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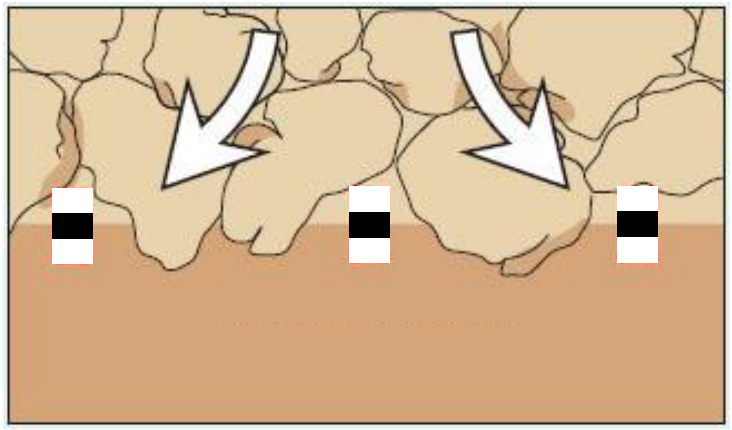
Najnowsze badania w pełnej skali nawierzchni podatnych z podbudową stabilizowaną georusztem wielokształtnym

Piotr Mazurowski
Menadżer ds. Technologii Nawierzchni

Kruszywo stabilizowane georusztem

Stabilizacja kruszywa georusztem

to poprawa parametrów (zagęszczenie, nośność) warstwy kruszywa niezwiązanego, uzyskiwana dzięki mechanicznemu zablokowaniu (*interlocking*) ziarn kruszywa w sztywnym oczku georusztu.



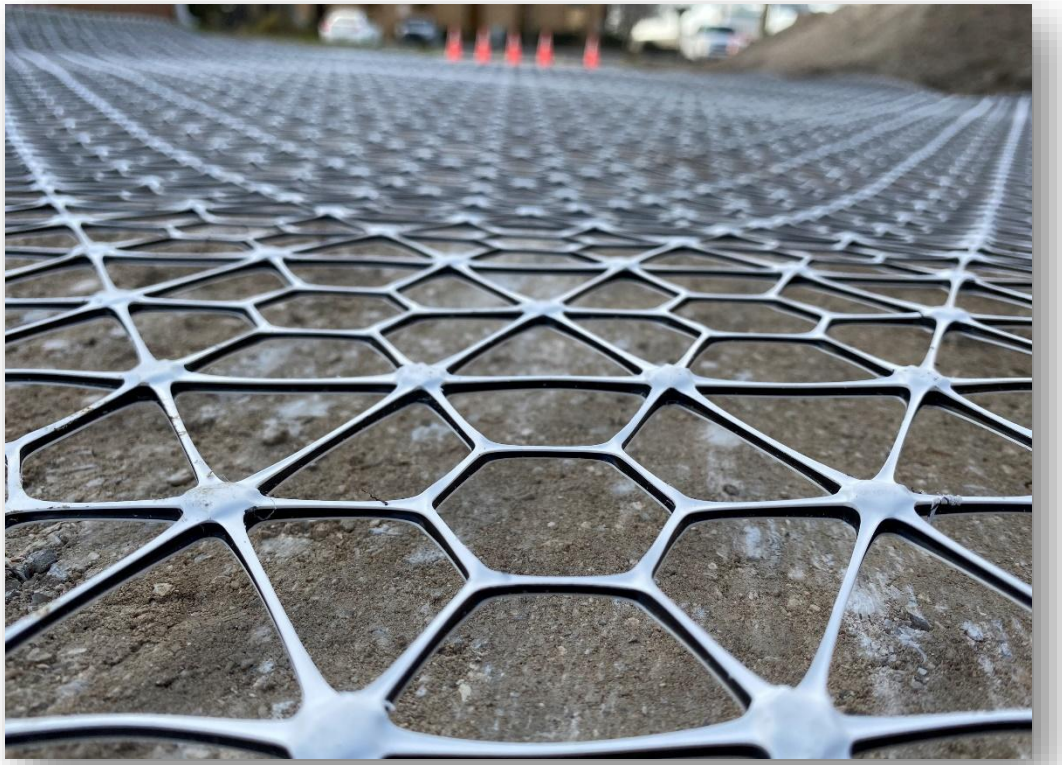
Tensar InterAx – najważniejsze cechy

Koekstruzja + zaawansowane badania materiałowe

- Zintegrowany rdzeń strukturalny
  - Czarny rdzeń o wysokiej trwałości
- Zewnętrzne warstwy wspomagające interakcję z kruszywem:
  - Podwyższona szorstkość, zwiększająca tarcie
  - Materiał trwały, lecz bardziej elastyczny i ściśliwy, co wspomaga zazębienie ziaren kruszywa

Zoptymalizowana geometria

- Poprawa zazębienia:
  - Zróżnicowane kształty i rozmiary oczek
  - Wysoki profil żebra



Dzięki połączeniu koekstruzji, zaawansowanych badań materiałowych i zoptymalizowanej geometrii Tensar InterAx zapewnia **najlepsze właściwości eksploatacyjne, przy poszerzonym zakresie dopuszczalnych typów kruszyw o różnym uziarnieniu i jakości.**

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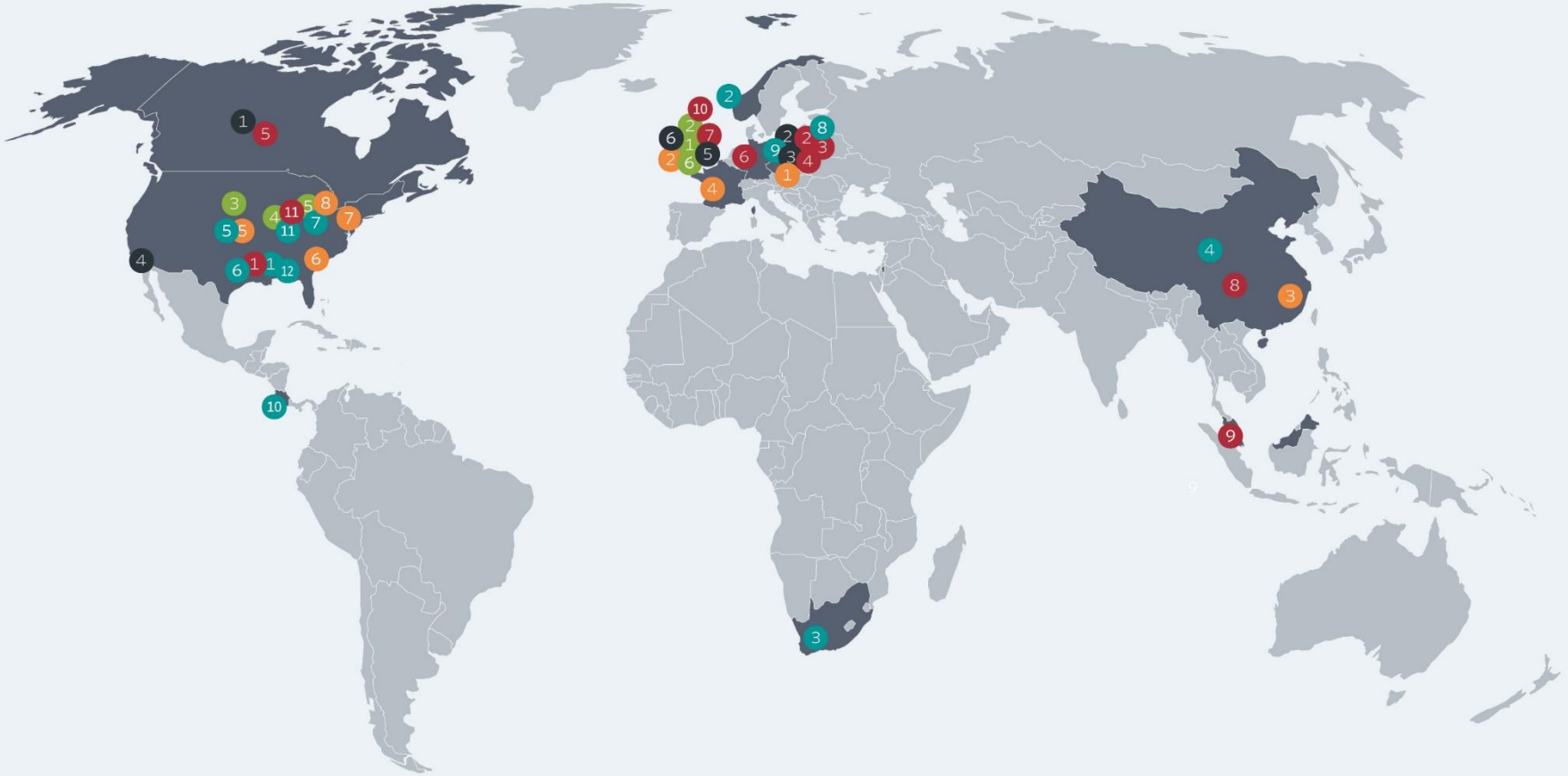


