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URSZULA KOŁODZIEJCZYK*, MICHAŁ ĆWIĄKAŁA**, ALEKSANDER WIDUCH**

Use of fly-ash for the production of hydraulic binding agents and for soil stabilisation

Introduction

A number of types of soil are encountered in practice, the use of which in construction is difficult or impossible. Hence, to improve their mechanical properties, numerous technologies are commonly used to reinforce and consolidate – in other words to stabilize – these soils (Wiłun 2008; Kraszewski 2009).

The implementation of new technological solutions to reinforce and improve weak subgrades enables the use in civil engineering of most local natural soils, as well as waste materials such as power station wastes (e.g. fly-ash and slag obtained through the combustion of hard coal and lignite) and metallurgy wastes (among others pelleted blast-furnace slag, steel slag) which, for many years, were regarded as unsuitable for use in construction (Gajewska, Kłosiński 2011; Kłosiński 2007).

Fly-ash from the burning of black coal or lignite is among the by-products of combustion. It is undoubtedly one of the cheaper types of basic substitute materials which are commonly used in road building (Gajewska 2007; Pachowski 2002; Rafalski 2007; Škvára et al. 2009; Sybilski, Kraszewski 2004; Widuch, Ćwiąkała 2010). However, in studies of the applications of fly-ash, besides considering financial factors, it is important to seek highly efficient processes that provide a product of higher quality than the material without fly-ash (Widuch et al. 2011a).

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* University of Zielona Góra, Poland

** Wapeco Limited Liability Company, Warsaw, Poland

Fly-ash from lignite from the Konin region (Pątnów Power Plant), classed as sulphate-calcium ash or high-calcium self-cementing ash, demonstrates good binding properties (hydraulic and pozzolanic) and is characterized by a high content of CaO, including free CaO (Kraszewski et al. 2003; Pachowski 1976; Kurdowski 2010; Widuch et al. 2011b). In order to improve the binding parameters of this waste, investigations were carried out into the use of a Wapeco magnetic activator (Fig. 1) an innovative technology for processing lignite fly-ash.

The technology for improving fly-ash in this activator involves the use of a spinning electromagnetic field (Ćwiąkała et al. 2008). As a result of the turbulent process taking place inside the activator, the fly-ash obtains the desired reactive properties in the form of increased specific surface area (active surface) and thus better hydraulic and pozzolanic properties (Kołodziejczyk et al. 2009; Ćwiąkała, Kmiotek 2008; Widuch et al. 2011a) which are important in the design of hydraulic binders (Halbiniak, Ćwiąkała 2010).

This study, examining basic mechanical parameters – compression strength (R_c) and bearing ratio (CBR) – sought to determine the usefulness of lignite fly-ash in the reinforcement of soil, and thus the applicability of this waste in the construction of road foundations and embankments. Experiments were carried out for this purpose using soil-binder mixtures made from natural soils from seven different deposits in the Lubuskie region (western Poland) and activated lignite fly-ash (produced at the Pątnów Power Plant). The main aim of this research was to identify new applications for lignite fly-ash as a full-value component of hydraulic road binders used for soil reinforcement.

Fig. 1. Wapeco magnetic activator (Widuch et al. 2011a)

Rys. 1. Aktywator magnetyczny Wapeco (Widuch i in. 2011a)

1. Materials

The experiments were carried out using lignite fly-ash originating from the Konin region (Pątnów Power Plant). Based on the relative percentage contents of the oxides SiO_2, Al_2O_3, and CaO, this ash is categorized in group III: sulphate-calcium ashes (Pachowski 1976). It was produced as a result of combustion in pulverized fuel boilers where it was captured by electrofilters and then conveyed to storage tanks by a pneumatic transport system. The chemical composition of this ash includes oxides of silicon (SiO_2), oxides of aluminium (Al_2O_3), oxides of calcium (CaO), and sulphates (SO_3 equivalent). The detailed chemical composition of fly-ash from the Pątnów Power Plant is shown in Figure 2.

An important property of the studied fly-ash is that it is not a hazardous material. This is confirmed by the low radioactivity values $f_1 = 0.14$ and $f_2 = 21.23$ Bq/kg which suggest that it can be used without harm to the natural environment.

Activated (modified) lignite fly-ash, treated as the main component in a binder, combines with cement to form a full-valued hydraulic road binder. In turn as the binding agent in soil-binder mixtures, it is a valuable component for subgrade stabilisation.

