# INFLUENCE OF GLASS AND CERAMIC TILE WASTES ON THE PROPERTIES OF CONCRETE

**SAMIA TARIQ**

Department of Civil Engineering, The University of Lahore, Pakistan
E-mail: saamiatariq@ymail.com

**Abstract -** Due to the requirement of preserving current natural resources, there have been efforts to explore alternate appropriate materials for concrete. In this process, waste materials from different industries have been used in concrete as partial replacements to its regular ingredients. This study focuses on the findings of concrete produced with glass and ceramic tile wastes to explore their influence on fresh and hardened properties of concrete. Total number of 63 cubes were prepared and tested. Compressive strengths were calculated at 7, 28 and 63 days of standard curing at varying waste contents as coarse aggregates. It is evident from the results that compressive strength of concrete containing glass waste decreased and containing ceramic tile wastes increased with curing time. The present study discusses the possible utilization of waste ceramic tiles as partial substitution of coarse aggregates in concrete.

**Keywords -** Ceramic Tile Waste, Coarse Aggregate, Compressive Strength, Concrete, Glass Waste.

## I. INTRODUCTION

Owing to the latest developments and increased production in today's modern world, the balance between the requirements of human beings and the environment has become more complicated, resulting in the increased utilization of energy and natural resources. The survival and progress of mankind is under threat due to these issues. The conventional construction materials, including concrete, bricks, hollow blocks, pavement blocks and tiles are being produced with the present natural resources [1]. This is harmful for the environment owing to the constant reduction of natural resources [2]. The addition of industrial wastes as constituents of construction materials is one of the pioneering efforts in this direction. However, detailed study towards discovering novel concrete ingredients is needed to produce sustainable and environmental friendly concrete [3]. This study investigates the possible utilization of two industrial wastes in the composition of concrete. It consists of the use of glass and ceramic tile wastes as partial replacements of coarse aggregates in concrete to analyze their effects on the slump, compacting factor, compressive strength and water absorption of concrete.

## II. RESEARCH SIGNIFICANCE

Although the utilization of industrial solid wastes has been under investigation, the concrete products modified with industrial wastes might not be functional unless their mechanical as well as durability performances are reasonable. Therefore, in order to use solid wastes in construction materials, quality control should be practiced for durability enhancement. Additionally, the effects of industrial wastes on the long term durability of concrete should be accurately investigated prior to its practical application. The behaviour of industrial wastes modified concrete in actual construction works should also be assessed before establishing secondary industries designated for waste recycling [4].

## III. EXPERIMENTAL PROCEDURE

### 3.1. Material properties

Ordinary Portland Cement, ASTM-1, locally available river Ravi Sand of specific gravity 2.67, fineness modulus 1.79 and Margalla crushed stone of maximum size 20 mm (0.787 in.), specific gravity 2.65 and fineness modulus 6.61 were used in the composition of concrete.

### 3.2. Properties of waste coarse aggregates

**Fig. 1** represents the glass and ceramic tile wastes that were utilized as coarse aggregates in the present study. The properties of waste coarse aggregates are presented in **Table 1.** This table also shows the comparison of their properties with the natural crushed stone.



**(a) (b)**

**Fig.1. (a) Glass and (b) ceramic tile waste samples utilized as coarse aggregate**

| Properties | Crushed stone | Glass Waste | Ceramic Waste |
|---|---|---|---|
| Specific Gravity | 2.65 | 2.50 | 2.30 |
| Fineness Modulus | 6.61 | 7.86 | 7.95 |
| Maximum size mm (in.) | 20 (0.79) | 20 (0.79) | 20 (0.79) |

**Table 1: Properties of all Course Aggregate Types**

## IV. MIX PROPORTIONS

Mix proportions of cement: fine aggregate: coarse aggregate (1:2:4) by weight were used to produce concrete with natural coarse aggregates as well as with glass and ceramic waste aggregates. The water to cement ratio used in the present study was kept constant for all seven types of concrete mixtures. In each concrete mix, the quantities of cement and sand were also kept as constants. **Table 2** represents the details of mix proportions.

## V. CASTING AND TESTING OF SPECIMENS

Concrete mixes were cast by following the ACI-211.1-91 code. Seven types of concrete mixes were produced in the concrete laboratory according to the ACI standards. Several trials were undertaken to determine the appropriate water to cement ratio and to reach the target compressive strength of 22 MPa. The water to cement ratio was kept same (0.55) for all types of mixes. No admixture was added in any mix. In total, 63 concrete cubes of size 150 x 150 x 150 mm (6 in x 6 in x 6 in) were cast to find their compressive strengths at the curing ages of 7, 28 and 63 days. For each mix type, 9 cubes were made to determine compressive strengths at already specified curing days. The acronyms used for mixes have been mentioned in Table 2. Before pouring into moulds, each mix was tested for slump and compacting factor. The specimens were demoulded after 24 hours of casting and were kept in standard water curing conditions at 22$^{o}$C (+/- 2$^{o}$C) until the age of testing. The cube compressive strength tests were carried out with the Universal Testing Machine in order to determine the compressive strength of each cube on the test days. Water absorption tests were carried out afterwards.