Temporary Working Platforms

1. Saskatchewan, Canada (24 PLT's)
2. Krakow 1, Poland
3. Krakow 2, Poland
4. Calfino, USA
5. NBIF, UK
6. Lomeshaye, UK

Unpaved Roads

1. USCoE, USA
2. Gdansk, Poland
3. Częstochowa, Poland
4. Pelplin, Poland
5. Saskatchewan, Canada
6. Wittenburg, Germany
7. Broken Cross, UK
8. Chongqing University, China
9. Kuala Lumpur, Malaysia
10. Edinburgh DEM modelling, UK
11. Iowa State University, USA

Paved Roads

1. USCoE, USA
2. Feiringburk, Norway
3. CSIR, South Africa
4. Chongqing University, China
5. APLT, USA (14 test locations)
6. Texas Expansive Soils, USA
7. Ingios Freeze Thaw, USA
8. Rzeszów, Poland
9. Głogów, Poland
10. UCR, Costa Rica
11. University of Kansas, USA
12. Alabama Expansive Soils, USA

Rail

1. Prague, Czech Republic
2. Heriot-Watt University, UK
3. Zhejiang University, China
4. SNCF, France
5. APLT, USA (4 test locations)
6. University of South Carolina, USA
7. Penn State University, USA
8. Michigan State University, USA

Fundamental Research

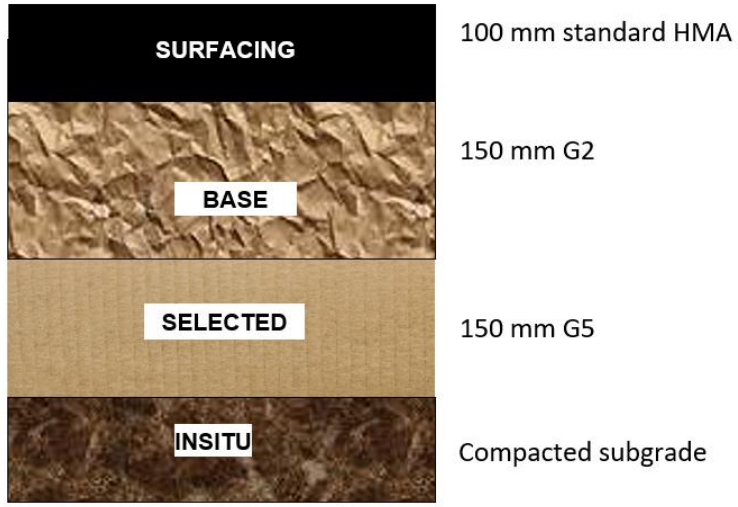
1. Blackburn, UK
2. Edinburgh University, UK
3. Illinois University, USA
4. Univerity of Kansas, USA
5. Ingios IMAS, USA
6. Southampton University, UK

CSIR RPA faza 2 (2024)

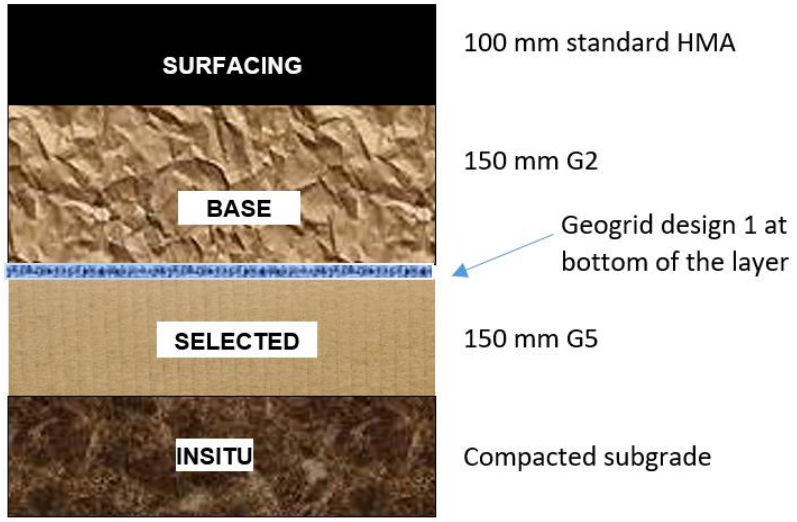
CSIR RPA faza 2 (2024)

CBR ~15%

CBR 7%



Conventional low volume European design



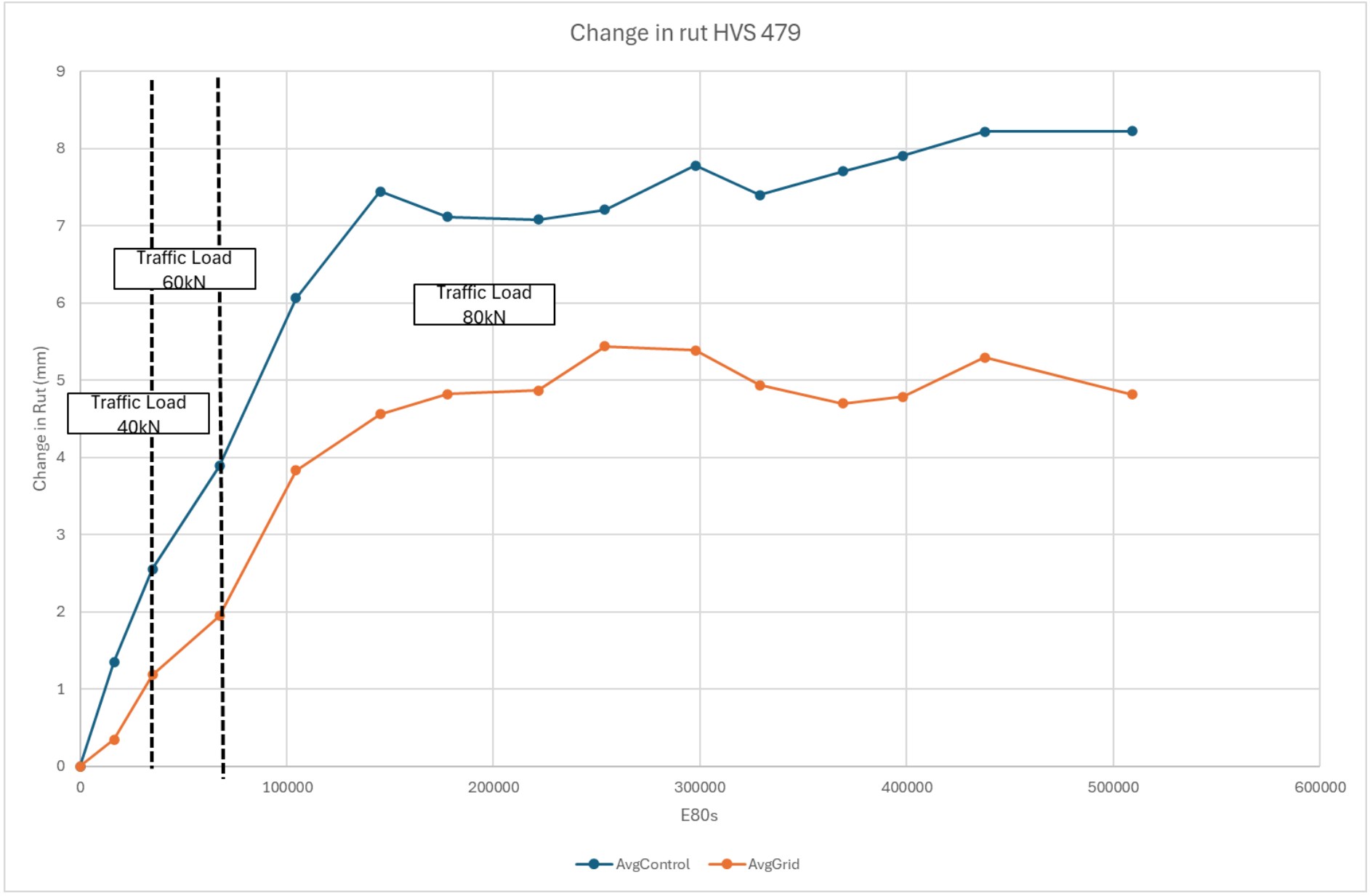
Conventional low volume European design with a geogrid

