ICSV6 99 - 6th International Congress on Sound and Vibration, 5 - 8 July 1999, Lyngby, Denmark

"Efficiency of a ballastless mass-spring-system with discrete elastic Sylodyn® bearings and of dynamically soft Sylodyn® ballast mats in a railway tunnel in Cologne"

by

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presented by

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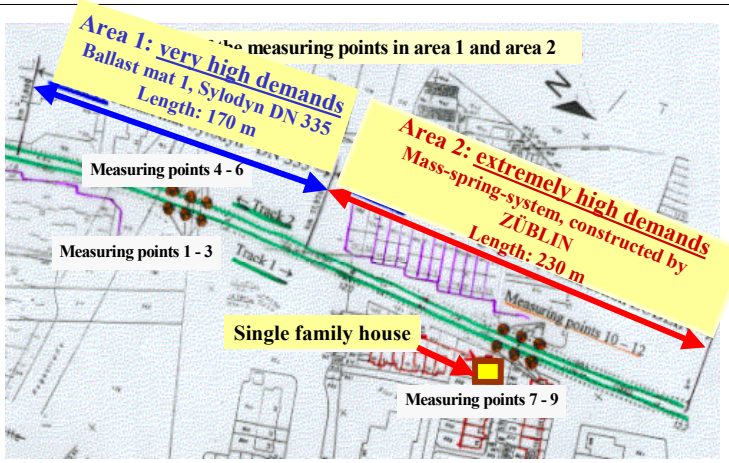
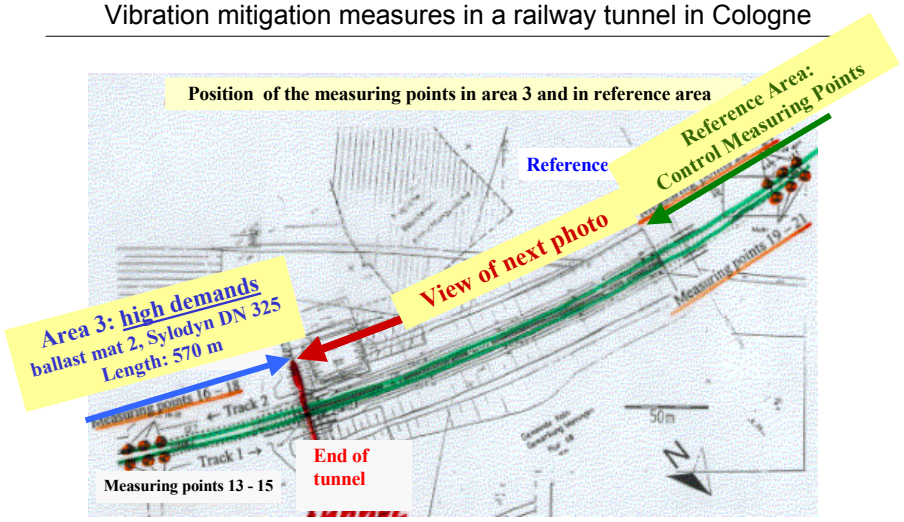
TABLE OF CONTENTS

Description of track sections and installed vibration mitigation measures

Area No.	Track position Demands	Vibration mitigation measure, Elastic element	Specification of elastic element
1	km 11.80 - 11.97 Very high	Ballast mat 1, Sylodyn® DN 335	Thickness: 35 mm Spec. static stiffness: 0.030 N/mm³ Spec. dynamic stiffness: 0.035 N/mm³
2	km 11.90 - 12.20 Extremely high	Ballastless mass-spring-system, constructed by ZÜBLIN, with discrete elastic bearings Sylodyn® N 70690/50	Thickness: 50 mm Static stiffness: 14 MN/m Dynamic stiffness: 17 MN/m
3	km 12.20 - 12.77 High	Ballast mat 2, Sylodyn® DN 325	Thickness: 25 mm Spec. static stiffness: 0.030 N/mm³ Spec. dynamic stiffness: 0.045 N/mm³





