HUESKER

Case history

# Motorway A1 in Poland

## Pyrzowice – Piekary Śląskie – Maciejów

**HUESKER has successfully completed the biggest geosynthetic project in the history of the company**

*Fig. 1: General view on one section of the A1 motorway under construction, Poland*

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## Introduction

A geosynthetic milestone project has just been completed by HUESKER and their partner in Poland INORA. A variety of high strength geosynthetics manufactured by HUESKER were delivered for the construction of the new motorway A1 in Poland. Two sections of this motorway pass through old mining area and this involves the risk of terrain subsidence, sinkholes, faults or other forms of deformation, which cannot be cartographically registered or predicted. Hence, bridging of sinkholes or faults is a major challenge when performing such construction. High strength HUESKER geosynthetics made of Aramid in combination with a sophisticated monitoring system prevents unacceptable deformations so to ensure traffic safety on the highway. Additionally there was also a large quantity of geosynthetics used for separation, slope reinforcement and erosion control.

## The Project

The motorway A1 in Poland will be the main highway running from north to south all the way through central Poland. It stretches from Gdansk on the Baltic Sea through Łódź and the 'Silesian Industry' area around Gliwice to the Polish-Czech border in Gorzyczki, where it will connect with the Czech motorway D1. The total length of the motorway is planned to be 565 km.


Fig. 2: Alignment of the motorway A1 in Poland


Fig. 3: Section Pyrzowice - Piekary Śląskie – Maciejów at Katowice

Fig. 4: Surface deformation due to mining activity, DK 44, Poland

Fig. 5: Deformations forming differential movements, DK 44 Poland

The first section from Gdansk to Grudziądz has been constructed between 2005-2008 and the last sections are planned to be upgraded by 2015. The majority of the A1, however, is to be finished by the spring of 2012, in time for Euro 2012 football championships.
Parts of the Motorway A1 are running through the Upper Silesian Industry area which is characterized by extensive underground mining activities dating back from the early 19th century up to today. The recent mining activities have led to a number of severe deformations on the ground surface as can be clearly seen on the existing infrastructure in the region.

## Geotechnical Situation

Due to this extensive mining activity, the existing ground conditions have proven to be very difficult for the construction of the motorway over this terrain. The faults and surface deformations (Fig. 4 & 5) due to the active mining are only one potential threat however to the stability and long term performance of the motorway. The second and most critical being considered old mining shafts and unstable mining chambers from the early mining activities which are not documented. These cavities date back to the early 19th century and were in danger of collapsing during construction and operation of the motorway. The collapse of such an underground cavity would eventually reach the surface and form a sinkhole in the motorway (Fig. 6 & 7).

*Fig. 6: Sinkhole forming during construction*

*Fig. 7: Sinkhole forming during construction*

The formation of sinkholes in the motorway is of course a severe risk to its stability and traffic safety. Therefore these special ground conditions had to be addressed accordingly in the design.

## The solution

Within two sections, amounting to approximately 36 km in total, the potential sinkhole and deformation areas have been identified and grouped into four categories. Structure no. 1 is least critical due to the lowest intensity of mining activity and thus the smallest associated risk of sinkholes and deformations. Structure no. 4 presents the highest risk of sinkholes or faults and also the biggest potential size of deformation which can occur. The design consists of conventional stability analysis of the embankment with the check of safety against deep sliding (Fig. 8).

The analysis of the complex geological situation in the design being based on a potential sinkhole diameter of 6 m and a maximum vertical fault height of 0.2 m. These deformations occurring under the embankment have to be bridged by the reinforcing system for a period of 90 days ensuring a safe and controlled traffic flow until the necessary remediation measures can be performed.

The potential diameters of sinkholes, however, are extremely difficult to predict due to the complex geotechnical situation. Therefore the project owner decided to use a combination of discrete interlinked concrete slabs and high strength **Fortrac®** geogrids for securing the motorway together with a sophisticated monitoring system. The details of this system in structure no. 4 areas are shown in the illustration (Fig. 9).

