CRACK RESISTANCE OF ECCENTRICALLY TENSIONED REINFORCED CONCRETE ELEMENTS UNDER UNILATERAL EXPOSURE TO HOT WATER

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Annotation:*The article presents an experimental study of the operation of eccentrically tensioned reinforced concrete beams made of heavy concrete and concrete on tension cement under the simultaneous action of a longitudinal tensile force, water and temperature.*

Key words:*Concrete, tension, cold and hot water, temperature, deformation, strength.*

The crack resistance of reinforced concrete elements under operating conditions under temperature and humidity influences significantly depends on the correct consideration of these influences on the properties of concrete and the resulting forces. The effect of temperature and water affect the nature of the work of a reinforced concrete structure. The transfer of heat and moisture causes the appearance of temperature and humidity gradients along the height of the section. The uneven distribution of temperature and humidity along the height of the section of the elements leads to the formation of temperature-humidity stresses and deformations, the formation and opening of cracks in the reinforced concrete element. Ensuring the durability and operational reliability of reinforced concrete structures can be achieved by studying the operation and developing the calculation and unilateral action of water and temperature in eccentrically tensioned reinforced concrete elements. For this purpose, an experimental study of the operation of eccentrically tensioned reinforced concrete beams made of heavy concrete and concrete on tension cement was carried out with the simultaneous action of a longitudinal tensile force.

Experimental studies were carried out on statically determined one-span length 2,2 m and statically indeterminate three-span reinforced concrete beams with a total length of 4,4 m 15x15 cm from heavy concrete and from concrete at the NC.

Unilateral action of water and temperature of 95 ºC caused the appearance of cracks. In a beam made of heavy concrete (11pt) from one-sided exposure to hot water at a temperature difference along the section height of 44ºC and in beams (13nt) made of concrete at the NC at a temperature difference of 46ºC, cracks were formed, normal to the longitudinal axis, in a stretched less heated and less humid zone concrete. The first cracks appeared in the sections of the beams above the middle supports. The temperature of the lower face of the beams 11pt and 13nt in contact with hot water was 66 and 68 ºC, respectively, and the moisture content of the concrete was 0.038 and 0.055 g/g, respectively. The temperature of the more stretched, less heated reinforcement was 26ºC for the heavy concrete beam, and 28ºC for the concrete beam at the NC. The moment from the unilateral action of hot water with a temperature of 95ºC in a beam of heavy concrete before the formation of cracks was 1.90 kN•m in a beam of concrete at the NC - 2.11 kN•m. the moment of crack formation in a beam made of concrete at NC is greater than in a beam made of heavy concrete.

The first short-term one-sided heating of beams (10pt) made of heavy concrete and (12nt) made of concrete at the NC at a temperature difference along the height of the section of 40 and 42 ºC, respectively, caused the formation of cracks in the concrete of the tension zone near the middle supports on the less heated face. At the same time, the temperature of the lower heated concrete face reached 60 and 61 ºC. The temperature of the more stretched and less heated reinforcement was respectively 24 and 25 ºC. The temperature moment of one-sided heating was 1.69 kN•m for the beam made of heavy concrete and 1.96 kN•m for the beam made of concrete at the NC. and was less than with unilateral exposure to hot water. The theoretical moments of crack formation, calculated without taking into account the forces from concrete shrinkage during storage of beams and temperature-humidity deformations from exposure to hot water, will exceed the experimental ones by 60-80%. When determining the moments of crack formation in reinforced concrete elements, taking into account the forces from concrete shrinkage and the linear distribution of temperature and humidity of concrete along the height of the section, the theoretical moments of crack formation decreased by 16-36%. Efforts from thermal shrinkage of drying concrete reduced the moment of crack formation under one-sided exposure to hot water by 34%, and with one-sided heating of drying concrete by 42%. The calculated moments of crack formation, calculated according to the formulas [6], exceeded the experimental ones by 9-10%, which indicates a satisfactory agreement. The discrepancy between the calculated moments of crack formation and the experimental ones is explained by the uneven heating of the extreme and middle spans of statically indeterminate reinforced concrete beams. The type of concrete and the humidity of the environment influenced the reduction in the moment of crack formation. With one-sided heating, the moment of crack formation in drying heavy concrete was less by 0.11 kN•m and in drying concrete on NC by 0.99 kN•m compared to the moment of crack formation from one-sided action of hot water. The decrease in concrete tensile strength during heating was caused by efforts from concrete shrinkage. Wet concrete swelling deformations reduced the deformations caused by concrete shrinkage.

To determine the moment from the unilateral action of water and temperature in statically indeterminate structures, it is necessary to know whether the cracks in the reinforced concrete element are through or not. Since the curvature of the axis and the rigidity of the sections depends on the nature of the cracks formed. When determining the curvature and stiffness of the section of the crack element from the unilateral action of water and temperature, it is important to know whether the crack intersects the less stretched, more heated reinforcement or not. This condition can be considered as a criterion for the formation of a through crack. The highest tensile stresses in concrete are assumed to be equal , taking into account the reduction in tensile strength of concrete from the effects of water and temperature. Stress in concrete of the compressed section zone ɢ S must be less than the design compressive strength of concrete. The stress in more tensile reinforcement ɢ S should not exceed the design tensile strength RS. If the value of x is relative, then there is no compressed zone of the section and the crack is connected. When the value of x is less than the thickness of the protective layer, the crack is non-through, but it crosses the less stretched reinforcement.

Calculation analysis shows that for reinforced concrete elements with an eccentricity of the longitudinal force less than 0.27 ho the cracks are through, which is confirmed by the experimental data from the works [1, 2, 3, 4, 6]. When the eccentricity of the longitudinal force is more than 0.6 ho there must be a compressed sectional zone. This was established in [3, 5, 6], where in the case of eccentric tension of reinforced concrete elements with eo=(0.5-0.73) ho in the section with a crack, a compressed zone was observed and less stretched reinforcement was outside the zone.

Thus, as calculations and experimental data show, when the longitudinal tensile force is located between the resultant forces in the reinforcement and the cracks in the reinforced concrete element are through. When the longitudinal tensile force is located outside the limits between the resultant forces in the reinforcement S and S1, the cracks in the reinforced concrete element are not through.

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