Plan obciążenia ruchem

- 35047 przejazdy przy obciążeniu 40kN (obciążenie osi 80kN);
- 32438 przejazdów przy obciążeniu 60kN (obciążenie osi 120kN)
- 441771 przejazdów przy obciążeniu 80kN (obciążenie osi 160 kN)

Łącznie: ok 509000 przejazdów, co odpowiada **3,4 mln obciążeń osi 100 kN**

CSIR RPA faza 2 (2024)



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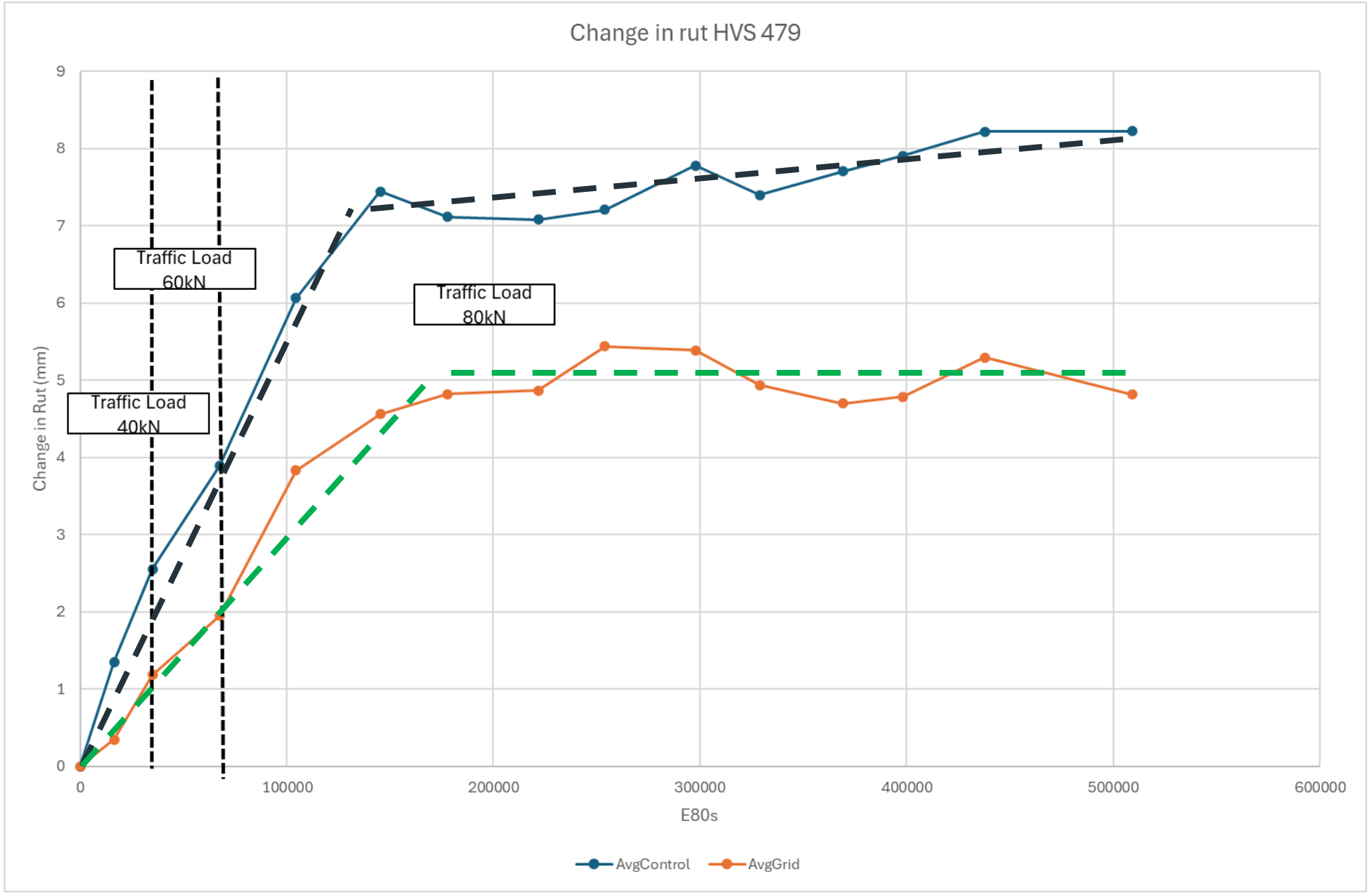

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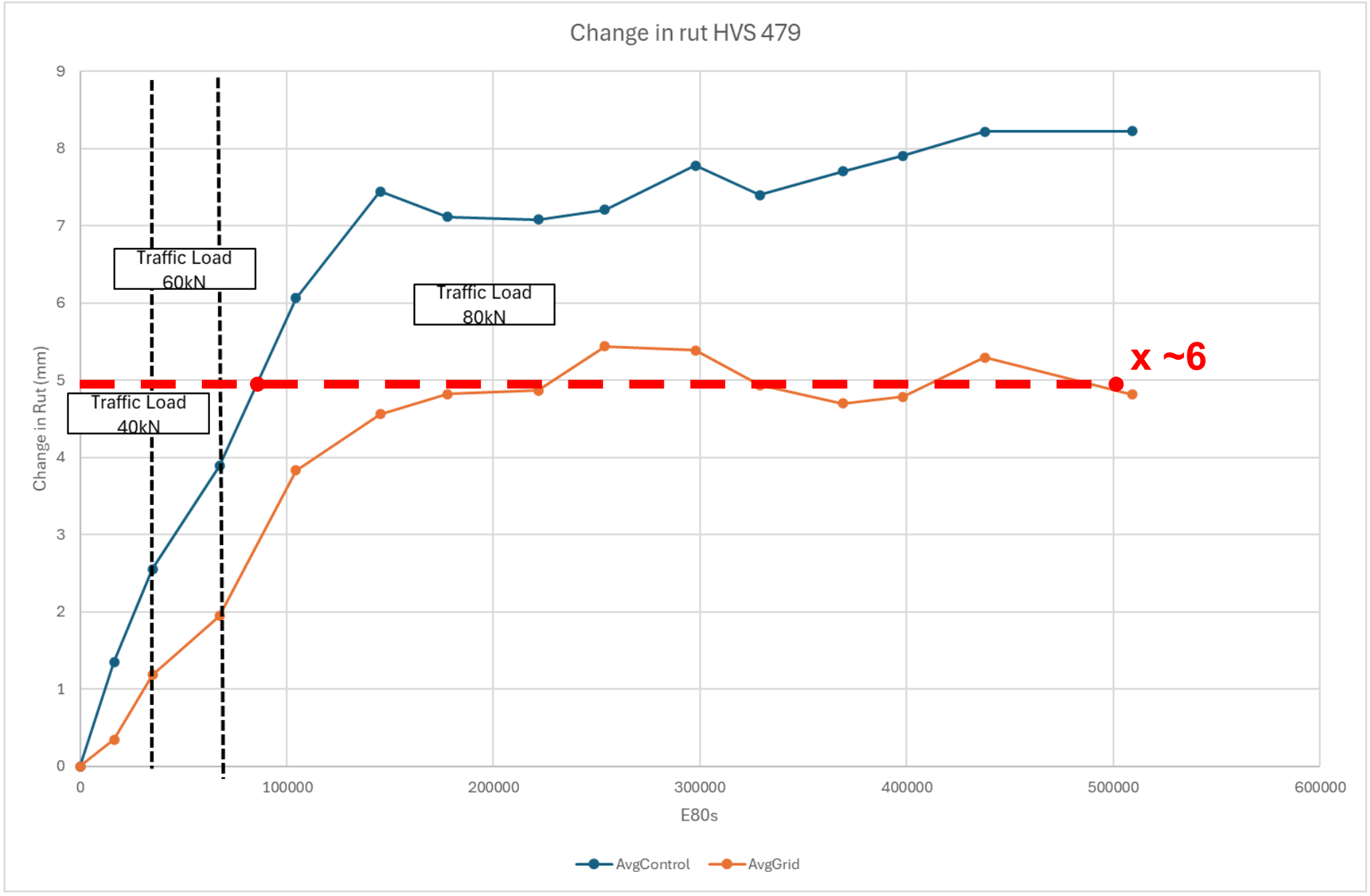
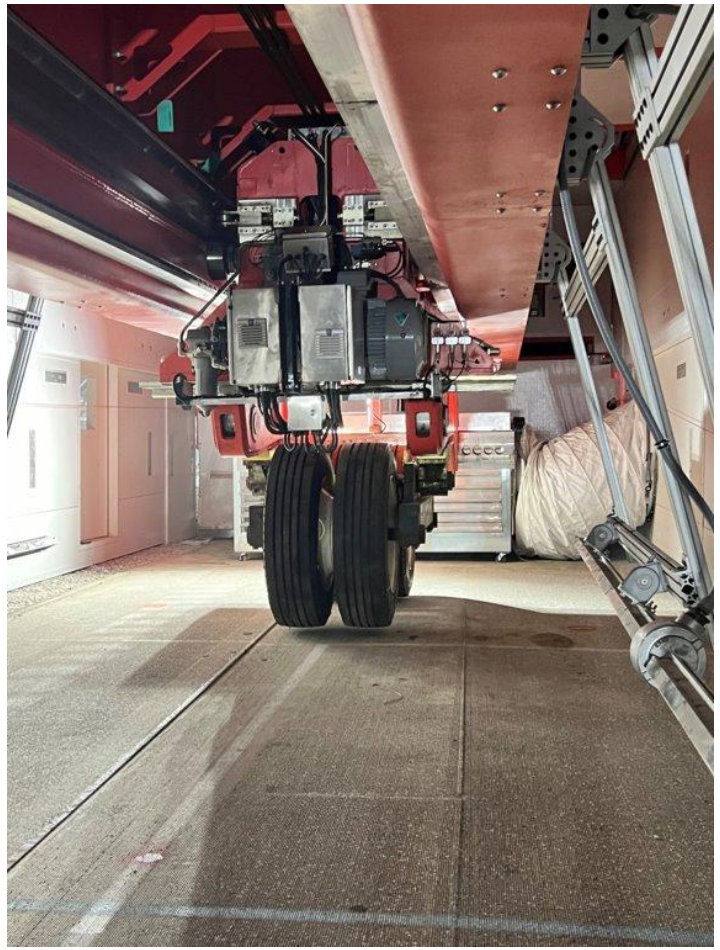


