

Case histories using foamglass for roads to reduce settlement and stability problems

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Many existing roads on fills in sloping terrain, experience problems with stability, bearing capacity and settlements. Lightweight fills with foamglass will reduce these problems.

There is a large potential for foamglass to be used for repair of unstable steep slopes that already have a problem with settlements and deformations. Foamglass can also be used as a lightweight fill material in planned roads where the ground is believed to have reduced bearing capacity. This method has been used on several projects.

This paper will focus on construction, testing and experience with several sites where foam glass have been used.

Highway 120 in Østfold in Norway was repaired because of soft ground in 2011, according to settlement and stability problems in steep slopes. Visual inspection on building site in november same year showed no negative results. Samples have been taken from the construction site and had this tested in the lab for different qualities.

KEY WORDS: Foamglass, repair of unstable steep slopes, lightweight embankments

Repair of unstable steep slopes

The building method described here is a relatively new method and differs from other more established methods ^[1]. Briefly the steep slope is stabilized by changing the existing masses in the ground on the facing slope side of the road. The superstructure is then rebuilt with foamglass in the enhancement layer, something that dramatically reduces the total weight of the filling. The last year this method has been used in several repair projects in Østfold (Norway) on roads where settlements and deformations has been a major. Foamglass has proven to have several good qualities for solving this problems.

Lightweight extruded clay has an inner friction angle at 35 degrees, so the internal stability is less beneficial if the steep slope were to be built after the same recipe. If the steep slope were constructed by EPS-blocks this involves a significantly longer building period. Above the EPS-blocks it is common to pour a concrete slab of 10 cm to distribute the load that the EPS-blocks are exposed for and to protect against any fuel leaks from tank-trucks, which can break down and destroy the material ^[2]. The concrete slabs are casted on site and contributes to a longer building period. In addition to this there is higher requirements for leveling the ground accurately where the EPS-blocks is laid to avoid any roughness on the top of the EPS-blocks and to achieve tight joints. This is also contributing factors for extending the construction period ^[1].

Most of the expectations to the above mentioned building method are related to repair- and maintenance of the existing road network, although it is also relevant on future roads where the stability in steep slopes is reduced ^[1].

Here are some of the benefits regarding the building method:

- Only one lane will be closed so that cars can pass
- Easy delivery (truck with side tipper)
- Low costs
- Short construction period
- Reduces need for road surface maintenance



Figure 1: This picture is from Fv 734 (Varmbuvegen) in Melhus in Sør-Trøndelag ^[13]. It is a typical example of problems with instability in steep slopes and where it is large expectations regarding the method described in this paper. In Norway there is a large number of steep slopes with similar problems.

In Norway a large percentage of the road network originally have been carriage roads. With time, many of these have been upgraded with increased width and asphalt to get an acceptable capacity to allow modern vehicles to use them^[1]. On many of these old existing roads the groundwork is commonly unknown or poorly executed, resulting in settlements and instability. If the settlements are of a moderate grade, the traditional solution is to repair the road with a new layer of asphalt. This leads to increased maintenance costs, but worse is that it increases the pressure towards the ground and worsens the problem from one year to another if the process is about to be repeated. Asphalt has a density of approximately 20 kN/m³, and contributes greatly to accelerate or exacerbate the stability and settlements^[3].

Density- and mass calculations (attachment not included in this paper) shows if the total thickness of the superstructure is 0,5 m and the foamglass filling is 1 m, the total pressure towards the ground is reduced by almost 50 %. The settlements is calculated to be reduced by 37% (attachment with calculation not included in this paper). The projectgroup used Janbus' direct method for stability calculations, but later discovered that this method only is to be used for homogenous masses. Unfortunately there was not enough time to calculate the stability with Janbu's method of slices, and therefore the projectgroup did not succeed to get an answer of the percentage increase regarding stability.

