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Effective utilization of crusher dust in sustainable concrete

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ABSTRACT
In the today's era with the growing expenses, abundant waste material is generated through processing units of stone industry, there is a need to increase awareness by utilizing economical substitutes to solve the problem of these waste. The utilization of crusher dust as fine aggregate for concrete has achieved more attention in recent year due to scary of natural river sand. Today continues efforts are made towards finding the substitute of natural resources. Research is therefore needed to least the environmental damages and to obtain sustainable construction. This review deals with how crusher dust would be utilized to deliver new items as additive for sustainable concrete. This study professed latest research on using crusher dust as replacement of sand in concrete. Effect on fresh and hardened properties of concrete with crusher dust is discussed in this paper.
Keywords **-** Acid attack, crusher dust, durability properties, environmental benefits, modulus of elasticity, water permeability

I. INTRODUCTION

Day by day more modern techniques and innovations are being developed in view, that of rapid industrial growth. Production of materials and items through these procedures is prompting generation of gigantic amounts of solid and unsafe waste by means of products. Waste can be used to produce new products so that natural sources are used more efficiently and the environment is protected from waste deposits [1]. This is relevant because dimension stone industry presents an annual output of 68 million tons of processed product [2]. Stone has played an enormous position in human endeavors due to the fact earliest recorded history and its utilization has advanced from back age-old time. As far as stone nature, the dimension stones segment essentially contains of two principle classes of rocks: "Calcareous material" or "Marble" and "Siliceous material" or "Rock" [3]. Crushing stone industry has developed essentially in the most recent decades. The focus of a good national development is to look inwards with intent to mobilize all natural resources for economic purposes [4].

Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and glues them together. The use of concrete, worldwide, is twice as much as steel, wood, plastics, and aluminum combined. The economy, efficiency, durability, rigidity of reinforced concrete make it an attractive material for a wide range of structural applications [5], continues research efforts have made to established green and sustainable concrete as a flexible material for huge development, because the entire materials of concrete are of natural/geological origin [6]. Its yearly overall production is around 3.8 billion m^3 - roughly i.e. 1.5 tons for each capita, as per information acquired from Portland Cement Association [7]. Indian construction industry is additionally leaning toward utilization of concrete with compressive strength of 60–85 Mpa [8]. High strength concrete are influenced by the properties of the aggregate and w/c ratio [9]. Additives are also used in producing concrete, these substances added to concrete that do not fall under the headings of binding agents and aggregates [10]. Today we need concrete which should be stronger and durable for a balance of the w/c ratio [5]. Accelerated productivity of concrete result as a multiple use of automation and more effective equipments [11].

In the construction industry, fine aggregate is use as an important building material, and the overall consumption of fine aggregate in concrete generation alone is around 1000 million tonnes per year, making it scarce and limited [12]. This scarcity of fine aggregate forces us to find the suitable substitute. The cheapest and the easiest way of getting substitute for fine aggregate is by using crushed natural stone to get artificial sand of desired size and grade which would be free from all impurities [13]. In the past years, the escalation in cost of fine aggregate due to administrative restrictions in India, demanded comparatively greater cost at around two to three times the cost of crusher dust even in places where fine aggregate is available nearby [14-15]. The volume of the crusher dust (high-volume, low-value commodity) produced is increasing day by day [16]. The owners finding difficulty to clear the dust from the crusher units [14].

The use of crusher dust in concrete is desirable because of its benefits such as useful disposal of by-products, reduction of fine aggregate consumption as well as increasing the strength parameters and increasing the workability of concrete [17]. The construction industries have identified some waste materials like flyash, slag, limestone powder and siliceous stone powder and crusher dust for use in traditional concrete [18-19]. Crusher plants produces large quantity of crusher dust as it is kept in abundance [19-20], which has landfill disposal problems, health and environmental hazards [21]. In India, there are over 12,000 stone crusher units and this number is expected to increase further with the development of the country. Crusher dust is a main by-product of this industry generally represents less than 1% of aggregate production [22-23].

The use of crusher dust as fine aggregate in concrete mixtures will reduce not only the demand for fine aggregate, but also the environmental burden [24]. Studies are done on the influence of crusher dust (finer than 75 microns) on the performance of fresh and hardened properties of concrete [4]. The presence of crusher dust as fine aggregate increases the water demand and so the filler effect [25]. Natural aggregate is one of the main ingredients in concrete production accounts for about 75% of any concrete mix. The strength of the concrete produced depends on the properties of aggregate used [26].

Transportation is a major factor in the delivered price of crusher dust. The cost of moving crusher dust from the plant to the market often equals or exceeds the sale price of the product at the plant. Because of the high cost of transportation and the large quantities of bulk material that have to be shipped, crusher dust is usually marketed locally [16]. Crusher dust is well appropriate in terms of strength and economy over fine aggregate for medium grade concrete [27]. The use of the replacement materials offer cost reduction, energy savings, comparably better product and fewer hazards in the environment [28]. It was observed that 40% fine aggregate can be effectively replaced with crusher dust [29]. The present study is an attempt to demonstrate the use of crusher dust to replace the fine aggregate in concrete.

