

Description

Superstructure Construction

The invention relates to a superstructure construction comprising a rail disposed above a support layer such as a concrete sleeper and in its turn extending from a securing device such as a ribbed plate, where at least one intermediate layer with a rigidity x is disposed between the support layer and the securing device.

Bedding sleepers on ballast or resorting to designs with a ballastless track and stable, rigid sleeper mountings is known. In the latter case, the sleeper such as a concrete sleeper is placed on asphalt or concrete supporting plates or suitable troughs and then partially cast in place using a sealing compound such as concrete or asphalt.

To achieve a reduction of the structure-borne and airborne sound emitted by a rail in ballastless tracks, a construction is known where a standard rail such as S54 is placed on a cork layer inside a channel comprising concrete or steel parts. In addition, cavities are provided that are filled at the top with a polyurethane/cork mixture to reduce sound.

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However, this construction has not brought the desired result, and indeed sound measurements show that there has even been a 10 dB sound increase compared with the ballast construction.

A device for mounting rails for rolling stock is known from DE 89 15 837 U1, in which a ribbed plate is disposed on an elastic intermediate layer whose thickness is at least that of the ribbed plate. The intermediate layer can here have a required elasticity thanks to certain geometrical parameters. The same applies for DE 40 11 013 A1, which relates to a tempered rail structure for high-speed tracks. It is intended here to ensure, by providing a cavity with plastic-modified adhesive mortar, that a direct transmission of heat energy or cooling energy to the rail is prevented.

According to DE 41 38 575 A1, the spring rigidity of an elastic intermediate layer can be designed dependent on the contact force.

EP 0 632 164 A1 contains the proposal to structure the bottom of an elastic intermediate layer such that under load a higher rigidity results, while the transmission of sound is to be restricted at the same time.

An elastic rail support layer with bottom compression points and all-round closed edge strip is known from DE 43 14 578 A1.

The problem underlying the present invention is to develop a superstructure construction, in particular one on a ballastless track, such that a reduction of structure-borne and airborne sound is achieved.

The problem is substantially solved in accordance with the invention in that the rigidity

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x of the intermediate layer is determined as a function of the maximum required foot-side rail stress in the rail, in particular in that the rigidity x is rated such that a maximum presettable rail stress can be generated in the rail on the underside of the foot.

In accordance with the invention, the intermediate layer is rated for the permissible or required maximum rail stress, which has the advantage that the rail itself is on a softer support, thus achieving a decoupling between the rail and the sleeper. The effect of this is a lower loading of the support point and in turn a reduction in the structure-borne sound. This can be improved by using as rails those with high moment of inertia and moment of resistance when seen over the rail central axis, for example a filled section rail, so that the rail can perform the function of a support and develop a load-bearing effect. This results in a further decoupling between rail and sleeper, whereby a further reduction is achieved of the structure-borne sound emitted by the rail when it is traversed by rolling stock.

In particular, the teachings in accordance with the invention are achieved in that the intermediate layer has a spring characteristic such that the intermediate layer has substantially non-elastic properties at maximum permissible and/or presettable rail stress. An intermediate layer is proposed that has a low rigidity before the maximum permissible and/or presettable rail stress is reached and a high rigidity when this rail stress is reached.

It is preferably provided here that the intermediate layer has a rigidity x of $x \leq 25$ kN/mm, preferably $4 \leq x \leq 25$ kN/mm, and/or that at the maximum permissible rail stress the intermediate layer has a rigidity x of $x \geq 35$ kN/mm, in particular $x \geq 90$ kN/mm, preferably in the vicinity of 100 kN/mm.

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In particular, and in accordance with a proposal inventive per se, it is proposed that when the intermediate layer is without load it has projections extending beyond its underside and surrounded within the intermediate layer by a cavity (recess) on the circumferential side. The cavity has a volume V_a , which is equal to a volume V_b that the respective projection has in its section projecting beyond the underside.

