CETRA 2010 17–18 May 2010, Opatija, Croatia
First International Conference on Road and Rail Infrastructure

RHEDA CITY SLAB TRACK SYSTEM SOLUTIONS FOR TRAM TRACKS

Ryan Stolpmann, Wojciech Nawrat
RAIL.ONE GmbH, Germany

Abstract

The RHEDA CITY ballastless track system requires almost no maintenance, offers perfect ride comfort, supports heavy loads, and ensures great safety. The RHEDA CITY system was designed especially for trams systems and surface commuter train lines. RHEDA CITY provides additional advantages by the monolithic structure of its track supporting layer, and by its low installed structural height.
The unique characteristic of the RHEDA CITY system consists of its capability of complete integration in all surfaces encountered in an urban context. The possible spectrum of solutions includes tracks integrated into the street surface and covered with asphalt, concrete, or block paving and extends to vegetated tracks separated from vehicle traffic.
The key element of the RHEDA CITY track system is the type TB/ZB precast concrete sleeper. The use of lattice-truss bi-block sleepers means very low sleeper weight of approx. 80 kg. This design simplifies handling on the construction site, while assuring track geometry (gauge and cant) after installation. With respect to gauge, rail type, rail fastening, cant, storage conditions, etc., it is possible to modify the sleepers in accordance with project requirements. For track systems covered by asphalt, etc., grooved tramway rails are typically used, with the type specified by the operators of the public transit network. Normally, vignol rails are employed for tracks with vegetation covering. The rails can be installed on a continuous-support system, or on discrete supporting points.
Various requirements will result for system installation, depending on the support system used. But construction benefits do not stop with RHEDA CITY with normal track alone: it is also possible to integrate turnouts into the same technology.

1 Introduction

Tram tracks are defined as rail-based systems of the local public transport. In the most cases, the planned track systems are installed segregated and integrated (flush-mounted with the street surface) of the road transport for cars and busses, respectively.
Fast, flexible, convenient, and cost-effective: trams and urban-suburban commuter railway systems are indeed attractive nowadays, down the whole line. And it's no wonder that the use of such services has become more and more popular. The growing positive importance of mass-rapid transport by rail, however, demands the ongoing development of innovative solutions and of new technologies with steadily improved cost effectiveness, safety, and environmental compatibility. RAIL.ONE has set the objective of making urban transit by rail even more attractive. Today, the need for mobility is of course taken for granted. Urban residents, especially those in metropolis areas, are critically dependent on an effectively functioning system of urban infrastructure. A rapid-transit network that meets these modern needs is one of the most vitally necessary facilities of any modern city. The better such a network functions, the more attractive a city becomes as a place to live and as a location for businesses.

2 Requirements and specifications for Tram tracks

The embedded track constructions are characterized by dependences of the track layout. For the warranty of a high track quality and reliability, the installation of a slab track system is recommendable, such as RHEDA CITY. RHEDA CITY System is optimized, modifiable and customized ballast less track system for different boundary alignment conditions. As an example for using on an embankment, in tunnel sections or integrated into existing traffic flows like buses or cars, RHEDA CITY could be adapted for all alignment specifications and can be covered with various layers like asphalt, concrete, grass vegetation or paving material.
Typical requirements and specifications for tram tracks, fulfilled by RHEDA CITY are:

- Simple and transparent system structure
- Modifiability and adaptability for different track requirements
- Elastic support of the rails
- Durability of quality
- Flawless of the track parameters: gauge and track geometry
- Low maintenance
- High availability and increased service life
- Electrical insulation of the rails against stray currents
- Minimization of structure-born noise
- Components shall be recyclable
- Track system integration in the existing city infrastructure

As an additional challenging for tram projects, nearly every tram operator follows own technical requirements. This situation is in the most cases because of historical reasons or of long ago made decisions about e.g. technical parameter for the set type of running rails, gauge, rail inclination, axle load or boogie distance. Furthermore to the given technical requirements the track structure must fit the environmental aspects, such as noise and vibration policies. Additional construction issues must complied, such as restricted construction time provision or the standards of available track construction tool and equipment. In general a innovative and customizable tram track system must be able to fulfill all these boundary conditions for different applications, such as given by using of the modular RHEDA CITY system solution by RAIL.ONE.

