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A Review on Potential of Quarry Dust Waste as An Aggregate in Concrete Production

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Abstract: A serious environmental problem is quarry dust, which is produced in large amounts from quarries. In construction applications, the use of these materials may lead to both economic and environmental benefits. This paper reviews recent research studies on the development of concrete materials, either as aggregates or as substitute materials for cement. Therefore, for this study, quarry dust waste will be used as the replacement of aggregate in concrete production. The aim for this research is to discover the potential and the mechanical properties of the quarry dust waste as a replacement of aggregate in concrete. The slump test, compressive strength test, flexural test and split tensile strength are the mechanical properties highlighted in this report. Both detail and data are taken from previous research articles. Different percentage replacement of aggregate into the concrete is proven to give the concrete different mechanical efficiency. It is found that 40.00 % replacement of fine aggregate by quarry dust gives maximum result in strength than normal concrete and then decreases from 50.00 %. The compressive strength is quantified for varying percentage and grades of concrete by replacement of sand with quarry dust.

Keywords: Quarry Dust Waste, Strength, Environmental Problem

1. Introduction

Concrete is the most widely used construction and building material. In 2001, the global concrete production reached 12 billion tons per year [1]. Typically, ordinary concrete consists of cement and aggregate (coarse and fine) in the ratio of 20.00 % and 80.00 % respectively. This implies that we were, globally, using a number of aggregates equal to 10 billion tons per annum for concrete production. This makes concrete one of the largest consumers of natural resources. It is predicted that the concrete requirement will reach 18 billion tons a year by 2050 [2].

In the light of increasing environmental consciousness, new environmentally friendly technologies should be built to better manage natural resources. Only if we consider from every corner of construction material, is cost-effective in building. Concrete is a composite material composed in particular in proportion by mixing cement, aggregate and water so that it fulfils a need for its workability, strength, durability and economic performance [3]. River sand is a great quality fine aggregate for producing

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concrete. It can be available in only small quantity for now because of the cost of sand from rivers. A research was performed to decide if quarry dust is suitable as an aggregate [4].

The cost of building can be minimized if quarry dust is available in close proximity to the site. Aggregates used in concrete are produced through open-cast mining and quarrying operations which have serious environmental and geotechnical problems such as contamination of the soil and water sources, alteration of groundwater regimes, disfigurement of the landscape, construction of tips, soil erosion, loss of flora and fauna, vegetation and soil degradation, ground instability and subsidence, and creation of dangerous voids [5]. The aggregate extraction process damages the land, making it derelict land which is incapable of beneficial use without treatment. It is not acceptable to leave large areas of land in a blighted and unusable state. Besides environmental degradation, considerable energy is consumed in mining or quarrying operations and transportation of aggregate materials. Utilization of waste or recycled materials in concrete help in conserving natural resources mitigate environmental pollutions, reduces the cost of concrete manufacturing, reduces landfill demand and its cost, and saves energy [6].

1.1 Problem Statement

Today, the use of aggregate for concrete production has risen significantly due to the rise in construction industries. The increase in the production of concrete causes a rise in the demand for raw materials which in turn puts a squeeze on the prices of raw materials. This explanation is due to the lack of raw materials. So, by using the quarry dust waste which is abundantly available from quarrying activities crushing stones. Much of the economy of construction could be saved.

1.2 Objective

- To determine the potential use of quarry dust waste as an aggregate in the concrete mixture.
- To identify parameter the characteristic of mechanical properties of quarry dust waste.

1.3 Scope of Study

To achieve the objectives of this project, the potential uses of this material will be compared from previous research paper. The scope will be focus to observe the potential of quarry dust waste material to substitute in concrete production in terms of characteristics of mechanical properties.

1.4 Significant of The Study

Waste material created by crushing rock ballast is a large quantity. This raises a significant concern about waste handling and disposal. Deforestation continues to spread across the world in many areas because of activities such as mining activities. This study focuses on the possibility of utilizing quarry dust as building materials in making concrete.

2. Literature Review

Recycled material has been used for two decades in concrete manufacturing. It deserves serious attention. Disposal of wastes like quarry dust, fly ash, silica fume, rice husk ash, blast furnace slag, recycled concrete aggregate and foundry refuses become serious problems from environmental and economic considerations. Processing of wastes to use them as construction materials is a huge improvement [7]. The transformation method that can fulfill the ultimate goal of waste management and natural resource protection at the same time.

