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Tools for Design and Laying of Precast Concrete Permeable Pavements

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Abstract: Concrete permeable pavements are more and more used in stormwater management. As there is neither French guidance nor standards about these products, nor European common specifications, the CERIB, Study and Research Centre for the French Concrete Industry, has established some tools for stakeholders in stormwater management. The first one defines technical requirements which could be applicable in France, mainly in terms of permeability and mechanical resistance, to ensure a relevant performance level. The second one is the development of a new functionality of the free "ODUC+" software, which permits the determination of the required performance of the pavement, and, if relevant, the required characteristics of the storage structure, depending on the project specific parameters.

Key words: precast concrete, road storage structure, design, infiltration, modular pavements

1. Introduction

In the Framework directive on water (2000/60/EC), orientations for balanced and sustainable management of water resources, as well as water quality and quantity objectives, are defined on major watersheds. The municipalities, encouraged by the ALUR law (Law for Access to Housing and Renovated Urban Planning), define in their PLU (Local Town Planning) rain zonages, accompanied by requirements of limitation of waterproofing and runoff.

Thus, more and more permeable pavements are being used, which allow integrated management of rainwater at the plot, as close as possible to their point of fall.

Existing European standards (NF EN 1338 for concrete pavers and NF EN 1339 for concrete slabs) do not cover all permeable pavements. Although some countries such as Belgium or Germany already have standards or recommendations on concrete draining products, there were no specific recommendations in France.

The CERIB, Study and research center for the French precast industry, therefore sought to define technical requirements applicable in France on the most common families of concrete products, namely porous concrete pavers, pavers with wide joints, and draining slabs of the "turf slabs" type.

As part of this work, CERIB has also defined a permeability measurement protocol, applicable to all products, and a method for the mechanical dimensioning of draining slabs of the "turf tile" type.

Finally, he has added to his ODUC + software a new module to determine, depending on the project parameters, both the necessary permeability of a draining pavements and, on the other hand, the characteristics of the possible underlaying storage layer.

2. Measurement of Permeability Coefficient

The coefficient of permeability of a pavement is a

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necessary dimensioning element for the designers of infiltration structures.

The permeability test developed by CERIB makes it possible to measure the coefficient of permeability of the set “products and materials for jointing or filling voids”. It does not take into account the influence of the laying bed and layers of foundations.

This test is performed on a representative pavement surface rather than on a single product. This allows:

• to avoid a possible dispersion between products;

• take into account the contribution of the joints, in order to be representative of the conditions of service;

• ensure vertical infiltration, which could not be achieved with a small scale test of a test tube placed on a product only.

On a surface of 1 m² of permeable pavement consisting of concrete products and their jointing material or filling voids, under a constant load of 1 cm of water, the test consists of measuring the amount of water that infiltrates in a given time. The schematic diagram is presented Fig. 2.

Fig. 1 porous pavers, pavers with wide joints, turf-slabs.

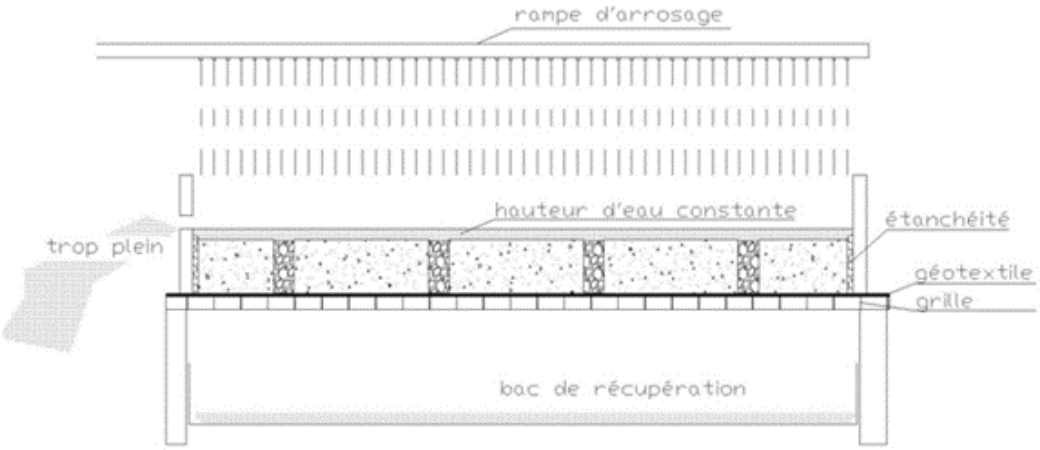

Fig. 2 Schematic diagram of the permeability coefficient test.

