The first EPS Geoblock Road Embankment - 1972

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ABSTRACT

When the first EPS geoblock road embankment was constructed in Norway in 1972, it was done with the conviction that the technical aspects were well documented. The first fill was therefore not really considered a "test embankment", but as a regular part of a heavily trafficked road, route 159 out of Oslo.

The paper describes the process that led to the construction of the embankment. Since this was the very first EPS embankment, protection of the polystyrene from petrol products was considered extremely important. The effect of long time vibrations in the EPS blocks caused by the moving traffic was also considered a major challenge.

The construction of the embankment was not the result of a planned search for an alternative light weight material for road embankments on soft ground, it was the the offspring of a large research project with a totally different aim - how to frost protect roads and engineering structures.

The way from the first sketches of an EPS road embankment, to an approved and completed project took only a few months and was the result of the cooperation between the Norwegian Road Research Laboratory (NRRL) and the Road Authorities of Akershus County who dared to carry out this pioneer project. This tight cooperation was possible in 1972 due to short lines between research, planning and construction. The present day organisational structure would have delayed or made this process difficult.

THE INITIATOR: THE "FROST ACTION IN SOILS" PROJECT (1969 - 1976)

Lots of things in this world just suddenly pops up. In the case of the EPS geoblocks the Norwegian Road Research Laboratory (NRRL) never intentionally looked for a new material for lightweight embankments. The history started with the Project "*Frost Action in Soils*", a large project in Norway from 1969 to 1976, where several research institutions in Norway collaborated in establishing basic knowledge of frost in ground. The Pavement Section at NRRL was a main participator in this work.

At that time boards of plastic foam were in its early use for frost protection of roads. It soon became apparent that, in the case of EPS

- the moisture pickup in EPS resulted in a rapid and unacceptable decrease in insulating properties (project: Kjellstad Road 1966)
- the unsatisfactory moisture properties could be overcome with an overlying waterproof membrane (project: Jevnaker 1970, membrane of roof asphalt sheets glued to the topside of the EPS board)
- the strength properties were adequate in order to provide a foundation for a 50 to 70 cm thick pavement structure

COMBINING POSSIBILITIES AND NEEDS

At the same time as the NRRL was busy with the Frost Action in Soils project, the Soil Mechanics Section worked with problems related to minimizing the problems related to stability and settlements for road embankments on soft ground. Lightweight embankments with Leca (expanded clay aggregate), waste of cellular concrete, as well as sawdust and bark residues were materials used for this purpose.

Through the Frost Action in Soils project the Pavement Section at NRRL built up a very good knowledge of the basic properties of expanded polystyrene like strength, deformation characteristics, fatigue and durability.

Cost and complexity in taking care of the moisture problem, when using EPS for frost protection, soon ruled this material out in favor of extruded polystyrene (XPS). However, having established that 5 to 10 cm of EPS would survive under a road pavement in terms of strength, why should it not survive in a thickness of 1, 5 or 10 m, as a lightweight fill, solving settlement or stability problems? With no technical problems in sight, only the price could be against such a use. And even at a very high cost, it was evident that a material with a near zero weight, could be a very economical solution where the only alternative would be a very costly bridge. It was also evident that moisture pickup in EPS thicknesses of 50 cm and above would not affect the density unfavorably.

The advantage of being a small country is less bureaucracy when introducing new ideas. In this organizational climate it was possible to go from

idea (note of August 1972, Geir Refsdal: The first EPS sketch, to
acceptance by the Road Authority to try out the idea in full scale on an actual road project and to
completed project in two months.

STEPS LEADING TO THE USE OF EPS GEOBLOCKS

20th May 1972 - Project proposal for in situ foaming of plastic

The Pavement Section at NRRL puts forward a proposal for a project with the aim to develop guidelines for in situ foaming of plastic materials for road embankments. The method is considered economic at a cost of less than 160 NOK per m^3. It is proposed that the project is headed by the Soil Mechanics Section.
The Director of NRRL is positive to the proposal and asks the Pavement Section to start the investigation into such use (*Project proposal signed by Geir Refsdal of the Pavement Section, NRRL*).