## VI. EXPERIMENTAL RESULTS AND DISCUSSIONS

### 6.1. Workability

Based on slump and compacting factor results, it was observed that control concrete achieved the highest workability measurements. However, the slump values and compacting factors were found to decrease with an increase in glass content incorporated as partial coarse aggregate in the composition of concrete. Nevertheless, ceramic tile wastes demonstrated the opposite trend than that of the glass wastes. The workability measurements (slump and compacting factor values) are given in **Table 3** and their graphical representations are provided in **Figs. 2** and **3** respectively.

| Mix Type | Slump mm (in) | Compacting Factor |
|---|---|---|
| CC | 28.10 (1.11) | 0.93 |
| G10 | 25.40 (1.00) | 0.91 |
| G20 | 20.32 (0.80) | 0.89 |
| G30 | 12.70 (0.50) | 0.88 |
| C10 | 28.87 (1.14) | 0.93 |
| C20 | 30.97 (1.22) | 0.94 |
| C30 | 33.27 (1.31) | 0.95 |

**Table 3: Slump and Compacting Factor Values**

C.A. Coarse Aggregate
CC Conventional Concrete
G10 Concrete containing glass replaced by 10% of C.A.
G20 Concrete containing glass replaced by 20% of C.A.
G30 Concrete containing glass replaced by 30% of C.A.
C10 Concrete containing tile replaced by 10% of C.A.
C20 Concrete containing tile replaced by 20% of C.A.
C30 Concrete containing tile replaced by 30% of C.A.

| MATERIALS | CC | G10 | G20 | G30 | C10 | C20 | C30 |
|---|---|---|---|---|---|---|---|
| Cement (kg) | 336 | 336 | 336 | 336 | 336 | 336 | 336 |
| Sand (kg) | 702 | 702 | 702 | 702 | 702 | 702 | 702 |
| Water (litre) | 182 | 182 | 182 | 182 | 182 | 182 | 182 |
| Crushed Stone (kg) | 1057 | 951 | 846 | 740 | 951 | 846 | 740 |
| Glass waste (kg) | 0 | 106 | 211 | 317 | 0 | 0 | 0 |
| Tile waste (kg) | 0 | 0 | 0 | 0 | 106 | 211 | 317 |

**Table 2: Mix proportions of concrete for one cubic meter**

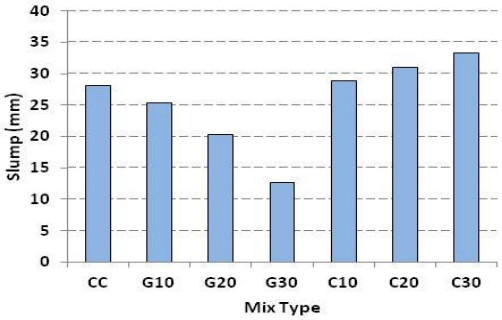


**Fig.2. Slump measurements of all mix types**

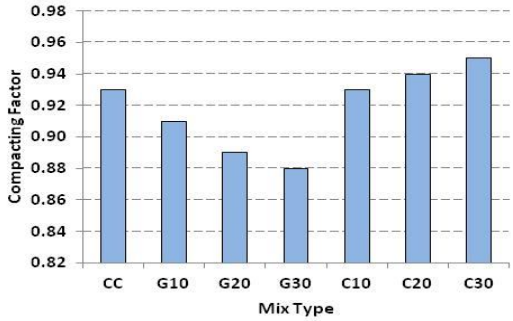


**Fig.3. Compacting factor values of all mix types**

### 6.2. Compressive strength

The conventional mix (CC) showed compressive strength ranging from 15.6 MPa (2265 psi) to 22.9 MPa (3316 psi). G10, G20 and G30 had unsatisfactory compressive strength results; that is, lower than the control specimen. However, C10 showed almost similar results as of control mix. Furthermore, C20 and C30 had higher compressive strengths than conventional concrete, ranging from 17.4 MPa (2525 psi) to 27.9 MPa (4057 psi) and 18.8 MPa (2727 psi) to 29.6 MPa (4297 psi) respectively. **Table 4** represents the compressive strengths achieved for concrete specimens at different ages and are represented graphically in **Fig. 4**. The increase in compressive strength of mixes containing ceramic tile pieces might be due to the addition of more pozzolanic material and the establishment of stronger bond between cement and ceramic tile aggregates. Conversely, the reduction in compressive strength of glass incorporated specimens might be linked to the sharp edges of glass aggregates present in the mixes, which deteriorated the mechanical characteristics of concrete, especially with the increase in glass content.