The vertical permeability coefficient K (or hydraulic conductivity) is then calculated on the basis of Darcy’s law and the results of three measurements, depending on the amount of water infiltrated during the duration of the test, the thickness of the pavement, and the height of water. The repeatability of the measurements is verified.

The coefficient is then compared to the permeability coefficient required for the infiltration pavement as a function of:

• typical infiltration rain defined by the client: duration of rain, return period, Montana’s coefficients applicable at the project site ...

• characteristics of the project: surfaces from which we want to recover rainwater, runoff coefficients ...

• a safety factor, including the risk of partial clogging.

3. Method for Mechanical Design of Draining Slabs of “Turf-Slabs” Type

Given their geometry and their laying conditions, draining slabs of the “turf-slabs” type can’t be designd following the same approach as for “solid” slabs covered by NF EN 1339 standard. The service behaviour of these two families being different, the application of a “solid slabs” approach could lead to erroneous design.

Thus, an approach for the specific design of these slabs, and integrating their conditions of use, was developed by CERIB. It allows to take into account:

• the necessary correlation between laboratory test results and performance in service conditions;

• the characterization of the products themselves and not just the concrete material;

• the desire to keep known test methods for factory production monitoring: the three-point bending test defined in standard NF EN 1339-Appendix F.

The test protocol defined to validate the field of use of turf slabs is a test in service conditions that allows:

• to be representative of real conditions of laying turf slabs;

• to simulate the continuity of a paved pavement and to overcome any edge effects;

• apply a sufficient load to reach the breaking of the products.

The test is performed on an area of at least 1.5 m by 1.5 m. The products are implemented according to the manufacturer’s installation recommendations, or in the absence of recommendations, according to professional installation recommendations. The structure consists of a foundation, a sand laying bed, and products usually filled with a topsoil-sand mixture in a proportion of 2/3-1/3.

The load is applied to the most unfavorable position in service, according to the geometry of the slab, on an footprint size representative of the intended field of application. The charge is gradually increased until rupture. The charge is then registered.

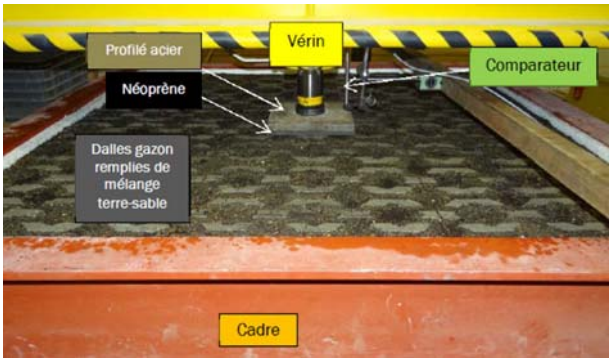

Fig. 3 Test on draining slabs of the “grass tile” type under laying conditions.

Factory production monitoring can then be carried out according to the bending test protocol described in standard NF EN 1339. The value of the resistance must take into account the specificities of the geometry of the products, on which several break sections are observed.

4. Design Help Software

For several years, CERIB has been developing and making available to drainage and sewer actors software for assisting the design of structures. First dedicated to the hydraulic and mechanical dimensioning of sewerage networks, this software has been enriched with new features over the years.

Version 2.0 of ODUC + was released at the end of 2018. It includes the determination of the required permeability of draining pavements, depending on the characteristics of the project (surface characteristics, rainfall to be taken into account). It also makes it possible to determine the volume of the possible underlaying structure, depending on the storage capacity of the material used, in a “reservoir structure pavement” orientation.

ODUC+ 2.0

Fig. 4 Oduc+ software

5. Conclusion

Given the absence of a specific recommendation on concrete products for draining coatings in France and shared provisions in Europe, the work of CERIB has made it possible to define the technical requirements that could be applied in France for the following product families: porous pavers, pavers with wide joints, as well as draining slabs of the "grass-tile" type.

The technical reference defines the functional characteristics of water-permeable concrete pavers and slabs and the requirements that these paving products must meet. A test was also developed in order to be able to measure the permeability coefficient of the cover of infiltration structures, desig element necessary for the designers of infiltration structures. The test protocol could be introduced in a future certification reference system. In addition, an initial type test representative of the laying conditions makes it possible to determine the field of use of the grass slabs. Finally, the free software ODUC + also makes it possible to determine the required characteristics of the draining pavement according to the parameters of the project, and to design the possible underlaying reservoir structure.

These tools constitute support for the design of infiltration structures, and should help to facilitate their prescription.

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