EXPERIMENTAL INVESTIGATION ON MECHANICAL AND DURABILITY PROPERTIES OF CONCRETE INCORPORATED WITH QUARRY DUST

K.S. Prasath[1], T. Tamilselvan[2], R. Manobala[3]

[1]Assistant Professor, Department of Civil Engineering Sri Manakula Vinayagar Engineering College, Puducherry, India
[2,3]UG Student, Department of Civil Engineering, Sri Manakula Vinayagar Engineering College, Puducherry, India

---***---

Abstract - *In construction materials, concrete is the largest production comparatively of all other materials. Aggregates are the important constituents in concrete. The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials which is obtained by means of various industries. Quarry dust is a by-product generated during the production of crushing coarse aggregate. In this study, the use of quarry dust as fine aggregate in concrete is investigated for this purpose, 5 different concrete mixtures with water/cement ratio of 0.45 are prepared. Compressive strength and durability properties of concrete are examined by using quarry dust as fine aggregate. In this study, the cubes casted in 0%, 5%, 10%, 15%, 20% and 25% of quarry dust as fine aggregate.*

***Key Words*: Fine Aggregate, Waste material, Quarry dust, Compressive Strength, Durability Properties.**

1. INTRODUCTION

Concrete is the second highest and the most popular building material used in the world. It is a composite material consisting of cementing material, fine aggregate, coarse aggregate and required quantity of water, in which fine aggregate is found to be an essential component of concrete. In some cases, particular admixtures, such as air-entraining agents, retarders, water-reducing agents, fly ash etc. will be selected. Each constituent influences the characteristics of the concrete and they must be controlled as to composition and quantity if the end product is to be within acceptable limits of uniformity, workability, and strength. The most commonly used fine aggregate is natural river or pit sand. Specifications for the fine aggregate fraction of concrete have been developed almost exclusively on the basis of experience with natural sand for many years, since it was virtually the only type utilized. Clean, natural sands have rounded particles that provide good workability in concrete without the addition of excessive quantities of either water or cement. When mineral fines are present in natural sand, the particles are frequently clay or silt particles that may be "deleterious" particles. These have an undesirable influence on water requirements, workability, and strength characteristics of concrete mixtures.

2. MATERIAL INVESTIGATION

2.1 cement

Cement is the most important material in concrete also known as the binder. The most common type of cement used in general is Portland cement. It consists of a mixture of calcium silicates (alite, belite), aluminates and ferrites - compounds which combine calcium, silicon, aluminium and iron in forms which will react with water. Portland cement and similar materials are made by heating limestone (a source of calcium) with clay and/or shale (a source of silicon, aluminium and iron) and grinding this product (called clinker) with a source of sulfate (most commonly gypsum).. The physical properties of cement are given in Table1.

Table -1: Physical Properties of Cement (OPC 43 Grade)

Sl. No	Property	Value
1	Specific gravity	3.2
2	Standard consistency (%)	32
3	Initial setting time	50 min
4	Final setting time	450 min

2.2 Aggregates

Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel, and crushed stone are used mainly for this purpose. Recycled aggregates (from construction, demolition, and excavation waste) are increasingly used as partial replacements for natural aggregates, while a number of manufactured aggregates, including air-cooled blast furnace slag and bottom ash are also permitted.. The physical properties of fine aggregate and coarse aggregates are shown in Table 2 & Table 3.

Table -2: Physical Properties of Fine Aggregate

Sl. No	Description	Quantity
1	Specific gravity	2.62
2	Water absorption (%)	1.15
3	Bulk density(kg/m^3)	1660
4	Fineness modulus	2.97

Table -3: Physical Properties of Coarse Aggregate

Sl. No	Description	Quantity
1	Specific gravity	2.62
2	Water absorption (%)	1.5
3	Bulk density(kg/m^3)	1540

2.3 Superplasticizer (SP)

The Chemical admixtures are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes. In normal use, admixture dosages are less than 5% by mass of cement and are added to the concrete at the time of batching/mixing. (See the section on Concrete Production, below).The common types of admixtures are Accelerators, Retarders, Air Entraining Agents, and Plasticizers etc.

