Railway construction vehicle, construction train comprising such a construction vehicle and process for building a railway

The present invention relates to a railway construction vehicle, a construction train comprising such a construction vehicle, and a process for building a railway without crosspieces using such a construction vehicle.

EP-A2-0,803,609 describes a method for building a railroad track in which a concrete slab is poured having a firm consistency and a uniform surface. While the concrete is fresh, tie plates are pushed into it, positioned in lines. Each tie plate is introduced into the concrete while being vibrated using a vibration device, until it reaches a given position. Owing to the vibration, the concrete surrounds the anchors of the tie plates to secure them with the concrete. The rails of the railway are next mounted directly on the tie plates, such that a railway without crosspieces is obtained. The vibration of the tie plates is generally done using a specialized construction vehicle comprising a system of hydraulic jacks able to perform this function.

However, the insertion of the tie plates requires relatively heavy means that are in particular not suitable for inclining the tie plates in the case of a railway having a substantial slope, or in general, a steep transverse gradient. Furthermore, if the railway to be produced extends within a tunnel, it may prove difficult to supply this specific construction vehicle with tie plates.

The present invention aims to resolve these drawbacks by proposing a new railway construction vehicle which, while having greater productivity than the vehicles of the prior art, facilitates railway production, in particular when the railways have a steep transverse gradient or are located in a railway tunnel.

The present invention relates to a railway vehicle, comprising:

- a gantry, which includes uprights, and
- a first means for moving the railway construction vehicle relative to the ground along at least one direction of advance of the railway construction vehicle.

According to the invention, this railway construction vehicle comprises at least one robotic arm mounted on the gantry, between the uprights. This robotic arm is configured to position at least one insert in a fresh concrete slab situated in a construction zone located below the gantry. The gantry comprises a roof support that connects the uprights to one another by an upper end of the latter, while the robotic arm is suspended from the roof support.

The construction vehicle according to the invention makes it possible to obtain particularly high productivity, inasmuch as the robotic arm is able to reach, for a given

position of the construction vehicle, an extended construction zone, while working at a relatively high speed. Furthermore, the arrangement of the robotic arm relative to the gantry makes it particularly suitable for inserting inserts in the context of the construction of a railway with a steep transverse slope.

According to other advantageous features of the invention, considered alone or in combination:

- The vehicle comprises a construction compartment within which the robotic arm is positioned, the construction compartment comprising two side walls, mounted on the uprights, as well as a lower opening, through which the robotic arm can reach the construction zone.
- Two robotic arms are provided while being positioned in pairs on either side of the sagittal plane of the railway construction vehicle, the sagittal plane being substantially perpendicular to the ground and parallel to the direction of advance.
- The robotic arm comprises at least one base rotating actuator, secured to the gantry, and a first member mounted on the base rotating actuator, the base rotating actuator being able to rotate the first member around a base axis, preferably substantially perpendicular to the direction of advance.
- The robotic arm has six degrees of freedom and is configured to vibrate the insert in the construction zone during the insertion of the latter into the fresh concrete slab.
- The robotic arms are able to be commanded independently of one another.
- The vehicle comprises a module supplying the robotic arm with inserts, the supply module including:
    - a ramp situated at a rear end of the railway construction vehicle, able to be supplied with inserts from outside the railway construction vehicle, and
    - an insert storage compartment, the storage compartment being supplied with inserts by the ramp and being situated between the ramp and the robotic arm,

and the robotic arm is configured to grasp the inserts in the storage compartment.

- The vehicle comprises a detection system configured to detect metal elements in the concrete of the slab and advantageously a member for controlling the position of the robotic arms able to modify an insertion position of the inserts based on a position of detected metal elements.

The invention also relates to a construction train comprising a railway construction vehicle according to the preceding, and a following vehicle including:

- an insert storage platform extending from a front end of the following vehicle,

- a second means for moving the following vehicle relative to the ground along at least one the direction of advance, and
- an automatic control module of the second movement means, the control module being configured to automatically control the movement of the following vehicle along the direction of advance via the second movement means, such that the front end of the following vehicle is kept at a predetermined following distance from the railway construction vehicle.

