

A RAIL TRACK TIE

The present invention relates to a rail track tie or "sleeper", of the type comprising:

- a rigid block presenting a bottom face, and a top
5 face for receiving at least one longitudinal rail;
- a cover for receiving the rigid block and in the form of a rigid shell comprising a bottom and a peripheral rim around the bottom; and
- a resilient soleplate disposed between the bottom
10 face of the rigid block and the bottom of the cover.

Such ties are frequently used for laying a rail track without ballast, e.g. in or on a structure such as a tunnel or a viaduct, where the ties are supported by a bed or a slab.

15 EP-A-0 919 666 describes a tie of this type. The rigid cover is embedded in a concrete slab, and together therewith it forms a rigid assembly.

Each rail generally rests on a resilient bearing element, disposed between each rail and the rigid block.
20 The resilient bearing elements thus form a first elastic stage. They may be mounted when the track is laid, or beforehand, e.g. when the tie is assembled.

The resilient soleplate placed between the block and the rigid cover forms a second elastic stage.

25 The vibration generated by the rails when trains pass is damped essentially in the first and second elastic stages.

However, the attenuation of mechanical vibration when a train is passing over such a track system as
30 presently known is not entirely satisfactory. The cut-off frequency and the insertion gain are both greater than those of a track system on floating slabs, for example.

An object of the invention is to improve the
35 vibration attenuation performance of the above-mentioned tie, in particular in a range of frequencies up to 250 hertz (Hz), which is considered as being capable of

generating nuisance for surrounding buildings, while also limiting the fatigue and the stress to which the rail system is subjected.

5 To this end, the invention provides a tie of the above-specified type, characterized in that the resilient soleplate has dynamic stiffness k_2 lying in the range 6 kilonewtons per millimeter (kN/mm) to 10 kN/mm, preferably in the range 6 kN/mm to 8 kN/mm.

According to other characteristics of the invention:

10 • the resilient soleplate has a substantially plane top face and a substantially plane bottom face;

• the block has four peripheral faces that connect the top face to the bottom face, the tie including resilient pads disposed between each peripheral face of
15 the block and the peripheral rim of the cover;

• the resilient pads comprise at least two longitudinal resilient pads of dynamic stiffness lying in the range 20 kN/mm to 25 kN/mm, and at least two transverse resilient pads of dynamic stiffness lying in
20 the range 15 kN/mm to 18 kN/mm;

• said tie includes, on the top face of the rigid block, a resilient bearing element of dynamic stiffness lying in the range 120 kN/mm to 300 kN/mm, preferably in the range 200 kN/mm to 300 kN/mm, the resilient bearing
25 element being designed to receive the rail bearing thereagainst;

• the tie comprises a single block and a single cover;

• the block presents weight in the range
30 350 kilograms (kg) to 450 kg, preferably in the range 400 kg to 450 kg;

• the tie comprises two blocks, two respective covers associated therewith, and a transverse spacer interconnecting the two blocks; and

35 • each block has weight lying in the range 100 kg to 150 kg, preferably in the range 130 kg to 150 kg.

The invention also provides a rail track segment characterized in that it includes a tie as described above and at least one rail bearing on the tie.

The invention can be better understood on reading the following description given by way of example and made with reference to the drawings, in which:

- Figure 1 is a diagrammatic cross-section view of a segment of rail track in a first embodiment;

- Figure 2 is a more detailed diagrammatic cross-section view of the tie of Figure 1 shown in section;

- Figure 3 is a diagrammatic longitudinal section view of the tie of Figures 1 and 2;

- Figure 4 is a diagram modeling the Figure 1 segment of rail track;

- Figure 5 is a graph showing the acoustic performance of a tie of the invention; and

- Figure 6 is a view analogous to Figure 1 and showing a segment of rail track in a second embodiment.

A segment 2 of rail track in a first embodiment of the invention is shown diagrammatically in Figure 1. The segment 2 comprises two longitudinal rails 4 fastened on a tie 8. The tie 8 comprises a single rigid concrete block 9 and two resilient bearing elements 10 disposed between each rail 4 and the block 9.

By convention, the longitudinal rails 4 define a reference for the longitudinal direction.

The resilient bearing elements 10 are substantially in the form of rectangular parallelepipeds. In the example shown in Figure 1, their width is substantially equal to the width of the base of the rail 4, and their length is substantially equal to the width of the block 9.

The resilient bearing elements 10 are received in respective recesses 12 in the block 9. The profile of each recess 12 in cross-section is substantially rectangular. The width and the length of each recess 12 in the example shown in Figure 1 are substantially equal

to the width and the length respectively of a resilient bearing element 10.