USCoE, USA (2023-24)

Przyspieszony test w pełnej skali nawierzchni podatnej z warstwami asfaltowymi.

Test przeprowadzony z wykorzystaniem nowego HVS (Heavy Vehicle Simulator) "Tytan" – największego tego rodzaju urządzenia na świecie. Długość testowanego odcinka do 21 m.



USCoE, USA (2023-24)

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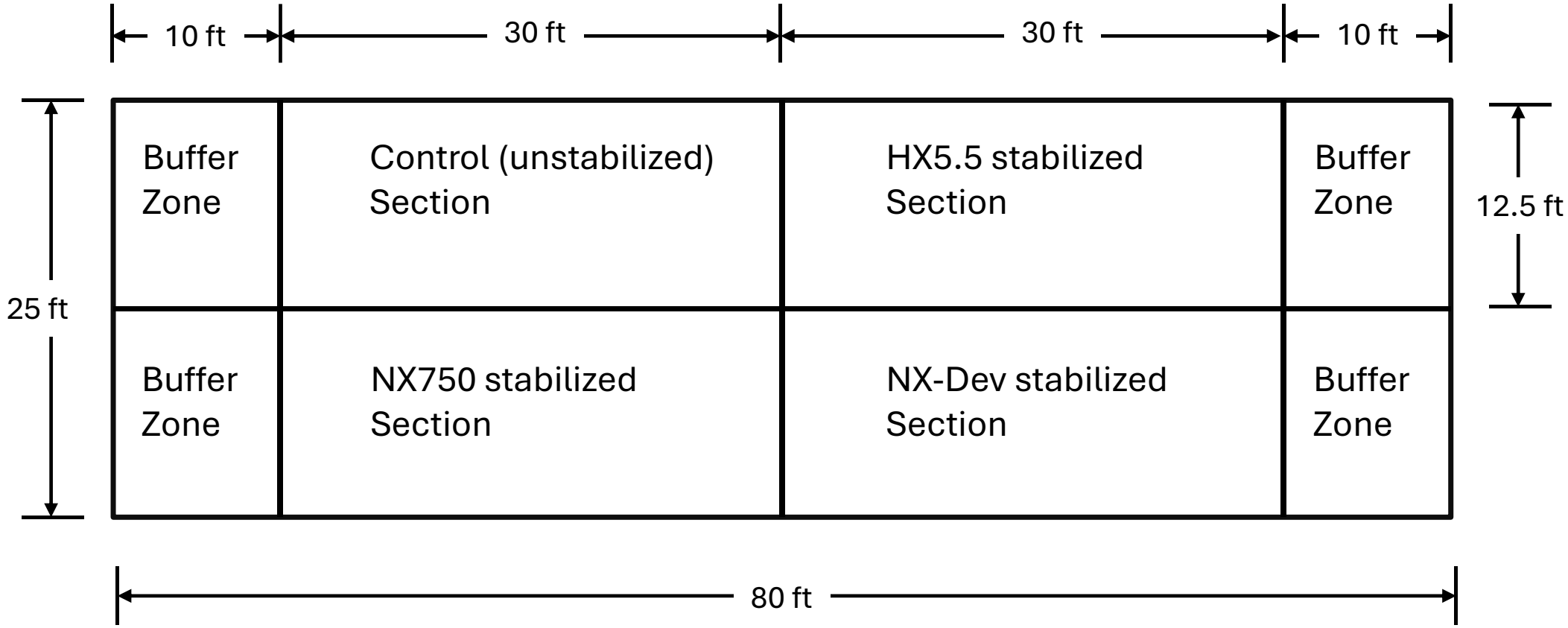
USCoE, USA (2023-24)



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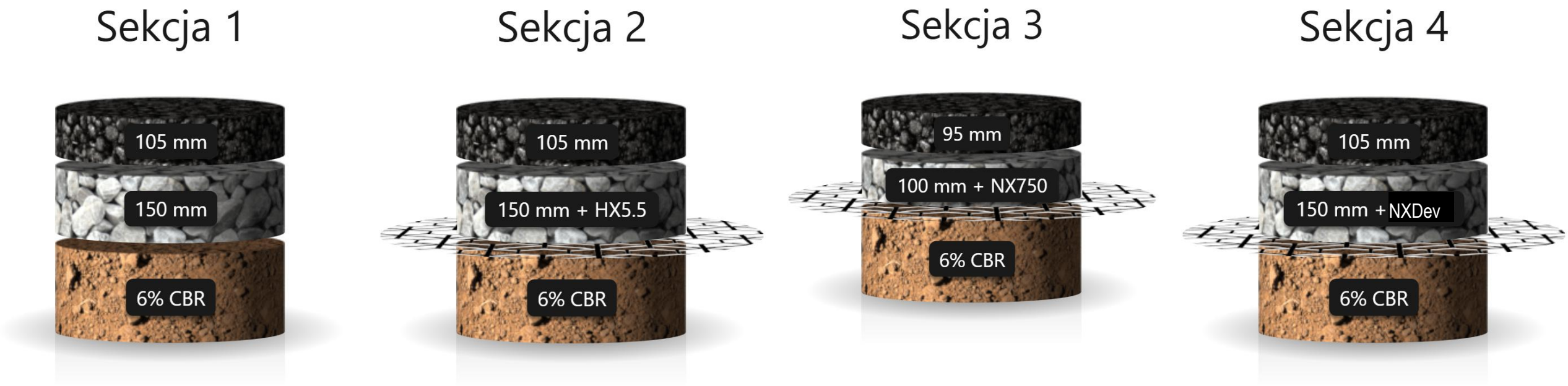
USCoE, USA (2023-24)



