

INFLUENCE OF PUBLIC FINANCIAL SUPPORT ON THE PROCESS OF ROOF COVERING REPLACEMENT AND SAFETY OF CIVIL STRUCTURES

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Abstract: This article constitutes an analysis of the influence of public financial support on the process of replacement of the asbestos-cement sheets used as a roof covering for materials safe for the environment. Commonly used asbestos-cement sheets, known under the commercial name of „Eternit”, should be removed of civil structures by 2032 following a program established by the Polish state. However, the carried-out analysis indicates that until present times the products containing asbestos have been properly identified in all municipalities across Poland, and also the amount of financial support that a property owner may obtain for removal of products containing asbestos is relatively low comparing to the costs of the roofing replacement. The cost of roof covering replacement falls within the range. 18.417 – 41.232 PLN/m², so for the roof area of 100 m² and considering the simplest roof structure (gable roof) the cost would total between 18.417 and 41.232 PLN. Therefore the existing system of public financial support providing funds for asbestos removal only will not affect the investor’s decision regarding replacement of roof covering and increase of civil structures safety. The replacement process of dangerous Eternit roof covering is slow and most probably the established programmed will not be completed on time.

Keywords: asbestos, asbestos cement sheets, building safety

1. INTRODUCTION

The production of asbestos-containing products, including asbestos-cement sheets commonly used as roofing in civil structures and having a hazardous effect on the human health has been prohibited in Poland by the Act on the prohibition of using products containing asbestos (Law – Journal of Laws, 1997). On the other hand, The European Union has introduced a prohibition on the extraction of asbestos and production and processing of asbestos-containing products by the of 2003/18/WE Directive of European Parliament and the Council dated 27th March 2003, and the absolute ban of asbestos application has been introduced on 1st January 2005 (Directive 1999/77/WE). Unfortunately, before the prohibition on using hazardous products containing asbestos has been introduced, many civil constructions and

buildings had been covered with asbestos-cement sheets that nowadays should be removed to prevent risk for human life and health and environmental threats (Paglietti et al., 2016; Maciołek et al., 2012; Domka, et al., 2001; Wachowski and Domkam, 2000). Until now, Poland is the first and only country in the European Union to undertake the challenge to withdraw all asbestos-containing products out of use.

On 14th May 2002 the Council of Minister adopted the nationwide „Program to remove asbestos and products containing asbestos used on Polish territory”. The Program has been planned for years 2003-2032. In 2008 the Council of Ministers adopted the report on realization of the program in years 2003 to 2007, and the conclusions contained in the report were used guidelines for “Program to rid Poland of asbestos for the years 2009-2032” (Annex to the Resolution No. 39/2010), that was adopted by the resolution of the Council of Ministers and constitutes an update and a follow-up of the first program, created in 2002. The program aims to eliminate negative health and environmental effects caused by asbestos through its gradual removal and neutralization of asbestos-containing waste. Asbestos-containing materials are particularly dangerous to human health as they cause asbestosis and lung cancer, and the harmfulness of products depends on the diameter and length of asbestos fibers used (Bernaciak and Bernaciak, 2016; Toyokuni, 2009). In Poland, the only acceptable form of final disposal of asbestos-containing waste is depositing in hazardous waste landfills or separated, allocated parts of non-hazardous or other types of landfills. Throughout the world, the management of asbestos waste is diversified (Li et al., 2014), and the laboratories perform research on thermal degradation of asbestos-containing materials (Kusiorowski et al., 2013; Gualtieri and Boccaletti, 2011). Research is also carried out on other methods of asbestos waste management (Nam et al., 2014; Plescia et al., 2003; Kozawa et. al., 2010; Gualtieri et. al., 2011). Management methods should be effective and environmentally safe (Ulewicz, 2013; Ulewicz 2016; Krynke and Mielczarek, 2016). It should be emphasized that the mere fact of adaption of the program for years 2009-2032 does not constitute a guarantee of safety for users of the civil structures in which the asbestos-containing materials have been applied. This material should be and disposed of. Unfortunately, the process of roofing replacement is long-lasting and costly, which means that without financial support investors are reluctant to undertake measures to replace the asbestos-cement roof coverings and eliminate this dangerous material.