Lignite fly-ashes, characterized by variable chemical composition, have limitations for soil stabilization (reinforcement) where durable compression strength is required. The limitations relate mainly to the high content of sulphates (SO_3 equivalent) that cause the phenomenon of swelling.

Therefore, it can be stated that the studied ashes may be used as an additive to cement-based systems on the condition that the adverse physicochemical phenomena (swelling and shrinkage) in the resulting binder are minimised. The binder should be designed so as to have a significant proportion of ash (relative to cement) both in terms of volume and mass.

Apart from the binder, the recipe for the soil-binder mixture also includes water (which enables the hydraulic and pozzolanic reactions) and natural soil.

Experiments on appropriate soil-binder mixtures were carried out using two types of hydraulic road binder with strength ratings of 3 MPa (90% activated fly-ash and 10%

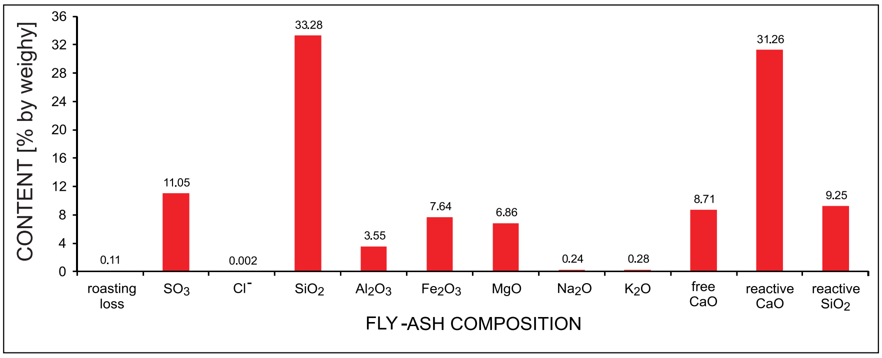

Fig. 2. Chemical composition of fly-ash from Pątnów Power Plant

Rys. 2. Skład chemiczny popiołu lotnego z Elektrowni Pątnów cement) and 9 MPa (80% activated fly-ash and 20% cement), which – in view of their small immediate compression strength and low production costs – are very popular road binders in Poland. These binders were added in proportions of 6% and 8% relative to the total density of solid soil particles. These were constituted by natural soils occurring in the Lubuskie region which differ (Fig. 3) in terms of grain-size distributions (U = 1.8–131.6), dust fraction (f_π = 0.5–49%), and clay fraction (f_i = 0–12%).

The characteristic physical properties of the hydraulic binders used in the experiments are given in Table 1.

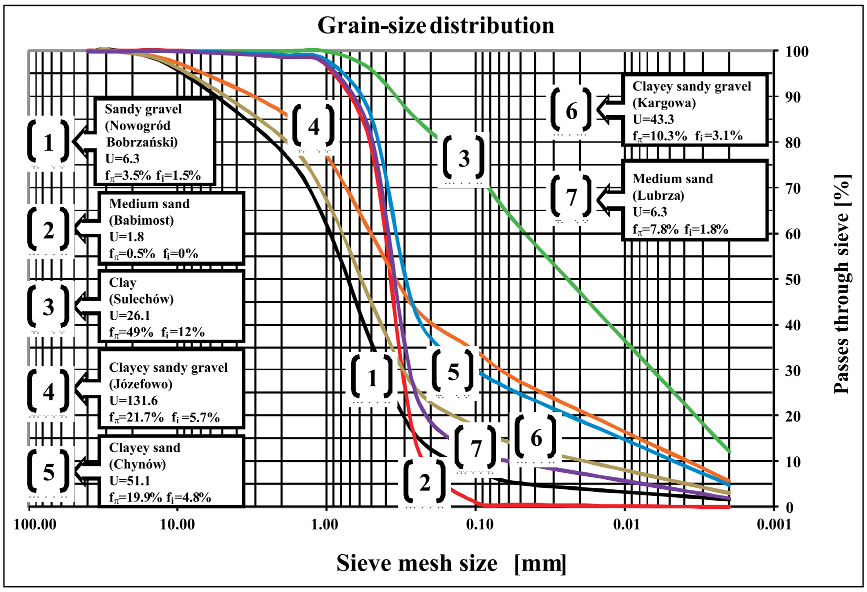

Fig. 3. Grain-size distributions of the soils used to make soil-binder mixtures

Rys. 3. Wykres uziarnienia gruntów użytych w mieszankach gruntowo-spoiwowych

TABLE 1

Physical properties of binders with strength ratings 3 MPa and 9 MPa

TABELA 1

Właściwości fizyczne spoiw o klasie wytrzymałości 3 MPa i 9 MPa

Binder type	Property				
	density [g/cm^3]	water demand [%]	start of binding time [min.]	end of binding time [min.]	blaine surface area [cm^2/g]
Binder with strength rating 3 MPa (90% activated fly-ash, 10% cement)	2.94	25.4	90	190	3 340
Binder with strength rating 9 MPa (80% activated fly-ash, 20% cement)	2.97	25.6	90	160	3 170