In this chapter, an overview of the results of previous research on the characteristics of above waste material application in concrete production are presented. The properties of concrete including workability, stability, strength have been measured because of the added material [7]. Concrete is the main production of all materials used in construction. Concrete and other building materials can still be obtained because of their materials extracted from earth. Despite this fact, wide spectrums of waste materials are not normally accepted for production of concrete.

From the viewpoint of maintaining the ecological balance, waste materials may have to be judiciously combined with other ingredients to produce concrete of acceptable strength and durability. Such materials are broadly grouped as marginal materials. The specific reasons for this classification of wide spectrum of materials are non-compliance with standard specification, incomplete exploration, poor performance and lack of appropriate technology.

Satisfactory utilization of marginal materials depends on the following factors:

- Technical Feasibility,
- Durability of the processed concrete, and
- Economic feasibility

There will be more material use as a result of continuous research activities, and the use of marginal materials will increase. In this review, the earlier findings of marginal materials other than Ordinary Portland Cement (OPC), sand, coarse aggregate and their application are discussed.

2.1 Concrete

According to Sidney and Francis Young (2003) [8], concrete consist of stone mixture diffuse rough, fine aggregate and cement. These substances blended and mixed with water, after that ignored it is hardened follow certain proportion to form concrete. Concrete manufacturing technique, concrete quality, concrete mixture ratio and should be emphasized for concrete production that good and quality. Concrete strength is one of the features of concrete that is important to giving comprehensive picture contact with concrete quality because strength is directly related structural hardest cement paste [9]. Concrete strength also increased according to the age and this strength expansion is continuing for a few moments. Nevertheless, concrete in 28-day age made yardstick to strength. Solidification of concrete strength expansion very depends on temperature and humidity during hardened process. Water cement ratio is among key factor which control concrete strength.

2.1.1 Cement

Cement is a substance made from extremely fine powders. Mixing this powder with water will create a paste that bonds and hardens when immersed in water. The composition and fineness of cement can vary because of the variations of the ingredients. Concrete is made from cement, the main ingredient [10]. It is economically and environmentally valuable material. Cement is formed by a clay and limestone mixture, which is then heated to 1,450 °C. This granular substance, called "clinker," is simply a mixture of calcium, silicate, alumina and iron oxide.

2.1.2 Water

In the making of concrete, water is a main ingredient. It is a substance in its own right as well. Knowing its properties is useful in gaining and understanding its impact on concrete and other construction materials. Water has properties that make it a crucial function in corrosion, even though it is essential to the construction process. It is also a highly efficient solvent and, when it travels from warm to cool regions in a system or structural member, may cause damage due to moisture migration [11].

2.1.3 Aggregates

In concrete, aggregates play an important role because aggregate is one of the materials in concrete production, because aggregate makes up 75 percent of concrete production. Concrete production will primarily rely on aggregate properties. Aggregates have high compressive strength, elongation, basic gravity, and resistance against deformation. In addition, the composition of aggregates, as well as the properties of aggregates such as density, porosity, absorption of moisture, soundness and strength of aggregates in the production of concrete, also influence the strength of aggregates in the production of concrete [12]. The choice of aggregates is essential to the strength, durability, mixing ratio, and that is economical towards concrete producers. A good aggregate should be composed of concrete materials that are durable and stable for long term use [13]. There will be a shortage of aggregate on the market as a result of the rise in the construction industry.

2.1.4 Quarry Dust

The construction industry has rapidly developed in recent years. Additionally, aggregate demand for concrete is expanding. It is a common understanding that waste materials like fine quarry dust can be produced during urbanization and industrialization. It is crushed rock dust obtained from stone boulders crushed in stone crushers during the processing of crude aggregates [14]. Quarry dust has other applications such as substitutes for solvents. Stone has a detrimental influence since it is used as a substitute sand. Quarry dust is residue, tailing, waste after mining and processing. To the river sand is an aggregate that is coarse fraction from the quarry, which is used as the fine aggregate in place of sand concrete production.

Recently, many researches had done studies on quarry dust to be used as an effective filler material in concrete instead of fine aggregate. Some studies were reviewed by Chandana et al., [15], on physical and chemical properties as per listed in Indian Standard. Table 1 and Table 2 show the physical properties and chemical properties of quarry dust and natural sand respectively.

