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ASBESTOS MATERIALS MANAGEMENT IN THE ASPECT OF ENERGY RENOVATION OF BUILDINGS IN EU COUNTRIES

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Abstract: This article presents the latest statistical data on the volume of asbestos mining production and asbestos products trade in the world. The legal conditions for the management of asbestos and used asbestos-cement products are characterized. The resources of asbestos-cement products incorporated into roof coverings in 27 European Union countries are identified. An attempt is made to answer the question of whether the renovation of buildings, included in the European Union policy as a key initiative aimed at increasing energy efficiency in the construction sector, will contribute to the removal of asbestos-cement products and the purification of air from asbestos dust. In addition, an assessment was made of the impact of new legal regulations in the EU on activities related to the management of asbestos and asbestos waste materials, and thus on the occupational safety of construction workers.
Keywords: asbestos, asbestos management, removal, asbestos-cement roofs

1. INTRODUCTION

Asbestos is defined by the United States Environmental Protection Agency as a group of six types of minerals, such as serpentine group - chrysotile, and amphibole group - amosite, actinolite, crocidolite, tremolite, anthophyllite. For these minerals, a Chemical Abstracts Service (CAS) registry number is used in trade (www.epa.gov). According to the EC Regulation 1272/2008, asbestos as a dangerous carcinogen is classified in category 1A. The most dangerous to health are crocidolite and amosite. Therefore, for a number of years many countries, including European Union countries, have been taking action to withdraw from sale and use of asbestos and products containing asbestos. However, this is a very difficult process, because this mineral is still mined in several countries, and many countries have implemented partial bans or no regulations at all.

Asbestos, due to its mechanical properties, has been used for many years in about 3,000 different industrial products, including building materials. In construction, asbestos was used mainly in asbestos-cement products for roofing as well as cement pipes and fittings. In many countries, after the introduction of legal restrictions on its use, asbestos materials are being withdrawn from use. Nevertheless, this material is still present around us. Asbestos fibers immobilized in a cement matrix do not pose a health hazard, but released into the air from damaged asbestos products (e.g. during dismantling work) pose a real threat to humans. Equally dangerous is the extraction and processing of asbestos

minerals. Inhaling fibres during various works causes a number of diseases (i.e. asbestosis, mesothelioma), which develop very slowly, and cancer symptoms can appear even 40 years after contact with asbestos (Ulewicz, 2023). Despite the fact that there are many reports in the literature about the harmfulness of this material, this material is still present in trade, and workers in many industries are still exposed to harmful asbestos fibers. Therefore, this article analyzes the current state of the asbestos and asbestos products economy in the world and identifies the resources of asbestos-cement products used in roofing in 27 countries of the European Union. Also, the impact of the European Union's policy on increasing the energy efficiency of buildings on the process of removing asbestos-cement roofing and cleaning the air from asbestos dust was analyzed.

2. MINING PRODUCTION AND ASBESTOS TRADE

Global asbestos production has fallen from about two million metric tons in 2010 to about 1.3 million metric tons in 2023. Currently, the world's largest producer of asbestos is Russia, which will produce about 630,000 million metric tons in 2023. Production of this mineral over the last four years is shown in Table 1. In addition, many countries have large reserves of this raw material, although the available information is often insufficient for accurate analysis. Countries such as Russia, China, and Brazil are reported to have significant estimated reserves of this material. They amount to 110 million Mg (Russia), 18 million Mg (China), and 11 million Mg (Brazil), respectively. Countries such as Kazakhstan and Zimbabwe, on the other hand, will not disclose the amount of their reserves (estimated to be large). It is worth noting that Zimbabwe, which has finished asbestos mining production, in 2019 began producing asbestos from tailings from the mining and processing of this mineral. Average monthly production in 2019 was 500 Mg. In addition, the Zimbabwe Mining Development Corporation is applying for a government loan to resume asbestos mining in the Shabaine-Mashava isolation mines in Zimbabwa. Also in Kazakhstan the issue of recycling of flotation waste (accumulated in the amount of about 300 million Mg) by a local processing plant (located in the city of Zhetikara, Kostanay region) is being considered. In the 1960s, this plant processed about 310 million Mg of asbestos ores (Baigenzhenov et al., 2022).

