VOL. 15, NO. 14, JULY 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

UTILIZATION OF QUARRY DUST IN PAVING BLOCKS

Shyam Prakash Koganti[1], M. Sai Narendra[1], D. Jaya Krishna[1] and Kaza Raga Sai[2]
[1]Department of Civil Engineering, PVPSIT, Vijayawada, India
[2]Department of Civil Engineering, LIMAT, Madalavarigudem Vijayawada, India
E-Mail: shyamprakashcivil@gmail.com

ABSTRACT

In India, National highways (NH) cover 1,00,087 km and other types of highways (state highways, major district roads, other district roads and village roads) cover 53,82,495 km. Sand is heavily used both in flexible and rigid pavements, created an increase in the demand of sand. As per National Highway Development Programme (NHDP), it is estimated to lay 30km road per day now. Presently, 71,772 km network of National Highways comprises only 1.7% of the total length of roads, but carries over 40% of the total traffic around the country both in length and breadth. Considering the target growth rate of about 9%, it is estimated that the total target National Highway network of about 85,000 km may be considered as reasonable for the 12th Five Year Plan (2012 – 2017), for the region development which are not connected by National Highway. During fifties concrete paver blocks were introduced due to scarcity of building materials in Holland. Paving blocks are in rectangular shape and bricks size. Paving blocks under non traffic category utilizes in Building premises, monument premises, landscapes, public garden/parks, domestic drives, paths and patios, embankment slopes, sand stabilization area, etc., Testing of compressive strength is classified into three series. The compressive strength results of quarry dust concrete (cubes) obtained in the first series, for normal cube it is observed as 28.45 N/mm^2. In the second series, the change in grades up to 40 percent replacement increases the compressive strength. As the increase in age of concrete the compressive strength increase up to 30 percent replacement of quarry dust as a fine aggregate in the third series.

Keywords: compressive strength, paving blocks, percentage, sand, quarry dust.

1. INTRODUCTION

There has been an extensive utilization of sand for various purposes. The mining of minerals and other products to meet the demands of industries are inevitable for the sustenance of civilization. In India, the mining activity is spread for all the major developed regions where having more population of both mid and low land. The demand for natural resources like hard rock, laterite, sand and soil in the past four to five decades for construction of buildings and other infrastructural facilities amplified many times the mining activities in the country. The mining activities are going on without break down due to freely available environment. Often, the process leads to conflicts among various stakeholders and as a result several cases are pending before the Honourable Courts and Government for clearance. There is no information on the level of gravity major goals to be ensured to change the existing systems which is challenging task to make mining normal stage.

Overall performance of concrete paver blocks used is mainly focused by physical properties of materials, water percentage, mixing and curing process. Fine aggregates for paving blocks are obtained from the conservative sources like natural river sand or sand from the crushed rocks. Demand for natural sand has improved due to the rapid growth in construction activities where river sand is used as a fine aggregate. The viability of using industrial by products and waste materials in the paver block manufacturing has studied in the past in various research conducted.

Footpaths along the roadside given a face lift. Enhanced look, better finish easy laying are the results of applying concrete paving blocks. The applications of cement concrete paving blocks can be found in various urban areas such as bus stops, footpaths, gardens, public places etc. Hence, the unit may be set up in urban and semi-urban areas, near the market. The accessibility of walking and the enhanced looks of the area are the benefits of using concrete pavement blocks to the walk ways.

The study concentrated on M30 grade of concrete by replacement of sand with quarry dust. As per the IS 15658:2006 the paving blocks categorized based on traffic condition. Here the study concentrated on non-traffic category with grade designation as M30. It is need to understand the concrete behaviour in paving block by varying percentage replacement of sand with quarry dust.

2. LITERATURE

Bala subramanian J. *et al*. (2006) argued that in the manufacturing of non structural building materials like solid pavement blocks, flooring tiles and bricks the replacement of up to 30% of cement with Effluent Treatment Plant (ETP) sludge along with quarry dust resulted in the strength and other properties which met the Bureau of Indian Standards and most of American Society for Testing and Materials (ASTM) standards.