By way of example, the resilient bearing elements 10 are adhesively bonded to the tie 8.

5 Each rail 4 is attached to the block 9 by means of rail fasteners (not shown) that prevent any transverse displacement of the rail relative to the block 9 and that secure the rail 4 with the block 9 and with each resilient bearing element 10.

10 Throughout the description below, given the range of frequencies under consideration (less than or equal to 250 Hz), dynamic stiffness is always considered as being constant and substantially equal to 130% of static stiffness.

15 The resilient bearing elements 10 form a first elastic stage 14 of vertical dynamic stiffness k_1 as shown in the model of Figure 4. Each rail 4 is modeled as being suspended on a first end of a spring 16 of dynamic stiffness k_1 . The second end of the spring 16 is
20 linked to the block 9.

Each resilient bearing element 10 has dynamic stiffness k_1 lying in the range 120 kN/mm to 300 kN/mm, and preferably in the range 200 kN/mm to 300 kN/mm. By way of example, the material used for each resilient
25 bearing element 10 is: rubber, polyurethane, or any other elastic material.

The tie 8 of Figure 1, shown in detail in Figures 2 and 3, comprises a cover 20 for receiving the block 9, a resilient soleplate 22 disposed in a substantially
30 horizontal plane between the block 9 and the cover 20, and four resilient pads 24, 26 disposed in respective substantially vertical planes between the block 9 and the cover 20.

The block 9 is substantially in the form of a
35 rectangular parallelepiped and essentially comprises a top face 32, a substantially plane bottom face 34 on which it rests, and four peripheral faces 36, 38

connecting the top face 32 to the bottom face 34 via respectively a rounded edge 44 and a chamfer 46. The peripheral faces 36, 38 comprise two longitudinal peripheral faces 36 and two transverse peripheral faces 38.

Each peripheral face 36, 38 has a substantially plane bottom portion 36A, 38A, and a substantially plane top portion 36B, 38B, with a substantially plane intermediate portion 36C, 38C interconnecting each bottom portion 36A, 38A to its corresponding top portion 36B, 38B. The longitudinal top portions 36B and the transverse top portions 38B converge mutually upwards. The longitudinal bottom portions 36A and the transverse bottom portions 38A converge mutually downwards. The longitudinal intermediate portions 36C and the transverse intermediate portions 38C converge mutually downwards, forming an angle relative to the vertical plane that is greater than the angle formed by each corresponding bottom portion 36A, 38A.

The block 9 is selected to be of particularly great weight. Its weight lies in the range 350 kg to 450 kg, and preferably in the range 400 kg to 450 kg. The weight of the block 9 is conventionally increased by adding metal elements in the concrete.

The cover 20 is formed by a substantially rigid shell. The cover 20 essentially comprises a bottom 48 and a continuous peripheral rim 50 going round the bottom 48.

The bottom 48 presents a substantially plane and rectangular top face 52.

The peripheral rim 50 of the cover 20 has four panels 54, 56. The four panels 54, 56 comprise two longitudinal panels 54 associated respectively with the longitudinal faces 36 of the block 9, and two transverse panels 56 associated respectively with the transverse faces 38. Each panel 54, 56 has a respective inside face 62, 64. Each inside face 62, 64 includes a housing 66,

68 substantially in the shape of a rectangular parallelepiped, each for receiving a respective resilient pad 24, 26.

5 The housings 66, 68 are substantially parallel to the corresponding bottom portions 36A, 38A of the peripheral faces 36, 38 of the block 9. Each housing 66, 68 presents a rectangular periphery defined by a continuous peripheral shoulder 66A, 68A. Each housing 66, 68 is also of substantially the same height and the
10 same length as the bottom portions 36A, 38A with which it is associated.

Each inside face 62, 64 has a top portion 62A, 64A that is plane and of inclination relative to the vertical that is substantially equal to or greater than the
15 inclination of the corresponding intermediate portions 36C, 38C of the peripheral faces 36, 38 of the block 9. The top portions 62A, 64A are of substantially the same height as the corresponding associated intermediate portions 36C, 38C of the block 9.

20 The top portions 62A, 64A of the inside faces 62, 64 of the panels 54, 56 are connected to a continuous top edge 70 of the rim 50. In the example shown in Figures 2 and 3, the top edge 70 presents two fingers serving to fasten a continuous sealing gasket 72. By way of
25 example, the gasket 72 is made of natural or synthetic rubber. It provides sealing between the block 9 and the cover 20 without impeding displacement of the block 9 in the cover 20. It is also possible to make the sealing gasket 72 by casting a material such as silicone or
30 polyurethane in the form of a continuous bead.

