STANDARDS AND SPECIFICATIONS FOR THE APPLICATION OF CONCRETE PAVING BLOCKS IN BELGIUM

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SUMMARY

Because of a still increasing use of concrete paving blocks, of various shapes and colours and for both residential and industrial applications, it seemed necessary to revise, adapt and even detail the out-of-date norms as well as the general specifications. The first part of the report deals with the adaptation of the standards, among others the requirements regarding the deviations of size measures which had to be fixed more strictly because of the now general applied techniques of manual or mechanical placing. As the compressive strength will be changed into splitting strength many tests were executed.
Attention was further paid to the resistance against de-icing products. So as to gain a clear understanding of that problem, a series of concrete blocks was tested based on the Rilem experimental method (ISO DIS 4846.2). As much interest is showed in coloured concrete paving blocks, it is being worked on a certification of those blocks, so that the permanence of the colour can be better guaranteed.

Regarding the revision of the General Specifications, and in order to improve the placement of the paving blocks, detailed specifications were elaborated, in particular in the TB 200, which is normaly used for the construction of secundary roads. The rather elaborate requirements refer to bedding layer, filling sand and laying pattern.

1. Revision of Belgian Standards

1.1. introduction

A revision of Standard NBN B21-311 of 1974 and Addendum I of 1983, both still applicable in 1991, was urgently needed. The specific aim of Addendum I of 1983 was to reduce the permissible deviations in size, mainly as a result of the evolution in laying techniques, allowing for very narrow joints. This has become standard practice in Belgium with blocks placed either mechanically or manually.

The existing Standard hampered the normalization of special concrete paving blocks such as square blocks with specific colours. The new NBN B21-311 aims at these specific blocks having to meet certain requirements as well. To allow for this, these blocks will be in a category of their own, with its own requirements.

In May 1991 a well advanced draft concerning concrete paving blocks was the subject of a critical discussion at the Belgian Institute for Normalization (BIN). The most important items of the new Standard will be examined hereafter. They cover:

- manufacturing;
- size and shape characteristics;
- physical and mechanical properties.

1.2. Manufacturing of concrete paving blocks

Concrete paving blocks may be manufactured with a facing layer (no less than 4 mm thick overall) of a different composition, to allow for the manufacturing of coloured blocks for example.

Coloured blocks

In 1990 Technical Regulations were designed concerning the colouring of concrete paving products, as well as an Application Regulation for certifying these products, in order to enable a guaranteed colouring technique.
one of the most important items in the Technical Regulations relates to the content of pigment which needs to be strictly observed.

1.3. Characteristics in size and shape

Work Sizes

The manufacturer normally indicates the work sizes. The ratio between length L and thickness h, rounded off to 0,5, will not exceed 3.5. The actually standardized thicknesses are: 60, 70, 80, 100, 120 and 130 mm.

Deviations in the actual main sizes

The main adaptations concern the introduction of smaller permissible deviations in size in relation to the main sizes, i.e.:
Length (L) and width (b): +/- 2 mm
Thickness (h) : +/- 3 mm.

These reduced deviations in size apply in virtually all countries in order to achieve a tight fit of the blocks.

Sides

The sides may be provided with spacer nibs or special surfaces (novelties proposed in Rome in 1988) to realize small tight fitting joints at regular spacings.

Chamfers

The revised NBN B21-311 states that the horizontal or vertical projections of chamfers will be at least 3 mm and at most 6 mm. Chamfers with projections measuring at most 2 mm are still allowed but will no longer be considered as chamfers.

Types of paving blocks

There are three types of paving blocks, according to their size and shape characteristics:

type A: rectangular paving blocks
type B: interlocking blocks
type C: special blocks whose horizontal section differs from those of type A and type B.

1.4. Mechanical and physical properties

1.4.1. Mechanical properties

Influence of storage conditions on compressive test

When revising NBN B21-311, the influence of storage conditions on the compressive strength was verified. According to the old norm, the samples had to be kept in a drying oven (at 105° C) for 24 hours before being subjected to a compressive test (method I).
Nowadays it is common practice to preserve samples submerged in water at 20° C for 48 hours at least, when checking concrete for road pavements (method II).

