International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
Research Symposium on
"Advancements in Engineering, Science, Management, and Technology"
Volume 5, Special Issue 04, April-2019.

Use of Stone Dust as a substitute material in concrete: A Review

Bisakha Chalisey[1], Chhavi Gupta[2]

[1]*Department of Civil Engineering, Sharda University,*
[2]*Department of Civil Engineering, Sharda University,*

Abstract*—Population around the globe is increasing exponentially and with the increasing population the demand for construction is also increasing. This cause pressure on the utilization of natural resources which eventually causes depletion of it. Quarry dust, produced in large quantities from quarries and ornamental stone plants, create a severe environmental problem. Disposal of quarry dust in landfills is also an issue as land is decreasing day by day. The use of these materials in construction practices, could lead to both economic and environmental benefits. Past studies has suggested that the waste of discarded rubber tyre, silica fume, glass, slag, metakaolin etc. can effectively replace a part of the conventional materials used for concreting. This paper reviews the recent research studies on the production of stone quarry dust which can be the replacement of fine aggregate or cement in the construction works. This paper also focuses on the effect of such materials on the strength and durability of the concrete and the factors affecting them.

Keywords- Quarry dust, Strength, Durability, Concrete, Ornamental stone plants, Landfills

I. INTRODUCTION

Concrete is a broadly used construction material entailing of cement, coarse aggregate, fine aggregate and water. Due to globalization, the need of infrastructure such as express ways, power projects and industrial areas is ever expanding and a large quantum of concrete is being utilized [1]. Sand, the popular raw material or the fine aggregate for the concrete comes from the river, has become expensive and scarce due to overexploitations of river. There are real challenges that this industry needs to consider due to limited sand resources, illegal mining and environmental impact of sand mining. Shortage of natural river sand for construction due to over exploitation from sources, the inability of the nature to replace it and increasing pressure from the locals are the consequences [2].
Large amounts of stone waste are generated in stone quarries, which have adverse effect on the environment and living beings. In fact, the advancement of concrete technology can reduce consumption of natural resources which in turn will further lessen the burden of pollutants on the environment [3].Quarry dust are limestone fines which are generated in large quantities, during the extraction, hauling and crushing processes for the production of aggregates [4]. According to Shyam Prakash et al. (2016), Quarry dust is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially in fine aggregates [5]. The utilization of quarry dust which can be called as manufactured sand has been accepted as a building material in the industrially advanced countries of the west for the past three decades [1]. Furthermore, quarry dust has been in use for different materials, road construction materials aggregates, bricks and tiles. However, quarry dust still remains an underutilised resource due to several restrictions regarding mainly the geographical distribution of the quarries [4].

II. OVERVIEW ON THE EFFECT ON STRENGTH AND DURABILITY PARAMETERS OF THE CONCRETE

The popularity of quarry dust as replacement of fine aggregates or cement in concrete is growing tremendously amongst the researchers worldwide. Compared to conventional concrete, the concrete incorporated with quarry dust has higher durability under sulphate attack and under acid action [6].

A. Compressive Strength

Compressive strength is defined as the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine [7]. V. Aishwaryalakshmi (2017), performed the experimental test on cubes on 7th day , 14th day and 28th day for different percentages of quarry dust 10%, 20%, 30% and compared it with conventional concrete. Results showed that 30% replacement of quarry dust for sand gave high value of compressive strength than the conventional concrete 32.86 Mpa [7]

Priyatham et al. (2017) casted three cubes for each percentage replacement of cement with marble powder 0%, 5%, 10% and 15% and tested for 7 days and 28 days after curing [8]. For result, it was observed that the compressive strength of concrete increased by the addition of marble powder up to 10% replacement by the weight of cement and then decreased. Then the quantity of fine aggregates was replaced by quarry dust keeping 10% replacement of cement with marble powder as optimum. The result showed that compressive strength increased by 10.56% by addition of quarry dust up to 30% replacement by weight of fine aggregate when compared with the conventional concrete [8].