June 1972

The Road Director of Akershus County, Bent Skari, asks The Norwegian Road Research Laboratory to look into the severe settlements on National Highway No159 at Flom Bridge outside Oslo in June 1972. With an ADT of 15 000 and with annual settlements of 5 to 6 cm at an increasing speed to approximately 20 cm in 1972, the situation is not satisfactory. The total settlement is now 80 cm, and constant resurfacing leads to increasing load. The subsoil consists of 3 m peat overlying 10 m soft, sensitive silty clay to firm bottom. Akershus County asks for a solution that could bring the road profile back to the original level, which would mean to raise it 0.8 to 1.2 m.

26th June 1972 - Contact with a foam producer

Scaniaplast AS, a Norwegian producer of polyurethane foam, is asked if they can deliver a plastic foam material, foamed in situ, and with the following requirements:

- compressive strength min 50 kN/cm^2 24 hours after the foaming, at max 5% deformation, alternatively 100 kN/cm^2
- resistance to pulsating loads of max 25 kN/cm^2
- resistance to humus acids, petrol, oils and other petroleum products
- density of max 100 kg/m^3
- resistance to volume changes
- the foaming capacity should be minimum 200 m^3 per day

These characteristics should be maintained for a period of at least 40 years.
(*Letter signed by Geir Refsdal of the Pavement Section, NRRL*)

28th June 1972 – The Road Authority of Akershus County is contacted

The NRRL writes to the Road Authority of Akershus County and proposes the use of 1000 m^3 in situ foamed plastic foam of 50 kg/m3, which would be 1/40 of the weight of ordinary fill materials and 1/20 of traditional lightweight materials like waste cellular concrete or bark. The price is indicated at 130 to 150 NOK/m^3.

In order to reach a load reduction of 0.5 ton/m^3, 0.75 m of the existing road would have to be removed and replaced with plastic foam with an estimated thickness varying between 1.0 and 1.3 m. The pavement thickness above the foam is estimated to approx. 0.5 m.

Waste cellular concrete or bark is presented as the alternatives to the plastic foam, but it is pointed out that such materials would not be able to stop the settlements.

With this new concept based on in situ foamed plastic foam, the Road Director of Akershus County is asked if he can accept this solution.

(*Letter signed by Nils Rygg and Tor Korpberget of the Soil Mechanics Section at NRRL*).

August 1972 - Sketches with alternative solutions

Two embankment solutions are now presented for the project.

alternative 1: based on one layer of EPS geoblocks 0.5 x 1.30 x 3,0 m and with a compressive strength of 50 kN/cm^2 with an overlay of polyurethane foam and with a pavement structure of 0.5 m.

alternative 2: based on an in situ foamed plastic foam with an overlaying pavement structure of 0,5 m.

The very first sketch of an EPS geoblock embankment at Flom Bridge is shown below. (*sketches made by Geir Refsdal*)

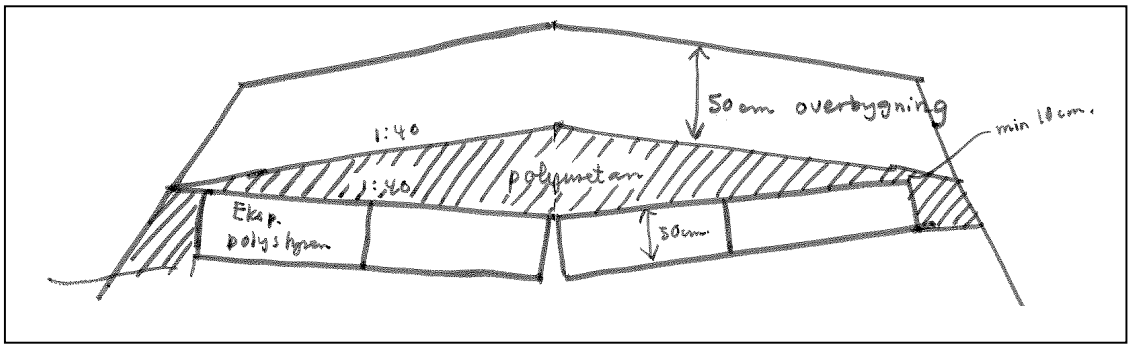


Figure 1. The first sketch of an EPS geoblock project (August 1972)

8th August 1972 - a technical note on concept details

The note states that the Flom Bridge project is ideal for a test including both EPS geoblocks and in situ foamed polyurethane in order to have some technical/economical competition.

