UDC 621.9

Part 3

ASH AND SLAG HANDLING

3.5. Applications of ash and slag from power coals

3.5.1.5. The practice of utilization of fly ash from Reftinskaya TPP

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ABSTRACT

The main directions for the protection of the environment are a course on the introduction of non-waste technology and the use of secondary resources. The acute problem of nowadays is the utilization of industrial wastes, a significant proportion of those are ash and slag from solid fuels. At the same time ash and slag are environmentally friendly mineral products that can replace natural materials. To date, 1.5 billion tons of ash waste has been accumulated in ash dumps of Russian Power Plants. Dumps area reaches 28 hectares (comparable with the territory of Irkutsk, Krasnoyarsk). Only 8% (2.1 million tons) of the annual output of ash wastes are recycled and used. If this trend continues, by 2020 the volume of accumulated ash wastes exceeds 1.75 billion tons. Meanwhile, The Industrial - Building Association Teplit Ltd in practice, successfully implementing the processing of fly ash and produces on its base quality building materials.

INTRODUCTION

The Industrial-Building Association Teplit Ltd has been working for 20 years in the area of recycling technogenic formations. The company production premises are located in the settlement Reftinsky and town Berezovsky .The company specializes in production of products of autoclaved cellular concrete (twinblocks) of an extensive nomenclature, using fly ash and modern methods of manufacture. The company production premises are located in the settlement Reftinsky and town Berezovsky. The total production capacity permits to recycle up to 180 thousand tons of fly ash per year and to produce 520 000 cubic meters of the aerated concrete blocks, from which one can build three thousand and five hundred houses of 150 square meters each. At that each house is by 85% composed of the ecofriendly fly ash. Since 1990 – 2014 the company has processed 1 020,806 million tons of fly ash, in the amount of 231 908 299 rubles. Today this is the maximum indicator for the Sverdlovsk region.

By the nature fly ash of Reftinskaya power station is unique and has a number of valuable properties that predetermines its effective utilization in production techniques of cellular concrete. The material is homogeneous enough, on 90 % will consist from aluminosilicates, and, about third falls SiO_2. Besides it practically does not contain not burned down particles which are harmful impurities. Ashes consist of an amorphous and crystal phase, and the first makes more than 70 %, due to what ashes possesses high activity (in comparison with quartz sand), the amorphous component basically is submitted by glass. The crystal component includes quartz, feldspars, mullite, etc.

The specific surface of ashes of Reftinskiy power station makes 280…350 m^2/kg. Its average density is within the limits of 1980…2000 kg/m ³, bulk density - 720…750 kg/m³. Humidity of ashes makes 0,1…0,2°%. Fly ash has the lowered value of specific effective activity EPH – 93 Bk/kg that gives the basis to speak about a sufficient degree, ecological compatibility of a product. On this parameter ash of Reftinskiy power station surpasses clay, cement and some kinds of quartz sand.

The main product of association is wall unreinforced products of cellular autoclave curing concrete (in accordance with GOST 31360-2007-Twinblock). Cellular concrete is made from knitting, sand or ashes, gas-former and waters. Knitting, lime and cement contain CaO which has crucial importance for process. Sand or ashes enters in process SiO2. From components: CaO, SiO2 and H2O in an autoclave at influence of a high pressure and high temperature the new mineral, tobermorite (C4S5H5), is formed.

Formation of new minerals of tobermorite structures also erects cellular autoclave curing concrete (in popular speech – cellular concrete) completely in other rank in comparison with foamed concrete. Autoclave processing provides considerably higher physical and chemical characteristics of products from cellular concrete in comparison with foamed products.

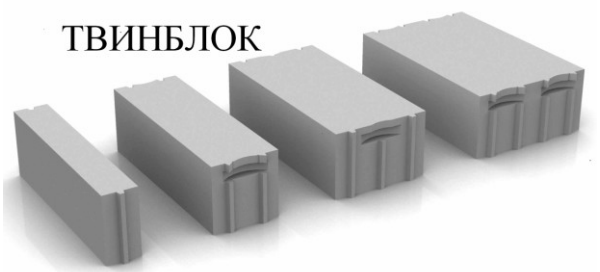

Fig.1. The products of cellular autoclave curing concrete (in accordance with GOST 31360-2007-Twinblock).