3. MIXPROPORTIONING

The mix proportion based on IS 10262 (2009) arrived for M30 grade of concrete using the above materials is given in the Table 4

Table -4: Mix Proportion for w/c 0.45

Sl. No	Materials	Quantity
1	Cement (kg/m^3)	350
2	Sand (kg/m^3)	783.48
4	Coarse aggregate (kg/m^3)	1162.25
5	Water (l/m^3)	140
6	Super plasticizer (%)	1

4. EXPERIMENTAL SCHEME

A total of 42 specimens of concrete cubes were prepared and tested for its compressive strength at 7 and 28 days using 100mm×100mm×100mm cube, 15 specimens of 150 mm x 300 mm for cylinders and 15 specimens of 100 mm x 100 mm x 500 mm for prisms are used.

5. TESTING OF SPECIMENS

5.1 Compressive Strength

Compression test were performed on samples made during at various curing ages. As discussed above a targeted compressive strength was used for this study. Results from compression strength tests performed. Here cube samples of size 100mm×100mm×100mm, were prepared and tested at 7and 28 days of curing in water under controlled lab conditions.

5.2 Tensile Strength

Split tensile test were performed on samples made during at curing ages. As discussed above a targeted split tensile strength was used for this study. Results from split tensile strength tests performed. Here beam samples of size 200mm×100mm, were prepared and tested at 28 days of curing in water under controlled lab conditions.

5.3 Flexural Strength

Flexural test were performed on samples made during at various curing ages. As discussed above a targeted flexural was used for this study. Results from flexure strength tests performed. Here samples of size 500mm×100mm×100mm, were prepared and tested at 7and 28 days of curing in water under controlled lab conditions.

5.4 Water Absorption

First three Samples of cubes are weighed using a weighting machine (W1). Then we put each sample in oven at105o C for 72 hours. After 72 hours we immerse the cubes in distilled water for 24 hours. Then we clean the surface of the cubes using a water absorbent cloth. Now we weigh it again (W2).

% Absorption of water= [(W2-W1)/ W1] X 100%

5.5 Acid Test

The behavior of acids on hardened concrete is conversion of calcium compounds into calcium salts of attacking acids. Hydrochloric acid with concrete produces calcium chloride, which precipitate as gypsum and nitric acid with concrete gives rise to calcium nitrate, as a result of this reaction, structure of concrete gets damaged. If the salt is soluble, the rate of reaction depends on the rate of dissolution of the salts. Acid attack completely changes the hardened cement paste on surface and destroys pore system of the hardened concrete. Therefore in the case of acid attack, the permeability of sound concrete is less important as compared to the reaction that takes place. The severity of deterioration of concrete depends on the concentration of acid and temperature. The effect of acid is mainly during the transformation of concrete from fresh state to hardened state. In fact, no ordinary Portland cement concrete is acid resistant. In general practice, degree of attack increases as the concentration of acid increases. When pH value is < 6.5 attack of acids will observe, if its reading is < 4.5, severe attack will be observed.

6. RESULT AND DISCUSSION

6.1 Compressive Strength

Totally 6 concrete cubes were casted and it is allowed for 7 days and 28 days curing. After drying, cubes were tested in

Compression Testing Machine (CTM) to determine the ultimate load. Replacement made for (0%, 10%, 15%, 20% and 25%) For this study the water cement ratio of 0.45 is maintained uniformly. The results of compressive strength obtained for the concrete mixes contain different proportions of quarry dust fine aggregates are presented. It is observed that the compressive strength of all the mixes increased.

