10th International Conference on Concrete Block Paving
Shanghai, Peoples Republic of China, November 24-26, 2012

Sound-Reduced Concrete Block Pavement

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Note: The following is the notation used in this paper: (,) for decimals and (.) for thousands.

Summary
In many European countries traffic noise is not only considered as disturbing in the sense of noise disturbance, but also as a negative factor influencing health conditions negatively. Therefore, often through roads and highways have been optimized sonically e.g. by using open pored asphalt and additionally, steps for sonic protection are taken successively by sonic protection walls. Local authorities and cities of course are trying to react adequately though here different constructional boundary conditions are present. Comprehensive sonic protection plans based on so called “noise mapping” are established and depending on the financial situation more and more suitable actions are taken. Besides traffic direction and speed limitations different paved areas of municipal roads and their sonic technical characteristics have become of interest to the city planners. “Pavement out” – “asphalt in” is roughly phrased the situation often met at local authorities and cities.

Against this important background with the potential loss of important market shares, SF-Kooperation started the”noise abating pavement” project. Target is the development of a paving construction method with concrete stones which is optimized in reference to sound emission. In cooperation with well-known German universities (TU Munich + University Kassel) and an engineering company for acoustics (Müller BBM) and by the financial support of the Federal Road Research Institute (Bundesanstalt für Straßenwesen (BASt)) this target shall be reached by March 2014 [1]. In general from the scientific-technical viewpoint three different approaches are taken. The current laboratory technical results, which are part of the presentation, show that the acoustic targets (at least equivalent to asphalt) can be achieved. The resulting requirements in concrete technology and production technology are in a realization status right now. The aspects of durability still have to be tested.

Basics

In general intra-urban traffic noise in industrial countries is primarily caused by the tyre-road-contact (fig. 1), as the modern motorization of the vehicles eclipses the engine noise more and more. Electrical vehicles or vehicles with hybrid driving systems almost have no engine noise any more! So the overall surface structure of paving areas including joints e.g. obviously becomes more and more important in reference to sonic emission. Also paving areas priory are built in roads with speed limits so that motor noise does not become dominant anyways, e. g. in housing areas, in old parts of cities or on parking lots of shopping malls.

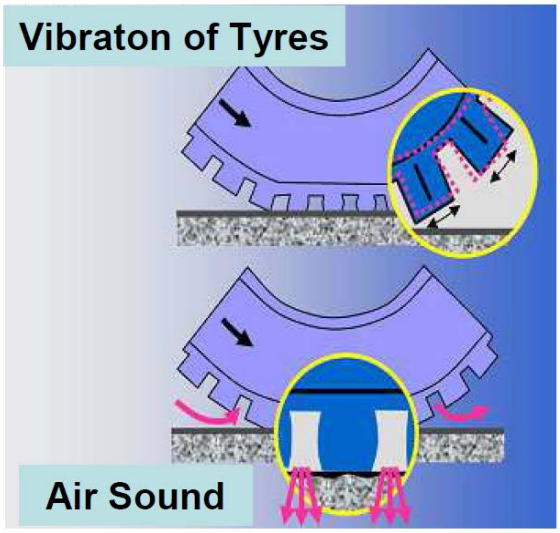

Fig. 1: Generation of road noise

Already in 1992 first tests took place in Germany to describe the sound emission of concrete paving areas and to reduce those as far as possible. The test of FIGE GmbH [2] posted the following premise for a noise lowering pavement construction with concrete stones:

- *Diagonal laying*
- *Joint+Chamfer-Width ≤8mm (Stretching bond)+ ≤12mm (Diagonal bond)*
- *Joint distance >150 mm (Rectangle stone)+ >110 mm (Interlocking stone)*
- *(Durable) even laying*
- *Surface texture with finely roughened surface*

This known information which could have been verified by modern measuring technique in the quality and quantity aspect - as far as you would like to apply it to the current marketing for concrete pavements – created the starting position for the project “noise abating pavement”.

As entry to the project first orientating measurements or simulations should help clarifying which potentials modern concrete paving systems show in reference to optimization of noise emission at all. For these tests the paving stone system VS5® of SF-Kooperation was chosen which is characterized by a close joint distance and shows a finely structured surface in its standard configuration. By the means of texture measuring the parameter “surface texture” including joint geometry was determined and by the means of simulation software SPERoN (www.speron.net) processed.