3 Slab track system types for tram track infrastructure

In tracks with conventional design, the rails are installed directly onto a supporting layer of asphalt or concrete. In conjunction with rail tie bars, which are bolted to the web of the rail, these rails make up a track panel. Normally, height adjustment of such tracks takes place by insertion of wedges, and by pouring compound under the track panel.
In contrast, the RHEDA CITY system consists of the core component of bi-block sleepers concreted into place with lattice girders, to form a monolithic concrete track-supporting layer. The result here, depending on the track model, is either a system of elastic point support, or a continuously elastically supported track. The rail fastenings in the RHEDA CITY models are pre-assembled in the sleeper factory. In conjunction with the rail fastenings, the sleepers create a specified track gauge. The adjustable rail fastenings compensate for any tolerance deviations. The track panel is measured at the top edge and at the gauge side of the rail, adjusted as necessary, and finally fixed into place. These measures produce an extremely high degree of precision and, later, an outstanding quality of track position and geometry. The track covering can be provided in several layers of asphalt, concrete, of paving blocks. The elastic joint sealing between the rail and the covering is provided in the form of special compounds. The elasticity of these compounds ensures that the sealing effect of the joint is not impaired by movements caused by rail operations.

RHEDA CITY system is based on the design and experiences of the RHEDA 2000 system, which was installed at first in 1972 close to the German train station in Rheda. The RHEDA 2000 system structure was developed for the specific conditions of urban traffic projects.
The system design is based on the theory of an elastic supported and monolithic slab track structure. The static calculation of the RHEDA slab track systems is based on the loading cases of the rolling stock vehicle including safeties for the to transmit forces occurring at the track concrete layer because of wheel load-dynamics during the operation on plain and curve track sections.
The track concrete layer as the supporting layer will design this way, that existing tensions fall below the permissible fatigue limit. Prerequisite is the construction of an existing substructure, e.g. a frost protection layer and planum with the essential deformation modulus E_{v2}.

4 RHEDA CITY system family

RHEDA CITY system is dimensioned and designed for the specific track requirements, such as usual axle loads of approximately 11 up to 13 tons and design speed of approximately 80 km/h. The RHEDA CITY system structure is applicable for all used covering layers, such as asphalt, concrete, paving stone for embedded track with mixed traffic situation by individual transport and tram operation. Also it is possible to design RHEDA CITY as separate track structure as open formation or green track.
RHEDA CITY system is a modifiable system structure for all applications. An overview of the core supporting solutions and possible cover layer types are listed on the following diagram. The RHEDA CITY bi-block sleepers were designed and produced based on the specific project conditions and bonded into the track concrete layer. The track concrete layer as a supporting layer will be constructed with a thickness of approximately 250 mm and a width of approximately 240 cm. The exact dimension of the track concrete layer depends on the loading cases of the track and the planum and sub-soil conditions respectively. In the case of an installed covering layer it is not necessary to install a continuously slab reinforcement. For the track concrete layer TCL usual the concrete type C30/37 will be poured. Additional requirements for the TCL will be fixed according to the specific project conditions.

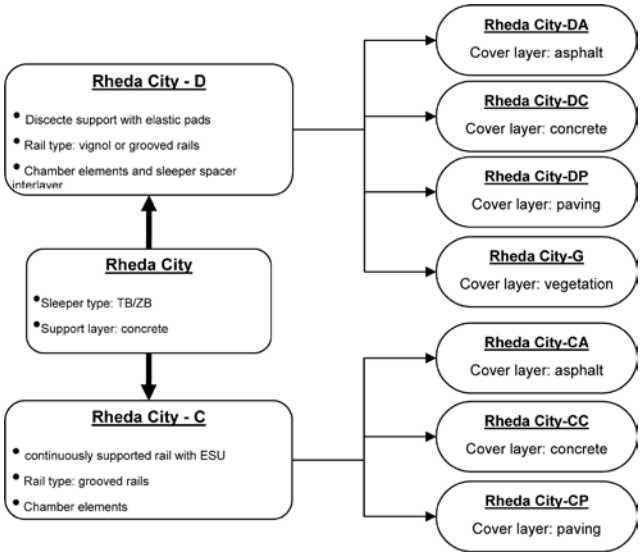
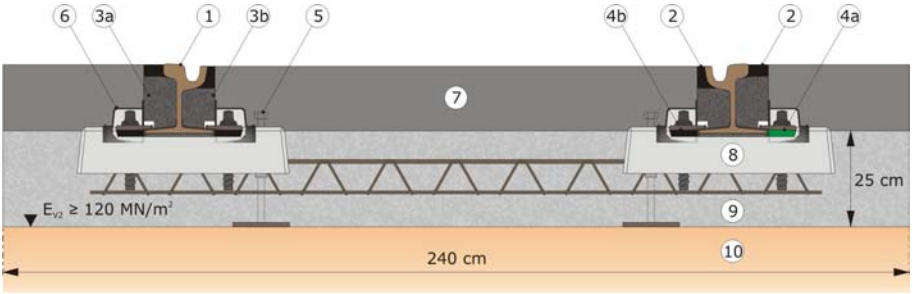