Advantageously, the following vehicle comprises means for conveying inserts stored on the storage platform toward the front end. The invention also relates to a method for manufacturing a railway without crosspieces; according to the invention, the method is implemented with a railway construction vehicle as described above, or with a construction train as described above.

The invention will be better understood upon reading the following description, provided solely as a non-limiting and non-exhaustive example, and in reference to the drawings, in which:

- figure 1 is a perspective view of a construction train according to the invention;
- figure 2 is a longitudinal sectional view, along a plane II-II visible in figure 1, of the construction train of figure 1;
- figure 3 shows a detail of an embodiment of the construction vehicle of figures 1 and 2, according to box III shown in figure 2;
- figure 4 is a cross-sectional view, along plane IV shown in figure 1, of the construction train of the preceding figures; and
- figure 5 shows a bottom view of the construction train of the preceding figures.

The construction train 1 shown in figure 1 comprises a construction vehicle 3, sometimes called insertion vehicle, as well as a following vehicle 5.

The construction train 1 is designed to produce a railway for the circulation of trains. Such a railway is preferably a so-called "crosspiece-free" railway, visible in figures 2 and 4, and comprising a longitudinal concrete slab 11, on which a pair of rails is installed, secured with this slab 11 via inserts 33, sometimes called tie plates, implanted in said slab 11. This type of railway and its inserts are known as such.

The vehicles 3 and 5 are able to move along a direction of advance D1 and along an opposite withdrawal direction D2, shown by arrows in the figures. To that end, each of the vehicles 3 and 5 is provided with several drive wheels using which they are supported on the ground. In the illustrated example, the vehicle 3 comprises two drive wheel bogies

7 making up these movement means relative to the ground, the vehicle 5 also comprising two bogies 9 with similar functions. The vehicles 3 and 5 are designed to move above the concrete slab 11 that extends parallel to the direction D1, the bogies 7 and 9 being configured so that the drive wheels roll on parallel tread surfaces between which the concrete slab 11 extends, as shown in figure 4. In practice, the tread surfaces are formed on the surface of a civil engineering work supporting the slab. The wheels rest directly on the work, preferably without rails or supports other than the work itself. Traditionally, the bogies 7 and 9 rotate around vertical axes to adapt to any curves in the future railway that the concrete slab 11 is intended to form. The direction of advance D1 is presently defined when the bogies 7 and 9 are oriented along a so-called straight orientation, for movement of the train 1 in a straight line, when the track itself is in a straight line.

In addition, the vehicles 3 and 5 respectively include a body 13 and 15 resting on the bogies 7 and 9. The body 13 defines a front end 13A of the vehicle 3, oriented along the direction D1, and an opposite rear end 13B, as illustrated in figure 1. Likewise, the body 15 defines a front end 15A of the vehicle 5, oriented along the direction D1, and an opposite rear end 15B. The ends 13B and 15A are adjacent.

The body 13 comprises, in a central part situated between the two bogies 7, a construction compartment 17 within which two robotic arms 19 are positioned. The body 13 also comprises, between the two bogies 7, a gantry 21, which includes four uprights 23, oriented vertically relative to the ground, each of the uprights 23 rising above one of the bogies 7 so as to form a framework for the construction compartment 17 and delimit the latter. The construction compartment 17 comprises two side walls 25, mounted on the uprights 23, the side walls 25 extending away from one another and being oriented in planes parallel to the direction of advance D1. The side walls 25 each form a panel that forms part of the outer enclosure of the body 13, covering at least a portion of the height of the body 13. The side walls 25 each extend in a plane substantially orthogonal to the axis of the wheels when the bogies 7 are in their straight orientation. The robotic arms 19 extend between the vertical uprights 23 of the gantry 21 and between the side walls 25. The gantry 21 further comprises a roof support 27, made up of a set of beams connecting the uprights 23 to one another by an upper end of the latter. The robotic arms 19 are suspended from the roof support 27 so as to be enclosed and protected in the construction compartment 17. The latter comprises a lower opening 29 opposite the roof support 27, and in particular visible in figure 5. The robotic arms 19 are configured to reach a construction zone 31 situated below the body 13 between the two bogies 7 via the opening 29 that emerges in this location. The robotic arms 19 can thus position the inserts

33 at this construction zone 31 in the concrete slab 11, when the concrete of the slab 11 is still fresh, to construct the aforementioned railway.