Thanks to the proposal in accordance with the invention, the projections have the function of a supporting spring which is effective when the maximum rail stress of the rail supported by the support layer has not yet been reached. If this is then reached, the projections are forced into the support layer such that the projections are flush with the underside of the intermediate layer and at the same time fill the entire cavities (recesses). As a result, the form factor of the intermediate layer is increased such that the maximum permissible rail stress is not generally exceeded even when further forces are introduced. The intermediate layer should have a rigidity x which is in the vicinity of 100 kN/mm in particular when the cavities in the support layer are completely filled by the material of the projections.

It is provided in particular that the rail is a Vignol rail with a maximum permissible rail stress of 70 to 100 N/mm² and that the intermediate layer has a rigidity x of approximately 4 to 16 kN/mm, provided the maximum permissible rail stress has not yet been reached.

Apart from the geometry of the rail, an embodiment of the invention provides that in particular rails are used that have a moment of inertia I_x with preferably $I_x \geq 3400 \text{ cm}^4$ and a moment of resistance W_x with preferably $W_x \geq 350 \text{ cm}^3$.

In particular, a superstructure construction with ballastless track is provided in which the

rail is a filled section rail with a moment of inertia I_x of $3700 \leq I_x \leq 3800 \text{ cm}^4$ and a moment of resistance W_x of $390 \leq W_x \leq 410 \text{ cm}^3$ and a maximum required rail stress σ can be generated (approx. $70 \pm 4 \text{ N/mm}^2$ for rail steel UIC Class A with 880 N/mm^2 tensile strength) and the intermediate layer has a rigidity x of approximately $10 \pm 2 \text{ kN/mm}$ for filled section tracks. In the case of traffic carriers with low axle loads, rigidities lower than the previously stated value are obtained.

In an embodiment of the invention, the invention provides for the rail to be designed at its foot such that the latter emits sound waves with a frequency ν when vibrations are excited, said waves being substantially outside a frequency range between 500 and 3000 Hz. This results in a rail foot design in respect of its vibration technology that ensures a considerable reduction of the airborne sound.

In addition, the rail can be designed without a web, which also prevents problems from unwelcome airborne sound.

If the rail has a web, the latter should be designed such that it emits sound waves with a frequency ν when vibrations are excited, said waves being substantially outside a frequency range between approximately 500 and 3000 Hz.

To ensure that the rail cannot tilt due to the fact that it rests on a relatively soft intermediate layer with its securing device, an embodiment of the invention provides that the rail forms together with the securing device such as a ribbed plate a unit which has the effect of widening the rail. The securing device here can be positioned inside the intermediate layer and enclosed by the latter along its longitudinal edge.

Further details, advantages and features of the invention are shown not only in the

claims and in the features they contain - singly and/or in combination - but also in the following description of preferred design examples shown in the drawing.

The drawing shows in

Fig. 1 a section through a superstructure construction with a first embodiment of a Vignol rail,

Fig. 2 a section through a superstructure construction with a second embodiment of a Vignol rail,

Fig. 3 a section through a superstructure construction with a filled section rail,

Fig. 4 a section through an intermediate layer with low effective rigidity,

Fig. 5 the intermediate layer according to Fig. 4 with high effective rigidity, and,

Fig. 6 a characteristic.

The figures - where as a general rule identical elements are identified by identical reference numbers - show sections through a ballastless track comprising a concrete sleeper 10, a ribbed plate 16 connected thereto by bolts 12, 14, and a rail attached to this ribbed plate, the rails being a UIC60 rail 18 in Fig. 1, a Vignol rail 20 in Fig. 2, which has a changed vibration technology compared with the UIC60 rail 18 in respect of the web 22 and the foot 24, and a filled section rail 26 in Fig. 3.

The respective rails 18, 20, 26 are secured to the ribbed plate 16 using suitable fasteners

such as clips 28, 30 resting on the feet 24 or 32, 34 of the rails 20 or 18 and 26 respectively. Here the connection between the fasteners 28 and 30 and the respective rail feet 24, 32, 34 is such that a mechanical unit is formed that leads to an apparent widening of the rail foot. As a result, the respective rail 18, 20, 26 attains a greater tilting stability.

As regards the fastening of the ribbed plate 16 to the concrete sleeper 10 using the bolts 12 and 14, reference is made to standard designs, in particular however to those found in WO 95/17552. To that extent, the disclosure in this respect is the subject matter of the present invention.

