



The potential use of cement–asbestos waste in the ceramic masses destined for sintered wall clay brick manufacture

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Abstract

Asbestos fibers are considered to be carcinogenic and to cause cancer, thus elimination of asbestos-containing materials from the environment is necessary. Currently, asbestos materials are stored in special landfills designed for hazardous wastes. However, this procedure is not a final solution to the problem and an alternative might be thermal recycling. This paper reports the results of a study on using asbestos–cement slates as an additive to ceramic masses that are typical in the manufacture of sintered clinker wall bricks. Green compacts containing various amounts (0–10 wt%) of asbestos–cement wastes were sintered at temperatures of 1100–1200 °C. Subsequently, ceramic product properties such as water absorption, open porosity, apparent density, compressive strength and freeze resistance were determined. The preliminary results of the study indicate that asbestos-containing materials can be used as one of the raw materials in the manufacture of clinker ceramic material, and that the origin of the asbestos–cement used does not have a significant influence on the basic properties of sintered clinker wall bricks. Main ceramic properties, such as water absorption, compressive strength and freeze resistance, comply with national standards and requirements for construction and road clinker ceramic.

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1. Introduction

Asbestos is the commercial name for fibrous silicate minerals which are characterized by unique chemical and physical properties. The most important features are high tensile strength, resistance to acids and bases as well as thermal insulation, sound absorption, microbiological and abrasion resistance [1]. In the 1960s, asbestos was one of the most popular and cheapest raw materials that was used in building materials. Asbestos was mostly used (approximately 85%) in the building industry in the form of asbestos–cement roofing. In its years of highest popularity, asbestos was used in about 3000 different products [2,3].

Asbestos minerals are divided into two groups depending on their crystalline structure. Like all silicate minerals, the basic building blocks of asbestos fibers are silicate tetrahedral, which

may occur as double chains, e.g. in amphiboles, or as sheets, e.g. in serpentines. Serpentine are hydrous magnesium silicates which include only one fibrous silicate mineral—chrysotile $Mg_3[Si_2O_5](OH)_4$. The group of amphiboles comprises silicates of magnesium, iron, calcium, sodium and aluminum. Five asbestos minerals belong to this group; these are, e.g. actinolite $Ca_2(Mg,Fe)_5[(OH)Si_4O_{11}]_2$, tremolite $Ca_2Mg_5[(OH)Si_4O_{11}]_2$, anthophyllite $(Mg,Fe)_7[(OH)Si_4O_{11}]_2$, riebeckite (crocidolite) $Na_2Fe_3Fe_2[(OH)Si_4O_{11}]_2$ and grunerite (amosite) $(Fe,Mg)_7[(OH)Si_4O_{11}]_2$. However, only three of these minerals were widely used in the industry, especially in building materials—chrysotile (white asbestos), crocidolite (blue asbestos) and amosite (brown asbestos) [1].

On the other hand, today it is known that asbestos possesses carcinogenic properties. What is hazardous to human health are its respirable fibers, which can easily penetrate deep into the respiratory system, where they are not removed by the body's natural cleansing mechanisms. This leads to the development of various diseases, e.g. asbestosis [4].

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In many developed countries the import, manufacture and marketing of asbestos-containing products has been banned. Products used before the ban was implemented may still be used, provided that they pose no threat to the environment. If the asbestos product is withdrawn from use, it becomes a hazardous waste. In the case of asbestos, a basic form of disposal is its storage in special landfills designated for dangerous wastes. However, such a procedure does not represent a final solution to the asbestos problem because asbestos' dangerous fibrous structure is maintained. It is necessary to find methods based on recycling in which it will be possible to change the harmful properties of asbestos minerals through destruction of the material's fibrous structure.

According to estimates of the Polish government, more than 15 million tons of asbestos wastes, of which over 90% are asbestos–cement waste, have been accumulated in Poland [2]. Therefore, this waste could be a potentially interesting secondary raw material. Among the many different proposed methods of asbestos and asbestos-containing materials, utilization of a method based on thermal treatment has widely been described [5–9] due to its simplicity of implementation and the potentially wide range applications of the obtained product [10–15].