2. Methodology

Before the start of the principal experiments on soil-binder mixtures, the fly-ash was modified in a Wapeco magnetic activator. The modified (activated) ash was then analysed for grain size, specific surface, and indicators of pozzolanic activity. The grain size distribution was determined using the methodology described in the PN-B-04481:1988 standard, the specific surface using Blaine's method (in accordance with PN-EN 196-6:1997), and indicators of pozzolanic activity (after 28 and 90 days of hardening) according to PN-EN 450-1:2007, PN-EN 196-3:2006, and PN-EN 196-1:2006.

The activated fly-ash, combined with cement, was used to make hydraulic binders (with a strength rating of 3 and 9 MPa) to reinforce soils from seven different deposits in the Lubuskie region. In this way, the various soil-binder mixtures were produced for use in the ensuing experiments.

Detailed tests were carried out on the soil-binder mixtures to determine their basic mechanical parameters, the bearing ratio (CBR), and compression strength (R_c), which affect the stability of road structures. The bearing ratio was determined immediately after the consolidation of the specimens, and the increment in that ratio was determined after the specimens had undergone curing for 7 days (including 4 days during which they were saturated with water). The compression strength was tested after 14, 28, and 42 days of hardening of the soil-binder mixture.

The soil-binder mixtures (for testing of both the bearing ratio and the compression strength) were made with the addition of 6% and 8% hydraulic binder. The ready mixture for testing compression strength (with optimum moisture content) was poured into a cylindrical mould (with height and diameter equal to 8 cm) and compacted dynamically in one layer (with energy of 0.59 J per cm^3 of mixture according to Proctor's normal method and in accordance with the PN-B-04481:1988 standard). The specimens used for determination of the bearing ratio were made and tested in accordance with Annex A to the PN-S-02205:1998 standard.

3. Results

In order to present the results of tests on fly-ash from the Pątnów Power Plant following activation (modification) in a Wapeco magnetic activator, the intention being to obtain better reactive properties, the study examined the grain size of the ash (Fig. 4), its specific surface (Fig. 5), and indicators of pozzolanic activity after 28 and 90 days (Fig. 6). To indicate the effects of that modification, the following graphs (Fig. 4 to 6) compare the results to tests on unmodified ash.

The results obtained (Fig. 4–6) confirm the advantages of using the Wapeco magnetic activator to obtain modified fly-ash with very favourable reactive properties. They also show that the process of activation (grinding) has a significant effect on the specific surface of the

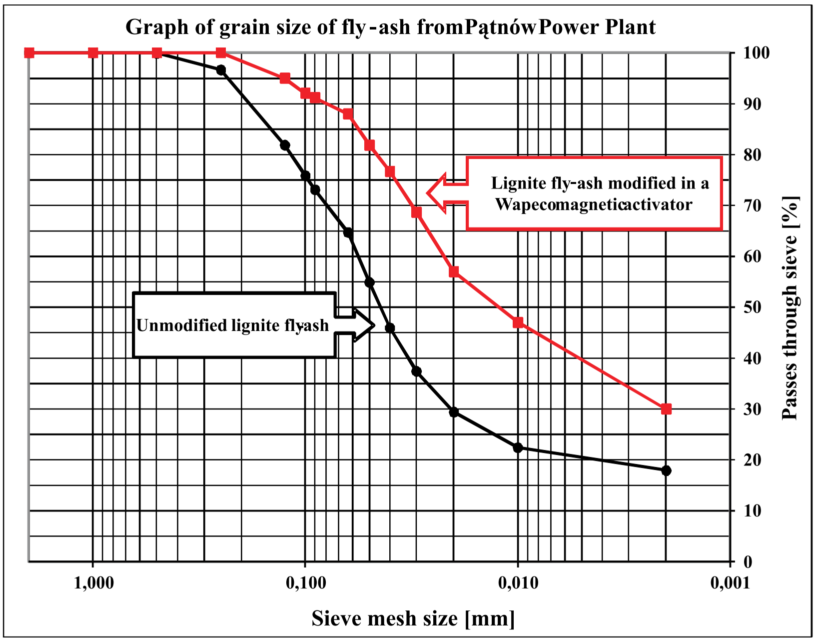

Fig. 4. Graphs of grain size of fly-ash (unmodified and modified) from Pątnów Power Plant