Figure 1 RHEDA CITY system family

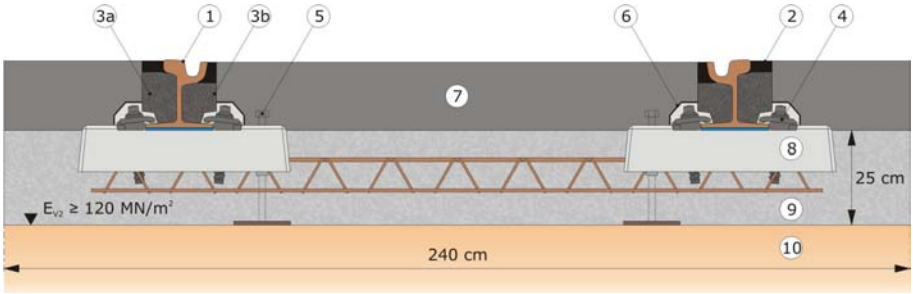
Core component of the RHEDA CITY system is the prefabricated bi-block sleeper with lattice truss reinforcement, which results a dimensional stability and a slight mass of approximately 80 kg up to 110 kg per sleeper.
Thereby an easy handling of the sleepers during the track construction processes without any special or heavy weight tools or equipments is possible. The bi-block sleeper ensure the exactness of the track geometry, e.g. gauge, and rail inclination and rail positioning during the track installation. The lattice truss reinforcement ensures an excellent bonding effect of the bi-block sleepers and the in situ concrete installed TCL. According to gauge, running rail type, fastening system, rail inclination, elastic support or specific solutions e.g. for check rail devices it is possible to modify the sleeper profile.
For embedded track systems usual grooved rails were installed. For green track or open formation track sections usual vignol rails were installed. In principle RHEDA CITY system is modifiable for all used rail types. Depending on the client requirements it is possible to design RHEDA CITY as a continuously or discrete supported system.
For RHEDA CITY C the running rails will be continuously supported by using of an elastic rail flange sheathing material (ESU), which will be clamped under the bottom of the rails. The static stiffness is adjustable by the mechanical properties of the ESU profile, based on the technical parameter of the tram vehicle and the required rail deflection line. The lateral forces during the train operation will be transmitted by the rubber chamber elements in the adjacent covering layer and by the bottom of the rails in the TCL.
For RHEDA CITY D (discrete supported) the running rails were fixed on the sleepers by using of rail fastening systems including elastic pads for the designed static track stiffness.
In the sleeper pockets between the sleepers, elastic filling profiles were installed under the bottom of the rails to ensure the vertical free movement of the rails during the train operation.



1 Grooved rail
2 Rail joint selant compound
3 Chamber elements a) outside b) inside
4 Gauge and clamping profile incl. ESU
5 Adjustment devices
6 Covering caps (optional)
7 Coverlayer
8 Bi-block sleeper
9 Track concrete layer
10 Frost protection layer

Figure 2 RHEDA CITY C cross section

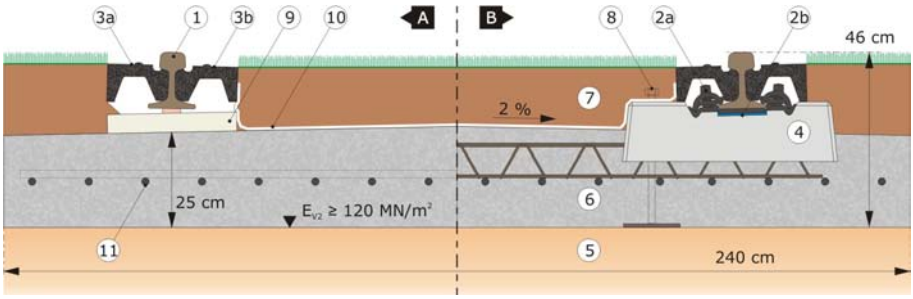
The sleeper distance or sleeper interval for RHEDA CITY depends also on the project boundary conditions and is usual 750mm for RHEDA CITY D and 1500mm for RHEDA CITY C. The static track stiffness and rail deflection line can be adjusted according to the client requirements by using of elastic elements, such as the elastic rail flange sheathing ESU or elastic pads. These elements results additional an electrical isolating effect to fulfil the set electrical insulating policies, e.g. according to EN 50122-3.