2. IDENTIFICATION OF ASBESTOS PRODUCTS

In the world, including Poland, asbestos has been widely used since the beginning of the 20th century, mainly as a roofing material for both residential and farm buildings (asbestos-cement sheets), displacing more expensive roofing-tiles. Asbestos was also used to make covering panels – cladding, pipes and connectors, asbestos sealants, woven and plaited tapes, ropes as well as asbestos-cement heat insulation and fittings (Table 1). Asbestos products attracted a lot of interest from investors because they were characterized by high mechanical strength, fire resistance, resistance to atmospheric conditions as well as water and sewage. Additionally, they were inexpensive. Unfortunately, these products are dangerous and should be withdrawn from use. Removal of asbestos-containing products will provide social, economic and environmental benefits, i.e.: reduction of asbestos fibres emission, improvement in the protection of inhabitants health, improvement in the external appearance of constructions and their technical condition.

Table 1
Table of codes for asbestos products and waste

Product code	Type of product containing asbestos	Product waste code	Unit of measure	Conversion to [kg]
W01	Asbestos-cement flat sheets used in construction	17 06 05	m ² , kg	15
W02	Corrugated asbestos cement sheets for building	17 06 05	m ² , kg	15
W03	Asbestos-cement pipes and joints	17 06 05	m ² , kg	40
W04	Spray insulations with asbestos containing agents	17 06 01	m ³ , kg	300
W05	Asbestos-rubber friction products	16 01 11	kg	11.5
W06	Special yarn, processed asbestos fibers (protective fabrics and clothing)	15 02 02	kg	11.5
W07	Asbestos sealants	17 06 01	kg	
W08	Woven and plaited tapes, cords and strings	17 06 01	kg	11.5
W09	Asbestos-rubber products, with the exception of friction products	17 06 01	-	-
W10	Paper, cardboard	17 06 01	m ² , kg	1.5
W11	Other asbestos-containing products, not listed separately			
W11.1	asbestos-cement coverings	17 06 01	m ² , kg	6
W11.2	asbestos-cement building blocks	17 06 01	m ² , kg	15
W11.3	asbestos-cement electrical insulating fittings	16 02 13	kg	-
W11.4	PVC tiles	17 09 03	m ² , kg	5
W11.5	fireproof boards	17 06 01	m ² , kg	20

Source: (Asbestos Database, 2019)

Poland is the only country in Europe that has established a deadline for the removal of asbestos-cement sheets (commercial name Eternit). The limit date for the disposal of asbestos products in Poland was set for 2032 so that products introduced to the market in the last year when they were legal (1997) could be used until the expiry of the guarantee, i.e. for 35 years.

Currently, over 8.2 million Mg (tons) of asbestos-containing products have been identified in ownership of natural and legal persons (Table 2), of which only over 1 million tons have been subjected to the process of disposal, and still more than 7.2 million tons awaits for disposal. Some asbestos products have still not been identified and entered into the asbestos database maintained by the Ministry of Development, which is a free and mandatory IT system for all local government units with the purpose of inventory of asbestos-containing products. For 2477 Polish municipalities, only 2435 municipalities (98%), provided data concerning natural persons and only 2261 communes (91%) provided data concerning legal entities. According to the information collected in the asbestos database, there are significant differences in the accumulation of asbestos products in individual voivodships (Table 3).

