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Full Length Research

Impact of clay particles on concrete compressive strength

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Aggregates are one of the components of concrete that have properties to be fulfilled before being used. The cleanliness of the aggregates is required by all the standards of construction. Among the undesirable matters in the aggregates, there is clay. This study investigates the impact of clay particles on compressive strength of concrete. The tests have been conducted on the most used concrete constituents in Rwanda. The properties of concrete containing clay properties were assessed in civil engineering laboratory. The specimens used for compressive strength were cylindrical. All test specimens were prepared in accordance with ASTM 192-00. The specimens were cured continuously in limewater after the initial 24-hour moist cure period until the time of testing. The control cylinders were moved into the saturated lime water bath after initial 24-hour moist curing under wet burlap and plastic sheeting. For all concrete strengths studied in this research the specimens were tested at the age of 3, 7, 14 and 28 days. The clay quantities in aggregates which have been considered in this study are 1%, 3%, 5%, 7% and 10% by weight. For all these clay quantities, the quantities of water and cement have not been changed, and the all results were compared to the properties of concrete which does not contain clay particles. It was found that the concrete strength is inversely proportional to the quantity of clay particles contained in aggregates.

Key words: Concrete compressive strength, concrete testing, sand, gravel, cement clay particles.

INTRODUCTION

Concrete is a construction material which is composed of three main materials, these being cement, water and aggregates (sand, natural gravel or crushed stone). Sometimes, an admixture, this being an additional material, is added in order to change or modify certain properties (such as water- repellent, on colouring agent or to retard an hasten setting)of concrete. The chemically active constituent of concrete is cement. The reactivity of cement is only guaranteed and achieved on mixing it with water. Aggregates do not have a role to play in the chemical reactions within concrete but they are very useful because they act as economic filler materials with good resistance to volume changes, which occur in concrete after mixing. Another important aspect of aggregates is that they improve the durability of concrete.

Concrete aggregates can sometimes contain impurities like clay particles which can have an impact on the concrete properties.

The earliest description of surface coatings on coarse aggregates was documented by Goldbeck (1932) for the Highway Research Board. In the report, Goldbeck summarized the properties of seven different types of aggregate coatings: stone dust, clay, organic, alkali and salt, bituminous oil, calcareous, and sugar coatings. Based on these general classifications, each aggregate coating investigated in this study was classified as a clay, dust, or carbonate coating. Clay coatings consist of clay particles that are held tightly to aggregate surface. Because the material usually adheres to the aggregate even after the concrete is mixed, it is believed to interfere with the aggregate-cement paste bond. Unlike clay coating, dust coating are easily removed during mixing and affect concrete performance by increasing the amount of fines dispersed in the mix. The fines can act as pozzalonic admixtures depending on the composition of the material (Schmitt, 1990). Carbonate coatings, similar to the calcareous coating type described by Goldbeck (1932), are deposited from solutions in the calcite deposits and typically consist of calcium carbonate material.

It is generally believed that the effect of aggregates coatings depends on whether or not the particles adhere to the aggregate surface after mixing. Because clay fines are bound to the aggregate by electrostatic forces, many researchers suggest that clay coatings disrupt the aggregate-cement paste bond (Dolar-Mantuani, 1983; Forster, 1994; Schmitt, 1990; Goldbeck, 1932; Neville, 1996). If the bond between the cement paste and the coating is stronger than the bond between the coating and the aggregate, a weak zone may develop at the coating-aggregate interface and significantly reduce concrete strength and durability (Foster 1994).

In addition to classifications that group coatings by composition or strength of adherence, researchers also classified aggregate coatings according to their source (Ozol 1979; Foster, 1994). Coatings deposited by water are mostly mineral in nature and include calcium carbonate, iron oxide, gypsum, and alkali sulfates.

Coatings containing clay, silt, and organic matter are found naturally in the overlying layers of the deposit or are artificially placed on the aggregate during processing. This article is limited to the impact of clay particles on concrete compressive strength.

Research scope and objectives

The primary objective of this study is to evaluate the impact of clay particles on the concrete compressive strength. The laboratory testing methods of concrete are in accordance with ASTM 192-00.

MATERIALS AND METHODS

Concrete mixtures

The concrete mixtures used in the laboratory portion of this research contain different quantity of clay particles. The concrete mixtures are given in Tables 1 - 6. Type of clay: Kaolinite

Table 1. Clay content in aggregates = 0%.

	Gravel	Sand	Water	Cement
Weight (Kg/m^3)	1000.53	667.44	185	334.8

Table 1. Clay content in aggregates = 1%.