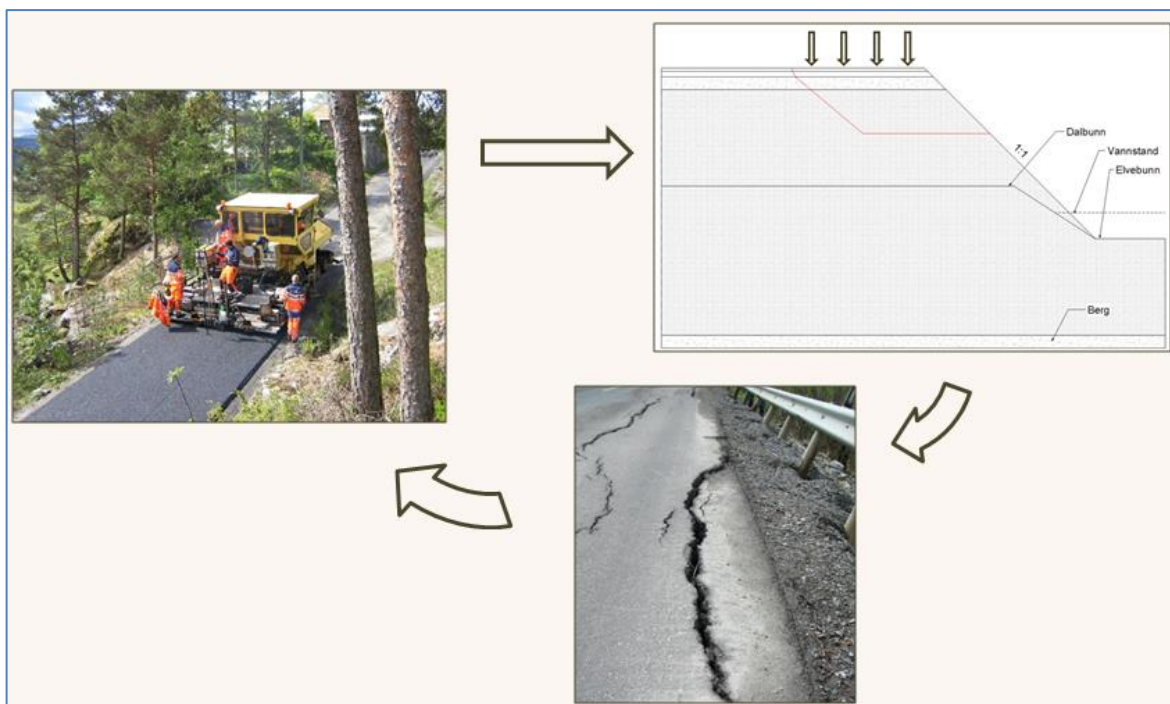


Figure 2: Traditional solution for repairing settlements of a moderate grade is to repair the road with a new layer of asphalt in the spring after the frost heave period is over. But this increases the pressure towards the ground because of asphalt's high density, and accelerates the settlements^{[3] [8]}.