Radhikesh P. Nanda *et al.* (2010) considered that paving blocks made of concrete are perfect materials for footpaths which are easy to lay and look better. Paver block produced using crusher dust is studied in the paper. The fine aggregate is replaced with crusher dust by different percentages and the mechanical properties and physical properties of paving blocks are investigated. Up to 50% of substitution of fine aggregate with quarry dust shows no effect on the properties as per the test results and

VOL. 15, NO. 14, JULY 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

there is also money saving up to 56%. Even though the cost savings are less the benefits are more for paving blocks due to mass production.

According to Prasanta Kumar Dey *et al.* (2008) Socio economic environmental factors, logistics, costs and resource availability are some of the factors which govern the selection of quarry site for the production of cement. Industrial output and sustainable growth of economy are facilitated by the sufficient consideration of all factors. Cement manufacturing in Barbados is supported by the operations of quarry expansion and the study helps in the process of that site selection.

According to Mukesh Patel B. *et al.* (2012), Cement manufacturing releases into atmosphere the carbon dioxide gas which causes global warming and greenhouse effect. The substitute materials for cement which are economical have to be developed. Quarry dust, silica fume, fly ash, recycled aggregates became solution for that problem which are abundantly available. Quarry dust and fly ash are used partially as a replacement of natural sand and cement respectively along with some mineral admixture for the preparation of concrete economically and to reduce the harmful effects on the environment.

Bahoria B. V. *et al.* (2013) surveyed the writing on Sand is useful for the filtration of ground water and for the safeguard of river beds from the process of erosion. If a material which can replace sand and the above said problems can be encountered. Researchers are done and noticed that Quarry dust and plastic wastes have been found as a useful replacement for the sand partially in the concrete constructions. Nagpur which has much number of stone quarries producing tons of dust resulting in serious problems. With the use of quarry dust as a replacement of sand the above said problem has been solved this is also good for the environment.

Bederina M. *et al.* (2013) concentrated that much of the area of laghouat is disposed with quarry dust and lime materials. In order to reduce the impact of disposal it is need to substitute in the mortar. It leads to reduce the impact on environment too and also it can reduce the sand extraction from river.

Nawagamuwa U. P. *et al.* (2015) concentrated that to reduce the damage to the environment and the cost of construction the quantities required by the construction industry has to be decreased. The commonly used materials in the construction industry are quarry dust and lateritic soils which will give enough densities and decrease the construction cost when stabilized for Municipal Sewage Waste (MSW).

Bahoria B. V. *et al.* (2016) examined on digital optical microscope is used to study densification of matrix using petro graphical examination. XRD is used to investigate the materials such as quarry dust, waste plastic (LDPE) and natural sand. Exhaustion of natural sand can be decreased by using quarry dust along with waste plastic as a substitute for sand as fine aggregate in mass concreting works. Economy and environmental conditions can be improved by using the quarry dust and plastic wastes.

Shubham Kothari *et al.* (2016) investigated the quarry dust provides good cohesiveness to the mix because of its high fineness and it also increases the demand of water which was observed. Micro filling ability is demonstrated by the use of quarry dust. Utilization of quarry dust in the manufacturing of concrete helps in the production of green concrete.

3. EFFECT OF QUARRY DUST IN PAVING BLOCKS:

During fifties concrete paver blocks were introduced due scarcity of building materials in Holland. Paving blocks are in rectangular shape and bricks size. From past five decades, the block shape has been studied from non-interlocking to partially interlocking to fully interlocking to multiply interlocking shapes. These paving blocks are two classified in to two groups as non-interlocking block pavement and interlocking block pavements and named as Concrete Block Pavements (CBP) for non-interlocking block pavement and Interlocking Concrete Block Pavement (ICBP). The CBP and ICBP are laid on surface layers, compacted bedding over a base course as a precast concrete pavers. The gaps between these paver blocks are filled with fine particles. The CBP and ICBP can be give good performance for the locations have lower service life like traffic, geological and environmental operations constraints.