1.1 Waste generation and environmental problem

Following are the major environmental problems associated with the crusher dust:

- Affect climate
- Air pollution[30-31]
- Noise pollution [7]
- Vegetation [30]
- Human health[32]

II. FRESH CRUSHER DUST CONCRETE PROPERTIES

Various findings are given by the researchers as an outcome of conducting tests on crusher dust is summarized below.

2.1 Workability

The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product [33]. Kapgate and Satone [6] measured slump values and compaction factor of quarry dust for a constant w/c ratio 0.44 for 0%, 20%, 25%, 30% and 35% replacement of fine aggregate by quarry dust respectively. It was observed that the slump value decreased and compaction factor increased (Fig. 1), with an increase in the percentage replacement of fine aggregate by quarry dust due to the high fines of quarry dust, requires greater amount of water.

Lohani *et al.* [34] reported the slump and compaction factor of concrete made with quarry dust for a w/c ratio 0.55. The slump and compaction factor was measured for replacement of fine aggregate by quarry dust at 0%, 20%, 30%, 40% and 50% respectively. It was observed that the slump value and compaction factor decreased with increase in percentage replacement of fine aggregate by quarry dust was due to extra fineness of quarry dust, requires large amount of water for ingredients to get closer packing.

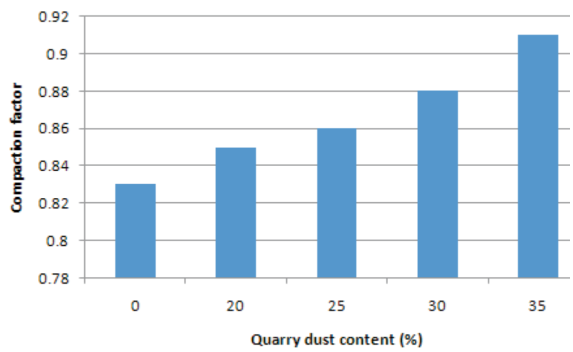


Fig. 1. Compaction factor of quarry dust concrete [6]

Shaman and Srivastava [35] reported that the workability of concrete decreases rapidly with an increment of stone dust in concrete. At the higher percentage level of stone dust, the slump was zero (i.e., no slump) due to the more water absorption capacity of stone dust.

Singh *et al.* [36] investigated the slump in concrete for replacement of fine aggregate by stone dust (0% - 100%) in 10% incremental order, with a constant dose of superplasticizer. Results in decrease in slump with increase in replacement level due to increase in water requirement for angular stone dust.

Karthick *et al.* [37] measured slump values of ordinary and quarry rock dust replaced concrete with w/c ratio 0.5 such as 0%, 20%,40% and 60% replacement respectively. Result indicates that the slump value increased with the increase in the percentage replacement of fine aggregate by quarry rock dust due to flaky particle shape of quarry dust. The increased slump value was shown in Fig. 2.

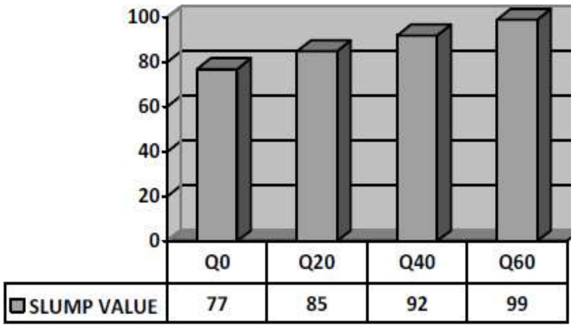


Fig. 2. Slump of quarry dust concrete [37]

III. HARDENED CONCRETE PROPERTIES

3.1 Compressive Strength

Compressive strength is the key property of concrete [38]. The Compressive strength of crusher dust concrete mixes evaluated by the several researches. Pofale and Quadri [5] reported that compressive strength increased by 22% and 16% with the use of crusher dust at 40% replacement of fine aggregate. The compressive strength of all mixes i.e., a partial replacement of fine aggregate with crusher dust at the levels of 30%, 40%, 50% and 60% showed an increase in compressive strength by 8.3%, 22.3%, 18.5% and 4.9% for M25 respectively and 5.2%, 16%, 12.5% and 8.9% for M30 respectively.

Kapgate and Satone [6] observed that the compressive strength of concrete cubes replacing fine aggregate by quarry dust at 28 days for 0% quarry dust was 36.3 MPa. Quarry dust content increases to 20%, compressive strength increased to 38.2 MPa and for 25% quarry dust content the compressive strength increased to 39.2 MPa. For further increased in quarry dust, compressive strength was decresed (Fig. 3).

Sakthivel *et al.* [14] carried out compressive strength test for 10%, 20%, 30% and 40% replacement of fine aggregate with quarry dust at 28 days. It was reported that the compressive strength of controlled concrete was 42.2 N/mm^2. Further on, with the increase in replacement of fine aggregate by 10% quarry dust, compressive strength increased and at 20%, 30% and 40% replacement level, there was a drastic reduction of compressive strength about 30% to 35%. The reduction may be due to the voids present in quarry dust concrete.