The stiffness of the cover 20 is reinforced by ribs 74 formed in relief on the outsides of the panels 54, 56, and in part under the bottom 48. By way of example, they are molded integrally with the cover 20. These ribs 74
35 may be of any suitable shape and of any suitable disposition relative to the cover 20, in a manner that is known in the state of the art, in particular from EP-A-

0 919 666. In the example shown in Figures 2 and 3, they present notches 76 enabling the cover 20 to be anchored on a strength member. While the track is being laid, the ribs 74 are embedded at least in part in concrete. They
5 thus serve to secure the cover 20 to the filler concrete.

In the example shown in Figures 2 and 3, the cover 20 is made as a one-piece molding. In a manner that is not shown, the cover 20 could be made by assembling together a plurality of partial shells, as disclosed in
10 the state of the art (e.g. EP-A-0 919 066). For a one-piece tie 8 in the first embodiment of the invention, these might comprise, for example two half-shells, one at each end, and a central shell interconnecting the two end half-shells.

15 By way of example, the cover 20 is made of molded thermoplastic material or of resin concrete.

The resilient soleplate 22 is substantially in the form of a rectangular parallelepiped and has substantially plane top and bottom faces for minimizing
20 the mechanical stresses to which the resilient soleplate 22 is subjected and avoids problems of fatigue. Its length and width are substantially equal respectively to the length and the width of the bottom face 34 of the block 9.

25 Its thickness lies in the range 10 millimeters (mm) to 20 mm, preferably in the range 16 mm to 20 mm. The resilient soleplate 22 thus remains in an elastic domain; which corresponds substantially to a maximum amount of deformation that is less than or equal to 40%. The
30 amount of deformation is the ratio of thickness variation presented by the resilient soleplate 22 between a free state and a loaded state.

The resilient soleplate 22 forms a second elastic stage 78 of vertical dynamic stiffness k_2 as shown in the
35 model of Figure 4. The rigid block 9 is modeled as being suspended on the first ends of two springs 80 of dynamic

stiffness k_2 . The second ends of the springs 80 are linked to the cover 20.

The resilient soleplate 22 of the invention has dynamic stiffness k_2 that is less than the dynamic
5 stiffness of the devices that are conventionally used. The dynamic stiffness k_2 lies in the range 6 kN/mm to 10 kN/mm, and preferably in the range 6 kN/mm to 8 kN/mm.

By way of example, the resilient soleplate 22 is made of a cellular elastomer material.

10 In a preferred embodiment, the resilient soleplate 22 has vertical dynamic stiffness k_2 that is substantially uniform over its entire area.

In another embodiment, the resilient soleplate 22 has vertical dynamic stiffness k_3 in a central zone of
15 the block 9 that is less than or equal to k_2 . The central zone comprises the middle of the block 9 and extends transversely on either side of the middle of the block 9 towards the ends over substantially half of the area of the block 9. Since this central zone is less
20 stressed, it is possible therein to use a material that is more elastic and therefore less expensive.

The resilient soleplate 22 can rest freely on the bottom 48 of the cover 20. It can thus easily be removed from the cover 20.

25 Advantageously, the tie 8 also has a substantially incompressible thickness piece 82, as shown in Figures 2 and 3.

The thickness piece 82 is substantially in the form of a rectangular parallelepiped. Its length and its
30 width are substantially equal to the length and the width of the top face 52 of the bottom 48 of the cover 20. Its thickness is less than or equal to 10 mm, and preferably lies in the range 2 mm to 4 mm.

The thickness piece 82 rests freely on the bottom 48
35 of the cover 20. It can thus be removed easily from the cover 20, or it can be added to the cover 20, in order to adjust the leveling of the track.

Advantageously, the resilient soleplate 22 rests freely on the thickness piece 82.

The surface of the thickness piece 82 is sufficiently rough to avoid the resilient soleplate 22 sliding in the cover 20. By way of example, this roughness is obtained by means of serrations, diamond tips, or barbs.

Each resilient pad 24, 26 presents an outside face 24A, 26A and an inside face 24B, 26B, and four peripheral faces.

The outside and inside faces 24A, 26A and 24B, 26B are of substantially the same dimensions and they present an outline that is substantially rectangular.

The outside and inside faces 24A, 26A and 24B, 26B are of length and width that are substantially equal respectively to the length and the width of the corresponding housings 66, 68 in the peripheral rim 50 of the cover 20.