A multilayer overbridging system is selected for the protection of the motorway against sinkholes and faults or steps in the base of embankment. The first monitoring level is installed at the embankment base in the

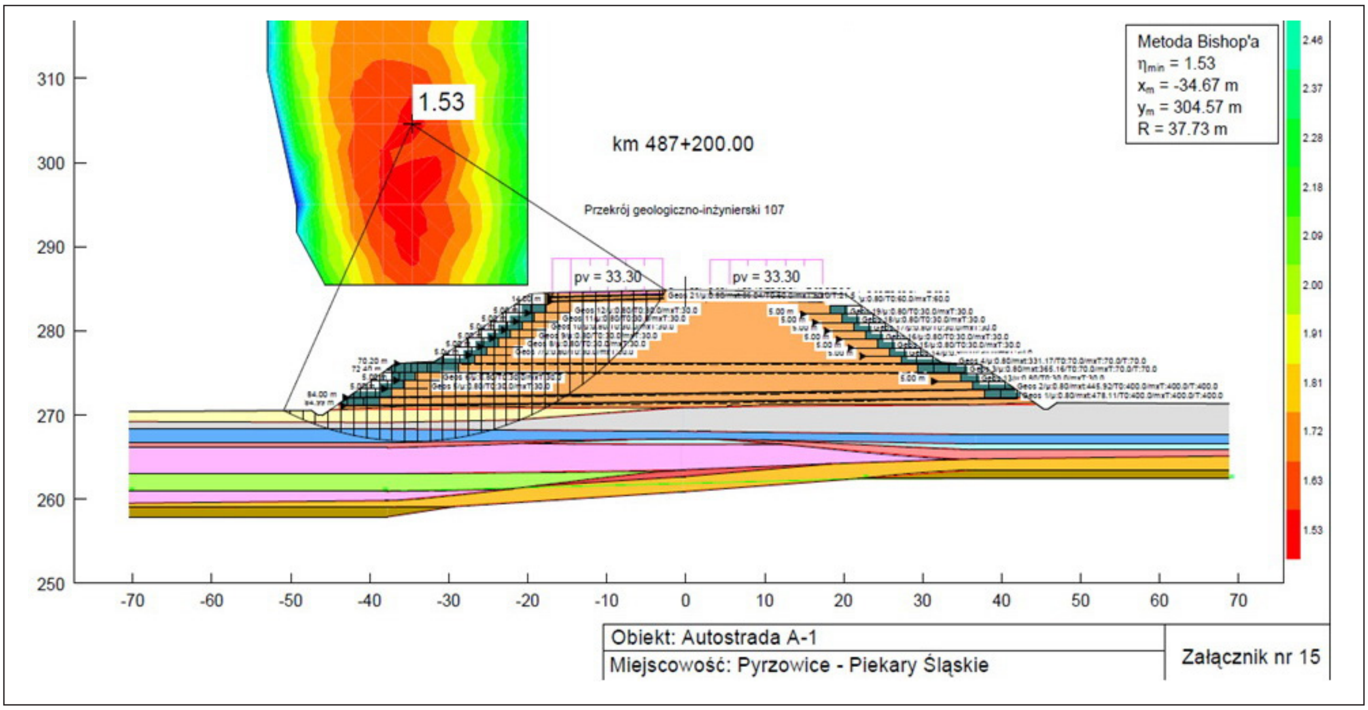


*Fig. 8: Design, check of global stability of motorway embankment, Bishop´s method*

form of diagonally placed measurement wires to detect, locate and measure deformations forming under the embankment (Fig. 10). This layer is followed by a 6 cm sand levelling layer and 20 cm crushed stone layer (0/63 mm), which both act on the first monitoring system as a ballast layer. Above this sandwich a 14 cm thick continuous mattress of discrete reinforced concrete slabs (130x130 cm) which are interlinked together.

The mattress of concrete slabs is then followed by two soil layers: 20 cm crushed stone layer (0/63 mm) and 20 cm round shaped gravel layer. Especially, the upper layer should act as self-levelling layer due to its round shaped grains. On the levelling layer a high strength **Fortrac®** geogrid system is then installed in four layers,