The enterprise has mastered the production of twinbloks by width from 100-400mm, a density of 400 -600 kg / m 3 with a strength class B 2, 0-3, 5.High strength of twinblocks allows using them for the erection of bearing constructions up to three floors and non-structural walls in monolithic and frame -monolithic construction without limiting of number of floors.

Power Efficiency of twinblocks is caused by porous structure. The cladding structures from twinblocks are in 3…5 times warmer than that from a brick. In winter they prevent significant losses of heat and allow avoiding too high temperatures in summer. In the process of operating of buildings with external walls made of twinbloks energy costs for heating (utility costs) is re-

duced by 25 - 30 percent. Using glue instead of mortar for masonry of twinbloks increases the thermal resistance of construction by 20 percent.

Table1. **Characteristics of building materials.**

Density, kg/m^3	Strength class	Mark on frost resistance	Coefficient of thermal conductivity, Vt/m·K	Drying shrinkage, mm/m
400	B 2,5	F50	0,09	0,47
500	B 2,5- 3,5	F100	0,12	0,57
600	B 3,5-5,0	F100	0,15	0,56

Twinblock is the material with the high fire resistance. Test fragment of walling of twinblock with thickness of 100 mm, conducted in the test center "Expert" 26th Central research Institute of defense Ministry of Russia, showed that over 2.5 hours of exposure to heat at T=1030^0 loss of structural integrity, and also the temperature increase on the unheated surface above 180^0 C (the loss of thermal insulation capacity) has not occurred. The maximum temperature recorded on the outer surface of a wall fragment by a 2.5 h was 77^0 C, in the inner surface was 130^0 C. The data obtained can be assumed that the loss of heat-insulating properties (temperature of the outer surface of a wall fragment above 180^0 C) will occur over 3.5 to 4 h of thermal influence on a wall fragment from twinblock. In other words we can say that the limit of fire resistance of a wall fragment from twinblock thickness of 100 mm will be 3.5-4 hrs. The obtained results are confirmed by the relevant fire certificate.

The distinctive feature of twinblocks is accuracy of the geometrical dimensions and high physico-mechanical properties, the presence of groove-crest system and of gripping pockets for hands. Due to this, the quality of the laying increases. This provides the rejection of the necessity to level the walls; it reduces the complexity of the process. In this regard, twinblock is used in the construction of the first 25-35 stores skyscrapers, in Yekaterinburg.

Twinblock is characterized as one of the most harmless materials.It does not contain heavy metals, carcinogenic and other harmful substances. Properties of twinblocks are close to a tree, and in the literature cellular concrete is called "a mineral tree".

Most of the goods are being implemented in the cities of the Sverdlovsk region. Furthermore, the products are delivered to the enterprises of the Ural region, Siberia, Kazakhstan, and also in regions of the European part of Russia. From aerated concrete are are being built apartment houses, industrial and public buildings.

Term of operation of houses made of aerated concrete in various climatic conditions is practically unlimited. So the houses built in Reftinsky, Sverdlovsk region, stand for 20 years without external finishing.

The technology of production and use of enlarged twinblocks of autoclave cellular concrete was developed in association. They differ from traditional blocks by large size (table.2): length of products is 1500 mm, height 625 mm, depth 400 mm.

Fig.2. The technological line for production of autoclave cellular concrete.

Application of the enlarged blocks gives essential increase in productivity of masonry works (in 2-3 times in comparison with the use of usual twinblocks). The brigade consisting of 3 persons is capable to build a three-storey cottage for a month. Besides the number of seams, the quantity of glue is reduced. And the uniformity of an erected construction is increased. In the end, it positively affects the power efficiency of the buildings.

Table 2. **Nomenclature of enlarged twinblocks**.

Marking	Geometrical dimensions, mm			Weight, kg
	length	width	height	
UTB 300 M	500	300	630	47,2
UTB 300 C	750	300	630	70,9
UTB 300 B	1000	300	630	94,5
UTB 300BM	1500	300	630	141,4
UTB 400 M	500	400	630	63,0
UTB 400 C	750	400	630	94,5
UTB 400 B	1000	400	630	126,0
UTB 400BM	1500	400	630	189,0

* The weight of twinblocks is defined by density 500 kg/m^3 and by humidity 0 %

For the construction of the houses from enlarged blocks are being used only mini crane (Fig. 3).