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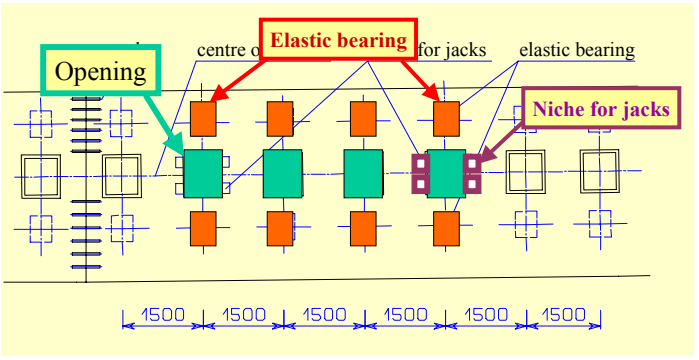

Top view of the Ballastless Mass-Spring-System, constructed by ZÜBLIN

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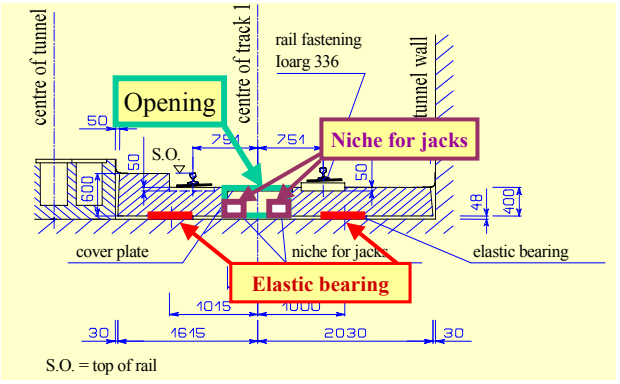
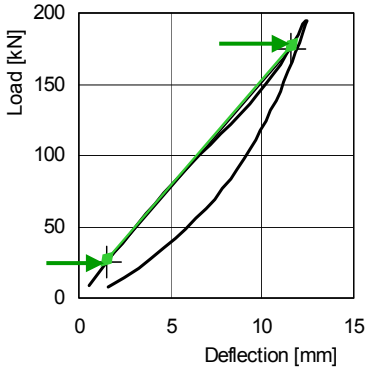


Cross Section of the Ballastless Mass-Spring-System, constructed by ZÜBLIN



Load deflection curve of the elastic bearing, type Sylodyn® N 70690/50 for the ballastless mass-spring-system in area 2.

Static secant stiffness:

$c_{stat} \approx 14$ MN/m

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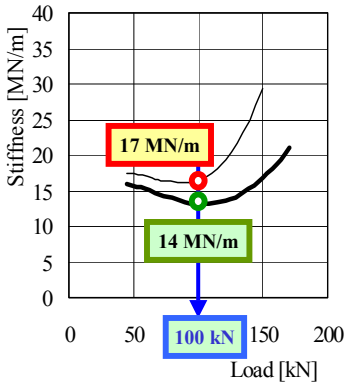

Static and dynamic stiffness of the elastic bearing, type Sylodyn® N 70690/50 for the mass-spring-system as a function load:

Static tangential stiffness;

Dynamic stiffness at 10 Hz.

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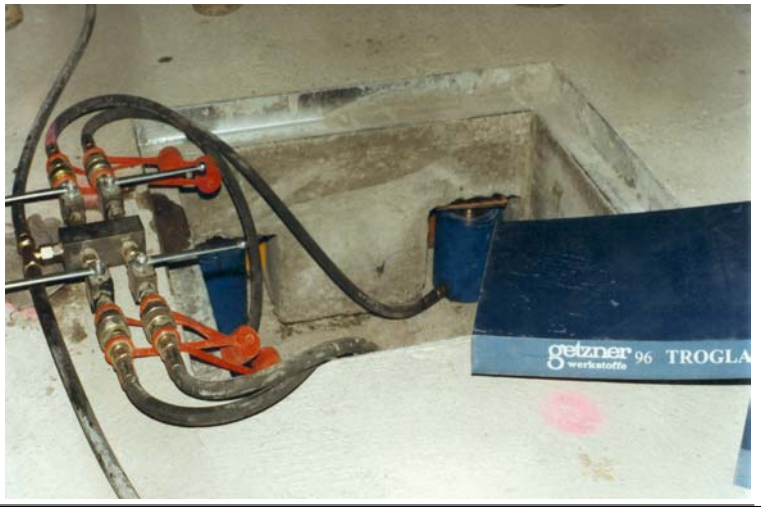