A good example is the utilization of various solid wastes in construction materials, whose applications in civil engineering have undergone considerable development in recent years, with the utilization of blast furnace slag, fly ash, lime sludge, and marble processing residues in construction materials constituting some successful examples [16]. On the other hand, in the manufacturing of building materials such as clay firing bricks, high-temperature treatment (at a temperature of about 1000 °C and higher) is required. Such high temperatures are sufficient for the thermal decomposition of asbestos minerals and lead to a change in their structure [17–25]. Thus asbestos wastes can then be introduced into raw material mixtures that are designed for the manufacture of building ceramics.

The aim of this study was to investigate the possibility of using asbestos–cement waste as one of the secondary raw materials (as an agent which reduces shrinkage) in the manufacture of clinker bricks and to compare whether the origin of asbestos waste has a significant impact on the ceramic properties of obtained clinker ceramic materials.

2. Experimental

2.1. Materials and methods

In this study a commercial plastic clinker mass was used which was provided by one of the factories producing ceramic building materials such as sintered bricks (CRH Klinkier; Patoka, Poland). This prepared mixture of raw materials contained 70 wt% of clayey minerals and 30 wt% of the component which reduces shrinkage. For this the manufacturing plant used quartz and milled brick wastes. Kaolinite and illite with a small participation of mixed-layer illite/smectite are the main mineral components of clay from the Patoka

deposit. Non-clay minerals are represented by quartz, which is accompanied by hematite and siderite [26].

For a comparison, i.e. whether the origin and composition of the asbestos–cement waste have an important influence on obtaining the desired ceramic properties, two different asbestos–cement slates were used in the present study. The samples came from different regions of Poland and were exposed to external weather conditions for about 30–40 years. The first sample was corrugated asbestos–cement slate (named ACB) which came from Upper Silesia and had been exposed to outside weather conditions for about 30 years. Both yellowish-green and dark-blue bundles of fibers (potentially chrysotile and crocidolite asbestos, respectively) were observed in the fracture of the sample. The second sample came from around the city of Żywiec in the Beskid Mountains (designated as ACD). This was a pressed flat sheet and contained only bright bundles of asbestos, probably chrysotile.

These asbestos materials were subjected to classical wet chemical analysis and the main chemical components were determined by standard laboratory procedure (Table 1). The qualitative phase composition was measurement by X-ray diffraction (XRD) and the microstructure was observed by scanning electron microscopy (SEM). As a raw material in the recycling study, these asbestos–cement slates were crushed and were wet-milled in a laboratory ball mill, obtaining powder with a grain size of less than 0.5 mm.

XRD analysis of the examined asbestos–cement samples was carried out using a PANalytical X'pert Pro diffractometer (CuK_α radiation, Ni filter, 40 kV, 30 mA, X'Celerator detector). The microstructure of the asbestos–cement samples and the obtained clinker ceramics was examined by a scanning electron microscope (Hitachi TM-3000 or Tesla BS340). Observations were made after coating the sample surfaces with a thin layer of gold in order to obtain conductivity.

2.2. Ceramic sample preparation

Different amounts of asbestos–cement samples (0–10 wt%) were added to the commercial clinker mass used in this study. These were introduced as a leaning agent partly replacing the components which reduced shrinkage used by the factory. Clay from the Patoka deposit was also added to maintain the proportions of raw materials. The raw materials had the

Table 1
Main chemical components of used asbestos–cement wastes.

Item	Content (wt%)	
	ACB	ACD
Type of asbestos–cement		
SiO ₂	18.5	17.8
CaO	41.9	42.7
MgO	3.7	5.4
Al ₂ O ₃	2.7	2.9
Fe ₂ O ₃	3.4	2.9
SO ₃	1.9	1.5
L.O.I.	25.5	23.3

L.O.I.—loss on ignition

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