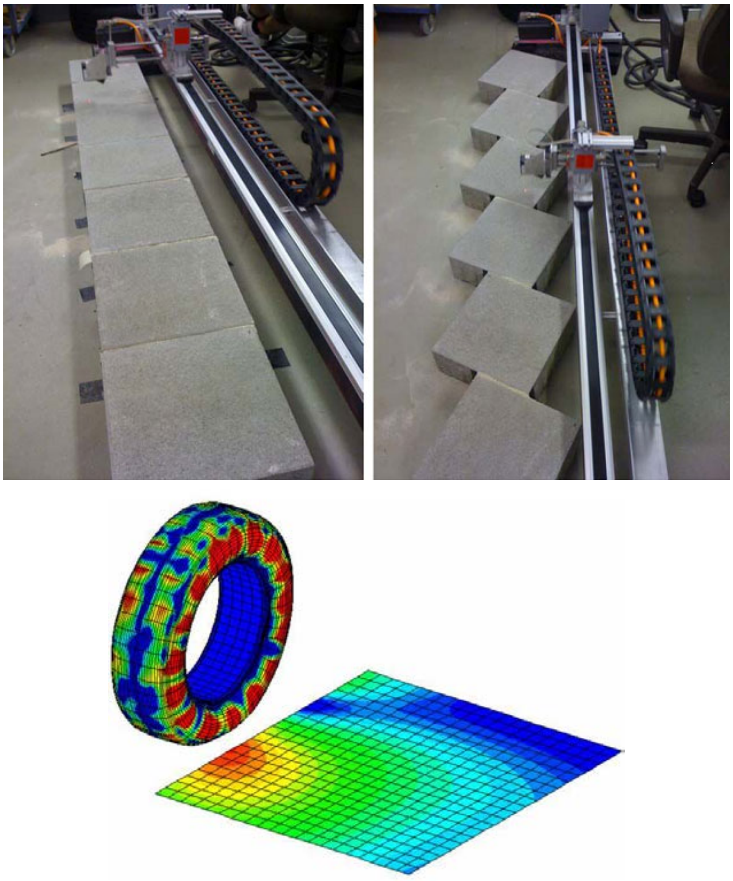

Fig. 2*: 3-dimensional texture measurements with 90° (left) and 60° (right) joint design; Simulation model of sound pressure distribution (SPERoN)*

The VS5®-stone system in its simulated diagonal laying kept up with the German calculated reference values of 70 dB(A) at speed of 50km/h for melted asphalt. By optimization of the surface textures the potential for improvement should be reached!

Development of a Noise-Abating Concrete Block Paver and an Adequate Paving Method

In knowledge of the optimized sonic technical surfaces from asphalt or concrete which are currently applied for the highway construction in Europe two concepts are followed up:

- Optimized surface texture
- Optimized open porous concrete (analogue to open porous asphalt)

General considerations in the area of general construction acoustics led to the acceptance of plasticized concretes (“rubber concrete“) for testing.

Based on the fact of current texture measurements and simulations with SPERoN new surface textures have been developed. The randomized rhomb structure (fig. 3) is the current final result of this development which of course now has to be tested for its technical realization in the concrete plant. Sonic technical field testing and tests of several permeability aspects will also be performed. By the means of SPERoN this rhomb texture received a certificate for sonic protection improvement factor of -3 dB (A) which would correspond to reducing the acoustically realized traffic amount by half.



Fig. 3: CBP with randomized rhombuses

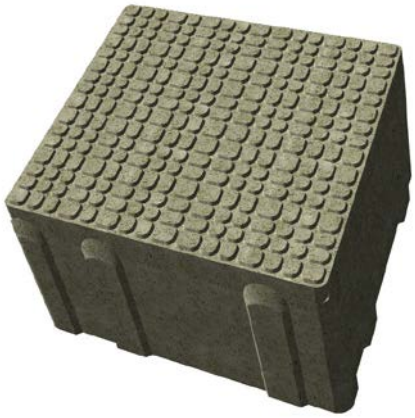

Fig. 4: First prototypes (wet-cast)

The open porous concrete for noise abating pavements ties with the knowledge in hydro-active surfaces (PPS) with stones of drain concrete; however the amount of pores as well as the distribution of pores thru the stone cross section has to be optimized to reach sufficient sonic technical improvements. Also of course a sufficient resistance towards frost-salt-attacks has to be granted to driven on surfaces. This is a special challenge!



Fig. 5 Open porous asphalt



Fig. 6 Open porous concrete

As known elastic materials absorb sound. Accordingly, sound protection walls from concrete are produced with the additives of rubber granulates and successfully applied [3]. Also there is historical proof for the use of caoutchouc concrete for paving stones in the area of the Manaus Opera, Brazil. Citation of the German version of Wikipedia: “The paving stones around the building have been produced of a mixture of sand and caoutchouc to avoid disturbance of the performances by horse carriages driving by” [http://de.wikipedia.org/wiki/Teatro_Amazonas].