A comparative test of concrete paving blocks (80 - 130 mm thick) from different manufacturers, on 7 samples per manufacturer has indicated an average ratio of 0,77 between storage method II and storage method I.

These tests were performed on 14 days aged samples. Tests on 7 days aged material, as usual for the normalized tests, resulted in an even lower relation: 0.7 approx.

One may conclude from this research that dry tests on fairly young manufactured material show a seemingly or artifically improved quality, i.e. the results from the tests give the impression of a concrete stronger than it is in reality. Besides, often the actual strength of blocks stored in the open air for 28 days often is less than the strength of 7 day old concrete showed in a dry atmosphere for 24 hours.

The effect of shape on compressive strength

Compressive tests on samples with h = Vs (s = surface) and on samples of complete blocks + packing pieces as specified in DIN 18501, both submerged in water for 48 hours, showed no different results (mean ratio 1,01!).

Change from compressive strength to split strength

As the "dry" compressive strength following by NBN B 21-311 was artificially high, it was suggested to switch over to the wet method when revising the norm. At the same time however, it was suggested at European level to replace compressive strength by split strength, so that the revised NBN B21-311 incorporates splitting strength as well.

The main reasons are:

. it is a simple test which can be carried out by simple testing apparatus;

. the stress which really occurs in blocks composing a road surface is well reproduced; the thinner the block, the more important the tensile strength;

. the test provides good criteria for concrete's durability;

. split strength is more selective than compressive strength regarding some structural shortcomings of the units.

Revision of Belgian Standard NBN B21-311

Additional research

In compliance with de developments in Europe, Belgium opted for the split strength test, (which possibly will be implemented on an experimental bas for one year).
The test is in accordance with Belgian Standard NBN B15-218. Each block is subjected to two tests. Compression is applied parallelly to the width of the blocks which are submerged in water for 4 to 5 hours.

Additional research is performed in order to obtain more detailed specifications concerning the tests. Also, the possible influence of the thickness of the blocks on the results of the tests needs to be investigated.

Research was also carried out on the dispersion characteristics in the factory with following results for the variation coefficient V:

V compressive : 6,1 %

V split: 9,0 %

With different manufacturers and equipments: V splitting = 12,3 % (n = 10).
The average v with various French manufacturers: 8,67 %.
Reference trials with prisms in a laboratory with homogeneous concrete : V split =4,6% (n = 5).

These various tests show that the variability of the quality of the blocks and the accuracy of the testing do affect the overall variation coefficient for about 50 %.

Additional findings of the compressive and splitting strength research.

- For thesame fabrication there is absolute correlation between the bulk specific gravity and water absorption by immersion.

- On the other hand there is no clear relation between compressive or split strength on the one hand and water absorption / bulk specific gravity on the other (see fig. 1, for example).

