ISSN 2250-3153

# An Experimental Study on Compressive Strength and Splitting Tensile Strength of Concrete with Partial Replacement of Cement with Stone Quarry Dust

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***Abstract***- Instead of using conventional approach researchers are, nowadays, taking interest in replacing the waste material with the ingredients of concrete to achieve the following benefits. First benefit is to minimize the pollution, second is to make the concrete cost efficient and third is to enhance the properties of the concrete i.e. Compressive Strength and Splitting Tensile Strength of Concrete. Cement is being replaced with different types of waste materials to achieve the aforementioned benefits. This research paper reveals the effect of the partial replacement of cement with the Stone Quarry Dust on Compressive Strength and Splitting Tensile Strength of concrete. Cement was replaced in the following percentages to test the samples; 0%, 15%, 25% and 35%. It was found after testing that strength was increased 2 time for $Q_{25}$ sample.

***Index Terms***- Concrete, Water/Binder Ratio, Stone Quarry Dust, Compressive Strength, Splitting Tensile Strength, Partial Replacement.

## I. Introduction

Concrete is a composite material made from cement, water, coarse and fine aggregate. The waste material, if not catered properly, directly damages the health. Polluting the environment is considered an offensive crime in most of the countries. There are different types of waste materials being used in the industry such as, Stone Quarry dust, "Fly Ash, Rice Husk, Clay Brick, Metakaolins, Palm Oil Fuel Ash, Bamboo Leaf Ash, Volcanic Ash, Ground Nut Husk Ash, Waste Glass Slurry, Glass Powder, Solid Wastes, Quarry Dust, Marble Dust Powder"[1-13] and etc. In an underdeveloped country like Pakistan, The construction is taking place at such a high pace that it is inevitable to stop the Stone Quarry blasting and thus the air pollution. Pakistan is rich in its minerals and known as the best aggregate producing country in the world. To produce aggregates, Stone Quarry blasting is essential and naturally production of Quarry dust also associates with it. Stone Quarry Dust results in harmful diseases like Lungs cancer, Asthma, Eye diseases and etc. Our aim was to replace the cement with the Stone Quarry dust so that it might result in an environment friendly step. Hence cement was replaced with the Stone Quarry dust to analyze the results.

***Table 1: Designation of Samples for different replacements***

| Designation | Percentage Replacement by Weight of Cement |
|---|---|
| $Q_0$ | 0% |
| $Q_{15}$ | 15% |
| $Q_{25}$ | 25% |
| $Q_{35}$ | 35% |

The materials used were brought from the surroundings of Taxila.150x150x150 mm cubes and cylinders having the diameter of 150 mm and height 300 mm were used.

## II. Literature Review

"A.V.S.Sai. Kumar and Krishna Rao in 2014 did research on the similar project by replacing the cement with the quarry dust. They replaced at 0%, 10%, 20%, 25% and 30% and found that 25% replacement gives the optimum results. The description of the materials is tabulated in Table-2."[14]

***Table 2: Description of materials used in the research work***

| Material | Description |
|---|---|
| Cement | Portland Pozzolana cement conforming to IS: 269-1976 and IS: 7031-1968. 53 Grade Cement. |
| Quarry Dust | Quarry collected from local stone crushing units. It was initially dry in condition when collected and was sieved by IS: 90 micron sieve before mixing in concrete. |
| Fine Aggregates | The fine aggregate used is natural sand obtained from the river Godavari. Specific Gravity was 2.57 |
| Coarse Aggregates | Coarse aggregate obtained from local quarry processing units has been used for this study. Specific Gravity was 2.78 |
| Water | Ordinary potable tap water available in laboratory was used for mixing and curing of concrete. |

"Venkata Sairam Kumar N, Dr. B. Panduranga Rao and Krishna Sai M.L.N also did the research on the similar project and replaced the cement with the quarry dust in following percentages; 0%, 5%, 10%, 15%, 20%, 25%, 35% and 40%. They used 150x150x150 mm cubes for the testing using different mix and water/cement ratios. From their experimental results they have inferred that replacing 25% cement with quarry dust has increased the hardened concrete properties. The description of the materials is tabulated in Table-3."[15]