Also, the enterprise produces the gutter blocks (Fig. 4). This product is intended for manufacturing precast-monolithic jumper (Fig. 5). In addition, the gutter blocks are used as a permanent formwork for execution of a concrete frame of the building contour. Currently adjusted release of the gutter blocks of two types: with a thickness of 300 and 400 mm.

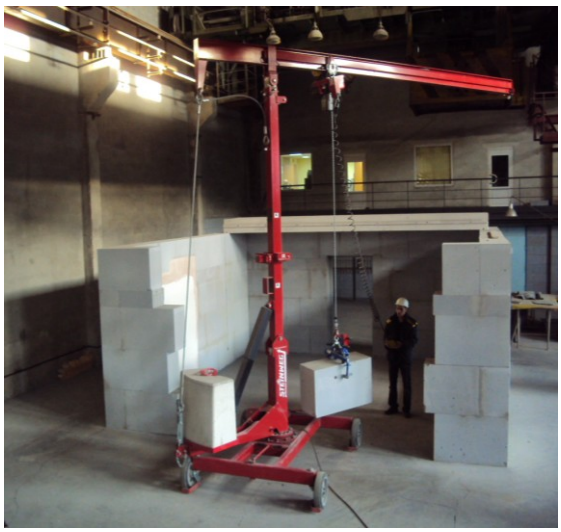

Fig.3. Assembling of the enlarged blocks by mini crane.

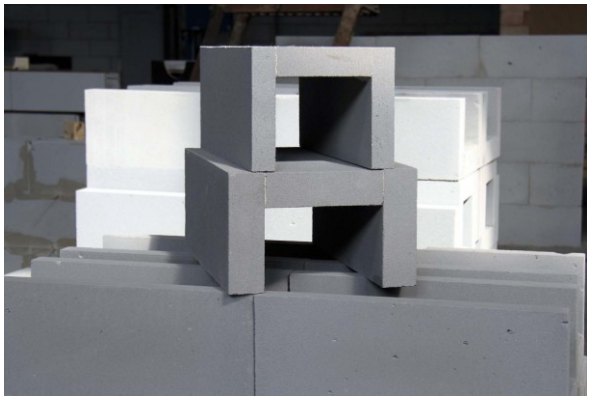

Fig. 4. The gutter blocks

In June 2012 the line for production of dry building mixes was launched in settlement Reftinsky. The line is equipped with modern automated equipment of company "Vselug". Production capacity of the line is 55.5 thousand tons of dry mixes per year.

For production of dry building mixes the following components are used: fly ash of Reftinskaya TPPs, portland cement, lime and additives. The compounding of glue and plaster for external and internal works on the basis of ashes was developed by St the Petersburg State Technological Institute.

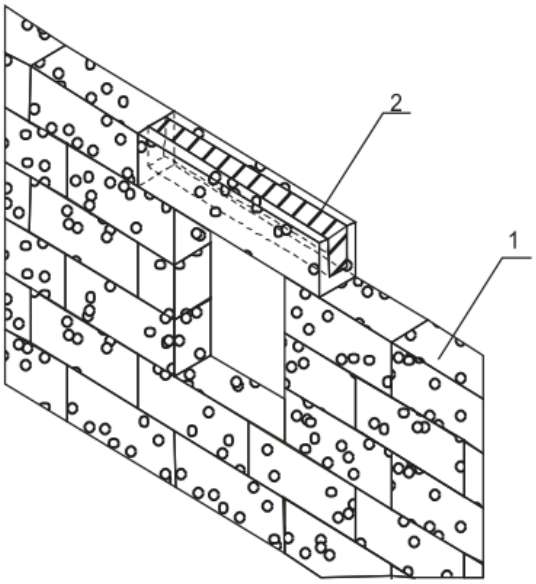

Fig. 5. Precast-monolithic jumper from the gutter blocks
1 — wall twinblocks; 2 — reinforced concrete

Currently, this technological line allows producing the following: glues for the laying of products from cellular concrete, mixes for finishing, mixes for soil stabilization. Mixtures for cellular concrete are packed in bags of 30 kg.

This technological line allows to recycle about 50 000 tons of fly ash per year; thereby the maximum total designed output of both production facilities is up to 230 000 tons per year.