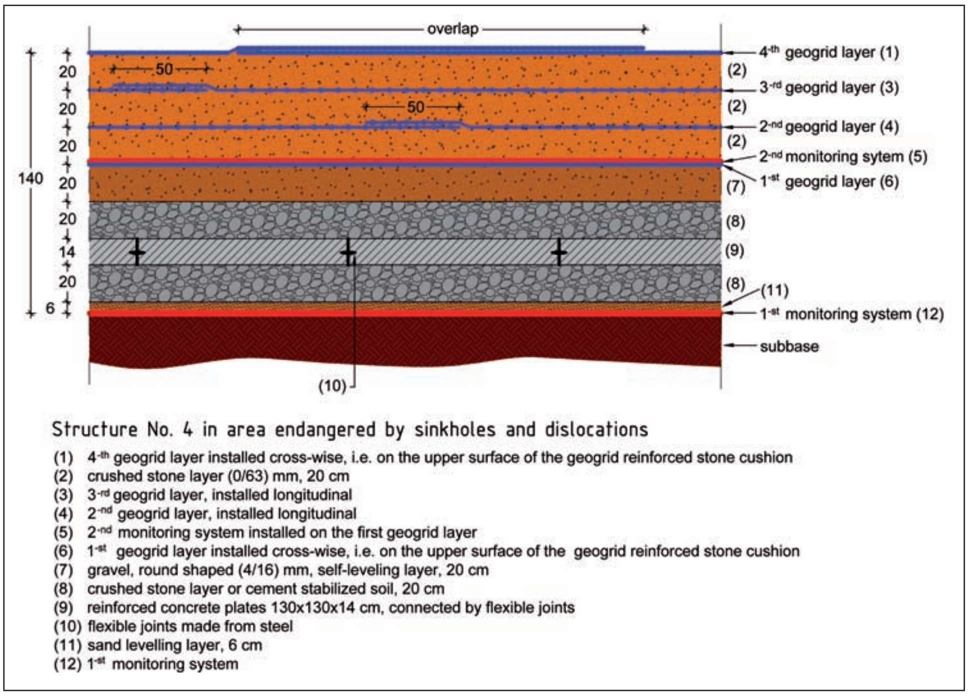


*Fig. 9: Designed cross section, structure no. 4*

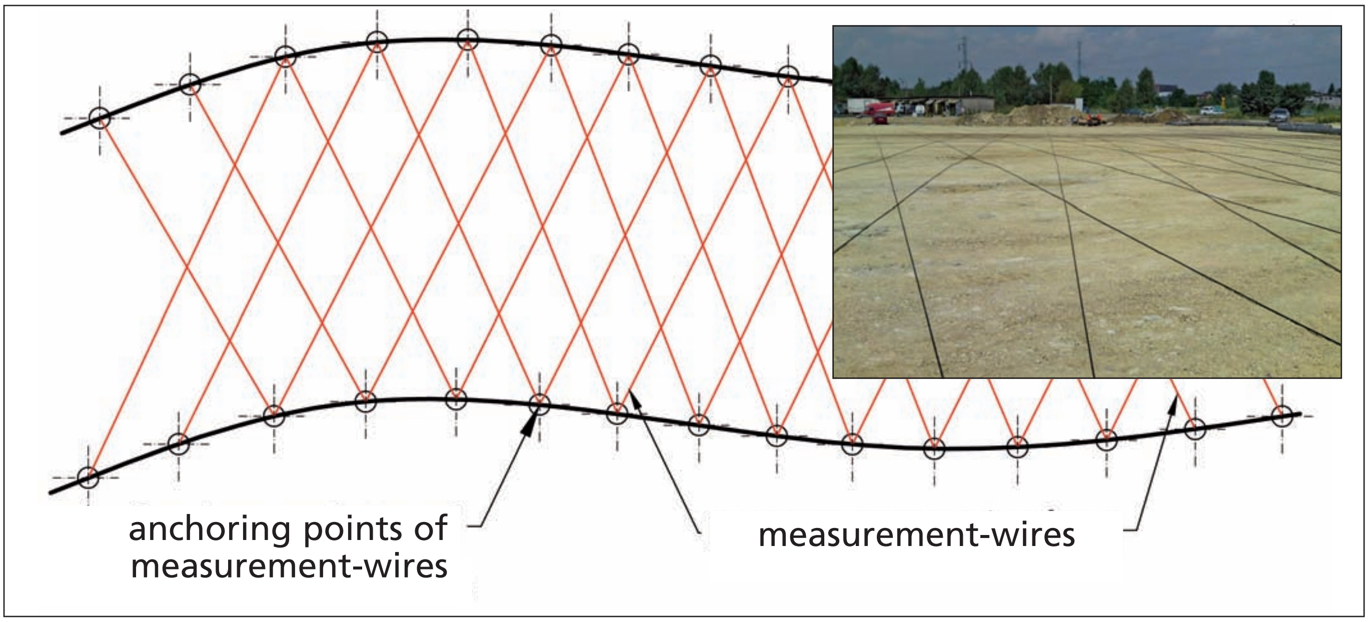


*Fig. 10: 1st monitoring system (warning layers) diagonal installed measurement wires, System NeoStrain®*