Patel et al. (2013) conducted an experiment on three cubes of concrete of mix ratio 1:1.01:2.5 M 25 grade with partial replacement of Portland Pozzolana cement PPC with stone waste as 10%, 20%, 30%, 40% and 50%. It was found out that the value of average ultimate compressive strength at 28 days was maximum 29.04 MPa for 20% replacement by weight of PPC. [16]

Furthermore, Malpani et al. (2014) carried an experiment on concrete cubes of 150 mm size. Tests were conducted on the Universal testing machine UTM on 7 days and 28 days. It was found that the mix with 8 mm slump values 20% quarry rock dust, 40% sand and 40% marble sludge powder had the best compressive strength.[3]

As for Prakash et al. (2016) the experiment was conducted in series i.e. in the first series, M30 grade of concrete with 20%, 25% and 30% replacement of quarry dust tested for 3, 7, 28 and 60 days and similarly M25 grade in the second series with same percentages of quarry dust as replacement. In the third series, M20, M25 and M30 grades of concrete with 20%, 25%, and 30% replacement of quarry dust by varying water-cement ratio 0.45 and 0.5[5]. Similarly, in the fourth series, M20, M30 and M40 grades of concrete with 20%, 30% and 40% replacement of quarry dust and water-cement ratio 0.45. Lastly, in the fifth series, M20 grade of concrete with 10% increment up to 100% replacement of quarry dust is tested. The result showed that strength of concrete is more for water-cement ration 0.45 as compared with water-cement ratio 0.5[5]. As the quantity of water increases, the compressive strength decreases when replaced with quarry dust which is due to the water absorption property of quarry dust. It was also found out that 40% replacement of sand by quarry dust gives maximum result in strength compared to the conventional concrete [5].

Ilangovana et al. (2018) Studied that the compressive strength for three grades M20, M30, and M40 cubes mixed by the Indian Standard method resulted in highly conservative results. The overall strength reported 10% to 15% increased for five methods of concrete mixes of natural sand when fully replaced by quarry rock dust.[1]

Moreover, Balamurugan et al. (2013) conducted the compressive test of two grades of concrete M20 and M25 having nominal mix proportion of 1:1.5:3 and 1:1:2 respectively at 7 days and 28 days after curing.[9] The result was obtained considering various factors affecting the compressive strength i.e. temperature and thermo shock. It was found that concrete acquired maximum increase in compressive strength at 50% sand replacement. It was also found out that after heating up to 1000 C and due to thermo shock, the compressive strength is maximum at 50% sand replacement.

Table 1 and Figure 1 shows the comparison of compressive strength when fine aggregate is replaced by quarry dust. The following data is sourced from V. Aishwaryalakshmi et al. [7].

TABLE I COMPRESSIVE STRENGTH

S.No	%Of Quarry Dust	7 days Mpa	14 days Mpa	28 days Mpa
1	10%	17.885	19.45	20.76
2	20%	21.65	23.65	25.27
3	30%	24.65	28.54	32.86

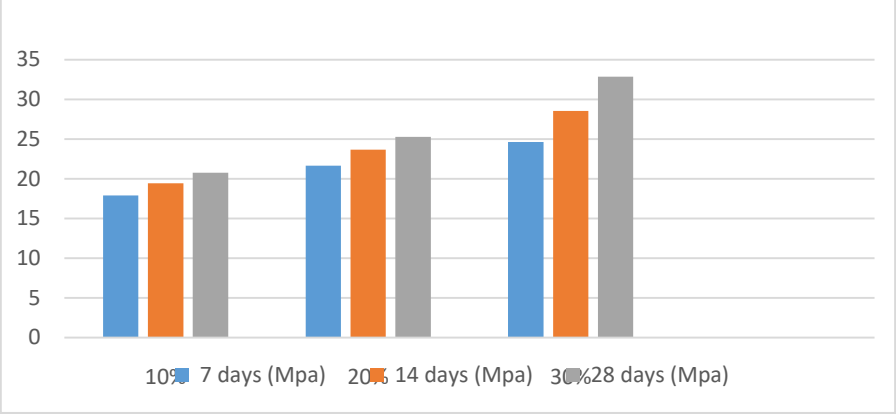

Figure 1 Variation of Compression Strength in Concrete

Table 2 and Figure 2 shows the comparison of compressive strength when cement is replaced by quarry dust. The following data is sourced from Patel et al [16]

