

DELTA®-TERRAXX

Structural and Hydraulic Loads Analysis

Under Soil and Overburden Structural Loads and Rainwater and Ground Water Hydraulic Loads



MORRISON HERSHFIELD

MH was requested by Dörken Systems to review the suitability of DELTA®-TERRAXX as a drainboard in several common waterproofing applications. The review included analysis of Structural Loads due to overburden, traffic, and lateral soil pressures. The review also included analysis of hydraulic loads due to rainwater and ground water flows. The waterproofing applications reviewed include:

- Foundation Wall Waterproofing – Positive Side
- Foundation Wall Waterproofing – Blindside
- Inverted Roof Assembly – Occupied Roof Terrace
- Green Roof Assembly – Unoccupied Extensive System
- Podium Deck Waterproofing – Landscaped Areas (Intensive Green Roof is similar)
- Podium Deck Waterproofing – Traffic Areas

DELTA®-TERRAXX is a high performance drainage composite consisting of dimpled drainage core and polypropylene geotextile. DELTA®-TERRAXX has the following characteristics:

- Compressive strength of 8,969 psf (**429 kPa**)¹
- Hydraulic flow capacity in the machine direction
 - Hydraulic flow capacity under 1.0m head of water (i.e. vertical orientation) of **3.44 LPS / m width²**
 - Hydraulic flow capacity under 0.1 m head of water (i.e. horizontal orientation) of **0.986 LPS / m width³**
- Hydraulic flow capacity in cross-machine direction
 - Hydraulic flow capacity under 1.0m head of water (i.e. vertical orientation) of **2.39 LPS / m width⁴**
 - Hydraulic flow capacity under 0.1 m head of water (i.e. horizontal orientation) of **0.645 LPS / m width⁵**

The review compared the structural and hydraulic loads for each application to the structural and hydraulic capacity to determine if DELTA®-TERRAXX is suitable for use in the various applications.

1. Positive Side Foundation Wall Waterproofing

DELTA®-TERRAXX is used in open cut foundation wall applications where it is installed on the exterior side of the foundation waterproofing system. In this application DELTA®-TERRAXX is subjected to lateral soil pressure loads as well as hydraulic loads due to water percolating through the soil which is drained vertically to foundation weeping tiles (or down to the water table) through the DELTA®-TERRAXX. Based on a 3-story deep open cut foundation and a water table occurring at a 2-story depth, DELTA®-TERRAXX is suitable for use in this application.

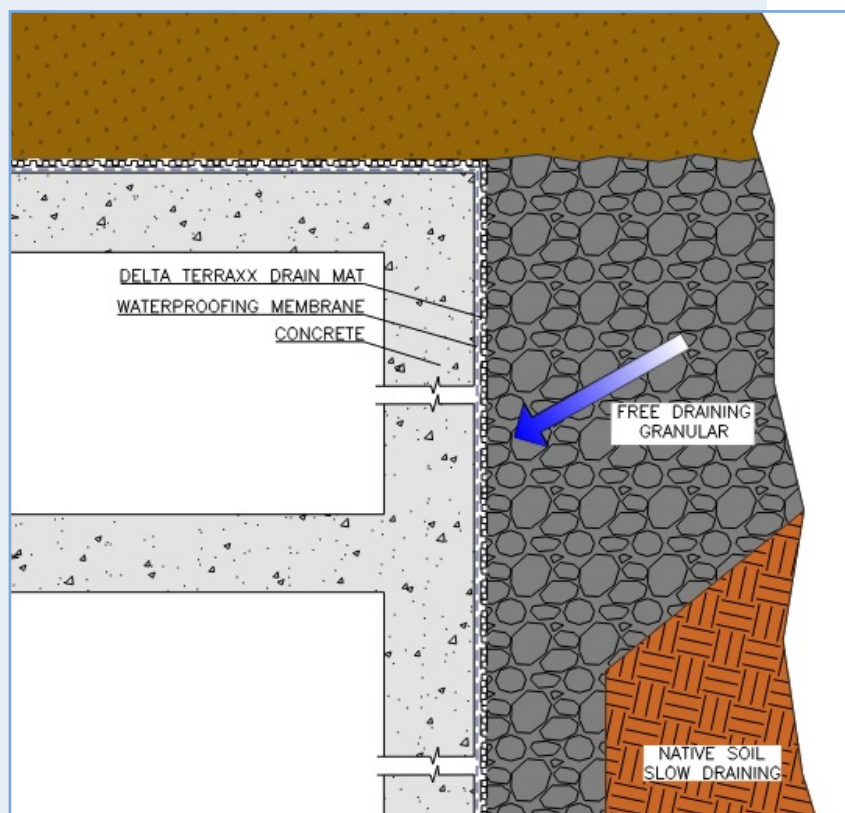
FIGURE 1: Positive Side Foundation Wall Waterproofing