Table 1: Shows the physical properties of quarry dust and natural sand

Property	Quarry Dust	Natural Sand	Test method
Specific gravity	2.54 -2.60	2.60	IS2386(Part III)- 1963
Bulk density (kg/m3)	1720- 1810	1460	IS2386(Part III)- 1963
Absorption (%)	1.20- 1.50	Nil	IS2386(Part III)- 1963
Moisture Content (%)	Nil	1.50	IS2386(Part III)- 1963
Fine particles less than 0.075 mm (%)	12-15	6	IS2386(Part III)- 1963
Sieve analysis	Zone-II	Zone-II	IS 383- 1970

Table 2: Shows the typical chemical properties of quarry dust and natural sand

Constituents	Quarry Dust (%)	Natural Sand (%)	Test method
SiO2	62.48	80.78	IS 4032-1968
Al2O3	18.72	10.52	
Fe2O3	6.54	1.75	
CaO	4.83	3.21	
MgO	2.56	0.77	
Na2O	Nil	1.37	
K2O	3.18	1.23	
TiO2	1.21	Nil	
Loss of ignition	0.48	0.37	

Table 3: Summary of findings on the utilization of quarry dust waste as an aggregate

Reference	Finding
A. Vijayakumar and K. Revathi C (2015)	The 50% of quarry dust was used as partial sand replacement in construction materials but, beyond of this percentage, the compression strength value is reducing and affected the workability of the concrete.
Selvakoodalingam and Palanikumar (2002)	Test of the 28-day compressive strength was completed they found that that the strength was maximum accurate at 50% and replacement.
Sahu (2003)	The addition of stone dust at 0.5% will substantially decrease the workability, but the workability can be improved by adding superplasticizer at a concentration of 0.2% and there would be a substantial improvement in compressive strength, tensile strength and modulus of rupture.
Chandrasekhara Reddy (2003)	50% of replacement mix achieved the target strength. The greater portions of fine particles reduced the workability of concrete. At 75% sand replacement, the ultimate strength of the test specimens was 40% higher than that of the reference mix.
Ilangovan and Nagamani (2004)	Concrete made of crushed rock showed that it has almost 13% more compressive strength than standard concrete.
Prachoom Khamput (2006)	The maximum strength of concrete was observed to be stronger with increasing replacement of sand with quarry dust waste as fine aggregate.
Priyanka A. Jagadev and Dilip K. Kulkarni (2012)	Compressive, flexural, and split tensile strength are higher for mixed with 60% sand replacement as opposed to cements with a reference mixed.
Joseph (2012)	Found that the tensile and flexural properties were marginally decreased when crushing stones replaced by quarry dust, with marble replacing sand.
Shahul Hameed (2009)	From the test results, water absorption was found to be significantly higher. For quarry dust and marble sludge powder mixture the compression strength was 14%. It is rather practical, less permeable than control concrete.
Manasseh Joel (2010)	Test results showed that the w/c ratio and slump value improved as sand with crushed finished granite was replaced. At 20% sand substitution, maximum tensile and compressive strength.

3. Methodology

In identifying sources for this literature review, multiple databases were used. Initially, Google scholar started a broad search for a list of main-source and peer-reviewed research papers. In the beginning, I use a basic search of ‘Assistive Technology efficacy’. When using these descriptors, the researchers were successful in finding relevant information: adult learners, distance learning, technology use and employee growth. The Universiti Tun Hussein Onn Library, known as the UTHM Library, was another database used for the location of sources. I mostly used UTHM Library to find conventional sources, including books and some articles of science. The faculty within the Department of Education Technology at Universiti Tun Hussain Onn was the third source to classify conventional sources.

3.1 Flowchart of the study

Prior to starting this project, a flowchart was developed at Figure 1. A flowchart is one diagram type, which represents a process or algorithm that shows the steps and how they are connected with arrows as boxes of different kinds.