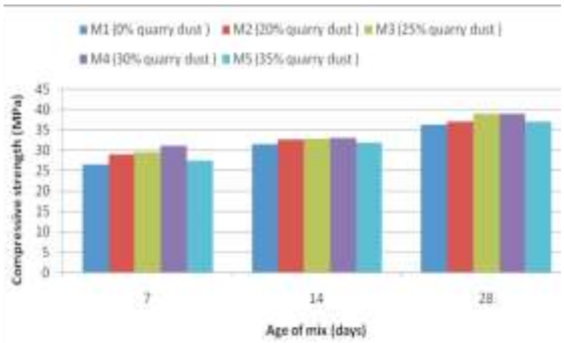


Fig. 3. Compressive strength of quarry dust concrete [6]

Shamim *et al.* [20] carried out an experimental study to find out the compressive strength of concrete for 0%, 50%, 60% and 70% replacement of fine aggregate by stone dust and 0% and 10% replacement of coarse aggregate by recycled aggregate. The 7 and 28 days compressive strength for 60% replacement of fine aggregate by stone dust and 10% replacement of coarse aggregate was observed 23.5 N/mm^2 and 36.8 N/mm^2 respectively. The stone dust concrete compressive strength is 10% higher than nominal concrete for 28 days. The increase in strength may be due to the sharp edge recycled aggregate, forms a strong bond in concrete production.

Sooraj and Narayan [22] analyzed compressive strength test for M20 and M25 grade concrete mix with replacement of fine aggregate by crusher dust at 20%, 40%, 60%, 80% and 100% respectively. For instance, 7 and 28 day compressive strength of M20 grade was 12.4 and 20.7 MPa, respectively and increased to 14.3 and 23.7 MPa, respectively for 40% replacement of fine aggregate by crusher dust. Crusher dust containing very fine particles which fill the voids of fine aggregate and this was the reason for increase in compressive strength. Lohani *et al.* [34] observed the compressive strength of concrete with fine aggregate replaced by quarry dust. Result shows that compressive strength increased till 30% replacement of fine aggrgegate by quary dust as shown in Fig. 4-5 for 53 and 33 grade of concrete.

Suman and Srivastava [35] observed that the maximum strength obtained at 30% replacement of fine aggregate by stone dust in 7 days and variation of strength within 18% throughout the replacement level of fine aggregate. The 28 days compressive strength was more than the designed value throughout the replacement level and maximum strength was obtained at 60% replacement of fine aggregate by stone dust, which was 17% more than concrete with zero percent stone dust. Result shows there was 5-12% increase in strength due to the silica substance present in the stone dust.

Karthick *et al.* [37] observed that the compressive strength of cubes at 28 days for controlled concrete was 23.3N/mm^2. Compressive strength for 20% and 40% replacement of fine aggregate with quarry rock dust was increased to 27.7 N/mm^2 31.5 N/mm^2 respectively. At 60% replacement of fine aggregate by quarry dust strength was decreased due to the flaky particles present in quarry dust which requires more water forms a unsettled concrete.

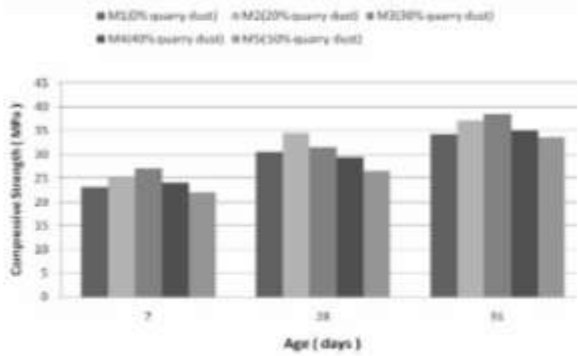


Fig. 4. Compressive strength of 53 grade of quarry dust concrete [34]

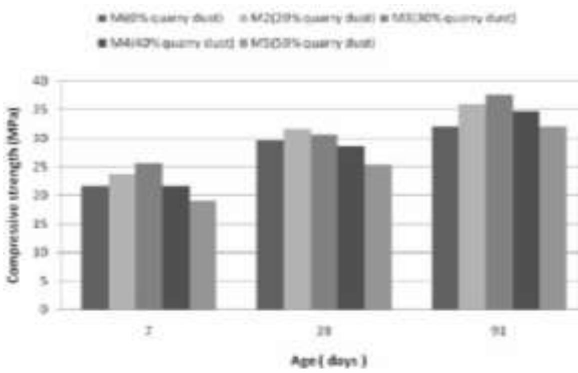


Fig. 5. Compressive strength of 33 grade of quarry dust concrete [34]

Balamurugan and Perumal [39] investigated compressive strength at the end of 7 days and 28 days for M20 and M25 grade of concrete (Fig. 8-9). The maximum strength was achieved at 50% replacement of fine aggregates by quarry dust, which is 13% to 16% higher as compare to nominal concrete. The higher strength may be due to the silicious substance present in the crusher dust.

