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Influence of Temperature on Concrete and its Modulus of Elasticity

Vliv teploty na beton a jeho modul pružnosti

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Abstract: *Influence of high temperature on characteristics of concrete is still toppical because properties of concrete aren't good known. Properties of concrete are major for design concrete and reinforced concrete. If temperature is increased, then properties of concrete are very changed. From concrete is evaporated free water. Water is evaporated from small pinholes when concrete is heated. Attack of agressive environment on concrete depend on content of water in pinholes. Material properties are changed with evaporated water, if is concrete heated.*
At Faculty of Civil Engineering CTU was tested concrete loaded with temperature. For testing were used temperatures 20, 50, 100, 125, 150 and 200°C. Concrete 30 MPa was used. This concrete is normal strength concrete and is usually used in building industry.
Specimens were tested in 28 days old. Strength of concrete is nearly to final strength of concrete, in this age. At 20°C concrete had same strength like concrete 30MPa. But with increasing of temperature, strength had another value then at 20°C.
Specimens were tested in testing machine with controlled post-peak loading of stress-strain diagram. Heating of specimens was perform in the kiln on defined temperature same like in the kiln. Properties of concrete like modulus of elasticity and strength are changed.

Keywords: specimens, concrete, testing machine DSM 2500, temperature, modulus of elasticity.

Introduction:
Testing of concrete at high temperatures bring very interesting results. Properties of concrete are depend on material compose. Influence of temperature on material properties is important too [3]. With increasing temperature strength is changed. Modulus of Elasticity is changed when temperature of concrete is increased.

Preparing of specimens:
For testing were used cylindric specimens with diameter 150mm and depth 300mm. Specimens were concreted to the steel forms. For preparing was used this mix formula.

Component	Content (kg)
Sand 0-4	740
Aggregate 4-8	340
Aggregate 8-16	670
Cement CEM II 32,5	325
Water	180

Tab.1 Concrete mix formula.

Concrete mix was design for nominal strength 30MPa. Concrete is from category normal strength concrete. Specimens were tested 28 days old. Concrete cylinders were take out from forms second

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day and placed into water basin. There specimens were deposit 25days. Two days before testing cylinders were take out from basin and loaded surface of specimens were finishing.
12 hours before testing specimens were placed into kiln and heated on defined temperature. Properties of concrete at high temperatures aren't good known.

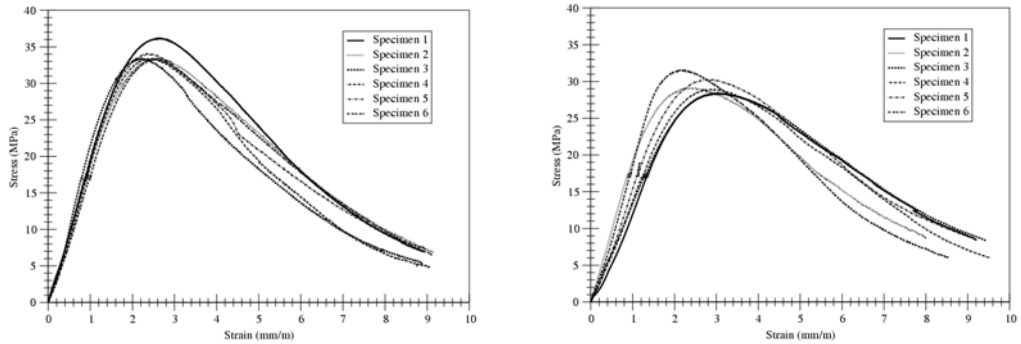
Test preparing:
At first picture is possible view testing machine DSM 2500 (picture 1). It is special equipment for testing concrete in compression with controlled deformation. For that reason is DSM 2500 used for testing quasi brittle material [2].
Test of specimen is controlled by increasing of the deformation. Therefore, deformation is controlled by tensometric gages placed on hydraulic cylinder. Other two tensometric gages were placed on specimen. For taking results is need measure deformation by standard.
Measuring of modulus of elasticity in compression is defined by standard ČSN ISO 6784. Specimens were loaded by force 250kN per minutes. It is slower than standard. Deformations were measured by two tensometric gages with measure length 150mm. Gages were placed in axial direction in half height of specimens.
On specimens tested at temperatures 20, 60, 100, 125 and 150°C were placed axial tensometric gages for measuring deformations on specimen and compute of Modulus of Elasticity.
Four tensometric gages were placed between loading platnes. Axial deformations were measured too, but by full length of the specimen. These deformations aren't suitable for computing of Modulus of Elasticity.

1. Testing machine DSM 2500.

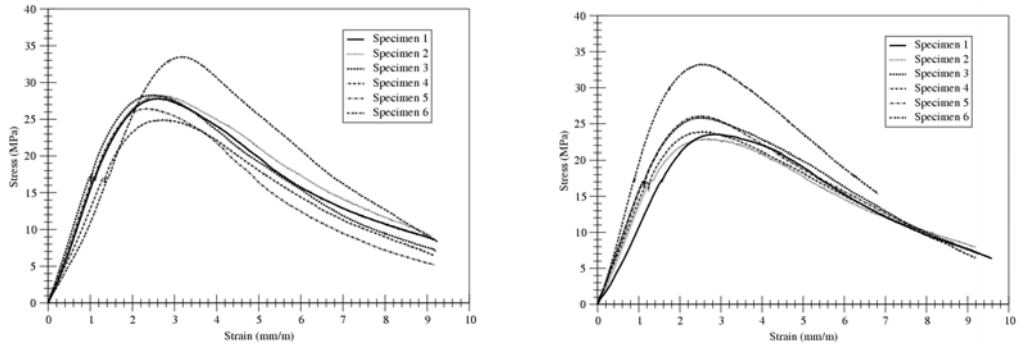
Specimens were tested at temperatures 20, 60, 100, 125, 150 and 200°C into sets with 6 cylinders. Specimen No.6 from every set was tested at temperature +20°C. Other specimens in sets were tested at dedicated temperature.

