THE ENERGY DISSIPATION "NEGATIVE" HYSTERESIS EFFECT IN THE MODIFIED HEAVY AND LIGHT-WEIGHT CONCRETES UNDER THE CYCLIC LOADING

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The work deals with the conditions of the "negative" hysteresis loop display in the melted sulphur impregnated concretes as well as in the finegrain and latex added light-weight concretes.
It is noted that in the concretes mentioned above the aggregate or the zone in the form of internal nucleus is in the compressed state.
It is concluded that the "negative" hysteresis effect in the concretes under cyclic loading results from the breaking of the structural connections in the part of the material which compresses the aggregate or the nucleus of the concrete.

Investigation of the damping characteristics of the melted-sulphur mpregnated heavy (in the limestone aggregate) and light-weight (in the volcanic slag porous aggregate) concretes and their mortar parts (the matrices) under few-cyclic loading with the skewness coefficient ρ=0 (the central pressing) have been carried out.

At the same time, for comparison the samples of non-sulphur impregnated concretes and their matrices have been made and tested. In addition to these the samples of light concretes and their matrices without sulphur and with the latex-bearing complex chemical admixture (LCCA) were also made and tested [1].

For the improvement of sulphur impregnation the heightened porousity samples of concretes and their matrices have been made. It was achieved by a discontinuous granulation of the fine aggregate in the sample - the sand fraction with d=1,25-2,5 mm was absent. The maximum size of the gravel aggregate grain was 10 mm and that of the sand grain was 5 mm.

The samples were made in the prism form measurin 4×4×16 sm. The conditions of the hardening were the following: steaming under 80^0C and for LCCA light concrete - steaming in the autoclave under the pressure above one atmosphere.

The testings were carried out on the hydraulic according to [2]. By means of 10 mm based tensotransistors which were pasted on the opposite sides of the sample, the longitudinal ε_1 and diametrical ε_d concrete deformations were measured. The deformations measurements were carried out under the stepped loading and unloading of the sample on the 1st, 10th, 25th, 50th, 100th, 150th and 200th cycle.

On the separate series of prisms from unmelted-sulphur impregnated concretes the mean relative longitudinal shortening deformations ε_{1s}, were measured. These deformations resulted from the concrete shrinkage, during the artificial concrete drying under 105^0C before the sulphur impregnation and then from the volume shrinkage under the cooling and hardening of sulphur. The mean value of the summary shortening deformation for the sulphur impregnated heavy concrete samples was $\varepsilon_{1s}^{h} = 12{,}12 \times 10^{-5}$ and for the light concrete samples $\varepsilon_{1s}^{l} = 9{,}7 \times 10^{-5}$. These deformations correspond to the tension σ=4,3 MPa in the diametrical prism section in the case of non-sulphur melted concrete and σ=2,2 MPa for the light concrete.

Under the cyclic loading the unimpregnated heavy concrete samples and their matrices showed the usual "direct" "pozitive" hysteresis loop, when the sulphur impregnated samples showed "inverse" "negative" hysteresis both on the ration of the tension level in

sample σ (which took place under the cyclic loading) to the destroying tension σ_b and on the microcracking level R^0_{bt} also on the modulus of elasticity E of the sample material came to light. The lower R^0_{bt} and the higher σ/σ_b and E, under relatively lower maximum of the cyclic loading, the "negative" hysteresis was revealed. In the figure dependence between ε and σ for the sulphur impregnated heavy concrete samples shows that at the first cyclic loading under the maximum tension $\sigma_{max.c}$=0,3σ_b the "positive" loop of hysteresis takes place. At the second cycle under $\sigma_{max.c}$ =0,77 σ_b an abrupt turning of the hysteresis loop to the reverse begins already from the tension 0,55σ_b. The sample was destroyed at the fifth cycle. The testing "twin" sample under $\sigma_{max.c}$=0,61σ_b showed the strength 1,085 R_b after the 200th cycle. The experiments also showed that the "negative" hysteresis in the melted-sulphur impregnated samples of the matrices takes place at relatively low ratio σ/σ_b, then in the sulphur impregnated concrete samples. This is typical both of heavy and light concretes. The "negative" hysteresis in the impregnated matrices is observed as far as 200 cycles.