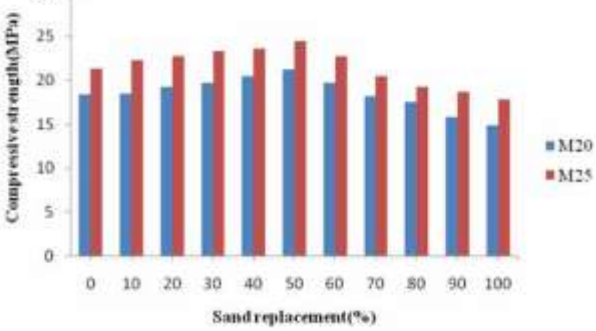


Fig. 6. Compressive strength of 7 days quarry dust concrete [39]

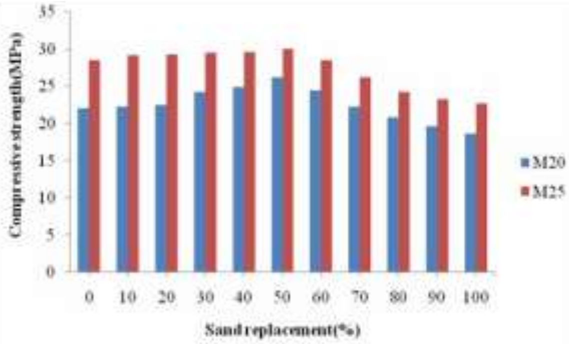


Fig. 7. Compressive strength of 28 days quarry dust concrete by [39]

Hameed and Sekar [40] carried out compressive strength test of M20 grade of concrete for 7 days and 28 days. Green concrete was having compressive strength of 6.5% and 9.5% higher than controlled concrete for 7 and 28 days respectively. The result shows that a slight decrease in strength of concrete at an early age, in some cases otherwise, it was beneficial to the durability of the concrete.

Thushar and Rao [41] studied compressive strength for 7 and 28 days for M20 and M25 grade of concrete. Quarry dust of fineness modulus 1.77 and 3 was taken for M20 and M25 grade of concrete respectively. Results shows the decrease in compressive strength about 33% - 36% for 100% replacement of fine aggregate by quarry dust.

Kumar and Singh [42] carried out experimental study, to replace fine aggregate in concrete with crushed stone dust and the compressive strength of concrete for M25 and M30 grade was tested. It has been observed that the strength increased upto 11.8% at 20% and 10% at 50% replacement of fine aggregate by stone dust, due to the fineness of stone dust fills the gap in the concrete.

Sivakumar and Prakash [43] investigated compressive strength of concrete cube of 100% replacement of fine aggregate with quarry dust. The compressive strength was observed at 100% replacement of fine aggregate by quarry dust for 0.6, 0.7 and 0.8 fine to coarse aggregate ratio to be 29.9 MPa, 33.6 MPa and 26.1 MPa respectively at 56 days.

Singh *et al.* [44] observed that up to 30% replacement of fine aggregate with stone dust, the compressive strength was decreased at 7 and 28 days (Fig. 8). Compressive strength for 40% replacement, the strength was increased for 28 days while it was decreased for 7 days. The compressive strength shows both behavior due to the presence of stone dust increases the water demand and so the filler effect, i.e. decreased by 4.6% in 7 days and increased by 4.8% in 28 days as compared to the referral concrete.

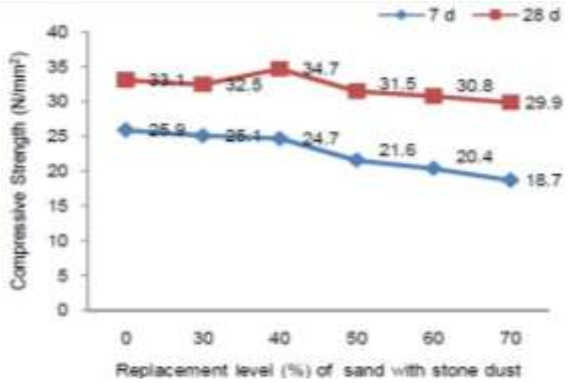


Fig. 8. Compressive strength of stone dust concrete reported by [44]

Sachan *et al.* [45] carried out an experimental study to find out the compressive strength of concrete for 0%, 50%, 60% and 70% replacement of coarse aggregate by recycled aggregate and 0% and 10% replacement of fine aggregate by stone dust. The 7 and 28 days compressive strength for 60% replacement of coarse aggregate by stone dust and 10% replacement of fine aggregate was observed 22 N/mm^2 and 36.1 N/mm^2 respectively. The increase in compressive strength was due to the sharp edges of stone providing stronger bond with cement compared to the rounded shape of ordinary fine aggregate. The variation in strength as shown in Fig. 9.