Application of CBP/lCBP technique is getting popular around the country, especially in metropolitan cities as well as in large and medium towns. Based on the seriousness towards application of this specialized paving technique, BIS recognizes the need to regulate the quality of paver blocks and CBP/ICBP so that the purchaser is ensured of uniformly good quality of blocks and CBP/ICBP. Accordingly, this standard specification for concrete paver blocks is being formulated as shown in the Table-1.

Table-1. Paver blocks recommended Grades for Different Traffic Categories.

S. No.	Grade	Compressive Strength at 28 Days (N/mm^2)	Traffic Category	Minimum Thickness
1	M30	30	Non-traffic	50
2	M35	35	Light-traffic	60
3	M40	40	Medium-traffic	80
4	M50	50	Heavy-traffic	100
5	M55	55	Very heavy-traffic	120

VOL. 15, NO. 14, JULY 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

4. APPLICATION OF PAVING BLOCKS

Paving blocks under non traffic category utilizes in Building premises, monument premises, landscapes, public garden/parks, domestic drives, paths and patios, embankment slopes, sand stabilization area, etc. Paving blocks under light traffic category utilizes in Pedestrian plazas, shopping complexes ramps, car parks, office driveways, housing colonies, office complexes, rural roads with low volume traffic, farm houses, residential roads, local authority footways, beach sites, tourist resorts, etc. Paving blocks under medium traffic category utilizes in City streets, small and medium market roads, low volume roads, utility cuts on arterial roads, etc. Paving blocks under heavy traffic category utilizes in Bus terminals, industrial complexes, mandi houses, roads on expansive soils, factory floor, service stations, industrial pavements etc. airport pavements, mine access roads, container terminals, ports, docks yards, bulk cargo handling areas etc.

Concrete paving blocks has the unique ability to transfer loads and stresses laterally by means of an arching of bridging between units, spreading the load over a large area, reduces the stress thereby allowing heavier loads and traffic over sub-bases normally require heavily reinforced concrete (Lohani T. K. *et al.* 2012). The process of manufacturing these rugged, shapely and beautiful pieces of concrete moulds involves a unique vibration and hydraulic compaction. This imparts high compressive strength and curability apart from aesthetic beauty to the entire range of products (Suresh Chandra H. S. *et al.* 2014). Concrete pavement block suits virtually all types of pavements and requires minimum maintenance. The range of concrete pavement block includes Light Duty, Medium Duty, Heavy duty and Decorative Landscape Pavers. Replacement of fine aggregate by crusher dust up to 50% by weight has a negligible effect on the reduction of any physical and mechanical properties like compressive strength, flexural strength, and split tensile strength in paving blocks (Radhikesh P. N. *et al*. 2010).

Overall behaviour and performance of concrete paver blocks used are mainly governed by properties of materials, water cement ratio, mixing process and curing process (Bahoria B. V. *et al.* 2014). The alternative sources of fine aggregates for paving blocks are river sand or alternatively, artificial sand by crushing rocks.

5. COMPRESSIVE STRENGTH OF PAVING BLOCKS

Testing of compressive strength is classified into four series. Series is divided based on the production of crushers per hour. As already discussed, 40 crushers are have their own respective production capacity. Most of the crushers are 10TPH (tones per hour) production. Few crushers are having the production capacity of 15TPH, 20TPH, 150TPH and 400TPH. In the first series, compressive strength is identified for all the 40 crusher's quarry dust samples which come under 10, 15 and 20TPH. In the second series, test conducted for 150TPH crusher's samples collected from PCL crusher. Third series concrete test is done for 400TPH crusher's samples collected from madhucon crushers. The testing process is done because the capacity and power of the plant is varying. So based on this, observed that any change in quarry dust samples which leads to the change of compressive strength. The program involves casting and testing cube specimens in each set consists of 3 cubes. The study involves casting and testing cube specimens in each set consists of 3 cubes. The target mean compressive strength was determined using 9.2.4.2 clause of IS 456:2000 as f_{ck} + 1.65s, here "s" stands for standard deviation can be assumed for each grade of concrete. Hence, it is assumed in the present studies that the "s" as 4 N/mm^2 for M20 and 5 N/mm^2 for M30, M40.

