USE OF SMALL WHEELS ON PAVING PRODUCTS LARGER THAN THE CONTACT AREA OF THE WHEEL.

by

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SUMMARY:

Normally in use of paving products we talk about the product's ability to spread load to the construction underneath. But this is not always the truth. If the pavers shall be able to spread load they have to be smaller than the contact area of wheel or container leg.

If the paving product is larger than the contact area there can be a load concentration in the joints between the pavers. This means that wheel or container leg loads giving relative small loads on the bedding sand and the base with small paving products can give tremendous high loads on the bedding sand and the base with large products.

Use of rolling equipment on paving products larger than each wheel's contact area (foot print).

On paving products larger than a wheel's footprint, a large part of the load can be on the joint between two products. We thus get a load concentration under the joint, and not, as we normally expect, an even load spreading over the whole area.

This problem can arise on many types of constructions, but with use of standard type of paving blocks it will mainly be on areas used by heavy equipment with small wheels. Either with compact or high pressure wheels.

Static loads can also create the same type of problems and the result will be cracked products.

This might be supporting legs for containers, cranes and simular equipment.

With the use of larger types of paving blocks and flags this problem can arise on any type of paved area.

The problem is easy to discover if we look at the wheels on the equipment using the area.

If we, for instance, study a street served by delivery vans, heavy lorries or buses, we will find out the following:

Delivery vans up to 7 tons might have a contact area of 210 x 210 mm, heavy lorries 240 x 240 mm to 280 x 280 mm, and buses 250 x 250 mm to 320 x 320 mm depending on the tyre pressure.
The actual foot print will vary according to the tyre

construction.

If products larger than 210 mm are to be used, one have to look into the real use of the paved area. For fighter air crafts like F-16 this is down to 180 mm.

In reality all products larger than 21 cm must be exactly judged before use. Especially flags, but also paving blocks laid in special pattern.

The best way to solve the problem would be never to use products larger than the contact area of the tyre in use.
This is of course neither practical nor possible to do. The only solution is to make an adequate design for these load concentrations.

What types of forces do we get in a pavement with concentrated joint load?

The main load will be vertical on the building up including the bedding sand. But we also get a horisontal force, by pressing one end of the paver down this will create a rotation in the product. This rotation will be prevented by the neighbouring pavers in a locked up system. The force on the neighbouring pavers depends on:

- height of the paver
- elasticity of the joints
- if the pavement is built as an arch
- the deflection of the pavement.

Special criteria for a pavement with high joint load:

1. A firm building up, max. deflection 0.3 mm.

2. There must not be any displacement or setting in the bedding sand under load. This can cause builing up of an arc under the paver and the paver starts to tilt. Special bedding sand must be used.

3. Firm joints with very little resilient:
If the pavement is able to move horizontally due to movement in the joints, the joints in the load area tend to open up and the jointing sand can drop.

4. To be able to have stable joints, the joint width should normally be between 2 and 3 mm. The variation in plain dimension on the pavers must be down to 1 mm to obtain this joint width.

5. The surface of the finished pavement has to be very even. Level differences between pavers should be max 1 mm. With higher tyre pressure than 300 psi (2.1 Mpa) and high speed this difference should be only 0.5 mm. To achieve this the thickness tolerances on the pavers can only be 2 to 3 mm depending on the traffic.

Joint width 2-3 mm, minimum 1.5 mm, max 3.5 mm.

Jointing sand, strong natural sand 0-2 mm (0.5-2mm).

Special types of flags may have wider joints and will need coarser jointing sand.

A strong and firm edge restrain is needed to prevent horisontal movements.

TESTS ON LARGER PRODUCTS

In order to study the performance of a building up with special bedding sand, an area was prepared for testing at Sola airport. This was on the military part of the airport. It was of special interest for the Airforce to do a test with F-16.

Test area at Sola Airport for F-16.

F-16 has a total weight of 15 tonnes, approximately 2 tonnes on the front wheel and 6.5 tonnes on each of the main wheels.

The main wheels have a tyre pressure of 300 psi (2.1 Mpa) and have a foot print of aprox 17x19 cm.

Blocks used: Uni-Coloc 80 mm. The L shaped Uni-Coloc has a length of 225mm each way, diagonal 310 mm. Max variation in thickness 2 mm.

The strength of these blocks were: Compression strength 60 Mpa and bending strength 6.5 MPa according to Norwegian test methods. The important strength was bending strength due to concentrated weight and total length of the blocks.

