A NEW VEHICLE-PAVEMENT INTERACTION TEST FACILITY AT BAST

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Abstract

One of the Federal Highway Research Institute's (BASt) research goals is to eliminate or at least reduce environmental stress caused by road traffic. This includes minimisation of noise generated by road traffic, which means minimisation of tyre road noise. To carry out examinations of this topic under laboratory conditions, a vehicle-pavement interaction facility was established at the Federal Highway Research Institute. Properties which can be tested here besides tyre/pavement noise emission measurements include the high speed and durability testing of tyres, rolling resistance measurements of tyres, as well as the testing of the stability of pavements, which means testing the rutting resistance of pavement surfaces stressed by truck tyres.

Keywords: Vehicle-pavement interaction test facility, Tyre/pavement interaction, Noise emission measurement.

Résumé

L'un des objectifs de recherche de l'Institut Fédéral de Recherches Routières est d'éliminer ou du moins de réduire les contraintes environnementales causées par le trafic routier. Ceci comprend la réduction du bruit engendré par le trafic routier, donc des nuisances sonores produites par les pneus sur les routes. Pour mener à bien les études en laboratoire sur ce sujet, une plate-forme dédiée à l'étude de l'interaction véhicule/chaussée a été installé à l'Institut Fédéral de Recherches Routières. Outre les mesures des émissions sonores provoquées par l'interaction pneu/chaussée, cet équipement permet de réaliser des essais de résistance des pneus et des essais à vitesses élevées, des mesures de résistance au roulage des pneus, ainsi que des essais de durabilité des chaussées, donc sur la résistance à l'orniérage des surfaces de la chaussée soumises aux passages des pneus de camions.

Mots-clefs: Plate-forme d'essai sur l'interaction véhicule/chaussée, interaction véhicule/ chaussée, mesures démissions sonores.

1. The Test Facility (PFF)

The vehicle-pavement interaction test facility consists of a large, rotatable, half-open drum with an internal diameter of 5,50 m, inside which caskets are mounted, which are filled with realistic road materials. Passenger car and truck tyres can roll on this road surface.

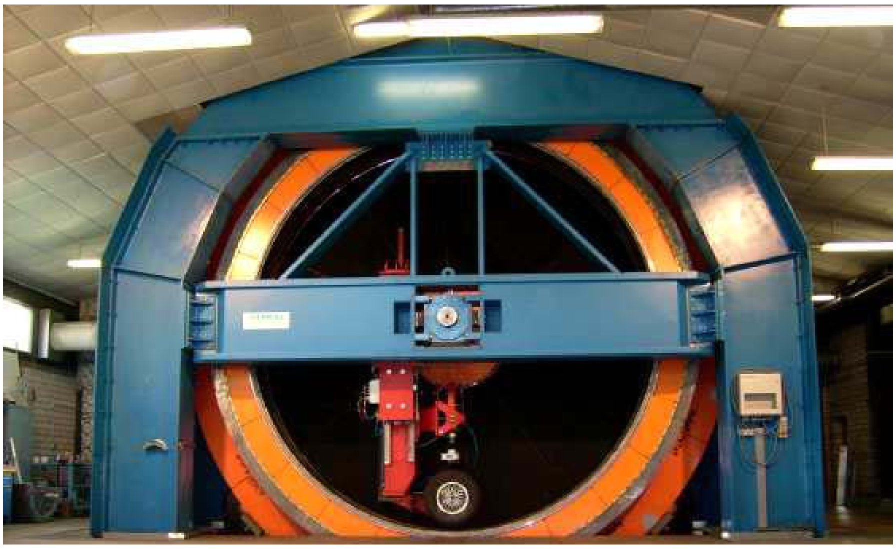

Figure 1 – The Tyre Road Interaction Test Facility (PFF) of BASt.

