INVESTIGATION OF MECHANICAL AND THERMOPHYSICAL PROPERTIES OF COMPOSITE MATERIALS BASED ON "BLACK BINDERS" WITH THE AIM OF OPTIMIZING THE PROCESS OF THEIR CEMENTING

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Optimum conditions for cementing prepared roofing paper are determined and an installation for laying prepared roofing paper as a hydroinsulating roofing carpet is designed.

Many composite materials, which make it possible to solve a number of problems of the national economy, have been developed on the basis of petroleum bitumens and a natural polymer material – cellulose – and are utilized in the national economy.

The experiments on the aging of bituminous materials in an artificial weather apparatus conducted by the Khar'kov Civil Engineering Institute, have shown that their properties change in steps. These experiments made it possible to establish the secret of durability and the necessary initial characteristics of the material.

The characteristics that are closest to the required ones belong to the material which has acquired the name of a melted-on prepared roofing paper, used in installing roll roofings. However, both mechanization facilities and the technology of producing a hydroinsulating carpet of prepared roofing paper with a melted-on mastic layer are imperfect as yet. There are no scientifically substantiated recommendations on a number of problems, the optimum parameters of devices for installing prepared roofing paper with a melted-on layer and their complete set are not determined, and the technology of work does not so far meet the requirements of industrial production and safety engineering. All this requires further investigation of the properties of materials and the development of equipment and attachments.

It is common knowledge that cementing of roofings as the most labor-intensive process can be accomplished by two methods – by the cold method and the hot one. With the cold method, a solvent is applied to a roll material; with the hot one, devices of the burner type are used to melt down the covering layer of a roll material. For uncoiling and pressing of the cemented prepared roofing paper, a roller-uncoiler is used.

The hot method is considered the most adaptable for streamlining production. However, experiments performed in the TsSL of Glavtyazhstroi have shown that, when the roofer relaxes his attention during the process of cementing, combustion of the material, volatilization of oils, and enrichment of asphaltenes with carbon may occur. At the same time, the execution of heating of the material is neither controlled nor technically supported. Therefore the thermophysical and physicotechnical properties of the Mastrum melted-on prepared roofing paper were studied in a research laboratory of the Belorussian Institute of Railway Transport Engineers. For this purpose use was made of the TsT-3 instrument, designed by the Institute of Thermal Physics of the Ukrainian Academy of Sciences and intended for determining thermal conductivity by a plate method.

The technical potential of the instrument made it possible to determine, besides the thermal conductivity of a composite material, another series of technical parameters necessary for developing the cementing technology as well as identifying the necessary characteristics of devices used for conducting the work.

The melted-on prepared roofing paper and packets made of it were investigated in the monotone regime, i.e., its average temperature varied with time as a result of the existing varying heat flux directed from the upper end of the specimen to the lower one. The possibility of using the formula

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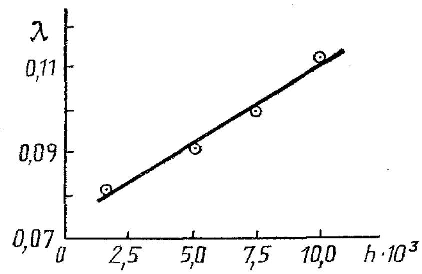

Fig. 1. Dependence of the thermal conductivity on the specimen thickness. λ, w/(m·K); h, m.

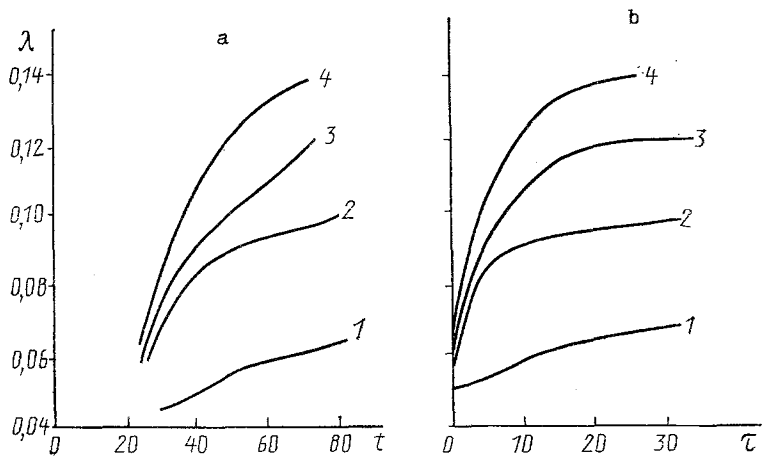

Fig. 2. Dependence of the thermal conductivity of a melted-on prepared roofing paper on time (a) and temperature (b) for a one-layer (1), two-layer (2), three-layer (3), and four-layer specimen (4). τ, min; t, °C.

