Noise reducing concrete block pavements

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Summary

In many towns and communities measures of traffic reduction are taken to increase roadworthiness and to improve the environmental conditions of residential areas. Concrete blocks are often used for these structures. There has been a planning unsureness in Germany concerning tyre-road noise on concrete block pavements. Therefore different investigations in this field were carried out during the last few years. The tested concrete block pavements differed concerning block shape and size, edge shaping, surface texture and laying pattern. The results show that concrete block pavement can be constructed the surface of which produces the same low traffic noise level as on asphalt pavements.

Generally, the results of the investigations admit conclusions as follows:

- Plain smooth (microtextured) surfaces offer the lowest noise generation.
- Larger block sizes (> 12 x 24 cm) are better with regard to noise reduction than smaller ones (less share of joints).
- The joints between the blocks contribute to the noise reduction characteristics. The influence increases with favourable surface textures and with wider joints also. Tyre-road noise is lower when cars drive over such joints diagonally or parallely.
- In case of favourable blocks laid with small joints (width < 5 mm) the axis of laying patterns becomes irrelevant.
- Using concrete block paving it is to differentiate between different speed zones: < 20 km/h, 20-30 km/h, 30-50 km/h and > 50 km/h.

In areas with a speed limit of 10 or 20 km/h the use of any kind of concrete blocks is not at all critical with regard to the tyre-road noise. The differences between the levels are so small that they are without any significance. Blocks should be chosen from the point of a handsome structure or a good suitability for walking, if relevant. Moreover, measures should be taken to ensure that the speed limit will really be kept. This applies to speed-30-zones as well. Here a higher tyre-road noise may indeed occur if an unfavourable concrete block pavement is used. The increase in level should then be avoided by lowering the speed.

In cases of a speed more than 30 km/h and up to 50 km/h only those concrete blocks should be used which generate no more tyre-road noise than asphalt. On roads with a speed limit higher than 50 or 60 km/h concrete block pavement can be used when noise protection is not important and the blocks offer high skid resistance, for example by a roughened surface.

Noise reducing Concrete Block Pavements

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In many towns and communities measures of traffic reduction are being taken to increase roadworthiness and to improve the environmental conditions in residential areas. Concrete blocks are often used for these structures. There has been a planning unsureness in Germany concerning tyre-road noise on concrete block pavements. Therefore different investigations in this field were carried out during the last years. The results show that concrete block pavement can be constructed the surface of which produces the same low traffic noise level as on asphalt pavements. Investigations in Austria reach the same conclusion.

Drive noise and tyre-road noise

It is well-known that the noise emitted by cars is mainly composed of the drive noise and the tyre-road noise. The drive noise is produced by engine, exhaust and other parts of the car and not causally related to the speed but to the engine speed and the engine load. Its general level is determined by the vehicle technique, its actual level by the traffic situation and the way of driving. The tyre-road noise is generated at their interface related to the speed and increases with it. Its level is determined by the tyre and the road surface as well.

Today, the drive noise is dominant only in cases of driving up and accelerating. In all other situations, the tyre-road noise is almost equal in weight or even dominant. For instance, it is known from traffic reduction measures accompanying investigations, that the share of the tyre-road noise of moving traffic at 50 km/h reaches about 80 per cent of the total noise. Even in so called speed-30-areas the tyre-road noise is still significant even the desired speed is kept.

The important fact has been that noise reducing concrete blocks and concrete block paving have had to be developed.

Ways of reducing tyre-road noise

The unevenness of a road surface, and joints activate the tyre into radial vibration. Its low frequent noise emission is all the more higher the rougher and more uneven the surface. High frequent noise is caused by air pumping in the tread grooves of the tyre. The smoother the surface the louder is the noise.

Ways for noise reducing pavements are in principle

- porous surfaces
- textures like sand paper and emery cloth with fine-grained chipping points (gaps < 10 mm) on a plain surface
- a plain smooth surface with narrow and with each other connected "channels" (width < 5 mm, depth > 10 mm) running longitudinally or diagonally to the direction of the traffic.

The second and especially the third possibility can be used to realise a noise reducing concrete block pavement. Another criterion is the number, width and direction of the joints.

