

INTERNATIONAL SOCIETY FOR SOIL MECHANICS AND GEOTECHNICAL ENGINEERING



This paper was downloaded from the Online Library of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). The library is available here:

<https://www.issmge.org/publications/online-library>

This is an open-access database that archives thousands of papers published under the Auspices of the ISSMGE and maintained by the Innovation and Development Committee of ISSMGE.

Contamination of made grounds

Pollution des remblais

Krzysztof Traczyński

Geotest Sp. z o.o. / Warsaw University of Technology, Poland

ABSTRACT: In cities the surface layers are built of made grounds. Traces of ancient civilisations are often found several meters or several dozen meters below the surface of the ground. Made grounds of significant thickness were formed as a result of warfare operations during World War II. A lot of Polish cities were bombed by the German troops but also by the Russian forces crossing Poland during the march to Berlin. In Warsaw, 84 per cent of the left-bank part of the city was devastated. 20 million cubic meters debris had to be removed from the demolished city. In the first weeks of the war the Nazis destroyed industrial facilities advertently. Bomb attacks reached chemical factories, metal works, gas plants, tanneries, etc. Not only did massive bombs demolish buildings but also formed large craters in the ground. During the construction of the second line of the Warsaw underground a heavy shell "Karl" was found at the depth of 6 metres below ground level. During the bomb raids contaminants were easily transferred to the ground. The fact is confirmed by the tests conducted in accordance with the new legal regulations. Much of the tested made grounds is polluted and needs decontamination.

RÉSUMÉ: Dans les villes les remblais construisent une couche de surface. Les remblais de grande épaisseur ont été créés par suite des actes de guerre durant la deuxième guerre mondiale. Plusieurs ville étaient bombardées par les armées allemandes, mais aussi par les troupes de soldats russes passant par la Pologne dans leur marche sur Berlin. A Varsovie 84 pourcents des constructions sur la rive gauche de la capitale ont été détruites. Il fallait enlever de la ville détruite 20 millions de mètres cubes de gravats.

Pendant les premières semaines de la guerre les hitlériens démolissaient délibérément des sites industriels. Sous une pluie de bombes se sont effondrés des usines chimiques, des établissements métallurgiques, des usines à gaz, des tanneries etc. Les grandes bombes non seulement détruisaient les bâtiments, mais aussi ont créé des entonnoirs profonds dans la surface. Pendant les travaux de construction de la II^{ème} ligne de métro à Varsovie on a déterré un obus d'artillerie lourd « Karl » qui s'est trouvé six mètres en dessous de la surface.

Durant les bombardements les pollutions ont pénétré facilement la couche. Ce fait est confirmé par des études réalisées selon les nouveaux actes législatifs. Une grande partie des remblais est polluée et exige une décontamination.

Keywords: contamination, remediation

1 DESTRUCTION OF WARSAW DURING SECOND WORLD WAR

The Second World War began on September 1, 1939. From the dawn German planes started dropping bombs on the capital of Poland – Warsaw. During the carpet raid carried out on 25 September, 630 tons of destructive and

incendiary bombs were dropped on the city. More than 200 fires broke out. About 10 thousand citizens died and 35 thousand were wounded. Three days later, the capitulation was announced. The Germans entered Warsaw and the time of the occupation began. In August 1944 an uprising broke out in Warsaw. For 63 days the soldiers of the underground army fought with the

overwhelming enemy forces. Every day the guerrilla positions were bombarded with airplanes and fired at with cannons. The city turned into a sea of ruins. Three months after the fall of the uprising, the Soviet Army entered Warsaw. Warsaw started returning to life gradually. The first task was to clear the capital out of unexploded shells and transport the rubble out of the city. It was necessary to remove about 20 million cubic meters of rubble. This volume is the equivalent of 90 10-storey buildings of the same dimensions as a football pitch. In Warsaw, 84 percent of the left-bank part of the capital was destroyed. Material from the demolished city was stored in various, specifically designated areas for this purpose. The new residential district of Muranów was built on the ruins of the ghetto. The area was raised nearly by 2 meters.