DELTA®-TERRAXX
Compressive Capacity
PASS (33% max)

Compressive Load (kPa)
142 kN/m²
(2,967 psf)

DELTA®-TERRAXX
Hydraulic Capacity
PASS (9% max)

Hydraulic Load (LPS / m)
0.21 LPS / m



Lateral soil pressures at various depths were calculated by $\sigma = K_a \gamma h + q K_a - 2 C \sqrt{K_a}$; with the following conservative assumptions: 12m depth (3-story), Non cohesive soil, Angle of friction (Φ) 25°, Bulk unit weight (γ) 25 kN/m³, Adjacent building surcharge (q) 50 kN/m², Rankine Earth pressure coefficient (K_a) based on angle of friction 0.41.

Hydraulic Loads were calculated by OBC 2012 - 4.1.7.3 and the National Plumbing Code with the following assumptions: 6m Depth to water table, 6m Distance to drain from podium, 6m Distance to drain from landscaping, flow converges in DELTA®-TERRAXX at 6m depth, 15 Min Rainfall = 28mm (London). Flow rate is Litres per second per metre width of DELTA®-TERRAXX. Hydraulic Load in DELTA®-TERRAXX = Podium Deck Waterproofing - Traffic Areas flow, plus 10% of total surface load of landscaping reflecting slow percolation rate.

2. Blindside Foundation Wall Waterproofing

DELTA®-TERRAXX is used in soil retained foundation wall applications where it is installed on the interior side of the soil support system (timber lagging or caisson wall) prior to installation of the foundation waterproofing system. In this application DELTA®-TERRAXX is subjected to lateral soil pressure loads as well as hydraulic loads due to water percolating through the soil and soil support system which is drained vertically to foundation weeping tiles (or down to the water table) through the DELTA®-TERRAXX. Based on a 7-story deep open cut foundation and a water table occurring at a 2-story depth, DELTA®-TERRAXX is suitable for use in this application.

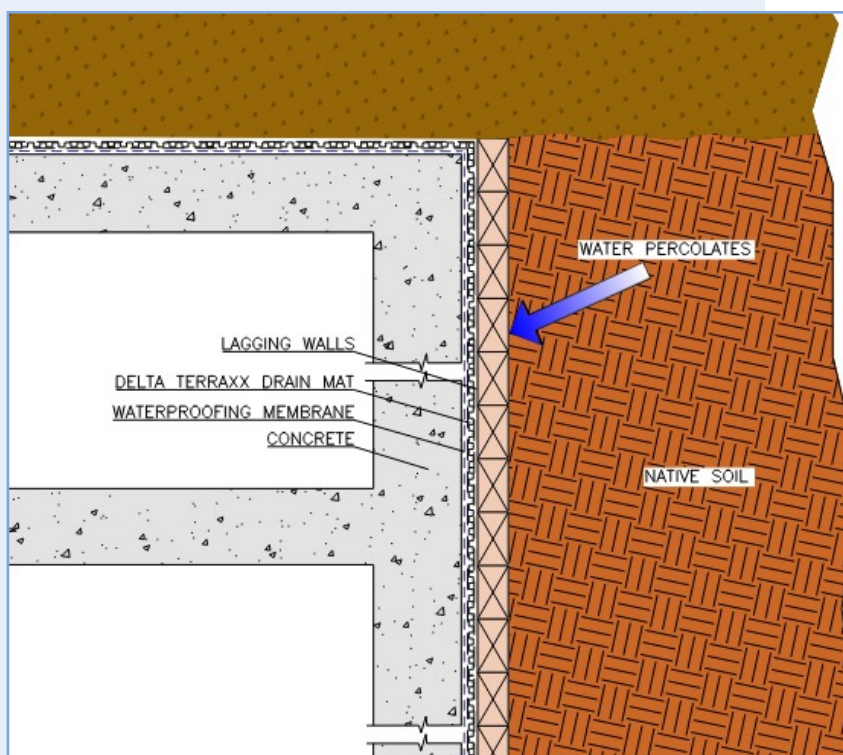
FIGURE 2: Blindside Foundation Wall Waterproofing