Measurements and results

The noise measurement method used for the investigations has been specified and introduced by the Federal Department of Transport. According to the discussion of the working group ISO/TC 43/SC 1 /WG 33 the method could be called the "Controlled Pass-by method". It relies on certain vehicles equipped with certain tyre types: two different cars with petrol engine, smaller and larger than cubic capacity

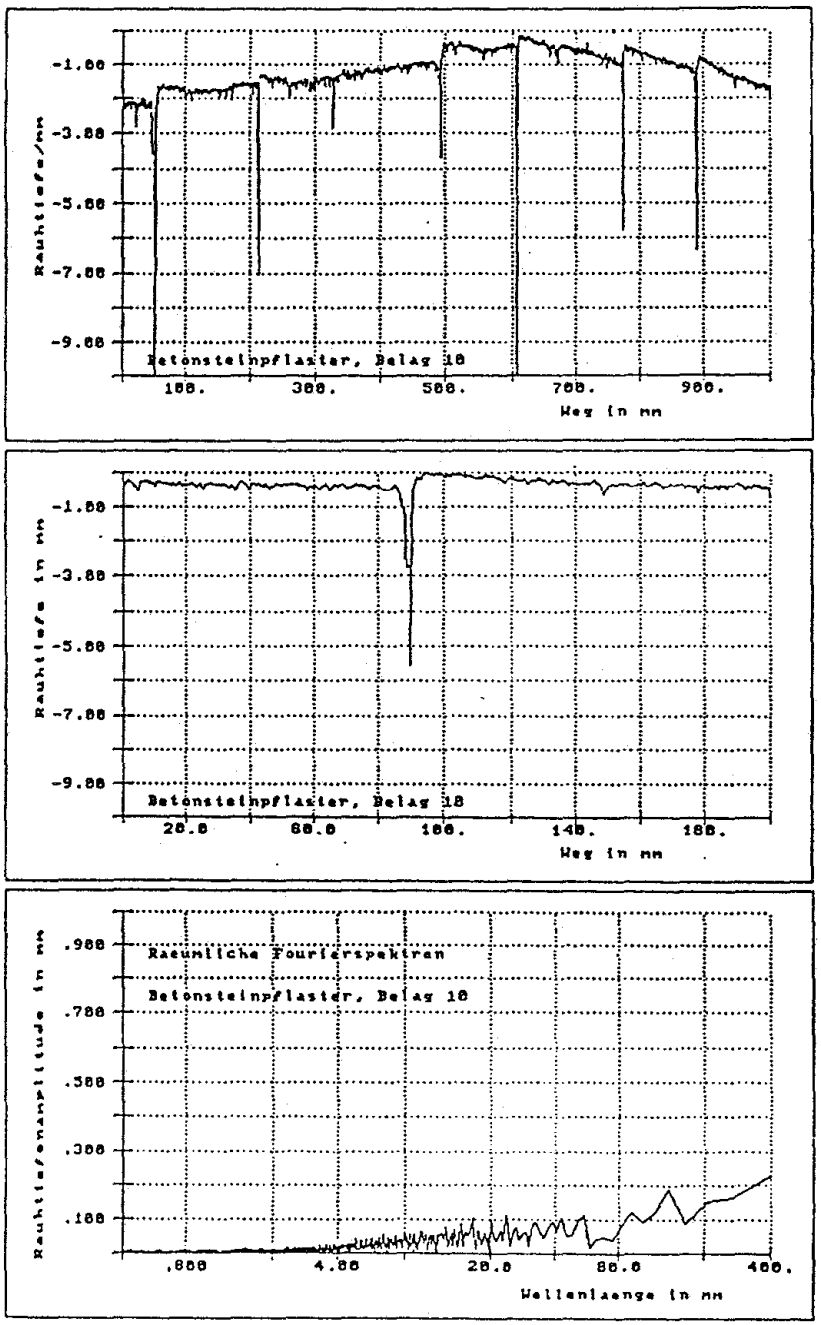

Figure 1: Surface roughness in mm versus the distance in mm and roughness amplitudes in mm correlated with the wavelength in mm (below)

2000 c.c., each with two different sets of tyres. Microphone is at a height of 1.20 m and at a distance of 7.50 m. The operating conditions are 2nd and 3rd gear constant 30 km/h and 3rd and 4th gear constant 50 km/h.