The base material: 0-80 mm crushed good strong material. One of the specifications was that it should be able to drain water after compaction and several years of use. The base material was very well compacted and fairly level +/- 15 mm. As top part of the base we put a 30 mm thick layer of 0-12 mm crushed material. This layer was laid with asphalt spreader and compacted. This gave an evenness of +/- 5mm.

Bedding sand: 30 mm of 0-8 mm crushed rock of good quality and with low content of fine material in order to obtain good drainage. This was compacted and screeded to an evenness of +/- 3 mm. This is long wave variation.

Jointing sand: 0.5-1.2 mm dry natural sand of good quality.

Sealing: Pavseel 1 litre covered 2.2 m2.

The blocks were laid with a hydraulic clamp fitted on a digger. This hydraulic clamp was of a new construction with the clamps fitted to the bottom of a high frame. This frame was treaded over a whole pallet and the clamps were locked on the lowest layer. The blocks were then laid cluster by cluster until the clamp was

empty and a new pallet was picked up.

The blocks were adjusted so they could move freely but within the joint tolerances. The joints were filled with dry sand and vibrated with a 70 kg vibrating plate. When the joint was properly filled, a 5 tonne vibrating roller was rolled over the area several times in order to get it as compact and stable as possible.

After the final compaction the area was brushed clean and treated with Pavseel 2.2 m2 per litre. The test with F-16 was done two days after the area was finished.

Test with F-16.

In the first part of the test the aircraft used its own engine. This test was done with the aircraft taxing with high speed and then with very low speed. When it was run at low speed it was stopped several times in order to enable inspection if there was any movement in the blocks.

In the second part of the test the aircraft was towed by a tractor. It was difficult to work close to the aircraft when the engine was running, and therefore deflection was measured with the engine stopped.

The deflection was less than 0.5 mm. It was not possible to detect any movement in the blocks.

The area has now been used for four years and is in the same good condition as when laid.

The second area prepared to take heavy joint loads is the ferry terminal in Sandefjord.

Here flags varying from 300 x 180 to 300 x 360 mm, and with thickness of 80 mm was used. They were mecanically laid, and the clusters were 1200 x 600 mm. To get a broken pattern the clusters were laid in herringbone pattern.

The base course was well compacted and levelled to the correct level. As bedding sand was used 0-16 mm crushed material. This bedding sand is not what we normally consider as a bedding sand, but in order to be able to carry the concentrated weight in the joints of the flags, this type was chosen. This material is very difficult to use as a bedding material, it has to be compacted and then levelled properly. This levelling is not an easy job, so a bedding material like this should preferably be given a rough levelling, and then covered with a thin layer of 0-8 mm sand to smooth the surface. In Sandefjord only the 0-16 mm was used, with an extra effort to get a good surface on the bed. With a bedding material like this with such coarse particles, extra high quality of concrete products is needed.

In addition to high concrete quality, small thickness tolerances - max. variation 2 mm - is needed. On a cluster 1200 x 600 mm, the maximum accepted variation in length and width is 5 mm and

3 mm resp. The flags used had dented sides. The dents gave a minimum joint width of 4 mm, and therefore the joint widths were from 5 to 6 mm (minimum 4 and maximum 7 mm). The jointing sand was natural sand 0 - 3.5 mm, and this coarse sand was chosen due to the joint width.

The area has been in use for 2 years and is functioning well.

Conclusions.

Making a design for a paved area with concentrated joint load is possible, but a number of factors have to be taken into consideration. The base has to be firm and very well compacted to avoid any setting under load. The bedding sand has to be stable under the design load and must be able to drain water even after a long time of use.

A lot of research is still needed to be sure about the different limits - especially on high speed roads. Some of these limits are: max deflection, type of bedding sand, joint width, tolerances on paving products, type of paving products, surfaces of products and finished road. This will also apply for other heavy duty areas. These questions and others need to have true answers and not like to day: conclusion after some special tests or smaller trials.

This would make it easier to make a proper specification for concrete block paving for for any heavy duty area.

Could it be an idea to make an information bank where all knowledge about pavers are collected and made accessible for everybody?