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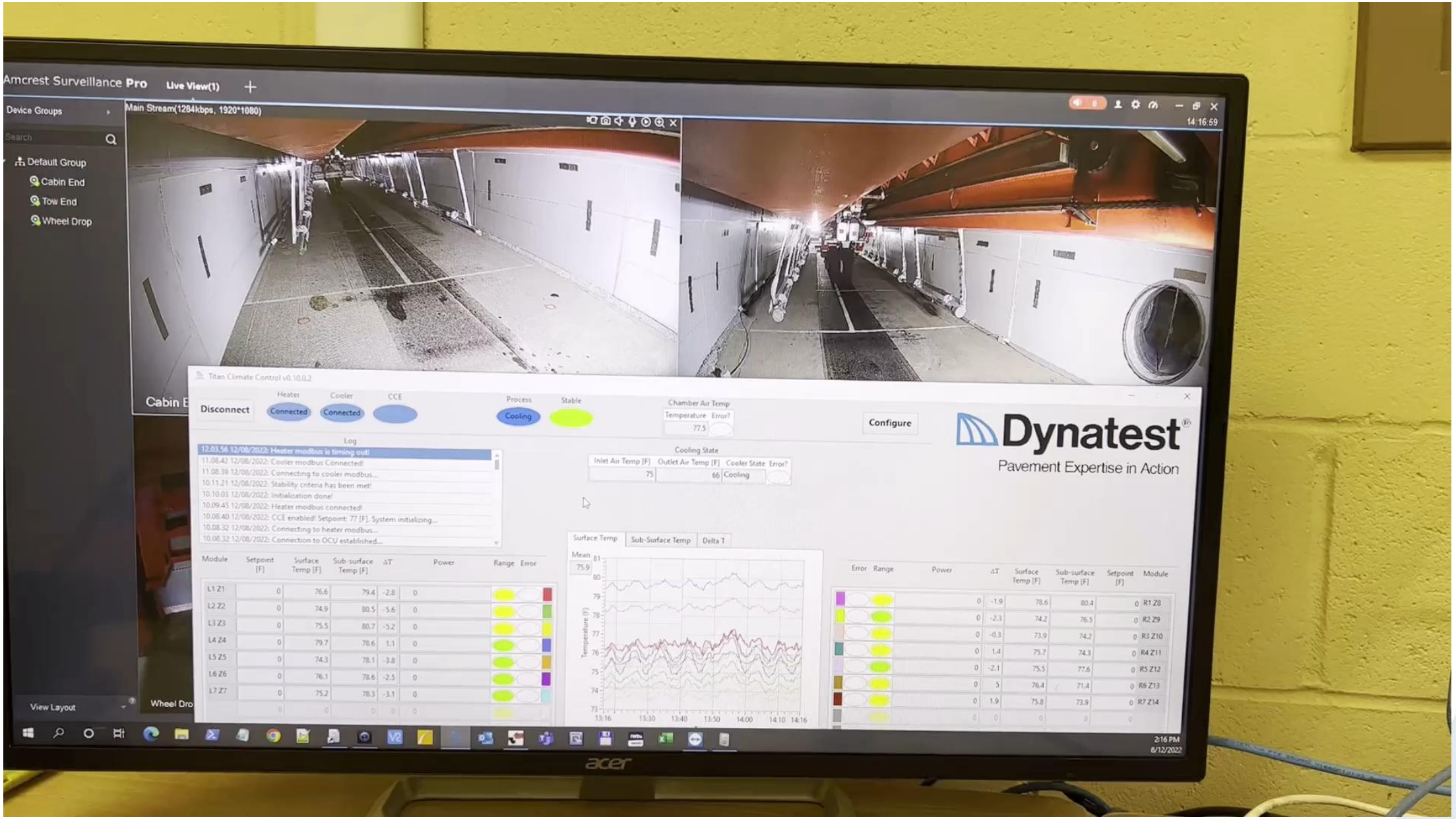
Amcrest Surveillance Pro
Live View(1)
Device Groups
Search
Default Group
Cabin End
Tow End
Wheel Drop
Main Stream(1284kbps, 1920*1080)
14:16:59
Titan Climate Control v0.10.0.2
Disconnect
Heater
Connected
Cooler
Connected
CCE
Process
Cooling
Stable
Chamber Air Temp
Temperature
Error?
77.5
Configure
Dynatest
Pavement Expertise in Action
Log
12:03.56 12/08/2022: Heater modbus is timing out!
11:08.42 12/08/2022: Cooler modbus Connected!
11:08.39 12/08/2022: Connecting to cooler modbus...
10:11.21 12/08/2022: Stability criteria has been met!
10:10.03 12/08/2022: Initialization done!
10:09.45 12/08/2022: Heater modbus connected!
10:08.40 12/08/2022: CCE enabled! Setpoint: 77 [F]. System initializing...
10:08.32 12/08/2022: Connecting to heater modbus...
10:08.32 12/08/2022: Connection to OCU established...
Cooling State
Inlet Air Temp [F]
Outlet Air Temp [F]
Cooler State
Error?
75
66
Cooling
Surface Temp
Sub-Surface Temp
Delta T
Mean
75.9
Temperature (F)
Module
Setpoint [F]
Surface Temp [F]
Sub-surface Temp [F]
ΔT
Power
Range
Error
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L3 Z3
L4 Z4
L5 Z5
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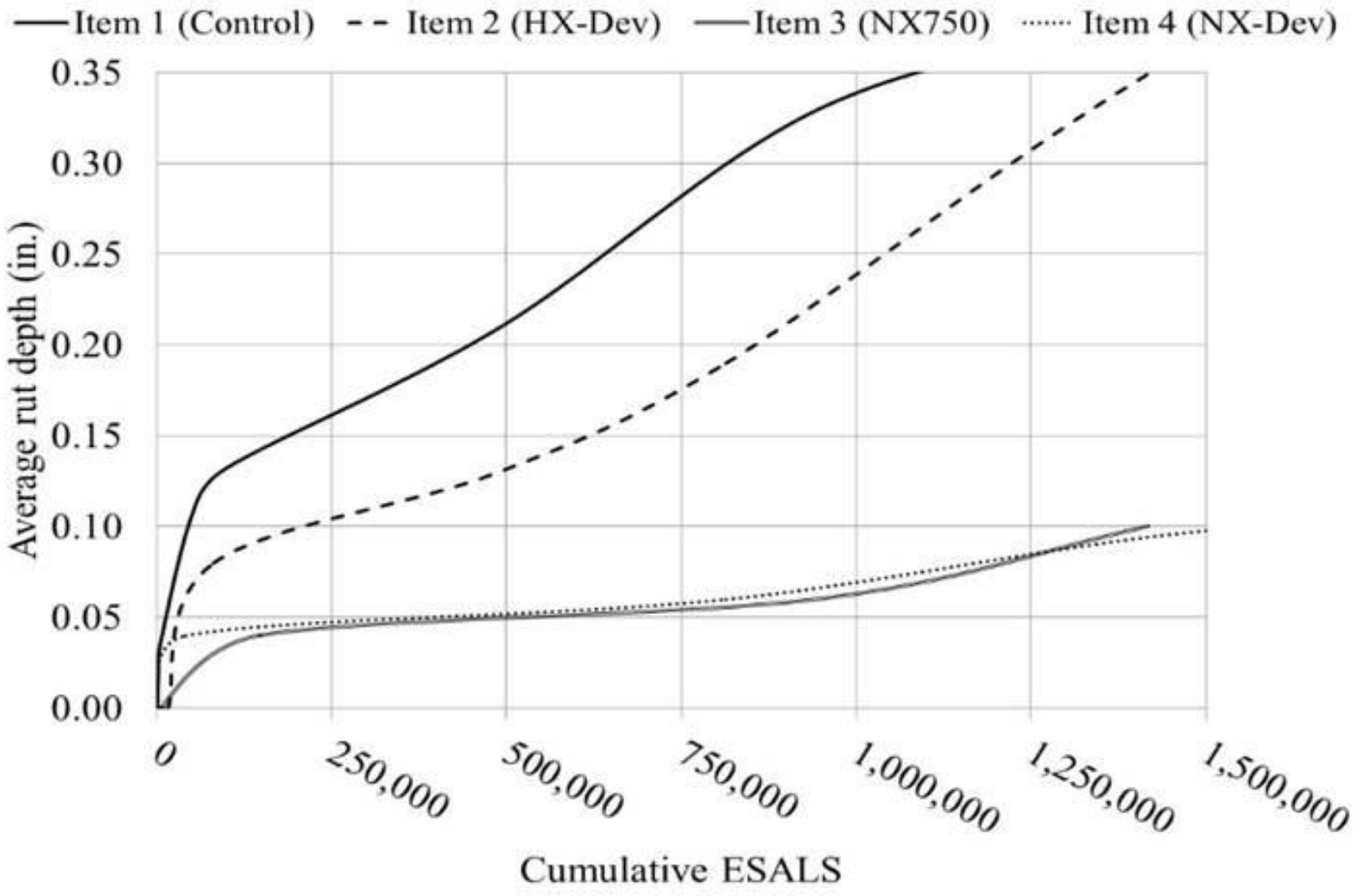
Tensar.

USCoE, USA (2023-24)

Figure 16. Rut depth progression with traffic.