In addition, the block pavement surfaces No. 1 - 12 (table 2) were scanned by a Laserprofilometer to get information about the texture and wavelength. Correlations between the surface, types of joints, and laying and the noise generation were meant to be discovered with this. Figure 1 shows an example of a noise reducing concrete block pavement. The double T interlocking blocks are laid with narrow joints, the surface is plain. Only small amplitudes occur in the long wavelength region, which is favourable for a tyre vibration as little as possible. There are no prominent discrete wavelengths. There is a good microtexture (wavelength < 10 mm) which suppresses the part of the noise caused by the tyre tread.

In table 1 individual investigations are drawn up. In some cases the results have been reported but not the noise level.

The reference pavement used is the asphalt wearing course (German abbreviation AB 0/11 mm) with a maximum grain size of 11 mm and without spreading chippings. This pavement is usually used in Germany within towns and regarded as a noise reducing one. The noise level of asphalt 0/11 varies within 3 dB(A) and is

L(30) = 61,8 dB(A) ± 1,5 dB(A) at 30 km/h
L(50) = 68,0 dB(A) ± 1,5 dB(A) at 50 km/h.

No.	block	size	edge	surface	laying	L (30)	L (50)
A	Tavolo	several rectangles	without bevel	not treated moderate rough	each diagonally laid in a mix of blocks	62,6	69,1
B	Tegula	several rectangles	hacked corners and edges	not treated moderate rough	13,9 x 16,4 cm 16,4 x 16,4 cm 21,4 x 16,4 cm 27,4 x 16,4 cm 28,0 x 16,4 cm	63,5	70,9
C	Tacato	several rectangles	with bevel	milled, rough		64,6	72,4
D	Siena	rectangle 15/20/12 cm	without bevel	smooth	diagonally laid herringbone pattern	as asphalt 0/11	
E	La Linia	rectangle 15/20/12 cm	without bevel	finely blasted	diagonally laid herringbone pattern	as asphalt 0/11	
F	Modula	rectangle 16/32/8 [1]	without bevel	face concrete smooth	diagonally laid herringbone pattern	as asphalt 0/11	
G	Rusta-lin	rectangle 16/24/8 cm	small bevel	finely scrubbed	diagonally laid	62,2	69,2
[1] also 16/16/8, 16/24/8, 16/16/12 and 16/24/12 cm							
reference pavement: asphalt 0/11 mm, variation ± 1,5 dB(A)						61,8	68,0

Table 1: Individual investigations

Table 2 describes the tested pavements of a widely laid out research project with twelve different concrete block pavements. They differed concerning block shape and size, edge shaping, surface texture, and laying pattern. The chosen blocks represent the whole range of usual blocks in Germany. The noise and texture measurements were carried out on special test sections to avoid any falsifying influence on the results.

No.	block	edge	surface	laying
1	rectangle 16/24/8 cm	without bevel	smooth	diagonally laid
2	rectangle 16/24/8 cm	with bevel 3/3	smooth	diagonally laid
3	rectangle 16/24/8 cm	without bevel	smooth	stretcher bond
4	rectangle 16/24/8 cm	with bevel 3/3	smooth	stretcher bond
5	rectangle 16/24/8 cm	without bevel	finely roughened (1-3), uneven, lightly scrubbed	stretcher bond
6	rectangle 16/24/8 cm	with bevel 3/5	roughened (2-5), finely scrubbed	stretcher bond
7	rectangle 16/24/8 cm	without bevel	sand blasted	stretcher bond
8	rectangle 9,5/19,5/8 cm	with bevel 3/3	smooth	stretcher bond
9	hexagonal 20[1]/8 cm	with bevel 2/3	smooth	diagonally laid [2]
10	double T 16,5/20/8 cm interlocking	without bevel	smooth	stretcher bond
11	around 11,2/22,5/8 cm interlocking	with bevel 4/6	smooth	stretcher bond
12	rectangle 16/24/8 cm	hacked corners and edges	smooth	stretcher bond

[1] measured perpendicularly to the parallel sides [2] two opposite edges parallel to the lane axis

Table 2: Test pavements

Figures 2 and 3 give the results of the noise measurements. The block numbers correspond to those of table 2. The noise levels are mean values from 16 measurements, two for each vehicle-tyre combination and two for each gear.

