

CLAIMS

1. A geogrid engineering construction for railways (railway geogrid construction), the construction comprising:
- 5 a track bed (optionally the track bed comprising rails) which defines a track located on a track plane;
- a mass of particulate material forming a layer located beneath the track plane; and
- at least one geogrid located in and/or below the particulate layer,
- where the at least one geogrid is located in a plane (geogrid plane) substantially
- 10 parallel to the track plane where the average distance between the track plane and geogrid plane, measured perpendicular to both planes, and denoted herein as D_r , is greater than 0.65 metres.
2. A railway geogrid construction as claimed in claim 1, where the particulate layer
- 15 is located immediately beneath the track bed.
3. A railway geogrid construction as claimed in claim 1 or 2, where the particulate layer has an average thickness less than D_r , preferably less than 0.5 m, more preferably less than 0.4 m, most preferably from 0.1m to 0.35 m.
- 20 4. A railway geogrid construction as claimed in any preceding claim in which D_r is greater than or equal to 0.7 metres, more preferably ≥ 0.8 m, even more preferably ≥ 0.9 m most preferably ≥ 1 m.
- 25 5. A railway geogrid construction as claimed in any preceding claim in which D_r is less than or equal to 5 metres, more usefully ≤ 4 m, even more usefully ≤ 3 m most usefully ≤ 2 m.
- 30 6. A railway geogrid construction as claimed in any preceding claim in which D_r is from 0.65 to 5 metres, conveniently from 0.7 to 5 metres, more conveniently from 0.8 to 4 m, even more conveniently from 0.9 to 3 m, most conveniently from 1 to 2 m.
- 35 7. A railway geogrid construction as claimed in any preceding claim where the particulate layer is additionally stabilized by at least one other mechanically stabilized layer and/or chemically stabilized layer.

8. A railway geogrid construction as claimed in any preceding claim, where the geogrid is in the form of an integral, molecularly oriented, mesh, which comprises polymers which are substantially molecularly oriented in at least one direction.
- 5 9. A railway geogrid construction as claimed in any preceding claim, where the polymers of the geogrid are molecularly oriented in at least two substantially perpendicular directions (biaxial orientation).
- 10 10. A railway geogrid construction as claimed in any preceding claim, where the geogrid comprises interconnecting mesh defining elements including elongate tensile elements.
- 15 11. A railway geogrid construction as claimed in any preceding claim, where the geogrid comprises transverse bars interconnected by substantially straight oriented strands, at least some of the strands extending from one bar to the next at a substantial angle to the direction at right angles to the bars and alternate such angled strands across the width of the geogrid being angled to said direction by equal and opposite angles.
- 20 12. A railway geogrid construction as claimed in any preceding claim, where the geogrid is in the form of an integral, molecularly oriented, plastics mesh structure.
- 25 13. A railway geogrid construction as claimed in any preceding claim, where the geogrid has a thickness of from 0.1 m to 5 mm, preferably from 0.2 to 2 mm.
- 30 14. A railway geogrid construction as claimed in any preceding claim, where the molecular oriented polymers that comprise the polymer geogrid are oriented by the polymer grid (and/or the polymer web from which the grid is formed) having been stretched in at least one direction at stretch ratio of at least 2:1, preferably of at least 2 to 1 to 12 to 1, more preferably of from 2 to 1 to 6 to 1.
- 35 15. A railway geogrid construction as claimed in any preceding claim, where the geogrid has a tensile strength of at least 10 kN /m.
16. A railway geogrid construction as claimed in any preceding claim, where the geogrid has mesh defining elements that have a width of 2 to 100 mm, the mesh

defining elements defining mesh apertures (optionally which apertures may be of identical size and/or shape) having a mean length and/or a mean width of from 5 to 400 mm.