	Clay	Gravel	Sand	Water	Cement
Weight (Kg/m^3)	16.679	990.775	660.516	185	334.8

Table 3. Clay content in aggregates = 3%.

	Clay	Gravel	Sand	Water	Cement
Weight (Kg/m^3)	50.039	970.758	647.172	185	334.8

Table 4. Clay content in aggregates = 5%.

	Clay	Gravel	Sand	Water	Cement
Weight (Kg/m^3)	83.398	950.743	633.829	185	334.8

Table 5. Clay content in aggregates = 7%.

	Clay	Gravel	Sand	Water	Cement
Weight (Kg/m^3)	116.758	930.727	620.485	185	334.8

Table 5. Clay content in aggregates = 7%.

	Clay	Gravel	Sand	Water	Cement
Weight (Kg/m^3)	166.797	900.704	600.469	185	334.8

Laboratory experimental design

Test specimen

The specimens used for compressive strength were cylindrical. All test specimens were prepared in accordance with ASTM 192-00.

Specimens curing

The specimens were cured continuously in limewater after initial 24-hour moist cure period until time of testing.

The control cylinders were moved into the saturated lime water bath after initial 24-hour moist curing under wet burlap and plastic sheeting.

Specimens testing

For all concrete strengths studies in this research the specimens were tested at the age of 3, 7, 14 and 28 days.

Test methods

The concrete compressive strength was conducted in accordance with ASTM C39-01 Standard.

Table 7. Compressive strength after 3 days.

Clay content in aggregates (%)	Concrete compressive strength in MPa
0	7.5
1	7.2
3	6.9
5	6.6
7	6.4
10	6.1

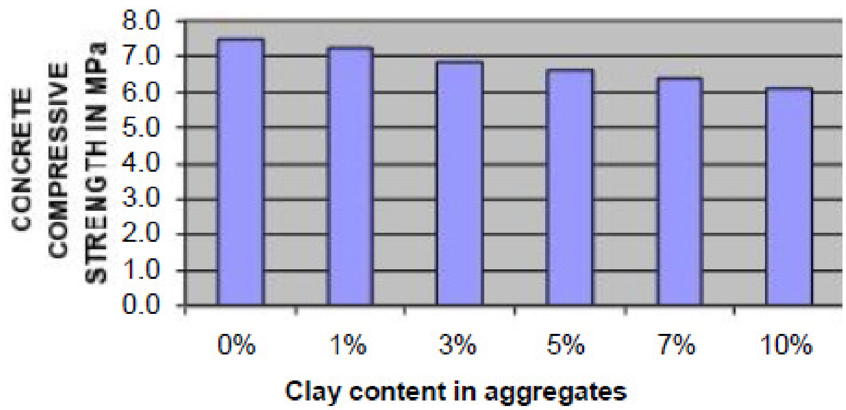

Figure 1. Compressive strength after 3 days.

Table 8. Compressive strength after 7days.

Clay content in aggregates (%)	Concrete compressive strength in MPa
0	13.2
1	12.8
3	12.2
5	11.7
7	11.3
10	10.8

PRESENTATION OF RESULTS

The results were obtained after laboratory testing of concrete specimens. The results are related to the impact of clay particles on compressive of concrete. The concrete tests were conducted in accordance with ASTM standards. Compressive strength of concrete containing clay particles after days (Tables 7-10 and Figures 1-4).

ANALYSIS AND DISCUSSION

Concrete strength decrease

In this study, It was found that the three-day compressive strength of concrete containing clay particles that decrease at the age of 3days (Figure 5) differs from the one which does not contain impurities as follow:

i. When the clay content in aggregates is 1% the loss of compressive strength is 3.69%.
ii. When the clay content in aggregates is 3% the loss of compressive strength is 8.5%.
iii. When the clay content in aggregates is 5% the loss of compressive strength is 11.92%.
iv. When the clay content in aggregates is 7% the loss of compressive strength is 14.92%.
v. When the clay content in aggregates is 10% the loss of compressive strength is 18.60%.