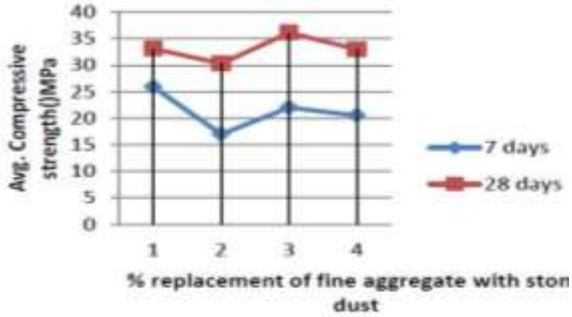


Fig. 9. Compressive strength of stone dust concrete [45]

3.2 Flexural Strength

It is also known as modulus of rupture, defined as the stress in a material just before it yields in a flexure test [46] and it represents the highest stress at its moment of rupture. Kapgate and Satone [6] showed that the flexural strength of concrete mix decreases with increase in quarry dust percentage replacement of fine aggregate (Fig. 10). The replacement of fine aggregate at 0%, 20%, 25%, 30% and 35% for quarry dust shows reduction in flexural strength for 7, 14 and 28 days. The reduction in flexural strength may be due to presence of flaky, badly graded and uneven textured particles result in mess concrete for given design parameters.

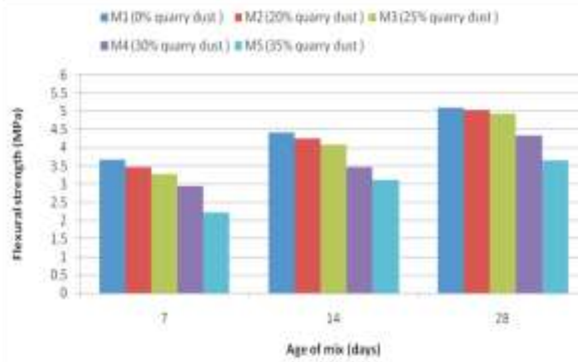


Fig. 10. Flexural strength of stone dust concrete [6]

Prakash *et al.* [8] observed that there is a slight reduction in flexural strength with addition of 60% stone dust as fine aggregate for w/c ratio 0.3 and 0.4. The percentage reduction in flexural strength for the mixes with stone dust compared to the normal concrete mix was less at the age of 7 days. The results were comparable at the age of 28 days. The maximum variation at the age of 28 days was about 9.9%. The variation in strength was due to the flaky particles present in stone dust which requires more water forms a unsettled concrete.

Sakthivel *et al.* [14] observed that at 10% and 20% replacement of fine aggregate by quarry dust, the flexural strength was increased to 11.2 N/mm^2 and 10.6 N/mm^2 compared to control specimens of 10.0 N/mm^2. For concrete with 30% and 40% replacement of fine aggregate by quarry dust, the flexural strength was reduced to 9.4 N/mm^2 and 9.2 N/mm^2 respectively (Fig. 11). This may be due to the voids present in quarry dust concrete.

Shamim *et al.* [20] investigated the behaviour of concrete with partial replacement of fine aggregate by stone dust (50%, 60% and 70%) and 10% replacement of coarse aggregate with recycled aggregate. Flexural strength increased by 4.3%, 12.0% and 31.2% respectively at 28 days for 50%, 60% and 70% replacement level.

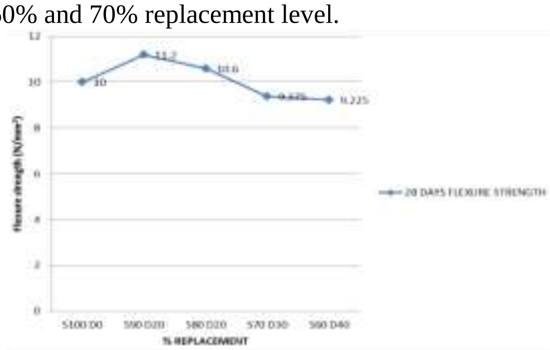


Fig. 11. Flexural Strength of quarry dust concrete [14]

Lohani *et al.* [34] carried out flexural strength test for replacement of fine aggregate by quarry dust at 0%, 20%, 30%, 40% and 50%. The decrease in flexural strength was due to quarry dust particles amount was not enough to fill all the voids between cement paste and aggregate particles, for both grades of cement (53 grade and 33 grade).

Karthick *et al.* [37] determined the flexural strength at 28 days with M20 grade of concrete for 20%, 40% and 60% replacement of fine aggregate by quarry rock dust. The result shows flexural strength increased at 20% and 40% and maximum at 20% (16% higher) compared with nominal concrete.

Balamurugan and Perumal [39] determined the flexural strength for 7 and 28 days of concrete casted by replacement of fine aggregate by quarry dust 0 to 100% in 10% incremental order. The result (Fig. 12) shows maximum flexure strength was achived at 50% replacement level. Which was 10% and 15% higher at 7 and 28 days respectively as compare to nominal concrete. The reason behind this was the silicious substance present in the quarry dust.