- 5 17. A railway geogrid construction as claimed in any preceding claim having a Rayleigh wave velocity (V_r) therein of at least 55 ms^{-1} (~125 mph or ~200 kph), more preferably $\geq 69 \text{ ms}^{-1}$ (~155 mph or ~250 kph).
- 10 18. A railway geogrid construction as claimed in any preceding claim, which further comprises a railway track having rails, where the rails have a critical track velocity at least 140 ms^{-1} (~310 mph or ~500 kph), more preferably at least 150 ms^{-1} (~335 mph or ~540 kph).
- 15 19. A railway geogrid construction as claimed in any preceding claim that has the one or more, preferably two or more, more preferably three or more, even more preferably four or more, most preferably five or more, for example all six, of any of the following properties selected from (i) to (vi)
- 20 i) Radial Secant stiffness at 0.5% strain of at least 100 kN / m , preferably of from 200 to 800 kN / m more preferably of from 220 to 700 kN / m , most preferably of from 250 to 600 kN / m with further optionally in each case a tolerance of from minus (-) 60 to minus (-) 100 .
- 25 ii) Radial Secant stiffness at 2% strain (in kN / m of at least 80 kN / m , preferably of from 150 to 600 kN / m more preferably of from 170 to 500 kN / m , most preferably of from 200 to 450 kN / m with further optionally in each case a tolerance of from minus (-) 60 to minus (-) 100 .
- 30 iii) Radial Secant stiffness Ratio (dimensionless) of at least 0.5 preferably of from 0.6 to 0.9 , most preferably of from 0.70 to 0.85 , most preferably of from 0.75 to 0.80 , with further optionally in each case a tolerance of from minus (-) 0.10 to minus (-) 0.20 , more optionally minus (-) 0.15 .
- 35 iv) Junction efficiency of at least 90% preferably at least 95% , more preferably of at least 97% , most preferably of at least 99% , for example of 100% , with further optionally in each case a tolerance of at least minus (-) 10 .
- v) Pitch (preferably hexagon pitch) of at least 30 mm , preferably of from 40 to 150 mm , more preferably of from 50 to 140 , most preferably of from 65 to 125 mm , with further optionally in each case a tolerance of from minus (-) 60 to minus (-) 100 .

vi) Product weight of at least 0.100 kg/m^2 , preferably of from 0.120 to 0.400 kg/m^2 , more preferably of from 0.150 to 0.350 kg/m^2 , most preferably of from 0.170 to 0.310 kg/m^2 , for example from 0.180 to 0.300 kg/m^2 with further optionally in each case a tolerance of from minus (-) 0.025 to minus (-) 0.040 , more optionally of from minus (-) 0.030 to 0.035 .

20. A method for constructing a geogrid engineering construction for railways (railway geogrid construction), optionally the railway geogrid construction as claimed in any preceding claim, the method comprising the steps of:

10 providing a track bed (optionally the track bed comprising rails) which defines a track located on a track plane;

providing a particulate layer lying beneath the track plane with a geogrid located in and/or adjacent to the particulate layer,

where the geogrid is located in a plane (geogrid plane) substantially parallel to the track

15 plane where the average distance between the track plane and geogrid plane, measured perpendicular to both, and denoted herein as D_r , is greater than 0.65 metres.

21. A geogrid suitable for use in a railway geoengineering construction as claimed

20 in any of claims 1 to 19 and/or in a method as claimed in claim 20, in which the geogrid has one or more, preferably two or more, more preferably three or more, even more preferably four or more, most preferably five or more, for example all six, of any of the following properties selected from (i) to (vi)

i) Radial Secant stiffness at 0.5% strain of at least 100 kN / m , preferably of from 200 to 800 kN / m more preferably of from 220 to 700 kN / m , most preferably of from 250 to 600 kN / m with further optionally in each case a tolerance of from minus (-) 60 to minus (-) 100 .

ii) Radial Secant stiffness at 2% strain (in kN / m) of at least 80 kN / m , preferably of from 150 to 600 kN / m more preferably of from 170 to 500 kN / m , most preferably of from 200 to 450 kN / m with further optionally in each case a tolerance of from minus (-) 60 to minus (-) 100 .

iii) Radial Secant stiffness Ratio (dimensionless) of at least 0.5 preferably of from 0.6 to 0.9 , most preferably of from 0.70 to 0.85 , most preferably of from 0.75 to 0.80 , with further optionally in each case a tolerance of from minus (-) 0.10 to minus (-) 0.20 , more optionally minus (-) 0.15 .

- iv) Junction efficiency of at least 90% preferably at least 95%, more preferably of at least 97%, most preferably of at least 99%, for example of 100%, with further optionally in each case a tolerance of at least minus (-) 10.
- v) Pitch (preferably hexagon pitch) of at least 30 mm, preferably of from 40 to 150 mm, more preferably of from 50 to 140, most preferably of from 65 to 125 mm, with further optionally in each case a tolerance of from minus (-) 60 to minus (-) 100.
- vi) Product weight of at least 0.100 kg/m², preferably of from 0.120 to 0.400 kg/m², more preferably of from 0.150 to 0.350 kg/m², most preferably of from 0.170 to 0.310 kg/m², for example from 0.180 to 0.300 kg/m² with further optionally in each case a tolerance of from minus (-) 0.025 to minus (-) 0.040, more optionally of from minus (-) 0.030 to 0.035.

