WIDENING WORKS ON THE MOTORWAY E 40 AT LEUVEN AND BERTEM (BELGIUM)

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During the morning peak hours traffic jams occurred in the direction of Brussels at the jonction of the motorways A2 and A3 (E40) near Leuven. A capacity increase of the motorway A3 (E40) in the direction of Brussels ended up being the most rational option.
For this purpose an additional lane has been constructed next to the 3 lanes which are each 3,75 m wide. In other words, the hard shoulder in asphalt pavement has been transformed into a full cement concrete lane measuring 3,75 m in width.

An additional hard shoulder (bituminous hardening) has been constructed in the zones where the motorway was excavated.
The new fourth lane will also be used as a "slow lane" for freight traffic. (figure 1).

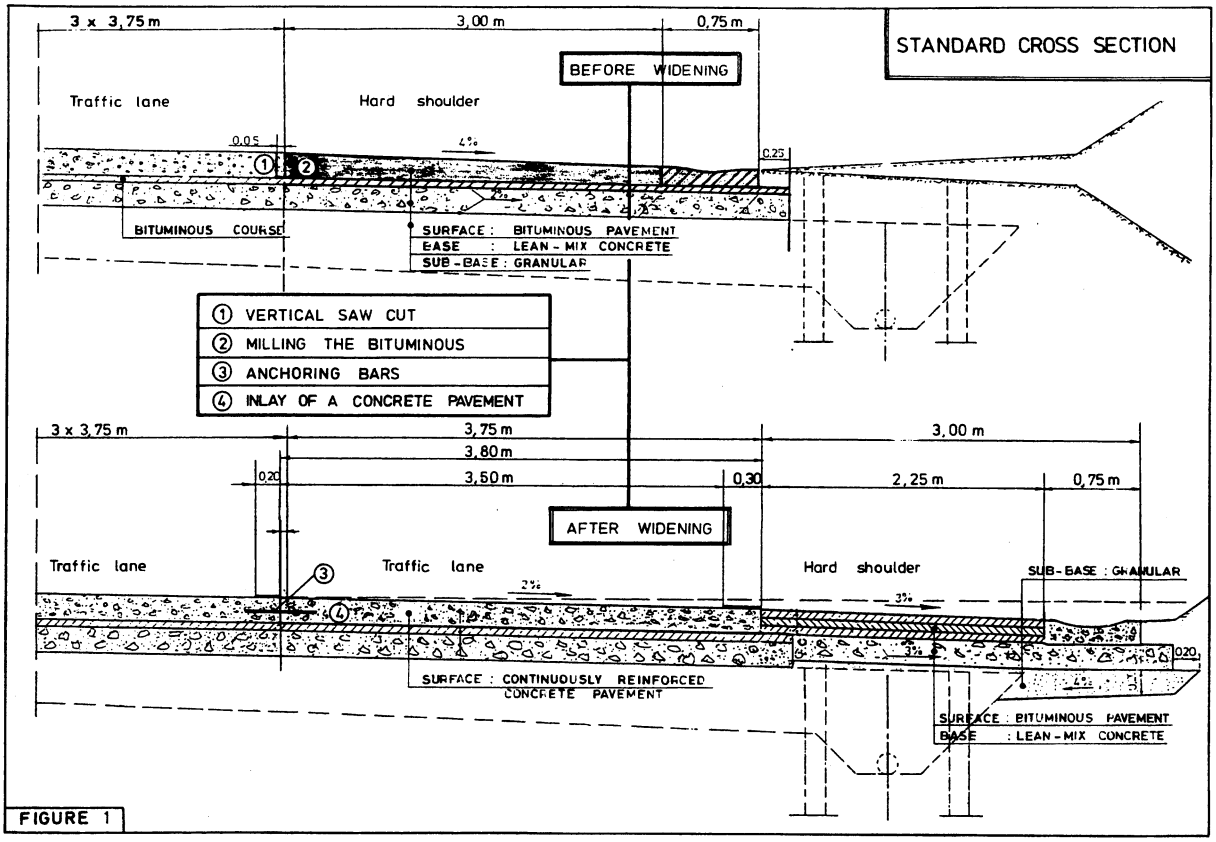


FIGURE 1

In recent years Belgian authorities payed much attention to the environmental effects due to large infrastructure works.
Harmful effects on the environment sometimes occur due to the dense road infrastructure and population : noise pollution due to dense traffic is just one example.
An environmental impact state has been formulated in accordance with the directive of the EEC Council before beginning the widening works.

