Concrete Paving Blocks for Port and industrial Areas – Test with Steel Fiber reinforced Blocks

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SUMMARY

The growing transport by trucks and the increasing use of containers have created an important need for durable pavements with low maintenance cost. On areas subjected to considerable settlements block paving is often preferred.
Since 1980, only in the port areas of Antwerp, Zeebrugge and Ghent more than 1,5 million container terminals have been paved with 12 cm thick concrete blocks, mostly laid mechanically.
In spite of the high quality (compressive strength more than 60 MPa) failures are observed, namely deformations due to settlements and sometimes damage, such as spallings and cracks due to shocks during the manupulation of containers. To solve this problem steel fiber reinforced concrete with high fatigue shock resistance and shear strength can give perhaps a solution.
Therefore a first investigation concerning the shock resistance of steel fiber reinforced concrete paving blocks was started in Belgium, using hooked DRAMIX fibers.
After this preliminary laboratory-test some port authorities are interesting and like to make in situ test near the dock side.

CONCRETE PAVING BLOCKS ON PORT AREAS - BELGIAN EXPERIENCE

Not only for roads but also for port areas there is always an important need for durable pavements with low maintenance cost.
In Belgium the authorities of port and industrial areas prefer very often to use concrete pavements as well monolithic concrete slabs as concrete paving blocks.
On areas subjected to considerable settlements block paving is preferred.
Since 1980, only in the port areas of Antwerp, Zeebrugge and Ghent more than 1,5 million container terminals have been paved with concrete blocks, mostly laid mechanically.
The structure which yet has become practically classic in Belgium for heavy duty pavements is the following:

- 12 cm rectangular concrete paving blocks (220 x 110 x 120) laid in herringbone pattern
- 5 cm bedding layer
- 35 to 40 cm cement bound materials.

The compressive strength of the blocks has to be more than 60 MPa. In the revised Belgian Standards (NBN B 21-311 of 1992) the compressive strength is replaced by the splitting strength which has to be minimal 4,5 MPa (average).

The behaviour of these pavements with the above mentioned structure and blocks is generally good.
Nevertheless locally some failures are observed which can be divided in two groups:
- deformations of the surface due to settlements of the land fill or caused by lack of workmanship during the construction of the bases and bedding layer (mainly near gullies and manholes);
- damage on the paving blocks, such as spallings and cracks.
  If such problems occur on high quality blocks, the damage is mostly due to shocks during the manipulation of containers, e.g. which the operator let fall down during decharging of ships. Also near rail tracks where the thickness of the blocks sometimes is limited high tensile stresses can result in cracks.

Taking in account the above mentioned problems some authorities would upgrade the concrete quality to 80 MPa or more. This seems not the indicated solution.
Steel fiber reinforced concrete gives perhaps a better solution. Indeed, it is well known that steel fiber reinforce concrete has some typical advantages such as:
- high flexural toughness,
- high crack strength
- very high energy absorbing capability
- high fatigue shock resistance and shear strength.

PRELIMINARY SHOCK TEST - STEEL FIBER REINFORCED BLOCKS

CHARACTERISTICS OF THE BLOCKS

A first investigation concerning the shock resistance of steel fiber reinforced concrete paving blocks was started by the Belgian factory of concrete blocks - DE CLERCQ-DE MAER-SCHALCK" in collaboration with BEKAERT NV, producer of hooked DRAMIX fibers. Normal Belgian concrete blocks were made without and with fibers, namely 15 kg ZP 30/50, which means fibers from harddrawn steel > 1200 MPa, 30 mm long and 0,5 mm thick.
The exact dimensions of the tested blocks were:

Length:	218 mm
Width:	108 mm
Thickness:	98 mm.