Table -5: Compressive Strength for Various Concrete Mixes (MPa)

Mix designation	w/c 0.45	
	7 days	28 days
Control mix	22.38	33.9
5% quarry dust	17.99	36.49
10% quarry dust	21.33	35.77
15% quarry dust	23.66	35.41
20% quarry dust	38.66	51.46
25% quarry dust	36.81	47.2

Table 5 shown the compressive strength for various concrete mixes for w/c 0.45

Chart -1: compressive strength for various concrete mixes at 7 & 28 days

6.2 Tensile Strength

Totally 3 concrete cylinders were casted for each percentage of replacement and it is allowed for 28 days of curing. After drying cubes were tested in split tensile testing machine (FTM) to determine the tensile strength test. Replacement made for (0%, 10%, 15%, 20% and 25%) of fine aggregate with quarry dust. For this study the water cement ratio of 0.45 is maintained uniformly.

The results of split tensile strength obtained for the concrete mixes contain different proportions of quarry dust are presented. The split tensile strength of all the mixes are been observed.

Table -6: Tensile Strength for Various Concrete Mixes (MPa)

Mix designation	w/c 0.45
	28 days
Control mix	3.2
5% quarry dust	1.19
10% quarry dust	1.32
15% quarry dust	1.37
20% quarry dust	1.99
25% quarry dust	1.74

Table 6 shown the split tensile strength for various concrete mixes for w/c 0.45

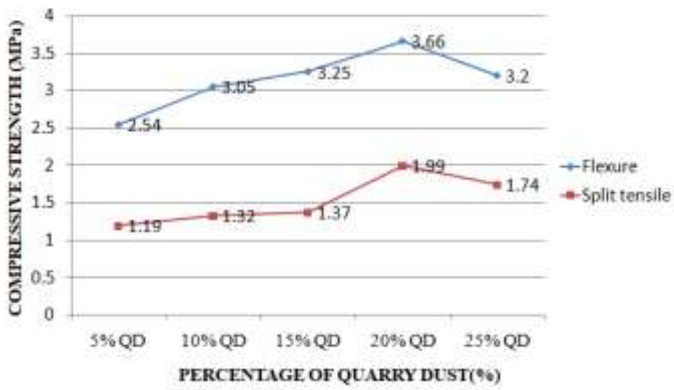

Chart -1: split tensile strength for various concrete mixes at 28 days

6.3 Flexural Strength

Totally 3 concrete prisms were casted for each percentage of replacement and it is allowed for 28 days of curing. After drying cubes were tested in flexural testing machine (FTM) to determine the tensile strength test. Replacement made for (0%, 10%, 15%, 20% and 25%) of fine aggregate with quarry dust. For this study the water cement ratio of 0.45 is maintained uniformly. The results of flexural strength obtained for the concrete mixes contain different proportions of quarry dust are presented. The flexural strength of all the mixes are been observed.

Table -7: Flexural Strength for Various Concrete Mixes (MPa)

Mix designation	w/c 0.45
	28 days
Control mix	4.2
5% quarry dust	2.5

10% quarry dust	3.15
15% quarry dust	3.25
20% quarry dust	3.75
25% quarry dust	3

Table 7 shown the flexural strength for various concrete mixes for w/c 0.45

6.4 Acid Test

Totally 3 concrete cylinders were casted for each percentage of replacement and it is allowed for 28 days of curing on 1 % of total value of water used for curing. Replacement was made for (0%, 10%, 15%, 20% and 25%) of fine aggregate with quarry dust. The results of compressive strength obtained for the concrete mixes contain different proportions of quarry dust fine aggregates are presented. It is observed that the compressive strength of all the mixes increased.

Fig -1: Acid Test on concrete

Table 8 show the Acid test for various concrete mixes for w/c 0.45

Table -8: Acid Test for Various Concrete Mixes (MPa)

Mix designation	w/c 0.45
	28 days
5% quarry dust	34.97
10% quarry dust	37.54
15% quarry dust	40.60
20% quarry dust	49.98
25% quarry dust	36.56

7. CONCLUSIONS

In this study, we investigated the use of quarry dust as partial replacement of fine aggregate with concrete production. The properties of the quarry dust were equally examined. The study concluded as follows:

- The Compressive Strength with quarry dust of 20% replacement is increased compared with conventional concrete.
- The increase in the strength is seen as 50% when compared with conventional concrete.
- The flexural strength is found to be decreased at 25% when compared with conventional concrete.
- The Split Tensile values are found to be decreased at 25% when compared to conventional concrete.
- The utilization of quarry dust will be a solution for disposal problem.
- Eco-friendly and Mass utilization of waste material is possible in construction by using quarry dust as partial replacement material for fine in concrete.

