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Concrete block permeable pavements, a Norwegian perspective

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Abstract:
Concrete block permeable pavements are used on parking and industrial areas in Norway. The pavements have proven to function well during winter conditions, and the strive towards even better functionality is continuing. Test- and demonstration sites as well as completed projects have given many useful and promising results. Performance during winter conditions and maintenance to retain infiltration capacity need to be further investigated. New applications are being developed - urban living roofs with detention of rainwater, which may be combined with rain gardens and the use of the sub-base beneath the permeable pavement as a detention basin.
Key Words: Permeable pavement; detention, infiltration, urban living roof.

1. Introduction

Climate changes are affecting Norway. The weather is becoming wetter and wilder. The annual rainfall is predicted to increase by 7-23 % towards year 2100. The number of days with extreme weather is expected to increase by 30 – 70 %. The amount of impervious surfaces is increasing due to urbanisation. The two factors in combination causes the water runoff from rainshowers to increase.

Authorities have decided to combat the increase in runoff. The drainage strategy is changing from discharging the runoff water as quickly and efficient as possible towards handling the runoff locally and as much as possible. Restrictions are introduced to new development. Plans to handle the runoff water has to be presented as part of the application for permission to build. Concrete block permeable pavements could be part of such a plan.

2. The use of concrete block permeable pavements in Norway

Concrete block permeable pavements have been used in Norway for more than 10 years. The total area is increasing by approximately 50 000 – 70 000 m2 each year dependent on the size and timing of projects. This areal increase has been stable over the past few years. Concrete block permeable pavements are currently being used mainly for parking areas and industrial areas.

The construction of the sub-base beneath the concrete pavers has evolved during those 10 years. The sub-base normally comprises a 30 mm thick laying course of 2-8 mm particles, a 150 mm thick upper sub-base of 4-32 mm particles and a 300-500 mm lower sub-base of 20-120 mm particles. The laying course and the sub-base contains no fine material. This is important for two reasons. Firstly, it secures that water will not accumulate within the sub-base and destabilise the construction. Secondly, it secures that water quickly percolates to the bottom of the sub-base for infiltration or drainage. This also prevents the water from freezing in the sub-base.

One example is from a bus terminal in Drammen in the eastern part of Norway. An area of 21 000 m2 was covered with a concrete block permeable pavement. It has sustained the heavy loads from busses. The infiltration capacity of the substrata is high and infiltration is used as the draining mechanism. The area exhibits a good permeability and it has coped very well with the rainfalls encountered sofar. Wintertime, the area is made less slippery by using sand of the same type as used in the joints, which ensures refilling of joints.

Another example is from a storage area for containers outside Stavanger on the southwestern coast of Norway. An area of 4200 m2 was covered with a concrete block permeable pavement. Here the substrata has almost no

infiltration capacity and drainage pipes are used as the draining mechanism. In designing the concrete block permeable pavement, two sensitivities were considered. Firstly, when the pavement is new, it has a large capacity with no runoff. The sub-base must then have sufficient capacity to store and detain the dimensioning rainfall. Secondly, during winter time the pavement is sometimes covered with ice when it starts raining. The surface area must therefore be shaped and pipes installed to form a safe flood water escape route.



Figure 1. The centre of Lyngdal. Photo: Inger Anita Merkesdal.

A third example is from the centre of Lyngdal on the southern coast of Norway (figure 1). Four streets have been upgraded. The road section was covered by a concrete block permeable pavement. The street has been given a v-shape with the lowest point in the middle. A shallow drainage pipe has been installed as a flood escape route if the permeable pavement for some reason should be tight due to ice cover. This has the additional benefit that cars lower the speed significantly.

The above projects are new. One key learning from other project is confirmation that the infiltration capacity of a concrete block permeable pavement reduces with time due to fine particles, moss and weeds down to around 1/10 of the original infiltration capacity. This is used as a design criterion in the capacity calculations. Work is progressing towards finding the optimum maintenance considering both summer and winter conditions.

Another key learning is that rainfall exceeding the design criterion may occur. Measures to reduce the consequences of a potential flooding should therefore be incorporated in the design of an area. A safe escape route for the flood water should be built.

The use of concrete block permeable pavements in Norway has not increased as much as expected. Two key questions need to be further illuminated – the maintenance required to retain the infiltration capacity and the performance during winter conditions. Two test areas have been built to address these two key questions.

3. Testing, documentation and innovation

A test and demonstration site was constructed at the premises of Multiblokk in Sandnes on the southwest coast of Norway (figure 1). The main purpose is to test concrete block permeable pavements under real life situations [1], although the scope has expanded to also cover other storm water managemet tools.



Figure 2. Test and demonstration site in Sandnes. Photo: Per Møller-Pedersen.

