Mass-spring-system in a railway tunnel of the high-speed-track Köln-Rhein/Main

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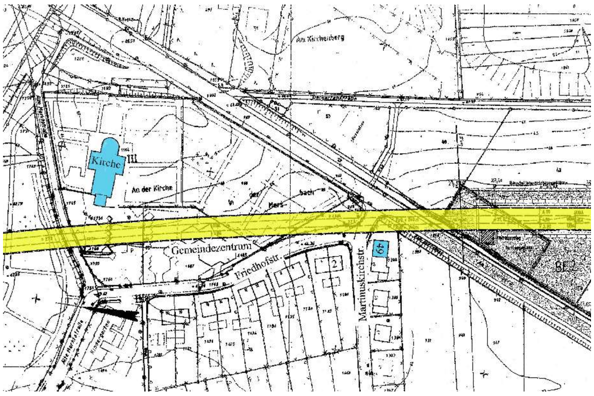
Introduction

Extensive examinations to evaluate the future immissions in the vicinity took place during the layout of the high-speed-track between Köln and Frankfurt. Building a tunnel in the city area St. Augustin became necessary. An approved slap-track was planned as the permanent way



picture 1: layout plan

A church (historical building), the community centre of the church and residential buildings lie very close to the tunnel. The situation is displayed in the layout plan (picture 1). The distance tunnel – residential buildings is 8,5 m. Cement injections determine the constructional situation around the church.

Calculations to forecast the vibration immissions in the nearby buildings took place. The structure-born noise level exceeded the limit value of 35 dB (A) (average maximum level), while the vibration immissions (evaluated according to DIN 4150) proved to be unproblematic.

It was therefore necessary to implement vibration mitigation measures in the tunnel. The construction company Ed. Züblin build tunnel and vibration mitigation measures.

The construction company could choose which type of protective system it wanted to install and has therefore the responsibility for the immissions occurring in the vicinity. Ed. Züblin chose to implement a mass spring system (MFS) for several reasons.

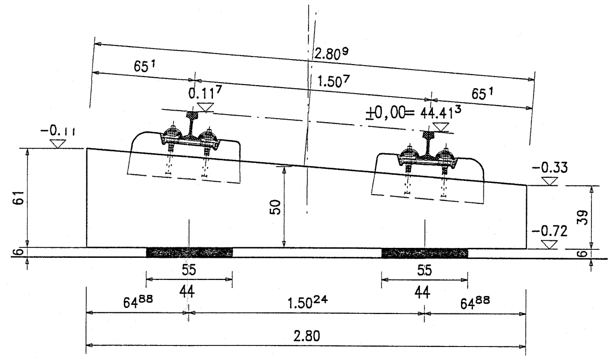
Planning and building of the MFS

Following requirements had to be considered during the MFS's planning:

natural frequency:	$f_{Ab} \leq 10$ Hz
vehicle velocity:	$v_F = 250$ km/h
permanent-way:	slap-track

The basic dynamic and static calculations were carried out by Ed. Züblin in coordination with I.B.U. Subsequently a review of the calculation by I.B.U. and the start of the approval procedure followed.

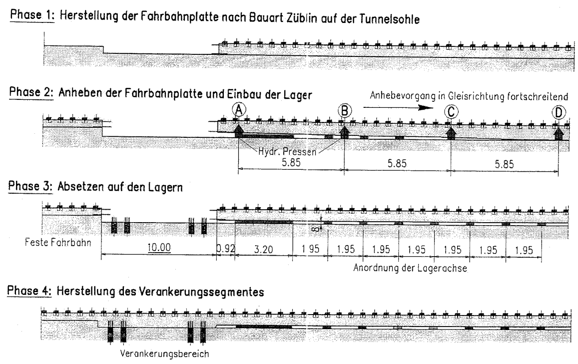
Two one-track concrete slabs were created continuously. Fixed points were installed at both ends of the MFS to absorb longitudinal forces. The concrete slab's cross section is displayed in picture 2. The concrete slab's mass amounts to aprox. 3300 kg per meter.



picture 2: concrete slabs cross section

The MFS was on both sides installed aprox. until 30 m behind the buildings. These short overlap area length was chosen considering experiences from other projects because of the building cost. The fixed points follow next to the overlap area.

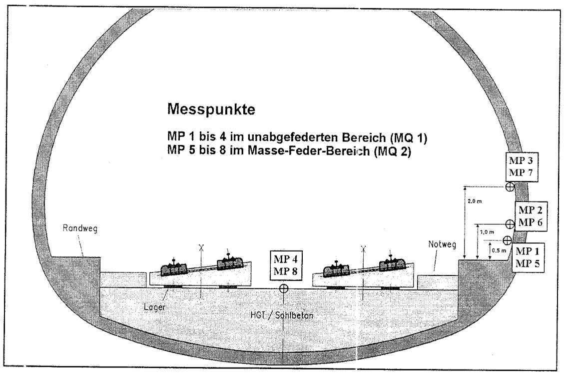
The concrete slabs of the MFS were directly concreted on the tunnel ground using a parting film, and were subsequently put on Elastomer bearings with hydraulic presses (picture 3).



