The use of fly ash the thermal power plants in the construction

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Abstract. The problems of ecological and radiation safety of the construction of man-made waste like fly ash thermal power plants were researched. The chemical composition of TPPs ashes of Primorsky Territory was studied, defined their specific effective activity of natural radionuclides. The most modern research methods were used - differential thermal analysis, thermogravimetry, X-ray analysis. It was revealed that the ash of the Primorskaya TPP and Partizanskaya TPP has exceed the permissible parameters of radioactivity, so not suitable for use in construction. Ashes of Vladivostok TPP-2 and Artem TPP of Primorsky Region on parameters radioactivity and chemical composition have suitable for use as a filler in the concrete.

1. Introduction
The use of technogenic waste in addition to saving material and natural resources, protects the environment. Therefore, during the design phase of the construction of the object should be possible to use a man-made waste. At the same time, once made a focus on the environmental aspect, you need carefully to select building materials.

In this paper we will focus on the study of the properties of fly ash thermal power plants as an additive in cement composite binder, and special attention will be paid to the assessment of its radioactivity.

2. The use of fly ash of thermal power plants
Waste heat power plants mainly divided into two categories: ash and fly ash, different way to remove [1-3]. According to [4], fly ash, it is a more effective additive in cement compositions than ash. In this case, the amount alite phase is increases and aluminat is decreases compared with a control sample, respectively, increases the strength of the cement stone [5-10].

The objects of study are fly ash of the largest thermal power plant Primorye Territory: Vladivostok TPP, TPP Artem, Primorye SRPS and Partizansk power station. An important factor is the ability to separate the selection of dry ash that is currently implemented in these thermal power plants [11-15].

The composition and structure and ash depends on a set of concurrent factors: the type and morphological features of combusted fuel fineness in the course of its preparation, the ash content of the fuel, the chemical composition of the mineral part of the fuel, the temperature in the combustion zone, the residence time of the particles in this zone, and others (figure 1).
The laboratory research have set the basic characteristics of the fly ash, determine the possibility of its use for the production of polymer-mineral construction materials.

The main criteria for the selection of fly ash for study the possibility of its use as a component of the composite binder:
- Shape of the particles;
- Particle size distribution;
- Specific surface area;
- Packing density;
- Chemical composition.

Samples of fly ash produced from a large silo capacity, where it could be shipped for delivery to consumers or, depending on the filling of the silo through the mixing device in the pressure system to move to the ash dump. After the selection of the private trials were combined, mixed thoroughly and quartering reduced to laboratory sample.

Laboratory samples of fly ash were sieved through 008; as a result of the screening on the sieve remained a significant part of the unburned coal particles, magnetite beads, and microspheres; ash, pass through a sieve, it was selected for the study and preparation of concrete.

Chemical analysis of the sol (Table. 1) is made in accordance with GOST 10538-87. This standard applies to brown and black coal, anthracite, oil shale, peat and coke and establishes methods for determining the fuel in the ash of silicon dioxide (SiO$_2$), iron oxide (Fe$_2$O$_3$), aluminum oxide (Al$_2$O$_3$), magnesium oxide (MgO), calcium oxide (CaO), potassium oxide (K$_2$O), sodium oxide (Na$_2$O),
phosphorous oxide \( (P_2O_5) \), titanium dioxide \( (TiO_2) \), sulfur trioxide \( (SO_3) \), mixed manganese oxide \( (Mn_3O_4) \).

The chemical composition of ashes TPPs the Primorsky Territory

| TPPs                  | Primorskaya | Vladivostok | Artem | Partizansk |
|----------------------|-------------|-------------|-------|------------|
| The predominant type of coal | Luchegorsk and Bikin | Primorsky lignite (Pavlovsky section) | Black coal | Neryungri black coal |
| SiO\(_2\)          | 55.3        | 63.0        | 48.1  | 47.4       |
| TiO\(_2\)          | 0.5         | 0.5         | 0.0   | 0.9        |
| Al\(_2\)O\(_3\)    | 12.6        | 21.4        | 29.3  | 22.3       |
| Fe\(_2\)O\(_3\)    | 10.7        | 7.5         | 6.5   | 19.6       |
| CaO                | 12.5        | 3.4         | 9.7   | 4.8        |
| MgO                | 3.5         | 2.1         | 1.8   | 2.8        |
| K\(_2\)O           | 1.0         | 1.3         | 1.2   | 0.1        |
| Na\(_2\)O          | 0.4         | 0.3         | 0.2   | 0.4        |
| SO\(_3\)           | 3.4         | 0.6         | 2.3   | 1.62       |
| CaO\(_\text{free}\) | 1.0         | 0.4         | <0.1  | no         |
| LOI                | 2.3         | 1.4         | 0.6   | <5         |

Table 1

The data on the chemical composition of the ash indicate that the contents of the individual oxides in the fly ash derived from the combustion of various kinds of pulverized coal has significant deviation. It determines the difference in the properties of ash and possible areas of use in the manufacture of building materials.