Table 2

Mass of all asbestos products, kg

	Total	Natural persons	Legal persons
Inventoried	8 208 722 198	7 487 496 887	721 228 311
Neutralized	1 018 301 130	890 782 763	127 518 367
Remaining for neutralized	7 190 450 032	6 596 740 089	593 709 943

Source: (Asbestos Database, 2019)

Table 3

Quantity of asbestos products by type, kg

No	Voivodeship	Flat panels	Corrugated panels	Cement-asbestos pipes and joints	Other
1	Lower Silesia	29 159	102 469	2668	4624
2	Kuyavia-Pomerania	11 546	467 589	5866	12004
3	Lodzkie	21 763	690 727	8 571	12 063
4	Lublin	102 549	14 296	4 844	7 243
5	Lubusz	5 129	61 251	15 855	3 432
6	Lesser Poland	73 578	266 722	1 862	4 402
7	Masovia	60 364	320 914	14 484	9 671
8	Opole	9 869	60 691	2 981	1 523
9	Subcarpathia	29 663	266 447	1 359	1 744
10	Pomerania	4 176	203 899	12 126	4 718
11	Podlaskie	20 098	493 706	1 528	1 619
12	Silesia	100 176	144 339	1 458	5 934
13	świętokrzyskie	24 773	439 459	1 828	2 900
14	Warmia-Masuria	3 615	191 669	4 166	2 334
15	Greater Poland	16 090	615 754	30 906	21 683
16	West Pomerania	2 988	132 849	3 911	7 175

Source: (Asbestos Database, 2019)

3. PUBLIC FINANCIAL SUPPORT FOR ROOFING REPLACEMENT

The total cost of implementing the Asbestos Removal Program in the years 2009-2032 was estimated at approximately PLN 40.4 billion, which includes own funds of property owners, investors, funds from the state budget and funds of local government units (Annex to the Resolution No. 39/2010). It has been planned that the Ministry of Economy (currently the Ministry of Entrepreneurship and Technology), as a part of the project implementation, would spend PLN 12.8 million on education, information and knowledge improving activities, updating brochures on financing asbestos removal and handling asbestos-containing products as well as organizing national and international conferences in order to exchange experience and know-how on the disposal of these products.

Under the first program in the years 2003–2008, the Ministry of Economy financed educational and information activities in the amount of PLN 3.3 million. Educational and information activities have been and are still financed by local government units, under the adopted program, either from their resources or resources obtained from environmental protection funds. The amount of this funding varies greatly depending on the municipality. The training activities financed as part of this activity are certainly raising the awareness of government and local government employees, children and

youth, as well as groups of professional workers related to asbestos issues, but they will not affect investors' decisions concerning roof covering replacement.

As a part of the national program, local government units could obtain financial support for the development of municipal, poviát and voivodship programs for the removal of asbestos-containing products, in the amount of PLN 1 million in the years 2009-2015. In addition, the Ministry allocated PLN 16.3 million to organize training for local entities authorized to remove asbestos-containing products in years 2010-2032. The program assumes that the municipality should ensure transport of asbestos-containing waste to the landfill, and the cost of such transport and neutralization of asbestos-containing waste should be covered from the municipality's own funds, but with a contribution of the property owners and subsidies and loans from environmental protection funds. Therefore, the municipalities have adapted or are in the process of developing various programs to support the roofing replacement initiative. Table 4 presents the adopted programs for voivodships.

Table 4
Asbestos programs by voivodship

	Voivodeship	Total	Project	Adopted	Realized
1	Lower Silesia	79	23	33	23
2	Kuyavia-Pomerania	76	11	32	33
3	Lublin	77	4	27	46
4	Lubusz	40	3	19	18
5	Lodzkie	69	25	27	17
6	Lesser Poland	96	39	30	27
7	Masovia	150	30	56	64
8	Opole	37	5	16	16
9	Subcarpathia	71	18	29	24
10	Podlaskie	55	7	30	28
11	Pomerania	70	4	32	34
12	Silesia	91	28	40	23
13	Swietokrzyskie	53	12	21	20
14	Warmia-Masuria	66	11	33	22
15	Greater Poland	75	19	29	27
16	West Pomerania	39	5	14	20
		1144	244	458	442

Source: (Asbestos Database, 2019)

Programs that include organizing disassembly, cleaning up the property area and transporting the asbestos-containing waste from the municipality and poviát to the landfill are financed from the municipality's own resources or with the participation of funds from the NFEPWM (National Fund for Environmental Protection and Water Management). Environment Protection Bank (BOŚ S.A) and Voivodship Fund for Environmental Protection and Water Management (WFOŚiGW) have also launched soft loans for all voivodships in Poland to enhance asbestos-containing products removal and thermo-modernization of buildings and civil structures. Property owners who plan to remove asbestos products may apply for a subsidy for the disassembly, transport and disposal of asbestos products, but the cost of new roofing and facade coverings will always be on their part. It is estimated that the cost of removing asbestos-

containing products incurred by property owners would amount to PLN 40 billion, taking into account all possible forms of financial support.

