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EFFECTS OF CLAY ON PROPERTIES OF CONCRETE

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Concrete is a versatile and most prevalent construction material. Its long-term performance depends on its interactions with the surrounding environment. The standards limit the ratio of the clay in aggregates due to its harmful effect on the concrete properties. This research paper presents the effect of different levels of clay addition on the concrete properties. Various levels of clay addition for different mixes were used in this experimental study. The effect of clay addition on workability, compressive strengths permeability and acid attack of concrete mixes was investigated. It has been seen that workability decreased by increasing the clay content to the mix. A drop in compressive strength of concrete up to 12% was observed by adding clay as compared with that of control samples. An adverse effect on resistance to permeability and acid attack of concrete was noted by increasing the clay content.

Keywords: Workability, Compressive strength, Acid attack on concrete, Water permeability.

1 INTRODUCTION

Concrete is a building material, which is most commonly used for construction. Failures in concrete can also be due to the use of improper aggregates. Aggregates cover about 65-80% of the volume of concrete. Aggregates should be characterized so that one could easily ascertain their role on the performance of concrete (Munoz *et al.* 2005, Neville 2000). Adverse effect on properties of concrete was observed with the presence of some types of micro fines on the faces of aggregates. Clay mineral was found as a major portion of micro fine gravel coatings. It has been widely reported that the compressive strength reduces and shrinkage increases in concrete due to presence of clays in aggregates. The effect of clays on various properties of concrete are not yet clear.

Teychenné (1978) noticed that the change in water demand of concrete mixes was related to the content of micro-fines present in the mix. Studies (Katz and Baum 2006) have shown that water to cement ratio equal to 0.49 was needed by a mixture (with no micro-fines) to achieve a certain value of slump. However, in order to get the same workability of this mix (with micro fines equal to 3.2 percent of the total weight of aggregate), w/c must be enhanced from 0.49 to 0.62. Another research showed that water demand was directly related to the content of fines in the concrete (Abou-Zeid and Fakhry 2003).

Kourd (1989) specified that the addition of micro-fines, known as dust, increased the shrinkage of concrete. According to research conducted by Goldbeck (1932) it was observed that the aggregate coatings with a high clay contents exhibited comparatively more adverse effects in terms of strength and durability as noted in case of the aggregate coatings that consisted of high volumes of carbonate and dust fines. Because of the adverse effects, most of the standards limit the ratio of clay in aggregates. ASTM C 33 (2003) limits the fine content in fine aggregate to 5% while the ratio of clay lumps is limited to 0.5%.

He *et al.* (1995) conducted experimental study in order to observe the effect of compressive strength, water requirement, pozzalanic activity and size distribution on various properties of concrete mixes having content of clays.

The overall objective of this study is to conclude how the existence of clay particles affect the compressive strength and other durability properties of concrete. The study will be helpful in reducing troubles and suffering caused by the different stakeholders of construction industries.

2 EXPERIMENTAL INVESTIGATION

2.1 Materials

The cement used is Ordinary Portland cement (Type I) manufactured by Fauji cement Company Pakistan. Its specific gravity is 3.15 and Blaine Fineness is 3,100 cm^2/g. A natural sand with Fineness Modulus 2.43 from the source of Lawrencepur quarries is used. The coarse aggregate used is natural crushed type having nominal maximum size equal to 19mm.The unit weight of the coarse aggregate is found to be 2,616 kg/m^3. Local sourced clay passing No. 200 sieve was used in this study.

2.2 Preparation of Mixtures

Three different mixing ratios of 1:1.6:3.2, 1:1.8:3.6, and 1:2:4 by weight of cement, sand and coarse aggregates were used in this study. The addition of clay content for each of the above ratio was kept equal to 0, 1.5%, 3%, 4.5%, and 6%. Another variable used in this study was the water-cement ratio (W/C) which was used as 0.50, 0.55, and 0.60. Hence, there will be total of 45 mixes. For each mix, the slump of the fresh concrete is taken and measured according to ASTM C 143 (2001). Standard cubes (see Figure 1) were cast from above mixes (twelve cubes for each mix) to calculate the compressive strength (average of three specimens) at the age of 3, 7, 14, and 28 days (B.S. 1881 Part 116).

Figure 1. Preparation of samples for compressive strength testing.

Figure 2. Samples for water permeation test.

Hence, there will be total 540 cubes for investigation of compressive strength. Samples were also cast to measure the effect of acid attack for an exposure period of 28 days. Two cubical and two cylindrical specimens, as shown in Figure 2, from each mix were cast to ascertain the permeation properties of concrete at the age of 28 days.