The difference between the lowest and highest pass-by level was 3.5 dB(A) in case of 30 km/h and 5.6 dB(A) in case of 50 km/h, in total (30 and 50 km/h) 11,1 dB(A). The greatest difference between the tyres was about 6 dB(A) (unfavourable block No. 8, 50 km/h, in case of asphalt 0/11 it was 3 dB(A)).

Seven among the twelve concrete block pavements generated noise levels which were as low as with asphalt 0/11.

Even on pavements with blocks with a small chamfer the noise level was equal to the asphalt pavement when larger block sizes (requirements less than 30 per square metre) and diagonal laying were used. For blocks without a chamfer it is also possible to use a stretcher bond.

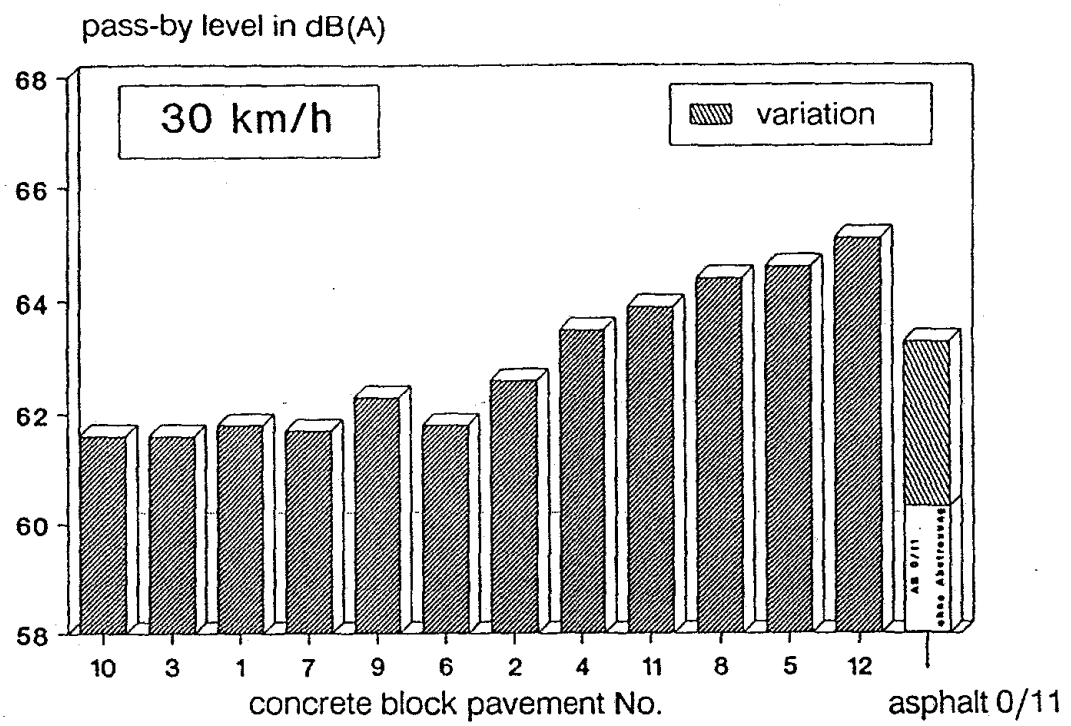

Figure 2: Pass-by level for different concrete block pavements and asphalt 0/11 (variation ± 1,5 dB(A)), speed 30 km/h