4. ANALYSIS OF ROOFING REPLACEMENT COSTS

The overall cost of replacing the asbestos-cement roof covering with an environmentally safe roof consists of the cost of disassembly, storing the resulting waste at the disassembly site, transporting secured waste and its disposal, as well as the cost of the new roof purchase and assembly at the construction site.

For the purpose of this article, the costs of removing asbestos products have been estimated based on data provided by specialized companies that provide comprehensive services for dismantling asbestos-containing products and removing asbestos waste. The data obtained shows that the price for disassembly of Eternit, including transport and utilization of asbestos to a landfill for 1 ton, ranges from PLN 950 to PLN 1,500 + VAT (www.azbest.co/cennikdemontazu.pdf).

This cost depends on many factors, including the location of asbestos products, the height of the object, the type and number of elements to be dismantled, and the distance from the landfill. Investors who want to replace the roofing and take advantage of the eternit utilization subsidies must take into account the expenses related to the installation of the new roof because they are not covered by the subsidy.

In buildings which are over 30 years old, this usually involves the necessity to check the condition of the roof truss and its load-bearing capacity. The condition of the rafter framing will determine the type of roof covering that can be made on a given structure. Before choosing the roofing material, you need to estimate the costs. Due to the lack of unambiguous and binding rules in the scope of preparing quotations of construction works, proven, well-established and widely used solutions in the construction industry are used to estimate the investment cost during the planning phase and to secure funds for the investment implementation

An example of the above-mentioned solutions is normative studies that determine the consumption of labour, material and equipment, such as KNR, KNNR and KSNR (official catalogues of outlays in-kind used to prepare cost estimates by investors). For the subject analysis, KNNR catalogues were used, and checking the correctness of calculations was based on the Catalogs of Combined Material Expenditures (KSNR). The following assumptions were presented for the analysis of unit costs for 1.00 m² considering the scope of works as dismantling the existing roof, making a new rafter framing structure and with one of several possible types of roof coverings:

- simple gable roof with collar beam structure, roof covering with plan tiles, double covering,
- simple gable roof with collar beam structure, roof covering with roofing sheets,
- simple gable roof with collar beam structure, roof covering with trapezoidal sheets,
- simple gable roof with collar beam structure, roof covering with heat-weldable roofing paper.

Following cost factors at the level of 2nd quarter of 2019 were considered to develop possible rafter framing and roof covering variants:

- Indirect costs K_p (R, S) – 65%,
- Calculated profit Z (K_p , R, S) – 12%,
- Man-hour R – 15,50 zł PLN,
- Material M – average market price including purchase K_z and delivery,

- Equipment S – average market price,
- Taxation: VAT – 8%,
- Rounding to the nearest – 0.01.

Following technical assumptions were made that may affect the calculated values:

- Average labour/man-hour expenditures,
- Average equipment operation time expenditures,
- Average quality of used materials,
- Rational and economical project management, including using modern equipment.

Numerical calculations were carried out using computer software called "Zuzia (C) DataComp" (license No. 4693), supporting the cost estimation process and operating on a fixed algorithm based on the KNNR and KSNR catalogues. The obtained results are presented in Table 5. At the same time, based on additional analysis of the RMS (labour, material, equipment) expenditures values affecting unit cost in the case of multi-hipped roofs, the adjustment of the unit price increase by 18.42% for variants 1 and 2 and the correction of the increase in unit price value by 12.67% for variants 3 and 4 should be taken into account (Table 6).