***Table 3: Description of materials used in the research work***

| Material | Description |
|---|---|
| Cement | Portland Pozzolana cement of 53Grade was used in this study. |
| Quarry Dust | Collected from local stone crushing units of Chowdavaram village, Guntur, Andhra Pradesh. It was initially dry in condition when collected and was sieved by IS: 90 micron Sieve before mixing in concrete. Specific gravity observed for quarry dust is 2.5. |
| Fine Aggregates | Krishna river sand having specific gravity of 2.61 and fineness modulus of 2.9 has been used as fine aggregate for this study. |
| Coarse Aggregates | Obtained from local quarry units has been used for this study. Maximum size of aggregate used is 20mm with specific gravity of 2.73. |
| Water | Ordinary potable tap water available in laboratory was used for mixing and curing of concrete. |

## III. MATERIALS

### A. Cement

Ordinary Portland cement was used in this study. The properties of the cement are tabulated in Table-4.

***Table 4: Results of different Tests performed on Cement***

| Sr. No. | Property | Test Result |
|---|---|---|
| **1** | Normal Consistency | 29% |
| **2** | Specific Gravity | 3.04 |
| **3** | Initial Setting Time | 1.25 Hours |
| **4** | Final Setting Time | 3.5 Hours |
| **5** | Maximum Strength | 8500 psi |

### B. Stone Quarry Dust

There are number of Stone quarries in Margalla Hills around Taxila city. For this case study we brought the Quarry dust from one of the Stone Quarries in Margalla Hills. The quarry is known for producing Basic aggregates. The dust of these Quarries is effecting 5-10 $Km^2$ surrounding area. The properties of the quarry dust are tabulated in Table-5.

***Table 5: Results of different tests performed on Stone Quarry Dust***

| Sr. No. | Property | Test Result |
|---|---|---|
| **1** | Specific Gravity | 2.54-2.60 |
| **2** | Bulk Relative Density ($Kg/m^3$) | 1750 |
| **3** | Moisture Content (%) | 0% |
| **4** | Particle Size | Passing Sieve No.200 |

### C. Fine Aggregates

Fine aggregates were brought from Lawrence Purr Sand quarry. This quarry is known for producing best sand in the region. Properties of the sand are tabulated in Table-6.

***Table 6: Results of different tests performed on Fine Aggregates***

| Sr. No. | Property | Test Result |
|---|---|---|
| **1** | Specific Gravity | 2.7 |
| **2** | Fineness Modulus | 2.4 |
| **3** | Bulk Density<br>i) Loose<br>ii) Compacted | i) 1367 $Kg/m^3$<br>ii) 1675 $Kg/m^3$ |

### D. Coarse Aggregates

Coarse aggregates were bought from the local crush suppliers of Taxila Quarries. Properties of the coarse aggregates are tabulated in Table-7.

***Table 7: Results of different tests performed on Coarse Aggregates***

| Sr. No. | Property | Value |
|---|---|---|
| **1** | Specific Gravity | 2.5 |
| **2** | Bulk Density<br>iii) Loose<br>iv) Compacted | i) 1237 $Kg/m^3$<br>ii) 1550 $Kg/m^3$ |
| **3** | Nominal Maximum Size | 7/8 inches |

ISSN 2250-3153

### E. Water

Ordinary potable tap water available in the laboratory was used for the casting and curing of the cubes and cylinders. Properties of the water are tabulated in Table-8.

***Table 8: Results of different tests performed on Water***

| Sr. No. | Property | Value |
|---|---|---|
| **1** | pH | 7.15 |
| **2** | Taste | N/A |
| **3** | Appearance | Clear |
| **4** | Turbidity (NTU) | 4.23 |

### F. Casting Specifications

Samples were casted using 1:2:4 mix ratio and Water/Binder Ratio of 0.55. This was taken because commonly this mix ratio is used in simple constructions subjected to less loads.