The calculations that have been carried out show that the total material damage suffered by the city and its inhabitants amounts to 54.6 billion dollars, of which 2.8 billion were industrial assets. In 1939 Warsaw had 2940 factories employing 101,000 people. 75 percent of the industry was destroyed (Falkowski, 2005).

Although 74 years have passed since the end of the war, we can still find the effects of the war efforts. In 2012, during the construction of the second metro line in Warsaw, a 2-tonne Karl missile was excavated in the city centre at a depth of 6.0 metres. Fortunately, it was safely taken out of the city and disarmed.



Figure 1. Karl missile discovered in the excavation

The layers of ground beneath the surface hide not only unexploded shells but also numerous contaminants which entered the ground during bombardments, artillery fire, but also later when the ruins were being cleaned up. Most of the



Figure 2. Warsaw in 1945



unexploded shells were removed, but the contaminants remained.

2 SOIL CONTAMINATION AT OBOZOWA STREET IN WARSAW

In 2016, the law was changed in Poland and new *Figure 3. Obozowa Street in 1935, 1945 and 2016*

rules of sampling for pollution testing were introduced^[1]. Prior to its introduction to the survey, samples were taken from the surface of

the area from a depth of 0 - 0.30 m, and also from greater depths from places where pollutants could accumulate. One of the places is the soil zone lying above the groundwater level or above an impermeable soil layer. This is the way that the research was carried out for the planned residential investment at Obozowa Street in Warsaw. The Chemical Plant, "K. Zawadzki i

Ska" producing pure salts of noble elements, crystalline and melted silver nitrate, colloidal silver, silver chloride, bromine and iodine