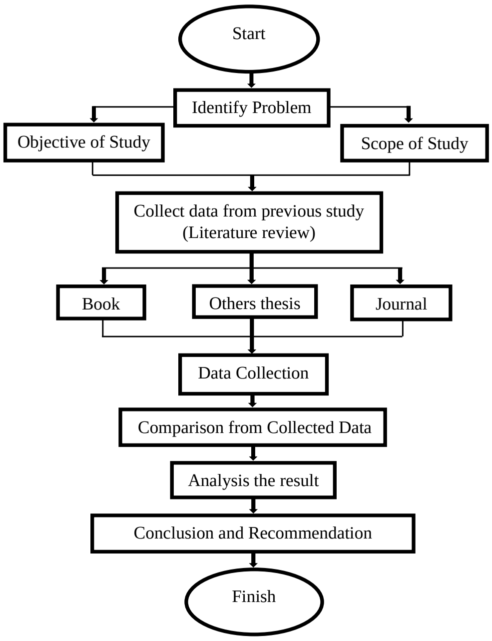

Figure 1: Flowchart order of methodology

4. Results and Discussion of Review

4.1 Properties on Hardened Concrete

4.1.1 Workability

The aggregate of quarry dust is coarser than sand, but the number of finer particles retained between 300 microns and 150 microns in sieve size is almost double the amount of sand that increased the water requirement. The quarry dust aggregate needed a water-cement ratio of 60.00 % to 100.00 % replacement, varying from 0.42 to 0.45 respectively. From the Figure 2, it was observed that the workability goes on reducing according to the percentage of sand replacement level in the slump test.

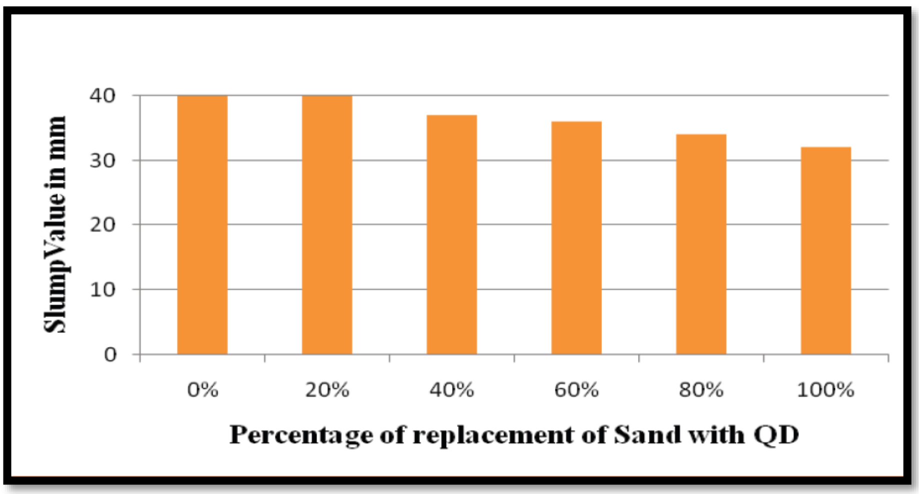

Figure 2: Workability characteristics for M30 Concrete

4.1.2 Compressive Strength

As strength is a vital property of concrete, among others, many investigations have reported on the development of strength of concrete with quarry dust in various ages. It has clearly emerged from their findings that partial replacement of natural sand with quarry dust results in higher strength up to 10.00-15.00 % higher than control concrete. Compressive strength was observed M15, M20, M30 and M35 using OPC in concrete. Compressive strength was computed at the age of 28 days.

Table 4: Compressive strength of concrete for various optimum proportion (at the age of 28-day)

Reference	W/C ratio	Mix proportions	Compressive strength (MPa)
A. Vijayakumar and K. Revathi C (2015)	0.55	1:1.5:3 (50%)	27.55
Selvakoodalingam and Palanikumar (2002)	0.5	1:2:4 (50%)	20.31
Sahu (2003)	0.5	1:1.5:3 (40%)	28.23
		1:0.75:1.5 (40%)	34.10
Chandrasekhara Reddy (2003)	0.5	1:1.5:3 (50%)	26.80
Ilangovan and Nagamani (2004)	0.50	1:1.5:3 (40%)	28.65
	0.50	1:0.75:1.5 (40%)	33.45
Prachoom Khamput (2006)	0.45	1:2:4 (70%)	17.22
Priyanka A. Jagadev and Dilip K. Kulkarni (2012)	0.45	1:1.5:3 (60%)	26.41
Joseph (2012)	0.65	1:1.5:3 (50%)	25.44
Shahul Hameed (2009)	0.5	1:1.5:3 (50%)	26.10
Manasseh Joel (2010)	0.45	1:0.5:1 (20%)	36.50

From the Figure 3 it is found that the 28 days compressive strength is maximum at 50.00 % replacement if coarse or medium quarry dust was used in place of sand. The percentage of increase in strength compared with control concrete is 10.82 and 13.82 respectively. But when fine quarry dust was used, maximum compressive strength is obtained at 30.00 % sand replacement. Compressive strength of concrete up to 70.00 % sand replacement by coarse or medium quarry dust is found to be greater than that of the control concrete. The compressive strength obtained by using fine quarry dust up to 50.00 % sand replacement is found to be greater than control concrete compressive strength.