Regardless of the type of fastening between the ribbed plate 16 or element with the same effect and the sleeper 10, however, it is provided in accordance with the invention that an elastic intermediate layer 36, 38, 40 passes between the ribbed plate 16 or corresponding securing device for the rail 18, 20, 26 respectively and the sleeper 10, said intermediate layer having a rigidity x that depends on the maximum required rail stress of the respective rail 18, 20, 26. In this case the ribbed plate 16 is preferably vulcanized into the intermediate layer 36, 38, 40, which in turn has a so-called kinked rigidity characteristic. This means that the intermediate layer 36, 38, 40 has properties which are soft in that working range in which the rail 18, 20, 26 has not yet reached the maximum permissible rail stress, but then abruptly become hard when the maximum permissible rail stress prevails. To obtain a so-called kinked characteristic, design measures to be found in WO 94/08093 can be selected. Reference is made here to the appropriate disclosure, which is the subject of the present invention.

In particular however, the measures to be found in Figs. 4 and 5 must be provided, in order to set the rigidity of the intermediate layer such that its properties are soft before

the maximum permissible rail stress is reached, and then change abruptly to hard properties when the maximum permissible rail stress prevails.

An intermediate layer 36, 38, 40 shown in Figs. 1 to 3 can in its principle have a design as shown in Figs. 4 and 5 and provided with the reference number 42. The intermediate layer 42 therefore has projections 46 projecting beyond its underside 44. At the same time, the projections 46 are surrounded by a cavity 48 (recess in the intermediate layer 42) when the intermediate layer 42 is without load. This cavity 48 has a volume V_1 corresponding to the volume V_0 of that section 50 of the projections 46 which extends beyond the underside 44 of the intermediate layer 42.

The projections 46 perform, under standard loading of the rail, i.e. before the maximum permissible rail stress is attained, supporting spring functions, and accordingly support the ribbed plate 16 alone. As the force introduced increases and, concomitantly, the rail stress likewise increases, the projection 46 is forced more and more into the intermediate layer 42, the result being that the cavity 48 is filled by the material of the projection 46. When the maximum permissible rail stress is reached, the projection 46 fills the entire cavity 48, so that as a consequence thereof the front face 52 of the projection 46 is flush with the underside 44 of the intermediate layer 42. Because of this, the entire intermediate layer 42 performs supporting functions, with the result that the intermediate layer as a whole is effective with a high rigidity. This in turn means that when further forces are introduced into the rail its rail stress can only be increased insubstantially, if at all.

Fig. 5 shows the intermediate layer 42 with the projections 46 forced into it. It can be seen that the front faces 52 of the projections are aligned with the underside 44 of the intermediate layer 42.

Fig. 6 shows purely in principle the characteristic of the intermediate layer 42. The subsidence s is therefore shown as a function of the force acting on the intermediate layer 42. In the area in which the maximum permissible rail stress has not yet been reached the characteristic has a flat curve, which rises steeply when the maximum permissible rail stress has been reached.

In other words, the intermediate layer 42 is designed such that the rail is bendable enough that the maximum permissible rail stress can be generated and when the latter is reached no further bending is possible, since the intermediate layer 42 has a high rigidity x which is preferably in the vicinity of 100 kN/mm or more.

The maximum permissible rail stress is that rail stress which can occur at the foot underside and can be ascertained using the measuring strip, for example. It is provided here for ballastless tracks that the maximum required rail stress is $70 \pm 4 \text{ N/mm}^2$ with a standard wheel load of 10 t in rolling stock traversing the rail.

To permit an appropriate maximum rail stress when rolling stock with a wheel load of 10 t traverses the rail, the rigidity x of the respective intermediate layer 36, 38, 40 is rated accordingly, i.e. the rigidity x of the intermediate layer 36, 38, 40 compared with known superstructure constructions is reduced, meaning that the rail 18, 20, 26 can have a softer support. This in turn results in a reduction of the structure-borne sound since the rail 18, 20, 26 is decoupled from the sleeper 10. The support point load too is reduced.