***Table 9: Casting details***

| Sr. No. | Description | Used |
|---|---|---|
| **1** | Mix Ratio | 1:2:4 |
| **2** | Water/Binder Ratio | 0.55 |

### I. Casting and Testing Details

To determine the Compressive strength of concrete 36 cubes having the dimensions 150x150x150 mm were casted using the mix ratio 1:2:4 and Water/Binder ratio 0.55. Cement was replaced with the stone quarry dust in the following percentages, 0%, 15%, 25% and 35%. For each percentage 9 cubes were casted. Tests on 7, 14 and 28 days were carried out. For each day testing 3 cubes were tested. This was done to minimize the error by taking the average value of the compressive strength.

To determine the splitting tensile strength of concrete 36 cylinders having 150mm diameter and 300 mm height were casted using the mix ration 1:2:4 and water binder ratio 0.55. Cement was replaced with the stone quarry dust in the following percentages, 0%, 15%, 25% and 35%. For each percentage 9 cylinders were casted. Tests on 7, 14 and 28 days were carried out. For each day testing 3 cubes were tested. This was done to minimize the error by taking the average value of the splitting tensile strength.

Samples were prepared using the electric drum. Before casting of cubes/cylinders molds were properly oiled and cleaned. For smooth surface, plates underneath the molds were placed. Slump was taken for each partial replacement. Tamping was done in 3 layers with the help of square tamping rod for the cubes and cylinders. After pouring the concrete in the required molds their surfaces were smoothen and then left for 24 hours to set. After 24 hours cubes and cylinders were de-molded and placed in the curing bath for the required period of time.

For the testing purpose, 24 hours prior to testing, the required cubes/cylinders were taken out of the curing bath and placed in an open space to let them dried.

"Compressive strength tests"[3] and "Splitting Tensile Strength"[4] were carried out under the BS 4550-3.4:1978 standard and ASTM C496/C 496M-04 respectively.

## IV. RESULTS

"Slumps were taken according to ASTM Standard using specified equipment's. The results obtained indicate that admixtures might be needed for increasing the workability of concrete. Moreover it was also seen that there was an increase in slump when cement was replaced with Stone Quarry dust by 25%."[5]

***Table 10: Slump for different Samples***

| **Replacement** | **$Q_0$** | **$Q_{15}$** | **$Q_{25}$** | **$Q_{35}$** |
|---|---|---|---|---|
| **Slump (mm)** | 45 | 40 | 48 | 43 |

Table 11 shows Splitting Tensile Strength values for $Q_o$, $Q_{15}$, $Q_{25}$ and $Q_{35}$ on different ages of concrete.

***Table 11: Compressive Strength Test Results for different samples on varying ages of Concrete***

| Sr. No. | Mix Ratio | Testing Days | Water Binder Ratio | $Q_0$ MPa | $Q_{15}$ MPa | $Q_{25}$ MPa | $Q_{35}$ MPa |
|---|---|---|---|---|---|---|---|
| 1 | 1:2:4 | 07 | 0.55 | **6.39** | **4.95** | **8.04** | **4.95** |
| 2 | 1:2:4 | 14 | 0.55 | **7.25** | **5.02** | **9.97** | **5.53** |
| 3 | 1:2:4 | 28 | 0.55 | **8.97** | **5.17** | **13.85** | **6.67** |

Figure 1 shows the variation in compressive strength for $Q_0$, $Q_{15}$, $Q_{25}$, $Q_{35}$ on 28 days age of concrete specimen. This figure depicts 155% increase in strength for $Q_{25}$ sample than that of $Q_0$ sample.