Advantageously, the vehicle 3, and in particular the body 13, is equipped with a detection system, not shown, configured to detect metal elements in the concrete slab 11, and in particular the presence of frameworks in the concrete of the slab 11. The detection system is in particular capable of determining a position of the detected metal elements.

Within the construction compartment 17, the two robotic arms 19 are positioned on either side of a sagittal plane P1 of the vehicle 3, the sagittal plane being substantially perpendicular to the ground and parallel to the direction of advance D1. When the bogies are oriented straight, the sagittal plane P1 is thus perpendicular to the axis of the wheels of the bogies 7 and forms a median plane of the vehicle 3. Thus, preferably, each of the robotic arms 19 is positioned near and above one of the future rails of the railway being constructed, i.e., over the installation position of the inserts 33.

Each robotic arm 19 comprises a base rotating actuator 35 by means of which it is installed in the roof support 27 of the gantry 21. This base rotating actuator 35 in particular comprises a support structure of the robotic arm 19 as well as a motor, and is schematically shown in figure 3 by a square. Each robotic arm 19 is thus suspended from the roof support 27, by means of its respective base rotating actuator 35, and protrudes downward toward the concrete slab 11. Each robotic arm 19 comprises a first member 37 that is mounted on the base rotating actuator 35, such that the base rotating actuator 35 rotates this first member 37 around a base axis X35, substantially perpendicular to the direction of advance D1 and parallel to the sagittal plane P1. This particular configuration gives the robotic arms 19 the ability to reach a particularly extended construction zone 31. The first member 37 comprises a first rotating actuator 39 around an axis X39, a second member 41 of the robotic arm 19. The axis X39 is perpendicular to the axis X35. The second member 41 forms an arm that extends from the first rotating actuator 39, perpendicular to the axis X39, to a second rotating actuator 43 of the robotic arm 19. The second rotating actuator 43 is configured to support and rotate a third member 45 of the robotic arm 19 around an axis X43 parallel to the axis X39. The third member 45 includes a third rotating actuator 49 supporting and rotating a fourth member 51 of the robotic arm 19, around an axis X49 orthoradial with respect to the axis X43. The fourth member 51 forms an arm that extends along the axis X49 and that is provided with a fourth rotating actuator 53 positioned at an end opposite the third rotating actuator 49. By means of the fourth rotating actuator 53, the fourth member 51 supports and rotates a fifth member 55 around an axis X53 perpendicular to the axis X49. The fifth member 55 forms an arm and includes a fifth rotating actuator 55 by means of which it supports and rotates a gripping

member 59 of the robotic arm 19 around an axis X57. The axis X57 is perpendicular to the axis X53 and coaxial with the fifth member 55. The gripping member 59 forms a terminal member of the robot 19. The gripping member 59 is able to grasp the inserts 33 and the robotic arm 19 to move its gripping member 59 by means of the various members and rotating actuators described above to insert them into the part of the slab 11 that is situated in the construction zone 31. Owing to its six rotating actuators and its various members, the robotic arm 19 has six degrees of freedom and is able to vibrate the insert 33 in the construction zone 31 during the insertion of this insert 33 into the fresh concrete of the concrete slab 11. Here, the rotating actuators 35, 39, 43, 49, 53 and 57 are formed by electric servomotors.

The two robotic arms are controlled completely independently and are mechanically independent of one another. In other words, the robotic arms are able to insert the inserts completely independently and with six degrees of freedom, in any position and with any incline in the construction zone 31. It is therefore in particular possible to install support inserts for a third rail, in particular supplying electricity, or for safety rails or guardrails or for derailment prevention devices or for other types of railway equipment, such as signal beacons.

The robotic arm 19 is preferably controlled by an automaton. This automaton is configured to operate the robotic arm 19 automatically. Optionally, the automaton and the robotic arm 19 can be controlled remotely from a remote control station. Alternatively, this control station is situated on board the construction train 1, or even the construction vehicle 3. This control station is not illustrated in the figures.

Also advantageously, the detection system is able to communicate the position where metal elements are detected in the concrete of the slab 11 to the automaton. The automaton is then configured to determine the insertion position of the inserts 33 as a function of the position of the metal elements. The automaton is for example able to offset, by a certain distance in the longitudinal direction, a predetermined insertion position of one of the inserts, if metal elements are detected in this predetermined position.