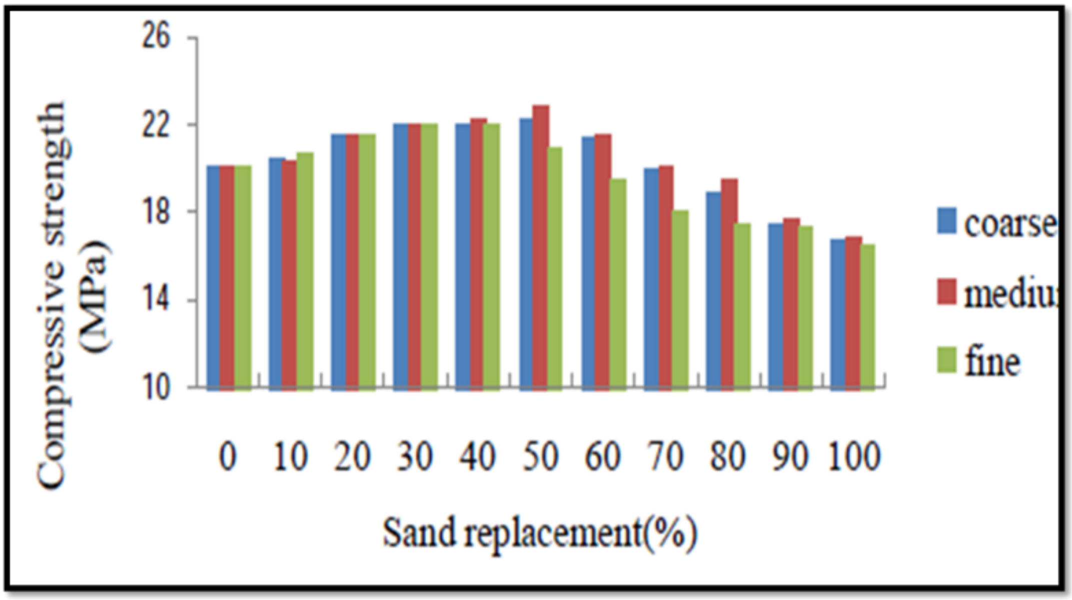

Figure 3: Compressive strength of M15 concrete using OPC at 28 days

4.1.3 Split tensile strength

Cylinders each having diameter 150 mm and height 300 mm were cured for 28 days and tested to determine the average split tensile strength. The trend for split tensile strength was similar to that obtained in the compressive strength. The maximum split tensile strength was obtained for 40.00 %, 50.00 %, 60.00 % and 70.00 % quarry dust proportion.

Table 5: Split tensile strength of concrete for various optimum proportion (at the age of 28-day)

Reference	W/C ratio	Mix proportions	Split tensile strength (MPa)
A. Vijayakumar and K. Revathi C (2015)	0.55	1:1.5:3 (50%)	2.83
Selvakoodalingam and Palanikumar (2002)	0.5	1:2:4 (50%)	2.85
Sahu (2003)	0.5	1:1.5:3 (40%)	3.21
		1:0.75:1.5 (40%)	4.11
Chandrasekhara Reddy (2003)	0.5	1:1.5:3 (50%)	2.73
Ilangovan and Nagamani (2004)	0.50	1:1.5:3 (40%)	2.79
	0.50	1:0.75:1.5 (40%)	2.42
Prachoom Khamput (2006)	0.45	1:2:4 (70%)	2.66
Priyanka A. Jagadev and Dilip K. Kulkarni (2012)	0.45	1:1.5:3 (60%)	3.24
Joseph (2012)	0.65	1:1.5:3 (50%)	2.72
Shahul Hameed (2009)	0.5	1:1.5:3 (50%)	3.05
Manasseh Joel (2010)	0.45	1:0.5:1 (20%)	3.20