Rys. 4. Wykresy uziarnienia popiołu lotnego (niezmodyfikowanego i zmodyfikowanego) z Elektrowni Pątnów

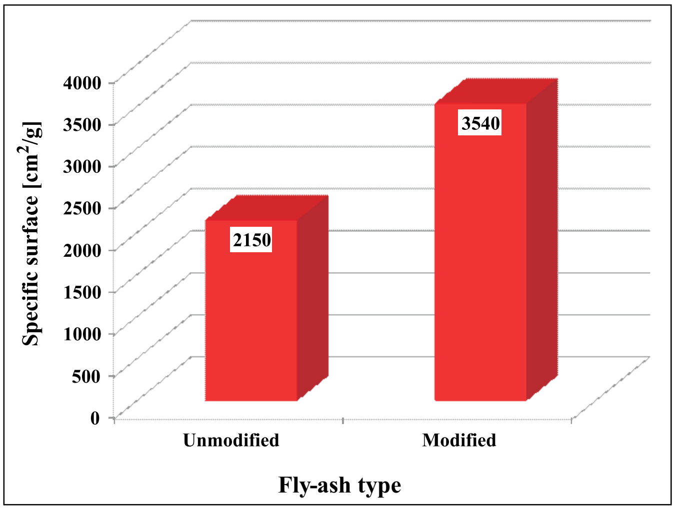

Fig. 5. Graph of specific surface of fly-ash (unmodified and modified) from Pątnów Power Plant

Rys. 5. Wykresy powierzchni właściwej popiołu lotnego (niezmodyfikowanego i zmodyfikowanego) z Elektrowni Pątnów

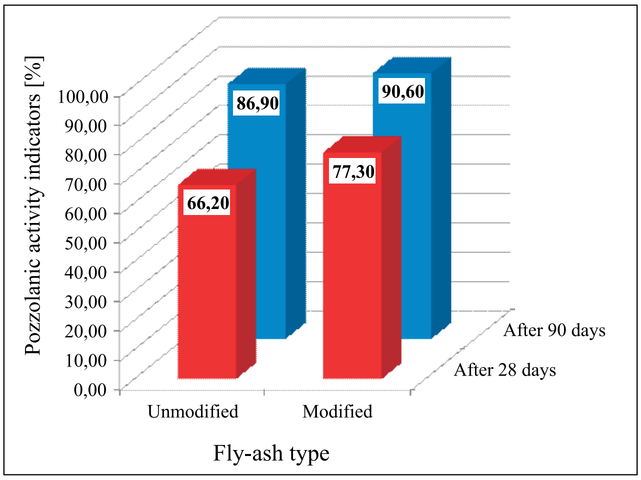

Fig. 6. Graphs of indicators of pozzolanic activity (after 28 and 90 days) of fly-ash (unmodified and modified) from Pątnów Power Plant

Rys. 6. Wykresy wskaźników aktywności pucolanowej (po 28 i 90 dniach) popiołu lotnego (niezmodyfikowanego i zmodyfikowanego) z Elektrowni Pątnów

ash, its grain size, and its pozzolanic activity. The modified lignite fly-ash obtained in the Wapeco magnetic activator has very small grain size (Fig. 4) in which the dust fraction (f_π) accounts for more than 50%, and the clay fraction (f_i) almost 30%. Hence, the process of grinding fly-ash in the Wapeco magnetic activator, which uses several times less energy than other existing technologies, aims to provide fractions as fine as possible in the shortest possible time, helping to obtain a final product with larger specific surface (Fig. 5) and better pozzolanic properties (Fig. 6) than the original (unmodified) fly-ash. It turns out that the specific surface of the unground ash (2 150 cm^2/g) was increased as a result of grinding by more than 64% (Fig. 5) which, in turn, brought about an increase in the indicators of the pozzolanic activity of the ash (Fig. 6) up to levels required in the PN-EN 450-1:2007 Standard “Fly ash for concrete – Part 1: Definition, specifications and conformity criteria”. Therefore, modified fly-ash can be classified as active mineral addition.

In view of the grain size (Fig. 4) and the Blaine surface area (Fig. 5) and in accordance with the accepted classification of Pachowski (1976), this ash, starting as a medium-grain material and following modification in the Wapeco magnetic activator, was reclassified as a fine-grain material. A fine-grain material is one in which particles larger than 0.075 mm account for less than 25% of the total (Fig. 4), and has a specific surface greater than 3000 cm^2/g (Fig. 5).