The construction vehicle 3 further comprises a module 61 supplying the robotic arms 19 with the inserts 33. This supply module 61 comprises a storage compartment 63 for inserts 33, which extends within the body 13 from the rear end 13B up to the construction compartment 17, as shown in figure 2. The compartment 63 contains a supply of inserts 33 and communicates with the construction compartment 17 such that the robotic arms 19 can themselves recover the inserts 33 contained in the compartment 63. The supply module 61 also includes a ramp 65 situated at the rear end 13B and protruding outside the compartment 63 along the direction D2, such that the ramp 65 can

be supplied with inserts 33 from outside the vehicle 3. The compartment 63 is thus supplied with inserts 33 by the ramp 65.

The vehicle 3 also comprises a generator unit 67 able to generate energy, to power the robotic arms 19 as well as the backup equipment of the construction train 1. The generator unit 67 extends from the construction compartment 17 to the front end 13A.

Alternatively, the vehicle 3 is able to be supplied with electricity from the vehicle 5, which is for example equipped with a generating set. This makes it possible to eliminate the vibrations inherent to the use of a generator unit on board the vehicle 3 and makes it possible to guarantee better precision of the positioning of the inserts in the slab 11.

The body 15 of the following vehicle 5 includes a platform 69 storing inserts 33 that rests on the bogies 9. The platform 69 advantageously extends from the front end 15A to the rear end 15B. The body 15 also comprises side walls 71 and 72 that form a tunnel with the platform 69, this tunnel being oriented along the direction of advance D1. Spare inserts 33 are stored within this tunnel in buckets 73, sometimes called "big bags", resting on the platform 69. Each bucket 73 preferably forms a large-capacity flexible container, provided with straps. The following vehicle 5 is provided with a means for conveying buckets 73, of the bridge crane type, symbolized by the square 75 in figure 2. The bridge crane 75 is able to move the buckets 73 within the body 15, in particular to bring them near the front end 15A. The inserts 33 are next transferred by an operator, manually, onto the ramp 65 in order to supply the vehicle 3. Alternatively, a bridge crane or jib crane may be provided to perform this transfer automatically or to assist the operator with this transfer operation. The vehicle 3 is thus able to be supplied with inserts from the vehicle 5 without it being necessary to stop the operation of the construction train 1 to resupply the vehicle 5 with inserts. Advantageously, the vehicle 5 is able to be resupplied with inserts while the vehicle 3 is operating and placing inserts in the concrete of the slab 11.

The following vehicle 5 is provided with an automatic control module 77 for the bogies 9. The control module 77 for example forms an automaton, which is configured to control the movement of vehicle 5 automatically along the directions D1 and D2 via bogies 9, such that the vehicle 5 follows the movement of the vehicle 3. In practice, the control module 77 moves the vehicle 5 such that the front end 15A of the vehicle 5 is kept at a predetermined following distance d from the rear end 13B of the vehicle 3. This following distance d is measured parallel to the direction of advance D1, from the end 15A to the end 13B, and is preferably comprised between 30 and 400 cm. Thus, the construction vehicle 3 and the following vehicle 5 are designed to move in a coordinated manner, but without being hitched together. The absence of hitching between the vehicles 3 and 5 makes it possible, when necessary, to particularly easily desynchronize the movement of

the vehicles 3 and 5. Thus, as an example, the vehicle 3 can perform construction on the railway while the vehicle 5 can be detached and sent into an insert (33) resupply area.

Alternatively, traditional hitching is provided between the vehicles 3 and 5 to perform a similar function.

The construction train 1 thus described is therefore particularly suitable for manufacturing a railway without crosspieces.

Alternatively, the construction vehicle 3 comprises a second pair of robotic arms, positioned in the construction compartment 17 or in a second construction compartment of the vehicle 3. This second pair of robotic arms is positioned such that the robotic arms are aligned with the future rails of the railway, i.e., on either side of the sagittal plane P1 of the vehicle 3.

Alternatively, the vehicle 3 comprises more pairs of robotic arms.

Also alternatively, the vehicle 3 comprises only one robotic arm, which is then preferably positioned in the sagittal plane P1.