Ashes depending on the total effective specific activity of natural radionuclides \( A_{\text{eff}} \) less 370 Bq / kg is applied to the production of materials, products and structures, residential and public buildings.

The results of determination of specific effective activity of fly ash on spectrometric complex "USC Gamma Plus" are shown in Table. 2.

Determination of specific effective activity of fly ash

TPPs the Primorsky Territory

| Parameter | Primorskaya TPP | Vladivostok TPP | Artem TPP | Partizansk TPP |
|-----------|-----------------|-----------------|-----------|----------------|
| Activity\(^{40}\)K | 496.9±101       | 392±89          | 342±68    | 516.9±101      |
| Activity\(^{232}\)Th | 153.6±20.3      | 31.5±19.7       | 29.5±15.7 | 193.2±22.3     |
| Activity\(^{226}\)Ra | 163.1±9.36      | 37.63±6.32      | 27.23±5.93 | 113.1±6.37     |
| \( A_{\text{eff}} = A_{Ra} + 1.31A_{Th} + 0.085A_{K} \) | >398            | 80±30           | 93±20     | >410           |

ashes of Vladivostok TPP and TPP Artem belong to the first class of materials (less than 370 Bq / kg) in accordance with GOST 30108-94 "Building materials and products. Determination of the specific effective activity of natural radionuclides". This material can be used for all kinds of construction work.

ashes of Primorskaya TPP and Partizansk TPP are exceed the permissible parameters of radioactivity, so not suitable for use in construction.
Thus, by GOST 25592-91 "Mixes slag thermal power plants for concrete" the ashes of Vladivostok TPP and TPP Artem are selected for further research. The high ash content in Al$_2$O$_3$ (to 29.3%) and SiO$_2$ (63%) can cause crystallization like mullite compounds. The loss on ignition of less than 1.5% say a small amount of residual fuel that minimizes manufacturing processes shrinkage during firing.

Thermal studies were performed on raw by thermogravimetric analyzer Shimadzu DTG-60H at a rate of temperature rise of 20°C / min, in the range of 20-1100°C. The results of thermal analysis are presented graphically in figure 2.

![Figure 2. The results of DTA and TG of Vladivostok TPP fly ash](image)

During heat treatment the ash in the range of 40-200 °C, is the loss of water adsorbed surface area of the particles. Carbonate decomposition is observed at a temperature of 712°C. Burning residual fuel - 500-700°C. The nature and intensity of loss of mass during this indicates an amount of unburnt residues are particles of coal and coke and semi-coke residue. Relatively small exotherm with a maximum of 932°C reflects the crystallization of compounds in mullitopodobnyh aluminosilicate phase.

XRD analysis showed that the ash except quartz is determined clearly expressed mullite phase (figure 3).

![Figure 3. XRD results of Vladivostok TPP fly ash. K - quartz, Ca - calcite, M - mullite](image)
3. Conclusion

The test material is relatively homogeneous, multicomponent. According to the composition closest to aluminosilicates, due to the high content of silicon and aluminum oxides to 80-90%, of which about 2/3 of silicon oxide. At the same time, fly ash has almost no unburned particles, in which tend to concentrate harmful components.

Ash consists of crystalline and amorphous phases. The crystalline phase contains quartz, feldspar, mullite, et al. The amorphous phase is represented primarily in the form of glass. Thus, the fly ash consists of minerals that are widely used separately as filler dispersed in composite binders. Therefore, we can assume that the ash CHP Primorsky Region on chemical composition suitable for use as a filler in the cement composition.

According to the classification of GOST 24640-91 selected are low-calcium fly ash (acidic) and serve as additives, the material composition of the components (active mineral additives having pozzolanic properties).

According to the classification committee RILEM, you can add that both selected fly ash (Vladivostok TPP and TPP Artem) pozzolanic have normal activity. Hydration products binders have high adhesion beans silica component, which has a significant amount of structural defects, which also contributes to the growth of a preliminary mechanical activation in the preparation of the composite binder, which allows us to strengthen and improve the processes of hydration of clinker minerals, and leads to the formation of more tumors by increasing the active nucleation sites on the particle surface.

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