$$\lambda = hq/\Delta t \tag{1}$$

(λ is the thermal conductivity; h is the specimen thickness; q is the value of the heat flux density; Δt is the temperature difference on the flat sides of the specimen) for the monotone regime stems from the fact that the thermal conductivity was estimated over a rather small interval when the heat flux through the specimens had no time to vary.

Figure 1 shows the dependence of the thermal conductivity on the specimen thickness. The data obtained require explanation. In heating of a packet during the experiment the effective thermal conductivity increases both at the cost of an increasd in thermal conductivity of bituminous layers with increasing temperature and at the cost of a decrease in the resistance of the air interlayers: under heat, the bituminous varnish softens, and air interlayers disappear. The latter circumstance leads to a sharp increase of λ_{ef} and the more so, the greater is the number of interlayers, i.e., the number of prepared roofing paper layers, in the specimen. Calculating λ_{ef} is quite possible with the aid of the proposed formula whose data agree with the experiment:

$$\lambda_{ef} = \frac{n\delta_b + n\delta_{varn}}{n\dfrac{\delta_b}{\lambda_b} + n\dfrac{\delta_{varn}}{\lambda_{varn}} + (n+1)r_{air}}, \tag{2}$$

where δ_b, δ_{varn} are the thicknesses of the board base and the bituminous coating; λ_b, λ_{varn} are the thermal conductivities of the corresponding layers; r_{air} is the thermal resistance of the air interlayers.

The greatest contribution to the thermal resistance is made by the layers of the prepared roofing paper board base ($r_b \approx 1.665 \cdot 10^{-2}$ $m^2 \cdot K/W$). The bituminous varnish layers exhibit far smaller resistance to the heat flux ($\lambda_{varn} \approx 1.53 \cdot 10^{-3}$ $m^2 \cdot K/W$). The resistance of the air interlayers is fairly large and based on evidence derived from the experiment can be estimated as a value of the order of (3-8) $\cdot 10^{-3}$ $m^2 \cdot K/W$.

Allowing for the particular contribution of every component to the thermal conductivity, one can arrive at the conclusion that, as the number of layers increases, the thermal conductivity of the packet will increase because of the growing importance of the thermal conductivity of the bituminous varnish (Fig. 2a). The given phenomenon can, in principle, be used to estimate the quality of sizing layers by developing a portable thermophysical device on its basis.

Melting of a bituminous layer leads both to the impregnation of the paper base by the varnish and to the formation of thread-like bitumen channels in the base. This contributes to an ever greater extent to an increase in the thermal conductivity of multilayer packets which is indeed confirmed by the results of the experiment (see Fig. 2b).

During the experiments it was established that positive results in cementing are obtainable with the aid of two factors combined – pressure to the cemented layer and temperature. At a pressure of $1 \cdot 10^3$ N/m^2 and temperature of 50°C we obtain a good-quality cementing.

From these data it is evident that there is no need whatsoever to heat up the mastic to 250°C, subjecting its quality to a test, especially since, under pressure, the hot mastic begins flowing from under the load, which deteriorates the quality of the covering.

It has been determined that the temperature range 80-110°C and the pressure $1 \cdot 10^3$ N/m^2 are optimum and can be taken as a basis for works in construction.

Insofar as a large variety of materials – glassisol, glassbit, melted-on prepared roofing paper, linoleum, etc. – are produced using a bituminous material the data obtained are of substantial scientific and technical value.

The results of the given work are protected by the inventor's certificate [1].

LITERATURE CITED

1. Unit for Cementing Prepared Roofing Paper, Inventor's Certificate No. 1,006,672 USSR, Class E04D 15/06.