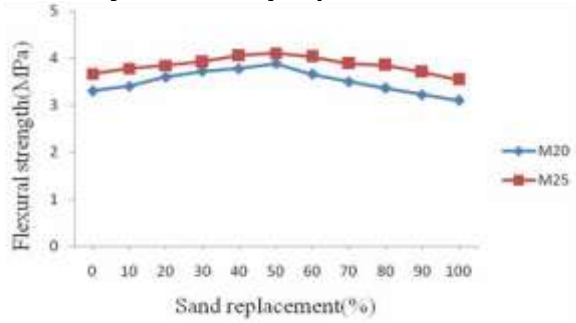


Fig. 12. Flexural strength of quarry dust concrete [39]

Kumar and Singh [42] carried out experimental studies to replace the fine aggregate in concrete with crushed stone dust. The flexural strength of concrete for M25 and M30 grade of concrete obtained by replacing 0%, 20%, 50% and 100% fine aggregate with crushed stone dust. Result shows increase in strength about 10% and 11% at replacement level 20% and 50% respectively due to the fineness of stone dust fills the gap in the concrete.

Singh *et al.* [44] observed that the flexural strength increased significantly with replacement (0%, 30%, 40%, 50%, 60% and 70%) of fine aggregate by stone dust as compared to the normal concrete due to the presence of stone dust increased the water demand and so the filler effect. The variation in flexural strength as shown in Fig. 13.

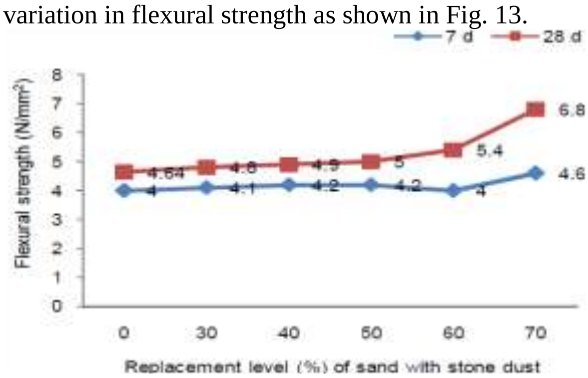


Fig. 13. Flexural strength of stone dust concrete [44]

3.3 Split Tensile Strength

Tensile strength is significantly used for plain concrete structures such as dam under earthquake excitations. Other structures which are designed based on bending strength, for e.g. pavement slabs and airfield runways, are subjected to tensile stresses [47, 48].

Prakash *et al.* [8] observed that the specimens of concrete with 60% of fine aggregate by stone dust and that without stone dust have similar tensile strength characteristics. This was due to the flaky particles which increased the water demand in concrete.

Sakthivel *et al*. [14] observed tensile strength test for 0%, 10%, 20%, 30% and 40% replacement of fine aggregate by quarry dust. Result indicated (Fig. 14) that 10% addition of quarry dust in concrete replacing fine aggregate gives higher strength, when compared to the control specimens. This was due to particle shape change from smooth and rounded to rough and angular in the case of quarry dust.

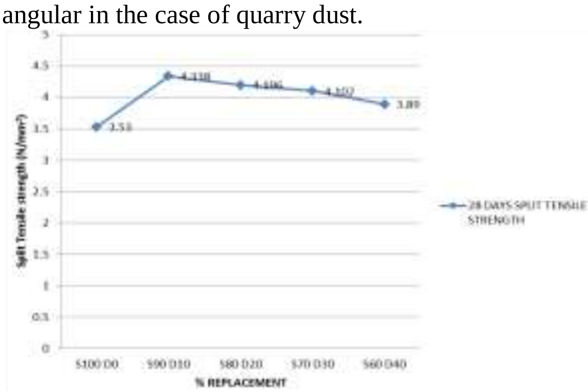
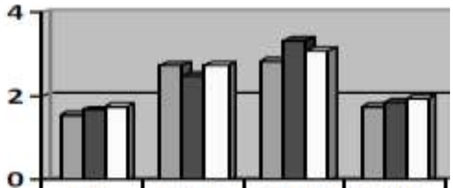


Fig. 14. Split tensile strength of quarry dust concrete [14]

Lohani *et al.* [34] carried out tensile strength test for replacement (0%, 20%, 30%, 40% and 50%) of fine aggregate by quarry dust. The maximum of tensile strength at 20% replacement was 3.5 Mpa for 53 grades and 3.5 Mpa for 33 grades at 91 days. The split tensile strength decreased as fine aggregate replacement increased due to the flaky quarry dust particles not able to fill the voids between aggregate and cement paste.

Karthick *et al.* [37] observed that the split tensile strength at 28 days curing for controlled concrete was 1.7 N/mm^2. For 20% and 40% replacement by quarry rock dust, tensile strength was increased to 2.7 N/mm^2, 3.1 N/mm^2 repectively due to the fineness of quarry dust. For 60% replacement by quarry rock dust, strength decreased to 1.9 N/mm^2. The variation in split tnsile strength as shown in Fig. 15.



	Q0	Q20	Q40	Q60
TRIAL 1	1.54	2.75	2.83	1.77
TRIAL 2	1.68	2.48	3.32	1.87
TRIAL 3	1.75	2.74	3.1	1.95

Fig. 15. Split tensile strength of quarry rock dust concrete [37]

Sivakumar and Prakash [43] investigated split tensile strength of concrete cube of 100% replacement of fine aggregate with quarry dust. The split tensile strength was observed at 100% replacement of fine aggregate by quarry dust for 0.6, 0.7 and 0.8 fine to coarse aggregate ratio. The maximum split tensile strength of 3.15 MPa was observed at 56 days.