As a result of this study, it has been decided to choose, amongst others, for the construction of a noiseless pavement.
Since the 3 existing lanes of the E40 already consisted of cement concrete hardening, the aim was to carry out a widening in a noiseless cement concrete pavement.

A combination of the undermentioned techniques offers the best guarantee to obtain maximum noise reduction :

1. During the construction of a cement concrete pavement it is possible to realize the texture of the road surface in such a way that, on the one hand the tyre vibrations and the airpumping effect are minimized, and on the other hand, the required skid resistance is achieved.
   In order to obtain a homogeneous macrotexture, washed out concrete offers good prospects. The washing out at a maximum depth of 1 or 2 mm guarantees both an optimal noise reduction and a good adhesion of the stones.

2. It has been proved in Austria that the optimal noise reduction is achieved by using a granulation of 7 or 8 mm for the stone chippings. The more the granulation of the uncovered stone chippings is evener and smaller, a better homogeneous macrotexture is obtained.
   Therefore it is proposed to clearly increase the fraction 2/7 (minimum 20 % of the aggregates) at the expense of the granulation 20/32. This fraction 20/32 affects the noise reduction in a negative way and will therefore be totally excluded out of the concrete composition. Nevertheless, the omission of the granulation 20/32 causes a less compact concrete due to the fact that the mortar will be relatively poorer. The judicious application of additifs, in particular the application of an air entraining agent, guarantees a cement concrete which resists the action of frost and thaw cycles in combination with thawing salts.

3. The unevennesses with a wave length of about 10 cm cause most of the rolling noise and even an additional rolling resistance. These unevennesses are a typical feature of cement concrete pavements and are due to compacting and leveling techniques.
   - A constant speed of the skidform is very important in order to obtain a good evenness. This can only be achieved by a constant supply of concrete. The deployment of an additional lorry to improve the constant supply is certainly not a luxury but a must.
   - The longitudinal finishing of the concrete pavement using a supersmoother offers additional guarantee to eliminate these small transverse unevennesses.
     An optimal eveness is essential to noise reduction.

THE CEMENT CONCRETE HARDENING

The new lane consists of a continuous cement concrete hardening (17.000 m²) parallel to the motorway axis and next to the existing cement concrete hardening which is equipped with 4 transverse abutements at both extremities.
The dimensions of the constructed concrete lane are : length 4.400 m, width 3,80 m, thickness 0,20 m.

Considering that the new lane was going to be situated on the former spot of a 26 cm thick hard shoulder (bituminous hardening), the bituminous hardening was first milled out in order to achieve the inlay of the 20 cm thick concrete hardening. The milled materials were efficiently reused as foundation materials for the new bituminous hard shoulder which has been constructed in the excavation zones next to the concrete hardening.

In order to achieve a perfect joint between the new and the existing cement concrete hardening a 5 cm wide strip of the edge of the latter was sawn of over the total length. After the road markings have been applied, the new 4th lane will equally be 3,75 m wide.
Moreover, the new concrete hardening is joined to the existing one by means of a drilled and glued transverse reinforcement.

Concrete Compositions :

porphyry 2/7	400 Kg/m³ (wet)
porphyry 7/14	390 Kg/m³ (wet)
porphyry 14/20	380 Kg/m³ (wet)
river sand 0/4	720 KG/m³ (wet)
cement HK 40	375 Kg/m³
added water	152 l/m³
plasticizer	1 l/m³ Pozzolith 200-N Master Builders-Cleveland-Ohio
air entraining agent	0,8 l/m³ Micro-air Master Builders-Cleveland-Ohio

Reinforcement :

longitudinal : ϕ 16 BE500 with 15 cm intermediate distance, the upper longitudinal bar being 11 cm above the foundation surface.

The percentage of longitudinal steel in proportion to the cross section of the concrete amounts to 0,67 % (which adds up to 12,10 Kg of steel/m²). Experience has learned that, considering this percentage and the good friction hardening/foundation, the cracks are smaller than 0,5 mm and that the prevailing intermediate distance of the cracks ranges from 0,2 m to 6 m.

transverse : ϕ 12 BE 500 with 70 cm intermediate distance meant as a support for the longitudinal reinforcement and meeting at an angle of 60 ° (with regard to the motorway axis) so as to avoid overlapping of transverse cracks and transverse reinforcement;

The mesh reinforcements were fabricated with bars linked in situ.