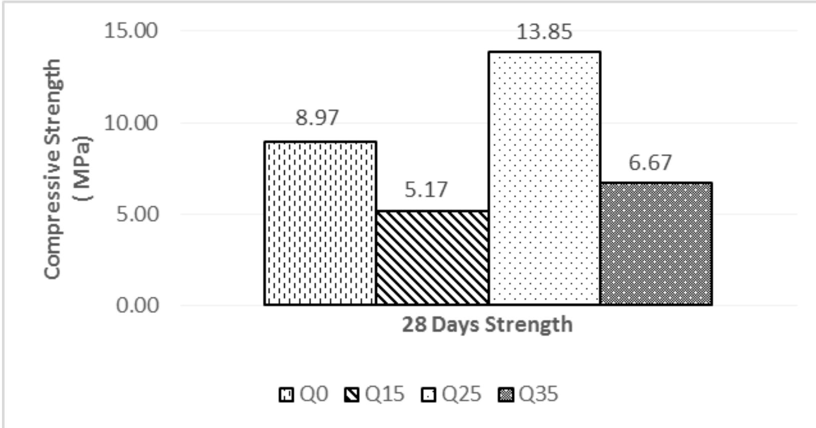


***Figure 1: Variation in compressive strength***

Figure 2 shows a variation in compressive strength against different replacements of stone quarry dust with cement. The figure depicts increase in strength with an increase in age of concrete specimen. $Q_{25}$ sample has comparatively greater strength than that of other samples.

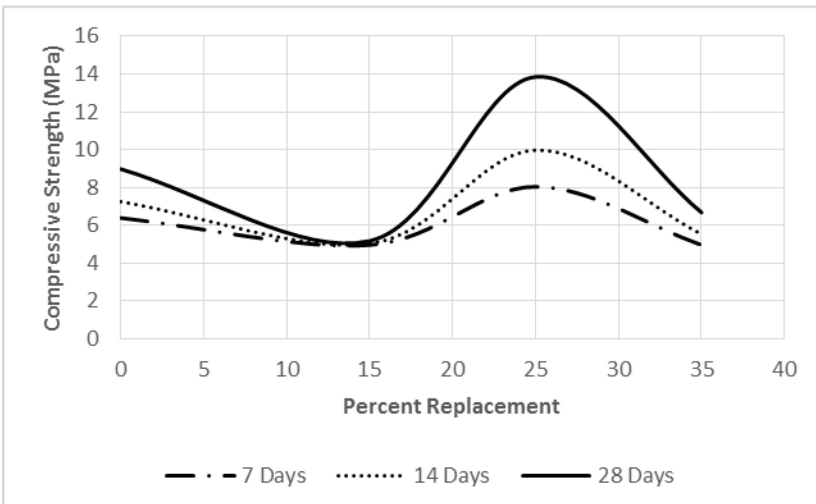


***Figure 2: Variation in Compressive Strength against different replacements***

Figure 2 shows variation in compressive strength of concrete specimen against different percentages. This shows greater strength of concrete at 28 days age than that of 7 days and 14 days.

***Table 12: Splitting Tensile Test results of different samples on varying ages of concrete specimen***

| **Sr. No.** | **Mix Ratio** | **Testing Days** | **Water/ Binder Ratio** | **$Q_0$ MPa** | **$Q_{15}$ MPa** | **$Q_{25}$ MPa** | **$Q_{35}$ MPa** |
|---|---|---|---|---|---|---|---|
| 1 | 1:2:4 | 7 | 0.55 | **0.65** | **0.53** | **0.85** | **0.45** |
| 2 | 1:2:4 | 14 | 0.55 | **0.70** | **0.56** | **1.04** | **0.62** |
| 3 | 1:2:4 | 28 | 0.55 | **0.88** | **0.66** | **1.5** | **0.92** |

Table 12 shows Splitting Tensile Strength values for $Q_o$, $Q_{15}$, $Q_{25}$ and $Q_{35}$ on different ages of concrete.