EPS Geoblock solution

In order to avoid side movements caused by traffic vibrations, it is proposed that the first layer of EPS is placed tilting slightly inwards into the pavement structure. The EPS blocks are covered with polyurethane, also on the sides, in order to protect the expanded polystyrene from possible spills of petrol products.

Both the inwards tilting of the geoblocks and the polyurethane cover were - at the time - considered key issues for a safe and successful road construction. Later experience has shown that these issues are not key issues after all.

In situ foamed polyurethane

It is proposed that the polyurethane solution is made up of foamed layers of max 10 cm foam. The upper surface should be covered with a 0.2 mm polyetylen membrane.

For both alternatives the material requirements are given as

- compressive strength: min. 50 kN/cm^2 at max 5 % deformation.
- density: < 100 kg/m^3

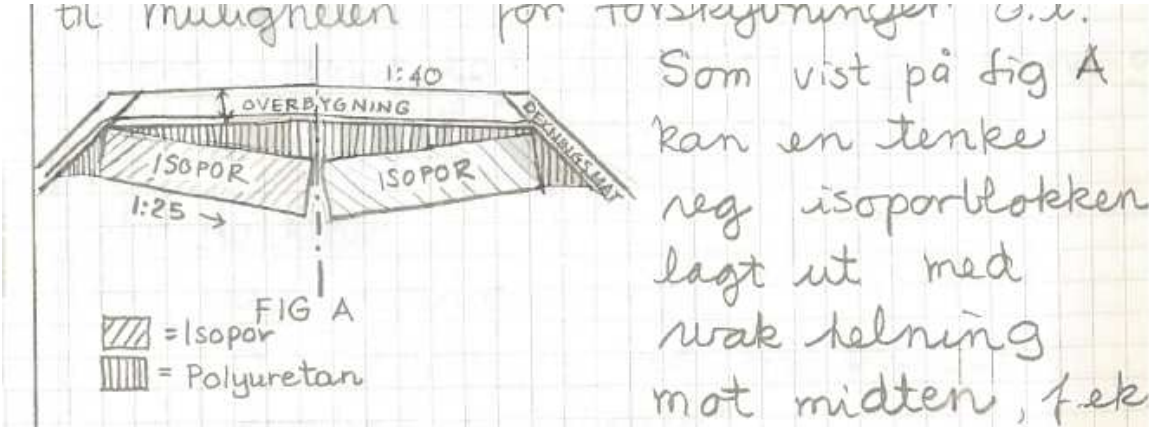


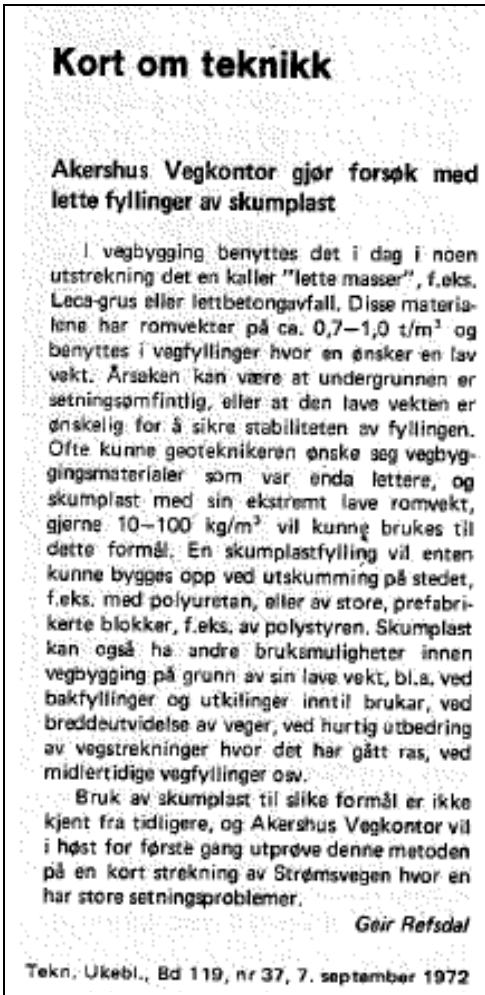
Figure 2. The second sketch for the EPS geoblock project at Flom Bridge

General
It is stated that it could be favorable with a 10 cm lean concrete layer above the plastic foam, but it is proposed that this is excluded in order to facilitate the long term monitoring of the embankment.