REFERENCES

[1] Anjali H Jamale, Urmila R Kawade, Effect of Quarry Dust and Fly Ash Mix on strength properties of M40 grade Concrete, International Journal of Engineering Research and General Science Volume 3, Issue 3, Part-2 , May-June, 2015 ISSN 2091-2730.

[2] Bahoria B.V, D.K. Parbat, P.B. Nagarnaik, U.P. Waghe , Effect of characterization properties on compressive strength of concrete containing quarry dust and waste plastic as fine aggregate, International Journal of Civil Engineering and Technology (IJCIET)Volume 8, Issue 3, March 2017, 699–707.

[3] Bahoria B.V, D.K. Parbat, P.B. Nagarnaik, Characterization study of natural sand, quarry dust, waste plastic (ldpe) to be used as a fine aggregate in concrete, International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 3, March (2017) 391–401K. Elissa, "Title of paper if known," unpublished.

[4] Bahoria B.V, D.K.Parbat , P.B.Nagarnaik XRD Analysis of Natural sand, Quarry dust, waste plastic (ldpe) to be used as a fine aggregate in concrete ,Materials Today: Proceedings 5 (2018) 1432–1438

[5] Bismark K. Meisuh, Charles K. Kankam, Thomas K. Buabin , Effect of quarry rock dust on the flexural strength of concrete , Case Studies in Construction Materials 8 (2018) 16–22.

[6] Chandana Sukesh, Katakam Bala Krishna, P.Sri Lakshmi Sai Teja, S.Kanakambara Rao, Partial Replacement of Sand with Quarry Dust in Concrete, International Journal of Innovative Technology and Exploring Engineering ISSN: 2278-3075, Volume-2, Issue-6, May 2013 .

[7] Charles K. Kankam, Bismark K. Meisuh, Gnida Sossou, Thomas K. Buabin, Stress-strain characteristics of concrete containing quarry rock dust as partial replacement of sand, Case Studies in Construction Materials(2017) 66-72.

[8] Dehwah H.A.F, Corrosion resistance of Self coMPacting concrete incorporated quarry dust powder, silica fumes and fly ash, Construction and Building Materials 37(2012) 277-282.

[9] Fauzi M. Zain M, Md. Safiuddin , T. K. Song , H.B.Mahmud , and Y. Matsufuji , Influence of admixtures and quarry dust on the physical properties of freshly mixed high performance concrete ,Structural Engineering, Mechanics and Computation (Vol. 2) 1381-1390.

[10] Ilangovana.R ,N Mahendrana and K.Nagamanib ,Strength and Durability Properties of concrete containing Quarry Rock Dust as Fine Aggregate, APRN Journal of Engineering and Applied Science

[11] Job Thomas, B.Harilal, Mechanical properties of cold bonded quarry dust aggregate concrete subjected to elevated temperature, Cement & Concrete Composites 62 (2015) 67–75

[12] Job Thomas, B.Harilal, "Properties of Cold bonded quarry dust coarse aggregates and its use in concrete" Construction and Building Materials 125(2016) 724-730.

[13] Lohani T.K., Padhi M., Dash K.P., Jena S Optimum utilization of Quarry dust as partial replacement of sand in concrete , International Journal of Applied Sciences and Engineering Research, Vol. 1, No. 2, 2012

[14] Omar M.Omar a, GhadaD.AbdElhameed b,*, MohamedA.Sherif a, Hassan A.Mohamadien, Influence of limestone waste as partial replacement material for sand and marble powder in concrete properties , HBRC Journal(2012) 8, 193–203