DELTA®-TERRAXX
Compressive Capacity
PASS (71% max)

Compressive Load (kPa)
304 kN/m²
(6,357 psf)

DELTA®-TERRAXX
Hydraulic Capacity
PASS (9% max)

Hydraulic Load (LPS / m)
0.21 LPS / m



Lateral soil pressures at various depths were calculated by $\sigma = K_a \gamma h + q K_a - 2 C \sqrt{K_a}$; with the following conservative assumptions: 28m depth (7-story), Non cohesive soil, Angle of friction (Φ) 25°, Bulk unit weight (γ) 25 kN/m³, Adjacent building surcharge (q) 50 kN/m², Rankine Earth pressure coefficient (K_a) based on angle of friction 0.41.

Hydraulic Loads were calculated by OBC 2012 - 4.1.7.3 and the National Plumbing Code with the following assumptions: 6m Depth to water table, 6m Distance to drain from podium, 6m Distance to drain from landscaping, flow converges in DELTA®-TERRAXX at 6m depth, 15 Min Rainfall = 28mm (London). Flow rate is Litres per second per metre width of DELTA®-TERRAXX. Hydraulic Load in DELTA®-TERRAXX = Podium Deck Waterproofing - Traffic Areas flow, plus 10% of total surface load of landscaping reflecting slow percolation rate.

3. Occupied Inverted Roof Terrace

DELTA®-TERRAXX is used in PMRA (Protected Membrane Roof Assembly) or inverted roof applications where it is installed on top of the roof membrane system and below the insulation and surface pavers. In this application DELTA®-TERRAXX is subjected to vertical loads from roofing pavers, snow loads, and pedestrian loads in the case of an occupied terrace. DELTA®-TERRAXX is also subjected to hydraulic loads due to rainwater, passing through surface pavers, which is drained horizontally to roof drains through the DELTA®-TERRAXX. Based on an occupied terrace assembly DELTA®-TERRAXX is suitable for use in this application.

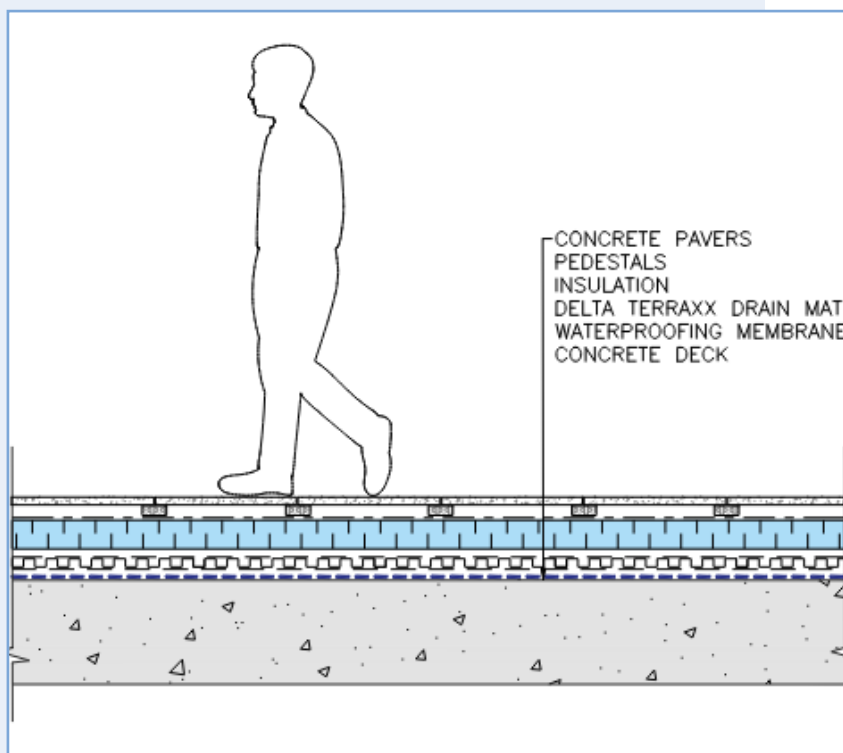
FIGURE 3: Occupied Inverted Roof Terrace