1 Grooved rail
2 Rail joint selant compound
3 Chamber elements a) outside b) inside
4 Vossloh rail fastening system incl. elastic pads
5 Adjustment devices
6 Covering caps (optional)
7 Coverlayer
8 Bi-block sleeper
9 Track concrete layer
10 Frost protection layer

Figure 3 RHEDA CITY D cross section drawing

The cover layer type will be selected by the principle, planner or operator. By using of grooved rails the designed rail joint on the covering layer will be closed usual with a permanent elastic and sealing up compound, e.g. bitumen or polysulfide material, which is adapted to the expected rail deflection line during the tram operation.
The Green Track RHEDA CITY GREEN can create optically attractive additional green zones in urban areas.
In addition, the government awards efforts for reduced noise, storage and delayed drainage of rainwater into the environment, as well as relief of storm sewers: local rates are lower for ground surfaces that are not sealed. From the design point of view RHEDA CITY Green will be installed on separately track lines with usual discrete supported system solution.
The modification of the vegetation layer, such as the thickness of the humus layer and the type of substratum depends on the specific local environmental and weather conditions. For the optimized layer thickness, the high of the RHEDA CITY Green sleepers will be adapted. The installed rubber chamber elements for the RHEDA CITY Green system works as a rail-to-earth-isolator and as a rail- and rail fastening protector against pollution respectively.



1 Vignol rail
2 a) Rail fastening system b) elastic pad eZw
3 Chamber elements a) outside b) inside
4 Bi-block sleeper
5 Frost protection layer
6 Track concrete layer
7 Vegetative Layer, e.g. grass
8 Adjustment devices
9 Elastic filling profiles between the sleepers
10 Vlies
11 Longitudinal reinforcement
cross section A: in the sleeper pockets between the sleepers / cross section B: in the sleeper areas

Figure 4 RHEDA CITY Green cross section drawing

5 Track construction process

RHEDA CITY systems will be installed in top-down principle. During this process the running rail level is the surveying reference for the track adjustment. This installation process results that inaccuracy of level ground and rail tolerances is not a crucial factor for the track alignment and can be adjusted by the given adjustment system adjustment reserves. Additional to the benefits by using the RHEDA CITY bi-block sleepers with pre-assembled rail fastening system and exact fixed dimension parameter as gauge and rail inclination ensures an easy track installation and a high quality track alignment. The track installation starts with the bi-block sleeper positioning on the existing soil or the pre-assembling of track panels in a depot, which will be positioned in the construction field.
After the track rough adjustment the track components like design and earthing components will be installed. RHEDA CITY track system will be vertically adjusted by using of adjustment devices (adjustment bolts and steel base plates), which are already integrated in the sleeper design. The track gauge adjustment because of existing grooves rail tolerances will be proceeding by using of the RHEDA CITY C gauge and clamping profile or of the adjustment reserves of the RHEDA CITY D rail fastening system.
In both cases it is possible to adjust the gauge accurate to the millimetre. The adjusted track will be fixed by using of e.g. vertically rods or bolts against an existing abutment. After the track fixation the track concrete layer will be poured to result a permanent and stable bonding effect of the bi-block sleepers within the supporting layer. If the concrete cured a minimum strength the adjustment devices will be unlocked and installed further on for the following track construction sections. In the case of embedded track sections with RHEDA CITY C the rubber chamber elements will be installed and the cover layer will be poured or installed. For the RHEDA CITY track construction process usual tools, machines and equipment can be used and no special machines or sophisticate framework are needed.

6 System design modification

The entire RHEDA CITY family are state of the art system solutions for all track applications. Under consideration of the essential technical and project parameter, e.g. type of tram vehicle, loading cases, design speed, rail type, gauge, electrification and drainage, RHEDA CITY are customized and modifiable system solutions to fulfil the fixed technical and economical requirements.

7 Long life cycle for RHEDA CITY system

Long life cycles in combination with a low track maintenance and high quality track alignment for urban traffic tracks are prioritised criteria by the tram operators and principles. Prospective given to the direct costs for planned tram tracks given by costs for the components and track construction itself also indirect costs fort he track availability, maintainability and customer satisfaction will be an essential part for the clients planning and design process. The first RHEDA CITY systems were installed and are still under operation since 1999 in many German cities and international project respectively with reference more than 160,000 track meter. In many cities, like in Berlin and Dresden, RHEDA CITY system has been established and will be installed as a standard track system solution.

8 Conclusion

Indeed: the careful selection of a track system saves good money in the long run. Responsibility to the environment can also be measured in terms of airborne noise and vibration. Innovative mass-spring systems and noise-absorbing products can produce results far below strict limit values: especially important in densely populated areas. RHEDA CITY is in all cases an excellent solution: as evidenced by outstanding experience gained in many cities.
The track requires practically no maintenance, supports heavy loads, and offers superior ride comfort together with great safety and long life cycle. For track transitions, turnouts or pedestrian crossings and other sensitive areas, RAIL.ONE offers special solutions. RHEDA CITY is also available as a green track with vegetation. The using of RHEDA CITY system with bi-block sleeper, installed in top-down process ensures a high construction performance and track quality for all construction site conditions.
RHEDA CITY is an optimised system for new lines, extensions or upgraded track sections: a sure track system concept for advanced tram traffic projects.