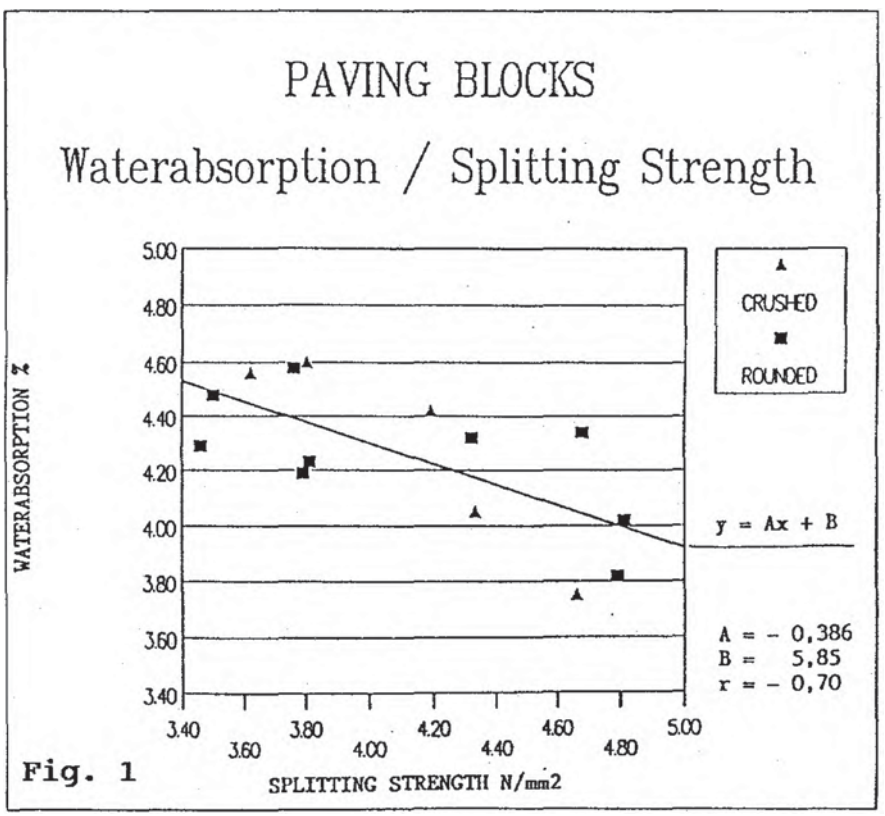


Fig. 1

Proposed split strength NBN B21-311

The latest version of the revised NBN B21-311 (June 1991) incorporates the following requirements, in accordance with the EN-draft Standard:

minimum characteristic split strength:
fs,k = minimal 3,5 N/mm^2 (28 days of age)
average splitting strength: fs,m = minimal 4,5 N/mm^2
(only for the delivery sampling plan).

Taking into consideration an average relation between compressive and splitting strength of 13,2 approx. (for blocks with a thickness 100 mm), the suggested requirements should correspond to a minimum compressive strength of 50 N/mm^2 to 55 N/mm^2 and an average compressive strength of 55 to 60 N/mm^2 (wet method), dependent on the variation coefficient.

In fact this means a significant improvement in quality from the present norm which requires an average of min. 60 N/mm^2, though after storage in a drying oven.

Abrasion

As the abrasion resistance test (Amsler) underwent changes as well, the requirements had to be readjusted, as follows:
individually: 2,5 mm maximum
on average : 2 mm maximum
(only for the delivery sampling plan).

It was suggested to make some allowances for certain ornamental pavements so that they would be identical to the requirements for flags (allowing for an additional 0,5 mm).

Physical properties

Water absorption

The previous norm already outlined the requirements concerning water absorption for the concrete to sufficiently resist frost and thaw as well as de-icing salts, as follows:

individually : 5,5 % minimum
on average : 5 % maximum
(only for the delivery sampling plan).