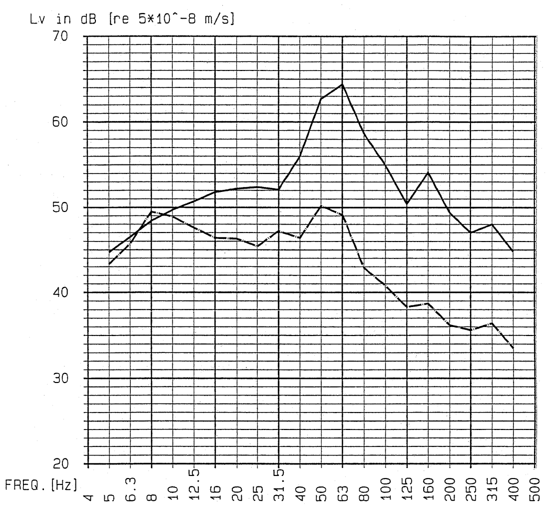
picture 3: building procedure (longitudinal section)

vibration measurements in the tunnel

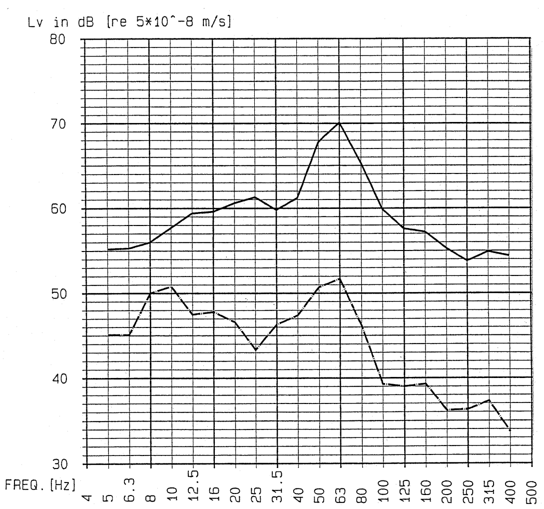
Vibration measurements in the tunnel were conducted to control the effectiveness of the MFS. The emission levels were measured during train passages. To do that vibration sensors were put on the tunnel wall and ground (picture 4). Picture 5 shows the at the tunnel wall in 2 m height measured results as average levels of ICE-passings. Sections with and without (not spring-mounted) mass spring system are displayed. Picture 6 shows the results of the measurement point at the tunnel ground.



picture 4: tunnel cross section with measuring points



picture 5: emissions tunnel wall



picture 6: emissions tunnel ground

The difference levels resulting from the comparison above are displayed in table1:

f_T in Hz	level difference in dB			
	tunnel wall			tunnel ground
	0,5 m	1 m	2 m	
5	3,7	4,2	1,4	10,1
6,3	1,6	1,4	0,7	10,2
8	1,7	0,0	1,1	6,0
10	1,0	2,0	0,7	6,9
12,5	3,2	5,2	3,1	11,9
16	6,0	4,0	5,3	11,7
20	7,5	7,5	5,9	14,0
25	9,0	8,5	7,0	18,0
31,5	10,1	10,0	4,8	13,5
40	9,7	10,7	9,5	13,7
50	13,7	13,5	12,5	17,1
63	18,0	18,1	15,3	18,3
80	17,6	17,1	5,7	19,1
100	16,5	15,8	14,2	20,6
125	13,6	12,6	12,1	18,5
160	14,2	10,0	15,3	17,9
200	14,8	14,2	13,2	19,0
250	12,7	12,2	11,4	17,5
315	12,7	12,6	11,5	17,6
400	12,4	12,2	11,2	20,7

table 1: level difference of the tunnel measuring

immission measurements in the buildings

Measurements inside one residential building and inside the church took place to prove the compliance of the, during the approval procedure defined, immission limit values. The measurements showed that structure-born noises were in both buildings not detectable. The basic noise level inside the church was already higher than the defined limit value. The basic noise level in the residential building caused by air and road traffic amounted 21–24 dB (A) in the basement and 26–33 dB (A) in the sleeping room. Passing trains caused no measurable increase of the sound level. The structure-born noise level of the trains should be therefore lower than the measured noise levels. Feelable vibrations were not not detectable in both buildings. The results show that the use of the mass spring system achieves very good immission reductions.

Bibliography

[1] I.B.U.-Messbericht (unveröffentlicht)
[2] V. Enoekl + U. Lenz: Erstes Masse-Feder-System auf einer HGV-Strecke, ETR 9/2003
weitere Literatur in [2]