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(54) **Supplementary pile foundation for a railway track**

(57) The invention relates to piling for rail tracks, and in particular to a method and system for piling railway tracks to improve the underlying foundation structure. Embodiments disclosed include a method of modifying an existing rail track structure comprising a pair of rails laid over a series of sleepers (101) on top of a ballast

layer (102), the method comprising forming a pile structure (201) extending vertically beneath and between adjacent ones (101) of the series of sleepers, wherein a top (202) of the pile structure (201) is separated from the series of sleepers (101) by the ballast layer (102).

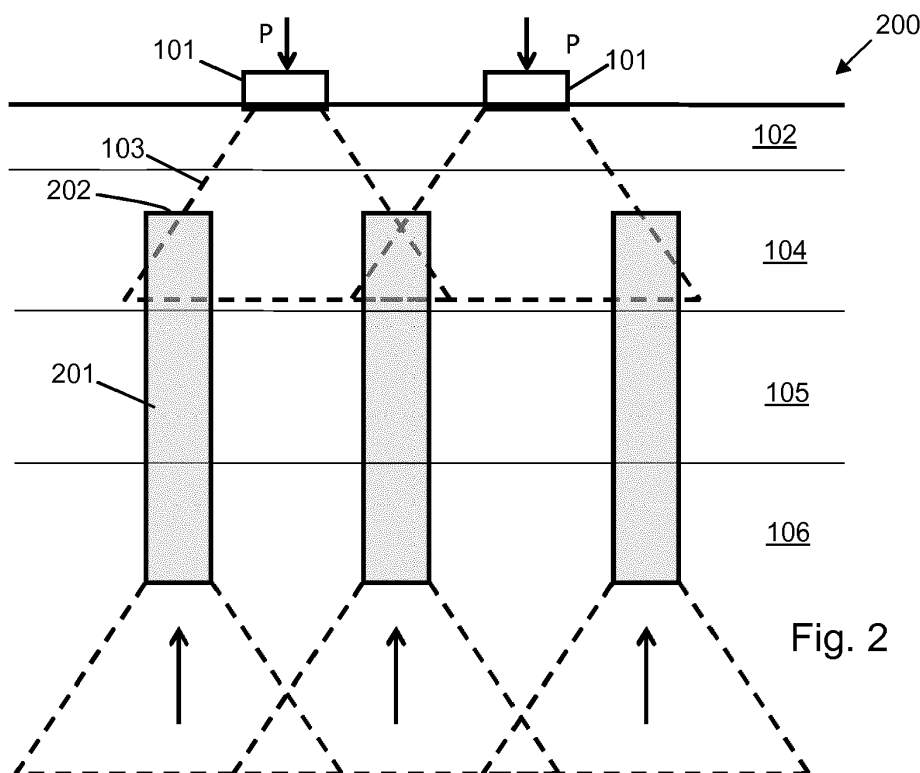


Fig. 2

Description

Field of the Invention

[0001] The invention relates to piling for rail tracks, and in particular to a method and system for piling railway tracks to improve the underlying foundation structure.

Background

[0002] A conventional rail track structure comprises a pair of continuously welded parallel steel rails supported by a series of concrete, wood or steel sleepers laid on top of a stone ballast foundation. The stone ballast foundation may be laid over a variety of different substructures, generally including a formation layer that defines the general form, i.e. the extent and gradient, of the rail track beneath the ballast layer.

[0003] A problem with existing conventional rail track structures is that the substructure can degrade over time, for example due to continued use of the track or due to environmental factors such as erosion or movement of the underlying water table. The underlying substructure may be unstable over time, or may become less suitable due to a requirement to use increased speeds on the track, resulting in increased loading and a need to maintain tighter tolerances on track uniformity. It may therefore become necessary to upgrade an existing track in order to allow the track to be optimally used with new rolling stock, otherwise the new rolling stock may be forced to travel along the track at a reduced speed or not be allowed to use the track at all.

[0004] Upgrading existing rail tracks to improve the track and substructure, for example to allow for increased speeds of travel, is generally extremely expensive, labour intensive, time consuming and disruptive due to the need for extensive excavation and construction works to be carried out around and underneath the track. In some cases it may be more cost effective and less disruptive to simply build an entirely new track rather than attempt to upgrade an existing track to meet more stringent requirements.