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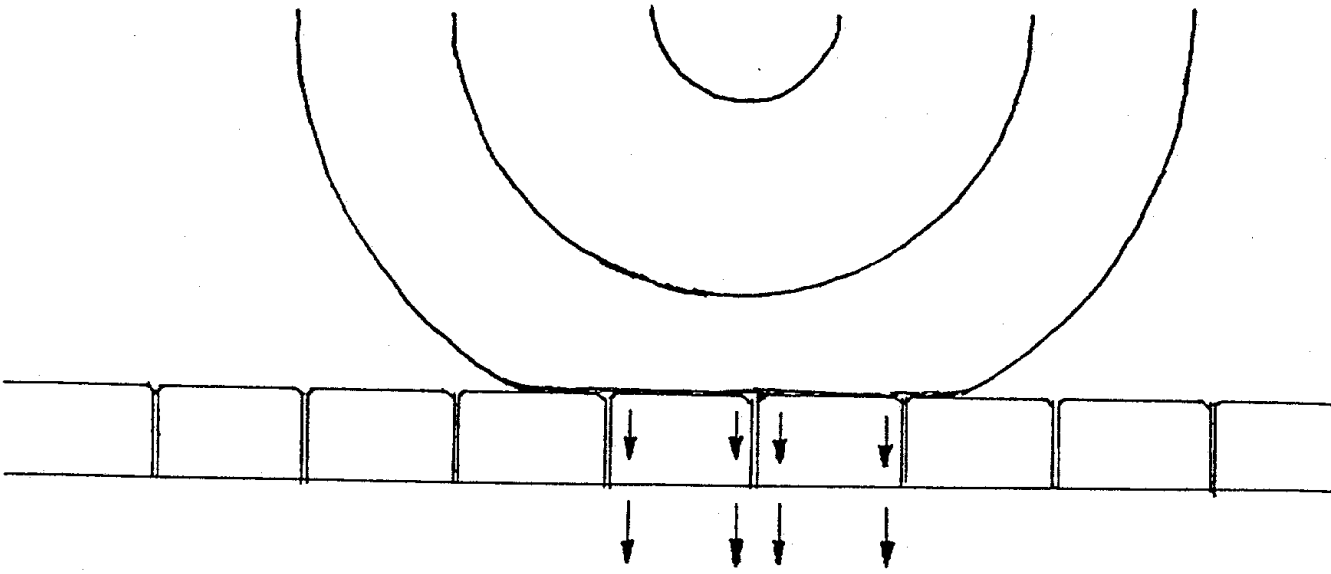
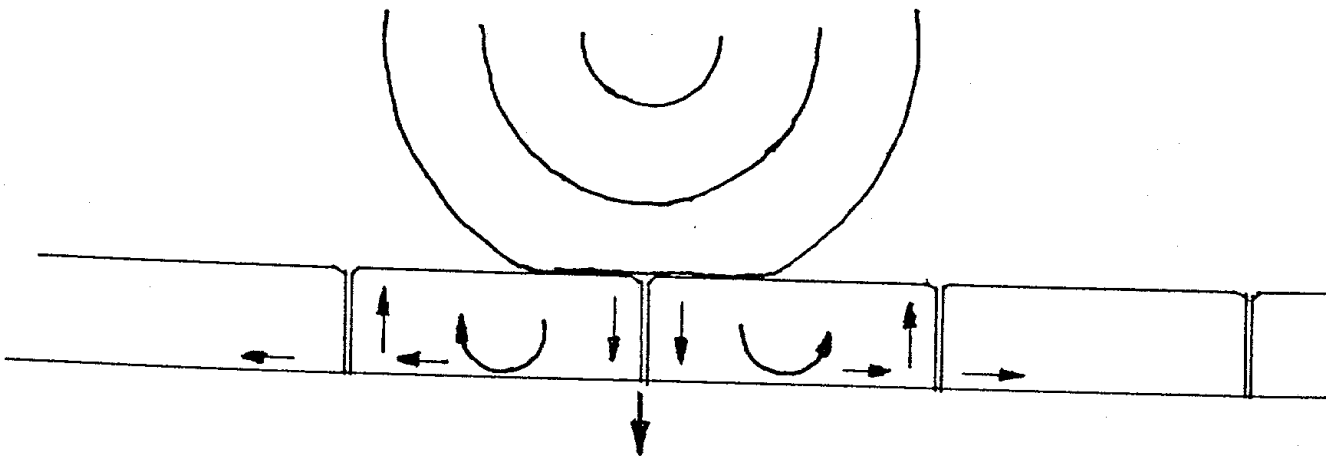


PAVEMENT IN BALANCE



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