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Cost optimization of highway, urban and rural facility using sustainable material

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ABSTRACT

In this paper, an experiment of replacement of sand with quarry dust for compressive strength, workability of concrete and cost comparison is done for cost-effectiveness in construction. In this study, there are three basic mix design considered (M20, M30, M40) and partially replacement with 20, 50, 80 and 100 percentage of quarry dust. It is very beneficial and economical for the replacement of natural sand with quarry dust. In this study, it was observed that when Sand is replaced by Dust the compressive strength was found to be increased. The cost of construction is also reduced by a reasonable percentage.

Keywords— *Concrete, Slump value, Workability, Crushing strength, Natural sand, Quarry dust, Cost analysis*

1. INTRODUCTION

The construction industry has an excessive demand for natural fine aggregate that to it is mainly used in the production of concrete due to which there is a higher sustainability issue. There is a high scarcity rate of river sand across the world. By using the recycled material or the waste product we can deal with the environmental concern. Quarry dust can be used as a substitute for natural river sand. In crusher plant rock are crush into different sizes, during the process of crushing the huge amount of dust is generated, this dust is called as quarry dust. It acquires a big amount of land mass for dumping and it also becomes useless material i.e. waste material. Quarry dust is a good alternative of a fine aggregate which can be used in construction activity due to which cost of construction can be reduced and natural resources can be preserved. Most of the developing countries are under tremendous pressure to replace natural river sand by an appropriate material without affecting the quality of concrete. In construction industry quarry dust is used in various purposes such as road construction, building construction and fine aggregate etc. the most common choice of fine aggregate for concrete is river sand but due to overused of river sand has brought scarcity. The best alternative purpose to river sand is quarry dust which gives additional benefit to concrete. By the use of quarry dust, the strength of the concrete increases when mixed with an equal part of river sand but there is reduction workability in concrete. Quarry dust, when used in concrete, gives desirable benefits such as a reduction in river sand consumption, reduction in disposal problem, increase in workability and strength in concrete. The requirement of natural sand in the construction industry is rapidly increasing day after day. Due to which price of the natural sand is increasing at a very high rate, hence increasing the construction cost of the project. Quarry dust as available in an abundant amount as it is a byproduct and waste material of a crusher plant and it is a good substitute for concrete. Quarry dust is available at a very reasonable price, if used in concrete it can reduce the construction cost of a project. The use of quarry dust can need for sustainability. In this study, the use of byproduct i.e. quarry dust which is a byproduct of a crusher plant can be used in the production of concrete by replacing sand. Partial replacement of sand is done by quarry dust in different grade of concrete.

The need for replacement of sand:

(a) The requirement of natural sand is rising day by day; therefore the cost of natural sand is also rising.
(b) The transportation cost is very high as the distance of the natural resources is long.
(c) According to the environmental aspect, the rigorous use of natural sand will lead to environmental impact.
(d) By the used of quarry dust, landfill areas get clear.

In each crusher unit the left out waste material as quarry dust is near about 20 % to 30% to get to achieve a compressive strength the ideal percentage to replace of san with quarry dust is 60 % to 70%. In case of addition of flash 100% of sand could be replaced from concrete. As it increases the workability and there is low cement consumption. By use of quarry dust, it reduces the disposal problem.

2. EXPERIMENTAL WORK

This paper is mainly based on experimental work and result and strength of observation in the laboratory. In this experiment, work dust is mainly collected from the nearby crushing plants

in Nagpur region. After the collection of the dust, specific gravity and fitness of modules were studied. Dust having a specific gravity of 2.69 and fitness of modules is 2.48. Portland cement is obtained from the cement factory. Cement concrete having fitness up to 340 m^2 /kg and having consistency 33%. Cement concrete having setting time of 190 min and final setting time 1200min. In this paper main natural sand collected from nearby location of Nagpur. After checking the specific gravity and fitness modulus, it is found that 2.80 and 2.01.

3. METHOD

In this experimental work, replacement is mainly conducted at 20, 50, 80, & 100%, also conducted a slump cone test on the concrete. Slump cone test was done by using (IS:1199-1959). The slump cone test result is shown in table .1. Fresh concrete was placed mould, having size 150mm compacted and was left for 20 hours. After 24 hrs the casted cube is placed for curing. Curing period was of done for 28 days and the cubes were tested on 7 and 28 days of curing. Each and every batch has six moulds, after the completion for curing period the compressive strength check was done.