Also alternatively, the vehicle 3 comprises a pair of robotic arms according to the preceding description, as well as an additional robotic arm positioned in the sagittal plane P1, such that the vehicle 3 is particularly suitable for the construction of a railway with three rails.

Alternatively, the movement means of the vehicles 3 and 5 are formed by crawlers or a system of wheels suitable for rolling on metal rails.

The embodiments and alternatives described above may be combined to form new embodiments.

CLAIMS

1.- A railway construction vehicle (3), comprising:

- a gantry (21), which includes uprights (23), and
- a first means (7) for moving the railway construction vehicle relative to the ground along at least one direction of advance (D1) of the railway construction vehicle,

wherein this railway construction vehicle (3) comprises at least one robotic arm (19) mounted on the gantry (21), between the uprights, wherein each of the at least one robotic arm is configured to position at least one insert (33) in a slab (11) of fresh concrete situated in a construction zone (31) situated below the gantry, wherein the gantry (21) comprises a roof support (27) that connects the uprights to one another by an upper end of the latter and wherein each of the at least one robotic arm (19) is suspended from the roof support.

2.- The railway construction vehicle (3) according to claim 1, wherein it comprises a construction compartment (17) within which each of the at least one robotic arm (19) is positioned, the work compartment comprising two side walls (25), mounted on the uprights (23), as well as a lower opening (29), through which each of the at least one robotic arm can reach the construction zone (31).

3.- The railway construction vehicle (3) according to claim 1 or 2, wherein two robotic arms (19) are provided while being positioned in pairs on either side of the sagittal plane (P1) of the railway construction vehicle, the sagittal plane being substantially perpendicular to the ground and parallel to the direction of advance (D1).

4.- The railway construction vehicle (3) according to any one of claims 1 or 2, wherein each of the at least one robotic arm (19) comprises at least one base rotating actuator (35), secured to the gantry (21), and a first member (37) mounted on the base rotating actuator, the base rotating actuator being able to rotate the first member around a base axis (X35).

5.- The railway construction vehicle (3) according to any one of claims 1 or 2, wherein each of the at least one robotic arm (19) has six degrees of freedom and is configured to vibrate the insert (33) in the construction zone (31) during the insertion of the latter into the fresh concrete slab (11).

6.- The railway construction vehicle (3) according to any one of claims 1 or 2, wherein the railway construction vehicle (3) comprises a plurality of robotic arms (19) and each of the robotic arms (19) is able to be commanded independently of one another.

7.- The railway construction vehicle (3) according to any one of claims 1 or 2, wherein it comprises a module (61) supplying the at least one robotic arm (19) with inserts (33), the supply module including:

- a ramp (65) situated at a rear end (13B) of the railway construction vehicle, able to be supplied with inserts from outside the railway construction vehicle, and
- an insert storage compartment (63), the storage compartment being supplied with inserts by the ramp and being situated between the ramp and the robotic arm (19),

and wherein each of the at least one robotic arm is configured to grasp the inserts in the storage compartment.

8.- The railway construction vehicle (3) according to any one of claims 1 or 2, wherein it comprises a detection system configured to detect metal elements in the concrete of the slab.

9.- The railway construction vehicle (3) according to claim 8, wherein it comprises a member for controlling the position of each of the at least one robotic arm (19) able to modify an insertion position of the inserts based on a position of detected metal elements.

10.- A construction train comprising a railway construction vehicle (3) according to any one of claims 1 or 2, and a following vehicle (5) including:

- an insert (33) storage platform (69) extending from a front end (15A) of the following vehicle,
- a second means (9) for moving the following vehicle relative to the ground along the at least one direction of advance (D1), and
- an automatic control module (77) of the second movement means, the control module being configured to automatically control the movement of the following vehicle along the at least one direction of advance (D1) via the second movement means, such that the front end (15A) of the following vehicle is kept

at a predetermined following distance (d) from the railway construction vehicle (3).

11.- The construction train according to claim 10, wherein the following vehicle (5) comprises means (75) for conveying inserts (33) stored on the storage platform (69) toward the front end (15A).

12.- A method for manufacturing a railway without crosspieces, wherein the method is implemented with a railway construction vehicle (3) according to any one of claims 1 or 2.