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Behaviour of Concrete Made by Partially Replacing Fine Aggregate with Foundry Sand and Quarry Dust

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Abstract - *In this experimental study, waste foundry sand and quarry dust are used as partial replacement of fine aggregate in making structural concrete. The fine aggregate portion of the mix is achieved by using 50% manufactured sand and the remaining is composed of varying percentages of waste foundry sand and quarry dust in steps starting with 35% waste foundry sand: 15% quarry dust (i.e., 35%-15%; 30%-20%; 25%-25%; 20%-30%; and 15%-35%). The properties of the prepared specimens are compared with control concrete of grade M30. To test the hardened properties, compression test, split tensile test, flexure test and shear test are conducted for 7, 28 and 56 days. All the strength properties show a declining trend from the control mix due to the increased addition of quarry dust.*

***Key Words*: Waste Foundry Sand, Quarry Dust, Partial Replacement, Hardened Properties, Compression Test, Split Tensile Test, Flexure Test, Shear Test.**

1. INTRODUCTION

Concrete is the most widely used material in the construction of buildings and infrastructure development. After water, concrete is the second most consumed material in the world. Cement is a binder, a substance used for construction that sets, hardens and adheres to other materials, binding them together. Cement is seldom used on its own, but rather to bind sand and gravel together.

Solid wastes generated from manufacturing industries are increasing at an alarming rate. The possibility of substituting natural fine aggregate with industrial by-products offers technical, economic and environmental advantages which are of great importance in the present context of sustainability in the construction sector. Among the many materials investigated, quarry dust and waste foundry sand appears to be suitable because of its availability in large quantities in most parts of the world.

Waste Foundry Sand (WFS) is a by-product of the ferrous and non-ferrous metal casting industries, generated from the released moulds for casting, after several reuses. WFS is basically high quality silica sand. Due to the chemicals present in the binders, the disposal of WFS for land filling may cause adverse environmental and ecological impacts. So WFS should be used for other beneficial applications to reduce its adverse effects.

A large quantity of dust is produced in the crushing process of stones. Raw quarry powder was considered only as a waste material and was used for land filling without pre-treatment, leading to environmental hazards. The benefits of developing saleable by-products from quarry residues are reduced environmental impact by stock piling and large quantity disposal.

2. MATERIALS

The materials used for the work are cement, manufactured sand, waste foundry sand, quarry dust, natural coarse aggregate and water. The physical properties of the materials are given in Table-1 and Table-2.

Table -1: Physical Properties of Cement

SI. No	Properties	Test Results
1	Specific gravity	3.125
2	Standard consistency (%)	32
3	Initial setting time (minutes)	85
4	Final setting time (minutes)	272

Table -2: Physical Properties of Aggregates

SI.No	Properties	Materials	Test Results
1	Water absorption (%)	Manufactured sand	1.2
		Waste foundry sand	0.42
		Quarry dust	10.6
		Natural coarse aggregate	0.3
2	Specific gravity	Manufactured sand	2.69
		Waste foundry sand	2.61
		Quarry dust	2.67
		Natural coarse aggregate	2.702

Manufactured sand belongs to Zone II, waste foundry sand belongs to Zone III and quarry dust belongs to Zone IV fine aggregate.

3. PREPARATION OF SPECIMENS

Five different concrete mixes were prepared by varying the proportions of the three constituent fine aggregates namely, manufactured sand (MS), quarry dust (QD) and waste foundry sand (WFS). The mix designation is given in Table-3.

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Table -3: Mix Designation

Mix Designation	Description	Zone of Fine Aggregate
$M_{100}W_0Q_0$	Control mix of grade M30	II
$M_{50}W_{35}Q_{15}$	50% MS + 35% WFS + 15% QD	II
$M_{50}W_{30}Q_{20}$	50% MS + 30% WFS + 20% QD	II
$M_{50}W_{25}Q_{25}$	50% MS + 25% WFS + 25% QD	II
$M_{50}W_{20}Q_{30}$	50% MS + 20% WFS + 30% QD	III
$M_{50}W_{15}Q_{35}$	50% MS + 15% WFS + 35% QD	III

The quantity of materials for 1 m^3 of concrete is given in Table-4 and Table-5.

Table -4: Mixes having Zone II Aggregate

Contents	Quantity
Cement	370 kg/m^3
Fine aggregate	933.53 kg/m^3
Coarse aggregate	1015.84 kg/m^3
Water	157.6 litres
Water-cement ratio	0.43

Mix proportion = 1: 2.52: 2.75

Table -5: Mixes having Zone III Aggregate

Contents	Quantity
Cement	370 kg/m^3
Fine aggregate	654.69 kg/m^3
Coarse aggregate	1277.62 kg/m^3
Water	157.6 litres
Water-cement ratio	0.43

Mix proportion = 1: 2.52: 2.75

4. TESTING OF SPECIMENS

Tests are conducted to study the mechanical properties of the prepared specimens. The tests include compressive strength test, split tensile strength test, flexural strength test, shear strength test and determination of modulus of elasticity.