Building method

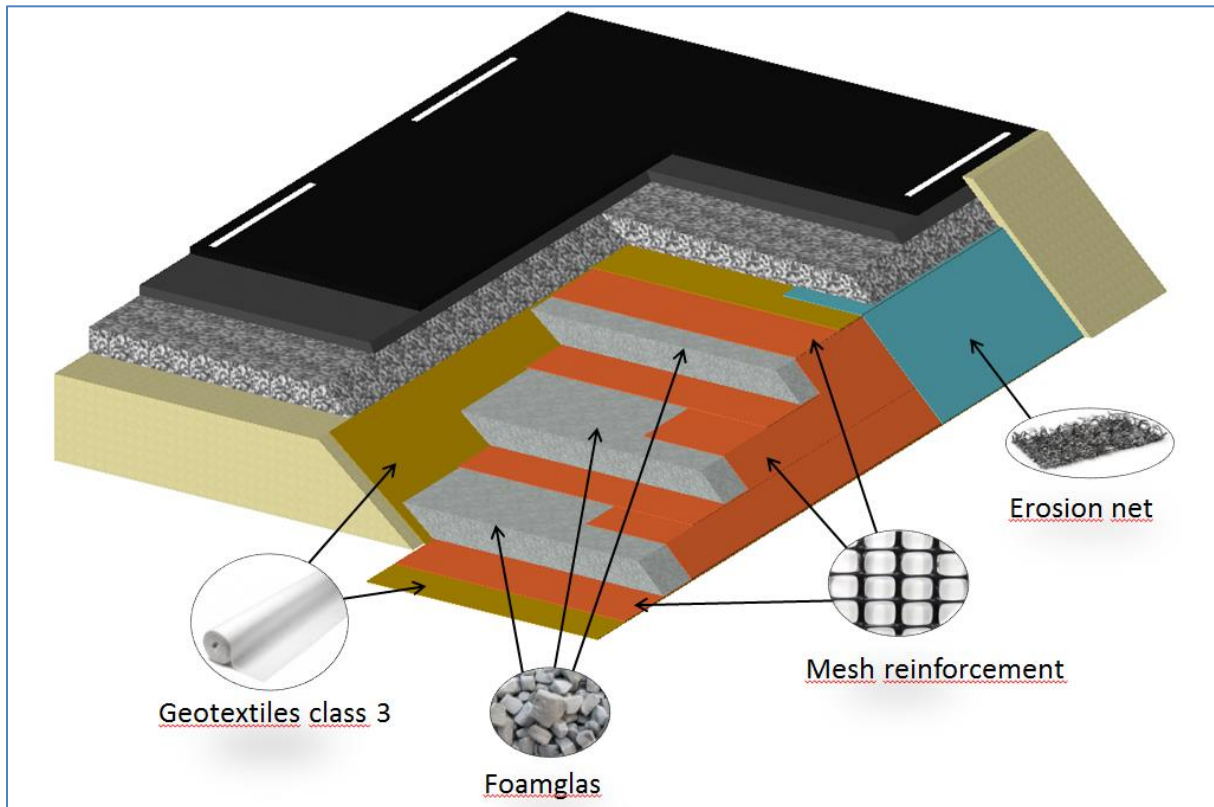


Figure 3: Illustration shows how to build a steep slope with foamglas. The inner half of the road is not renewed, which makes it possible for cars to pass during construction phase ^[8].

The here mentioned building method is based on the process for stabilizing steep slopes on highway 120 in Østfold. Foamglas is used in 3 layers, whereas each layer is separated and anchored with mesh reinforcement. It is the building technique with 3 layers of foamglas, combined with mesh reinforcement to stabilize the filling, that differs this method from others and more established building methods. The inner half driving lane remains untouched during the construction period, allowing traffic to be maintained. On the construction sites in Østfold the traffic has been regulated with traffic lights ^[4].

At first the existing masses is removed from the middle of the road and towards the facing slope side. The slope angel is about 40 degrees on figure 3, and also the calculations regarding density take in to consideration of an angel equal to 40 degrees. On the actual construction sites this angel was significantly higher (70 up to almost 90 degrees) ^[1]. It is at this time unclear whether a steep angel can cause problems regarding frost heave, because of an abrupt transition between a frostsafes and not frostsafes road ^[5]. Therotically the inner road can rise during frost heave if the slope angel is significantly higher than 40 degrees. The here mentioned method is so new that we do not know for certain whether this can actually become a problem.

Regardless a larger amount of the masses is changed with a higher slope angel, and further reduces the weight of the filling ^[1]. The actual weight reduction on the construction sites is therefore probably higher than the calculated 47 %, according to the density attachment (not included in this paper). When the masses have been removed, geotextiles class 3 is added at the bottom of the excavated area. Another benefit concerning an operative inner driving lane: Truck with side tip simplifies the delivery of foam glass.

A 15 ton excavator with tracks drove over the foamglass once to allocate it. The excavator has a ground pressure well below maximum at 50 kN/m^2 . Thereafter each layer of foamglass were compressed by a 60-70 kg vibroplate. The total thickness of the three layers of foamglass is 1 meter after compression. Each layer has the same thickness. For each layer mesh reinforcement is wrapped around the foamglass with an overlap of 1 meter. Then a new layer of mesh reinforcement is added from the inner edge of the excavated area, to the edge and around the foamglas with 1 m overlap, exactly like the layer beneath. The mesh reinforcement that was used is Tenax Geogrid LBO 330 ^[4] (figure 6).