Table 5

Four variations of estimated costs of rafter framing structure dismantling and new roofing installation, gross amounts including 8%VAT

Variation	Rafter framing structure and roof covering	The cost of 1 m ² zł PLN	The cost of a roof with an area 100 m ²
Variation 1	A simple gable roof with collar beam structure, roof covering with plain tiles, double covering	412.32 zł/ m ²	41 232 zł PLN
Variation 2	A simple gable roof with collar beam structure, roof covering with roofing sheets	275.16 zł/ m ²	27 516 zł PLN
Variation 3	A simple gable roof with collar beam structure, roof covering with trapezoidal sheets	256.11 zł/ m ²	25 611 zł PLN
Variation 4	A simple gable roof with collar beam structure, roof covering with heat-weldable roofing paper.	184.17 zł/ m ²	18 417 zł PLN

Table 6

Four variations of estimated costs of rafter framing structure dismantling and new complicated roofing installation, gross amounts including 8%VAT

Variation	Rafter framing structure and roof covering	The cost of 1 m ² of roof (in zł PLN)	The cost of a roof with an area 100 m ²
Variation 1	Complicated, multi-hipped roof with purlin structure, roof covering with plan tiles, double covering	$412.32 \text{ zł/m}^2 \times 1.1842 =$ 488.27 zł/ m²	48 827 zł PLN
Variation 2	Complicated, multi-hipped roof with purlin structure, roof covering with plan tiles, double covering	$275.16 \text{ zł/m}^2 \times 1.1842 =$ 325.84 zł/ m²	32 584 zł PLN

Variation 3	Complicated, multi-hipped roof with purlin structure, roof covering with trapezoidal sheets	$256.11 \text{ zł/m}^2 \times 1.1267 =$ 288.56 zł/ m²	28 856 zł PLN
Variation 4	Complicated, multi-hipped roof with purlin structure, roof covering with heat-weldable roofing paper.	$184.17 \text{ zł/m}^2 \times 1.1267 =$ 207.50 zł/ m²	20 750 zł PLN

Depending on the voivodship, the amount of funding for asbestos removal ranges from 60 to 100% of the costs incurred for dismantling and utilizing asbestos. The investor receives a refund only after completion of the works, to which he must allocate own funds and upon presentation of documents confirming the legal removal of asbestos. Considering that the weight of a 100 m² roof covering is on average 1.5-2.5 tons, and for 1 ton you have to pay between 950 and 1500 PLN + 8% VAT, the cost of removing eternit from the roof ranges from 1,539 to 4,050 PLN. In a municipality where only 60% funding can be obtained, the investor must take into account that the cost of purchasing and installing a new roof covering must also include the cost of dismantling, exporting and utilizing eternit in the amount of PLN 615.60 to 1620. Thus, the amount of public financial support is insufficient incentive for the investor who, assuming the cheapest variant (i.e. gable roof with a collar beam structure and covering with heat-weldable roofing paper) needs PLN 18,417 for this investment. If the building is covered with a complicated, multi-hipped roof with a purlin structure, the investor must spend PLN 20,750 for the cheapest roof covering with heat-welded roofing felt. A significantly higher investment (PLN 41,232) must be borne by the investor if they decided to cover the roof with plain tiles (double covering). This cost would increase further to PLN 48,827 in case of a complicated, multi-hipped roof with a purlin structure

5. CONCLUSION

The above analysis shows that the costs of replacing the asbestos roof covering with an environmentally safe one, carried out for a house with an area of 100 m², is very high (PLN 18,417 – 48,827), and the financial support for the removal of asbestos is low. It should be emphasized that the cost of replacing the roofing increases significantly together following the increase in the size of the roof surface, and the investor often, in addition to replacing the roofing on a residential building, must consider replacing the roofing on farm buildings, since most often this material was used in rural areas. Thus, the current level of financial support for the replacement of roofing materials is insufficient to enhance deciding on the implementation of such an investment, and the rate of replacement of roofing materials is low. In conclusion: without changing the level of support "Asbestos Removal Program 2009-2032" will not be implemented nor completed on time.