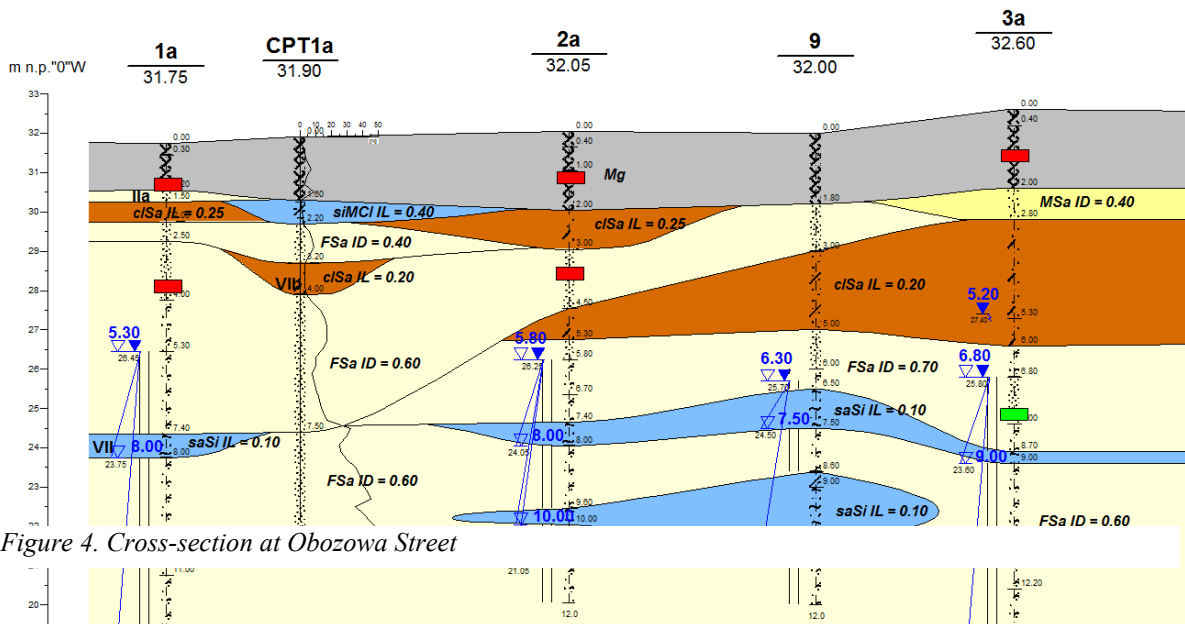


Figure 4. Cross-section at Obozowa Street

formulas, has been operating on this plot since the 20s of the last century. The plant was destroyed during the war. After the war, there was a production plant opened in newly built buildings – it produced TV sets. At the beginning of the 21st century, the plant ceased to operate. On the site, there was a residential building with one level of underground garages planned to be built. Zoological research was carried out before the commencement of construction. 17 soil samples were examined. In three wells, exceedances of barium, lead, oil, sum of petrol and ethylbenzene, xylene and toluene from the BETEX group were discovered^[2].

Because of the research, a soil remediation plan was developed. When the trenching was started, the soil of a highly irritating smell was found. The construction was suspended and additional tests, which revealed the presence of substances with concentrations and quantities exceeding quality standards were carried out. A new remediation plan was prepared.

In the first stage, the air was sucked out of the ground with pumps, fitted with active carbon filters. This work lasted for a month. Then a huge tent was set up in the part of the plot where the greatest contamination was found. Trucks entering the tent were loaded with the contaminated soil. The air from the tents was sucked out with the vacuum pumps. The land was transported to a special hazardous material storage site located 150 kilometres from Warsaw.

Discovering significant amounts of contaminated land held up the construction and extended the construction time by several months. The investor incurred significant unforeseen cost before the commencement of construction.

3 SOIL CONTAMINATION AT OBJAZDOWA STREET IN WARSAW

According to the new rules, research on a plot of land located at Objazdowa Street was carried out. Before the war, there was a "Drucianka"

factory created by the Belgian Joint Stock Company of the Warsaw Wire, Sticks and Nails Factory. During the war, the factory was destroyed in 60 percent. Post-war photographs show the destroyed buildings and bomb craters. The factory was rebuilt, and production restarted. Over the years, the factory stopped working and the whole area was used for housing construction.

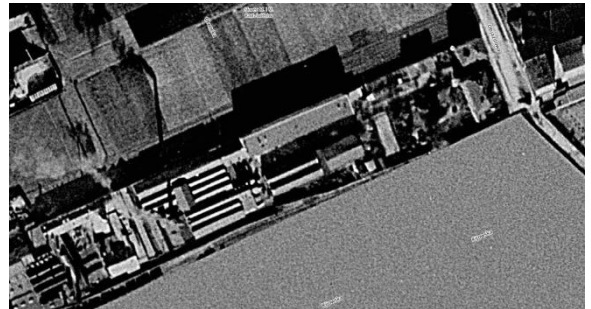


Figure 5. Objazdowa Street in 1935



Figure 6. Objazdowa Street in 1945

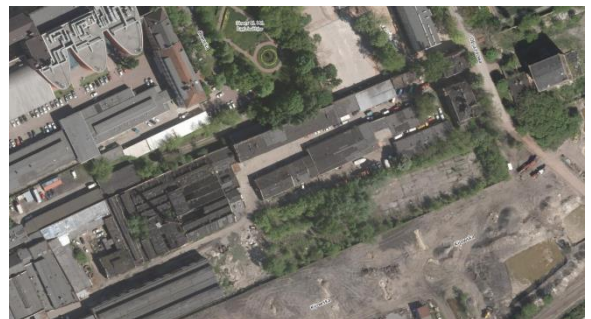


Figure 7. Objazdowa Street in 2016

The purchaser of the plot of land has carried out sozological research. In accordance with the new regulations from 2016, the area was divided into sections, and samples were taken from each section, with special attention paid to anthropogenic soils. In the area of 4.1 ha, a large part of which was covered with old factory buildings, 44 samples were taken, of which 11 were surface samples and 33 plunge samples. The anthropogenic land on the plot reached

the depth of 1.60 - 2.30 m below ground level. The samples were mainly contaminated with cadmium, lead, barium and arsenic. Samples taken from loose soil were polluted. Only one sample of native soil was characterized by values higher than acceptable. Detailed research made it possible to determine the areas of land intended for remediation. The amount of contaminated soil was estimated at 22.6 thousand tons^[3].