The Concrete compressive strength decrease at the age of

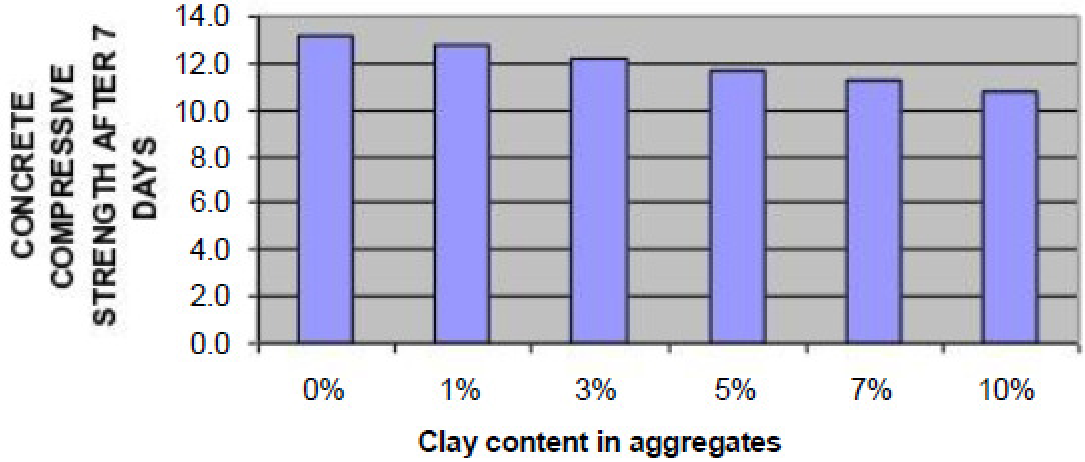

Figure 2. Compressive strength after 7 days.

Table 9. Compressive strength after 14days.

Clay content in aggregates (%)	Concrete compressive strength in MPa
0	17.9
1	17.4
3	16.5
5	15.9
7	15.3
10	14.7

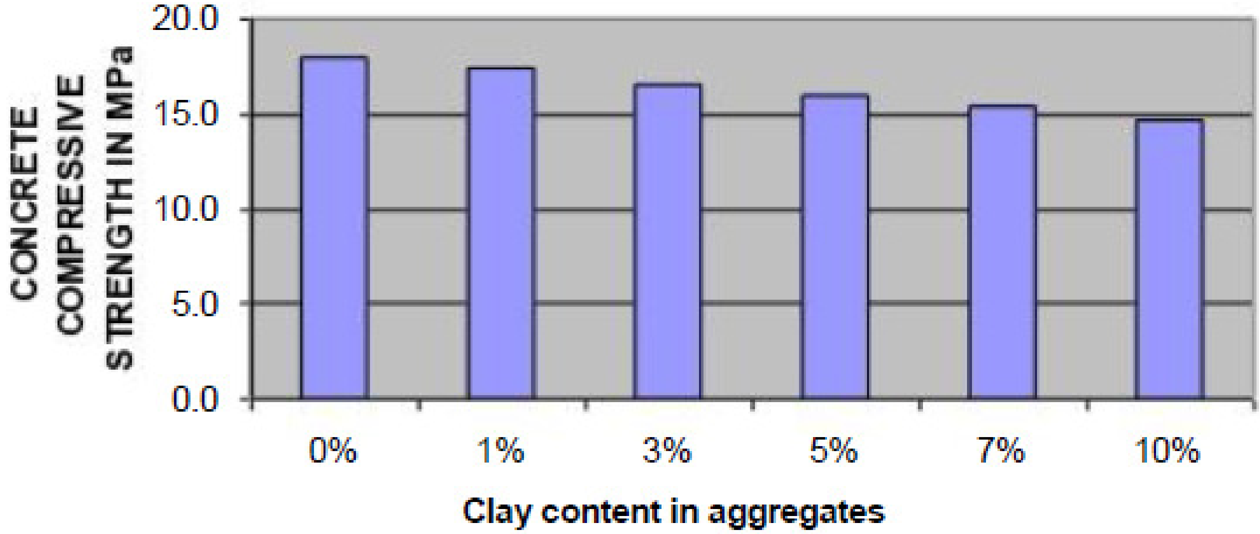

Figure 3. Compressive strength after 14 days.

14 days (Figure 6). The seven-day compressive strength losses were as follow:

i. When the clay content in aggregates is 1% the loss of compressive strength is 3.08%.

ii. When the clay content in aggregates is 3% the loss of compressive strength is 7.93%.

iii. When the clay content in aggregates is 5% the loss of

Table 10. Compressive strength after 28days.