The drum is fixed to a central shaft by 12 spokes and is driven by a 350 kW electric linear motor which allows a maximum speed of 280 km/h. The spokes are covered by sheet metal plates to avoid air turbulence and these are coated with sound-absorbing material. The central shaft is pivoted inside a frame structure with crossbeams. This test facility can be used to scientifically examine the following aspects:

- Tyre/pavement noise on novel, quiet pavement types
- Noise at bridge and carriageway expansion joints
- Noise from passenger car and truck tyres on standardised road surfaces
- High speed performance of passenger car tyres
- Durability performance of truck tyres
- Rolling resistance of tyres on different types of pavement
- Rutting of road surfaces by truck tyres (single and twin tyres)

Tyre/pavement noise can be measured in the near field and far field. Two different sets of roadway caskets can be installed in the drum for the purpose of testing:

- 50-centimeter wide caskets with a road surface filling height of 4 cm
- 85-centimeter wide caskets with a filling height of 8 cm

This permits various pavement structures comprising asphalt (dense or porous) or concrete to be installed in the test bench's caskets. Three height-adjustable wheel stations are present for mounting different wheels:

- Passenger car wheel station with steering angle adjustment (+/-15°),
- Passenger car wheel station without steering angle adjustment but with a device for rolling resistance measurements,
- Truck wheel station (without steering angle adjustment) with two different hubs for wheels sized 19.5 and 22.5 inches in single or twin mode.

The wheel load for truck tyres can be adjusted pneumatically to a maximum value of 6.5 tons. The reconstruction of the test facility PFF was carried out by Siemens Automation and Drives. After a 3 year construction phase the test facility was opened in April 2007. This paper describes the test facility in detail with respect to future truck tyre experiments. The installation of pavements into the test facility's caskets and the manufacturing process of the different pavements itself are described. The single reconstruction steps are described by the Figure 2.

Figure 2 – Reconstruction of the PFF: traverse shaft spokes (uncovered).

2. Preparation of Caskets

The standard casket size of the 18 caskets - each100 cm long - for the PFF is: 50 cm road surface width and a surface filling height of 4 cm. Because of the new bearing system of the PFF the steel drum could be broadened to 95 cm width a new set of 18 caskets were designed with 85 cm surface width and filling height of 8 cm. This height is needed to install twinlay porous surfaces for instance.

These new delivered casted caskets were not flat and rounded in the shape of the PFF drum. They had inside a convex shape from the casting process. This casket unevenness is unfeasible for the slab installation. Therefore the inner surface of the slabs had to be reworked. To get the same curvature as the PFF drum the PFF was used as a lathe (Figure 3).

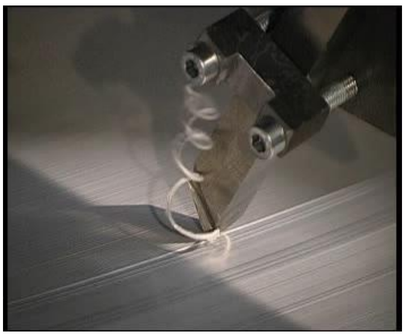

Figure 3 – Rework of the new PFF caskets, PFF used as lathe.

3. Casket Filling Pre-Tests

In pre-tests it was proven that a surface slab would lay down by it's own weight into the curved shape of the caskets. For this reason a piece of surface material of 4 cm height was cut out of a porous surface and was laid into the casket under normal temperature (Figure 4).

Figure 4 – Bending of a road surface slab into the casket shape.

Figure 5 – Marshall specimen glued on an alloy plate in the oven.

The gluing of the surface slab into the casket was another problem to solve. In pre-tests two different possible solutions were proved. One was gluing with an epoxy and one with a polymer modified binder. A Marshall specimen was glued onto a piece of alloy sheet metal and was hung top down into an oven and stored at 40°C for one week, see Figure 5. Both gluing possibilities seem to be sufficient for gluing road surfaces into the caskets.

Because of later casket cleaning reasons, (the dust of epoxy is toxic), the polymer modified binder was chosen to glue the slabs into the caskets, although a pre-heating of the binder is necessary.