Joint between existing and new concrete hardening :

A hole of ϕ 22 mm was drilled, mainly with a hammer drill, on a depth of 30 cm and at half height; a diamond drill was used in the existing concrete hardening which was cast on a double reinforcement mesh. After dedusting the drilling holes a wetted joining cartridge (GOLDENBERG) was put in. These cartridges trigger off the joining within 30 minutes after moisting. The joining agent is a cement component.

10 minutes after the moistening, a reinforcement bar, ϕ 16, length 60 cm, was introduced in the drilled hole which was filled with a joining cartridge.
These anchored bars resisted tensile forces between 30 and 40 kN.

Most important cement concrete hardening requirements

content of enclosed air measured on newly cast concrete : 3,5 to 6 %
individual compression strength : ≥ 47 MN/m² after 90 days
average compression strength : ≥ (50 + 1,64s) MN/m² after 90 days, s = standard deviation.
individual water absorption : ≤ 6,8 %
average water absorption : ≤ (6,8 - 1,64s) % s = standard deviation.
surface texture : the average levelling depth which is aimed for, is 1,2 mm measured in a sand mark test. The principle of this test is as follows : a certain amount of sand is equally spread out on the road surface. When the sand is spread out, it fills the road surface texture and forms a circular mark called "sand mark". Per definition the average levelling depth of the road surface is obtained by dividing the spread out sand volume by the area of the sand mark.

Processing

The concrete was processed by means of a slip form paver GOMACO type GP 2500 with 9 vibrating needles with a supersmoother.
The average concrete consistency measured in a VEBE test according to ISO 4110 was 4 to 5 sec.
The average wet volume mass was 2360 kg/m³.
Dayly production was between 300 m and 500 m (limited by the capacity of the concrete mixer).
Immediately after casting the concrete, an setting retarding agent was sprayed over the concrete surface and covered with a plastic sheet. The cement which setting was retarded, was brushed of. The brushing was carried out in dry conditions (without the use of water) in order to achieve the necessary average levelling depth.

The rolling noise measurements

On Octobre 10th, 1992 the German FIGE (Forschungsinstitut Geräusche und Erschutterungen) carried out rolling noise measurements with a totally acoustically insulated trailer pulled by a vehicle at a speed of 120 km/h. The rolling noise is measured by means of microphones which are installed in front of and behind 4 different testing wheels 15 cm above the hardening. The results show that the rolling noise on the low noise level concrete is lower than the rolling noise measured on cement concrete hardenings which were grinded and even lower than the rolling noise measured on solid bituminous hardenings.
In order to compare measurements were carried out on different lanes at Bertem, Bekkevoort, Bierbeek and Holsbeek. The comparison of the average noise levels in dB (A) in these measuring zones goes without saying (figure 2).