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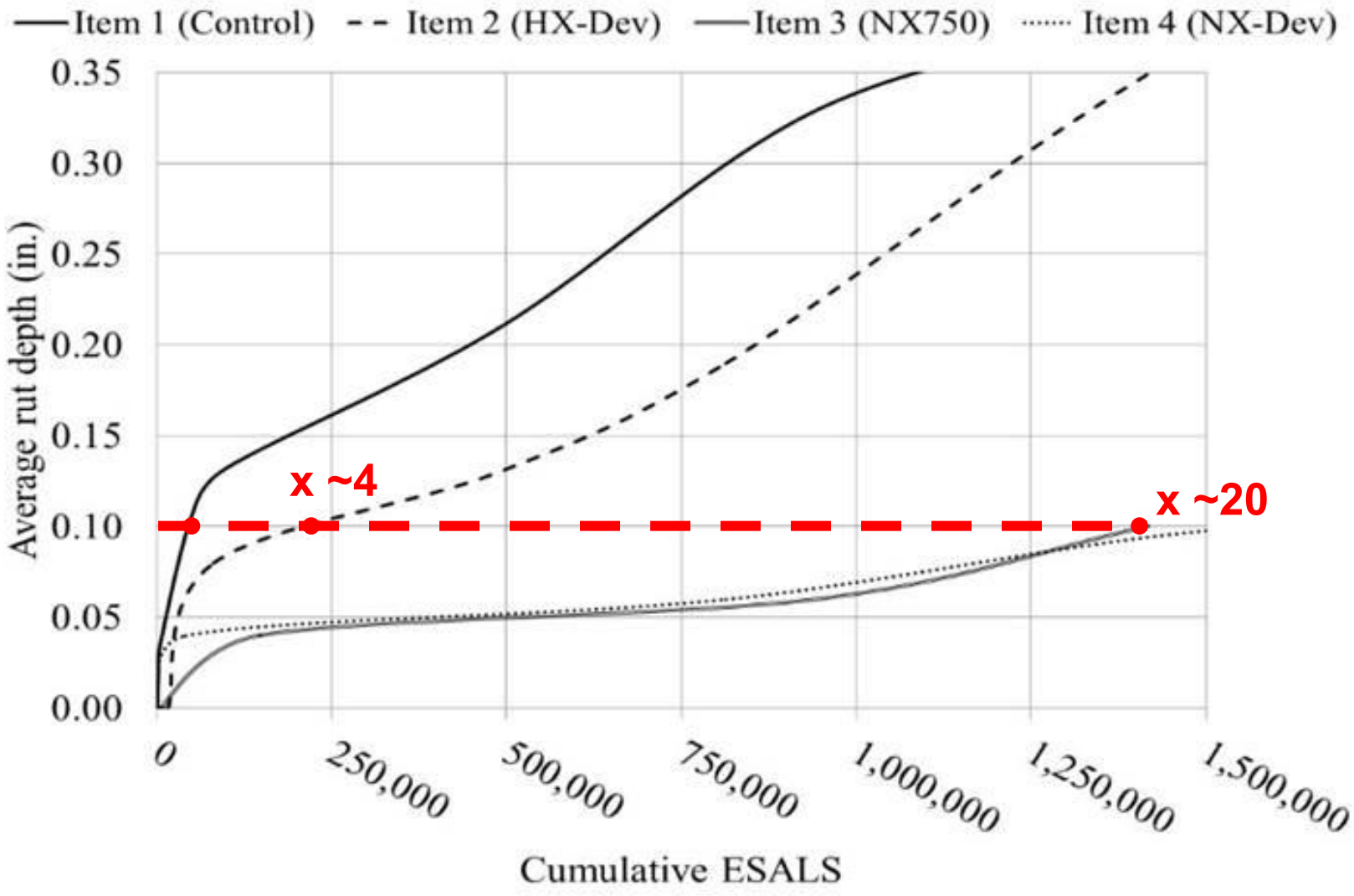
USCoE, USA (2023-24)

Figure 16. Rut depth progression with traffic.



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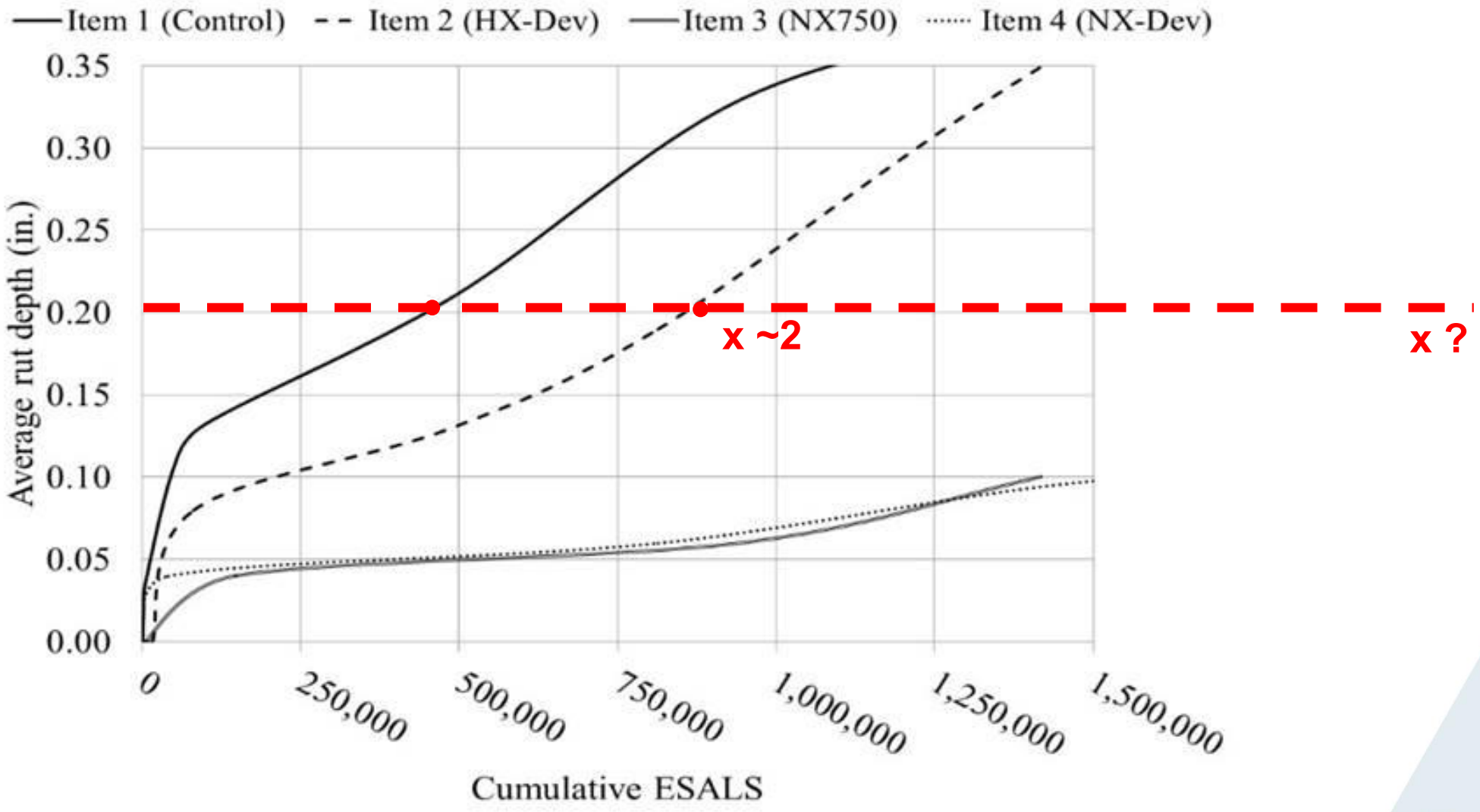
USCoE, USA (2023-24)

Figure 16. Rut depth progression with traffic.