The principal experiments carried out in the course of this work involved tests of the rate of increase in strength (R_c) and load bearing capacity (CBR) of soil-binder mixtures carried out on seven differing soils (in terms of origin and grain size).

These experiments determined the increment in the bearing ratio of particular soil-binder mixtures immediately after consolidation and after undergoing curing for 7 days, obtained for the seven different soils, two types of hydraulic road binder (with strength ratings of 3 MPa and 9 MPa), and different quantities of binder (6% and 8% relative to the total density of the solid soil particles). The results are shown in Table 2.

The tests show that the analysed specimens of soil-binder mixtures (Table 2) have high bearing ratios where, in general, higher values were recorded for mixtures containing a binder with the higher strength rating (9 MPa), those with the higher percentage content of binder (8%), and also those which were tested after a longer curing time (7 days). Hence,

TABLE 2

The test results for maximum bearing ratio (CBR) of soil-binder mixtures

TABELA 2

Zestawienie wyników badań maksymalnych wskaźników nośności (CBR) mieszanek gruntowo-spoiwowych

Type of soil	Testing method	Maximum bearing ratio (CBR) [%]			
		hydraulic binder with strength rating of 3 MPa		hydraulic binder with strength rating of 9 MPa	
		addition of binder [%]		addition of binder [%]	
		6	8	6	8
Sandy gravel from Nowogród Bobrzański	Immediately after consolidation	78	57	78	81
	After curing for 7 days (incl. 4 days of saturating with water)	358	358	358	358
Medium sand from Babimost	Immediately after consolidation	19	16	18	21
	After curing for 7 days (incl. 4 days of saturating with water)	52	69	96	134
Clay from Sulechów	Immediately after consolidation	16	18	16	17
	After curing for 7 days (incl. 4 days of saturating with water)	53	65	61	71
Clayey sandy gravel from Józefowo	Immediately after consolidation	10	13	14	14
	After curing for 7 days (incl. 4 days of saturating with water)	137	157	156	188
Clayey sand from Chynów	Immediately after consolidation	15	16	14	13
	After curing for 7 days (incl. 4 days of saturating with water)	113	185	136	200
Clayey sandy gravel from Kargowa	Immediately after consolidation	43	44	35	34
	After curing for 7 days (incl. 4 days of saturating with water)	283	341	349	354
Medium sand from Lubrza	Immediately after consolidation	43	50	48	56
	After curing for 7 days (incl. 4 days of saturating with water)	258	275	271	358

the best results for bearing ratios using binders with strength ratings of 3 MPa and 9 MPa with different contents of binder (6% and 8%) and tested after curing for 7 days were obtained for the following soil-binder mixtures (Table 2):

- sandy gravel from Nowogród Bobrzański, with 6% binder of strength ratings 3 MPa and 9 MPa, with CBR 358%;
- sandy gravel from Nowogród Bobrzański, with 8% binder of strength ratings 3 MPa and 9 MPa, with CBR 358%;
- clayey sandy gravel from Kargowa, with 6% binder of strength ratings 3 MPa and 9 MPa, with CBR 283% and 349% respectively;
- clayey sandy gravel from Kargowa, with 8% binder of strength ratings 3 MPa and 9 MPa, with CBR 341% and 354% respectively;
- clayey sand from Chynów, with 6% binder of strength ratings 3 MPa and 9 MPa, with CBR 113% and 136% respectively;
- clayey sand from Chynów, with 8% binder of strength ratings 3 and 9 MPa, with CBR 185% and 200% respectively.

The foregoing analysis shows that soils with substantial dust and clay fractions (e.g. the clayey, sandy gravel from Kargowa and clayey sand from Chynów) which have, up to now, been regarded as unsuitable for road building can be used for the building of road embankments when improved with hydraulic binders based on activated lignite fly-ash (Technical Approval 2009; Ćwiąkała et al. 2008; Widuch, Ćwiąkała 2010; PN-S-02205:1998).

Besides the bearing ratio, another significant parameter that determines the utility properties of road structures is compression strength (R_c). The rate of increment in this parameter for seven types of soil stabilized using two types of hydraulic binder (3 MPa and 9 MPa), observed after 14, 28, and 42 days, is shown on line graphs (Fig. 7–8). The results are given according to the PN-S-96012:1997 standard (“Roads. Foundation and improved subgrade using soil stabilized with cement”).