Table 1
World mining production of asbestos in 2000-2024, Mg

Country	2020	2021	2022	2023
Brazil	60 000	154 000	197 000	190 000
China	100 000	130 000	130 000	200 000
Kazakhstan	210 000	250 000	230 000	260 000
Russia	790 000	699 000	750 000	630 000
Zimbabwe	8 000	10 000	-	-
Total	**1 168 000**	**1 243 000**	**1 307 000**	**1 280 000**

Source: (U.S. Geological Survey, 2021,2022, 2023 and 2024).

According to the World Integrated Trade Solution (WITS) report prepared by the World Bank in cooperation with the United Nations Conference on Trade and Development (UNCTAD), asbestos and asbestos products are still traded. In 2023, the top exporters of asbestos were Brazil, Kazakhstan, China, India, and United States (Table 2). The list of exporters covering 15 countries also includes Poland, which exported products with code HS 252400 in the amount of 900 kg (value $2.68K). While the import of the product with

code HS 252400 was recorded in 44 countries, among which the main importers in 2023 were India, Indonesia, China, Uzbekistan, and Thailand. In addition, asbestos products are still traded worldwide. The main exporters of products marked with HS code 681120 were: United States, Thailand, China, UE and Belgium. While, the importers were: Canada, United States, United Kingdom, other Asian countries, and Philippines (https://wits.worldbank.org).

Table 2
Top exporters and importers of asbestos products (HS trade code 252400 and 681120) in 2023 (https://wits.worldbank.org)

Product Code	Country	Trade Flow	Trade Value 1000 USD	Quantity, kg
HS 252400	Brazil	Export	95,956.10	190,023,000
	Kazakhstan		82,977.74	269,637,000
	China		30,213.85	-
	India		2,378.83	2,833,050
	United States		87.14	51,000
	India	Import	296,960.11	485,182,000
	Indonesia		61,216.71	-
	China		55,802.81	195,793,000
	Uzbekistan		37,872.26	106,663,000
	Thailand		25,316.78	37,636,100
HS 681120	United States	Export	196,574.94	195,347,000
	Thailand		181,092.40	875,200,000
	China		155,501.38	288,269,000
	European Union		126,242.19	118,374,000
	Belgium		104,737.47	90,386,700
	Canada	Import	157,496.11	142,702,000
	United States		144,076.54	170,463,000
	United Kingdom		115,206.38	178,584,000
	Other Asia		66,196.08	190,595,000
	Philippines		60,403.35	331,400,000
HS Code 252400: Asbestos HS Code 681120: Sheets nes, panels/tiles, etc of asbestos-cement				

3. ASBESTOS CONSUMPTION IN BUILDINGS IN EU COUNTRIES

Asbestos in construction was used to manufacture a number of products. The mineral was most widely used to manufacture asbestos-cement roofing, which contained 10 to 20% asbestos fibres. The largest amount (70-90%) of extracted asbestos fibres was used to manufacture asbestos-cement sheets, which were incorporated into various constructions worldwide (Lee and Kim, 2021; Ulewicz and Liszewski, 2020). Other popular asbestos cement products include wall sheets, sewage pipes, rainwater drainage fittings, hot water pipe insulation, drinking water tanks, separating panels and ventilation ducts. The content of asbestos fibres (raw asbestos) in such products is about 15% (Gualtieri, 2012). The asbestos fibres are also found in sprayed asbestos materials generally used for sound and fireproofing. The content of asbestos in such materials varies from 5% up to 95% (Dumortier and De Vuyst, 2012).