The cubes were casted using standard one set is concentrated with cube size of 50mmX50mmX50 mm and other two sets cube size of 150mmX150mmX150mm. Specific gravity of sand and quarry dust is 2.62 & 2.70 for zone II classified type is obtained. 53-grade cement is used for the mix. Concrete mix was cured with conventional moist curing. Compression testing machine of 2000 KN capacity was used to test the cubes specimens. The set of three series is as follows:

a) The compressive strength results of quarry dust concrete (cubes) obtained in the first series, for normal cube it is observed as 28.45 N/mm^2. Whereas it is find out that M30 grade of concrete with 10%, 20%, 30%, 40%, 50%, 60% and 70% replacement of quarry dust with the cube dimension of 50*50*50mm for paving blocks is concentrated and presented the results in Table-2.

VOL. 15, NO. 14, JULY 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

Table-2. Compressive strength of M30 grade with percentage replacement.

Crusher No.	10% QD	20% QD	30% QD	40% QD	50% QD	60% QD	70% QD
1	32.2	33.7	35.7	36.5	35.4	30.5	28.3
2	31.4	34.1	33.9	32.4	32.9	31.4	27.6
3	30.5	34.6	33.3	35.2	30.5	33.9	27.2
4	32.1	35.4	34.9	33.1	37.4	31.6	26.7
5	34.3	32.1	33.1	36.8	31.6	31.3	28.0
6	32.4	31.3	36.3	33.9	32.3	30.5	26.3
7	30.4	34.5	33.7	34.3	35.1	32.8	28.3
8	30.2	33.7	34.1	33.4	32.4	29.7	27.9
9	34.6	34.6	35.2	36.6	30.5	30.4	26.8
10	32.3	32.1	34.3	35.5	32.8	32.5	27.7
11	30.1	34.5	32.3	35.2	37.9	31.6	28.3
12	31.5	31.3	34.4	36.4	34.6	31.3	26.6
13	30.8	33.7	35.1	33.8	33.3	30.2	27.2
14	30.9	34.1	36.1	35.3	37.1	33.5	28.1
15	32.4	33.2	35.4	36.6	32.4	32.5	26.9
16	34.3	32.3	36.1	34.4	30.5	33.7	27.7
17	33.5	31.5	35.7	35.1	35.4	29.1	28.5
18	33.4	33.4	36.1	36.7	30.9	32.5	27.3
19	30.2	35.6	34.7	34.3	34.3	30.63	28.1
20	31.1	32.4	34.4	34.8	35.6	33.8	27.5
21	33.4	34.5	36.7	36.1	30.4	34.9	27.9
22	34.6	32.4	33.6	32.9	33.8	28.5	28.4
23	32.8	31.3	34.8	33.4	31.1	29.4	27.5
24	33.1	34.5	33.5	31.3	37.1	30.7	28.7
25	30.3	32.4	32.9	36.5	33.3	30.5	27.9
26	34.5	30.8	34.3	30.6	32.5	34.4	29.1
27	32.2	35.9	35.2	33.8	35.4	31.4	27.6
28	30.4	32.7	35.9	31.9	30.8	30.5	28.0
29	33.3	33.8	36.6	33.1	30.9	31.8	28.5
30	34.1	33.9	34	36.2	31.6	30.5	28.9
31	32.3	34.5	36.7	31.4	35.7	33.8	27.9
32	30.1	30.4	34.5	32.3	34.4	31.4	28.9
33	30.4	34.6	35.4	36.6	33.6	32.2	29.2
34	31.5	33.8	33	36.3	33.8	31.2	27.4
35	32.3	30.9	34.8	31.6	37.3	32.5	28.1
36	31.7	31.4	36.2	33.3	32.1	30.4	27.7
37	30.9	30.2	33	36.3	30.4	33.5	27.6
38	30.1	34.1	34	34.7	37.6	34.2	27.3
39	31.3	33.6	33.9	36.4	35.9	31.1	26.5
40	30.8	31.7	35.1	30.7	35.4	30.5	27.6