The greatest compression strength was recorded for mixtures made using binder with the higher strength rating (9 MPa) and having the greater binder content (8%), and also for those tested after a longer curing time (42 days).

Based on the PN-S-96012:1997 standard, the highest compression strength (after 28 days of hardening) was obtained for soil-binder mixtures made using:

a) clayey, sandy gravel from Kargowa with 8% binder of strength rating 3 MPa (Fig. 7);
b) clayey, sandy gravels from Józefowo and Kargowa with 6% and 8% binder of strength rating 9 MPa (Fig. re 8).

It follows from the above that soil-binder mixtures based on clayey, sandy gravels (including pure sandy gravels) stabilized with a suitable type of hydraulic binder can certainly be used to make road foundations (Fig. 8). Also, in making the upper and lower layers of improved subgrade it is possible to use soil-binder mixtures containing clayey sands, medium sands, and in some cases even clays (Fig. 7–8).

In other words, the best results for compression strength (R_c) among the tested soils stabilized with hydraulic binders (3 MPa and 9 MPa) were obtained for soils with a high

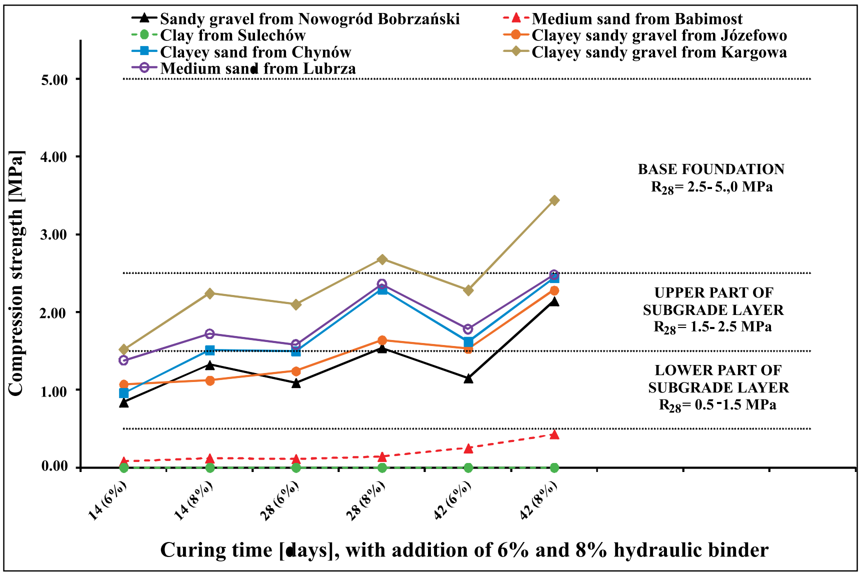

Fig. 7. Rate of increment of compression strength (R_c) of soil-binder mixtures when hydraulic binder with a strength rating of 3 MPa is used

Rys. 7. Dynamika narastania wytrzymałości (R_c) mieszanek gruntowo-spoiwowych przy zastosowaniu spoiwa hydraulicznego o klasie wytrzymałości 3 MPa

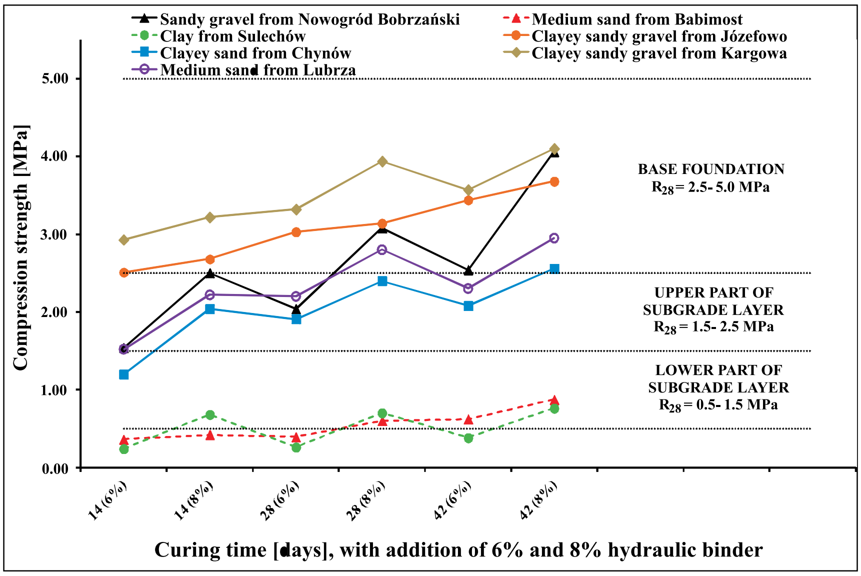

Fig. 8. Rate of increment of compression strength (R_c) of soil-binder mixtures when hydraulic binder with a strength rating of 9 MPa is used