The asbestos construction products, despite numerous reports of its harmfulness, are still widely used in developing countries. Inexpensive, mass-produced roofing is incorporated

into buildings, and supporters of this type of material claim that chrysotile (white) asbestos is safe when used in controlled conditions. On the other hand, more economically developed countries, including EU countries, have introduced a ban on the use of asbestos materials in construction. However, before it came into force, buildings erected in the years 1970-2003 in EU countries often contained significant amounts of asbestos. According to a Science for Policy report prepared by the Joint Research Centre (JRC), the use of asbestos products in construction varies across countries. Estimated asbestos consumption in buildings in EU27 and United Kingdom prepared by JRC are presented in Fig.1. The data refer to the years 1920–2003, therefore JRC, in order to present the asbestos situation in the EU countries, processed and disaggregated the data to the EU countries we know today (in particular, this concerned the Czech Republic and Slovakia, known as Czechoslovakia (1920–1990), Latvia, Lithuania and Estonia - a part of the Soviet Union (1920–1990), and Croatia and Slovenia, which were part of Yugoslavia (1930–1990), as well as Belgium and Luxembourg, and West and East Germany, which are given together).The details can be found in the report (Maduta et al.,2022).

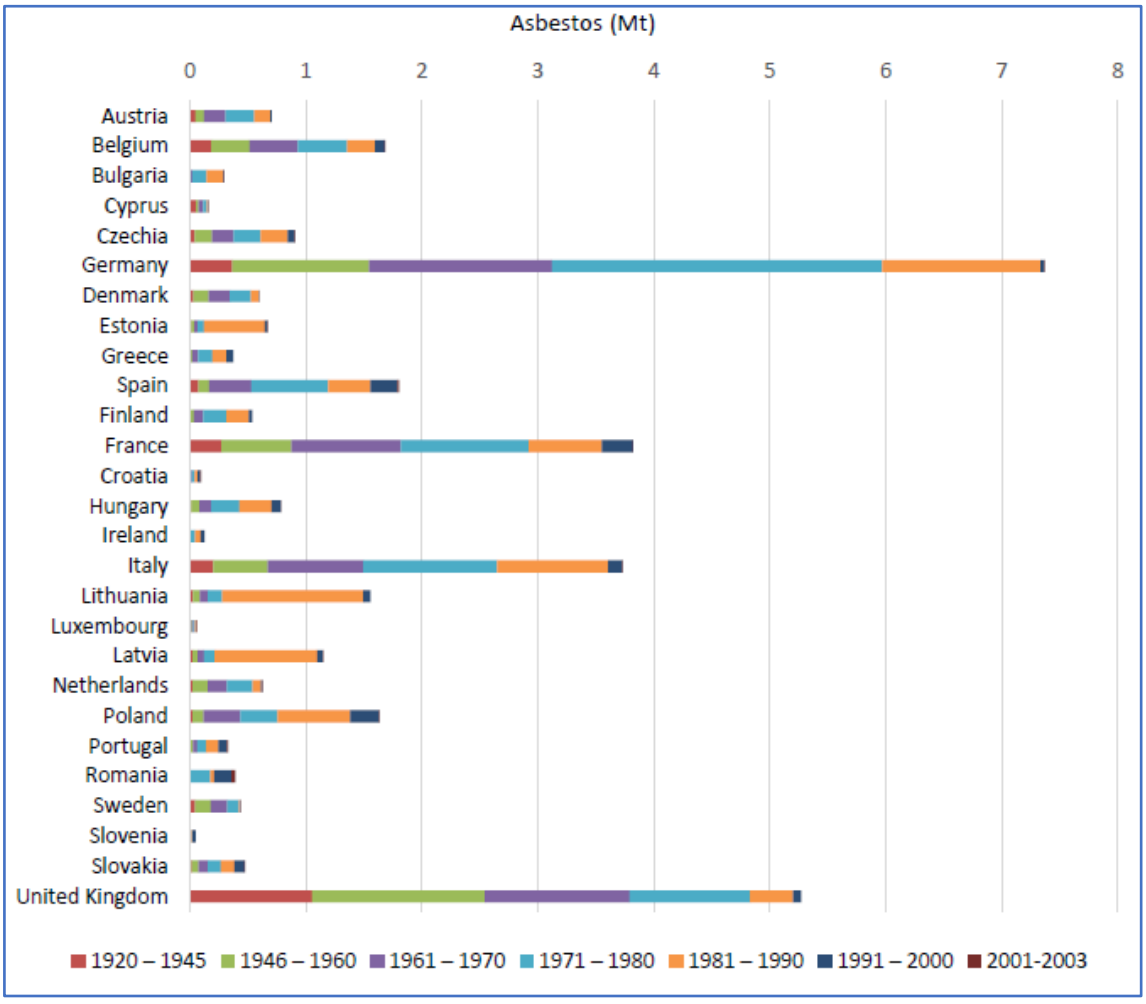

Fig. 1. Estimated asbestos consumption in buildings, EU27+UK, (Maduta et al.,2022)