The compressive strength of the 10 cm thick concrete blocks according the old NBN-B21-311 was:

without fibers	with fibers
63,92 MPa	78,46 MPa
62,51 MPa	77,35 MPa
60,44 MPa	80,13 MPa

RESULT OF TEST WITH FALLING WEIGHT OF 5 KG
(falling height = 1 m - see photographic illustrations)

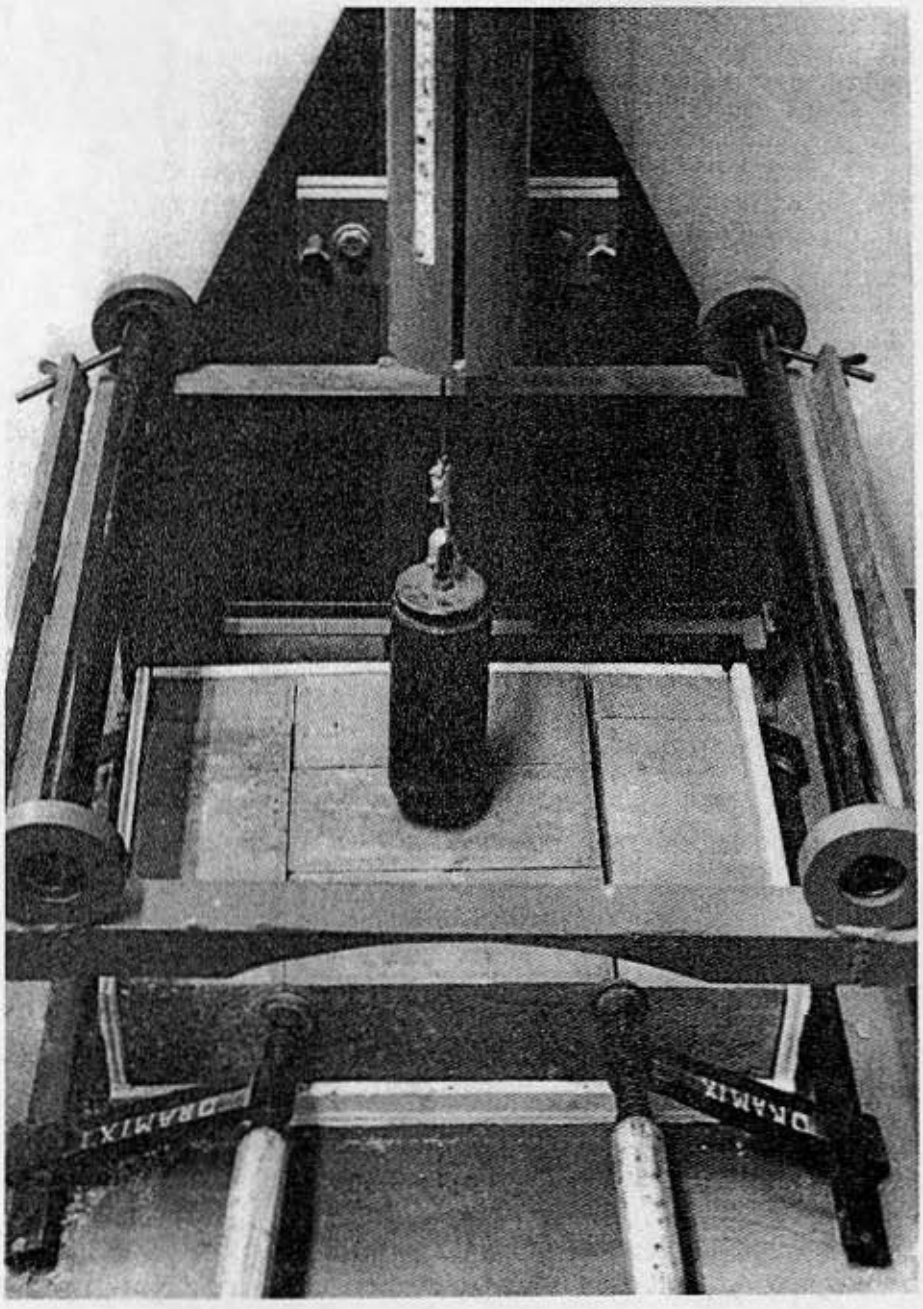
without fibers	with fibers ZP 30/50
I On a sand layer (1cm)	
N 3 XXX 3 XXX 3 XXX	N 5 XX 4 XX 3 XX 3 X 4 XX 3 X 4 XX
II On a fixed steel plate	
N 4 XXX 4 XXX 3 XXX	N 4 X 5 XX 3 X 5 XX 5 X 6 XX 3 X 5 XX 4 X 5 XX

N = number of shocks for causing damage on a set of blocks
Degree of damage:
x = small crack
xx = transverse crack
xxx = completely broken.