Sachan *et al.* [45] investigated the split tensile strength for 0%, 50%, 60% and 70% replacement of coarse aggregate by recycled aggregate and 0% and 10% replacement of fine aggregate by stone dust. The split tensile strength of replaced concrete was increased by 40% due to the sharp edged recycled aggregate and silicious substance present in stone dust at the age of 28 days.

3.4 Modulus of Elasticity

It is an important mechanical parameter, defined as the ratio between normal stress to strain below the proportional limit of a material, and it is used to calculate the material's capability to distort elastically[49, 50]. Lohani *et al.* [34] concluded that the modulus of elasticity at 28 days for nominal concrete mix was achieved 32617 Mpa and 31000 Mpa respectively for 53 and 33 grade cement. For replacement of fine aggregate by quarry dust i.e. 20%, 30%, 40% and 50% shows a reduction in modulus of elasticity by 1.7%, 5.2%, 8.4%, 13.7%, respectively in comparison with nominal concrete mix for 53 grade. For replacement of fine aggregate by quarry dust i.e. 20%, 30%, 40% and 50% shows reduction in modulus of elasticity by 2.7%, 3.7%, 6.6%, 11.2%, respectively in comparison with nominal concrete mix for 33 grade. This reduction in ductile behavior of quarry dust concrete mix as compared to that of conventional concrete was due to reduced difference between modulus of aggregate and hydrated cement paste.

Sivakumar and Prakash [43] observed effects of quarry dust on elastic modulus at 100% replacement of fine aggregate and 0.6, 0.7 and 0.8 fine to coarse aggregate ratio had showed 15% higher elasticity than controlled concrete specimens. The effects of quarry dust on the elastic modulus property was found to be consistent with conventional concrete.

IV. DURABILITY PROPERTIES

The durability of cement concrete is outlined as its potential to withstand environmental actions, chemical attack and abrasion. The durability of concrete is the important factor as it directly affects the service life of the structure [51]. Durable concrete may be defined as concrete that retains its original form, quality, and serviceability when exposed to its environment [52].

4.1 Water Permeability

Property of a material that lets fluids to diffuse through it to another medium without being chemically or physically affected.[53] High permeability will allow fluids to move rapidly through rocks. Permeability is also defined ability to resist weathering action, chemical attack, abrasion, or any process of deterioration.[52]

Hameed and Sekar [3] observed minimum and maximum penetration depths of two mixes. This was due to the pozzolanic and filling effects of quarry rock dust. There was more cementitious material formed with dense structure, therefore, it was easy to prepare a high impermeable concrete.

Ilangovana *et al.* [54] carried out an experimental study to find greater penetration depth of the two mixes (Fig. 16). Result shows that natural concrete has more penetration depth because the size of capillary pores in aggregate was much larger and high fineness of quarry rock dust.

Balamurugan [56] experimented the water permeability test and found co-efficient of permeability for concrete as replacement of fine aggregate by quarry dust from 0% - 100% in 10% incremental order for M20 and M25 grade of concrete. Results shows the decreased co-efficient of permeability at 50% replacement of fine aggregate by quarry dust. This was due to the sharp edges of particles in quarry dust provides better bond with cement then rounded particles.

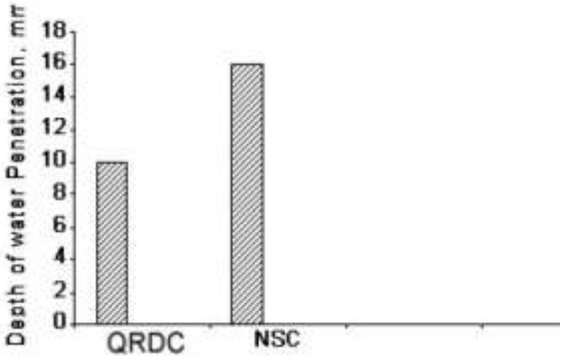


Fig. 16. Depth of water penetration between quarry rock dust concrete (QRDC) and natural sand concrete (NSC) [54]

4.2 Acid Resistance Test

A measurement of a surface's ability to resist the corrosive effect of acids. Concrete uncovered to acidic environment require prior capabilities of the affect of sulphate and HCL on the crusher dust. Concrete properties changes mainly due to the acid attack on the specimen, deterioration occurs in terms of reduction in strength and appearance [55].

Prakash et al. [8] observed that the percentage loss in weight of concrete cubes after 45 days immersion in 1% sulphuric acid solution and 3% sodium chloride solution. The loss in weight was negligible in the case of 60% replacement of fine aggregate by stone dust and that without stone dust. For both concrete mixes, the specimens of 60% replacement of fine aggregate by stone dust and that without stone dust are attacked by acid was more or less in the same manner. This was due to that the active SiO_2 in stone dust can react with the Ca $(OH)_2$ in concrete to form secondary calcium silicate hydrate and make it chemically stable and structurally dense.