2.3 Testing Methods

The workability of concrete is measured in terms of slump. For each mix, the slump of the fresh concrete is taken and measured according to ASTM standard procedure (ASTM C 143). To determine compressive strength of concrete mixes, cubes were cast in lubricated steel molds and compacted using rod, according to BS standards (BS 1881-116:1983). In this study, 5 % solution of sulphuric acid has been used to study the Acid attack affect. Water permeability test was conducted to study the water permeation property of concrete. Four Cell Automatic Concrete Water Permeability Apparatus as shown in Figure 3 was used. Steady flow method was applied to determine water permeability of concrete (Khatri and Sirivivatnanon 1997). Pressure of 5 bars as recommended by Chan and Wu (2000) was applied till steady state was developed. Permeability coefficient in cm/sec was calculated by using Darcy’s equation.

Figure 3. Four cell automatic concrete water permeability apparatus.

3 RESULT AND DISCUSSIONS

3.1 Workability

Results of slump values having different clay content are shown in Figure 4 and 5. Figure 4 shows that slump value decreases with increase in clay content for same water cement ratio this might be due to small particle size and higher in surface area of clay. Therefore, for the same W/C, concrete made with cement containing clay is less workable than the control mixture (0% clay content). It is depicted from the Figure 4 that for same W/C and clay content, the richer the concrete, the lesser the slump. This could be due to increase in contents of cement and sand, resulting in increased surface area. Same trend was observed for W/C 0.55 as shown in Figure 5.

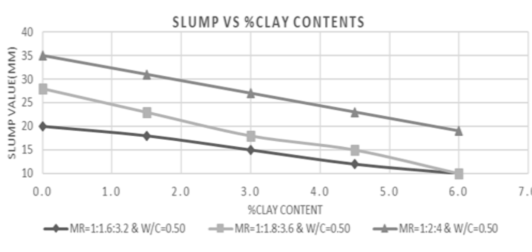

Figure 4. Slump vs. clay content at W/C 0.50.

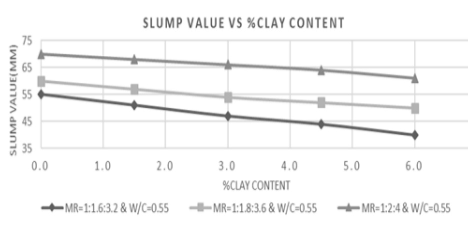

Figure 5. Slump vs. clay content at W/C 0.55.

The figures show that the value of slump goes on decreasing as clay content is increased for all the mixes regardless of the W/C. The observed trend from the graph is that the slump value is flat in the start and then becomes steeper as the amount of clay increases for all the mixes regardless of the proportion of the mix or W/C used. Results reported here are in agreement with the previous studies (Forster 1994, Katz and Baum 2006).

3.2 Compressive Strength

Compressive strength of various mixes were calculated at the age of 3, 7, 14, and 28 days. Only 28 days compressive strength results are selected to be discussed here. The compressive strength results of different mixes at the age of 28 days for various W/C are presented in Figure 6 to 8.

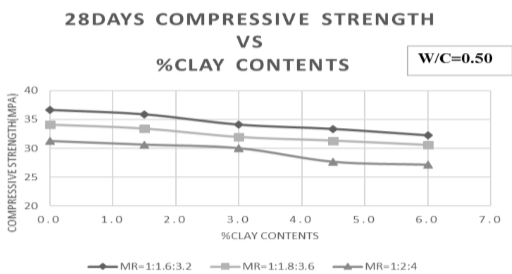

Figure 6. Compressive strength at W/C 0.50.

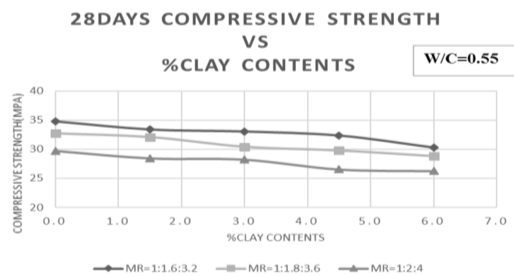

Figure 7. Compressive strength at W/C 0.55.

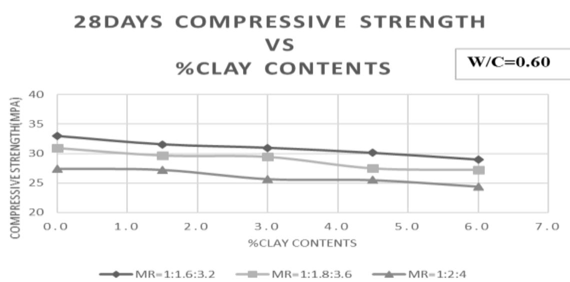

Figure 8. Compressive strength at W/C of 0.60.