4. RESULT

4.1 Compressive strength M20 grade

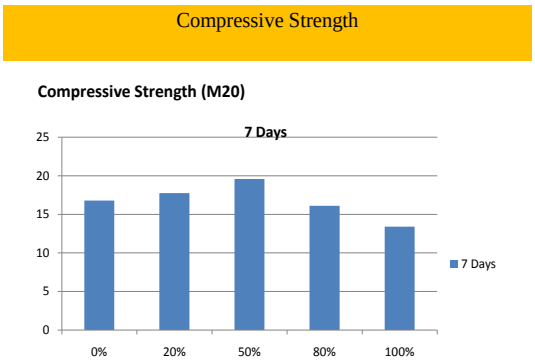

Fig. 1: Compressive strength M20 grade for 7days

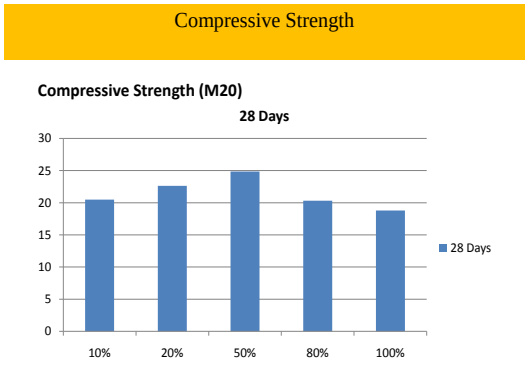

Fig. 2: Compressive strength for M20 28days

Table 1: Compressive Strength of M20 grade Concrete

Stone Dust/ Natural Sand (in %)	7th Day	28th Day	Plastic fiber and admixture used
0%	16.80 Mpa	20.5 Mpa	Nil
20%	17.75 Mpa	22.63 Mpa	Nil
50%	19.58 Mpa	24.87 Mpa	Nil
80%	16.10 Mpa	20.32 Mpa	Nil
100%	13.34 Mpa	18.8 Mpa	Nil

4.2 Compressive strength M30

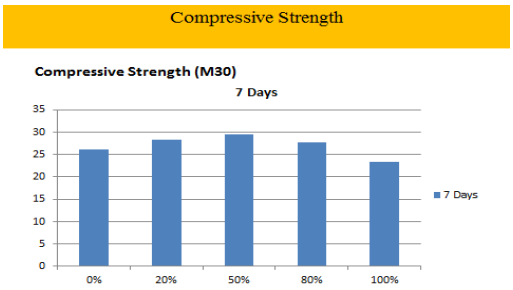

Fig. 3: Compressive strength M30 grade for 7days

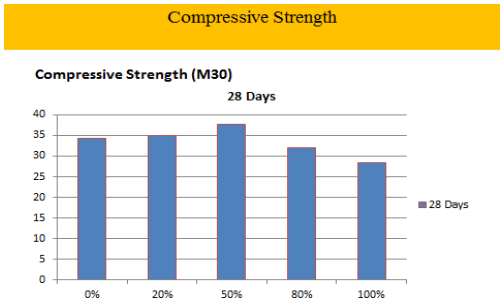

Fig. 4: Compressive strength M20 grade for 28 days

Table 2: Compressive Strength of M30 grade Concrete

Stone Dust/ Natural Sand (in %)	7th Day	28th Day	Plastic fiber and admixture used
0%	26.21Mpa	34.20 Mpa	Nil
20%	28.38 Mpa	35.03 Mpa	Nil
50%	29.60 Mpa	37.77 Mpa	Nil
80%	27.78 Mpa	32.10 Mpa	Nil
100%	23.40 Mpa	28.54 Mpa	Nil

4.3 Compressive Strength of M40

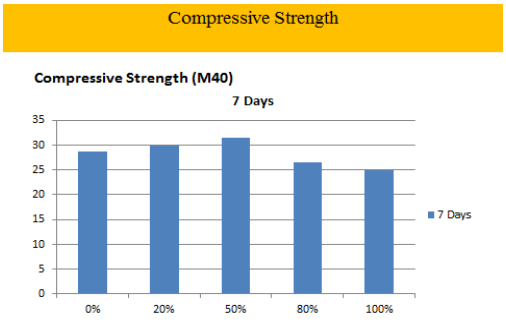

Fig. 5: Compressive strength of M40 for 7days

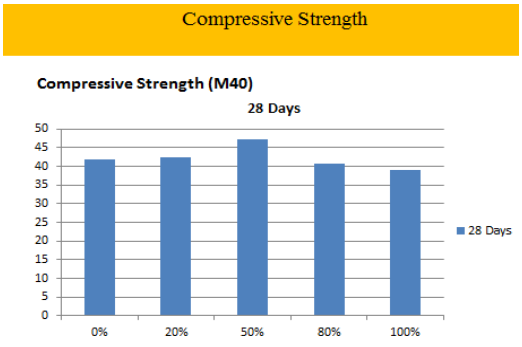

Fig. 6: Compressive strength of M40 for 28days

Table 3: Compressive Strength of M40 grade of concrete

Stone dust/natural sand (in %)	7th day	28th day	Plastic fiber and admixture used
0	28.80Mpa	41.80Mpa	Nil
20	29.90Mpa	42.36Mpa	Nil
50	31.50Mpa	47.20Mpa	Nil
80	26.51Mpa	40.78Mpa	Nil
100	24.91Mpa	39.80Mpa	Nil