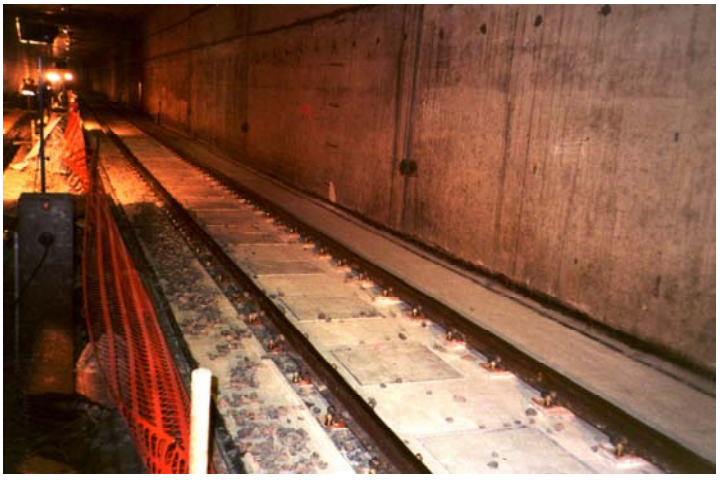

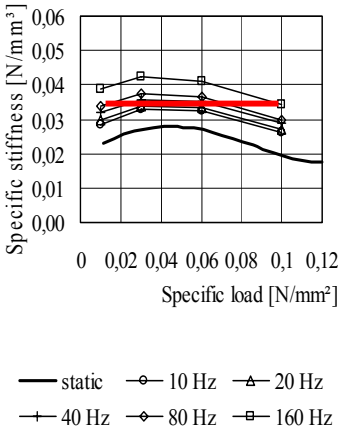

Static tangential stiffness and dynamic stiffness at different frequencies of the Sylodyn® DN 335 ballast mat as a function of specific load *).

*) According to Müller-BBM Report No. 32.242/12, July 1996.

Value of the dynamic stiffness which is used for calculation of the insertion loss:
$c_{dyn} \approx$ **0.035 N/mm³**

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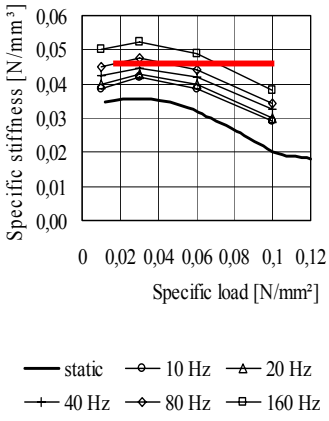
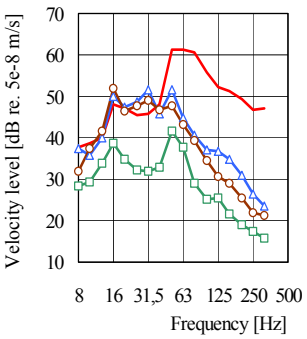


Static tangential stiffness and dynamic stiffness at different frequencies of the Sylodyn® DN 325 ballast mat as a function of specific load *).

*) According to Müller-BBM Report No. 32.242/9, July 1996.

Value of the dynamic stiffness which is used for calculation of the insertion loss:

$c_{dyn} \approx$ **0.045 N/mm³**



1/3-octave-band spectra of the velocity level, measured at the tunnel wall during train passages, before and after modification of the track: Average track 1 + 2.

— **Before modification**: Average of all 24 measuring points;
After modification: 6 measuring points in areas 1, 2 and 3 at a time;
Δ—Δ 3: Ballast mat Sylodyn® DN 325;
o—o 1: Ballast mat Sylodyn® DN 335;
□—□ 2: Mass-spring-system.