VOL. 15, NO. 14, JULY 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

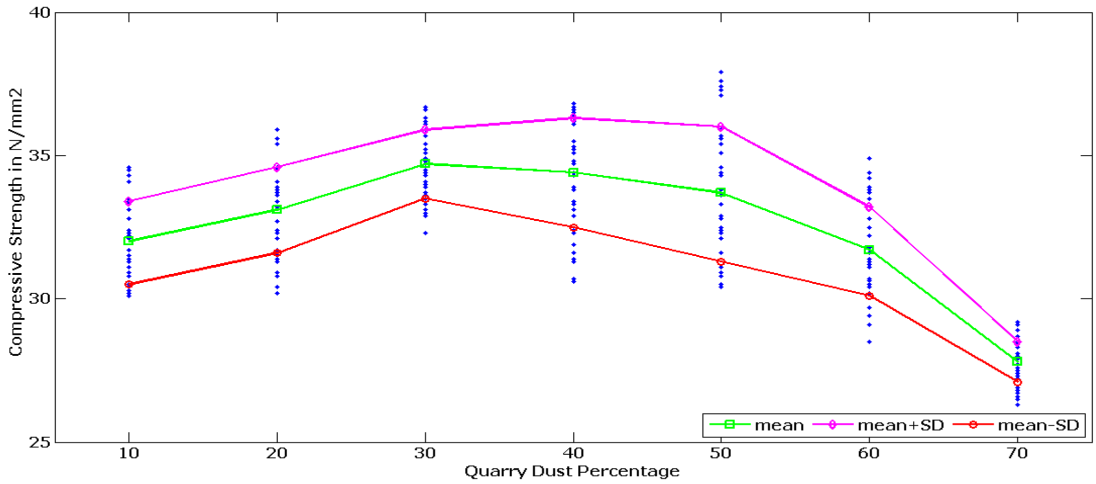

Figure-1. Compressive Strength of M30 grade paving block with 10, 20, 30, 40, 50, 60 and 70 percentage replacement of quarry dust.

Quarry dust replaced for 20% strength was increased by 40%, for 30% replacement strength was increased by 40% and for 40% replacement strength increased by 45%. For 50% replacement of sand with quarry dust there is a drop down of strength started. The compressive strength for 60% and 70% replacement of sand with quarry dust is decreased when compared to 40% replacement of sand. It is understood that the compressive strength of M30 grade for paving block is shows good results for 40% replacement of sand with quarry dust as shown in the Figure-1.

b) The compressive strength results of quarry dust concrete (cubes) obtained in the second series, M20, M30 and M40 grades of concrete with 20, 30 and 40 percent replacement of quarry dust with water/cement ratio of 0.45 is concentrated and presented the results in Table-3. Quarry dust samples collected from PCL crusher (150TPH).

Table-3. Compressive strength of M20, M25 and M30 grade with percentage replacement.

Grade	Percentage of replacement	Compressive Strength (N/mm^2)
M20	0	19.9
	20	26.5
	30	27.5
	40	28.3
M30	0	30.22
	20	31.03
	30	33.03
	40	33.48
M40	0	36.3
	20	37.8
	30	42.6
	40	47.8

