МИНИСТЕРСТВО ОБРАЗОВАНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
ПОЛОЦКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
БЕЛОРУССКИЙ НАЦИОНАЛЬНЫЙ ТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ
ИНСТИТУТ СТРОИТЕЛЬНЫХ МАТЕРИАЛОВ ВИЛЬНЮССКОГО ТЕХНИЧЕСКОГО УНИВЕРСИТЕТА им. ГЕДЕМИНАСА
БЕЛОЦЕРКОВСКИЙ НАЦИОНАЛЬНЫЙ АГРАРНЫЙ УНИВЕРСИТЕТ (УКРАИНА)
ПОЛИТЕХНИЧЕСКИЙ ИНСТИТУТ г. ЛЕЙРИИ (ПОРТУГАЛИЯ)
АРИЭЛЬСКИЙ УНИВЕРСИТЕТ (ИЗРАИЛЬ)
ПЕРМСКИЙ НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ (РОССИЯ)
ПЕТРОЗАВОДСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ (РОССИЯ)

АРХИТЕКТУРНО-СТРОИТЕЛЬНЫЙ КОМПЛЕКС: ПРОБЛЕМЫ, ПЕРСПЕКТИВЫ, ИННОВАЦИИ

Электронный сборник статей
международной научной конференции,
посвященной 50-летию Полоцкого государственного университета

(Новополоцк, 5-6 апреля 2018 г.)

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Новополоцк
Полоцкий государственный университет
2018

УДК 72:624/628+69(082)

АРХИТЕКТУРНО-СТРОИТЕЛЬНЫЙ КОМПЛЕКС: ПРОБЛЕМЫ, ПЕРСПЕКТИВЫ, ИННОВАЦИИ [Электронный ресурс] : электронный сборник статей международной научной конференции, посвященной 50-летию Полоцкого государственного университета, Новополоцк, 5–6 апр. 2018 г. / Полоцкий государственный университет ; под ред. А. А. Бакатовича, Л. М. Парфеновой. – Новополоцк, 2018. – 1 электрон. опт. диск (CD-ROM).

Рассмотрены вопросы архитектуры и градостроительства в современных условиях, прогрессивные методы проведения инженерных изысканий и расчета строительных конструкций. Приведены результаты исследований ресурсо- и энергосберегающих строительных материалов и технологий, энергоресурсосберегающие и природоохранные инновационные решения в инженерных системах зданий и сооружений. Рассмотрены организационные аспекты строительства и управления недвижимостью, проблемы высшего архитектурного и строительного образования.

Для научных и инженерно-технических работников исследовательских, проектных и производственных организаций, а также преподавателей, аспирантов, магистрантов и студентов строительных специальностей учреждений образования.

Сборник включен в Государственный регистр информационного ресурса. Регистрационное свидетельство № 3671815379 от 26.04.2018.

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ISBN 978-985-531-608-5

UDC 666.97

RESEARCH OF FLY ASH AND SLAG (BOTTOM ASH) FROM MUNICIPAL WASTE INCINERATION. THE POSSIBILITIES OF SECONDARY USE

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Incineration of MSWI allows a great reduction in the quantity of the wastes of 65–80% in mass and 85–90% in volume. Nevertheless, several residues, with different characteristics of hazard, remain after the incineration. They can be broadly divided into bottom ashes (slag) and fly ashes. MSWI fly ash are fine and are normally characterized by a high content of chlorides (NaCl, KCl, CaCl, KCaCl) even higher than 10-15%) and significant amounts of dangerous substances (As, Pb, Cr, Cu, Hg) such as heavy metals). MSWI bottom ashes (slag) have coarser dimensions (particles can reach several tens of millimeters in size), and the amount of chlorides and hazardous chemicals is usually much lower than that of MSWI fly ash.
Keywords: MSWI, hazardous waste, fly ash, bottom ash (slag), heavy metals, chloride.

Concerns about the large volume of fly ash and bottom ash generated by the incineration of municipal solid waste (MSW) have induced the scientific community to seek ways to reduce their environmental impact.

Incineration is one of the alternatives for managing municipal solid waste (MSW). Given the steep rise in MSW generation, the number of incinerators in developed countries is expected to grow steadily, with a concomitant increase in the amount of bottom and fly ash. Although some 46% of MSW incinerator ashes in Europe is re-used, billions of tonnes remain which must be treated to prevent subsequent environmental problems [1].Although incineration could significantly reduce the waste volume by approximately 85–90% [2] and provide usable energy, it is still imperfect for MSW disposal. One of the main concerns for MSW incineration is the generation of potentially hazardous residues such as fly ash. The weight of fly ash from MSW incineration (MSWI FA) is up to 2–5 wt% of the original MSW [3]. MSWI FA is usually considered as a hazardous waste due to its high content of toxic substances (e.g., heavy metals, dioxins, and furans).