[0005] Conventional track maintenance and renewal may involve replacement of the ballast layer, which may be done at the same time as realigning the track and sleepers. This does not, however, affect the underlying foundation structure, which can still be subject to movement that may result in the track requiring further maintenance.

[0006] It is an object of the invention to address one or more of the above mentioned problems.

Summary of the Invention

[0007] In accordance with a first aspect of the invention there is provided a method of modifying an existing rail track structure comprising a pair of rails laid over a series of sleepers on top of a ballast layer, the method compris-

ing forming a pile structure extending vertically beneath and between adjacent ones of the series of sleepers, wherein a top of the pile structure is separated from the series of sleepers by the ballast layer. As well as being separated by at least a portion, if not the whole of, the ballast layer, the top of the pile structure may also be separated from the series of sleepers by other layers such as a sub-ballast layer and/or a formation layer.

[0008] A feature of the invention is that the pile structure extends vertically between the existing rails and sleepers, thereby allowing the method to be used on existing rail tracks with reduced disruption to the track structure, reducing the need to excavate and transport material for disposal. The invention allows for a reduction in plant and maintenance activities, allowing such activities and plant to be redirected to improving more existing rail track. The invention may also reduce or remove the need for temporary speed restrictions, thereby reducing the impact on use of the rail track.

[0009] By having the pile structure not directly connected to the sleepers, but instead via at least a portion of the ballast layer (and optionally also a sub-ballast layer and/or a formation layer), the rail track is supported over a wider area and the method of installing the pile structure is greatly simplified compared to one where a physical connection may need to be made between the pile structure and the sleepers.

[0010] The top of the pile structure (or pile cap) may be at least 0.5m, 0.6m, 0.7m, 0.8m, 0.9m or 1m beneath the series of sleepers. The depth of the top of the pile structure may vary depending on the support required. A deeper placed pile structure may, for example, be used when the ballast contains higher levels of fine grained materials to support the rail track, with each pile structure effectively supporting multiple sleepers, whereas a shallower pile structure may be used when the ballast is clean, i.e. with lower levels of fine grained materials.

[0011] The pile structure may have a length of 1 m or longer, optionally between 1 and 8 m, between 1 and 3 m, and in a particular example around 2 m long. The length of the pile structure will depend on the type of subsurface material beneath the rail track, and how deep any sound underlying material is upon which the pile structure transmits any downward forces.

[0012] The pile structure may comprise a cemented column, optionally comprising one or both of a cemented granular stone fill material and a metal reinforcement structure. An alternative pile structure may comprise a metal (typically steel) tube, grouted internally and externally with cement and with a grouted steel pile cap and cutting shoe. Either form of pile may be formed using a temporary metal outer casing which is removed following pile installation and reinstatement of the track ballast. The granular cemented pile may be a free draining (porous) or solid (non-porous) structure.

[0013] The method may comprise vertically inserting a tube, typically a metal tube, between adjacent sleepers of the rail track through the ballast layer using an auger.

When the tube is in place, the pile structure may be inserted or formed within the tube, followed by backfilling with railway ballast material and removal of the tube. In some embodiments, the hole formed by the auger and defined by the tube may be cemented after the auger is removed, following which the tube is removed. The hole may alternatively be cemented during removal of the auger. A membrane layer and/or a reinforcement structure may be applied around the hole formed by the auger and tube to further strengthen the pile and reduce ingress of any surrounding fine grained materials.

[0014] In accordance with a second aspect of the invention there is provided a rail track structure comprising a pair of rails laid over a series of sleepers on top of a ballast layer, a pile structure extending vertically beneath and between adjacent ones of the series of sleepers, wherein a top of the pile structure is vertically separated from the series of sleepers by the ballast layer.

[0015] A plurality of said pile structures may be provided in a regular array, extending in a travel direction along the rail track. A horizontal spacing of the pile structures, i.e. a spacing in a travel direction along the rail track, may be an integer multiple of a horizontal spacing of the series of sleepers, i.e. a pile structure may be provided between each pair of sleepers, between alternate pairs of sleepers or between pairs of sleepers at regular intervals. Pairs of pile structures may be provided between adjacent pairs of sleepers, i.e. each pile structure may be accompanied by another pile structure positioned between the same pair of adjacent sleepers.

[0016] The various other optional features associated with the first aspect of the invention may also be applied to the second aspect.