REFERENCES

- Annex to the Resolution No. 39/2010 of the Council of Ministers of 15 March 2010 - Programme for asbestos abatement in Poland 2009-2032.
- Asbestos database. Available online: <https://www.bazaazbestowa.gov.pl/en/> (accessed on 10 November 2019).

- Bernaciak, A., Bernaciak, A., 2016. *The efficiency of systemic solutions for the removal of asbestos in Poland – current status and prospects*, Economic and Environmental Studies, 16, 787-801.
- Domka, L., Domka, L., Kozak, M., 2001. *Utilization of asbestos wastes*, Physicochemical Problems of Mineral Processing, 35, 83-90.
- Gualtieri, A., F., Giacobbe, C., Sardisco, L., Saraceno, M., Gualtieri, M. L., Lusvardi, G., Cavenati, C., Zanatto, I., 2011. *Recycling of the product of thermal inertization of cement-asbestos for various industrial application*, Waste Manage, 31, 91–100.
- Gualtieri, A., Boccaletti, M., 2011. *Recycling of the product of thermal inertization of cement-asbestos for the production of concrete*, Constr. Build. Mater., 25, 3561–3569. doi.org/10.1016/j.wasman.2010.07.006
- Kozawa, T., Onda, A., Yanagisawa, K., Chiba, O., Ishiwara, H., Takanami, T., 2010. *Thermal-decomposition of chrysotile-containing wastes in a water vapor atmosphere*, J. Ceram Soc. Jpn., 118, 1199–1201. DOI: 10.2109/jcersj2.118.1199
- Krynke, M., Mielczarek, K., 2016. *Problems concerning product quality enhancement*, Production Engineering Archives, 10, 17-20. DOI: 10.30657/pea.2016.10.05
- Kusiorowski, R., Zaremba, T., Piotrowski J., Gerle A., 2013. *Thermal decomposition of asbestos-containing materials*, J. Therm. Anal. Calorim., 113, 179–188. DOI 10.1007/s10973-013-3038-y.
- Law from 19 June 1997 on the prohibition of the use of asbestos-containing products (Dz. U. 1997, 101, poz. 628).
- Li, J., Dong, Q., Yu, K., Liu, L., 2014. *Asbestos and asbestos waste management in the Asian-Pacific region: Trends, challenges and solutions*, J. Clean. Prod., 81, 218-226.
- Maciołek, H., Zielińska, A., Domarecki, T., 2012. *The impact of asbestos on people and the environment*, Journal of Ecology and Health, 16, 112-119.
- Nam, S. N., Jeong, S., Lim, H., 2014. *Thermochemical destruction of asbestos-containing roofing slate and the feasibility of using recycled waste sulfuric acid*, J. Hazard. Mater., 265, 151-157.
- Paglietti, F., Malinconico, S., Conestabile della Staffa, B., Bellagamba, S., De Simone, P., 2016. *Classification and management of asbestos-containing waste: European legislation and the Italian experience*, Waste Manag., 50, 130-150.
- Plescia, P., Gizzi, D., Benedetti, S., Camilucci, L., Fanizza, C., De Simone, P., Paglietti, F., 2003. *Mechanochemical treatment to recycling asbestos-containing waste*. Waste Manag., 23, 209-218.
- Toyokuni, S., 2009. *Mechanisms of asbestos -Induced carcinogenesis*, Ngoya J. Med. Sci., 71, 1-10.
- Ulewicz, R., 2016. *Quality management system operation in the woodworking industry*, The Path Forward for Wood Products: A Global Perspective - Proceedings of Scientific Papers, 51-56.
- Ulewicz, R., 2013. *Effectiveness assessment of functioning of quality assurance system*, Production Engineering Archives, 1, 38-40. DOI: 10.30657/pea.2013.01.12.
- Wachowski, L., Domka L., 2000. *Sources and effects of asbestos and other mineral fibres presence in ambient air*, Pol. J. Environ. Stud., 9, 443-454.