Haiying et al. [4] investigated the utilization of municipal solid waste incineration fly ash in production of clay bricks. It was found that the optimal mixture ratio of materials, fly ash: red clay: feldspar: sand, was 20:60:10:10, and the optimal sintering temperature was 950 °C. The results as a whole suggested that utilization of fly ash in production of clay bricks constituted a potential means of recycling municipal solid waste incineration fly ash.

Lin [5] studied the utilization of municipal solid waste incinerator bottom ash to partially replace clay for the production of fired clay bricks. Brick samples were heated to temperatures between 800 and 1000 °C for 6 h. Physical, mechanical and leaching tests were conducted on the clay brick samples. The results indicated that the heavy metal concentrations in the leachate met the regulatory thresholds. Increasing the amount of MSWI bottom ash resulted in a decrease in the water absorption rate and an increase in the compressive strength of the clay bricks. The addition of MSWI bottom ash also reduced the degree of firing shrinkage. So the MSWI slag was suitable for partial replacement of clay in production of fired clay bricks.

The method for producing clay bricks from MSWI bottom ash or fly ash through firing is very similar to the conventional clay brick production process. Therefore, this method can be easily executed without making major changes in the conventional clay brick production line.

Although much research has been conducted, the commercial production of clay bricks from fly ash and bottom ash is still very limited. The possible reasons are related to the methods for producing clay bricks from fly ash and bottom ash, the potential contamination from the fly ash and bottom ash used, the absence of relevant standards, and the slow acceptance of waste materials-based clay bricks by industry and public.

For wide production and utilization of clay bricks from MSWI bottom ash and fly ash, further research and development is needed, not only on the technical, economic and environmental aspects but also on standardization, government policy and public education.For wide production and utilization of clay bricks from MSWI bottom ash and fly ash, further research and development is needed, not only on the technical, economic and environmental aspects but also on standardization, government policy and public education.

Fly ash and bottom ashes (slag) from municipal solid waste incinerators in Lithuania were considered. The oxide composition of fly and bottom ashes is shown in Table 1.

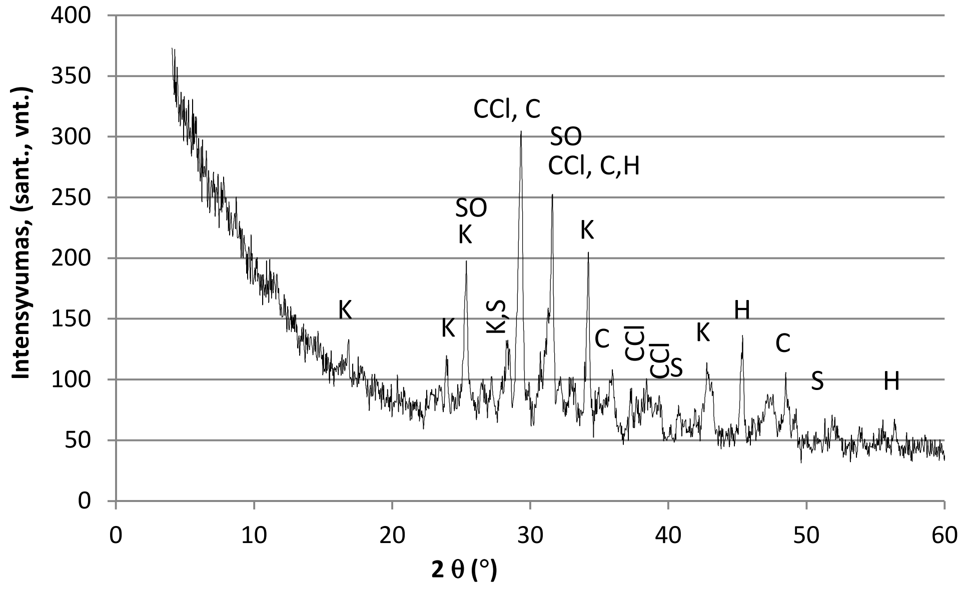
Table 1. – Chemical composition of MSWI bottom and flyashes