two layers cross-wise and two layers longitudinal to the road axis. The first layer is installed in the cross direction of the motorway, followed by two layers in the longitudinal direction and then finished by the wrap back of the first layer in the cross direction. Each layer is embedded in a 20 cm crushed stone layer (0/63 mm) on either side, top and bottom.

On the lowest layer of **Fortrac®** a second monitoring system is installed directly on the geogrid (Fig. 11). This system consists of sensors installed cross-wise to the roads axis. The sensors are attached to the geogrid by a specially developed system and protected by steel covers to ensure the devices are not damaged during the construction and operation of the project (Fig. 11 & 12). The sensors are permanently measuring the strain in the geogrids at 5 minute intervals and therefore the performance data of the geogrids. The data from the two monitoring systems is permanently collected in a data logging station for the whole endangered stretch of motorway and graphically presented on the monitors.

*Fig. 11: 2nd Monitoring system on **Fortrac®** geogrid, System NeoStrain®*

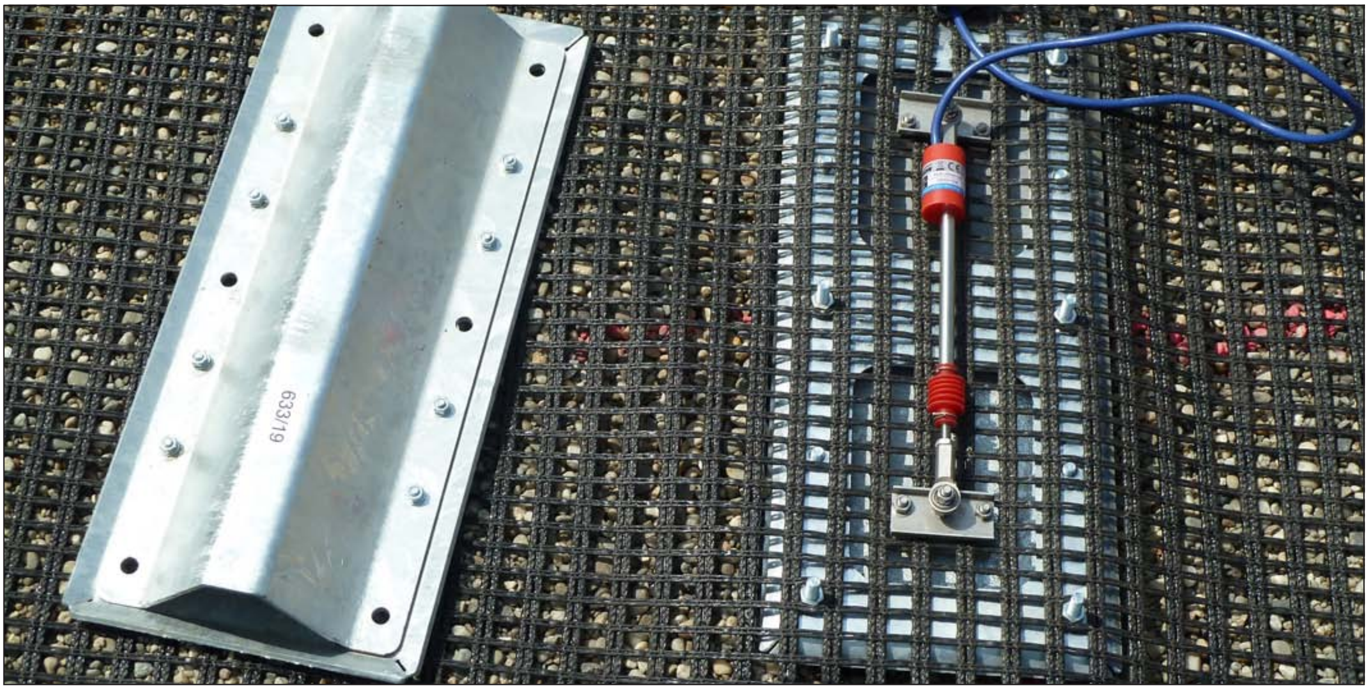

*Fig. 12: 2nd Monitoring system on **Fortrac**® geogrid, system **NeoStrain**®*

The monitoring of the vertical deformation under the embankment base and the monitoring of strain in the reinforcement present an integral part of the overall design to ensure that the allowable strain limits in the reinforcement as well as the allowable deformations of the embankment are not exceeded.

## Materials used

Due to the size of the potential sinkholes and the stringent deformation criteria, a special **Fortrac**® R 1200/100-10 A is used for sinkhole bridging having a very high ultimate tensile strength of 1,200 kN/m at only 2.5% strain in the roll direction.

*Fig. 13: **Fortrac 3D**® slope reinforcement in cut section*

This special geogrid has proven its excellent performance in a number of sinkhole projects over the past years, for example motorways A 143 and A 38 or railway junction Gröbers in Germany. The key to the outstanding performance is the combination of being stiff enough to adopt high loads at very small strain and yet being flexible enough to be easily installed and effectively interlock with the fill material to anchor the high tensile forces.

In those stretches of the motorway with a lower category of mining activity and therefore smaller associated risk of sinkhole and faults, different grades of high strength **HaTe**® polyester woven of up to 1,710 kN/m are used. For this project seven different custom made geosynthetic types have been manufactured by HUESKER Synthetic to exactly fit to the requirements of the design.

*Fig. 14: Close up of **Fortrac 3D**® structure supporting the vegetation*

*Fig. 15: Fill section of highway embankment*

