Vibration Isolation of Rail and Transit Systems

Summary: Mass transport systems often require vibration and structure-borne noise control in inner city, residential and office areas to ensure the comfort of the occupants.

Urban areas are nowadays only attractive for people, if they offer certain facilities. These facilities include short and fast transport links to and within that area. Fast links can be provided by mass transport, but surface level tracks for mass transport can limit the access and movement of individuals. Bridges and tunnels are necessary, otherwise crossing the track becomes dangerous and time consuming. It is, therefore, preferable to leave the surface space track free and to move mass transport into tunnels or to elevate them. A positive side effect of this is that transit distances can even be shortened. It is also a good idea to modify, for example, terminals into transit stations as projected in “Stuttgart 21”, “Frankfurt 21” or the “City Tunnel Leipzig”.

Such measures move the transport systems right next to residential and office areas. Since the wheel- rail contact of the trains causes noise and vibration, which are transmitted via the subsoil and the foundations into the neighbouring structures, mitigation measures are often necessary to reduce this transmission to acceptable levels.

A very effective way of achieving this is to elastically uncouple the vibration source and surroundings, using for example, helical springs. This can be done either at the source or as a base isolation system for the buildings.

At the source, floating trackbeds provide the best results. They consist of the base, the trackbed and the spring elements as an interface (see picture 1).

Pic. 1: Arrangement of GSIV Elements in a Two-Track Tunnel
The trackbed itself can be a rigid slab (see pictures 2 and 4) or a trough filled with ballast (see picture 3). The spring elements can be arranged below the trackbed (see pictures 5, 8, 9, 15) or partially or completely integrated into the trackbed (see pictures 6 and 7). These systems are today standard technology and have already been installed three times in and around Cologne.

The advantages of these systems are:
- System frequencies between 4 and 8 Hz
- Effective three-dimensionally with high horizontal stability
- Substantially smaller horizontal motions than with conventional systems
- Minimal gaps necessary below the track slab
- Concrete track slab may be cast directly on the base mat during construction
- Simple lifting of the track slab by portable hydraulic systems inserted from above (see picture 10; System with spring elements integrated into the trackbed)
- Inspection and subsequent alignment possible at any time
- Simple correction of gradients from soil settlements, also easy at a later date
- Unlimited life span

Pic. 2: Rigid slab of a subway track in Stuttgart, Germany (during installation)
Pic. 3: Concrete trough with ballast bed in Puchon, Korea

Pic. 4: Rigid slab of a subway track in Stuttgart, Germany (in operation)
Pic. 5: Spring elements are placed from the side into recesses in the concrete troughs

Pic. 6: Installation procedure for spring elements of type GSIV
Pic. 7: Spring element of type GSIV

Pic. 8: Floating trackbed system with twin steel beams with concrete slab on top (Airport Frankfurt, Germany)
Pic. 9: Spring element used at the Frankfurt Airport, Germany

Pic. 10: Simple lifting of the track slab by portable hydraulic systems inserted from above
If a non-isolated trackbed exists already, it is necessary to isolate new structures completely or partially - it is sometimes sufficient to isolate only particulary sensitive areas inside the building. This method, based on helical steel springs, has already been in use for more than 15 years. An approval by the Institute for Bautechnik in Berlin confirms this also as an accepted, standard technology. The spring elements are available in two versions, which have different advantages. Prestressable spring elements (see pictures 11 and 16) – access necessary – provide the following advantages:
- No load dependent change in height during construction
- Removal and/or replacement is easily possible, even subsequent to installation
- Levelling and adjustment to the actual structural load is possible, even subsequent to installation
- Vertical alignment after major settlements is possible at any time by shimming

Pic. 11: Elastic support of a cinema above a bus station and beside a high speed train line with prestressable spring elements in Siegburg, Germany

Advantages of the non-prestressable spring elements (see pictures 12, 13 and 14) are:
- Minimal height
- Mat like arrangement with optimal use of the support area
- No access necessary
Pic. 12: Elastic support of a residential building on top of a subway tunnel with non-prestressable spring elements in Berlin, Germany

Pic. 13: Elastic support of a residential building on top of a subway tunnel with non-prestressable spring elements in Berlin, Germany
Pic. 14: Non-prestressable spring elements

Both systems, at the source as well as in base or floor isolation, are adjustable for alignment in case of positive or negative settlements.

Pic. 15: High speed train line with ballast bed and concrete slab on top of prestressed spring elements in Chonan, Korea
Pic. 16: Prestressable spring element