To realize the teachings in accordance with the invention, however, it is provided that the intermediate layer 36, 38, 40 has in respect of its spring properties or rigidity a so-called kinked characteristic. The intermediate layer 36, 38, 40 therefore has elastic or "soft" properties as long as the maximum permissible or presettable rail stress has not

yet been reached. If this rail stress does prevail, the intermediate layer 36, 38, 40 is "hard", i.e. has a high rigidity, so that there is no further bending of the rail 18, 20, 26 and hence no increase in the rail stress.

Since a rail can, depending on its geometry, more or less perform the function of a support and hence develop a load-carrying effect, a reduction of the rigidity x of the intermediate layer results when the moment of inertia I_x and the moment of resistance W_x of the rail are increased, i.e. for example when the geometry of a standard UIC60 rail 18 is altered to the effect that the web 22 is widened and the rail foot 24 merges with a slight curvature into the web 22 in accordance with Fig. 2. The result of this is that the rail 20 can be mounted more softly without exceeding the maximum permissible rail stress of $70 \pm 4 \text{ N/mm}^2$ in particular. Soft mounting means however a further decoupling from the sleeper 10, with the consequence that the structure-borne sound emitted by the rail 20 is reduced.

Even better results are obtained with the filled section rail 26 according to Fig. 3, since the even higher moment of inertia I_x and moment of resistance W_x permit an even softer mounting before the maximum permissible rail stress is attained.

The geometry of the rail 20 or that of the filled section rail 26 furthermore has the advantage that the foot 24 or 34 respectively has been changed in its vibration technology compared with the UIC60 rail 18, such that when vibrations are excited the emitted sound is not in the undesirable frequency range between 500 and 3000 Hz. The widening or shape alteration of the web 22 of the rail 20 also reduces the airborne sound usually emitted by the web of a Vignol rail.

On the basis of the teachings in accordance with the invention, that the rail 18, 20, 26

is elastically mounted on the intermediate layer 36, 38, 40 such that under normal wheel loads the maximum permissible rail stress can be reached, but - thanks to the kinked curve of the characteristic - is not generally exceeded, the advantage is obtained that the rail 18, 20, 26 and the sleeper 10 are decoupled such that undesirable structure-borne sound is prevented. If in addition a filled section rail 26 or a Vignol rail 20 with web 22 of modified vibration characteristics and foot 24 is used in order to largely suppress the emission of airborne sound in the range between 500 and 3000 Hz, the result is an improvement of the ballastless track from the acoustic viewpoint.

Taking into account the teachings in accordance with the invention, the result for a filled section rail Vo 1-60 with $I_x = 3760 \text{ cm}^4$, $W_x = 430 \text{ cm}^3$ and a maximum permissible rail stress of 73 N/mm^2 for the intermediate layer 40 is a rigidity of 10 kN/mm , from which in turn a maximum support point load of 25.3 kN is calculated. These values apply in that working range in which the maximum rail stress is not exceeded. If by contrast the latter is reached, the rigidity of the intermediate layer 40 changes such that the latter is "hard", i.e. largely non-elastic, so that there is no further bending of the rail. In this "hard" range the rigidity x should be $\geq 35 \text{ kN/mm}$.

These values show that the filled section rail 26 is decoupled from the support layer 40 to an extent that when it is traversed by rolling stock the structure-borne sound of the rail 26 is only transmitted to a minor extent to the sleeper 10 and hence to the substructure.



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Claims

Superstructure Construction

1. A superstructure construction such as a ballastless track comprising a rail (18, 20, 26) disposed above a support layer such as a concrete sleeper (10) and in its turn extending from a securing device (16) such as a ribbed plate, where at least one intermediate layer (36, 38, 40, 42) with a rigidity x is disposed between the support layer and the securing device,
w h e r e i n
the rigidity x of the intermediate layer (36, 38, 40, 42) is rated such that a maximum permissible and/or presettable rail stress can be generated in the rail (18, 20, 26) on the foot side.
2. Superstructure construction according to Claim 1,
w h e r e i n
the intermediate layer (36, 38, 40, 42) has a spring characteristic such that the intermediate layer has substantially non-elastic properties at maximum permissible and/or presettable rail stress.