[0017] Pile structures formed according to the invention can enhance the properties of an existing track bed, improving track quality and extending the life of the track system. The pile structures act to regulate system stiffness and rate of change of stiffness, thereby improving ride quality and reducing maintenance intervention. The properties of the existing track bed can also be enhanced by improving stiffness to allow an increased line speed as well as improving track drainage.

Detailed Description

[0018] The invention is described in further detail below by way of example and with reference to the accompanying drawings, in which:

- figure 1 is a schematic cross-sectional diagram of an existing rail track structure;
- figure 2 is a schematic cross-sectional diagram of an exemplary series of pile structures provided beneath an existing rail track; and
- figure 3 is an further schematic cross-sectional diagram of an exemplary series of pile structures provided beneath an existing rail track.

[0019] Figure 1 illustrates schematically a loading distribution of an existing rail track structure 100, indicating a pair of sleepers 101 laid over a ballast layer 102. Vertical forces P from the overlying track (not shown) and any rolling stock are transmitted through the sleepers 101 into the ballast layer 102. Dotted lines 103 indicate the general area the load is transmitted from each sleeper 101 through the ballast layer 102, an underlying formation layer 104, a weak soil layer 105 and a strong soil layer (or bedrock layer) 106, the load footprint of the sleeper becoming progressively larger as the load is transmitted further into the rail track substructure. The various layers 102, 104, 105, 106 are shown by way of example, are not illustrated to scale, and should be taken as only illustrative of the type of arrangement of subsurface layers that may be encountered typically.

[0020] Figure 2 illustrates a cross-sectional schematic diagram of a rail track structure 200 comprising an exemplary piling system in place beneath the rail track. As with figure 1, a series of sleepers 101 are laid over a ballast layer 102 overlying a formation layer 104, a weak soil layer 105 and a strong soil layer (or bedrock layer) 106. A vertical pile structure 201 is provided between adjacent sleepers 101, the pile structure 201 extending through the formation layer 104, weak soil layer 105 and strong soil layer 106. The loading from each sleeper 101, the spreading of which is indicated by dotted lines 103, is transmitted to the top of each pile structure 201. The vertical stiffness of the pile structure 201 transmits this load directly through the intervening layers into the strong soil layer 106, thereby adding support to each of the sleepers 101 without a direct connection between the pile structure 201 and the sleepers 101. The load is spread from the bottom of the pile structure 201 into the strong soil layer 106, providing a matching upward force to that applied to the sleepers 101.

[0021] As can be seen in figure 2, the top 202 of each pile structure 201 is vertically separated from the adjacent sleepers 101 by the ballast layer 102. In the embodiment in figure 2, the top 202 of each pile structure 201 lies beneath the ballast layer 102 and extends through the underlying foundation layer 104, the pile structure 201 being separated from the sleepers by the ballast layer 102 and a portion of the foundation layer 104. In alternative embodiments the top 202 of the pile structure 201 may extend into the ballast layer 102, provided there is a vertical separation between the top 202 and the sleepers 101.

[0022] Figure 3 illustrates schematically a more detailed view of an exemplary embodiment of a rail track structure 300 incorporating a piling system. Vertical pile structures 301 are provided between adjacent pairs of sleepers 101, on which a rail 309 is laid. Dotted lines 303 indicate the approximate extent of the load footprint beneath each sleeper 101, indicating that the top 302 of each pile structure 301 lies within the footprint of four sleepers 101. The particular arrangement in figure 3 allows for a pile structure 301 to be provided in alternate

spaces between adjacent sleepers 101. The dimensions of the rail track structure 300 allow for a nominal 0.8 m vertical distance between the bottom of the sleepers 101 and the top 302 of the pile structures 301, and a horizontal spacing of 1.3 m, i.e. around twice the 0.660 m horizontal spacing of the sleepers 101 (sleeper spacings typically vary between 610 and 760mm). In a general aspect, a horizontal spacing of the pile structures 301 may be an integer multiple of a horizontal spacing of the sleepers 101, the multiple typically ranging between one and four.

[0023] Each of the pile structures in the embodiment shown in figure 3 is nominally 2 m long and 0.24 m in diameter. Each pile structure 301 is effectively a stone column formed from compacted granular material such as ballast material. The pile structure 301 may be reinforced with an external grid reinforcement structure, which may be formed from a polymer material, and may comprise a membrane layer (known as a geotextile sock) to provide a barrier between the pile structure and the surrounding fine grained materials.

