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# Change of Material Properties of the Cement Paste CEM I

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**Abstract:** Paper consider research in laboratory. The theme of research are material qualities of cement paste and their dependency on variation of temparature. The introducion includes general qualities of cement. In particular parts of paper are solve mass density, compressive strength, stress-strain curves. The results of admeasurement and calculation are statistically evaluated and analysed in tables and graphs.

**Keywords:** Cement Paste, Compression, Compression Test, Flexural Test

## 1. Introduction

In the last time is large focus devote for the fire resistant of building constructions. The concrete structures forms a capital part of building constructions. Material properties are very important data for correct design of construction. For the mathematical simulations [1] of the concretes creep, construction behaviour, are important material properties of cement paste. Strength of cement paste is tested in compression test in the MTS Alliance RT 30 equipment. Modulus of Elasticity is tested in MTS equipment, too.

Material tests presented in this paper have the approximate problems in change of material properties of cement pastes [2] exposed on influence of thermal loading i.e. high temperatures. Knowledge of behaviour of the cement paste like a basic structure for composite material (concrete) is important for correct design of concrete structure.

Temperatures above 150°C change content of the water in cement paste. At temperature approximately 500°C calcium hydrate is starting the break the structure. The paper described compression tests of the specimens the cylindrical shape and bend tests of the small prisms.

## 2. Specimen

For compression tests were used cylindrical specimens with diameter 10mm and length 40mm [2]. Cylindrical specimens were made into the plastic moulds (length

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100mm). After hardening process were specimens cut at length 35mm. Specimens were made from Portland cement CEM I 42.5R and water, without plasticizer. Water cement ratio was 0.5, 0.4 and 0.3. Only cement paste with w/c ratio 0,3 was prepared by plasticizer Stachement 2090. Plasticizer was used in quantity 2% weight of the weight the cement.

The bend tests were realized at prisms with dimension (100 x 20 x 20mm) made from Portland cement CEM I 42.5R. Prisms were made into the steel form. Cement paste was prepared like in the case cylindrical specimens. Water cement ratio was 0.3, 0.4 and 0.5. For preparing the specimens was used plasticizer Stachement 2090, too.

## 3. Testing equipment

Measuring of the material properties was realized in the MTS Alliance RT 30 testing equipment. By MTS Alliance were tested: strength, Modulus of elasticity [3] and tensile strength in the three points bend test. Distance of the backing was 80mm and load was applied at the half of bracket. Firstly were tested specimens in compression at temperature 20°C. Next tested temperatures were 200°C, 450°C and 600°C. Specimens were heated at the temperatures before testing the mechanical properties. Temperatures influenced the specimens 2,5hour. All specimens were loaded by constant rate of loading during whole test procedure.

At the same temperatures were tested specimens in bend test. Before the testing at high temperatures specimens were heated in the electric furnace. Specimens were token out from water basin one day before heating in the furnace and leave for air-drying. Curve of the heating depend at the required temperature. First part was the heating at the required temperature (form 30 to 60minutes). Second part was 2.5hour long and specimens were heated by constant (demand) temperature. Third part was cooling at the 20°C during the 1day.

## 4. Compression tests

Cylindrical specimens were tested in compression tests. In the group were three sets of specimens tested (Table 1). First set was prepared from cement and water with w/c = 0.3 with addition the plasticizer in quantity 2%. The set included 4 or 5 specimens. Cement paste was tested at temperatures 20, 200, 300, 450 and 650°C. Average strength of specimens tested at temperature 20°C was 147.01MPa. For temperature 200°C was average compression strength 107.67MPa. Third set of specimen (300°C) achieved the average strength 81.07MPa. Compression strength of specimens decreased at 47.94MPa for temperature 450°C and 23,87MPa for temperature 600°C.

Second set of the specimen was prepared with w/c = 0.4. Cement paste was tested at temperatures 20, 200, 300, 450 and 650°C. Average strength of specimens tested at temperature 20°C was 60,03MPa. For temperature 200°C was average compression strength 86,92MPa. Third group of specimen (300°C) achieved the average strength 66.49MPa. Compression strength of specimens decreased at 15.73MPa for temperature 450°C and 17.70MPa for temperature 600°C.