The resilient pads 24, 26 are faced in the corresponding housings 66, 68. By way of example, they are held by friction between the peripheral faces of the resilient pads 24, 26 and the peripheral shoulder 66A, 68A of each housing 66, 68. The resilient pads 24, 26 can thus be removed easily.

Each resilient pad 24, 26 may also be held by snap-fastening. For example, the housings 66, 68 may have grooves and the resilient pads 24, 26 may have complementary fluting.

The resilient pads 24, 26 present thickness greater than the depth of the housings 66, 68 so that they project relative to the shoulders 66A, 68A.

The inside faces 24B, 26B merely press against the corresponding bottom portions 36A, 38A of the peripheral faces 36, 38 of the rigid block 9.

As shown in Figures 2 and 3, the inside faces 24B, 26B are provided with grooves increasing their flexibility.

The resilient pads 24, 26 have dynamic stiffness in the range 12 kN/mm to 25 kN/mm. By way of example, they are made of rubber, polyurethane, or any other elastic material.

5 The longitudinal pads 24 corresponding to the longitudinal peripheral faces 36 are subjected to greater forces than the transverse pads 26 corresponding to the transverse peripheral faces 38. The longitudinal pads 24 can thus advantageously be selected to have dynamic
10 stiffness greater than that of the transverse pads 26. Thus, the longitudinal pads 24 have dynamic stiffness lying in the range 20 kN/mm to 25 kN/mm, for example, while the transverse pads 26 have dynamic stiffness lying in the range 15 kN/mm to 18 kN/mm.

15 Under normal conditions of operation, the resilient pads 24, 26 hold the block 9 away from the inside faces 62, 64 of the cover 20.

 The resilient pads 24, 26 thus provide horizontal damping for the block 9. This horizontal damping is
20 decoupled from the vertical damping obtained by the resilient bearing elements 10 and the resilient soleplate 22.

 It should be observed that the number of resilient pads is not limiting. By way of example, the tie 8 may
25 have two transverse pads 34 side by side on each side of the block 9.

 Figure 5 shows the acoustic performance of a prior art tie and of a tie in accordance with the invention. Figure 5 plots insertion gain as a function of frequency.
30 Insertion gain in this example is the ratio expressed in decibels (dB) between the value of a measured magnitude (speed, acceleration, force, etc.) obtained when a resilient soleplate is included and the value obtained when it is not included (see French standard ISO 14837-
35 1:2005). In the example described, this is the force exerted on the cover 20. A reduction in the value of the

magnitude is expressed by insertion gain having a negative sign.

Furthermore, the cut-off frequency is the frequency beyond which insertion gain is observed to decrease.

5 k_{ldyn} is the dynamic stiffness of the resilient bearing elements 10, k_{2dyn} is the dynamic stiffness of the resilient soleplate 22, and M is the weight of the block 9.

10 The curve representing insertion gain as a function of frequency for $k_{2dyn} = 21.3$ meganewtons per meter (MN/m), $M = 200$ kg, and $k_{ldyn} = 150$ MN/m constitutes a reference curve S1 showing the performance of the prior art device. A second curve shows the performance of a tie of the invention with $k_{2dyn} = 8$ MN/m, $M = 400$ kg, and
15 $k_{ldyn} = 270$ MN/m.

 In the range 0 to 10 Hz, the vibration attenuation performance is substantially the same. In the range 10 Hz to 25 Hz, the insertion gain is a few dB greater than for the curve S1. In the range 25 Hz to 250 Hz, the
20 insertion gain is several dB less than that of the curve S1.

 Furthermore, the cut-off frequency is lower than that of the curve S1 (20 Hz instead of 32 Hz).

25 Thus, in the range 25 Hz to 250 Hz, the performance of a tie of the invention is substantially better.

 In a second embodiment shown in Figure 6, the tie 108 comprises two rigid blocks 109 interconnected by a spacer 184. Insofar as the two-block tie 108 is very similar to the single-block tie 8, the same references
30 are used in Figure 6 as the references used in Figures 1 to 4, but with the addition of 100.

 The length of the covers 120 is adapted to receive the blocks 109. The same applies to the transverse pads 126 and the resilient soleplates 122. Figures 2 and 3
35 which show a single-block tie 8 are also entirely applicable for illustrating a tie 108.

The main difference between the single-block tie 8 and the two-block tie 108 lies in the presence of a spacer 184 penetrating into the two blocks 109.

5 The reduction in the dynamic stiffness k_2 of the resilient soleplates 122 and/or the increase in the weight of the blocks 109 generate a large longitudinal bending movement.