Clay content in aggregates (%)	Concrete compressive strength in MPa
0	22.6
1	22.0
3	20.9
5	20.1
7	19.4
10	18.6

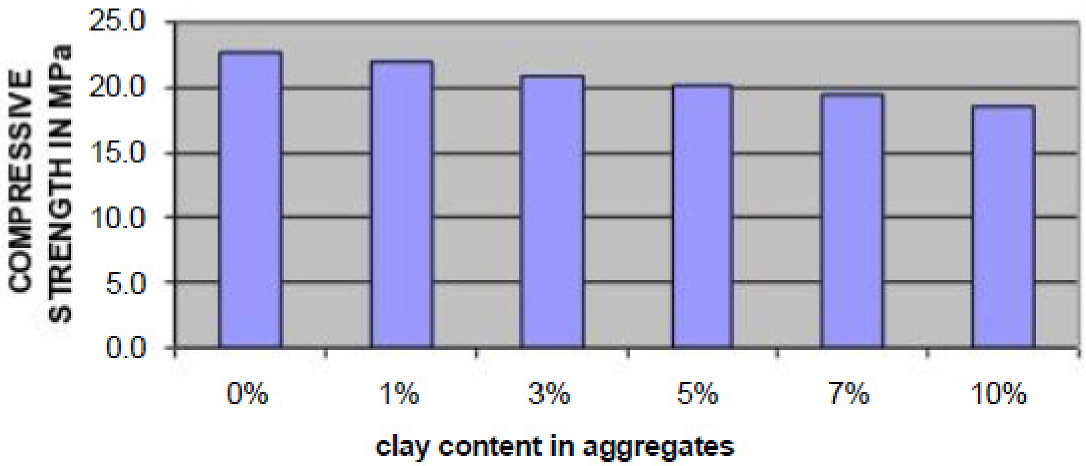

Figure 4. Compressive strength after 28days.

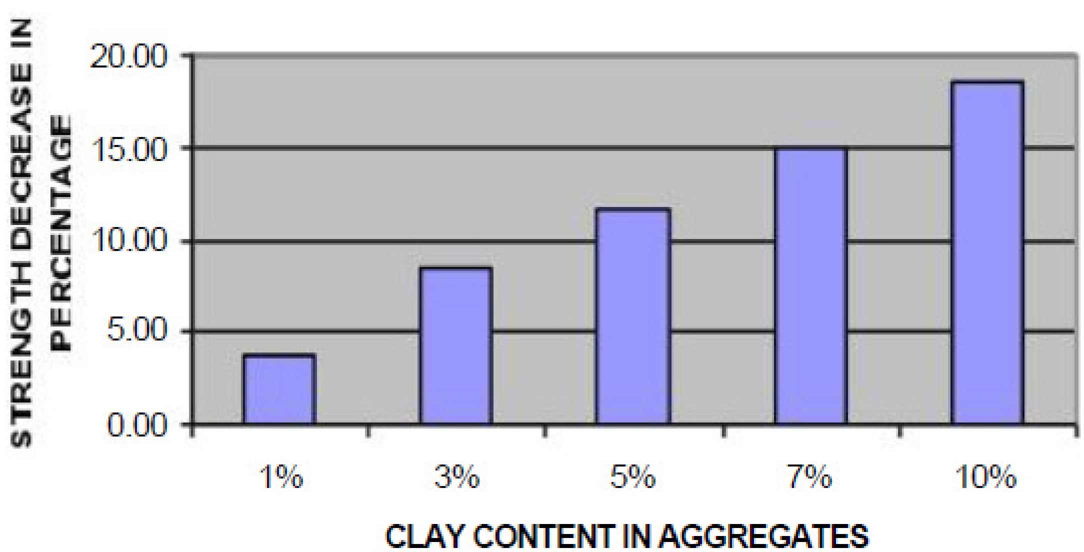

Figure 5. Concrete compressive strength decrease at the age of 3 days.

compressive strength is 11.16%.
iv. When the clay content in aggregates is 7% the loss of compressive strength is 14.39%.
v. When the clay content in aggregates is 10% the loss of compressive strength is 18.08%.