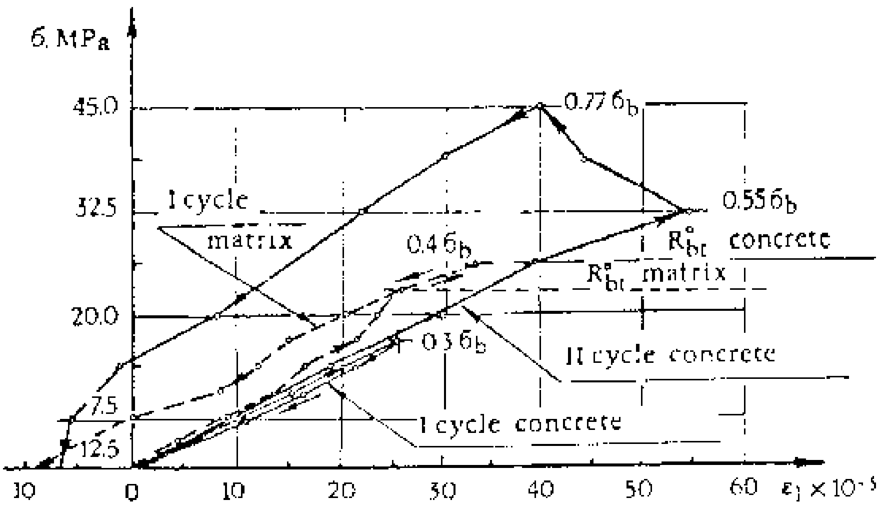

Fig. 1. The average longitudinal deformations $\varepsilon_l \times 10^{-5}$ depending on the tension σ MPa sulphur impregnated samples of prisms on the heavy aggregate during cyclic compressing loading

While testing the light concrete samples the "negative" hysteresis loop takes place in the non-sulphur impregnated light concrete matrices (i.e. fine light concrete). For the first time the "negative" hysteresis loop in the unimpregnated matrices under $\sigma_{max.c}$=0,6σ_b comes after the 25th cycle, then it turns into the general "positive" loop and again becomes "negative" at the 150th cycle, but at the 200th cycle there is again the "positive" loop. So, the periodicity is observed according to the degree of accumulation of the structure destructions. In the sulphur impregnated light concrete matrix at the very first cyclic loading under $\sigma_{max.c}$=0,375σ_b the "negative" hysteresis loop appears. In the sulphur impregnated light concrete the "negative" hysteresis comes at the 50th cycle under $\sigma_{max.c}$=0,45σ_b. In LCCA light concretes the "negative" hysteresis is also observed at the 50th cycle, but under $\sigma_{max.c}$=0,7σ_b.

The after testing investigation of destructed concrete structure shows that almost all the samples are completely sulphur impregnated. In the central part of some samples only weak impregnated or unimpregnated concrete nuclei are revealed.

If taking into account that the porous aggregate in the light concrete mixing process shows the "selfvacuuming" property [3,4] and at the same time while hardening the light concrete possesses relatively parge shrinkage deformation, then it becomes clear that the "skeleton" of the fine and gravel light concrete is compressed to a certain degree like the shrinked structure of the melted sulphur impregnated concrete.

Taking into consideration that the injection of the latex bearing additives into the concrete mixture shuts the small and middle pores closing the gaslike phase, so the fact that in the process of concrete hardening the volume of latex emulsion diminishes it can be supposed that in the LCCA light concretes the aggregate "skeleton" is more compressed than the "skeleton" of the concrete without the additives.

By all that has been said above and by the carried-out experiments it can be proved that the effect of "negative" hysteresis in the concretes under the cyclic loading results from the breaking of the structural connections in the part of the material which compresses or restrains the compressed aggregate or the compressed zone in the form of the concrete "nucleus".

The relatively earlier appearance of the "negative" hysteresis effect in the melted sulphur impregnated matrices is explained by their less (compared with impregnated concretes) crack stableness, less viscosity and more earlier appearance of the microcracks. This is confirmed by the ratio of the tension intensity critical coefficients of the sulphur impregnated matrix and concrete $K_{IC}^{matrix} / K_{IC}^{concrete}$, which is equal to 0,553 for heavy concretes and 0,600 for light concretes.

Though the sulphur impregnation of the concretes and LCCA addition into concretes heighten the endurance of the concretes, improving its strength characteristics, in the case of the definite combination of unfavourable factors the appearance of the "negative" hysteresis effect is fraught with consequences as the self-sustained oscillation or the parametric resonance in the oscillation systems prepared from the materials touched upon above. In fact, instead of dissipation the energy "feeding" of the oscillation system will inrease the oscillation amplitude. The "feeding" of the system takes place at the expence of the internal energy which is released in the process of oscillation caused by the breaking of the structural connections restraining the compressed aggregate or the compressed nucleus in the concrete.

Generalizing the rezults of the above-mentioned experiments it may be said that the effect of the "negative" or "inverse" hystersis loop rezults from the internal structural changes which take place under tension and this effect can be expected in the oscillated solids or the solids subjected to the repeated-alternating loading. The solids are composed of the matrix compressing the elastic inclusions or of uniform material, the external layers of which due to a number of cause compress internal layers and in the case of destroying the matrix structure or the compressing external layers, the elastic inclusions or the nucleus from internal layers have enough energy for changing the body dimensions.

It is evident that by analogy with the aforesaid, under definite conditions the "negative" hysteresis can be expected in the self-stressed cement concrete samples too, when under the cyclic loading the clutch between the matrix and the aggregate is disturbed or the aggregate is destroyed. The "negative" hysteresis can appear in such solids, where the external layers under the action of internal tensions are ready to increase the dimensions of sample and under influence of the cyclic loading the destruction of the internal layers and of the internal nucleus takes place or the disturbing of the connections between the external and internal layers occurs.

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