Figure 4 presents the variation of tensile strength for M15 concrete for sand replacement from 0.00 % to 100.00 % at increments of 10.00 %. It is observed that the tensile strength is maximum at 50.00 % sand replacement for both coarse as well as medium quarry dust usage in place of sand. The percentage of increase in tensile strength compared with control concrete is found to be 37 and 34.7 for coarse and medium quarry dust respectively. But when fine quarry dust was used, it is observed that the maximum tensile strength is obtained at 30.00 % sand replacement and the percentage of increase in strength is 17.67.

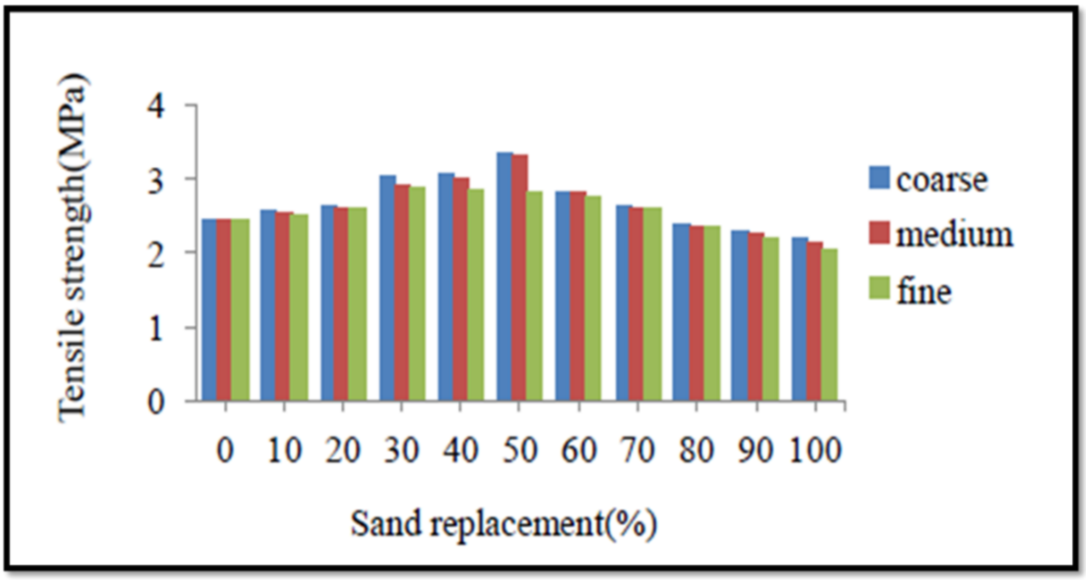

Figure 4: Tensile strength of M15 concrete using OPC at 28 days

4.1.4 Flexural test

Flexural test was done from previous researcher. To obtain the flexural strength of concrete specimens with different type of ratio and replacement percentage of quarry dust waste. The data collect at the age of 28 days with optimum replacement percentage state by researcher.

Table 6: Flexural strength of concrete for various optimum proportion (at the age of 28-day)

Reference	W/C ratio	Mix proportions	Flexural strength (MPa)
A. Vijayakumar and K. Revathi C (2015)	0.55	1:1.5:3 (50%)	3.216
Selvakoodalingam and Palanikumar (2002)	0.5	1:2:4 (50%)	3.136
Sahu (2003)	0.5	1:1.5:3 (40%)	3.264
		1:0.75:1.5 (40%)	2.924
Chandrasekhara Reddy (2003)	0.5	1:1.5:3 (50%)	3.408
Ilangovan and Nagamani (2004)	0.50	1:1.5:3 (40%)	3.128
	0.50	1:0.75:1.5 (40%)	2.838
Prachoom Khamput (2006)	0.45	1:2:4 (70%)	3.029
Priyanka A. Jagadev and Dilip K. Kulkarni (2012)	0.45	1:1.5:3 (60%)	3.219
Joseph (2012)	0.65	1:1.5:3 (50%)	3.355
Shahul Hameed (2009)	0.5	1:1.5:3 (50%)	2.984
Manasseh Joel (2010)	0.45	1:0.5:1 (20%)	3.040

Figure 5 presents the variation of flexural strength for M15 concrete for sand replacement from 0.00 % to 100.00 % at increments of 10.00 %. It is observed that the flexural strength is maximum at 50.00 % replacement for both coarse as well as medium quarry dust usage in place of sand.