Thus, The Industrial - Building Association Teplit Ltd expands the scope of the proposed construction materials and services. Besides wall materials, we provide related materials (glue, the gutter blocks and others), and also we perform construction-assembly works and provide services to rent mini cranes used for construction of low-rise houses.

Although the utilization of ash and slag materials of power stations in the country has been engaged by various organisations, enterprises, scientific-research, technological and design institutes (in total, in the USSR there were at least 400), was gained from 200 to 300-processing technologies and use of ash, great progress in the practical implementation of the developed technologies were not achieved.

Table 3. **Characteristics of the glue mixture**

Name of indicator	Type of mixture		
	Glue for the laying of products from cellular concrete «Twinblock–KL»	Mixes for finishing	
		For interior works	For exterior works
Physical appearance	Dry mixture of gray color without clods and mechanical admixtures		
Mobility on Rк, cm	168		
Time of fitness of mortar to use, h, not less	2		
Water-retaining ability of mortar mixtures, %	99,3		
Strength class at the age 28 days, MPa	4,7		
The strength of adhesion of a mortar to the basis, MPa	0,2		
Frost resistance, no less	F35		

There are a number of reasons, which restrain further growth of the use of ash and slag to the average European level on the whole territory of Russia:

1. The lack in the country of a technical policy and the system approach at the decision of the specified problem;

2. The lack of economic interest of power stations to recycle ash and slag materials. As the main task of power stations is the generation of heat and electricity. In addition, all costs of transportation, warehousing and storage of ash and slag materials are included in the production cost price and are paid by energy consumers, and real economic incentives to reduce such costs are absent;

3. Decrease of profitability of the use of cheap raw materials (ash and slag) of thermal power by industry of construction materials, due to a sharp increase in the cost of rail and road transportation;

4. The lack of legislative and regulatory frameworks sufficient to economic incentives to increase the use of ash and slag materials;

In order to increase the use of ash and slag materials would be effective the following measures:

1. The adoption by the State Duma of the Russian Federation laws to encourage recycling of ash and slag materials both at manufacturers and consumers, with the aim of improving the environment, in areas of power station operating on coal.

2. Region administrations, the enterprises of manufacturers of ash and slag materials should facilitate the creation of enterprises, including small and medium business, specializing in production of wide assortment of products using ash and slag materials and supply them as a commodity output to local regional organizations. As enterprises processing ash and slag materials pay huge expenses on the purchase of equipment, it will be advisable to provide for them exemption from payment of the profit tax in the first 3 to 5 years.

3. The state should regulate the execution of programs for processing ash and slag materials at the regional level. The regional authorities should, in turn, promote the use of ash and slag materials instead of natural resources in the construction of housing, roads and land reclamation.

4. The price of ash and slag materials should not exceed the price of natural raw materials.

5. Processing of ash and slag materials should be economically beneficial to the state, producers and consumers.

CONCLUSION

Today products of cellular concrete receive the increasing distribution, superseding others wall materials. This is because the application of materials of cellular concrete allows to reduce cost of construction, labor input and power consumption at simultaneous increase of durability and comfort of erected buildings, and also maintenance of their ecological compatibility.

This confirmation is the fact that the products of the Industrial-Building Association «Teplit» are demanded by many big developers of the Ural-Siberian region. Also “Teplit” expands the scope of the proposed construction materials and services. Besides wall materials, the company produces on the basis of the fly ash related materials (glue, gutter blocks and others), and also carries out construction and installation works. In addition to the production and economic activities, the company performs environmental function, processing hundreds of thousands of tons of fly ash, producing valuable, ecologically clean, high-quality material – cellular concrete, while reducing the consumption of natural resources.

The solution of the problem of processing of ash and slag materials is entirely in the hands of state regulatory bodies. To create and operate the system of processing of ash and slag materials in Russia should, in turn, create a system of measures of state regulation and incentives for companies-manufacturers of ash and slag materials and processing enterprises.

V. Levchenko. The practice of utilization of fly ash from Reftinskaya TPP // Proceedings of the V Conference “Ashes from TPPs: removal, transport, processing, storage”, Moscow, April 24–25, 2014 — M.: MPEI Printing House, 2014. P. 184– 187.