22. A geogrid stabilized particulate layer for suitable for use in a railway geoengineering construction as claimed in any of claims 1 to 19 and/or in a method as claimed in claim 20, which is obtained and/or obtainable by use of a geogrid as claimed in claim 21.

23. Use of a geogrid and/or component thereof to increase the speed of the Rayleigh wave therein (V_r) and/or increase the critical track velocity along rails of a track laid thereon (V_c) above a maximum allowed train velocity denoted V_t , where V_t is at least 55 ms⁻¹, preferably ≥ 69 ms⁻¹

24. A geogrid engineering construction for railways (railway geogrid construction), the construction comprising:
a track bed (optionally the track bed comprising rails) which defines a track located on a track plane;
a particulate layer lying beneath the track plane; and
a geogrid located in and/or adjacent to the particulate layer,
where the geogrid is located in a plane (geogrid plane) substantially parallel to the track plane such that the geogrid stabilizes the particulate layer such that the properties of the particulate layer satisfy Equation 4A;

$$55 \geq \left(\frac{A+Bv}{1+v} \right) \sqrt{\frac{G_0}{\rho}} \quad \text{Equation 4A}$$

where

v denotes the Poisson ratio of the particulate layer, which preferably is from 0.1 to 0.5, more preferably from 0.2 to 0.4, most preferably from 0.2 to 0.35;

G_0 the small strain stiffness property of the particulate layer; and

ρ is density of the particulate layer; and

where optionally the average distance between the track plane and geogrid plane, measured perpendicular to both, and denoted herein as D_r , is greater than 0.65 metres.

25. A method for constructing a geogrid engineering construction for railways (railway geogrid construction), the method of construction comprising:
 defining a track bed plane (optionally the track bed comprising rails) along which the track bed will be located;
 providing an particulate layer beneath the track plane with a geogrid located in and/or adjacent to the particulate layer,
 where the geogrid is located in a plane (geogrid plane) substantially parallel to the track plane such that the geogrid stabilizes the particulate layer such that the properties of the particulate layer satisfy Equation 4A;

$$55 \geq \left(\frac{A+Bv}{1+v} \right) \sqrt{\frac{G_0}{\rho}} \quad \text{Equation 4A}$$

where

v denotes the Poisson ratio of the particulate layer, which preferably is from 0.1 to 0.5, more preferably from 0.2 to 0.4, most preferably from 0.2 to 0.35;

G_0 the small strain stiffness property of the particulate layer; and

ρ is density of the particulate layer; and

where optionally the average distance between the track plane and geogrid plane, measured perpendicular to both, and denoted herein as D_r , is greater than 0.65 metres.

26. Use of a geogrid in a method to construct a geogrid engineering construction for railways (railway geogrid construction comprising:
 defining a track bed plane (optionally the track bed comprising rails) along which the track bed will be located;
 defining an particulate layer lying beneath the track plane with a geogrid located in and/or adjacent to the particulate layer,
 the geogrid being located in a plane (geogrid plane) substantially parallel to the track plane such plane being defined such that the geogrid is calculated to stabilize the particulate layer such that the properties of the particulate layer satisfy Equation 4A;

$$55 \geq \left(\frac{A+Bv}{1+v} \right) \sqrt{\frac{G_0}{\rho}} \quad \text{Equation 4A}$$

where

ν denotes the Poisson ratio of the particulate layer which preferably is from 0.1 to 0.5, more preferably from 0.2 to 0.4, most preferably from 0.2 to 0.35

G_0 the small strain stiffness property of the particulate layer; and

5 ρ is density of the particulate layer; and

where optionally the average distance between the track plane and geogrid plane, measured perpendicular to both, and denoted herein as D_r , is greater than 0.65 metres more preferably D_r has and/or is in any of the values and/or the ranges as described herein as desired and/or suitable for the present invention.

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27. A particulate material stiffened and/or strengthened by the method of claim 20 or 25.

15 28. A railway geoengineering construction comprising a mass of particulate material strengthened by embedding therein a geogrid as claimed or described in any preceding claim.