According to this data (Fig. 1), in the years 2020-2003, the most asbestos was used in Germany, Great Britain, France and Italy. The material was especially popular in the years 1971-1990. It is worth paying attention to the presented in raport data on asbestos

consumption per dwelling (FIg.2). From this perspective, the most unfavorable situation occurs in Cyprus, Latvia, Lithuania, Estonia and Belgium. Asbestos consumption in Cyprus reaches almost 16 kg/dwelling. Cyprus is seen as one of the oldest sources of asbestos and was one of the largest producers of chrysotile asbestos in Europe. The high asbestos use per dwelling for the countries of the former Soviet Union (Latvia, Lithuania) was caused by the development of construction in these areas between 1981 and 1990 (Maduta et al., 2022).Generally, in most EU Member States, buildings built between 1960 and 1990 are at risk of containing higher amounts of asbestos than buildings from other decades.

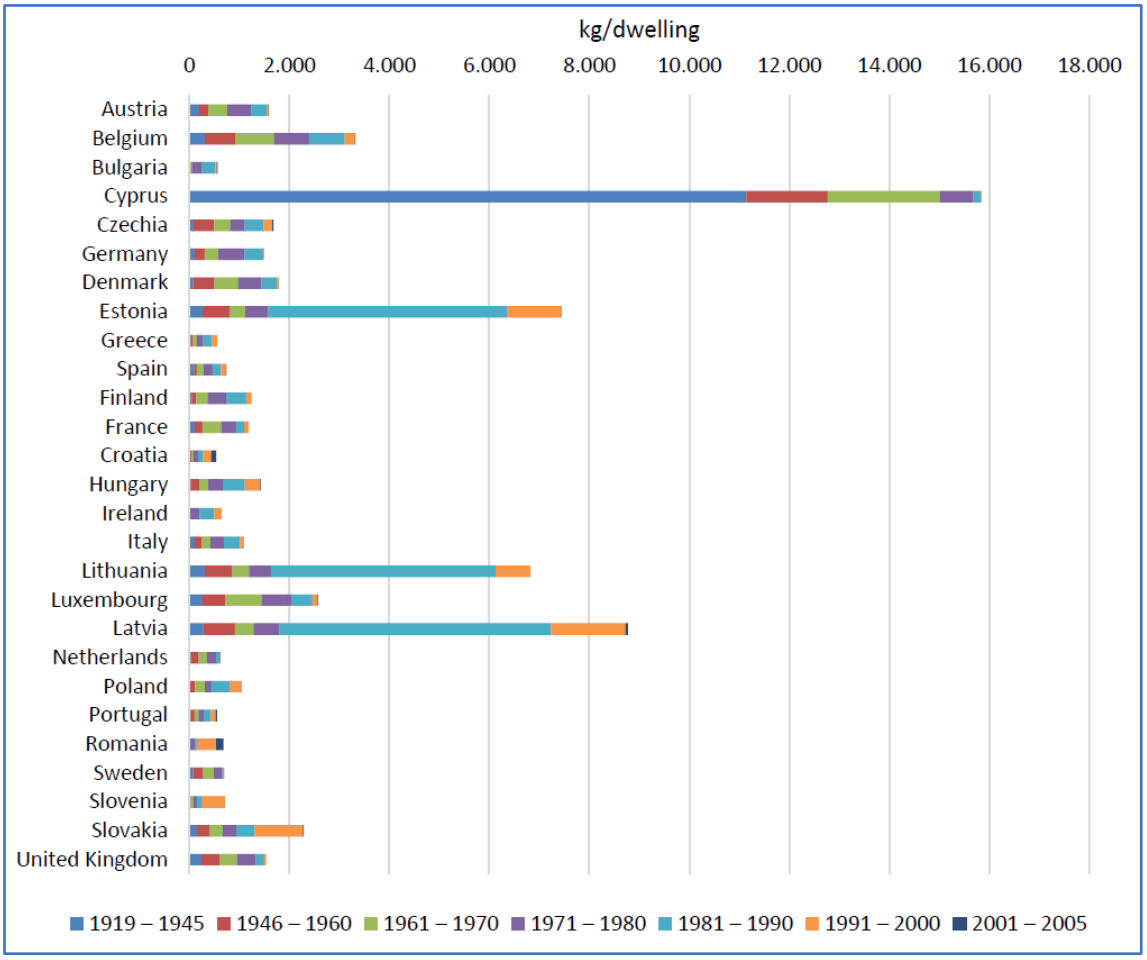

Fig. 2. Estimated asbestos consumption per dwelling, EU27+UK, (Maduta et al.,2022)

In the European Union countries, the building stock is quite old and is subject to gradual, albeit slow modernization, resulting from the need to adapt them mainly to energy efficiency requirements. Many existing buildings contain hazardous asbestos-cement materials that pose a threat to the health of users. These materials should be removed from the buildings during renovation and modernization work. According to the JRC report, the average amount of asbestos per apartment in energy renovation plans at NUTS3 level in individual EU member states is very diverse (Fig.3). In countries such as Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Latvia, Lithuania, Luxembourg and Slovakia, the accumulation of asbestos exceeds 240 kg per apartment. High levels of asbestos are also found in most regions of Central Europe, ranging from 160 to 240 kg

per dwelling. Smaller levels are found in 17 countries, with many regions of Romania, Croatia and Slovenia having less than 60 kg of asbestos per dwelling (Kakoulaki et al., 2023). The regions visible in the figure, where large amounts of asbestos have been built into residential buildings for many years, are exposed to higher concentrations of asbestos fibers both in residential buildings and in the air. Therefore, when planning the renovation of buildings in connection with their adaptation to energy efficiency requirements (NUTS3 level), they should be considered first (Kakoulaki et al., 2023).