Rys. 8. Dynamika narastania wytrzymałości (R_c) mieszanek gruntowo-spoiwowych przy zastosowaniu spoiwa hydraulicznego o klasie wytrzymałości 9 MPa content of dust and clay fractions (Fig. 7–8). This means that in the case of soils such as clays; clayey sands; and clayey, sandy gravels, the addition of hydraulic binder (in quantities of 6% and 8%) produced using activated lignite fly-ash and cement brings about good stabilization (strengthening) of this type of mixture. Hence, soils which are generally regarded as unsuitable (or of a low level of usefulness) in road construction can, in fact, be used to build structural layers of road surfaces when stabilized with hydraulic binders (Technical Approval 2009; Kołodziejczyk et al. 2009; Widuch et al. 2011b).

Soils improved with hydraulic binders (containing activated lignite fly-ash) demonstrate a continuous increase in compression strength even after 42 days of hardening of the soil-binder mixtures (Fig. 7–8). In connection with this, the strength of soil-binder mixtures obtained after 42 days (when hydraulic binders with active fly-ash are used) ought to be regarded as a final value.

A necessary condition for the use of soil-binder mixtures in the structural layers of a road, apart from compression strength requirements, is the fulfilment of a frost resistance criterion. If this criterion is not met, the mixtures can be used only in places which are dry or are protected from the inflow of groundwater. The desired indicators of frost resistance (PN-S-96012:1997) for soil-binder mixtures were obtained in the case of the addition of 8% binder (with strength rating 3 MPa) and 6% binder (with strength rating 9 MPa) for almost all of the soils used in the tests (with the exception of the clay from Sulechów and medium sand from Babimost).

Making hydraulic binder from lignite fly-ash processed in a Wapeco magnetic activator subsequently used to make soil-binder mixtures provides an opportunity to make soils such as clayey sand; clayey, sandy gravel; and clays into materials fully suited to road construction, and in particular for the making of embankments and other structural layers of road surfaces.

Conclusions

The tests carried out on the compression strength (R_c) and bearing capacity (CBR) of soil-binder mixtures (containing activated lignite fly-ash from the Pątnów Power Plant) lead to the following conclusions:

1. Lignite fly-ash, used as a principal component of hydraulic road binders which are then used to make soil-binder mixtures, significantly improves the parameters of those mixtures in terms of compression strength (R_c) and the bearing ratio (CBR), and this effect becomes particularly strong after a longer mixture curing time.
2. The making of soil-binder mixtures from hydraulic road binders with activated lignite fly-ash fulfils the requirements of the following standards: PN-S-02205:1998 ("Roads. Earth works. Requirements and tests") and PN-S-96012:1997 ("Roads. Foundation and improved subgrade using soil stabilized with cement"). This means that such mixtures can be used to build road embankments and to strengthen the upper layers of weak

subgrade (made of soils of uncertain properties or susceptible to swelling), and also the lower parts of improved soil subgrade layers (when the surface structure is founded on subgrade made of soils that are sensitive to the action of frost and water), or even for the base foundations of road structures.

3. The high demand for quality aggregate materials (fulfilling the criteria laid down in the standards), as well as rising cement prices, have resulted in a search for alternative materials. Industrial wastes such as lignite fly-ash, after processing and when the relevant criteria are fulfilled, may become full-valued products (alternative materials) for the production of hydraulic binders to reinforce commonly occurring mineral raw materials so as to raise their technical parameters to a level corresponding to high-value aggregates.
4. The production of hydraulic road binders using activated lignite fly-ash is a method of utilizing industrial waste and also of obtaining new materials and technologies for road construction.
5. The planned development of open-cast lignite mining and power generation in the Lubuskie region (the mine and power plant at Gubin) may prove to be less of a burden on the environment if the fly-ash produced at the power plant, in combination with local mineral raw materials, is used to produce soil-binder mixtures for subgrade reinforcement in construction projects.

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ZASTOSOWANIE POPIOŁÓW LOTNYCH DO PRODUKCJI SPOIW HYDRAULICZNYCH I WZMACNIANIA GRUNTU

Słowa kluczowe

Popioły lotne, stabilizacja gruntów, hydrauliczne spoiwa drogowe, mieszanki gruntowo-spoiwowe

Streszczenie

Popiół lotny jest odpadem produkcyjnym, wytwarzanym w wyniku spalania węgla w kotłach energetycznych. Rocznie na świecie wytwarza się miliony ton tego odpadu, stąd niezwykle ważne jest umiejętne jego zagospodarowanie, w tym – uzyskanie materiału o wyższej jakości niż zastosowany produkt wyjściowy.