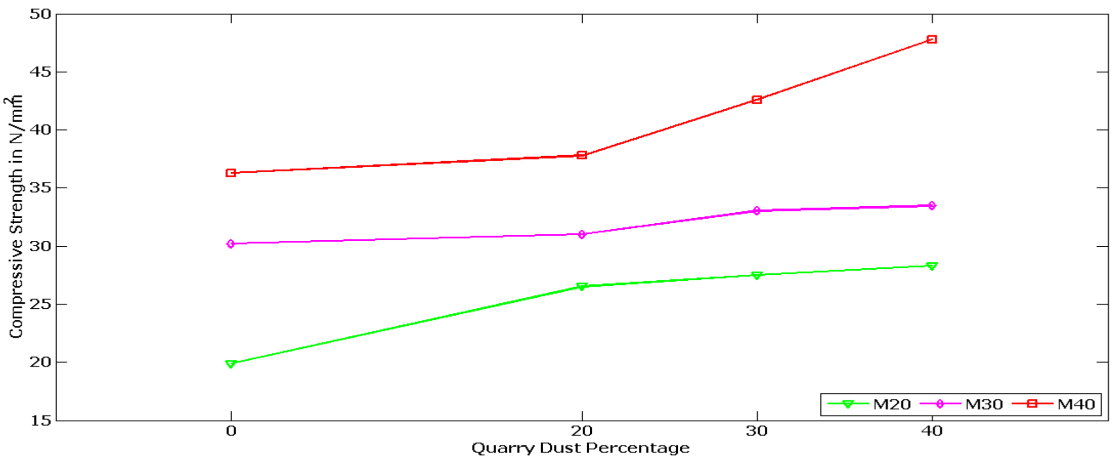

Figure-2. Compressive strength of M20, M30 and M40 grade up to 40 % replacement of quarry dust.

The observations also concentrated on variation of grades of concrete by replacement of quarry dust. The change in grades up to 40 percent replacement increases the compressive strength. The Figure-2 shows the compressive strength of varying grade and age of concrete by replacement level up to 40%. The compressive strength of M30 grade possesses the good results than the M40 grade concrete. The observation here in the graph regarding the compressive strength up to 40% is increases for the grade changes as M20, M30 and M40.

c) The compressive strength results of quarry dust concrete (cubes) obtained in the third series is studied and presented the results in Table-4. The specimens were casted with conventional materials i.e. fine aggregate is natural river sand with M30 grade by using Ordinary Portland cement (OPC). Quarry dust samples collected from madhucon crusher (150TPH).

Table-4. M30 grade of concrete with 20, 25 and 30 percent replacement of quarry dust tested for 3 days, 7 days and 28 days.

Compressive Strength	0% QD	20% QD	25% QD	30% QD
3 days	18.9	17.93	17.85	20.74
7 days	28.44	29.63	30.81	28.89
28 days	38.66	41.19	44.30	44.30

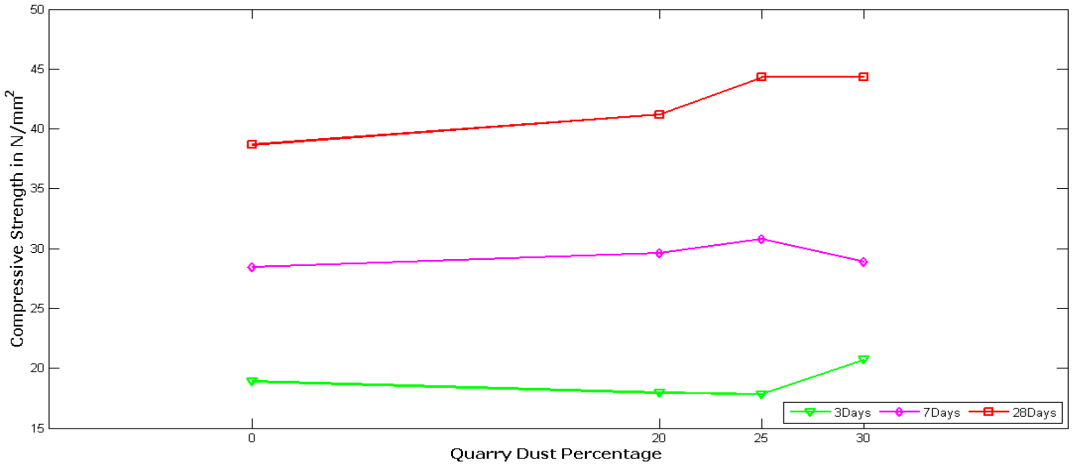

Figure-3. Compressive strength of M30 grade with change in age.