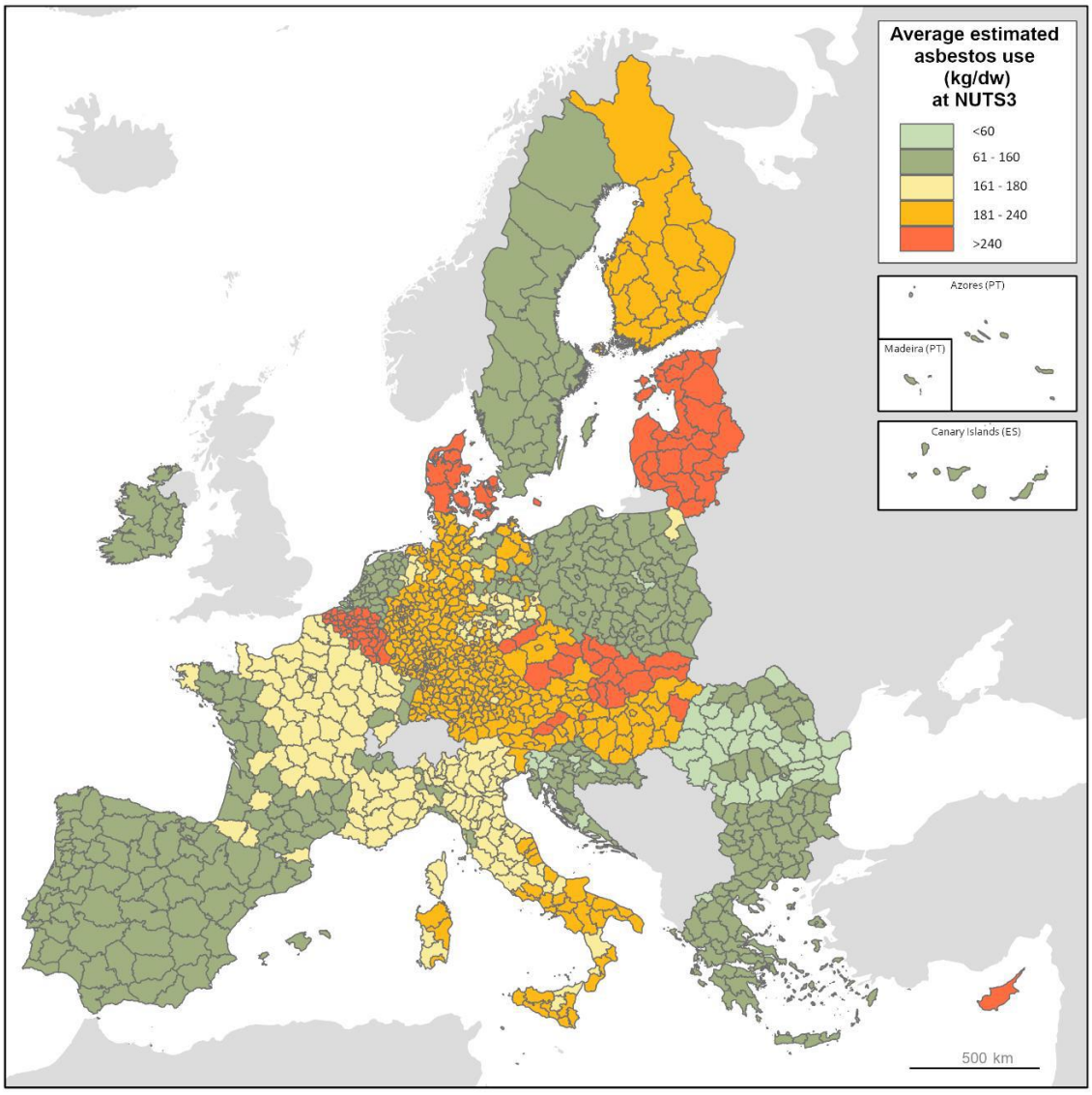

Fig. 3. Estimated average quantity of asbestos in the EU dwellings, energy renovation plans at NUTS3 level, (Kakoulaki et al., 2023)

Renovation of buildings is a chance to get rid of asbestos products that are harmful to users. Considering the financial implications of construction processes, such as the removal of hazardous materials like asbestos, it is essential to analyze long-term cost-effectiveness and the economic impact on regional development. Similar studies highlight the importance of detailed financial analysis in the context of construction projects, as demonstrated by Kalichak et al. (2024) in their assessment of construction processes in

Ukraine. The construction industry has a significant impact on many sectors of the economy, as well as on local jobs and the quality of life of society. It should be emphasized that the construction waste stream constitutes the largest part of industrial waste, therefore there is a key need to search for new circular solutions, especially in the construction sector (Andriulaitytė and Valentukeviciene, 2020). Therefore, every direction of management of used materials containing asbestos should be considered. Unfortunately, the current management of these wastes is limited to their controlled depositing in landfills, which does not ultimately solve the problem of their impact on the environment in the future (Brycht, 2022; Brycht and Ulewicz, 2022). In addition, in Poland, due to the low level of subsidies available for the replacement of asbestos-cement roof coverings, there is low interest in removal of hazardous