Celem pracy jest określenie przydatności przetworzonych popiołów lotnych z węgla brunatnego do wzmocnienia (stabilizacji) gruntów stosowanych w budowie nasypów drogowych oraz podbudowy dróg. Wyniki pracy są sposobem na utylizację odpadów, a jednocześnie – uzyskanie nowych materiałów i technologii w budowie obiektów liniowych. Jest to zagadnienie istotne zarówno z punktu widzenia ochrony środowiska przyrodniczego, jak i pozytywnego wpływu przetworzonych popiołów lotnych na trwałość obiektów drogowych.

W pracy przedstawiono wyniki badań przeprowadzonych na popiołach lotnych z węgla brunatnego wytwarzanych w Elektrowni Pątnów. Popioły te zostały najpierw zmodyfikowane (aktywowane) za pomocą „aktywatora magnetycznego Wapeco”, a następnie – użyte do wytworzenia spoiw hydraulicznych (z dodatkiem cementu) oraz mieszanek gruntowo-spoiwowych. Poszczególne mieszanki sporządzono na bazie surowców mineralnych zalegających w siedmiu różnych złożach regionu lubuskiego (zachodnia Polska). Zastabilizowano je dwoma spoiwami hydraulicznymi (o wytrzymałości 3 i 9 MPa), przy zróżnicowanym dodatku spoiwa hydraulicznego (6% i 8% w stosunku do masy gruntu). Podczas badań określono przyrost wytrzymałości badanych próbek (po upływie czasu: 14, 28 i 42 dni) oraz przyrost wskaźnika nośności (bezpośrednio po zagęszczeniu i po 7 dniach).

Interpretacja wyników badań pozwoliła na ocenę dynamiki wzrostu wytrzymałości na ściskanie i nośności różnych gruntów zastabilizowanych spoiwami hydraulicznymi, wytworzonymi na bazie popiołu lotnego z węgla brunatnego, oraz – wskazanie możliwości zastosowania tych materiałów.

Przeprowadzona analiza wykazała, że istnieje możliwość wzmocnienia gruntów za pomocą tych spoiw, a następnie – zaliczenia gruntów uznawanych dotychczas za słabonośne (tj. piaski gliniaste, pospółki gliniaste, gliny) do materiałów w pełni przydatnych w budownictwie drogowym.

USE OF FLY-ASH FOR THE PRODUCTION OF HYDRAULIC BINDING AGENTS AND FOR SOIL STABILISATION

Key words

fly ash, soil stabilisation, hydraulic binding agents, soil and binder mixtures

Abstract

Fly-ash is a form of production waste produced as a result of the burning of coal for energy production. Millions of tonnes of this waste are produced worldwide every year; hence it is extremely important to dispose of it in a useful way, including through treating the initial raw material to obtain a material of higher quality.

The aim of the present work is to determine the suitability of processed fly-ash from lignite for reinforcing (stabilizing) soils used in the building of road foundations and embankments. The results provide a method of recycling this waste while at the same time obtaining new materials and technologies for use in road building. This is an important issue both environmentally and in terms of the positive effect that processed fly-ash can have on the stability of road structures.

This article presents the results of experiments carried out using fly-ash produced from lignite at the Pątnów Power Plant. This ash was first modified (activated) using a Wapeco magnetic activator, and then used to produce hydraulic binders (with the addition of cement) and soil-binder mixtures. These mixtures were made using natural soils from seven different deposits in the Lubuskie region (western Poland). They were stabilized using two hydraulic binders (strength ratings 3 MPa and 9 MPa) added in different amounts (6% and 8% relative to the mass of the soil). During the experiment, a determination was made of the increase in the strength of the analysed samples (after 14, 28, and 42 days) and the increase in the bearing ratio (immediately after consolidation and after 7 days).

Interpretation of the results of the experiment made it possible to assess the dynamics of the increase in compression strength and load-bearing capacity of various soils stabilized with hydraulic binders produced from lignite ash, and to indicate possibilities for the use of these materials.

The analysis showed that it is possible to use these binders for the stabilisation of soils, enabling soils formerly considered to have weak load-bearing capacity (clayey sand; clayey, sandy gravel; clays) to be classified as fully usable in road construction.