Geotextiles is added at the top of the foamglass, and is then covered with a 30 cm thick layer of crushed rock, as part of the upper superstructure. The geotextiles prevents the stone materials from mixing with foamglass. Before the layer of crushed rock is added, erosion net is added 1 m within the slope edge. The weight of the superstructure anchors the erosion net well. The erosion net is added above the geotextiles.

The erosion net that was used was Naue Secumat 20 mm ^[4] (figure 5). The layer of crushed rock was compressed by a 500 kg vibroplate. Above was added a 20 cm thick layer of asphalt, which eventually was rolled.

After the superstructure was completed, a cogging (figure 7 7) was cutted into the asphalt approximately 0.5 m into the untouched part of the road to create a joint that is not thorough. This also prevents water from entering ^[4].

The guardrail posts that were used was 3.5 m. The usual length for guardrail posts in Norway is 2-2.5 m. The guardrail posts penetrates the three layers of foamglass and anchors deeper into the ground. When the guardrail posts are forced down to the ground, the mesh reinforcement is punctured at the location of the post without compromising the structure particularly ^[5].

Increase soil is added in the slope above the erosion net. The thickness should be at least 10 cm, and it is important that vegetation is established to prevent erosion of the new slope ^[4].



Figure 4: Foamglass is delivered. levert. Notice the geotextiles at the lower background in the picture. This slope is located on highway 120 north of Tomter, Østfold ^[14].



Figure 5: Erosion net Naue Secumat 20 mm ^[15].

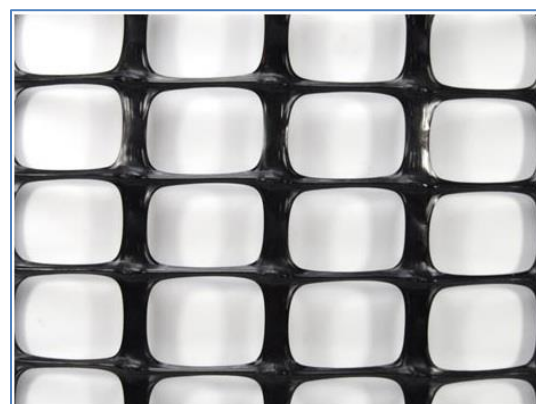


Figure 6: Armeringsnett av typen Tenax Geogrid LBO 330 ^[16].

According to Handbok 274 ^[2] ordinary soil can be used which is laid out with a thickness of at least 0.5 m to cover the foamglass. This is a requirement that mainly concern new roads ^[7]. It has not been possible to meet this requirement at the here mentioned slope, due to the steep slope angel. Erosion net and spray seed is combined to stabilize the soilmasses that covers the foamglass,

Spray seed leads to faster growth, promotes desired vegetation, and reduces the growth of weeds. At the same time it prevents erosion and run-off. Spray seed is an especially fast and efficient way to sow large areas. One spray seed truck can cover up to 7000 m² and have a spray range of 30-40 m.



Figure 7: New layer of asphalt. Notice the cogging that is cutted into the untouched part of the road ^[9].



Figure 8: Geotextiles are joined with strips ^[14].



Figure 9: Picture from Fv 115 south for Mønster bridge before the repairations were started in fall 2011^[9].



Figure 10: Picture from Fv115 south for Mønster bridge (Østfold, Norway) during constructuin phase. Observe the three layers with foamglass which is separated by reinforcing mesh ^[9].



Figure 11: Mesh reinforcement around the foamglass ^[9].



Figure 12: Same place as figure 2. Picture is taken 9th may 2012 when the projectgroup was on inspection. 6 months after the first inspection there is no signs of deformation or settlements of the area that was repaired in fall 2011 ^[14].

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