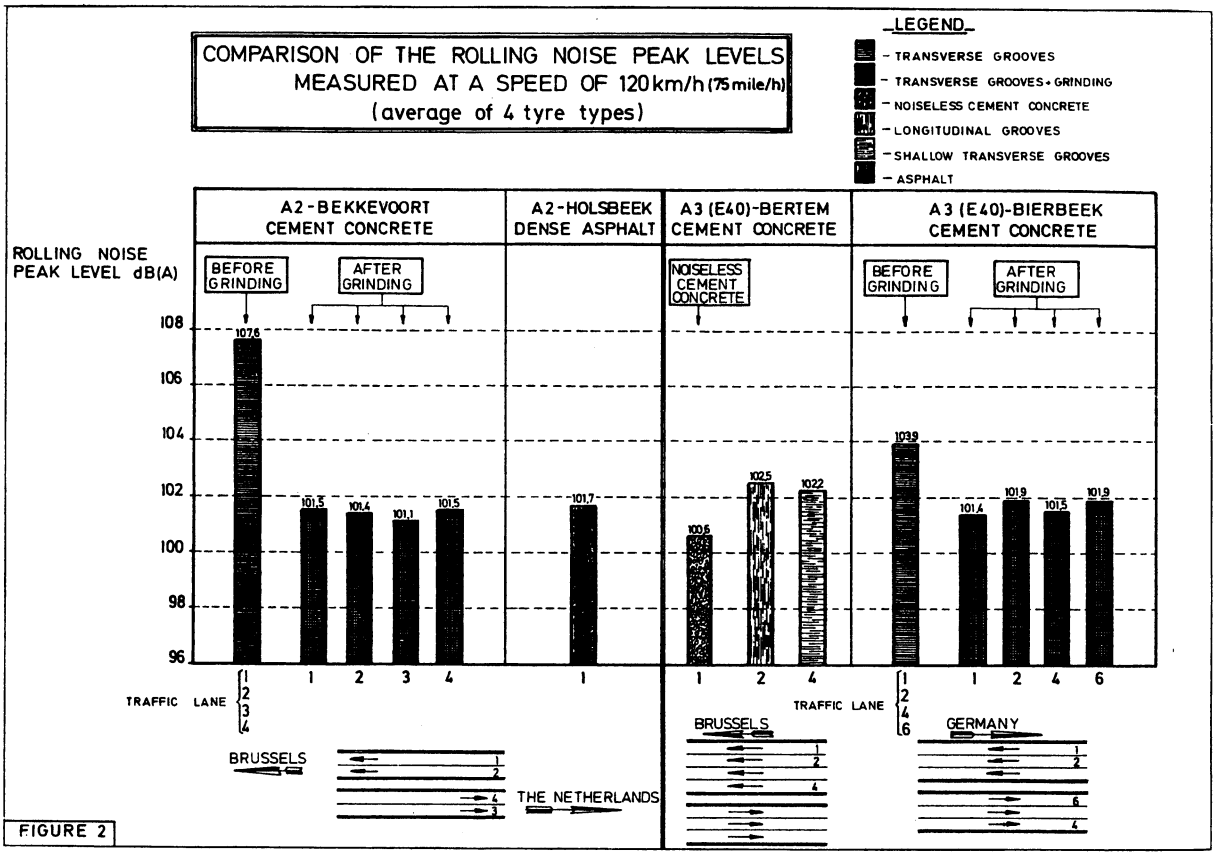


FIGURE 2

THE HARD SHOULDER CEMENT BOUND FOUNDATION

The bituminous waste materials resulting from the milling of the bituminous hardening with a WIRTGEN 2100 DCR in view of the inlay of the 20 cm thick cement concrete hardening, are sieved on a sieve with 32 mm square meshes and subsequently used as admixture for the cement bound foundation of the new hard shoulder. This offers the advantage that not only the milled asphalt rubble can be reused, but also enables to achieve a stable semi-rigid foundation which is less subject to cracks than the usual poor concrete. This appears to be an interesting technique as well for economical as for ecological reasons.

Composition of the cement bound foundation :

Milled and sieved asphalt rubble 0/	:	1495 kg/m³ (dry)
quarry sand 0/6,3	:	355 kg/m³ (dry)
cement HL 30	:	80 kg/m³
fly ash	:	20 kg/m³
water	:	100 l/m³ (of which 50 l has been added)

The wet volume mass was ± 2.220 kg/m³
The compresssion tests carried out on cylinders ϕ 152 mm, heigt 127 mm and compressed according the modified Proctor test gave the following minimum values : 3,1 N/mm² in 7 days and 4,3 N/mm² in 28 days.

TABULAR SUMMARY

Section : BERTEM
E 40 motorway : (London - Brussels - Aachen - (Cologne - Ankarra)
Area : 4.400m x 3,8m = 16.720m2

Traffic : 65.000 vh/d — Commercial vehicles : 20%
Construction motorway : 1971 — Year of widening : 1992

Road structure before widening :

Traffic lane : - surface : continuously reinforced concrete pavement- thickness 20cm
- base : lean-mix concrete - thickness 20cm with a bituminous course - thickness 6cm as a separation layer between base and surface
- sub-base: granular - thickness 30cm

Hard schoulder: - surface : bituminous pavement - thickness 19,5cm - 13,5cm
- base : lean-mix concrete - thickness 20cm with a bituminous course - thickness 6cm as a binder between base and surface
- sub-base: granular - thickness 30cm

Widening :

-milling the bituminous of the hard shoulder

-inlay of a continuously reinforced concrete pavement - thickness 20cm

longitudinal reinforcement : ø 16mm/15cm
transverse reinforcement : ø 12mm/70cm/30° angle
longitudinal joint : anchoring bars ø 16 BE500/75cm/60cm length
abutments with 4 anchoring lugs each
surface treatment : chemical exposure
concrete composition : porphyry 2/7 : 400kg/m3
porphyry 7/14: 390kg/m3
porphyry 14/20:380kg/m3
sand 0/4 : 720kg/m3
water : 152l/m3
cement HK40 : 375kg/m3
admixture - plasticizer : 1l/m3(pozzolith 200-N)
- air entraining agent : 0,8l/m3 (Micro-air) (Master Builders-Cleveland,Ohio)
concrete compression strength at 90 days : 47 MN/m2 at least (50+1,64 standard deviation) MN/m2 average