MSWI ash	Oxide, (% or mg/kg)									
	CaO	Chloride	Na_2O	K_2O	SO_3	Al_2O_3	Fe_2O_3	MgO	SiO_2	L.o.i
Bottom ash (slag)	20,8%	0,4%	3,0%	1,3%	2,9%	8,4%	9,7%	2,7%	47,6%	3,2%
Fly ash	47,17%	19,01%	2,65%	3,52%	1,56%	1,08%	6938 mg/kg	1,15%	0,23%	-
	MnO_2	As	Pb	Cd	Cr	Cu	Ni	Zn	Ba	Sr
	334 mg/kg	13,8 mg/kg	1987 mg/kg	83,4 mg/kg	50,5 mg/kg	625 mg/kg	12,2 mg/kg	10209 mg/kg	237 mg/kg	239 mg/kg

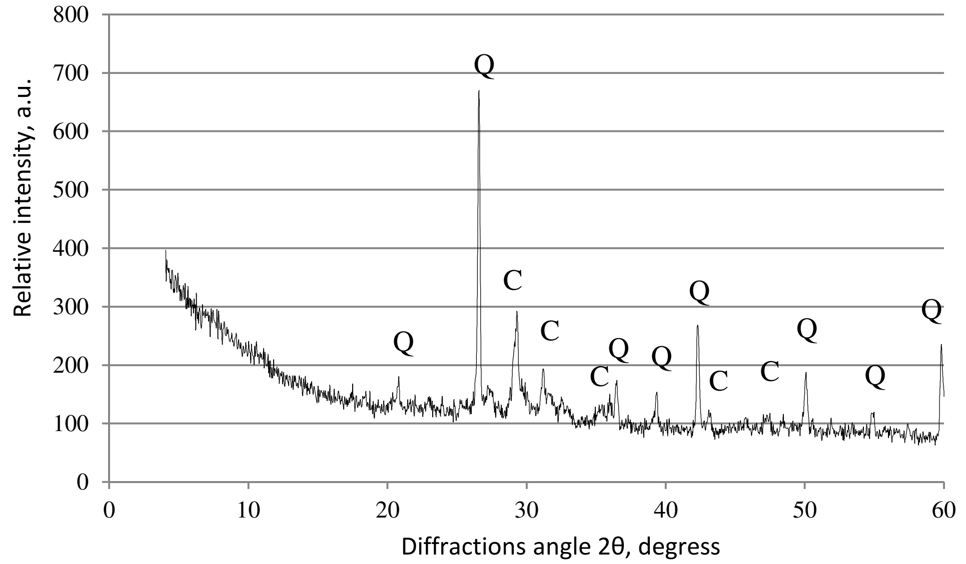
The major chemical components of MSWI bottom ash were SiO_2, CaOand Fe_2O_3. A chloride content of about 19% by mass was measured in the fly ash. The major chemical components of MSWI fly ash were CaO, K_2O, Na_2O. Table 1 shows the concentration of heavy metals in the fly ash sample.It was determined that pH of fly ash is 11,93, electrical conductivity 15,26 µS/cm; pH of bottom ash is 10,23, electrical conductivity 899,5 µS/cm.

As shown in the XRD pattern in Fig. 1 (a), the crystalline phases in MSWI fly ash were principally halite (NaCl), sylvite (KCl), calcite ($CaCO_3$), calcium chloride ($CaCl_2$), anhydrite ($CaSO_4$), bottom ash (Fig.1 b) were principality quartz (SiO_2) and calcite ($CaCO_3$).

The SEM images of fly ash and bottom ash are presented in Fig. 2. It can be seen that particles with various shapes and sizes. The pores distribution is quite heterogeneous. The particles are amorphous structure are not well connected (Fig.2 a and c). From the images of b in Fig. 2, it can be seen that there are needle-shaped particles. From the images of d, it can be seen that there are needle-shaped particles. Elongated particles which have dense structure are seen as well (Fig. 2 d).