DELTA®-TERRAXX
Compressive Capacity
PASS (1% max)

Compressive Load (kPa)
4.9 kN/m²
(90 psf)

DELTA®-TERRAXX
Hydraulic Capacity
PASS (98% x-machine)

Hydraulic Load (LPS / m)
0.63 LPS / m



Vertical loads were calculated with the following assumptions: Inverted roof with continuous pedestrian paver surface 1.16 kN/m², snow loads 1.36 kN/m², live load for occupied terrace 2.40 kN/m².

Hydraulic Loads were calculated by OBC 2012 - 4.1.7.3 and the National Plumbing Code with the following assumptions: 900m² Drainage area, 22m Distance to drain, 2% slope, 15 Min Rainfall = 28mm (London). Flow rate is Litres per second per metre width of DELTA®-TERRAXX. Hydraulic Load in DELTA®-TERRAXX = 50% of total surface load per "Hydraulic Characterization and Design of Permeable Interlocking Concrete", Kevern et al 2015.

4. Green Roof – Unoccupied – Extensive

DELTA®-TERRAXX is used in green roof applications where it is installed on top of the roof membrane system (conventional assembly) or on top of the insulation (PMRA assembly) and below the green roof growing media and surface plantings. In this application, DELTA®-TERRAXX is subjected to vertical loads from green roof and snow loads but not from pedestrian loads as these extensive systems are not occupied. DELTA®-TERRAXX is also subjected to hydraulic loads due to rainwater, passing through green roof growing media and plantings, which is drained horizontally to roof drains through the DELTA®-TERRAXX. Based on an unoccupied extensive green roof assembly DELTA®-TERRAXX is suitable for use in this application.

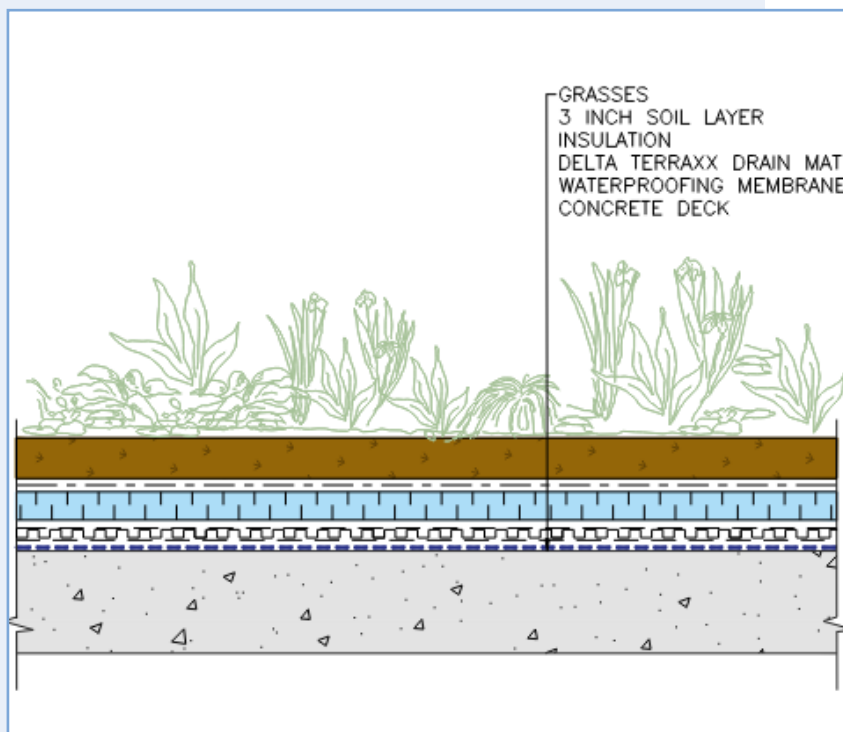
FIGURE 4: Green Roof – Unoccupied – Extensive