5. RESULTS AND DISCUSSIONS

5.1 Compressive Strength

Compressive strength of concrete mixtures made by partially replacing fine aggregate with waste foundry sand and quarry dust are determined for 7, 28 and 56 days of curing. For each concrete mix, the compressive strength is determined on three 150×150×150 mm cubes. The results are shown in Chart-1.

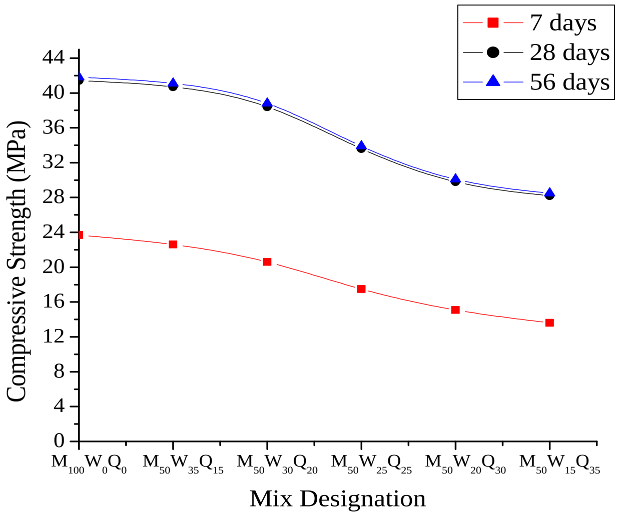

Chart-1: Compressive Strength Results for Different Mixes

The compressive strength of all the mixes show a gradual decrease from the control mix. The reason for the trend may be due to the increased addition of quarry dust, which results in the shifting of the zone of fine aggregate from II to IV. For the mixes $M_{50}W_{35}Q_{15}$ and $M_{50}W_{30}Q_{20}$, the strength exceeds the target mean strength and these can be successfully used as structural concrete.

5.2 Split Tensile Strength

Split tensile strength of concrete mixtures made by partially replacing fine aggregate with waste foundry sand and quarry dust are determined for 7, 28 and 56 days of curing. Split tensile strength test is carried out on 150 mm diameter and 300 mm long cylinder. The results are shown in Chart-2.

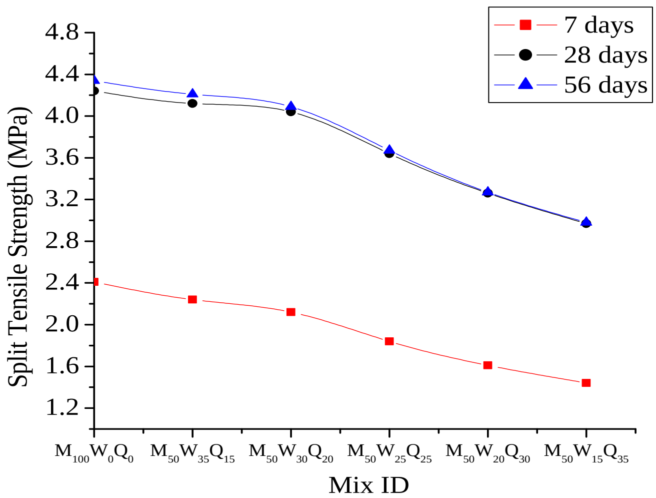

Chart-2: Split Tensile Strength Results for Different Mixes

The split tensile strength of all the mixes show a gradual decrease from the control mix. The reason for the trend may be due to the increased addition of quarry dust, which results in the shifting of the zone of fine aggregate from II to III.

5.3 Flexural Strength

Flexural strength of concrete mixtures made by partially replacing fine aggregate with waste foundry sand and quarry dust are determined for 7, 28 and 56 days of curing. Flexural strength test is carried out on beams of size 500×150×150 mm. The results are shown in Chart-3.