a

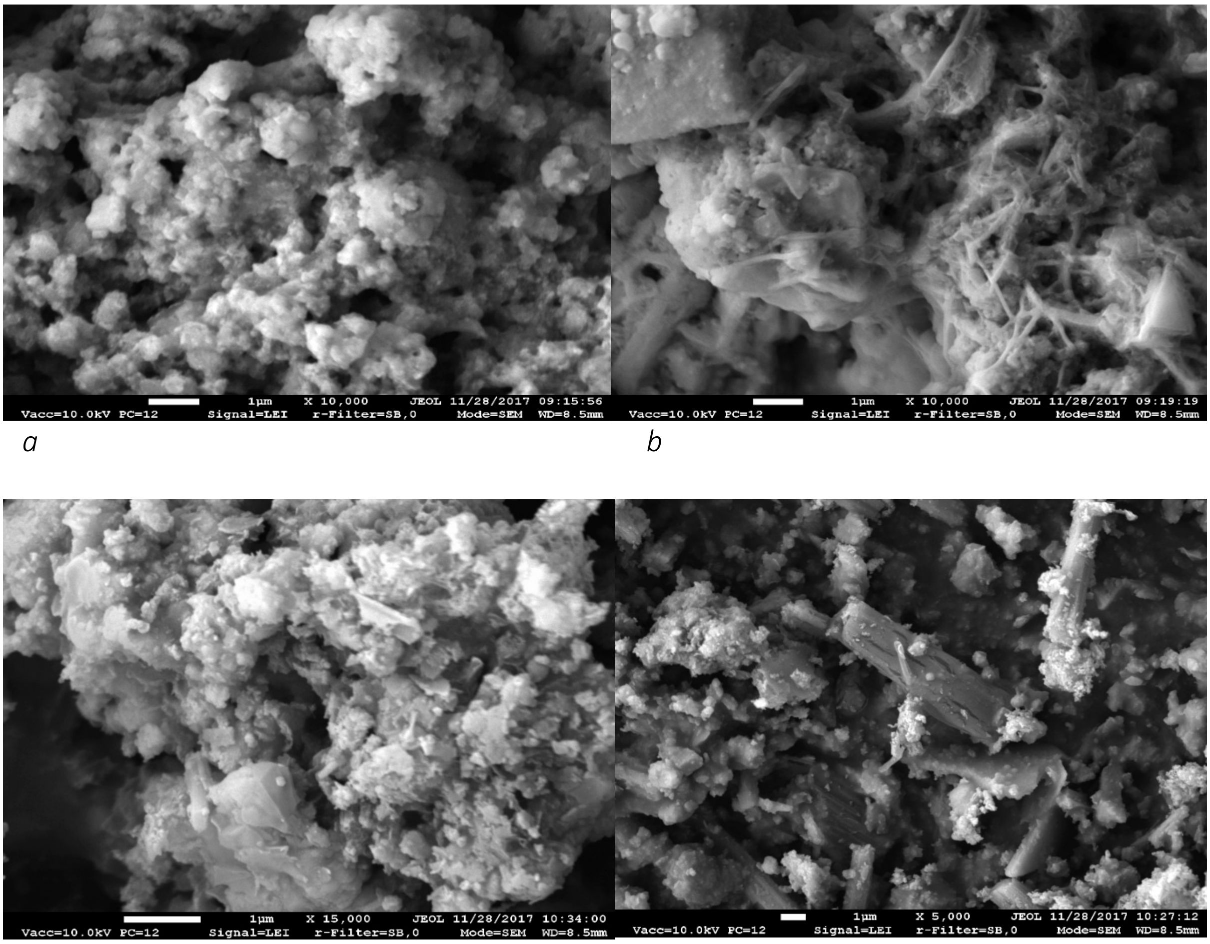


b

Figure 1. – XRD of fly ash (a) and bottom ash (b):
CCl – calcium chloride, C - calcite, O – potassium calcium chloride, H – sodium chloride,
S – potassium chloride, SO – anhydrite, Q -quartz

Since MSWI bottom ash and fly ash contain contaminants within them, for production of bricks from bottom ash and fly ash using whatever method, it is important to ensure that the heavy metals within the original waste material are effectively and safely immobilized. Leaching analyses can be conducted following 2003/33/EC [6], USEPA, ASTM and/or other standard methods to check if the leached elements meet the related standard criteria.

According to normative reference [7] (LR AM įsakymas D1-805), slag may be used for civil and building engineering purposes when the metal content in it is not more than 5%, organic content – not more than 3% of its weight, heating loss – not more than 6% and leaching rate – not more than the specific indicated values.



a *b* *c* *d*

Figure 2. –SEM of fly ash (*a, b*) and bottom ash (*c, d*)

The application of municipal solid waste incineration fly ash in alumosilicate systems is greatly relevant when it is necessary, at high temperatures, to bind and immobilise heavy metals into insoluble compounds. At high temperatures, Pb and Zn metals are encapsulated in alumosilicate systems, thus leading to considerably low leaching values [8, 9]. In order to accelerate carbonation processes, before the use, fly ash may be additionally treated with water thus reducing amounts of Pb, Zn, Cu elements [10]and chlorides [11]. It can be as well treated with water and cleaned using electrolytic process [12].

Based on the experience of other countries, authors think that municipal solid waste (slag and fly ash) may be effectively used for the production of alumosilicate products.

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