DELTA®-TERRAXX
Compressive Capacity
PASS (1% max)

Compressive Load (kPa)
3.5 kN/m²
(73 psf)

DELTA®-TERRAXX
Hydraulic Capacity
PASS (39% x-machine)

Hydraulic Load (LPS / m)
0.25 LPS / m



Vertical loads were calculated with the following assumptions: Extensive green roof, 75mm saturated growing medium 1.14 kN/m², snow loads 1.36 kN/m², live load 1.0 kN/m².

Hydraulic Loads were calculated by OBC 2012 - 4.1.7.3 and the National Plumbing Code with the following assumptions: 900m² Drainage area, 22m Distance to drain, 2% slope, 15 Min Rainfall = 28mm (London). Flow rate is Litres per second per metre width of DELTA®-TERRAXX. Hydraulic Load in DELTA®-TERRAXX = 20% of total surface load per published 50% water retention of extensive assembly.

5. Podium Deck Waterproofing – Landscaped Areas

DELTA®-TERRAXX is used in podium deck waterproofing assemblies under landscaped areas (or intensive green roof assemblies) where it is installed on top of the horizontal podium deck waterproofing (or green roof membrane) system. DELTA®-TERRAXX is typically installed below the landscaping soil (or intensive green roof growing media) on top of insulation (if applicable). In this application, DELTA®-TERRAXX is subjected to vertical loads from landscaping soil and plantings, snow loads, and limited pedestrian loads. DELTA®-TERRAXX is also subjected to hydraulic loads due to rainwater, passing through the soil and plantings, which is drained horizontally to roof drains (or to podium downturns) through the DELTA®-TERRAXX. Based on a podium deck waterproofing assembly under landscaped areas, DELTA®-TERRAXX is suitable for use in this application.

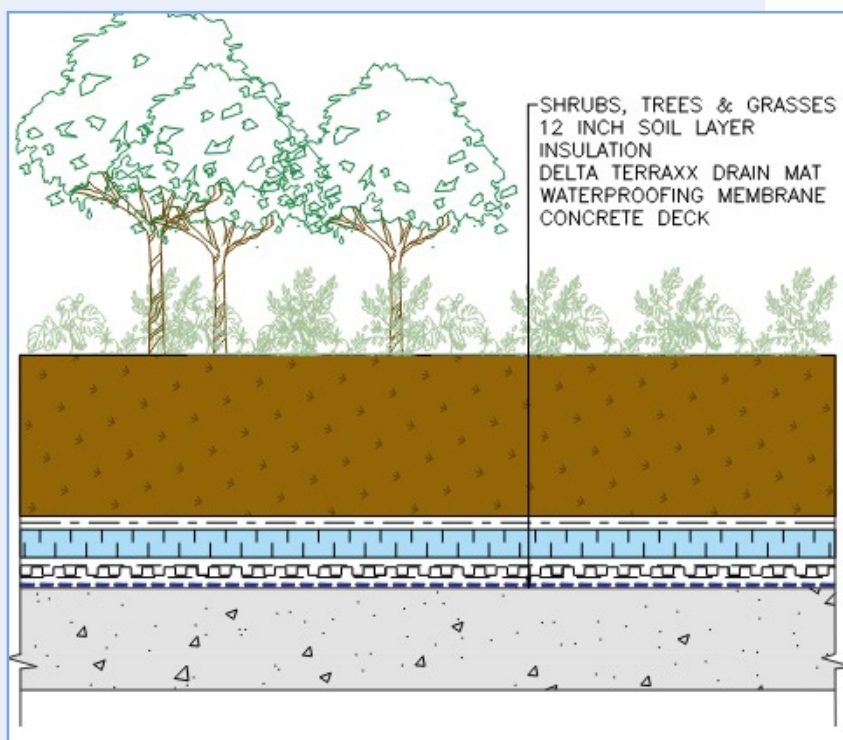
FIGURE 5: Podium Deck Waterproofing – Landscaping or Intensive Green Roof