The following control and monitoring is recommended:
- settlement development
- moisture pick up in the foam
- deflection measurements with Benkelman Beam to measure the bearing capacity of the final pavement structure

(A four page technical note by Geir Refsdal)

1st September 1972 - Patent considerations
Prior to the construction of the Flom Bridge embankment in 1972, the thought struck, that the use of EPS for road fill purpose either ought to be patented immediately or described in a way that should make a patent from a third party impossible. The NRRL director (Kaare Flaate) decided that it would be best to describe the use in a public available magazine or paper. This was considered the best way of getting the method into practical use. The following note was literally rushed into the Norwegian Technical Journal in its 7th September 1972 issue. Plastic foam foamed in situ and prefoamed EPS geoblocks are described, and many possible applications related to road construction are mentioned.



Kort om teknikk

Akershus Vegkontor gjør forsøk med lette fyllinger av skumplast

I vegbygging benyttes det i dag i noen utstrekning det en kaller "lette masser", f.eks. Leca-grus eller lettbetongavfall. Disse materialene har romvekter på ca. 0,7—1,0 t/m³ og benyttes i vegfyllinger hvor en ønsker en lav vekt. Årsaken kan være at undergrunnen er setningsømfintlig, eller at den lave vekten er ønskelig for å sikre stabiliteten av fyllingen. Ofte kunne geoteknikeren ønske seg vegbyggingsmaterialer som var enda lettere, og skumplast med sin ekstremt lave romvekt, gjerne 10—100 kg/m³ vil kunne brukes til dette formål. En skumplastfylling vil enten kunne bygges opp ved utskumming på stedet, f.eks. med polyuretan, eller av store, prefabrikerte blokker, f.eks. av polystyren. Skumplast kan også ha andre bruksmuligheter innen vegbygging på grunn av sin lave vekt, bl.a. ved bakfyllinger og utkilinger inntil brukar, ved breddeutvidelse av veger, ved hurtig utbedring av vegstrekninger hvor det har gått ras, ved midlertidige vegfyllinger osv.

Bruk av skumplast til slike formål er ikke kjent fra tidligere, og Akershus Vegkontor vil i høst for første gang utprøve denne metoden på en kort strekning av Strømsvegen hvor en har store setningsproblemer.

Geir Refsdal

Tekn. Ukebl., Bd 119, nr 37, 7. september 1972

Short technology note

The Road Administration in Akershus County tests out the use of lightweight embankments with plastic foam

In road construction to some extent "lightweight materials" are used, like expanded clay aggregate (Leca) and cellular concrete. These materials have densities of approx. 0.7 – 1,0 t/m³ and are used in road embankments where a low weight is required. The reason could be that the subgrade is sensitive to settlements, or a low weight is required in order to secure the stability of the fill. The soil mechanics engineer would of course prefer a material with as low weight as possible, and plastic foam, with its extremely low density, typically 10 – 100 kg/m³ would be possible to use for this application.

A plastic foam fill could either be built up by in situ foaming, for instance with polyurethane, or by large prefabricated blocks, for instance of polystyrene. Plastic foam may also have other possible applications for road purpose, due to its low weight, for instance backfilling and transitions zones up to bridge abutments, for road widening, for rapid repair of road slides, for temporary road structures, etc.

The use of plastic foam for such applications is not known previously, and the Road Authority of Akershus County will this autumn, for the first time, take this in use on a short section of the Strøm Road with large settlement problems.

Geir Refsdal

Technical Journal., Bd 119, no. 37, 7th Sept. 1972

Original note - in Norwegian	*Translated note*

Figure 3. A profylactic message about possible use of plastic foam was rushed into the weekly Norwegian Technical Journal on 7. September 1972, prior to the start of the first EPS geoblock project

4th September 1972 - Plastic foam material requirements given

The Akershus County is recommended to ask for in situ polyurethane with a compressive strength of min 50 kN/cm^2 and density < 100 kg/m^3. It is referred to two offers for this material: 200 NOK/m^3 from AS Jotungruppen/AS Teknisk Isolering, and 260 NOK/m3 from Scandiaplast AS. *(Letter signed Svein Alfheim, Pavement Section and Nils Rygg, Soil Mechanics Section, NRRL)*

8th September 1972 - Detailed project description

A detailed plan for the project is worked out. With an EPS price of 126 NOK/m^3 Akershus County decides to continue with the combined EPS geoblock/and polyurethane cover alternative. The tilted subgrade surface is now not longer a part of the project.

