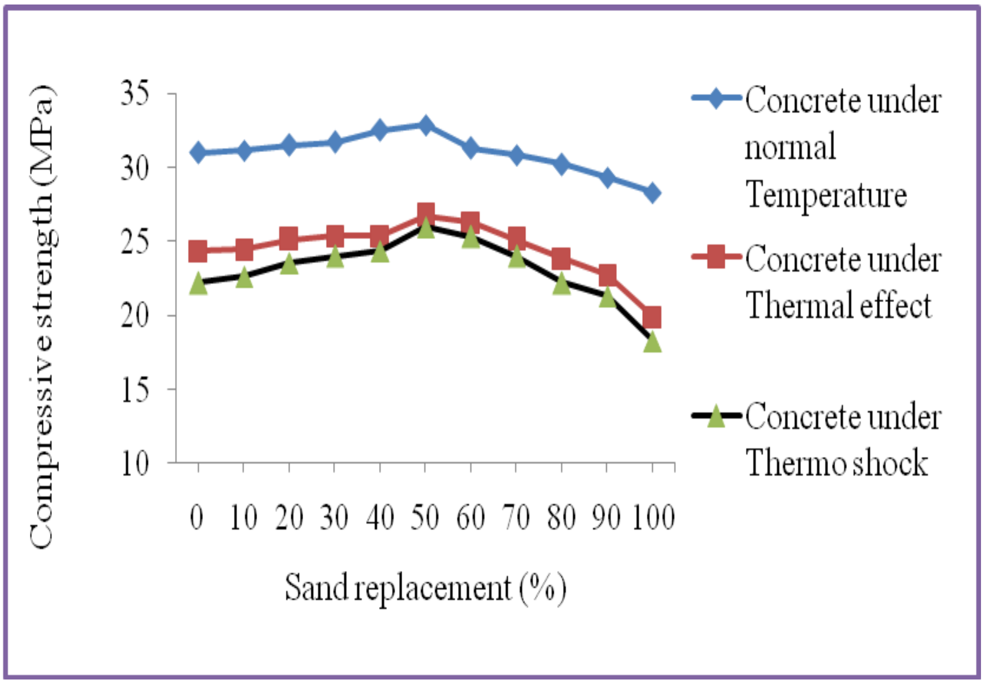

Figure 4: Temperature effect on compressive strength of M25 concrete

VI. Conclusions

Based on above discussions, following conclusions are drawn;

1) Concrete acquires maximum increase in compressive strength at 50% sand replacement. The percentage of increase in strength with respect to control concrete is 24.04 & 6.10 in M20 and M25 respectively.

2) After heated to 100oC, the maximum compressive strength is obtained at 50% sand replacement. The percentage of reduction in strength with respect to control concrete is 6.67 & 13.80 in M20 and M25 respectively.

3) Due to thermo shock also the compressive strength is maximum at 50% sand replacement only. The percentage of reduction in strength with respect to control concrete is 13.01 & 16.22 in M20 and M25 respectively.

The above conclusion gives clear picture that quarry dust can be utilized in concrete mixtures as a good substitute for natural river sand with higher strength at 50% replacement.

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