roofing materials (Ulewicz and Liszewski, 2023). It can therefore be assumed that the introduction of new regulations and the need to increase the energy efficiency of buildings will increase interest in replacing old, hazardous roof coverings.

Currently, Poland is the first and only country in the European Union to have taken up the challenge of phasing out all products containing asbestos. In May 2002, the Council of Ministers adopted a national "Programme for the removal of asbestos and products containing asbestos used in Poland" (M.P. 2009, 50, item 735). Its implementation is planned for the years 2003-2032. Currently, over 8.7 million Mg of products containing asbestos have been identified in Poland, of which only over 1.8 million Mg have been subjected to the process of neutralization, and still over 6.9 million Mg await neutralization. Some asbestos products have not yet been identified and entered into the asbestos database subordinate to the Ministry of Development and Technology. Of the 2,477 Polish municipalities, 2,471 (99.7%) provided data on natural persons and 2,375 (95.8%) on legal persons who own facilities containing asbestos materials (https://bazaazbestowa.gov.pl). According to the report of the Supreme Audit Office, discrepancies in the amount of asbestos contained in the Asbestos Database in relation to the data held by local government units occurred in 18 out of 23 audited communes (which constitutes 78.2%). The statistics of collected data are mostly influenced by the timeliness of sending reports, in extreme cases delays reached almost four years (NIK report, 2022).