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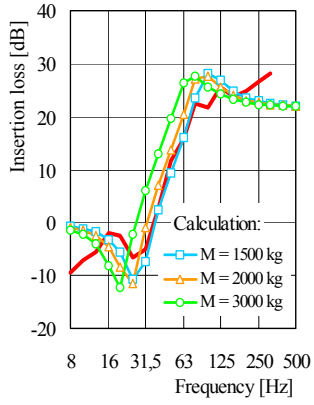
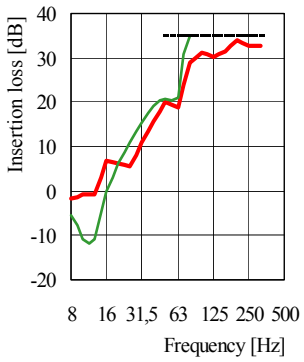


Measured and calculated insertion loss of the vibration mitigation measure in area 1: Ballast mat Sylodyn® DN 335.

— Measurement: average track 1+2;

Calculation *): Dynamic stiffness of ballast mat s" ≈ 0.035 N/mm³;
Parameter:
unsprung mass M of wheel set.

*) According to Wettschureck, R. and Kurze, U. J., Acustica 58 (1985), pp. 177-182



Measured and calculated insertion loss of the vibration mitigation measure in area 2: mass-spring-system (MSS).

——— Measurement: average track 1+2;
——— Calculation, Mass of MSS-slab per meter of track: 4000 kg/m;
Dynamic stiffness of elastic bearing: Approx. 17 MN/mm at 10 – 20 Hz;
------ Restriction because of the validity limits of the used SDOF model.

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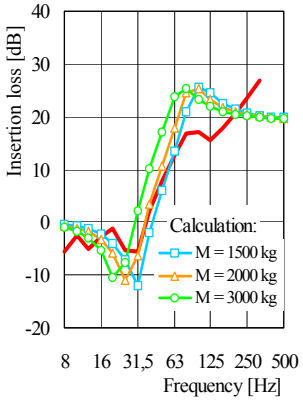
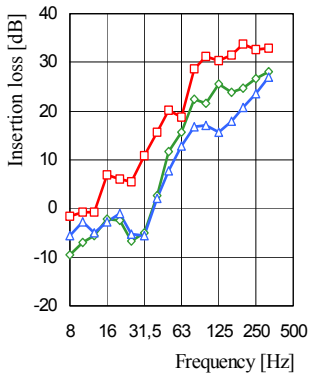


Measured and calculated insertion loss of the vibration mitigation measure in area 1: Ballast mat Sylodyn® DN 325.

----- Measurement: average track 1+2;

Calculation *): Dynamic stiffness of ballast mat s'' ≈ 0.045 N/mm³;
Parameter:
unsprung mass M of wheel set.

*) According to Wettschureck, R. and Kurze, U. J., Acustica 58 (1985), pp. 177-182



Measured insertion loss of the installed vibration mitigation measures in areas 1, 2 and 3;

- Area 2: Mass-spring-system;
- Area 1: ballast mat 1, Sylodyn® DN 335;
- Area 3: ballast mat 2, Sylodyn® DN 325.

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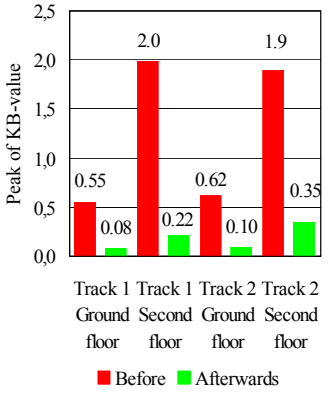

Peak of KB-values according to DIN 4150, part 2, measured in a house situated diagonally across the railway tunnel during train passages, before and after installation of the mass-spring-system.

SUMMARY

- Two types of **highly-effective ballast mats and a mass-spring-system** were installed over a total length of 970 meters in both tracks of a railway tunnel in Cologne in order to reduce the vibrations caused by the rail traffic.
- The mitigation measures, in particular **the elastic components** applied for vibration mitigation **are described.**
- **The efficiency of the vibration mitigation measures, i.e. their insertion loss, was determined by means of structure-borne noise measurements** carried out in the tunnel during train passages before and after installation, as well as in a residential unit which was seriously affected.
- **The insertion loss** of the installed vibration mitigation measures **was also calculated** using lumped-parameter models ⇒ **SDOF systems**.
- **The measurement results show a very good consistency with the calculation** and completely confirm the high expectations placed in the vibration mitigation measures.

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End of Presentation