The concrete compressive strength decrease at the age of 14 days (Figure 7). The fourteen-day compressive strength

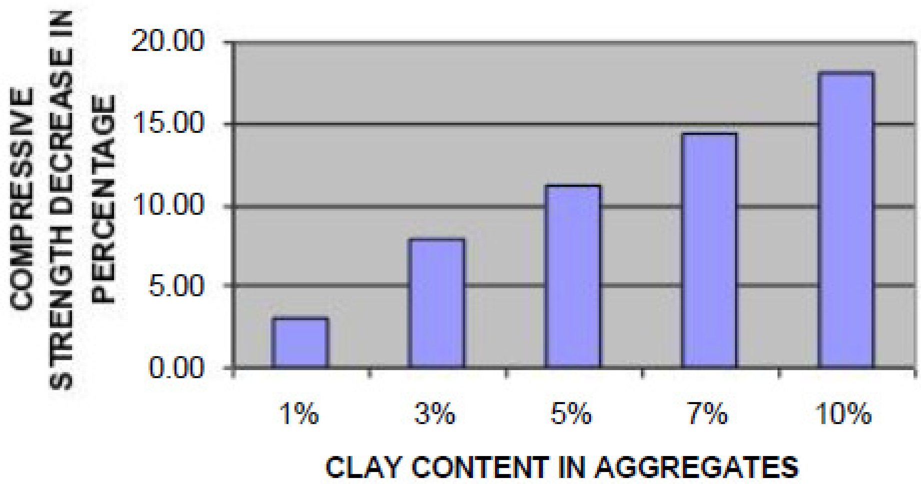

Figure 6. Concrete compressive strength decrease at the age of 7 days.

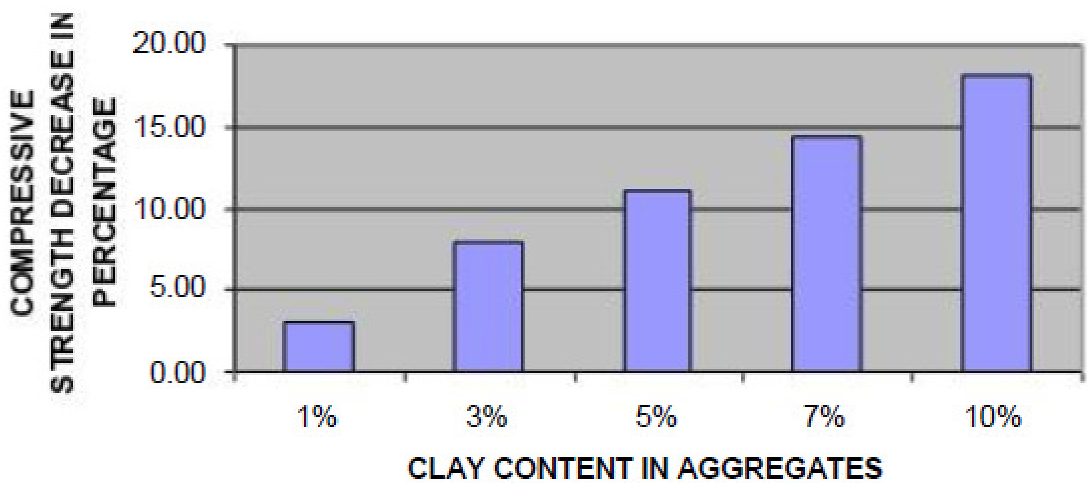

Figure 7. Concrete compressive strength decrease at the age of 14 days.

losses are as follow:

i. When the clay content in aggregates is 1% the loss of compressive strength is 3.05%.
ii. When the clay content in aggregates is 3% the loss of compressive strength is 7.90%.
iii. When the clay content in aggregates is 5% the loss of compressive strength is 11.13%.
iv. When the clay content in aggregates is 7% the loss of compressive strength is 14.37%.
v. When the clay content in aggregates is 10% the loss of compressive strength is 18.06%.

The concrete compressive strength decrease at the age of 28 days (Figure 8). The Twenty eight-day compressive strength losses are as follow:

i. When the clay content in aggregates is 1% the loss of compressive strength is 2.65%.
ii. When the clay content in aggregates is 3% the loss of compressive strength is 7.52%.
iii. When the clay content in aggregates is 5% the loss of compressive strength is 11.06%.
iv When the clay content in aggregates is 7% the loss of compressive strength is 14.16%.
v. When the clay content in aggregates is 10% the loss of compressive strength is 17.70%.