5. COST ANALYSIS

5.1 Cost Comparison of concrete for 1 Cu.m for M20 Grade

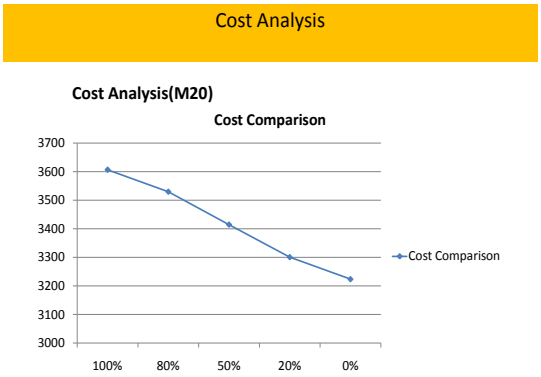

Fig. 7: Cost comparison of concrete for 1 Cu.m for M20 Grade

Table 4: Cost comparison of concrete for 1 Cu.m for M20 Grade

Concrete consisting stone dust/natural sand	Amount
00%	3607
20%	3530
50%	3415
80%	3301
100%	3224

5.2 Cost Comparison of concrete for 1 Cu.m for M30 Grade

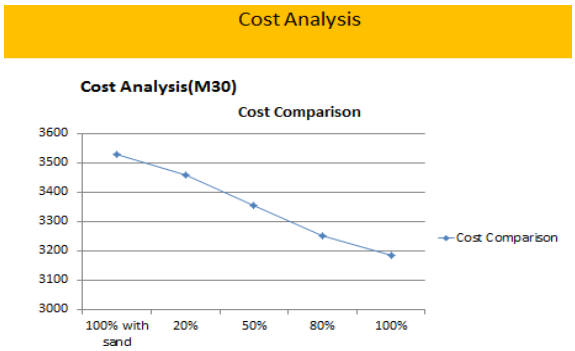

Fig. 8: Cost Comparison of concrete for 1 Cu.m for M30 Grade

Table 5: Cost Comparison of concrete for 1 Cu.m for M30 Grade

Concrete consisting stone dust/natural sand	Amount
00%	3527
20%	3459
50%	3355
80%	3252
100%	3183

5.3 Cost Comparison of concrete for 1 Cu.m for M40 Grade

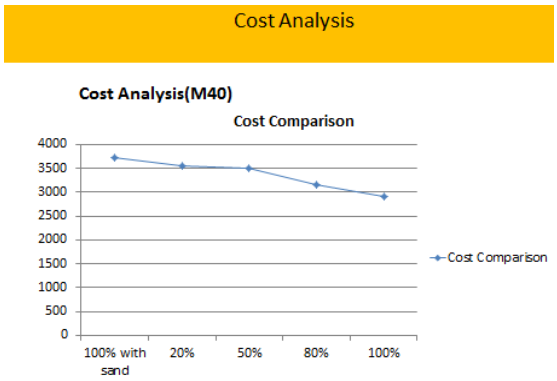

Fig. 9: Cost Comparison of concrete for 1 Cu.m for M40 Grade

Table 5: Cost Comparison of concrete for 1 Cu.m for M40 Grade

Concrete consisting stone dust/natural sand	Amount
00%	3725
20%	3558
50%	3490
80%	3153
100%	2910

6. CONCLUSION

The idea of replacement of river sand (fine aggregate) with quarry dust which is used in the present experiment has potential to utilized quarry dust, hence reducing land fill area requirement and it helps for the conversation of the river sand for a sustainable developed. Concrete gets its strength from the bonding of fine aggregate which fills the empty space between the course aggregate. The strength of concrete depends upon water-cement ratio as the water increases in the compressive strength is decrease where it is replaced with quarry dust. The compressive strength of concrete which comprises of quarry dust decreases as there increase in quantity of W/C ratio, this because of the water absorption property of quarry dust. The strength decreases as the water-cement ratio increases. It is a non-linear graph of compressive strength when compared with quarry dust. From the present experimental study, the conclusion is that the quarry dust could be used as an optimum replacement of fine aggregate. With a replacement of 40% of sand with quarry dust leads to maximum strength compared to normal concrete. The strength decreases when the quarry dust exceeds more than 50%. The cost of concrete also reduces as quarry dust is cheaper than river sand and it also enhances sustainability.

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