In addition to the large amount of geosynthetics for reinforcement used under the motorway embankments, a significant amount of **Fortrac 3D**® is used to protect the slopes along the motorway in the cut sections with its 20 kN/m ultimate tensile strength it provides a reinforcing function with additional erosion protection to the surface of the cut slopes (Fig. 14).

## SCOPE OF WORK

The section Pyrzowice – Piekary Śląskie has a length of 16 km and is constructed by a consortium of Budimex S.A. and Mostostal Warszawa S.A. The section Piekary Śląskie – Maciejów has a length of 20 km and is constructed by Dragados S.A.

The size of the project with its 36 km of motorway to be constructed within only 23 months is a big challenge for the two main contractors Budimex S.A. and Dragados S.A. on these sections. Especially the enormous earth movements in the section Pyrzowice – Piekary Śląskie with approx. 5.4 million cubic-metres of soil to be excavated in the cut sections (Fig. 13) and installed again in the fill sections (Fig. 15) required detailed planning of earth movements to keep the environmental impact as low as possible. Similarly the geosynthetics had to be supplied according to a very tight supply schedule agreed with the contractors to fit into their working schedules. HUESKER has proven to be the right partner for this mega project and has supplied more than 150,000 m$^2$ of high strength geosynthetics per week over a period of five months during the peak time of the project.

This great performance was possible due to the high capacity of HUESKER production facilities in Germany and a thorough project management in combination with a very close cooperation with HUESKER partner INORA in Poland. INORA has significantly contributed to the success of the project by providing engineering support and technical assistance on site. Furthermore they are in charge for supplying, installation and long term monitoring of the installed systems which are an integral part of the design and overall concept.

## SUMMARY

The motorway A1 in Poland is a milestone project for HUESKER Synthetic. The unique scale of the project, not only in terms of the quantities of high strength geosynthetics supplied, but also regarding the high level of engineering and site support are a new benchmark in the geosynthetic industry.

The close cooperation between HUESKER an their partner INORA in Poland enabled a sophisticated, high quality reinforcing and monitoring system to be developed and successfully installed into this technically demanding project; thereby satisfying all clients requirements.

The reliability of HUESKER and their local partner INORA was a key factor for the contractors to meet their project specific targets in term of quality, time and finance.

**Fortrac**® high strength geogrids have again proven to be the ideal products for over bridging systems even in geotechnically complex projects such as the A1 motorway in Poland.



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