Influence of Constant Rate of Loading on Ultimate Strain of Lightweight Concrete.

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The aim of the investigation described in this paper was to identify the influence of loading on strain at the moment when the maximum compression strength of lightweight concrete of compact structure was reached and to make a comparison with common concrete.

As lightweight aggregates we used foamed high-furnace slag, cinder, expanded clay, hollow ceramic bullets and crushed burnt bricks. The concrete specimens hardened under normal laboratory conditions and werw loaded at the age of 7, 28 and 60 days. Among the autoclaved lightweight concretes we tested gas concrete with unit weights of 500 and 1000 kg/m^3. Specimens made of common concrete made with natural river gravel were carried out in parallel. The total number of the tested specimens the size of which was 10 x 10 x 40 cm amounted to 240.

Longitudinal strains werw measured continuously during the loading process by means of resistance strain gauges with a baselength of 150 mm the measurements being taken from both opposite faces of the specimens and the values were registered by a coordinate recorder.

There were six loading patterns for the loading tests of all concrete specimens varying from each other only by the overall time T of load increase to failure of the specimen. The range of variation of parameter T was assessed to be

1. $3 \leq T\,[min] \leq 540$

The strength of prismatic specimens of the tested lightweight and common concrete specimens varied in the range

2. $25 \leq R\,[kg/cm^2] \leq 350$

Hence it follows that the various types of concrete classified under the same loading pattern differed by a stress increment per unit of time as given by formula

3. $\frac{d\sigma}{dt} = \frac{R}{T} = const.$

The upper and the lower limit of the increment $\frac{d\sigma}{dt}$ for individual loading patterns are given in Tab. 1. Among the platted stress- strain curves we have compared values on the level of 100 % and 80 % of strength of prismatic specimens. In this way we have obtained an idea not only of the variation of ultimate strain but also on the changes occurring during the deformation process, the variation plot being fixed by three points for $\frac{\sigma}{R}$ = 0; $\frac{\sigma}{R}$ = 80 % and $\frac{\sigma}{R}$ = 100 %.

The variation of the ultimate strain as well as the character of the plots of strain variation as function of the total time of loading until failure was expressed in terms of multiples of values of the basic strain- curve for T = 60.

From the above statements there follows that

4. $\varepsilon_T = f_T \cdot \varepsilon_{60}\ [\%]$

where: ε_T ... strain for the rates of loading $3 \leq T \leq 540$ min.

ε_{60} ... strain for the rate of loading T = 60 min.

By computing average values of the obtained laboratory results the values function f_T have been determined for the stress levels $\frac{\sigma}{R}$ = 100 % and $\frac{\sigma}{R}$ = 80 %. These values are given in Tab. 2. The mean values of function f_T are plotted in Fig. 1.

It appeared that if the overall time of loading to failure of the tested types of concrete vas varies from 3 to - 540 min. there arose on the average a 30 % increase of the ultimate strain. The strains due to loads on the level of 80 % of ultimate strength increased under the same conditions by 25 %.

The mathematic formulation of the function f_T was in terms of an logarithmical relationship in the form

5. $f_T = A \log T + B$

For the investigated concrete specimens of our tests Eq. 5 assumed for load on the level of 100 % of strength of prismatic specimens the following particular form

6. $13{,}07 \log T + 76{,}77$

The conclusions have been formulated as follows:

1. In the light of results in Tab. 2 the influence of rate of loading on ultimate strain of various types of lightweight and common concretes may be expressed in term of function f_T in the range of the

investigated parameter T varying within the range

$3 \leq T \leq 540$ min.

2. If the function f_T is used as basis on the level of 100 % and 80 % ofstrength of prismatic specimens it is possible to compare tentatively the variation of strain values for different loading rates under the constant T.

Loading pattern	Overall time in minutes	Limit of increment $\frac{d\sigma}{dt}$ kp/cm2/min.		
1	3	8,333	≤	116,666
2	6	4,166	≤	58,333
3	30	0,833	≤	11,666
4	60	0,416	≤	5,833
5	360	0,069	≤	0,972
6	540	0,046	≤	0,648

Tab. 1

Investigated loading patterns.

Percentage of prismatic strength	Value of T in minutes					
	3	6	30	60	360	540
100	82	85	95	100	106	113
80	82	84	91	100	102	105

Tab. 2

Overall f_T value on the level of 100 % and 80 % of strength of prismatic specimens.

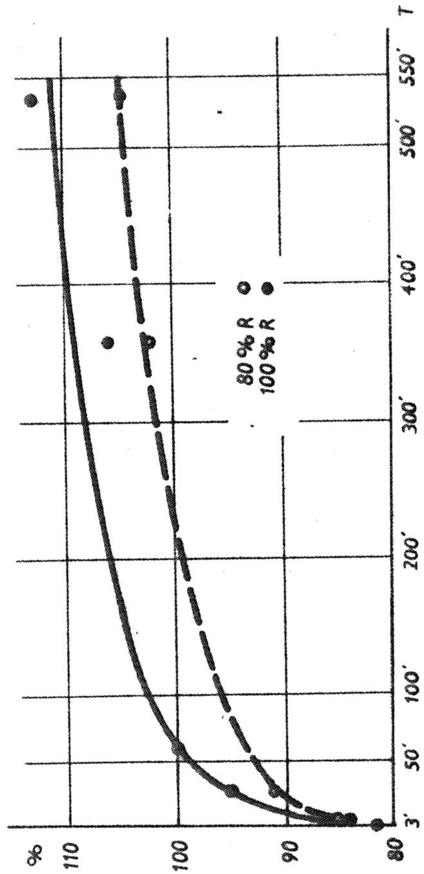

Fig. 1.

LABORATORY VALUES AND ANALYTICALLY DEDUCED FORMULA (6) FOR FUNCTION f_T