DELTA®-TERRAXX
Compressive Capacity
PASS (1% max)

Compressive Load (kPa)
3.5 kN/m²
(73 psf)

DELTA®-TERRAXX
Hydraulic Capacity
PASS (39% x-machine)

Hydraulic Load (LPS / m)
0.25 LPS / m



Vertical loads were calculated with the following assumptions: Intensive green roof or landscaped podium, 300mm saturated growing medium 4.53 kN/m², snow loads 1.36 kN/m², live load 1.0 kN/m².

Hydraulic Loads were calculated by OBC 2012 - 4.1.7.3 and the National Plumbing Code with the following assumptions: 900m² Drainage area, 22m Distance to drain, 2% slope, 15 Min Rainfall = 28mm (London). Flow rate is Litres per second per metre width of DELTA®-TERRAXX. Hydraulic Load in DELTA®-TERRAXX = 20% of total surface load.

6. Podium Deck Waterproofing – Traffic Areas

DELTA®-TERRAXX is used in podium deck waterproofing assemblies under traffic areas where it is installed on top of the horizontal podium deck waterproofing system. DELTA®-TERRAXX is typically installed below the traffic bearing pavement assembly on top of insulation (if applicable). In this application, DELTA®-TERRAXX is subjected to vertical loads from snow loads, and significant vehicle wheel point loads. DELTA®-TERRAXX is also subjected to hydraulic loads due to rainwater, passing through the soil and plantings, which is drained horizontally to roof drains (or to podium downturns) through the DELTA®-TERRAXX. Based on a podium deck waterproofing assembly under traffic areas, DELTA®-TERRAXX is suitable for use in this application.

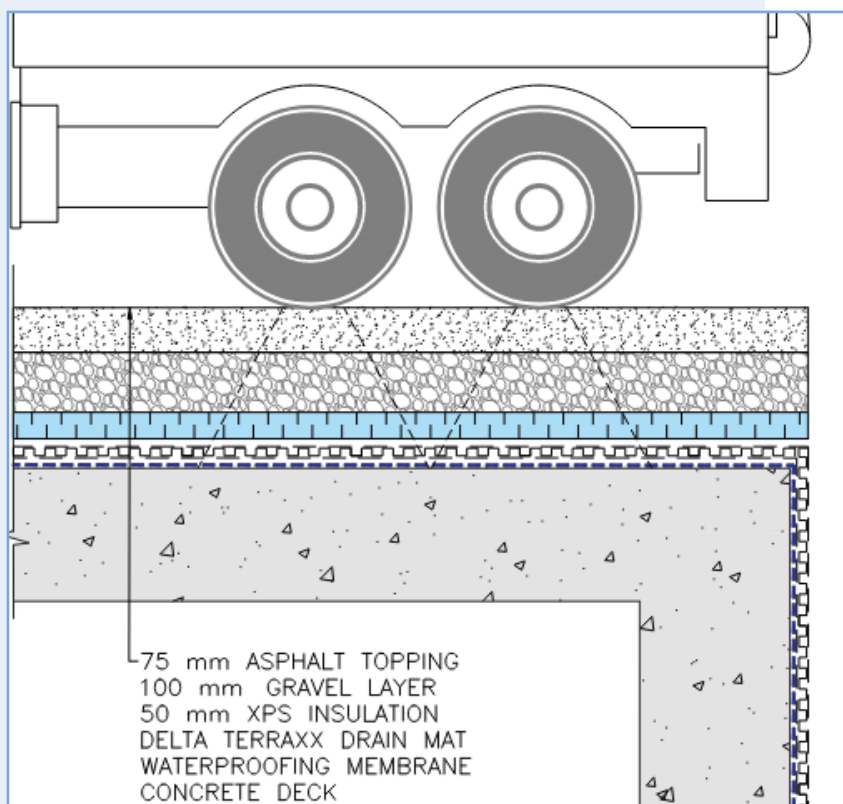
FIGURE 6: Podium Deck Waterproofing – Traffic Areas