10 Thus, the spacer 184 is of a shape adapted to obtain a second moment of area that is large. For example it may be in the form of an angle bar or of a cylinder. By way of example, the spacer 184 has a cross-sectional area lying in the range 800 square millimeters (mm^2) to 1500 mm^2 , and thickness lying in the range 6 mm to 10 mm. By way of example, it may be made out of a steel
15 complying with the standard EN 13230-3.

Each block 109 has weight lying in the range 100 kg to 150 kg, preferably in the range 130 kg to 150 kg.

It should be observed that the single-block tie 8 is particularly good at withstanding the additional
20 mechanical stresses that result from the invention.

It will be understood that with a tie of the invention, the reduction in the dynamic stiffness k_2 of the resilient soleplate 22, 122 serves to obtain better vibration attenuation performance, in particular by
25 lowering the cut-off frequency and by lowering the insertion gain in the range 25 Hz to 250 Hz.

The increase in the weight of the block 9, 109 also makes it possible, for given dynamic stiffness k_2 of the resilient soleplate 22, 122, to lower the cut-off
30 frequency and thus to improve the performance of the tie 8, 108 at low frequencies. Nevertheless, above a certain weight, the mechanical stresses to which the tie 8, 108 are subjected become too great.

The increase in the dynamic stiffness k_1 of the
35 resilient bearing elements 10, 110 decreases the insertion gain in the range 200 Hz to 250 Hz and shifts the resonant frequency towards higher frequencies, with

the resonant frequency being the frequency at which the insertion gain is observed to rise.

5 The invention thus makes it possible to approach the vibration attenuation performance obtained with a floating slab having its cut-off frequency lying in the range 14 Hz to 20 Hz, and having insertion gain of -25 dB situated at 63 Hz.

CLAIMS

1. A rail track tie (8; 108) of the type comprising:
 · a rigid block (9; 109) presenting a bottom face (34), and a top face (34) for receiving at least one
5 longitudinal rail (4; 104);
 · a cover (20; 120) for receiving the rigid block (9; 109) and in the form of a rigid shell comprising a bottom (48; 148) and a peripheral rim (50; 150) around the bottom (48; 148); and
10 · a resilient soleplate (22; 122) disposed between the bottom face (34) of the rigid block (9; 109) and the bottom (48; 148) of the cover (20; 120),
 the tie being characterized in that the resilient soleplate (22; 122) has dynamic stiffness k_2 lying in the
15 range 6 kN/mm to 10 kN/mm, preferably in the range 6 kN/mm to 8 kN/mm.
2. A tie (8; 108) according to claim 1, characterized in that the resilient soleplate (22; 122) has a
20 substantially plane top face and a substantially plane bottom face.
3. A tie (8; 108) according to claim 1 or claim 2, characterized in that the block (9; 109) has four
25 peripheral faces (36, 38) that connect the top face (32) to the bottom face (34), the tie (8; 108) including resilient pads (24, 26; 124, 126) disposed between each peripheral face (36, 38) of the block (9; 109) and the peripheral rim (50; 150) of the cover (20; 120).
30
4. A tie (8; 108) according to claim 3, characterized in that the resilient pads (24, 26; 124, 126) comprise at least two longitudinal resilient pads (24; 124) of dynamic stiffness lying in the range 20 kN/mm to
35 25 kN/mm, and at least two transverse resilient pads (26; 126) of dynamic stiffness lying in the range 15 kN/mm to 18 kN/mm.

5. A tie (8; 108) according to any preceding claim, characterized in that it includes, on the top face (32) of the rigid block (9; 109), a resilient bearing element (10; 110) of dynamic stiffness lying in the range 120 kN/mm to 300 kN/mm, preferably in the range 200 kN/mm to 300 kN/mm, the resilient bearing element (10; 110) being designed to receive the rail (4; 104) bearing thereagainst.
6. A tie (8) according to any preceding claim, characterized in that the tie (8) comprises a single block (9) and a single cover (20).
7. A tie (8) according to claim 6, characterized in that the block (9) present weight in the range 350 kg to 450 kg, preferably in the range 400 kg to 450 kg.
8. A tie (108) according to any one of claims 1 to 5, characterized in that the tie (108) comprises two blocks (109), two respective covers (120) associated therewith, and a transverse spacer (184) interconnecting the two blocks (109).
9. A tie (108) according to claim 8, characterized in that each block (109) has weight lying in the range 100 kg to 150 kg, preferably in the range 130 kg to 150 kg.
10. A rail track segment (2; 102), characterized in that it includes a tie (8; 108) according to any preceding claim, and at least one rail (4; 104) bearing on the tie (8; 108).