Variation of compressive strength losses for the different ages of concrete Figure 9 shows how the losses decrease progressively when the age of concrete increases

Conclusion and recommendation

In most situations in Rwanda like in other African countries, the concrete is the main building material

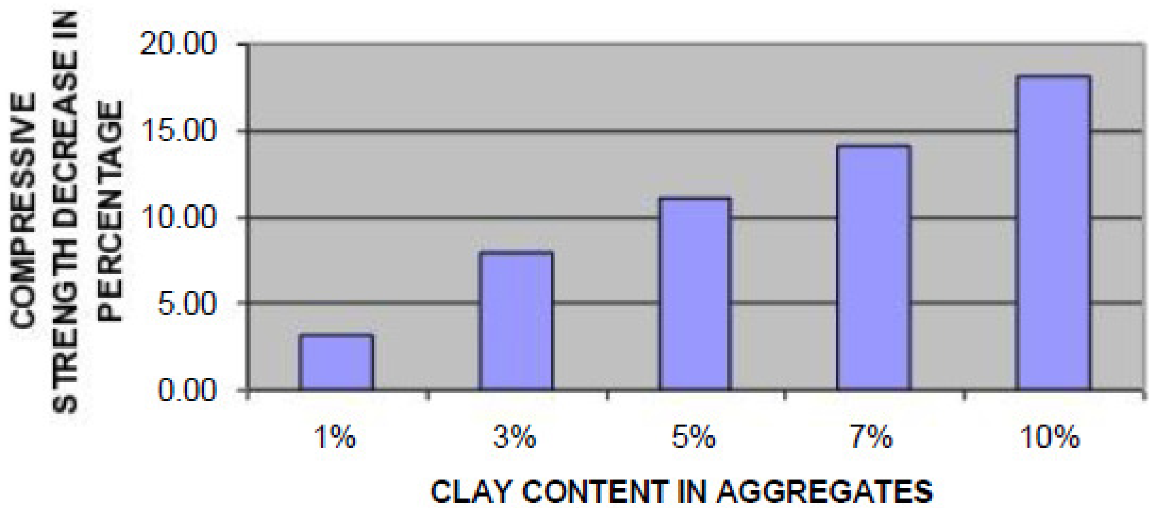

Figure 8. Concrete compressive strength decrease at the age of 28 days.

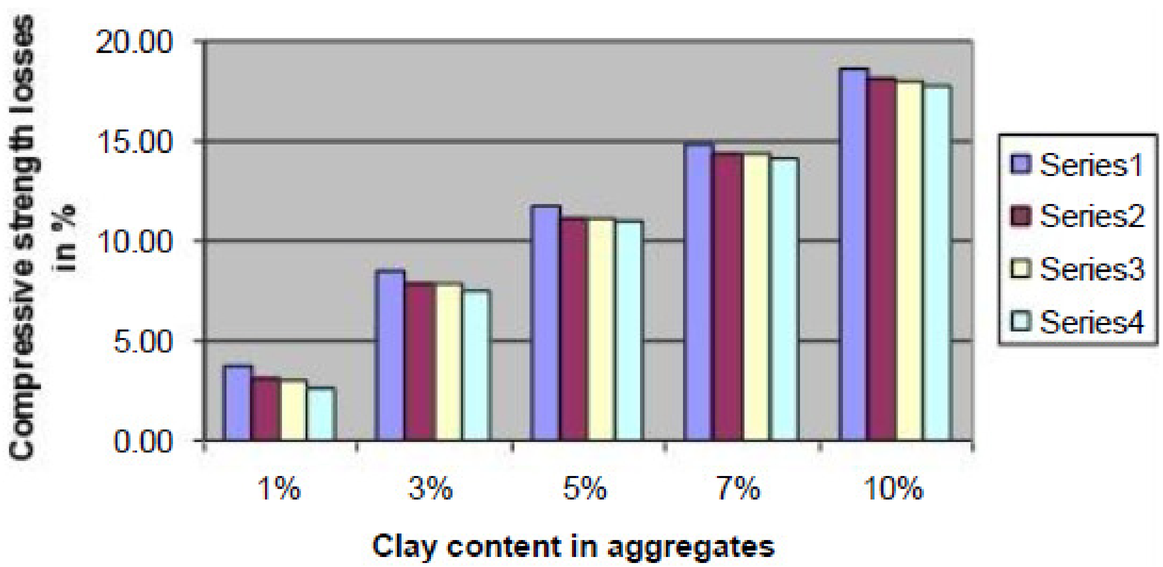

Figure 9. Variation of compressive strength losses.
Series 1: compressive strength losses at the age of 3 days
Series 2: compressive strength losses at the age of 7 days
Series 3: compressive strength losses at the age of 14 days
Series 4: compressive strength losses at the age of 28 days

which is used to construct modern and durable infrastructures like multi-storey buildings, bridges, water tanks, retaining walls etc.

The aggregates used in the mentioned cases are not always tested in order to know if the material meets the construction standards. The content of impurities in aggregates should always be determined before they are used.

The content of clay particles in aggregates should never be greater than 1%.

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