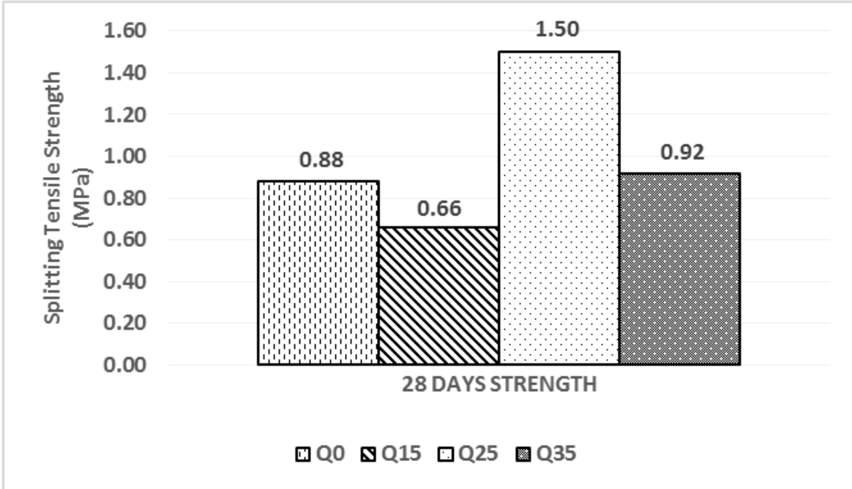


***Figure 3: Variation in Splitting Tensile strength***

Figure 3 shows the variation in compressive strength for $Q_0$, $Q_{15}$, $Q_{25}$, $Q_{35}$ on 28 days age of concrete specimen. This figure depicts 155% increase in strength for $Q_{25}$ sample than that of $Q_0$ sample.

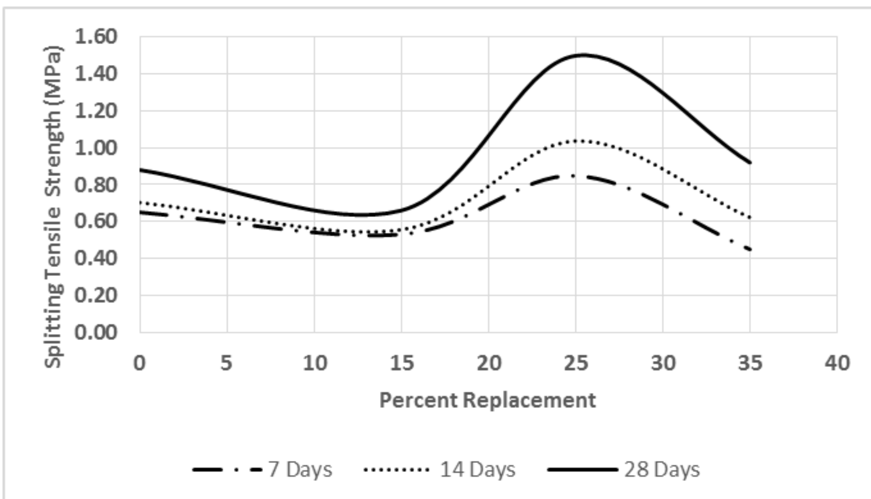


***Figure 4: Variation in Splitting Tensile Strength against different replacements***

Figure 4 shows variation in splitting tensile strength of concrete specimen against different percentages. This shows greater strength of concrete at 28 days age than that of 7 days and 14 days.

## V. CONCLUSION

After the thorough research work on the aforementioned subject different conclusions were drawn out. These conclusions are purely based on the observations and results of the research work. Following conclusions were drawn out from this study.

1. Compressive Strength and Splitting Tensile Strength were increased approximately 2 times after replacing cement with 25% Stone Quarry dust.
2. $Q_{25}$ yielded optimum results.
3. Slump for $Q_{25}$ mix was greater than that of $Q_0$, $Q_{15}$ and $Q_{35}$ mixes.
4. Since the slump was in low range, therefore, to increase the workability of concrete admixtures can be used.

## ACKNOWLEDGMENT

I would like to thank ALLAH Almighty for giving me opportunity and ability to complete my research work. My research supervisor for his polite behavior and exceptional guidance.

I would also like to thank Lab Engineers and Lab Attendants of Civil Engineering Department University of Engineering and Technology, Taxila and my colleagues.

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