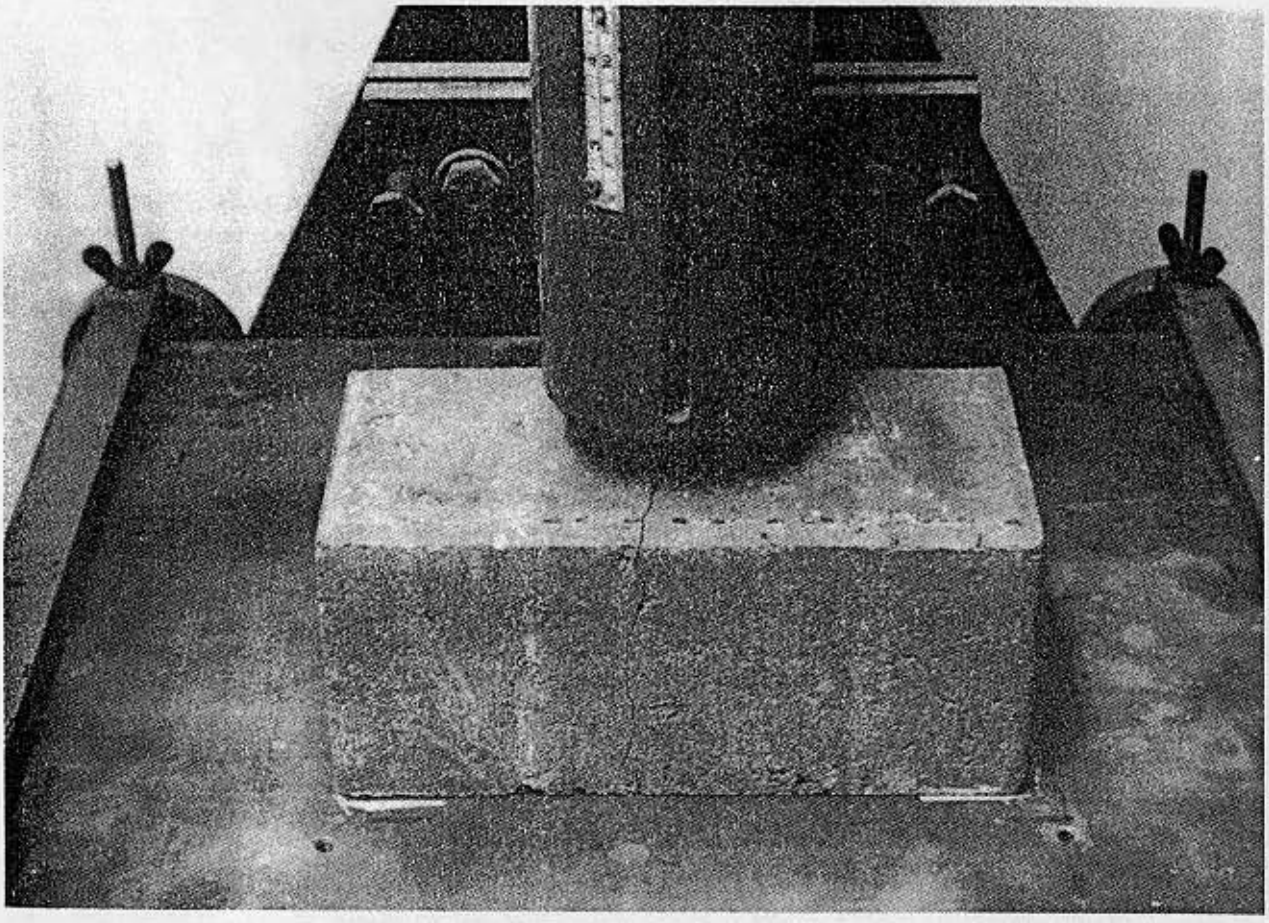
CONCLUSIONS

- After the preliminary laboratory test it seems worthwhile to continue the investigation e.g. for testing the splitting strength according the revised NBN B21-311 and also the other mechanical and physical properties according the NBN B21-311 (The new Belgian Standard of concrete paving blocks).
- Furthermore Belgian port authorities want to test these new paving blocks in situ near the dock sides, eg. for renewing old and damaged block pavements.

Photographic illustration of the falling weight test (1)



Photographic illustration of the falling weight test (2)



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