The current tests show that binding in a “rubber granulate” of 200 kg/m³ into the concrete matrix alone does not lead to the target. Significant improvements of sonic emissions can be reached if the rubber granulate is on the surface to be driven on.



Fig. 7 *"Washed concrete surface" with rubber granulate 8 mm, uncoated (TU Munich)*

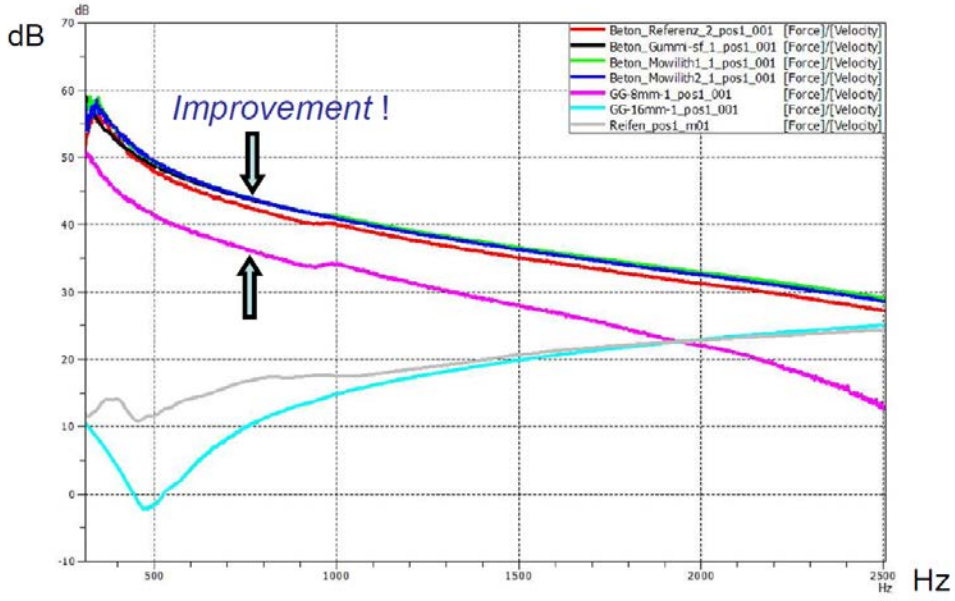

Fig. 8 Improvement of concrete block pavement with rubber granulate 8mm, uncoated (Müller BBM)

But also for this technological approach the important aspects of permeability have to be clarified.

Besides product development the laying technology and also the overall construction require high attention. Because a permeable layer is the prior condition for a permeable low sonic emission!

Accordingly, for this construction method highly compressed, unbound or hydraulically bound bearing layers have to be planned. The water impermeability of the bearing layers which is connected to this requirement (alternative: drainage bearing layers) might lead to a high damage potential. Here again a combination with the ECOPREC®-construction method

offers a way for solution. Corresponding testing fields will assist in verification of these considerations.

At the official finalization of the project “noise abating pavement” in spring 2014, which additionally is being accompanied by the additional testing of the German professional association SLG and the Research institute for road and traffic (FGSV) for sonic emission of present paving areas, it should become clear if and in which extent concrete paving stone systems can attractively contribute to the reduction of traffic noise load in our cities in future. A report will follow during the 10th ICCBP 2015 in Dresden, Germany.

References

[1] Bundesanstalt für Straßenwesen (BASt), Deutschland, 2011, Nationales Innovationsprogramm Straße; Förderschwerpunkt: „Leise innovative Fahrbahndecke aus Beton und auf Kunststoffbasis“; Forschungsantrag: Lärmarmes Betonsteinpflaster (Antragsteller: SF-Kooperation GmbH, Bremen); unveröffentlicht

[2] FIGE GmbH Forschungsinstitut Geräusche und Erschütterungen, Deutschland, 1992, Geräuschemission auf Betonsteinpflaster (Auftraggeber: Deutscher Beton- + Fertigteilverband e.V.)

[3] Gelbrich, S.; Unger C.; Kroll, L.: Ressourceneffiziente Lärmschutzelemente in Leichtbauweise – Effektiver Lärmschutz mit verbesserter Dauerhaftigkeit durch Gummirecyclinggranulate. Tagungsband Bautechnik-Forum. Chemnitz: 2009.