TABLE II COMPRESSIVE STRENGTH OF CUBES

S.No	%Of Quarry Dust	7 days Mpa	14 days Mpa	28 days Mpa
1	10%	18.96	20.59	31.56
2	20%	22.67	26.52	29.04
3	30%	13.67	20.07	21.04

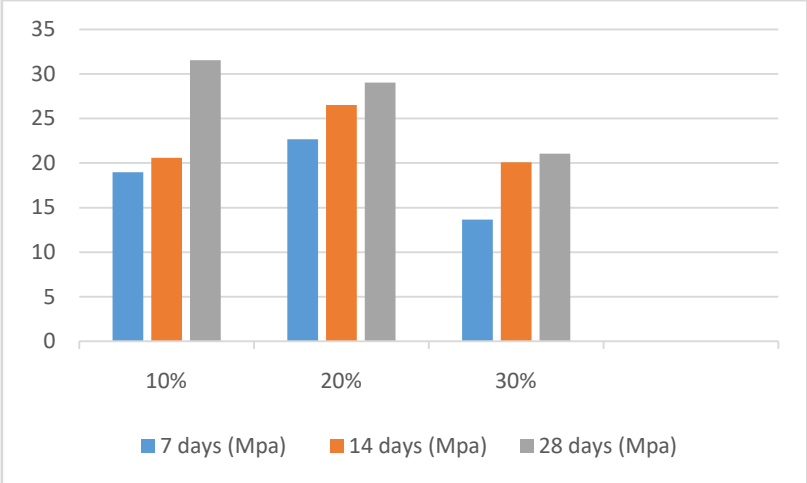

Figure 2 Variation of Compression Strength in Concrete

Overall, the compressive strength of concrete increases when the fine aggregate or cement is partially replaced by quarry dust which is beneficial for both environment and construction industry as a whole.

B. Split Tensile Strength

Split Tensile strength is a method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter**.** Aishwaryalakshmi et al. tested the cylindrical specimen using the compressive testing machine CTM. The proportions of quarry dust was 10%, 20%, 30% replacement by weight of the fine aggregates[7]. It was found that at 30% replacement, the split tensile strength of the cylinder was maximum 28 days strength- 3.11 MPa. It showed that with the increasing percentages of quarry dust the split tensile strength of the specimen increases [7]

Similarly, Priyatham et al. (2017) also tested the split tensile strength of the cylinders as per IS 516-1999. It was tested at different percentage of marble powder content in concrete and quarry dust in fine aggregates[8]. The tensile strength of the concrete when cement replaced by marble dust was maximum i.e. 28 days strength- 3.78 MPa at 10% replacement of marble dust. After that, the strength is decreased. The addition of marble powder into the concrete improved its split tensile strength by 13.17% when compared with conventional mix. Similarly, the addition of quarry dust 30% by weight of sand into the concrete improved its tensile strength by 7.78% when compared with conventional concrete. Also on further addition of 0.5% of glass fibre by weight, the split tensile strength of concrete increased by 17.36% [8].

Malpani et al. (2014) conducted the split tensile strength test on concrete cylinders of size 1500 mm diameter and 300 mm height. The test was carried out for eight types of mix designs. Among the eight types of mix design, Mix 3 having 8 mm slump value viz. 20% sand, 40% quarry rock dust and 40% marble sludge powder had the best value 3.15 MPa[3].

In conclusion, the studies suggest that the split tensile strength of concrete increases when fine aggregates or cement is partially replaced by quarry dust in conventional concrete.