(Kjell Aarhus: Report: "Project C74 Rehabilitation of Strømsvegen at Flom Bridge - test with Expanded polystyrene and polyurethane" /2/)

13th September 1972 - Project meeting

In a project meeting the plans for the project is reviewed, and the plans are accepted. The construction period is set to 18th September to 2nd October, and the following responsibilities during the construction are given:

General leveling works: Road Authority of Akershus County
Control of plastic foam: Svein Alfheim
Control of settlements for the new embankment:
Equipment: Eivind Hagen
Levelling: Eivind Hagen and Charles Øverby
16 mm film: Rolf Eirum
Check list for all operations: Eivind Hagen

CONSTRUCTION PERIOD - 14th SEP TO 2nd OCT 1972

The construction is carried out according to plans. The final design adopted was two 50 cm layers of EPS covered by 10 cm of in situ foamed polyurethane (PUR). This resulted in a 5 kN/m^2 reduction of the weight on the subsoil, as 80 cm of the existing road material was excavated.

Due to delivery problems with Norwegian producers, the EPS foam was take in from two producers in Sweden and from one Norwegian producer. A 100 kN/m^2 quality foam was used instead of the 50 kN/m^2 foam described. This was done as it was easier to obtain 100 kN/m^2 quality material, as this was the standard product. The 100 kN/m^2 quality has later become the standard for most types of EPS embankments.

Figure 4. The first layer of EPS geofoam blocks are placed.

Photo: unknown

No particular construction problems were experienced, but the spraying of PUR was experienced to be rather time consuming due to problems with the spraying nozzles. Also, in rainy weather the production of PUR stopped completely. The spraying of PUR was therefore not a full success, and Flom Bridge is the only site where PUR materials have been used as a protective cover.

Up to 1979 the settlements were only 8 cm, and no further settlements were observed from 1979 to 1982.

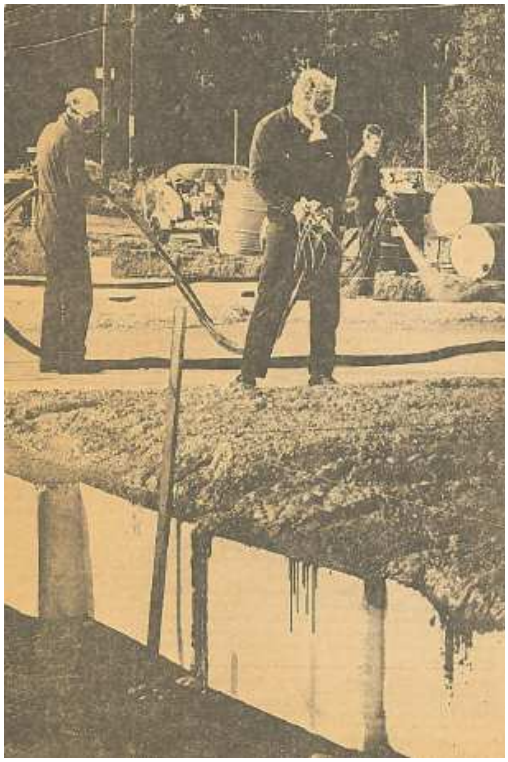


Photo: Aftenposten

Photo: Norsk Plast No 10 1972 / JTK

Figure 5 A protection layer of polyurethane is foamed over the EPS blocks

LESSONS LEARNED

At the time of the first project we were particularly concerned about the following

- the constant vibrations of the traffic which possibly could cause horizontal movements of the fill structure
- leakage of petrol following a tanker accident which could cause the embankment to dissolve

In order to safeguard the repeated vibrations, the first EPS embankment was meant to be built up with a small slope towards the centre of the road. The contractor eventually ignored this, and such precautions were later never prescribed.