**DELTA®-TERRAXX
Compressive Capacity
PASS (66% max)**

**Compressive Load (kPa)
280 kN/m²
(5,850 psf)**

**DELTA®-TERRAXX
Hydraulic Capacity
PASS (98% x-machine)**

**Hydraulic Load (LPS / m)
0.63 LPS / m**



Vertical loads were calculated with the following assumptions: Pervious traffic paver assembly at minimum 150mm thickness near drain 3.03 kN/m², snow loads 1.36 kN/m², tandem truck wheel point load 276 kN/m².

Hydraulic Loads were calculated by OBC 2012 - 4.1.7.3 and the National Plumbing Code with the following assumptions: 900m² Drainage area, 22m Distance to drain, 2% slope, 15 Min Rainfall = 28mm (London). Flow rate is Litres per second per metre width of DELTA®-TERRAXX. Hydraulic Load in DELTA®-TERRAXX = 50% of total surface load per "Hydraulic Characterization and Design of Permeable Interlocking Concrete", Kevren et al 2015.

Summary

MH has completed the review of the suitability of DELTA®-TERRAXX as a drainboard in several common waterproofing applications. DELTA®-TERRAXX by Dörken Systems is suitable for use in all six (6) of the applications analyzed. The structural compressive strength of DELTA®-TERRAXX exceeds the structural loads in all applications analyzed. The hydraulic capacity of DELTA®-TERRAXX exceeds the hydraulic loads in all applications analyzed. The results are summarized in the following table.

APPLICATION	Compressive Load (kPa / psf)	Compressive Capacity (pass/fail)	Hydraulic Load (LPS / m)	Hydraulic Capacity (pass/fail)
Positive Side Waterproofing 3 Story Deep	142 2,970	PASS 429 8,969	0.21	PASS 2.39 (9%)
Blindside Waterproofing 7 Story Deep	304 6,360	PASS 429 8,969	0.21	PASS 2.39 (9%)
Inverted Roof Occupied Terrace	4.9 103	PASS 429 8,969	0.63	PASS 0.645 (98%)
Green Roof Unoccupied Extensive	3.5 73	PASS 429 8,969	0.25	PASS 0.645 (39%)
Podium Deck Waterproofing Non-traffic	7.1 148	PASS 429 8,969	0.25	PASS 0.645 (39%)
Podium Deck Waterproofing Traffic Loads	280 5,850	PASS 429 8,969	0.63	PASS 0.645 (98%)
MAXIMUMS	304 6,360 psf	PASS (71%)	0.63	PASS (98%)

Closing

In our professional opinion the compressive strength of DELTA®-TERRAXX is suitable for use in vertical waterproofing systems up to 7 stories below grade, and in horizontal waterproofing systems including under typical traffic loads.

Sincerely,

Morrison Hershfield Limited

A handwritten signature in blue ink, appearing to read "S. Murray". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

Steven Murray, P.Eng.
Director, Building Science
Building Specialty Services



¹ Analysis Report 4208-0805-1A, SCC Accreditation No.: 40, prepared by SAGEOS, dated October 12, 2022.

² Analysis Report 4208-0805-1A, SCC Accreditation No.: 40, prepared by SAGEOS, dated October 12, 2022.

³ Analysis Report 4208-0805-1A, SCC Accreditation No.: 40, prepared by SAGEOS, dated October 12, 2022.

⁴ Analysis Report 4208-0835-4A, SCC Accreditation No.: 40, prepared by SAGEOS, dated January 9, 2023.

⁵ Analysis Report 4208-0835-4A, SCC Accreditation No.: 40, prepared by SAGEOS, dated January 9, 2023.