construction : slip form paver GOMACO type GP 2500 with supersmoother

contractor : N.V. BETONAC - St. Truiden



Photo 1 : Longitudinal and transverse reinforcement

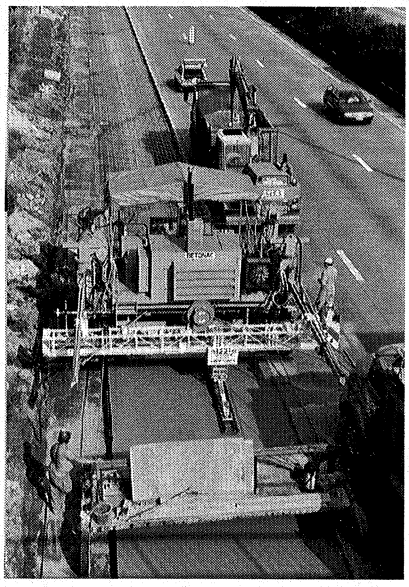


Photo 2 : Concrete train

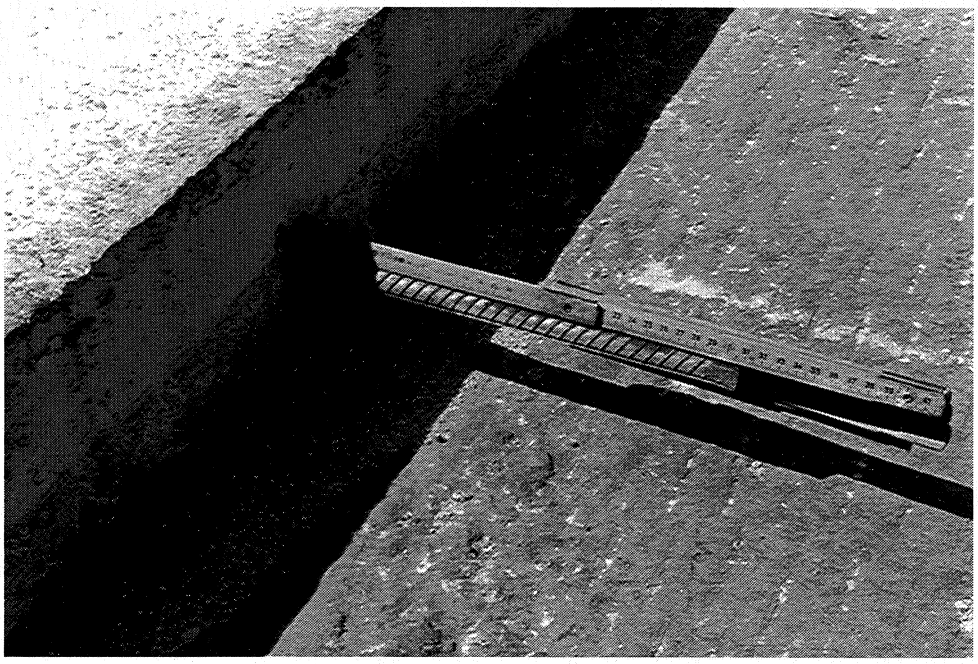


Photo 3 : Detail transverse anchoring