The parking area has an impervious pavement, which drains towards an area with a concrete block permeable pavement. The impervious pavement is 15 times greater than the permeable area. This enables accelerated testing with runoff water and dust. What normally happens over 15 years is compressed into one year. The maximum infiltration capacity and its reduction with time has been investigated. Analyses of the runoff has confirmed a correlation between the rainfall, infiltration capacity and age; much in line with the findings of Borgwardt [2]. A master thesis conducted for the permeable area concluded that the dust and fine particles accumulates in the upper 10-20 mm of the joints. The infiltration capacity was restored when the top layer of the joints was removed and replaced.

The access road to Multiblock in Sandnes was built with a concrete block permeable pavement. During three and a half year, it has been exposed to the load of some 300 000 tonn of heavy trucks. The subsidence has been to be up to 20 mm, which is acceptable for this type of road. This is one of the many useful insights that the test- and demonstration site has provided. The area will now be rebuilt to test other challenges.

A new test site specifically for winter conditions is currently being built at the premises of Vikaune Fabrikker outside Trondheim in the middle part of Norway. Six areas will be built to 1) test the stability against different constructions of the sub-base, 2) detention and drainage without infiltration and 3) weather conditions alternating between colder periods with snow and ice and warmer periods with rain. The test site will provide answers to important questions.

Another new application for concrete permeable pavements was developed as part of a major research project Klima 2050. A conventional roof was converted to an urban living roof with built-in detention of rain water. The urban living roof is constructed with a layer of crushed aggregated clay, which has a significant detention capacity. The detention layer is covered with a new, light-weight permeable paver specifically designed and developed for urban living roofs. The weight is around one third of a traditional concrete paver.

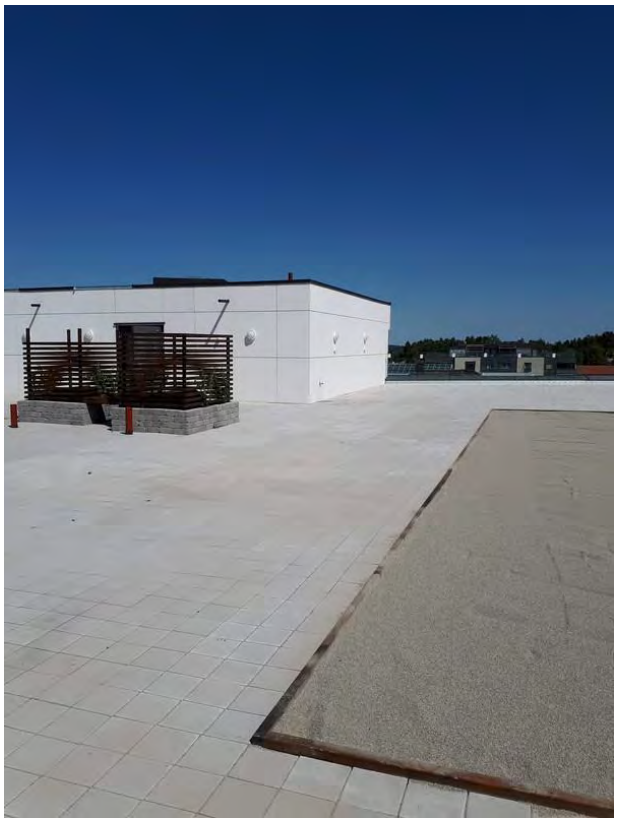

Figure 3. Urban living roof at Lilleborg Terrasse
Photo: Rune Egeland

Results of the tests are encouraging. The dentention capacity is significant and peak runoff is typically delayed by 2 hours and reduced by 80%. Furthermore, the urban living roof dampens the temperature fluctuations and provides extra insulation wintertime and a cooling effect summertime [3]

The concept was introduced to the market in October 2017. The first pilot was installed at Lilleborg Terrasse in Stokke in the southeastern part of Norway. It is an apartment block where part of the roof has been converted to an urban living roof with facilities for playing boccia, tables and chairs etc.

The concept is being further developed. The runoff from an urban living roof can be led to a raingarden for further detention and use. The combined effect is significant and the rainwater is harvested.

Other applications for concrete permeable pavements are being developed and tested. One new application in Norway is to use the substrata beneath the permeable cover as a water storage basin. This is being done in other countries, however, the functionality during winter conditions needs to be further investigated.

4. Conclusion

The use of concrete block permeable pavements is still limited in Norway, however the interest is increasing. The performance of concrete block permeable pavements under Norwegian conditions is reasonably well understood, however, more research and further tests are needed on the maintenance required to retain the infiltration capacity as long as possible and on the performance during winter conditions.

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