4. EFFECTS OF THE IMPACT OF ASBESTOS FIBERS

According to a number of studies (Le et al., 2024; Kameda et al., 2014), asbestos is a dangerous carcinogen that significantly contributes to cancer, especially in people working with materials containing asbestos fibers. It is estimated that in the European Union (except Germany, Portugal, Greece) in 2019, asbestos caused 71,750 deaths due to occupational exposure and is responsible for approximately 78% of occupational cancers diagnosed in this counties (https://ec.europa.eu/eurostat). The data on asbestos-related diseases in 2013-2021, broken down by type of disease and gender are presented in Table 3. In Poland, 3002 cases of occupational diseases were reported in 2023. Pneumoconiosis (caused by coal, asbestos and silica dust) was the second largest group of reported diseases - 578 cases were recorded (19.3% of all occupational pathologies). 195 cases of asbestosis were reported, which constituted 33.7% of diseases caused by dust (Świątkowska and Hanke, 2024).

Table 3
Occupational cancers asbestos related, 2013–2021 in EU* and Switzerland

Occupational cancers asbestos in 2013–2021	
Mesothelioma and lung cancer	
Mesothelioma due to asbestos	13789
Lung cancer due to asbestos	12338
Total mesothelioma	14729
Total lung cancer	14055
Total occupational cancers	28784
Mesothelioma by sex of the victim	
Females	799
Males	10937
(*) Data for DE, EL, PT not available	

Source: (https://ec.europa.eu/eurostat).

The harmful effects of asbestos on human health stem from the inhalation of airborne fibers, which can accumulate in lung tissue over a lifetime. The health risks associated with asbestos exposure are influenced by the extent of fiber penetration and the quantity of fibers retained in the lower respiratory tract. A critical factor in the tumor-inducing potential of these fibers is their physical characteristics, specifically a diameter of less than 3 μm and a length exceeding 5 μm. The asbestos fibers to provoke inflammatory and cancerous responses in lung and pleural tissues, leading to conditions such as asbestosis, various types of cancer, and mesothelioma. Importantly, diseases caused by asbestos exposure often manifest only after prolonged latency periods, spanning years or even decades (Raczko et al., 2022).

4. ASBESTOS WORK SAFETY IN THE CONSTRUCTION SECTOR

In the construction sector, the risk of exposure to asbestos is primarily related to the impact of asbestos fibres dispersed in the air during construction work, i.e. renovation, modernisation and demolition of buildings. Similarly to the management of hydroengineering infrastructure, where a comprehensive approach to assessing the technical condition of structures is crucial (Gavardashvili and Vartanov, 2023), planning the renovation of buildings containing asbestos requires a detailed analysis of technical and environmental risks. In managing renovation processes, particularly when dealing with the removal of hazardous materials like asbestos, the application of modern tools to enhance operational efficiency is crucial. As demonstrated in studies on the implementation of Lean tools in the ceramics industry (Ulewicz et al., 2021), process optimization enables significant cost reductions, quality improvements, and streamlined task execution. Such an approach can be successfully adapted to construction project management to ensure greater efficiency and safety. It is estimated that between 4.1 and 7.3 million workers are exposed to asbestos, of which 97% work in the construction sector, including related professions (i.e. roofers, plumbers, carpenters, floor layers), and 2% in the waste management industry. Therefore, combating exposure to asbestos at work is one of the priorities of the EU Strategic Framework on Health and Safety at Work 2021-2027 (Brussels COM, 2022). The average patient diagnosed with asbestosis as an occupational disease is a person over 65 years of age with at least 15 years of work experience involving exposure to asbestos dust (Świątkowska and Hanke, 2020).The risk of developing cancer from exposure to asbestos fibers depends on the type of asbestos,

