Drying Dinas Concrete Blocks

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In the Pervourals Dinas Factory studies have been made of the heat-engineering processes involved in drying Dinas concrete blocks in tunnel driers. Measurements were made of the quantity of heat carrier, the moisture content of the dry and wet heat carrier, the temperature and hydraulic cycles in the driers, and also the moisture content and loss of moisture of the Dinas concrete blocks.

The quantity of heat carrier was located by means of a pneumometric tube and a micromanometer. The consumption of heat carrier in the drier was found to be from 2600 to 3000 m$^3$/h, and the velocity from 5.56 to 6.30 m/sec.

The moisture content of the heat carrier was determined from readings of the dry and wet thermometers, and then with respect to the graph $I-d$. The degree of saturation on input was $\varphi = 5\%$, with a moisture content of $d \approx 5-9$ g/kg, and on exit $\varphi \approx 27\%$, $d = 22.8$ g/kg.

In order to determine the temperature cycle measurements were made of the gas temperature along the length of the drier; the hydraulic cycle for drying was established by measuring the pressure over the length of the drier with a micromanometer.

The temperature of the heat carrier at the entrance to the drier varied from 70 to 90°C, the static pressure of the heat carrier $h_0$ on input from $-0.1$ to $+2.0$, and on exit from $-0.18$ to $-1.2$ mm water.

The moisture content of the material during the drying stages was located by drying specimens taken from different parts of the block to constant weight. Eight blocks of DVK-4 were made for each drying cycle, and 16 control blocks with edges measuring 200 mm.

After each weighing one of the blocks was broken to determine the moisture content. The specimens used to determine the moisture content were selected at four points across the section of the block.

The loss in moisture content during drying was determined every 24 h over a period of 10 days.

For each weighing a check was made on the grain-size distribution of the aggregate, the composition of the batch, the density of the water glass, and also the moisture content and grain-size distribution of the body.

Using separate control cubes, the compressive strength, the open porosity, the apparent density, the moisture content, the gas permeability, and the thermal-physical coefficients of the concretes were determined.

The results of the tests and qualitative factors of the experimental concretes (blocks DVK-4 and cubes) are shown in Fig.1.

During the drying of Dinas concrete blocks in driers the most intensive loss of moisture occurs in the first five days.
Subsequently the moisture removal is considerably retarded. By the end of five days drying, the compressive strength reaches about 185 kg/cm², that is, it satisfies the requirements of GOST. The subsequent increase in the strength of the concrete is apparently connected with the recrystallization of the densified silicic acid gel:

\[ a\text{[Si(OH)]}_n\rightarrow \text{[Si(OH)]}_s \times n\text{H}_2\text{O}. \]

One of the basic factors determining the resistance of Dinas concrete blocks in soaking pits is the reduction in their moisture content [2]. With a moisture content of approximately 1%, there is no spalling (scaling). The continuation of the drying after the fifth day does not produce any noticeable reduction in the moisture content of the blocks, and therefore is uneconomical.

Investigations established the following heat-engineering parameters for the operation of tunnel driers: the temperature of the heat carrier at the input end 80-90°C, at the exit 50-60°C; relative humidity at input 5-10%, at output 45-50%; and the consumption of heat carrier 2600-2700 m³/h.

The drying time of the blocks was reduced to 120 h. In this case the average specific consumption of standard fuel was reduced from 163 to 62 kg/ton, which gives a saving of about 15,000 rubles per annum.

The possibility of using Dinas concrete blocks in service without artificial drying was also studied. The specimens were maintained in air at positive temperatures for periods of 1-10 days, and then their compressive strength, apparent density, open porosity, and moisture content were determined. After 24-h storage the moisture content dropped from 6.5-7.0% to 5.0-5.5%, and the compressive strength under these conditions was about 109 kg/cm².

Figure 1 shows the moisture content of blocks compared with the control cubes after artificial and natural drying at the Pervourals Dinas Factory.

During artificial drying the most rapid removal of the moisture occurs in the first five days; with natural drying only in the first 24 h is there a substantial reduction in the moisture content of the blocks, and then in the next four days it hardly alters; after the fifth day a further noticeable reduction in moisture content commences. With artificial drying, in the first five days the blocks lose about 83% of the moisture, and in the remaining five only 4.7%; with natural drying in the first 24 h about 13% of the moisture is lost; in the next four days the removal of the moisture is retarded, and after 10 days the blocks lose about 30% moisture.

An increase in the strength of the concrete in both cases is noted after the first 24-h drying, and this continues for the entire process. Adequate structural strength is achieved in the blocks during artificial drying after four days, and with natural drying after five days.

In order to determine the transportability of the concrete blocks in railway cars we prepared six Dinas concrete blocks which were stored for seven days in air at positive temperatures. After natural drying and marking, the blocks were sent to the Chelyabinsk Metallurgical Factory where after external examination and checking they were fixed into a soaking pit. The Dinas concrete blocks operated reliably in the pit for more than a year.

Consequently the blocks were deemed transportable, and can be used in furnace construction.

However, an increase in the moisture content in the blocks after natural drying causes a reduction in the rate of temperature rise during the warming up of the structure in the soaking pits after repairs. Therefore, the final conclusion about the possibility of using blocks without artificial drying may be made only after the completion of experiments on heating the blocks in the structure, and explaining the nature of the breakdown with various moisture contents in the block and various heating rates. Studies on the natural drying of Dinas concrete blocks and their warming up in the structure should be continued.

**CONCLUSIONS**

A study was made of the change in the moisture content and compressive strength of Dinas concrete blocks with artificial and natural drying. During artificial drying intensive moisture removal from the blocks occurs in a period of the first five days, and the subsequent change in the moisture content is slight.

A cycle was developed for the artificial drying of Dinas blocks in tunnel driers at the Pervourals Dinas Factory. The drying time was reduced from 240 to 120 h. The specific consumption of standard fuel was cut from 163 to 62 kg/ton.