Photo 4 : Widening location

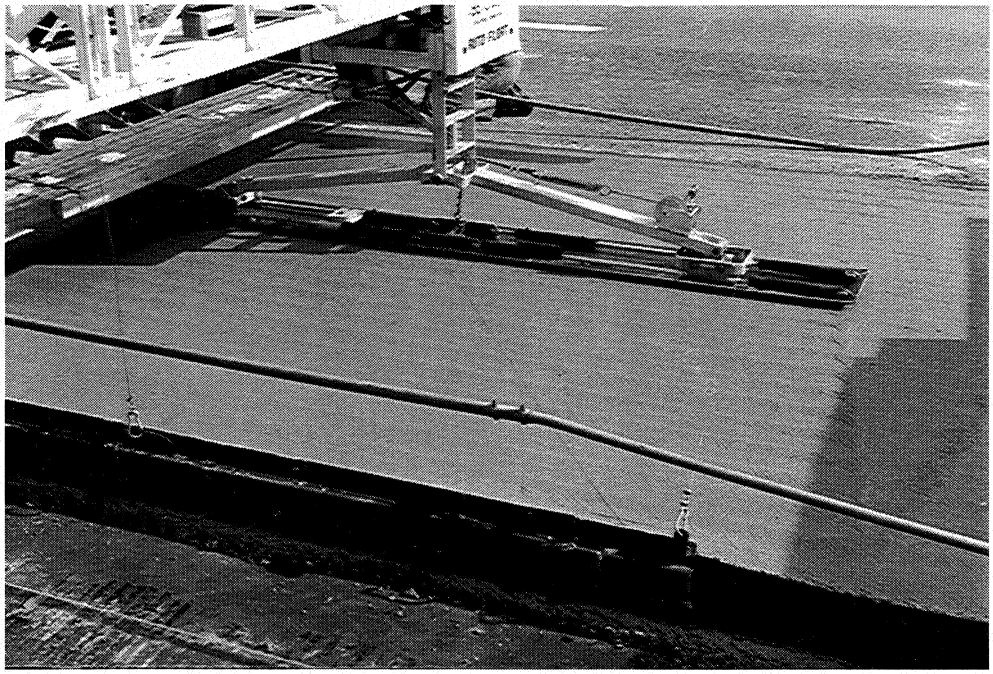


Photo 5 : Use of supersmoother

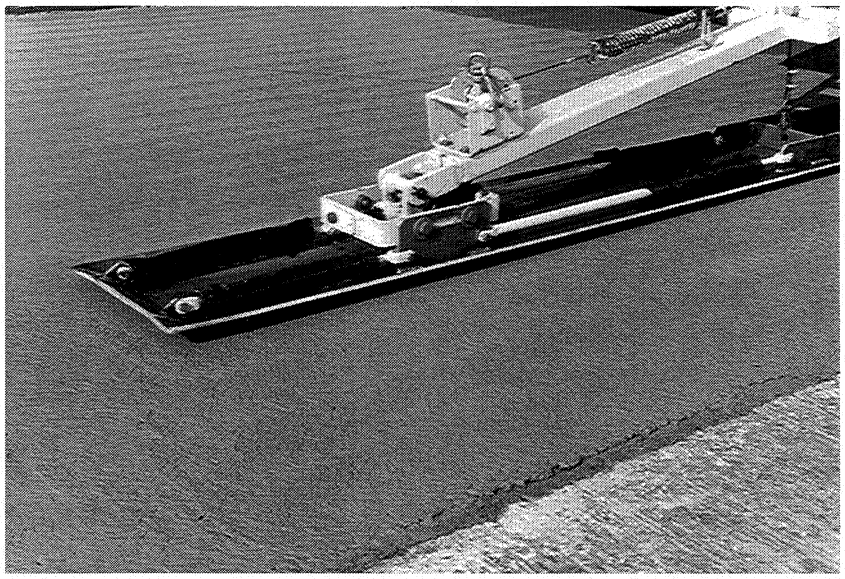


Photo 6 : Detail supersmoother



Photo 7 : Newly cast concrete covered with plastic sheet

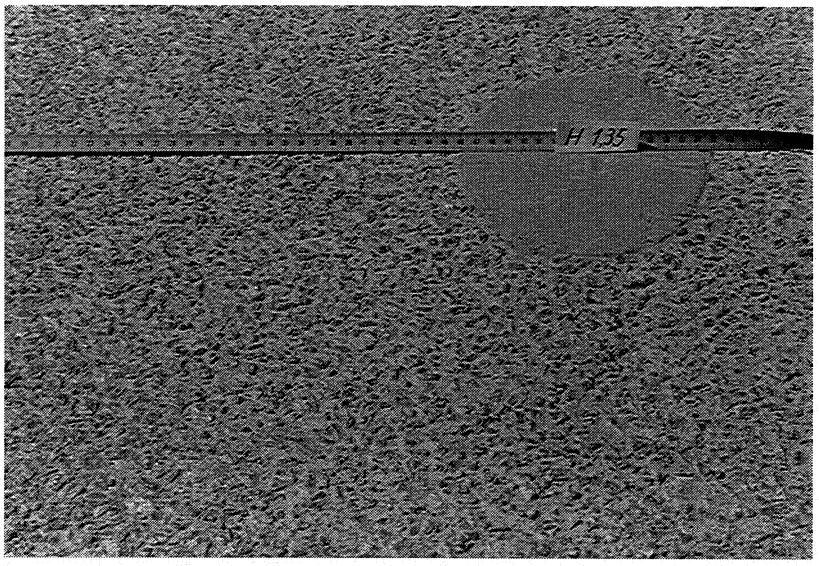


Photo 8 : surface texture - Sand mark test