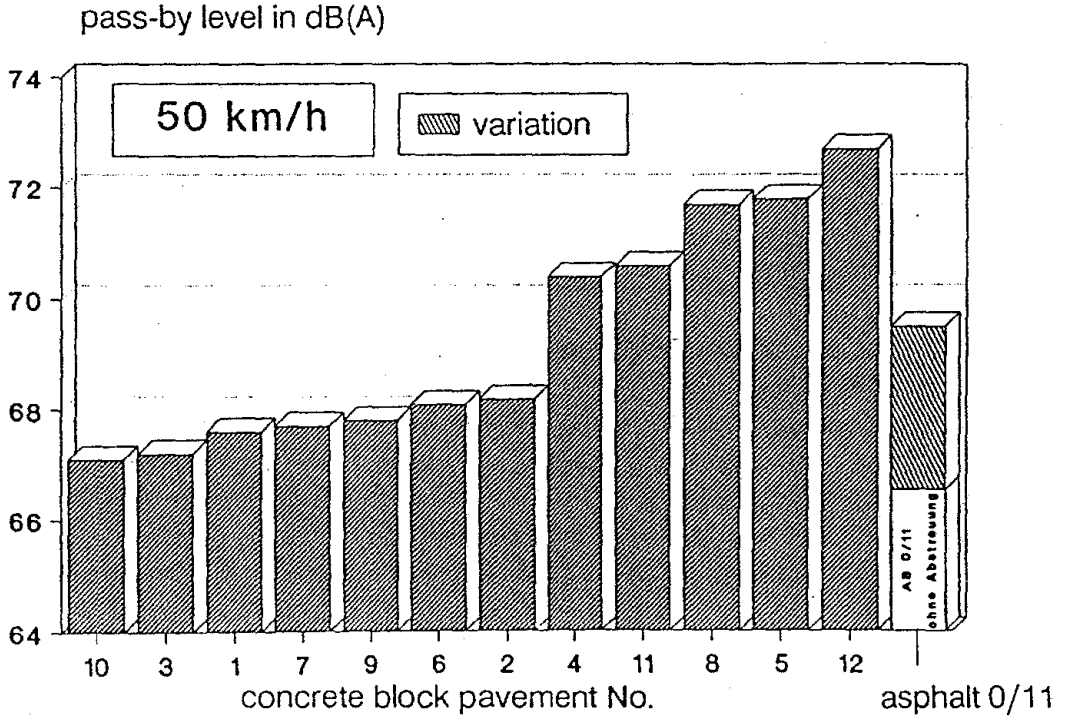

Figure 3: Pass-by level for different concrete block pavements and asphalt 0/11 (variation ± 1,5 dB(A)), speed 50 km/h

Conclusions

Generally, the results of the investigations admit conclusions as follows:

- Plain smooth (microtextured) surfaces offer the lowest noise generation.
- In case of a rough surface and increasing speed the noise level increases more than on finely textured surfaces.
- Smooth finely textured (grain mix up to 2/5 mm) or finely scrubbed or sand blasted surfaces are better than very smooth surfaces. This is particularly true of wider joints and stretcher bonds.
- Larger block sizes (> 12 x 24 cm) are better with regard to noise reduction than smaller ones (less share of joints).
- Subject to blocks being (neither large nor small) medium sized, the joints between the blocks contribute to the noise reduction characteristics. The influence also increases with favourable surface textures and with wider joints. Tyre-road noise is lower when such joints are diagonal or parallel to the direction of traffic.
- In case of favourable blocks laid with small joints (width < 5 mm) the axis of laying patterns becomes irrelevant.
- For blocks with a chamfer, especially for rectangle blocks, diagonally laying should be preferred.
- Long-term evenness of the pavement surface has to be guaranteed.
- Increased noise is caused by

  - joint plus chamfer width
    in case of stretcher bond: more than 8 mm
    in case of diagonal laying: more than 12 mm

  - joint spacing
    in case of rectangle and hexagonal setts: less than 150 mm
    in case of interlocking setts: less than 110 mm

  - sett size and requirements per m^2
    in case of rectangle and hexagonal setts: more than 36 blocks per m^2
    in case of interlocking setts: more than 39 blocks per m^2

  - texture/evenness
    depth of roughness more than ± 1 mm within a wavelength from 20 to 200 mm.

Recommendations to decision makers and planners

There is no reason why, because of their supposedly high noise levels, concrete block pavements should not be used for restricted traffic areas and roads with an

upper speed limit of 50 km/h provided attention is paid to the above mentioned conclusions and the following recommendations. Additionally, it is to differentiate between different speed zones.

In areas with a speed limit of 10 or 20 km/h the use of any kind of concrete blocks is not at all critical with regard to the tyre-road noise. The differences between the levels are so small that they are without any significance. Blocks should be chosen from the point of a handsome structure or a good suitability for walking, if relevant. Moreover, measures should be taken to ensure that the speed limit will really be kept. This applies to speed-30-zones as well. Here a higher tyre-road noise may indeed occur if an unfavourable concrete block pavement is used. The increase in level should then be avoided by lowering the speed.

In cases of a speed more than 30 km/h and up to 50 km/h only those concrete blocks should be used which generate no more tyre-road noise than asphalt. On roads with a speed limit higher than 50 or 60 km/h concrete block pavement can be used when noise protection is not important and the blocks offer high skid resistance, for example by a roughened surface.

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