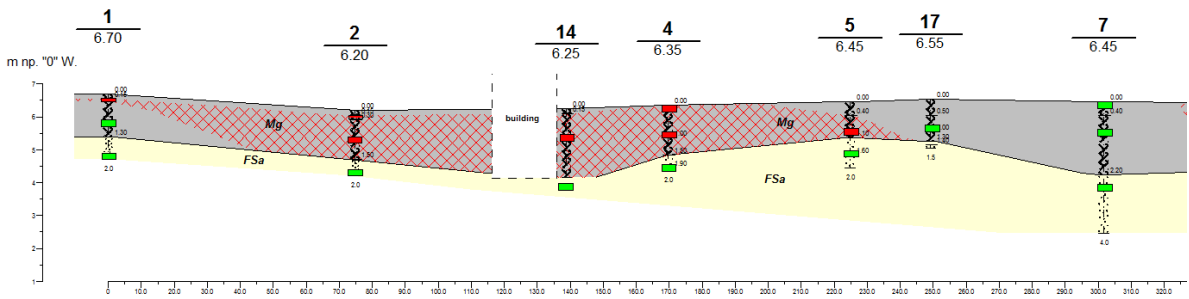


Figure 8. Cross-section at Objazdowa Street



Figure 9. Map of soil quality at depth of 0.25 m below ground level or lower, Objazdowa Street

4 CONCLUSIONS

In cities destroyed during warfare, there is not only the risk of unexploded shells present, but in particular - environmental pollution risk.

Thorough research should be carried out, particularly in the areas of destroyed industrial plants, chemical factories, landfills and warehouses.

Increased attention should be paid to anthropogenic land, which is the main location for the occurrence of pollution.

5 REFERENCES

Falkowski, Wojciech (editor). 2005. *Straty Warszawy 1939-1945. Raport*, Miasto Stołeczne Warszawa, Warsaw

[1] Dziennik Ustaw Rzeczypospolitej Polskiej Poz. 1395, Rozporządzenie Ministra Środowiska z dnia 1.09.2016 w sprawie sposobu prowadzenia oceny zanieczyszczenia ziemi (*Journal of Laws of Republic of Poland, Pos. 1395, Regulation of the Minister of the Environment from 1.09.2016 on the assessment of soil pollution*)

[2] Badanie i ocena stanu zanieczyszczenia gruntu, znajdującego się na terenie działki w Warszawie przy ul. Obozowej (*Examination and assessment of the condition of soil pollution, located at Obozowa Street in Warsaw*), ZBG Geotest, June 2013

[3] Dokumentacja badań wstępnych i szczegółowych, określająca stan jakości gruntu – etapy I-V na terenie zlokalizowanym w Warszawie przy ul. Objazdowej 1 (*Documentation of preliminary and detailed tests, defining the quality of the ground – stages 1-4 in the area located at 1st Objazdowa Street in Warsaw*), Geotest Sp. z o.o., Warsaw 2018

Figures' sources:

Figure 1. Photo by Dariusz Borowicz for *Gazeta Wyborcza*, <http://bi.gazeta.pl/im/4/11114/z11114494V,Wydobycie-bomby-z-wykopu-metra.jpg> [28.10.2018]

Figures 2, 3, 5, 6, 7. Official Map of Warsaw, <http://www.mapa.um.warszawa.pl/> [28.10.2018]

Figures 4, 8, 9. Own sources of Geotest Sp. z o.o., 2013 and 2018