[0024] The following paragraphs describe two specific exemplary embodiments of methods of forming pile structures.

[0025] In a first exemplary embodiment, where a piling system is installed without removal of the track, steel axial piles are installed, preferably in pairs, between the two running rails within the sleeper crib, i.e. between adjacent sleepers. A temporary 275mm diameter steel tube is inserted into the ballasted sleeper crib by using an auger inserted inside the tube. As the auger is rotated inside the tube, the tube sinks into the ballast layer to a depth of around 700mm below ground level (i.e. the sleeper top level), with approximately 100mm of tube left protruding above ground level. The auger is removed, leaving the temporary steel tube in-situ during the installation of the pile structure. A steel pile is rotated into the ground within the temporary tube to the required depth, which can be up to several metres beneath the sleepers depending on ground conditions. As the steel pile is installed it is simultaneously grouted internally and externally, external grouting being applied via the pile head. The finished steel pile cap is located at a depth of approximately 1m below ground level and grouted on top to a depth of 200mm to increase the pile cap load bearing area. The remainder of the tube is backfilled with track ballast to sleeper top level. The temporary steel tube is then withdrawn using the on-track machine. The depth and the length of the pile varies depending on the track bed & sub-grade conditions

[0026] In a second exemplary embodiment, also undertaken without removal of the track, stone or granular pile structures are installed, preferably in pairs, between the two running rails within the sleeper crib (i.e. the space between adjacent sleepers). A temporary 275mm diameter steel tube is first inserted into the ballasted sleeper crib by using an auger inserted inside the tube. As the auger is rotated inside the tube the tube sinks into the ballast layer to a depth of around 2200mm below ground

level (sleeper top level), with approximately 100mm of tube left protruding above ground level. The auger is removed leaving the temporary tube in-situ during the installation of the stone column pile structure. To form the pile structure, the steel tube is backfilled with a granular / cement mix to a depth of approximately 700mm below ground level (sleeper top level). The remainder of the tube is then backfilled with track ballast to sleeper top level. The temporary steel tube is then withdrawn using the on-track machine. The depth and the length of the pile varies depending on the track bed & sub-grade conditions.

[0027] Other embodiments are intentionally within the scope of the invention as defined by the appended claims.

Claims

1. A method of modifying an existing rail track structure comprising a pair of rails laid over a series of sleepers on top of a ballast layer, the method comprising forming a pile structure extending vertically beneath and between adjacent ones of the series of sleepers, wherein a top of the pile structure is separated from the series of sleepers by the ballast layer.
2. The method of claim 1 comprising:
 - inserting a tube between adjacent sleepers of the rail track structure through the ballast layer using an auger;
 - removing the auger;
 - inserting or otherwise forming the pile structure within the tube; and
 - back-filling the tube with ballast material.
3. The method of claim 2 comprising removing the tube after forming the pile structure.
4. A rail track structure comprising a pair of rails laid over a series of sleepers on top of a ballast layer, a pile structure extending vertically beneath and between adjacent ones of the series of sleepers, wherein a top of the pile structure is vertically separated from the series of sleepers by the ballast layer.
5. The method or rail track structure of any preceding claim wherein the top of the pile structure is at least 0.5m, 0.6m, 0.7m 0.8m, 0.9m or 1m beneath the series of sleepers.
6. The method or rail track structure of any preceding claim wherein the pile structure is greater than 1m long, optionally between 1m and 8m long.
7. The method or rail track structure of any preceding claim wherein the pile structure comprises a cement-

ed column.

8. The method or rail track structure of any preceding claim wherein the pile structure comprises one or both of a cemented granular stone fill material and a reinforcement structure. 5
9. The method or rail track structure of any preceding claim wherein the pile structure comprises a metal outer casing. 10
10. The method or rail track structure of any preceding claim wherein a plurality of said pile structures is provided in a regular array. 15
11. The method or rail track structure of claim 10 wherein a horizontal spacing of the plurality of pile structures is an integer multiple of a horizontal spacing of the series of sleepers. 20
12. The method or rail track structure of claim 10 or claim 11 wherein pairs of pile structures are provided beneath adjacent pairs of sleepers. 25