As the increase in age of concrete the compressive strength increase up to 30 percent replacement of quarry dust as a fine aggregate. The partial replacement of Quarry Dust gave a 28 days peak compressive strength at 30% replacement level. The Figure-3, shows that the compressive strength of M20 grade with varying age of concrete by replacement level up to 30%.

6. CONCLUSIONS

a) It is observed that the 50 percent of sand can be replaced with quarry dust in concrete as paving blocks for light and medium traffic.

b) In the second series, compressive strength of M20, M30 and M40 grades of concrete by replacement level up to 40 percent possess the good results.

c) The compressive strength of M30 grade of concrete possesses better results up to 30 percent replacement of quarry dust in place of fine aggregates.

REFERENCES

Balasubramanian J., Sabumon P. C., John U. Lazar, Ilangovan R. 2006. Reuse of textile effluent treatment plant sludge in building materials. Waste Management. 26: 22-28, DOI:10.1016/j.wasman.2005.01.011.

Radhikesh P. Nanda, Amiya K. Das, Moharana N. C. 2010. Stone crusher dust as a fine aggregate in Concrete for paving blocks. International journal of civil and structural engineering. 1(3): 613-620.

Prasanta Kumar Dey, Eugene K. Ramcharan. 2008. Analytic hierarchy process helps select site for limestone quarry expansion in Barbados. Journal of Environmental Management. 88: 1384-1395, 2008, DOI:10.1016/j.jenvman.2007.07.011

Lohani T. K., Padhi M., Dash K. P., Jena S. 2012. Optimum utilization of Quarry dust as partial replacement of sand in Concrete. International Journal of Applied Sciences and Engineering Research. 1(2): 391-404, DOI:10.6088/ijaser.0020101040.

ARPN Journal of Engineering and Applied Sciences

Mukesh Patel, Charkha S. D. 2012. Effect of Silica Fume and Partial Replacement of Ingredients on Flexural and Split Tensile Strength of Concrete. International Journal of Engineering Research and Applications. 2: 1782-1785.

Bahoria B. V., Dr. Parbat D. K., Dr. Naganaik P. B., Dr. Waghe U. P. 2013. Comprehensive literature review on use of waste product in concrete. International Journal of Application or Innovation in Engineering & Management. 2(4): 387-394.

Bederina M., Makhloufi Z., Bounoua A., Bouziani T., Queneudec M. 2013. Effect of partial and total replacement of siliceous river sand with limestone crushed sand on the durability of mortars exposed to chemical solutions. Construction and Building Materials. 47: 146-158, DOI: http://dx.doi.org/10.1016/j.conbuildmat.2013.05.037

Suresh Chandra H. S., Sarangapani G., and Naresh Kumar B. G. 2014. Experimental Investigation on the Effect of Replacement of Sand by Quarry Dust in Hollow Concrete Block for Different Mix Proportions.International Journal of Environmental Science and Development. 5(1), DOI: 10.7763/IJESD.2014.V5.443

Nawagamuwa U. P. 2015. Study on Compaction Characteristics of Lateritic Soil/Quarry Dust Stabilized Municipal Solid Waste.International Conferences on Gender Equality (ICGE) Colombo. pp. 273-276.

Bahoria B. V., Parbat D. K., Nagarnaik P. B. 2016. XRD Analysis of Natural sand, Quarry dust, waste plastic (ldpe) to be used as a fine aggregate in concrete. Materials Today. pp. 1-7.

Shubham Kothari, Trilok Gupta, Dr. Ravi Kr. Sharma. 2016. Effective utilization of crusher dust in sustainable concrete. International Journal of Engineering Research and Applications. 6: 20-30.