C. Durability

Ilangovana et al. (2008) Carried out the durability test on the conventional concrete and quarry rock dust concrete as per the Indian Standard mix fixed 1:0.99:1.56 and 1:0.91:1.16 respectively [1]. This test was carried out to investigate the drying shrinkage studies, deterioration and water absorption studies for both conventional concrete and quarry rock dust concrete as per codal provisions. The results showed that drying shrinkage strains of quarry rock dust concrete are quite large to the shrinkage strain of conventional concrete. The durability of quarry rock dust concrete under sulphate and acid action is higher inferior to the conventional concrete. Also, it was found that the permeability of quarry rock dust concrete is less than that of conventional concrete and the water absorption of quarry rock dust concrete is slightly higher than conventional concrete.

Likewise, Almeida et al. (2006) presented the test results in terms of voids volume and water absorption, calculated according to ASTM C-642-90giving insights on these concrete mixtures durability properties[11]. According to the water-cement ratio variation, hardened property related with durability were expected to be higher up to a 15% stone dust substituting sand ratio. It was found that a 16% reduction in voids volume and water absorption for specimen CSDMS indicating that the stone dust particles secured a more effective dispersion of cement particles, thus enhancing hydration chemical reaction. Furthermore, the results showed that the substitution of 5% of the sand content by stone slurry induced higher compressive strength, higher splitting tensile strength, and higher modulus of elasticity and improvement of properties related to durability. The feasibility of incorporating up to 20% stone slurry in detriment of the respective amount of fine aggregate without prejudicing mechanical properties in a serious manner was also determined [11].

Mashaly et al.(2017) performed an experimental investigation to determine the durability performance of mortar and concrete incorporating granite sludge as cement replacement [15]. All durability tests including abrasion resistance, soundness and freeze thaw (for concrete) were performed on mortar and concrete samples of sizes 80x40x40 mm and 50x50x50 mm and cured at 28 days and 90 days according to ASTM C-241-1997. The results showed that using 10% granite sludge showed an improvement in water absorption and apparent porosity, while using 20% granite sludge led to a slight increase in these parameters. Also the granite sludge mortar mix showed an increase in abrasion loss as well as mass and strength loss by sulphate attack. Furthermore, it was found that the concrete mixes incorporating 10% and 20% granite sludge displayed an improvement in the resistance to freeze and thaw as well as sulphate attack relative to the control mix in terms of mass and strength loss.

Omkar et al. (2017) conducted an experimental investigation to study the durability properties of concrete [13]. It was found that the concrete containing fly ash have low resistant to the H2SO4 solution over the controlled concrete after the acid resistance test. Similarly, Lohani et al. (2012), studied the property of the quarry dust and its suitability to use partial replacement for sand[17]. Design mix of M20 grade of concrete was prepared with partial replacement of 0%, 20%, 30%, 40% and 50% of sand by quarry dust. The durability of concrete was studied by immersing the concrete cube in 5% solution of MgSO4, 5% solution of NaCl and 2N solution of HCl for 28 and 91 days and results were compared with the standards to achieve the desired parameters.

The durability properties of concrete are improved when quarry dust is replaced partially as fine aggregates or as cement in conventional concrete benefitting both the environment and the construction industry.

III. CONCLUSIONS

In conclusion, the further researches on aspects related to the utilization of quarry dust for construction materials needs to be done in order to improve the strength and durability of the concrete as well as conserving the environment. Based on this review, replacement of fine aggregates with quarry sand improves the compressive strength and split tensile strength of the concrete as compared to the conventional concrete. Also the durability properties of the concrete is improved. Thus, the reusing of quarry dust from quarry industry is such a sustainable approach in order to fulfil with future needs of environmental and concrete technology.

REFERENCES

[1] R.Ilangovana, N.Mahendrana and K.Nagamanib, "Strength and durability properties of concrete containing quarry dust as fine aggregate", Pg.No. 20 References to 26, ARPN Journal of Engineering and Applied Science, Vol.3, No.5, October 2008

[2] Appukutty, P., & Murugesan, R. "Substitution of quarry dust to sand for mortar in brick masonry works" International Journal on Design and Manufacturing Technologies, 3(1), 5963.2009.