It is observed from the Figures 6 to 8 that for same W/C ratio, compressive strength of concrete decreases with increase in clay content. It has also been observed from these figures that the richer mix has higher compressive strength for same clay content and same W/C ratio. Decrease in strength was observed with increase in clay content for all W/C as compared to control mix (0% clay contents). It is, therefore, clear that clay content has negative effect on compressive strength of concrete. This might be due to hindrance provided by clay in the formation of proper hydrates from the chemical reaction including primary as well as secondary pozzalanic reactions.

3.3 Acid Attack

Mix with W/C equal to 0.6 were selected for the discussion of results. Following results were obtained for cubes compressive affected by sulfuric acid for 28 days. From Figure 9, it is observed that resistance to acid attack decreases with increase in clay content. Decrease in compressive strength due to acid attack was observed maximum at maximum clay content (i.e., 6%). Same behavior was observed for richer mixes (1:1.8:3.6 and 1:2:4) shown in Figures 10-11.

Figures 9 to 11 shows that with increase in clay content, the concrete mix is more prone to acid attack. This might be due to firm coating of aggregates by clay content, which weakens the bond between aggregates and cement matrix.

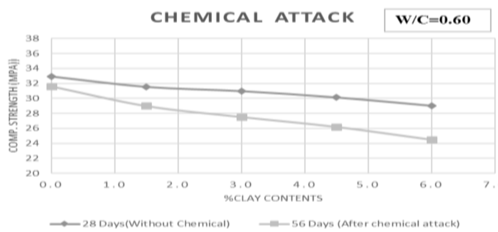

Figure 9. Acid attack of mix 1:1.6:3.2.

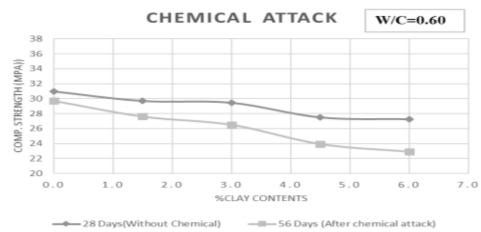

Figure 10. Acid attack of mix 1:1.8:3.6.

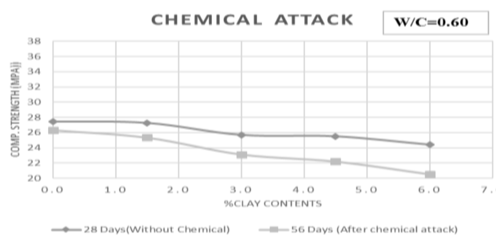

Figure 11. Acid Attack of mix 1: 2: 4.

3.4 Water Permeation

Coefficient of water permeability of concrete containing various clay content are shown in Figures 12 to 14, at the age of 28 days.

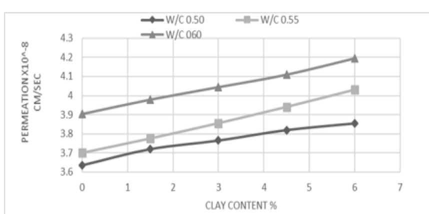

Figure 12. Permeation value for 1:1.6:3.2.

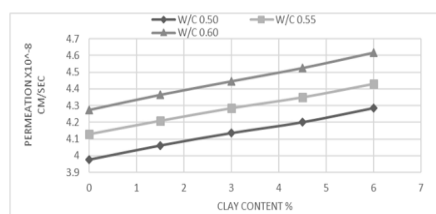

Figure 13. Permeation value for 1:1.8:3.6.

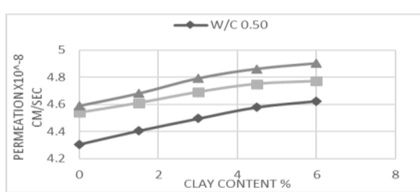

Figure 14. Permeation value for 1:2:4.

Figures 12 to 14 shows that coefficient of permeability increases with increase in clay content for same W/C and same mix ratio. It was observed that water permeability of concrete increase with W/C ratio for constant clay content and mix ratio. It was also found form the Figures 12 to 14 that for same W/C and clay content, value of coefficient of water permeability decreases. It is concluded from the results that with increase in clay content resistance of concrete to water permeability decreases.

4 CONCLUSIONS

The following general conclusions can be drawn from the study provided in the paper:

1. It was observed that the value of slump goes on decreasing as amount of clay added to the mix increases.
2. It was noted that the Compressive strength decreases as ratios of clay added increases.
3. It was observed that the compressive strength of cubes decreased by 3% to 12% for adding the clay content up to 6%.
4. It has been observed that strength goes on decreasing with increase in the percentage of clay added. Deviation of strength at earlier has been less but at later stages becomes more.
5. Results have shown that permeability increased with increase in amount of clay content. It was also found that the permeability of concrete increases with increase in water cement ratio.

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