the physicochemical properties of the fibers, the period and intensity of exposure, and in some cases also on co-exposure to other carcinogens (e.g. smoking, aromatic hydrocarbons, heavy metals). Studies have clearly shown that the greatest risk of disease occurs in the case of exposure to amphibole fibers, then mixed fibers (amphibole and chrysotile), and finally chrysotile fibers. Scientists agree that the intensity of exposure required to develop mesothelioma may be lower than that required for lung cancer or pulmonary fibrosis (asbestosis) (Rodilla et al., 2022). Therefore, protecting workers in the construction sector from exposure to asbestos is particularly important as the EU implements the European Green Deal, which aims to increase the rate of renovation of buildings, as they account for 36% of greenhouse gas emissions. It is estimated that by 2050, over 85% of existing buildings will need to be renovated in terms of energy efficiency in order to meet the EU's energy efficiency targets. Renovating such a large number of low-energy buildings constructed using asbestos could significantly increase the number of people exposed to the negative effects of asbestos. The number of exposed workers, currently 4.1-7.3 million, is expected to increase by 4% per year over the next 10 years (Brussels, COM 2022).

Therefore, it is worth emphasizing that the European Union is still taking significant steps to limit the negative effects of asbestos exposure.The European Union has taken a significant step to protect workers from the dangers of asbestos exposure. The new Directive EU 2023/2668, amending the previous Directive 2009/148/EC, was adopted on 22 November 2023, focusing on enhancing the safety and health of workers handling asbestos in various sectors, including construction. Taking into account the relevant scientific knowledge, in order to ensure adequate protection of workers, it is necessary to establish revised limit values which, depending on the fibre counting method used in a specific Member State, should be equal to 0.002 fibres per cm^3 when counting fibres with a width of 0.2 to 3 micrometres or 0.01 fibres per cm^3 when counting fibres with a width of less than 0.2 micrometres, as a time-weighted average over an eight-hour reference period (Directive EU 2023/2668).

In the construction sector, asbestos-containing materials have been extensively used in building structures for many years. Despite changes in regulations and significant efforts by investors and engineering staff, it will not be possible to quickly dismantle and safely dispose of all hazardous asbestos-cement materials in buildings across Poland and other EU countries. Given this reality, it is essential to assess the technical condition and potential for continued safe use of structures containing asbestos elements, particularly roofs and facades. Products in poor condition, exhibiting visible damage, should be promptly dismantled and properly disposed of. Conversely, materials not deemed urgent for removal should be safeguarded, for example, through the application of protective coatings using deeply penetrating asbestos-binding agents. These agents must have appropriate technical certifications. Various types of polymer-based facade paints are available on the market, including acrylic, acrylic-silicone, epoxy, and chlorinated rubber options, as well as paints based on silicone resin (Ulewicz, 2023). Bituminous paints can also be applied, with the choice depending on specific requirements and environmental conditions, such as temperature. Regardless of the product selected, it is crucial to ensure thorough surface preparation before beginning work and to adhere strictly to safety protocols during application. Coatings applied to asbestos-cement products effectively seal micropores in the cement structure, thereby significantly reducing the risk of asbestos fiber release.

5. CONCLUSION

The negative impact of asbestos fibers, both free and released from built-in building materials, is known and documented. The ban on the use and use of products containing asbestos is justified, but unfortunately it covers less than half of the countries (71 out of 195) in the world. In the EU countries, the most asbestos is found in construction products, mainly asbestos-cement boards, which will have to be dismantled and disposed of as renovation and modernization works are carried out. Considering their harmfulness, the ban on the extraction of asbestos fibers and the use of products containing them should cover all countries, and ensuring the safety of work with asbestos fibers should be one of the strategic priorities of all countries.

Renovation Wave" strategy, implemented across European Union countries, aims to increase the building renovation rate and provides an opportunity to remove asbestos from older buildings. This initiative will improve energy efficiency as well as the safety and comfort of residents. The new EU Directive 2023/2668 introduces more stringent safety standards for workers handling asbestos, limiting the permissible concentration of asbestos fibers to 0.002 fibers/cm³ for fibers between 0.2 and 3 micrometers and to 0.01 fibers/cm³ for smaller fibers.

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