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University of Illinois, USA (2024)

Badanie modułu sprężystości kruszywa w zakresie małych odkształceń z użyciem piezoelementów typu bender (*bender elements*)

Geosynthetic-stabilized aggregate: quantitative modulus evaluation via bender element

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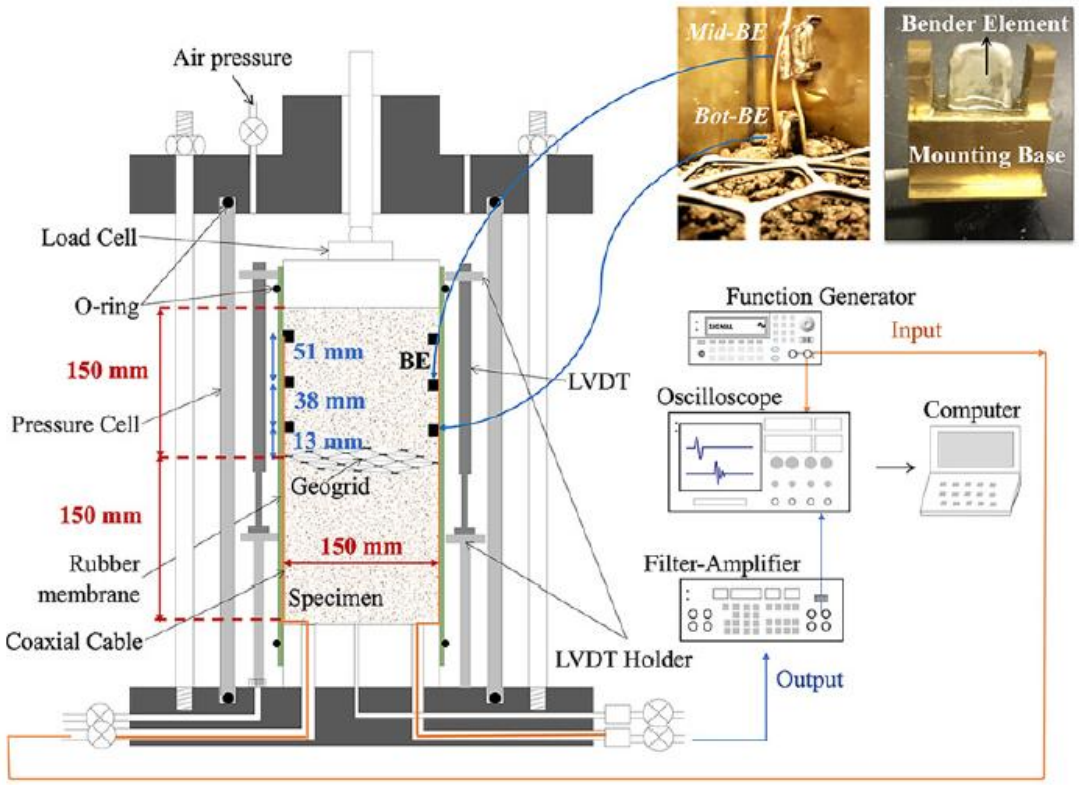
Received 28 June 2024, accepted 05 November 2024, first published online 11 November 2024

ABSTRACT: Geosynthetics, mainly geogrids and geotextiles, are commonly used to mechanically stabilize unbound aggregate layers in paved road applications. They provide lateral restraint to aggregates to initially increase the layer modulus during construction and minimize its time-dependent decrease under vehicular traffic loading. Different types of geosynthetics may provide different improvement mechanisms and stiffness enhancement levels. Quantitative evaluation of various stabilization geosynthetics is presented herein to compare modulus improvement trends and help incorporate geosynthetic benefits into state-of-the-art mechanistic-empirical (M-E) pavement design procedures. Five geogrids (three extruded, one woven, and one welded) and two geotextiles (one woven and one nonwoven) were studied with a dense graded aggregate in laboratory triaxial testing. Geosynthetics were placed at specimen mid-height and three pairs of Bender Element (BE) sensors were placed at various heights above the geosynthetic to collect shear waves and quantify the degree of mechanical stabilization during resilient modulus testing. While resilient moduli did not distinguish effectiveness of different geosynthetics, shear wave measurements could clearly show local stiffness increases achieved with geosynthetic inclusions. Meanwhile, trends observed in shear modulus profiles at various distances from the geosynthetic, when compared to that of control specimen, properly established the modulus enhancement level achieved in mechanical stabilization with geosynthetics.

KEYWORDS: Geosynthetics, Geogrids, Geotextiles, Unbound aggregates, Bender element, Shear wave transducer, Small-Strain shear modulus

REFERENCE: Wang, H., Kang, M., Kim, Y., Qamhia, I. I. A., Tutumluer, E. and Shoup, H. (2024). Geosynthetic-stabilized aggregate: quantitative modulus evaluation via bender element. *Geosynthetics International.* [https://doi.org/10.1680/jgein.24.00078]

University of Illinois, USA (2024)



Badanie wykonane w aparacie trójosiowego ściskania. Każda konfiguracja badana 15 razy (po trzy wartości obciążenia dla pięciu wartości ciśnienia ograniczającego („*confining pressure*")). Pomiar prędkości fal wykonywany za każdym razem po 100 cyklach obciążeń.

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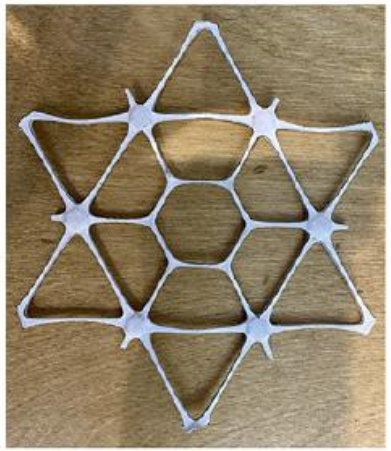
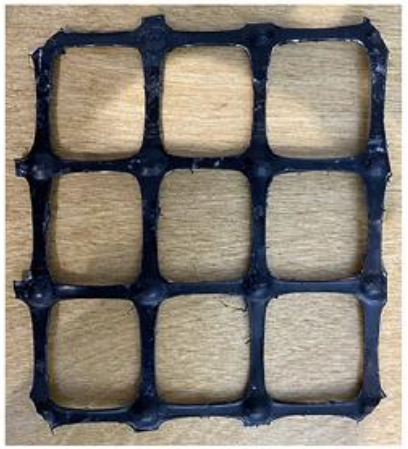
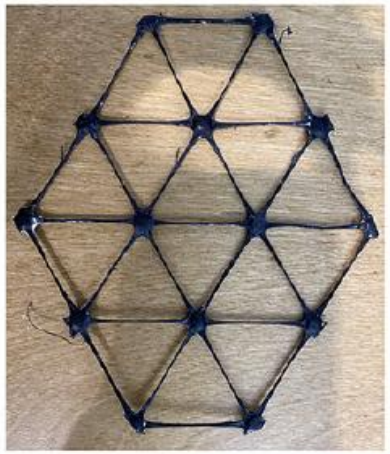