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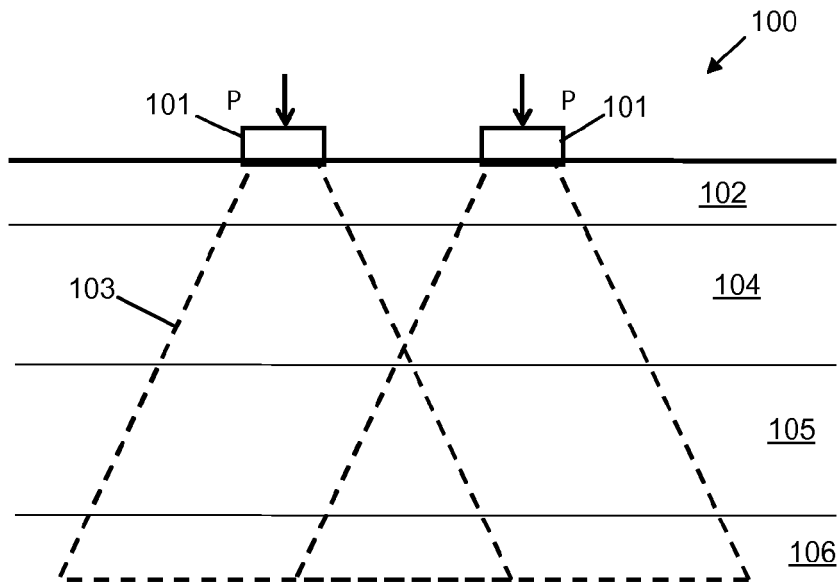