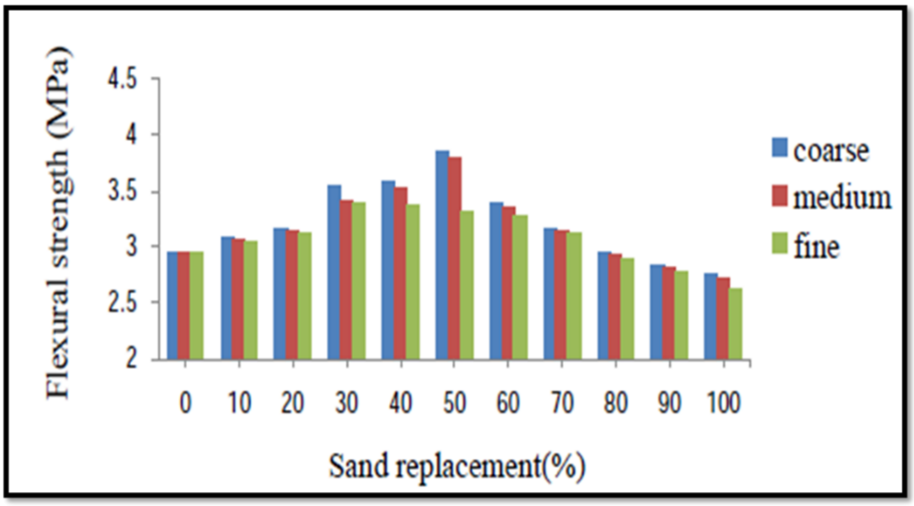

Figure 5: Flexural strength of M15 concrete using OPC at 28 days

5. Conclusion

In this report, all the papers reviewed point out the need to handle by-products of quarry dust waste in such a way that the environmental impact is minimized. It appears that the use of these waste materials as building materials is a feasible solution to the waste accumulation issue. The literature review found that most researchers used quarry dust replacement as fine aggregate in concrete production. In order to improve consistency and improve the mechanical properties of the specimens, sand has been added to the mixtures developed for the manufacture of concrete, while superplasticizers have been added to the concrete mixtures in order to reduce the water content and achieve the desired workability properties.

The first objective is to determine the potential use of quarry dust waste as an aggregate in the concrete production. The utilization of waste materials for construction materials are looking forwards to give benefits in term of durability of the concrete as well as conserving the environment. Overall, the 40.00 % of quarry dust was used as partial sand replacement in construction materials but, beyond of this percentage, the compression strength value is reducing and affected the workability of the concrete. Thus, the reutilizing of quarry dust from quarrying industry is such a sustainable approach in order to comply with future needs of environmental and concrete technology.

Second objective is to identify parameter the characteristic of mechanical properties of quarry dust waste in terms of compressive strength, flexural strength, splitting tensile strength and workability. The compressive, tensile, and flexural strengths of the concrete developed as fine aggregate using the quarry dust waste were found to rely to some degree on the aggregate's physical strength, which was found to be higher than that of the natural sand. The presence of Quarry dust waste increases the concrete strength, but the replacement of 40.00 % Quarry dust waste gives appropriate value. The workability of fresh concrete mix decreases with the replacement of Quarry dust waste, but the workability can be improved by adding superplasticizer at a concentration of 0.20 % and there would be a substantial improvement in compressive strength, split tensile strength and flexural test.

5.1 Recommendation

One of the key problems that had to be overcome by the researchers during the experimental procedure was the determination of the required amount of water to be added to the formulated mixtures. The optimum water to cement ratio had to be developed in order to obtain the necessary flowability and workability of the mixtures and to produce concrete with better mechanical behavior and higher erosion resistance.

As a result of this study, it becomes apparent that further research is required into aspects related to the use of waste materials as building materials, as the use of such materials appears to be an efficient way of mitigating environmental emissions, improving the quality of concrete under extreme conditions and meeting many potential needs. New development processes, such as the manufacture of extruded concrete goods, should be investigated. The optimal addition of admixtures such as binders, dispersants and surfactants to the cement powder is required in order to achieve a mixture that has features suitable for extrusion.

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