4. Surface Manufacturing Process at RW TH Aachen

Two different surfaces were chosen as reference surfaces for manufacturing:

- SMA 0/8 for the smaller caskets with 4 cm filling height
- Twinlay 0/16 below and 0/8 on top for the wider caskets with 8 cm filling height

They were manufactured by a small paver at the RW TH Aachen, Institute of Road Construction. Two steel beams, one on each side, were fixed to the wooden underlay sheet to avoid that the mixture flues away sideways. The 4 cm high surface was laid down onto the wooden plates by the paver, see Figure 6. The specified mixture was delivered by a plant. In the cooling phase the SMA 0/8 was rolled by a standard roller.

After cooling the surface was cut into 1,05 m long pieces with a width of 45 cm, see Figure 7 and delivered on pallets to BASt

Figure 6 – Underlayer: wood plate with steel bars left and right before paving, paver in the background

Figure 7 – After paving: cutting out slabs to be glued later into the caskets

After delivery a texture measurement was carried out on the flat slabs by BASt, see Figure 8.

Figure 8 – 3D Texture measurement

After texture measurement the slabs were laid down in the caskets and after 48 hours they have assumed the curvature of the caskets.

5. Casket Filling Process

Figure 9 show the process from bending the slabs to gluing the slabs with hot polymer modified bitumen into the caskets. The caskets had to be pre-warmed to ensure that the bitumen stays fluid before fixing the slabs. Because the slabs were cut out a little bit longer than the caskets, the filled caskets (the overstaying surface) had to be cut off at the front and rear ends.

Subsequently all 18 caskets were ready for balancing with equal weight and then for installation into the test facility PFF.

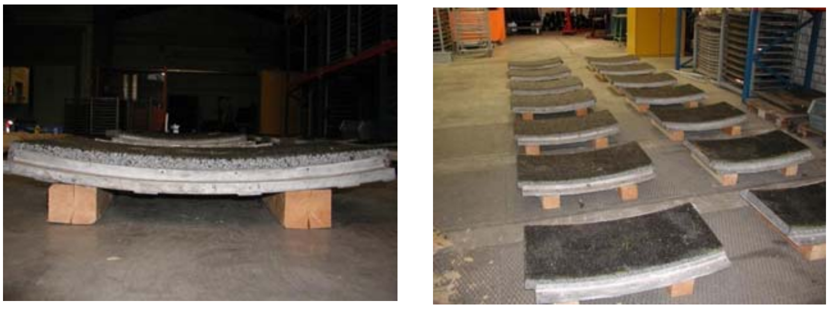

Figure 9 – Gluing the slabs into the caskets.

6. The truck wheel station

The truck wheel station was designed as an independent wheel suspension, which is similar to towed axles of semitrailers on glass transporters. The wheel suspension was manufactured by TRIDEC. It has changeable hubs for 19,5 inch and 22,5 inch rims. The axle ends and hubs were manufactured by the Bergische Achsenfabrik BPW (Figure 10 and11).

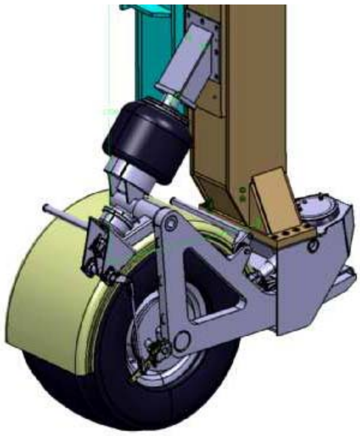

Figure 10 – Design of the truck wheel station as independent wheel suspension

Figure 11 – Truck wheel station at PFF with twin tyre assembly

The wheel is loaded by a pneumatic suspension and allows a maximal wheel load of 6,5 tons. The velocity of the test facility is limited to 120 km/h if the truck wheel station is mounted. Figure 11 shows the assembly of the truck wheel station.

7. Summary

BASt now has a new test facility (PFF) to prove truck tyres (e.g. tyre durability tests) truck tyre/road interaction (e.g. Tyre/road noise) and road surfaces (e.g. rutting of road surfaces caused by truck tyres). First tests with passenger car tyres were carried out successfully, tests with truck tyres will start in mid 2008. At the next conference we will report and present first results.