2. Tested specimens at temperature +150°C.

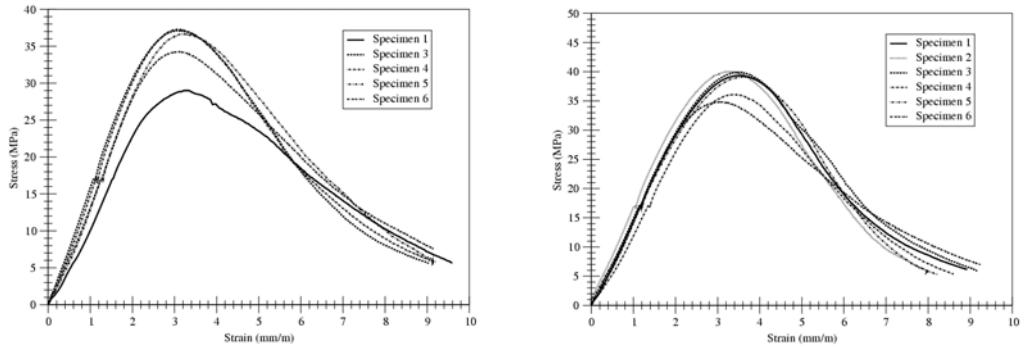
Results:
On next graphs are displayed stress-strain diagrams tested specimens. In every set 6 specimens were tested, but at +150°C only 5 cylinders were loaded because one of them was destroyed on start of the test.



3. Stress-strain diagrams of specimens at temperature +20°C (left) and +60°C (right).



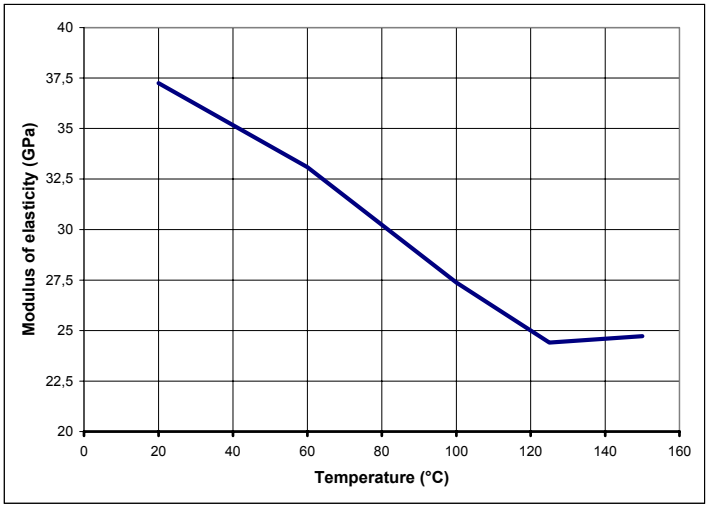
4. Stress-strain diagrams of specimens at temperature +100°C (left) and +125°C (right).



5. Stress-strain diagrams of specimens at temperature +150°C (left) and +200°C (right).

Stress-strain curves have same post peak part. From picture No.4 is distinctive that strength at +20°C is higher than specimens tested at +100 and +125°C.
At temperature +20°C average strength was 33,488MPa, but at +60°C was lower about 14,6% (28,62MPa). Effect decreasing of strength is visible from picture No.3. With increasing of temperature at +100°C and +125°C average strength still go down at 27,6MPa and 24,01MPa. This is about 28% lower then strength at +20°C.
Last two sets at +150°C and +200°C have strength higher than specimens tested at +20°C. Strength at +150°C was 37,0MPa and strength at +200°C was 39,6MPa. It is about 18% over strength at

+20°C. With increasing temperature, strength decrease. Effect decrease of strength is possible observe to temperature +125°C. Over +125°C strength increase with increasing of temperature.
Relation between modulus of elasticity and temperature is described at last picture No.6. On picture isn't modulus of elasticity at +200°C. It wasn't measure, because temperature resistant of gages have upper limit at +180°C.
Modulus of elasticity had a similar trend like strength [1]. Its value decrease to 65% at temperature +125°C from value of modulus of elasticity at +20°C. But at temperature +150°C value of modulus of elasticity is similar like at temperature +125°C. From results of measuring, modulus of elasticity is distinct changed with increasing of temperature.



6. Relation between modulus of elasticity and temperature.

References:

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[2]Konvalinka, Petr, Padevět, Pavel, Příspěvek k metodice uspořádání zkoušky pracovního diagramu betonu v tlaku, Stavební obzor 8/2001.
[3]Padevět, Pavel, Experimentální zjišťování parametrů a metodika testování betonu v tlaku, thesis, Prague 2000.

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