Lohani *et al.* [34] investigated the durability of the concrete formed by 50% replacement of fine aggregate by quarry dust. The effect on concrete cubes on immersion in 5% solution of magnesium sulphate, 5% solution of sodium chloride and 2N hydrochloric acid solution on compressive strength and weight was observed at 28 days and 91 days (Fig. 17-18).

There was no loss of strength for immersion in $MgSO_4$ and NaCl solution in comparison with immersion in normal water and the strength gain continue on almost all the specimens with no loss in weight.

In case of HCl solution, loss of strength and weight in comparison with immersion in normal water was observed. The loss in strength increased with increase in days of immersion in HCl solution observed for all concrete mix.

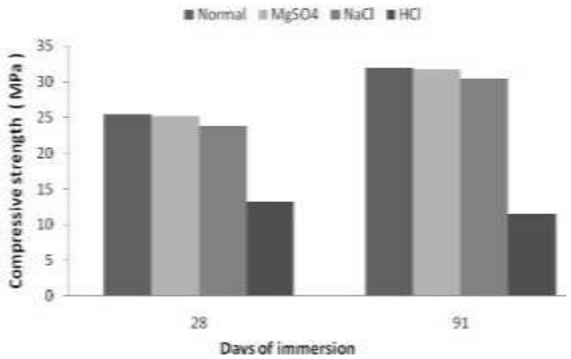


Fig. 17. Compressive strength in immersion with different solutions for 53 grade of quarry dust concrete [34]

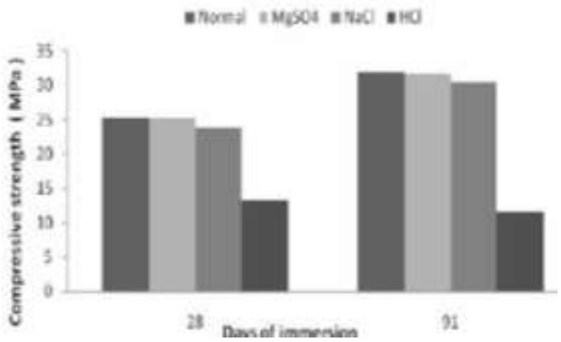


Fig. 18. Compressive strength in immersion with different solutions for 33 grade of quarry dust concrete [34]

Ilangovana *et al.* [54] carried out experimental study to evaluate the degree of deterioration of two concrete mixes against accelerated magnesium sulphate and hydrochloric acid. Standard prism specimens were immersed in testing baths (one containing 7.5% $MgSO_4$ and 7.5% Na_2SO_4 by weight of water and other containing H_2SO_4 of pH value 2). Result shows that durability of quarry rock dust concrete under sulphate and acid action was higher to that of natural sand concrete (Fig. 19).

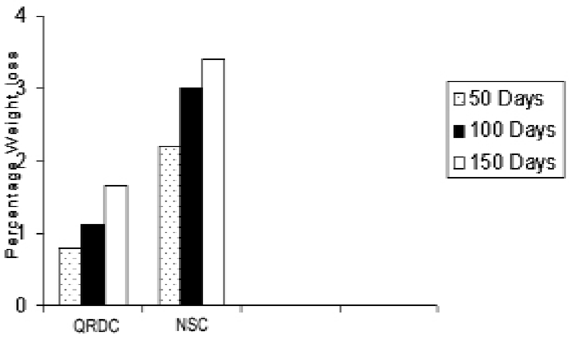


Fig. 19. Percentage weight loss between Quarry Rock Dust Concrete (QRDC) and Natural Sand Concrete (NSC) [54]

4.3 Rapid Chloride Permeability

The test method is according to ASTM C 1202-97. One of the main characteristics influencing the durability of concrete was its permeability to the entrance of chloride [57]. The chloride ion present in the concrete can have harmful affect on concrete as well as on the reinforcement. Singh [57] investigated the chloride ion permeability of M20 and M25 grade of concrete formed by replacement of fine aggregate by waste foundry sand for 0%, 5%, 10%, 15%, 20% replacement. RCPT for 28, 91 an 365 days curing, result shows the chloride ion permeability decreased with the increase in WFS. Which indicates that concrete became more dense due to reduction in voids.

V. SUMMARY AND CONCLUSIONS

The use of crusher dust as a partial replacement of fine aggregate in concrete has been broadly investigated in recent years. This review paper has presented aspects on crusher dust and its usage in concrete, which could be summarized and concluded as:

1. According to prior test studies, it refers that utilization of crusher dust had a good prospective in partial replacement of natural river sand.
2. Crusher dust has control on the workability property of concrete. The slump value and the compaction factor decreased with the increase in crusher dust due to high fineness and flaky particles of crusher dust, requires greater amount of water.
3. According to the study, crusher dust has high fineness which provides sensible cohesiveness of the mix and increases the water demand.
4. As per the study, it demonstrates an increment in strength and quality when crusher dust replaces fine aggregate up to certain rate.
5. Concrete produced by using crusher dust has durability properties comparable to or superior than, proportional control mixes.
6. Utilization of crusher dust demonstrates efficient micro filling ability.
7. Use of crusher dust waste in concrete mix proved exceptionally helpful to produce green sustainable concrete.

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