| Mix Type | 7-days MPa (psi) | 28-days MPa (psi) | 63-days MPa (psi) |
|---|---|---|---|
| CC | 15.6 (2265) | 21.2 (3068) | 22.9 (3316) |
| G10 | 14.7 (2140) | 21.0 (3043) | 18.4 (2663) |
| G20 | 14.4 (2088) | 22.5 (3265) | 18.1 (2622) |
| G30 | 14.1 (2048) | 16.8 (2438) | 16.2 (2351) |
| C10 | 15.8 (2301) | 21.3 (3087) | 22.8 (3310) |
| C20 | 17.4 (2525) | 23.9 (3460) | 27.9 (4057) |
| C30 | 18.8 (2727) | 25.3 (3672) | 29.6 (4297) |

**Table 4: Compressive strength at different curing ages**

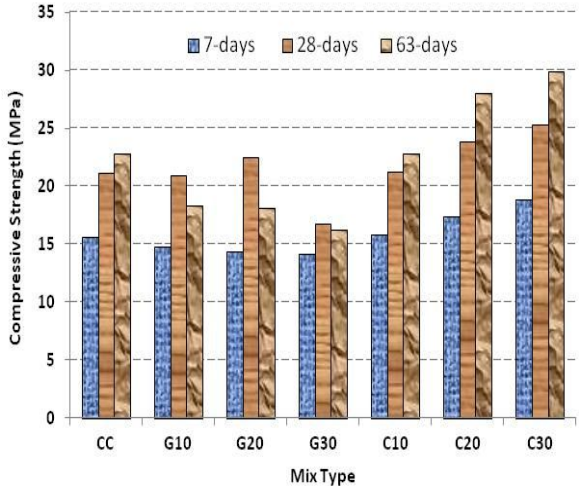


**Fig.4. Compressive strength development in all mix types**

### 6.3. Water Absorption

It was found from the experimental investigations that water absorption of C30 was even higher than the control concrete and also the maximum compared to other mixes. A clear increasing trend was observed in water absorption of ceramic tile concrete mixes and decreasing trend in concrete mixes incorporating glass wastes. **Table 5** and **Fig. 5** represent the tabular and graphical water absorption percentages of all mixtures respectively. The increase in the water absorption in ceramic tile aggregate incorporated concrete might be due to the porosity of the ceramic waste aggregate that has adequate capability of absorbing moisture. On the other hand, the reduction in moisture absorption of coarse glass aggregate concrete mixes might be linked to the fact that glass material does not permit sufficient water penetration though its microstructure.

| Mix Type | Water Absorption (%) |
|---|---|
| CC | 7.84 |
| G10 | 9.96 |
| G20 | 7.06 |
| G30 | 6.22 |
| C10 | 8.65 |
| C20 | 10.87 |
| C30 | 11.18 |

**Table 5: Water absorption in percentages for all mix types**

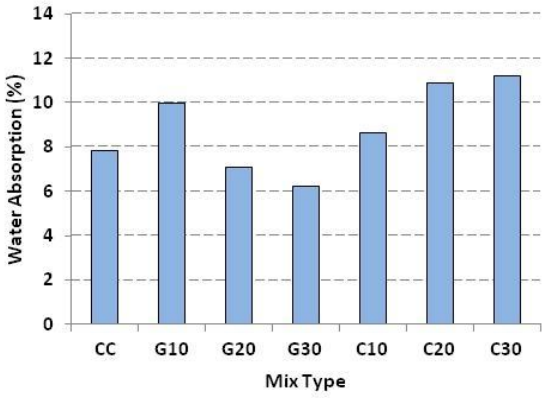


**Fig.5. Water absorption of all mix types**

## CONCLUSIONS

The thorough assessment of the findings obtained from the experimental trials provided the following conclusions. The slump, compacting factor and water absorption of glass modified concrete decreased as the glass content in concrete increased. On the contrary, the slump, compacting factor and water absorption of concrete mixes produced with ceramic wastes increased with the increase in ceramic contents. Glass showed irregular pattern of compressive strength due to its sharp and angular edges. Its strength increased up to 28-days, followed by a significant decrease on 63-days age showing its non-durable nature. The addition of 10% ceramic waste replaced by coarse aggregates demonstrated

approximately similar performance than that of control concrete. The compressive strength increased with the addition of ceramic content in concrete. This concludes that waste ceramic tiles can be utilized as a partial replacement to coarse aggregates in concrete.

## RECOMMENDATIONS FOR FURTHER STUDY

It is suggested to expand this study with higher percentages of coarser and finer ceramic tile wastes to evaluate the compressive, tensile and flexural strength behaviour of the resulting concrete. Ceramic tile waste is expected to perform as a promising waste material that can be used in the production of concrete for practical applications. Likewise, finer glass powder can also be considered to investigate its influence on compressive, tensile and flexural strengths.

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