PHYSICAL AND MECHANICAL INDEXES OF CONCRETE UNDER ITS RETARDED REVERSIBLE DEFORMATION

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We studied the peculiarities of the behavior of concrete in time and the nature of its characteristics in terms of the adsorption theory of concrete and solid body creep. The theory was substantiated and proposed by V.K. Balavadze and further developed in collaboration with M. Lordkipanidze.
The results of studies in the form of a theoretical graph, which were subsequently confirmed by experimental data.
To conclude, it should be emphasized that the peculiarities of concrete behavior in time and its ultimate characteristics obtained theoretically were completely confirmed by experimental data.

Key words: *physical, mechanical characteristics, deformation, surface-active materials, elastic deformation*

We studied the peculiarities of the behavior of concrete in time and the nature of its characteristics in terms of the adsorption theory of concrete and solid body creep. The theory was substantiated and proposed by V.K. Balavadze and further developed in collaboration with M. Lordkipanidze [1].

Fig. 1 shows the results of studies in the form of a theoretical graph, which were subsequently confirmed by experimental data (Fig. 2). Let us subject the concrete prism to axial compression or tension and measure deformations expressed in terms of coordinates σ, ε with the origin at the point 0^1. After recording the moment of time at which concrete deformation starts, we instantly apply a minimal, instantly breaking load. Fix D and N. Readings will be taken not at the point 0^1, but at the point 0 which is the actual coordinate origin because concrete started to work at that point. After connecting 0 with N, we obtain the triangle 0DN which expresses the strength characteristic of concrete of the considered given composition and age, where 0D corresponds to the actual concrete ultimate strength R, which is a maximal strain value obtained as a quotient of the division of the instantly applied instantly breaking load to the working cross-section area of the concrete element. Therefore R is a completely defined strength characteristic and fixes a strength increase depending on an extent of restriction of tensile deformation of concrete since irreversible micro cracks may emerge and develop in concrete by the moment of time of its instant breaking. The ultimate deformation ε_{ult} which corresponds to R and is wholly elastic, has the property which is intrinsic only in this kind of deformation: for the tested concrete and at a given extent of restriction, the value of ε_{ult} is constant, does not depend on the concrete age. 0N expresses the linear relation between σ and ε of concrete, the tangent of whose angle of slope to the abscissa axis is the concrete elasticity modulus.

The above facts indicate the following: 1) concrete works by Hooke's law until it reaches R and its elastic modulus is a constant value, does not depend on its state of stress; 2) irreversible micro cracks emerge and spread in concrete only after it reaches R; 3) in the presence of surface-active materials the coalescence of particles does not waken in the region of elastic deformation; 4) the upper boundary of elastic deformation of concrete is its R; 5) the breaking of concrete takes place in two ways: after reaching R if the creep deformation is undamped and at ε_{ult} simultaneously corresponding to R if the load increases.

Let us explain the physical essence of these two cases of concrete breaking. We draw the vertical line through N normally to the abscissa axis. For the considered concrete with a given restriction extent, independently of the concrete age, this vertical line, which with time grows to N^1, restricts all maximal ultimate deformations irrespective of a loading character.

As different from the central tension of concrete, in the case of axial compression the restriction of tensile deformation takes place because of the friction of concrete butt- ends against the press

cheeks. Therefore, if friction is removed, the curve change points $0e^1$,$0b^1$ and $0r^1$ on σ, ε (Fig. 1) will lie on the vertical line Mn, will simultaneously fix the end points ((e^1, b^1, r^1) of maximal breaking deformations and the time of concrete breaking. Moreover, the higher the concrete loading velocity, the greater they are. If to the concrete prisms we instantly apply the loads corresponding to the change points e^1, b^1 and r^1, then on the straight line 0N we immediately obtain the points e, b and r which fix aggregate ultimate elastic deformations occurring under load. However the breaking will not occur until the initial creep at these points reaches the corresponding points e^1, b^1 and r^1, i.e. until aggregate total maximal deformations reach the vertical line Mn, and they must be equal to the deformation DN and be as elastic as this latter deformation. Thus the breaking of concrete takes place only when concrete reaches R and ε_{ult}. This however takes place only in the case of undamped creep of concrete, i.e. after the ultimate strength is reached, there appears additional strain. All this indicates that in the region of elastic deformation, concrete works by Hooke's law. Curvilinear relations are obtained because not deformations under load are not plotted on the abscissa axis, but aggregate deformations caused by additional strain which is not plotted on the ordinate axes.