In order to protect against petrol leakage, the embankment was protected with a 10 cm polyurethane cover. Very soon it also became apparent that the risk for an overturning tanker on an EPS embankment was extremely low, and that the use of a concrete slab was a more practical way of combining the required protection of the underlying EPS blocks with the need for pavement strength and binding together the EPS structure.

Since 1972 four EPS embankments have gone up in fire during construction. One fire was initiated by children playing with matches, one was caused by youngsters passing an EPS site under construction and two caused by a spark from welding operations. These fires took place more than

20 years ago. With the large number of EPS embankments carried out in Norway (around 500), four damaged embankments are not overwhelming.

The lessons learned include

- spin off effects from one technology area may fill gaps in another.
- a company policy which allows untraditional thinking is essential. It is also essential to accept that not all attempts are successful.
- introducing new technology takes time and setbacks are inevitable. When opposition strikes - shut your mouth and carry on.

EPS GEOBLOCK PROJECTS IN NORWAY

The Flom Bridge project was followed by other EPS road embankments in Norway, but for the first few years at a rather slow rate:

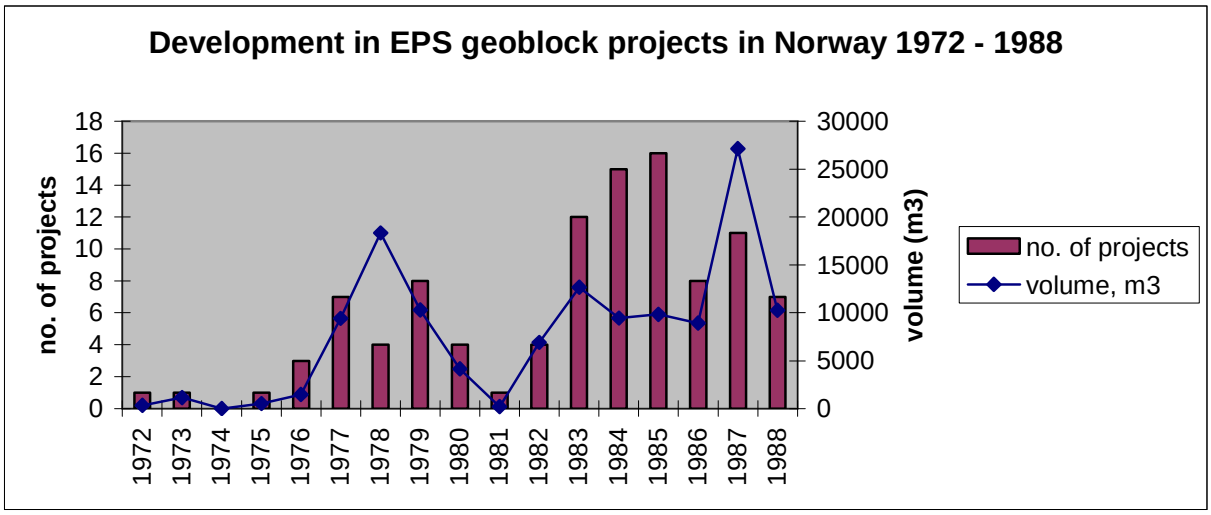


Figure 6 Development in EPS geoblocks in Norway 1972 - 1988

EPS geoblock project no. 100 in Norway was completed in 1988.

The method was presented to the Nordic countries at the Nordic Road Congress, arranged by the Nordic Road Association in Sweden in 1977 (*Geir Refsdal: An alternative material for the construction of lightweight embankments"*).

Later, with more than ten years of experience with a successful use of EPS fill projects in Norway, it was time to present the information for a wider international public. Several state of the art papers were presented at a one day conference and excursion in Oslo, Norway on 22. June. 1985. The state of art papers were later presented in Publication No. 61 from NRRL /11/. These papers were prepared by

- Tor Erik Frydenlund: *"Soft ground problems"*
- Øystein Myhre: *"EPS – material specifications"*
- Geir Refsdal: *"EPS – design considerations"*
- Roald Aabøe: *"13 years of experience with EPS as a lightweight material"*

- Geir Refsdal: *"Future trends for EPS use"*
This symposium triggered off a wide international use of EPS geoblocks in lightweight road embankments.

REFERENCES

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