[3] Malpani, Ronak & Kumar Jegarkal, Sachith & Shepur, Rashmi & Kiran, Ravi & Adi, Veena. (2014), "Effect of Marble Sludge Powder and Quarry Rock Dust as Partial Replacement for Fine Aggregates on Properties of Concrete", 2278-3075

[4] Galetakis, M., Soultana, A, "A review on the utilisation of quarry and ornamental stone industry fine by-products in the construction sector". Construction and Building Materials 102 769–781, (2016)

[5] K. Shyam Prakash and Ch. Hanumantha Rao, "Study on Compressive Strength of Quarry Dust as Fine Aggregate in Concrete," Advances in Civil Engineering, vol. 2016, Article ID 1742769, 5 pages, 2016

[6] N. J. A. Hamid, A. A. Kadir, N. A. F. M. Kamil, and M. I. H. Hassan, "Overview on the utilization of quarry dust as a replacement material in construction industry", Int. J. Integr. Eng., vol. 10, no. 2, pp. 112–117, 2018.

[7] Engineering College Sec, Saveetha & Prathap, M G & Aishwaryalakshmi, V & Kumar, Nilesh & Seshachalam, Haribabu. Experimental study on strength of concrete by partial replacement of fine aggregates with quarry dust. International Journal of Civil Engineering and Technology. 8. 12-17, (2017).

[8] Priyatham, B.P.R.V.S. & Chaitanya, D.V.S.K. & Dash, B. "Experimental study on partial replacement of cement with marble powder and fine aggregate with quarry dust". International Journal of Civil Engineering and Technology. 8. 774-781.. (2017).

[9] G.Balamurugan, Dr. P. Perumal, "Use of Quarry Dust to Replace Sand in Concrete – An Experimental Study". International Journal of Scientific and Research Publications, Volume 3, Issue 12, December 2013

[10] Amin, Muhammad & Khan, Kaffayatullah & Saleem, Muhammad & Khurram, Nauman & Umar Khan Niazi, Muhammad. Aging and Curing Temperature Effects on Compressive Strength of Mortar Containing Lime Stone Quarry Dust and Industrial Granite Sludge. Materials. 10. 642. 10.3390/ma10060642. (2017).

[11] Almeida, Nuno & Branco, Fernando & Brito, Jorge & Roberto Santos, José. High-performance concrete with recycled stone slurry. Cement and Concrete Research. 37. 210-220. 10.1016/j.cemconres.2006.11.003. (2006).

[12] P. Suraneni, T. Fu, V.J. Azad, O.B. Isgor, J. Weiss, Pozzolanicity of finely ground lightweight aggregates, Cement and Concrete Composites, doi: 10.1016/ j.cemconcomp.2018.01.005. (2018)

[13] Kamasani, Chandrasekhar Reddy & M Omkar, S. Investigation on durability properties of concrete with partial replacement of sand by quarry dust & cement by fly ash. International Journal of Research in Engineering and Applied Sciences. 7. 102-107. (2017).

[14] Alzboon, Kamel & Tahat, Montasser & Abu-Hamatteh, Ziad & Al-Harahsheh, Mohammad. Recycling of stone cutting sludge in formulations of bricks and terrazzo tiles. Waste Management & Research. 28. 568-574. (2010).

[15] O. Mashaly, Ahmed & Shalaby, B & Rashwan, Mohammed. Performance of mortar and concrete incorporating granite sludge as cement replacement. Construction and Building Materials. 169. 800-818. 10.1016/j.conbuildmat.2018.03.046. (2018).

[16] Nileshchandra Patel, Ankit & Pitroda, Jayeshkumar. Stone Waste: Effective Replacement Of Cement For Establishing Green Concrete. International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075. 2. 24-27. (2013).

[17] Lohani T.K., Padhi M., Dash K.P., Jena S. "Experimental investigation on Durability properties of concrete by using Quarry dust," Int. Journal of Applied Sciences and Engineering Research, Vol. 1, No. 2, 2012.