Fig. 1

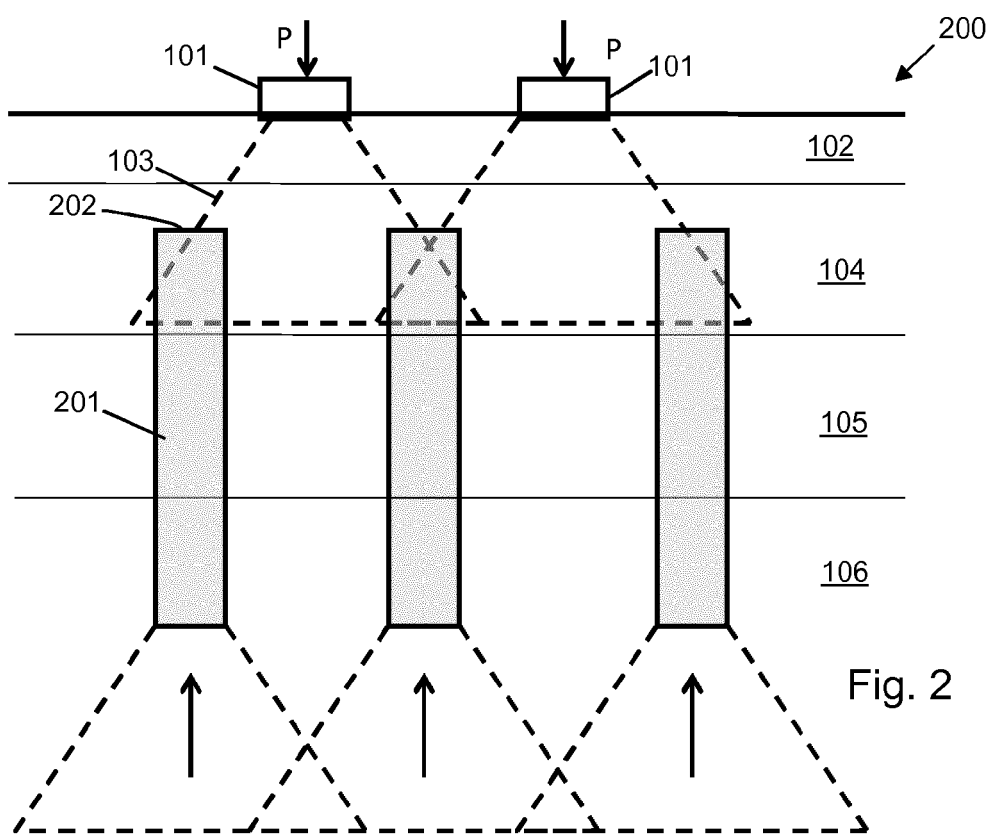


Fig. 2

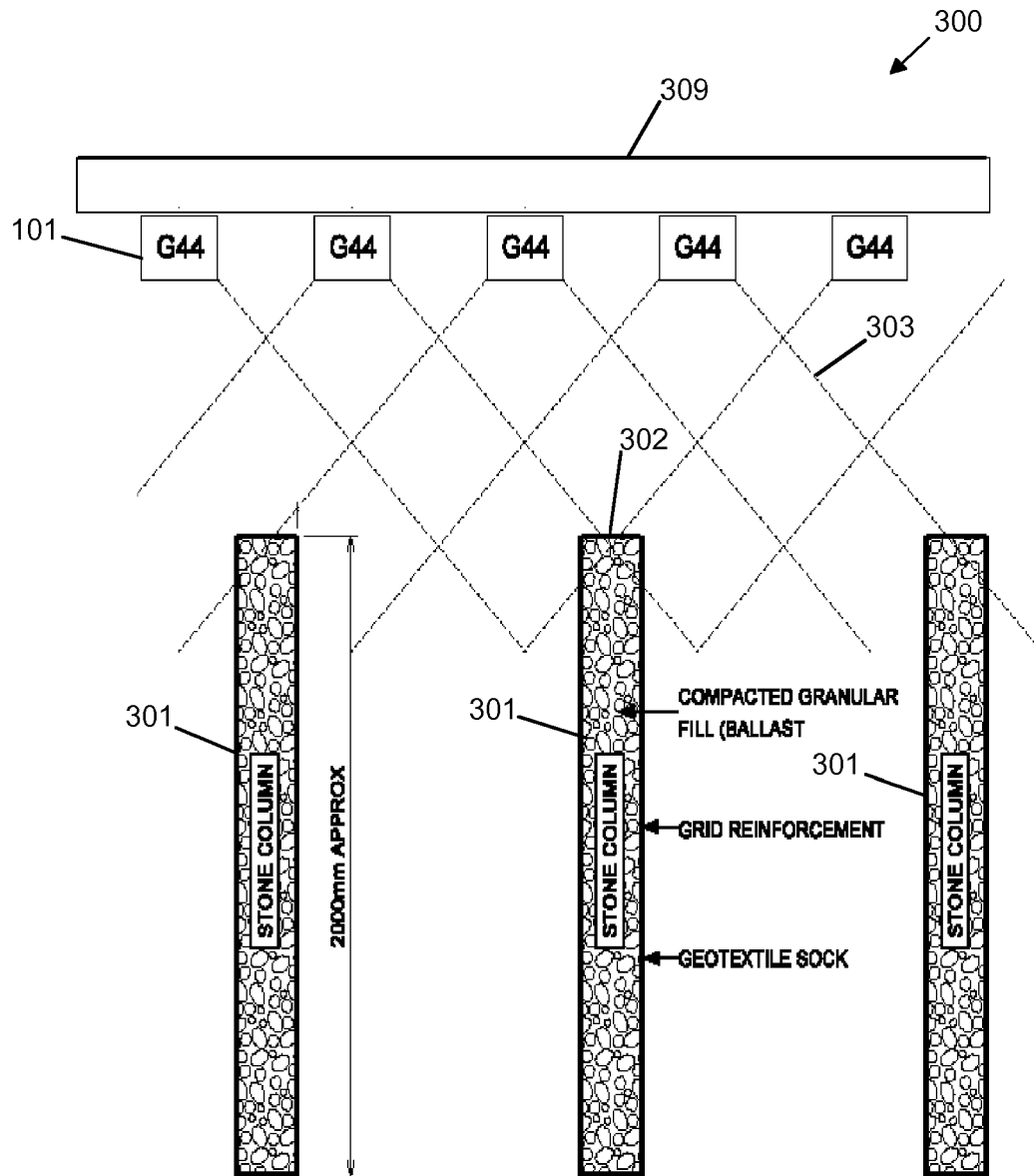


Fig. 3



EUROPEAN SEARCH REPORT

Application Number
EP 14 27 5169

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 2 493 731 A (ASPINS FOUNDATIONS LTD [GB]) 20 February 2013 (2013-02-20) * the whole document * -----	1-12	INV. E01B2/00
			TECHNICAL FIELDS SEARCHED (IPC)
			E01B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 22 January 2015	Examiner Schwertfeger, C
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