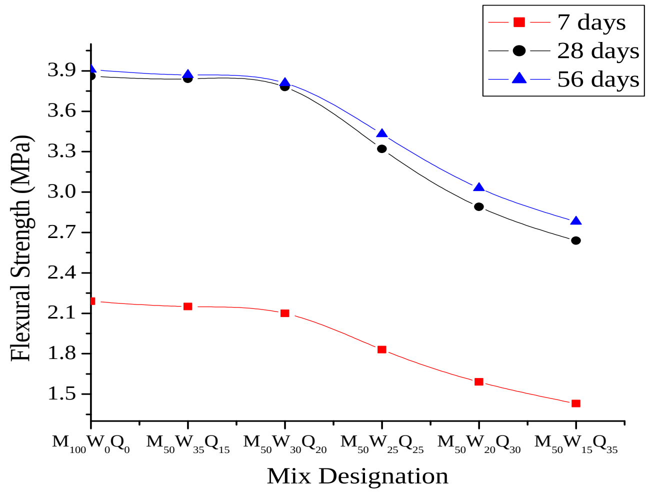

Chart-3: Flexural Strength Results for Different Mixes

The flexural strength of all the mixes show a gradual decrease from the control mix. The reason for the trend may be due to the increased addition of quarry dust, which results in the shifting of the zone of fine aggregate from II to IV.

5.4 Shear Strength

Shear strength of concrete mixtures made by partially replacing fine aggregate with waste foundry sand and quarry dust are determined for 7, 28 and 56 days of curing. Shear strength test is carried out on beams of size 250×150×150 mm. The results are shown in Chart-4.

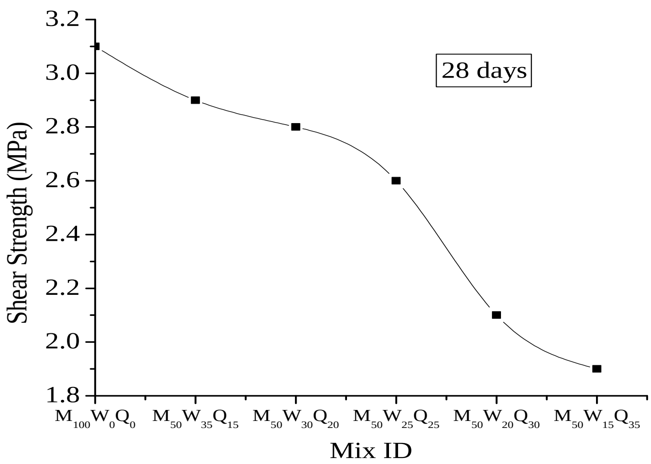

Chart-4: Shear Strength Result at 28 Days of Curing

The shear strength of all the mixes show a gradual decrease from the control mix. The reason for the trend may be due to the increased addition of quarry dust, which results in the shifting of the zone of fine aggregate from II to IV.

5.5 Modulus of Elasticity

The modulus of elasticity was determined by subjecting cylinders to uniaxial compression and measuring the deformation by dial gauges which is fixed between gauge length. The results are shown in Chart-5.

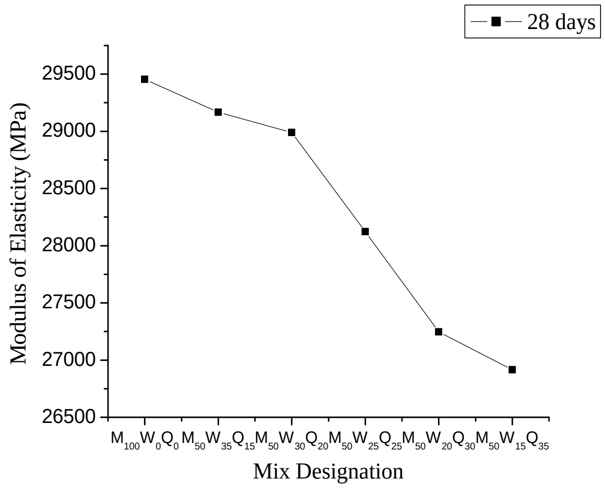

Chart-5: Modulus of Elasticity Result at 28 Days of Curing

6. CONCLUSIONS

- The incorporation of waste foundry sand and quarry dust causes systematic decrease in workability due to the presence of very fine binders.
- Concrete acquires comparable compressive strength with the control mix for mix M1 containing 50% manufactured sand, 35% waste foundry sand and 15% quarry dust. In the mix, the combined fine aggregate belongs to Zone II.
- The reason for the trend can be attributed to the presence of fine particles of waste foundry sand and quarry dust, which results in a denser concrete mix, and due to the presence of high silica content in waste foundry sand.
- Similar trend is observed for split tensile strength and shear strength.
- All the strength values decrease with the increase in addition of quarry dust.
- Non availability of natural sand at reasonable cost led to the search of alternative materials. Quarry dust and waste foundry sand are suitable alternatives for natural sand at very low cost also solving the problem of waste disposal.

7. FUTURE SCOPE OF WORK

- The present work can be done on concrete of higher grades.
- Durability properties of the prepared specimens can be studied.
- There can be inclusion of fibers and pozzolanic materials.
- Different percentages of waste foundry sand and quarry dust can be combined along with manufactured sand to constitute fine aggregate.
- Permeability and durability studies can be conducted.

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