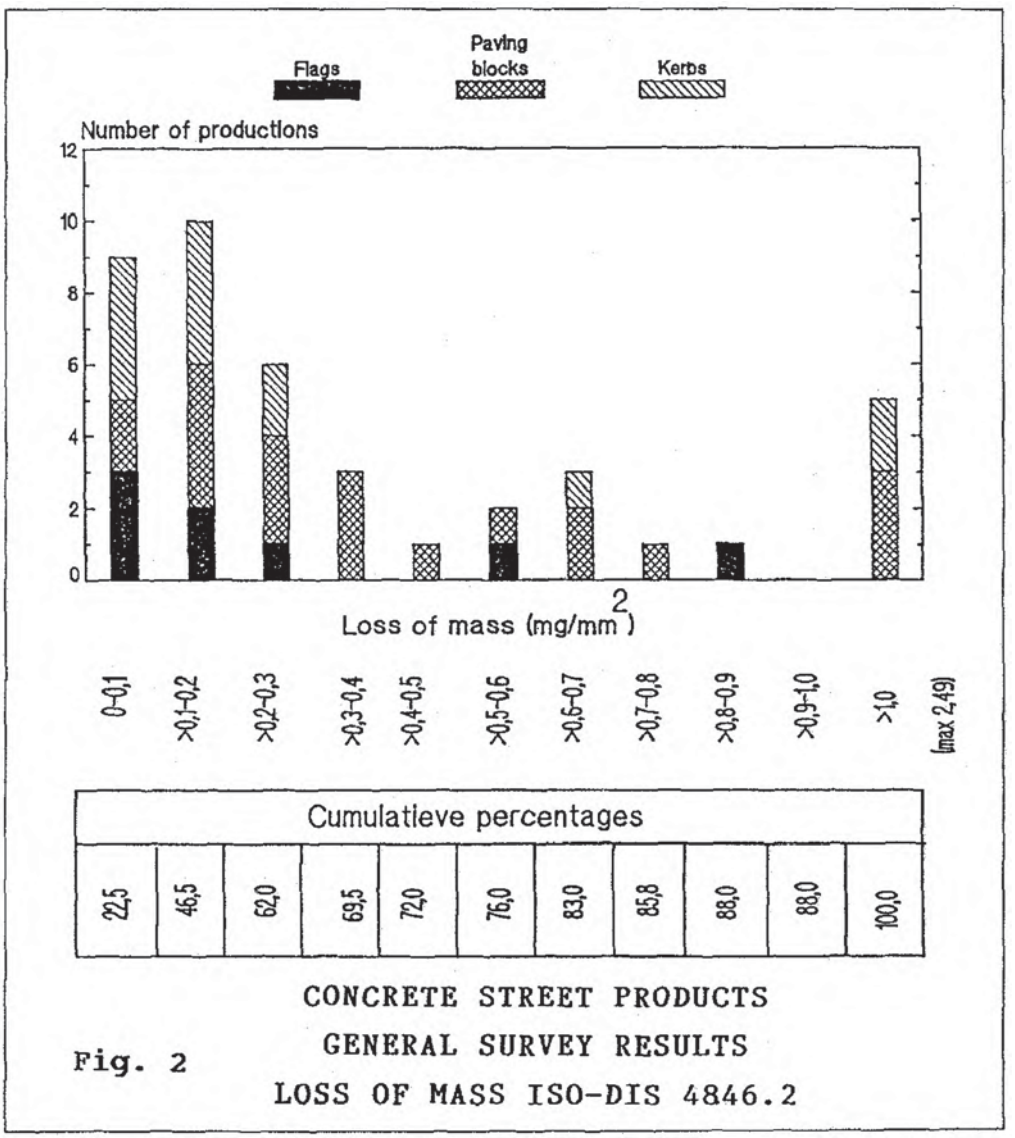
This water absorption is expressed in percentages of the dry mass at 105° C. Identical requirements can be found in the new norm. But for certain decorative pavements to comply with NBN B21-311, it was suggested to make the water absorption of these blocks (class II, for example) subject to the same demands which govern concrete flags, i.e. 1 % over the above percentages.

Resistance to de-icina salts

While revising NBN B21-311, the feasability of introducing a test concerning the resistance to de-icing salts was studied, as Belgium applies more and more concrete paving blocks in the construction of roads which are subjected to de-icing salts such as $CaCl_2$ and NaCl in wintertime.

Limited information was available on the resistance of paving materials to de-icing salts. Trials had taken place with crash barriers, both cast in place (with slipform-paver) and with prefab units, by the Belgian National Cement Research Center in accordance with the method ISO DIS 4846.2.
No relation was found between water absorption and loss of mass at a water absorption of less than 6 %; at a higher percentage a relation did exist and the loss of mass was over 10 g/dm^2 (after 25 cycles).

In recent years these BENOR certified products were subjected to a number of tests in accordance with the method above mentioned, with a view to revising the standards concerning concrete paving blocks, flags and kerbs (see figure 2).



CONCRETE STREET PRODUCTS
GENERAL SURVEY RESULTS
LOSS OF MASS ISO-DIS 4846.2

Fig. 2

These tests show that 72 % of the 37 paving products lost less than 5 g/dm^2 of their mass after 25 frost-thaw cycles. It has been accepted that no important scaling takes place as long as the loss of mass stays within 10 g/dm^2 - a limit considered acceptable for pavements made of cement concrete. Often the absolute maximum for kerbs and additional road structures is 20 g/dm^2.