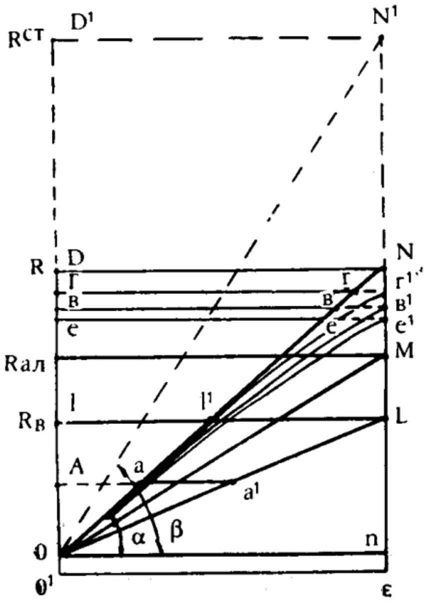

Fig. 1.

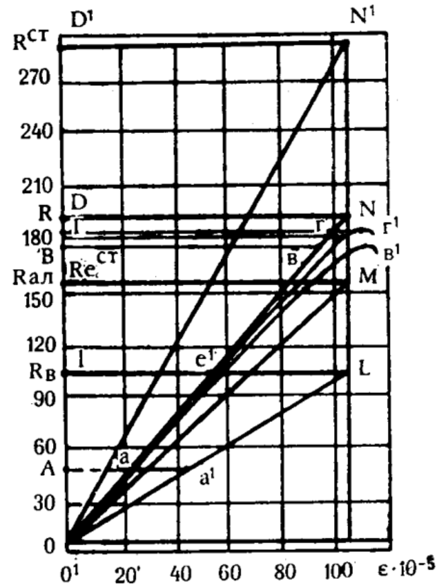

Fig. 2.

Thus, creep deformation increases with time and becomes the peak breaking deformation at the point M. If above the point M, creep deformation was undamped, then, on reaching at this point, it gets damped, and below this point it decreases in direct proportion to the load on the straight line OM. At the level M, simultaneously with reaching the peak breaking creep deformation and therefore with deformation damping, the growth of concrete strength in time stops and due to concrete damping no additional strain arises with reaching R and ε_{ult} and there will be no concrete breaking. Therefore, in the considered case the breaking of concrete occurs not after reaching R and ε_{ult}, but with a load increase.

The strength characteristic of the concrete life at the point M of its stress-deformed state is the limit of long-term resistance of concrete, which is the ultimate strain under load, for which no concrete breaking occurs and at the same time such results are achieved as the damping of creep deformation, obtaining a maximal limit value of this deformation, termination of concrete strength growth in time and obtaining the actual ultimate strength R. However the difference R - R is consumed by concrete creep. Hence the most important task of increasing the useful strength needed for maintaining the carrying capacity of concrete is to lower its creep deformation.

Now let us consider the case of restriction of tensile deformation of concrete. If in the case of friction absence, the points of the curves σ, ε lie on the vertical line Mn and are at the same time the end points of ultimate deformations, then in the case of friction the vertical line moves to the right and the curve change points will lie to the right of it and higher. The points of intersection of these curves with the new vertical line will be the actual end points of ultimate deformations. In the considered case, after reaching ultimate deformations, concrete does not break though irreversible micro-cracks have already appeared and developed in it. The concrete breaking is prevented by friction and starts only when friction forces become predominant. The breaking of concrete occurs at the time of appearance of irreversible micro-cracks, i.e. when deformation reaches the new vertical line. The point M, just as the points lying above it on the vertical line, will move further to the right and higher. However the breaking of concrete will occur not at the time of reaching ultimate deformation, but after it. The breaking should have been inevitable, which is indicated by the points lying above M. However, as different from them, at the point M there is no action of additional strain since it is damped. The resistance of friction forces and molecular cohesion to the development of irreversible micro-cracks turns out to be enough to prevent the breaking of concrete restricted by friction.

The ultimate strength characteristic of concrete life is the endurance limit R_{endu}, which is the ultimate strain of concrete of the considered age, which was subjected to the action of repeated loads, for which the concrete creep gets damped and it reaches R, but withstands breaking. If under the action of repeated loads on concrete of the considered age, we quickly achieve maximal ultimate deformation and continue to apply repeated loads to it, then with the lapse of time its both age and strength will increase. Since ultimate deformation has a tendency to decrease, in order to keep it constant, it is necessary to increase the intensity of repeated loads until the concrete strength growth stops. In that case we reach R and R_{endu}. Hence, like in the case of constant loads, the maximal ultimate deformation of concrete of the considered composition under repeated loads will be a constant value and will not depend on the age of concrete.

To conclude, it should be emphasized that the peculiarities of concrete behavior in time and its ultimate characteristics obtained theoretically (Fig. 1) were completely confirmed by experimental data (Fig. 2).

R E F E R E N C E S

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