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3. Superstructure construction according to Claim 1 or Claim 2,
w h e r e i n
the intermediate layer (36, 38, 40, 42) has a low rigidity before the maximum permissible and/or presettable rail stress is reached and a high rigidity when this rail stress is reached.
4. Superstructure construction according to at least one of the preceding claims,
w h e r e i n
the intermediate layer (36, 38, 40, 42) has a rigidity x of $x \leq 25$ kN/mm, preferably $4 \leq x \leq 25$ kN/mm, in the range of permissible rail stress.
5. Superstructure construction according to at least one of the preceding claims,
w h e r e i n
at the maximum permissible rail stress the intermediate layer (36, 38, 40, 42) has a rigidity x of $x \geq 35$ kN/mm, in particular $x \geq 90$ kN/mm, preferably in the vicinity of 100 kN/mm.
6. Superstructure construction according to at least one of the preceding claims,
w h e r e i n
the rail is a Vignol rail (20) with a maximum permissible rail stress of 70 to 100 N/mm² and wherein the intermediate layer (38) has a rigidity x of approximately 4 to 16 kN/mm before the maximum permissible rail stress is reached.

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7. Superstructure construction according to at least one of the preceding claims,
w h e r e i n
the rail is a filled section rail (26) preferably of a rail steel UTC Class A with approximately 880 N/mm² tensile strength with a moment of inertia I_x of $I_x \geq 3700 \text{ cm}^4$ and/or a moment of resistance W_x of $W_x \geq 390 \text{ cm}^3$, and wherein at a maximum required rail stress of approximately $70 \pm 4 \text{ N/mm}^2$ the intermediate layer (40) has a rigidity x of approximately $10 \pm 2 \text{ kN/mm}$.
8. Superstructure construction according to at least one of the preceding claims,
w h e r e i n
the rail (20) is designed at its foot such that the foot (24) emits sound waves with a frequency ν when vibrations are excited, said waves being substantially outside a frequency range between 500 and 3000 Hz.
9. Superstructure construction according to at least one of the preceding claims,
w h e r e i n
the rail (26) is designed without a web.
10. Superstructure construction according to at least one of the preceding claims,
w h e r e i n
the rail (20) is designed at its web such that the web (22) emits sound waves with a frequency ν when vibrations are excited, said waves being substantially outside a frequency range between 500 and 3000 Hz.

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11. Superstructure construction according to at least one of the preceding claims,
w h e r e i n
the rail (18, 20, 26) forms with the securing device (16) a unit effecting a
widening of the rail foot.
12. Superstructure construction according to at least one of the preceding claims,
w h e r e i n
the securing device (16) is positioned inside the intermediate layer (36, 38, 40),
preferably enclosed by the latter along its longitudinal edge.
13. A superstructure construction such as a ballastless track comprising a rail (18, 20,
26) disposed above a support layer such as a concrete sleeper (10) and in its turn
extending from a securing device (16) such as a ribbed plate, where at least one
intermediate layer (36, 38, 40, 42) with a rigidity x is disposed between the
support layer and the securing device,
w h e r e i n
the rigidity x of the intermediate layer (36, 38, 40, 42) is rated such that the rail
(18, 20, 26) is deformable on the foot underside up to the rail stress in the range
from 70 to 100 N/mm².
14. Superstructure construction according to preferably at least one of the preceding
claims,
w h e r e i n
when the intermediate layer (42) is without load it has projections (46) projecting
beyond its underside (44) and surrounded by a cavity (48) inside the intermediate
layer on the circumferential side, with each cavity (48) having a volume V_a equal

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to a volume V_p corresponding to that of a projection (46) in its section (50) projecting beyond the underside of the intermediate layer.

15. Superstructure construction according to at least Claim 14,

wherein

when the maximum permissible rail stress prevails the volumes of the cavities (48) are completely filled by the material of the projections (46) and wherein the projections are flush with the underside (44) of the intermediate layer in order to achieve a high rigidity x of the intermediate layer (42), in particular in order to achieve a rigidity x in the vicinity of 100 kN/mm.

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