ISO DIS 4846.2 classifies concrete with a loss of 0,5 mg/mm^2 or 5 g/dm^2 as being of mediocre quality and susceptible to slight scaling, which seems a very strict assessment judging by recent experiences. Going by the results of Belgian research the following maximum tolerances seem acceptable for paving products, dependent on the application of colouring specifically of the upper layer:

not coloured: 10 g/dm^2 maximum
coloured : 5 g/dm^2 "

Coloured paving products should meet stricter demands as regards the resistance to de-icing salts, in order to better safeguard the surface quality and its related colour-fastness.

Decisions regarding physical properties

Nearly 90 % of the analyzed BENOR-paving products (37 in all) with a water absorption of less than 5 % and an abrasion below 2,5 mm, lost less than 10 g/dm^2 of their mass after 25 frost-thaw cycles.

It has therefore been concluded therefore that low water absorption and little abrasion seem to guarantee the resistance to de-icing salts. Therefore a test concerning de-icing salts has not yet been included in the revised Standard; the amount of time required for such a test was another reason for omitting it for the time being.

When water absorption and/or abrasion is to high, the test can be applied as an additional measure or to provide proof to the contrary - for example in the case of special concrete paving blocks of relatively little density which might contain a high proportion of cement for the required durability.

Generally speaking however, one should aim for compact concrete with low water absorption capacities - not only to offer resistance to de-icing salts but also to counter both pollution and the development of micro organisms.

2. Regulations concerning tenders (General specif leaf, ion nr. 200i

2.1. The need for specifications on paving

In the seventies and eighties the paving with small scale products gained in importance in estates, town and community centres (because of revaluations, for example), etc., as demonstrated by the increase in production of concrete paving blocks: 742.000 m^2 in 1970, 4.800.000 m^2 in 1989.

This is mainly due to new ideas as regards town architecture which put the emphasis on residential areas, residential streets, separated footpaths, etc., as well as to policies aimed at channeling the few funds available to renovating operations.

Due to the near lack of regulations concerning the laying of paving blocks, their base and bedding layer, the filling of joints, etc. General specification nr. 200, edition 1983 of the Ministry of Flemish Community added a chapter "Paving with small sized materials" to its chapter on paving which covered both traditional asphalt paving and cement concrete pavements.

Originally, standard specification nr. 200 was created in order to meet the need for standardizing the regulations governing the construction of secundary roads.

Up till the early eighties, General Specification nr. 108 was resorted to when it came to constructing residential streets and council roads. However, these specifications had been designed primarily for the construction of motorways and roads for heavy traffic, which were built extensively in Belgium between 1965 and 1980.

At the 1977 Belgian Road Congress in Namur it became obvious that there was a demand for standard regulations regarding the construction of secundary roads which were gaining in importance.

As a result of the first Belgian state reform, two General Specifications came into being: nr. 200 of the Ministry of Flemish Community (edition 1983) and nr. 300 of the Ministry of the Walloon Region (edition 1982). Both contain a chapter on "block paving".

Notwithstanding the fact that these specifications were drafted in close coordination between the two regional Ministries of Public Works, General specification nr. 200 contains more detailed regulations governing concrete block paving.

2.2. Revision of the chapter "Block paving" (G.S. nr. 200)

General specification nr. 200 has been in existence now for eight years, and experience has shown some shortcomings - reason why it has been under revision during the last two years. Besides, the application of the first regulations provided additional information on the construction of paved roads, their base, the filling of joints, etc.
Early 1991 saw the finalization of the revised General specification nr. 200. It only required official approval and publication.

Some important alterations have been made to the chapter on "Block Paving", such as:

- the chapter has been redesigned according to the nature of the paving material, as each type of paving requires different bases, joints, etc.

  Up till now, separate chapters covered bases, bedding layers, laying system, etc., causing practical problems to contractors laying one specified type of paving;

- a clear distinction has been made between sand intended for bedding layers and sand for the filling of joints;

- for the laying of blocks on a mortar bed (decorative paving), a description of cement mortar improved by "latex" was introduced;

- a paragraph on laying bonds with patterns was added in order to put an end to the confusion in terminology. This allows for an exact understanding of specifications describing a specific laying pattern, such as "herringbone pattern" with desired orientation.