Third set of the specimen was prepared with w/c = 0.4. Cement paste was tested at temperatures 20, 200, 300, 450 and finally 650°C. Average strength of specimens tested at temperature 20°C was 60.23MPa. For temperature 200°C was average compression strength 67.26MPa. Third group of specimen (300°C) achieved the average strength 57.75MPa. Compression strength of specimens decreased at 4.94MPa for temperature 450°C and 4.00MPa for temperature 600°C.

**Table 1. Compression strength of specimen of cement paste from CEM I (MPa)**

| Set of specimens at temperature | w/c 0.3 | w/c 0.4 | w/c 0.5 |
|---|---|---|---|
| 20 | 147.01 | 60.03 | 60.23 |
| 200 | 107.67 | 86.92 | 67.26 |
| 300 | 81.07 | 66.49 | 57.75 |
| 450 | 47.94 | 15.73 | 4.94 |
| 600 | 23.87 | 17.70 | 4.00 |

The lowest strength was measured for specimens with w/c ratio 0.5. The highest strength was achieved for paste with w/c ratio 0.3.

## 5. Bend test

Tests were realized by prism specimens with dimensions (20 x 20 x 100mm). Distance between supports was 80mm. All sets were tested at same temperatures like the specimens in compression test. Average strength of specimens tested at temperature 20°C was 2.27MPa. For temperature 200°C was average tension strength 4.80MPa. Third set of specimen (300°C) achieved the average strength 2.76MPa. Average tension strength of specimens was 2.74MPa for temperature 450°C and 1.09MPa for temperature 600°C.

Second set of the specimen achieved these values of tensile strength: At temperature 20 °C was average strength 2.69MPa. At temperature 200°C achieved cement paste value of average tensile strength 6.06MPa. Next value was 1.89MPa for specimens heated at 300°C. At temperature 450°C was average tensile strength 0.30MPa, and at 600°C was value of strength 1.18MPa.

**Table 2. Tensile strength of specimen of cement paste from CEM I (MPa)**

| Set of specimens at temperature | w/c 0.3 | w/c 0.4 | w/c 0.5 |
|---|---|---|---|
| 20 | 2.27 | 2.69 | 1.24 |
| 200 | 4.80 | 6.06 | 1.70 |
| 300 | 2.76 | 1.89 | 1.50 |
| 450 | 2.74 | 0.30 | 0.39 |
| 600 | 1.09 | 1.80 | |

Third set the specimen achieved these values of tensile strength: Average strength of specimens tested at temperature 20°C was 1.24MPa. For temperature

200°C was average tension strength 1.70MPa. Third set of specimen (300°C) achieved the average strength 1.50MPa. Average tension strength of specimens was 0.39MPa for temperature 450°C. At temperature 600°C were specimens damaged and its testing weren't possible.

## 6. Conclusion

The paper is focused on the compare results of measuring of properties of cement paste loaded by temperature. Strength in compression decrease with increasing temperature applied at the specimens. The best results are for cement paste made with w/c ratio 0.3 opposite the cement paste with w/c 0.5 (Table 1). For cement paste w/c 0.5 are strength at temperatures 450 and 600°C nearly to 0.

In the second case trend a decrease of strength with increasing temperature and w/c is same like in the first case (Fig. 1 and 2).

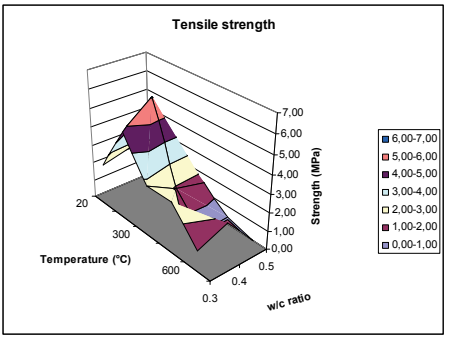


**Fig. 1.** Tensile strength.

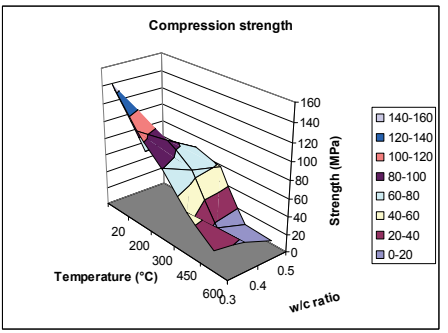


**Fig. 2.** Compression strength.


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