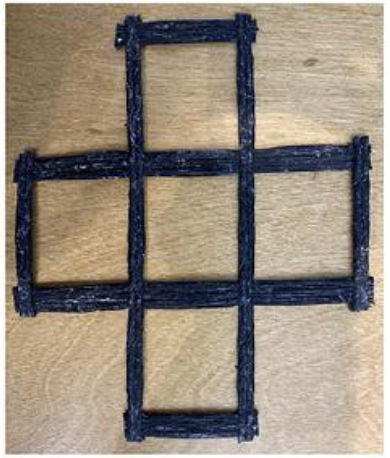
(a) GG1



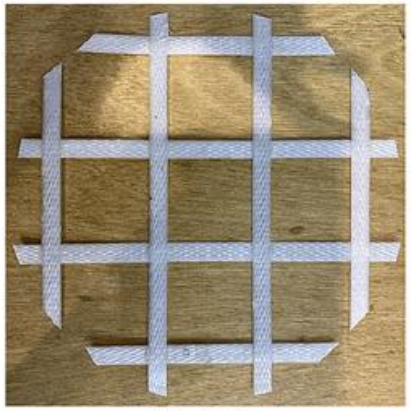
(b) GG2



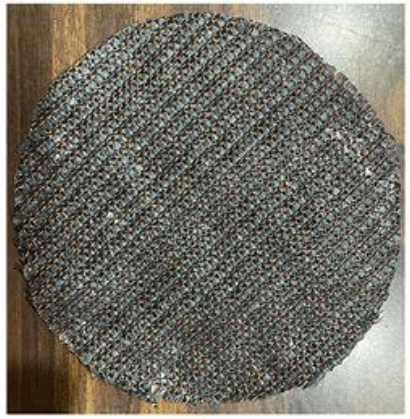
(c) GG3



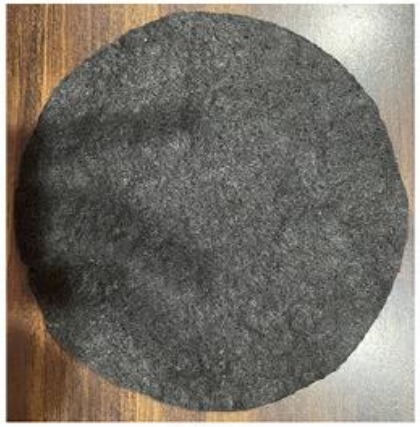
(d) GG4



(e) GG5



(f) GT1



(g) GT2

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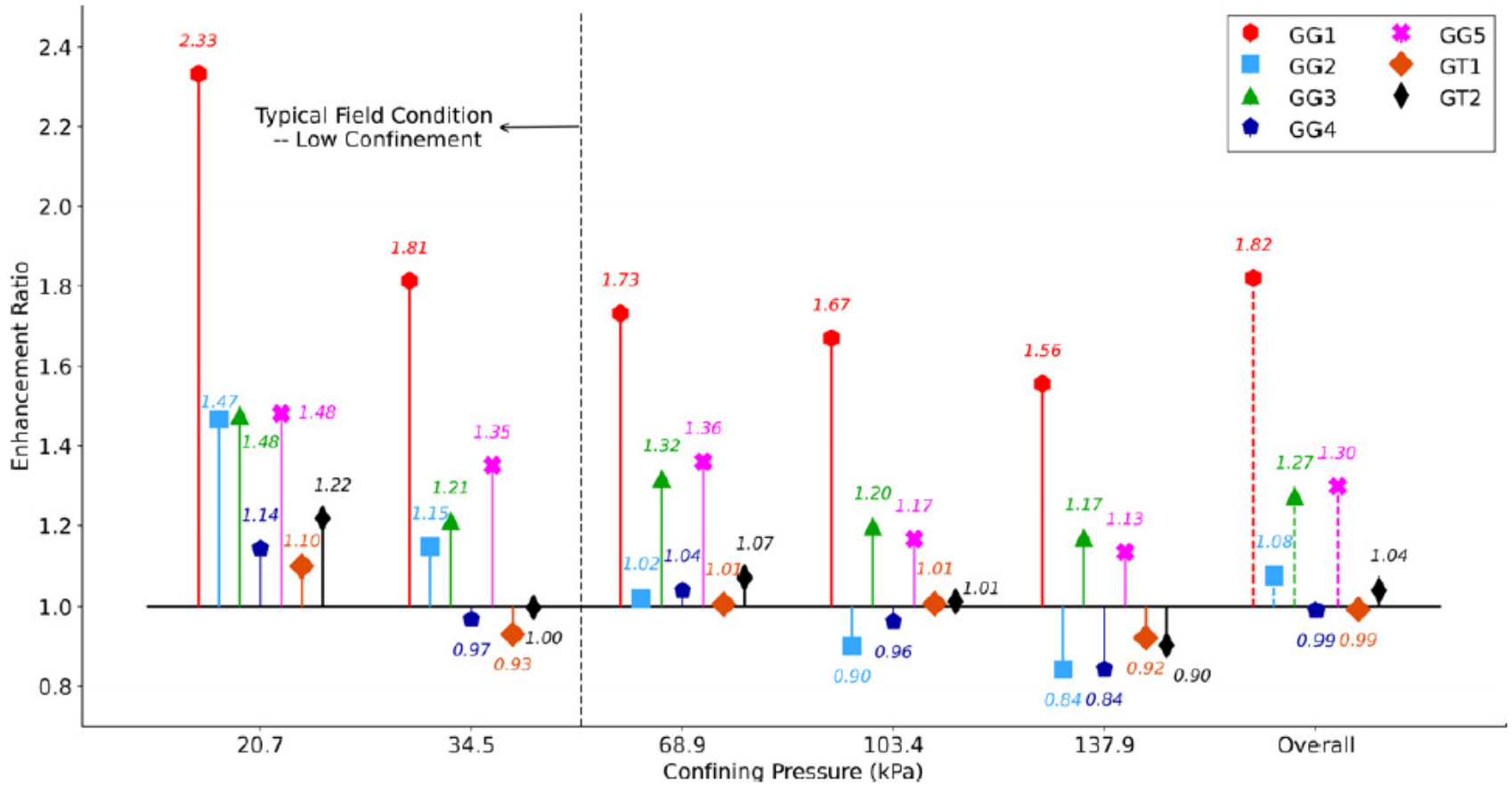

Wartości współczynnika wzrostu modułu kruszywa dla różnych zakresów ciśnienia ograniczającego w bezpośredniej bliskości geosyntetyku

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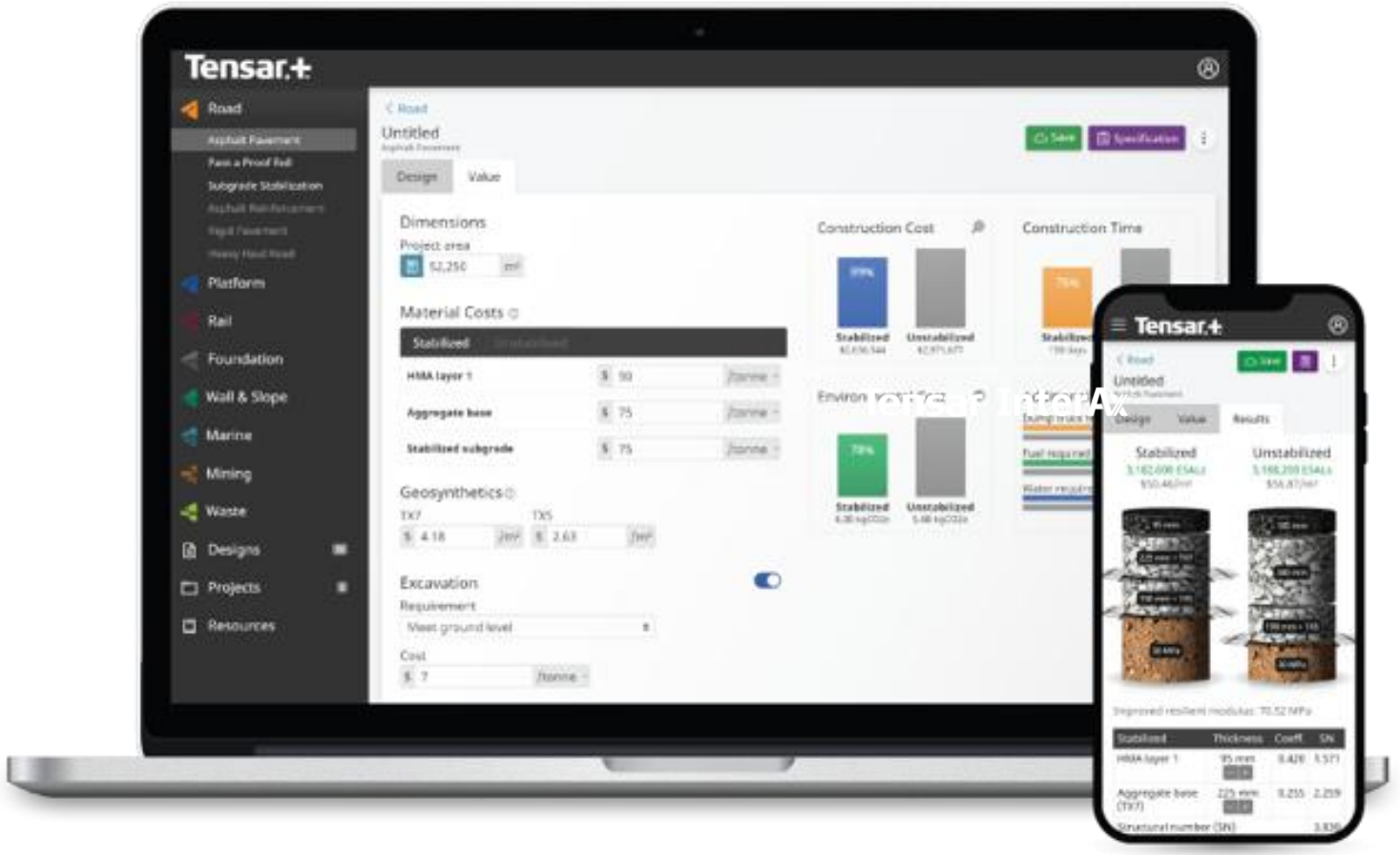
Podsumowanie

- Kolejne badania w pełnej skali potwierdziły znaczący wpływ stabilizacji kruszywa wielokształtnymi georusztami stabilizacyjnymi na trwałość konstrukcji nawierzchni
- Georuszty zwiększają trwałość nawierzchni również w przypadku konstrukcji wykonywanych na podłożu o wysokiej nośności
- Badanie modułu sprężystości kruszywa z użyciem piezoelementów typu bender (bender elements) wykazały najwyższą skuteczność georusztów wielokształtnych spośród szeregu testowanych geosyntetyków



Innowacyjny program
Tensar+

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Dziękuję za uwagę