Durability statement for Tensar InterAx geogrids

Introduction

This document summarises the assessment of the durability of Tensar InterAx geogrid products for CE Marking purposes, but also goes beyond the basic requirements of the European Assessment Document (EAD) for InterAx which is broadly equivalent to "Annex B" of the relevant harmonised European standards (hEN's) to consider also the guidance documents PD ISO/TS 20432:2022 "Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement" and PD ISO/TS 13434:2020 "Geosynthetics. Guidelines for the assessment of durability", together with additional relevant information.

Tensar InterAx geogrids

Under PD ISO/TS 13434:2020, Section 5, the Tensar range of InterAx products can be described as predominantly polypropylene (PP) geogrids, manufactured by a process consisting of co-extruding, punching and stretching sheet under controlled conditions of load and temperature to achieve a high level of molecular orientation. Specifically, Tensar InterAx geogrids are manufactured from >85% polypropylene. The outer white "cap" layers and the black inner "core2 layers are appropriately stabilised for UV protection and a combination of short-term and long-term anti-oxidants provide protection from thermo-oxidation. Thermo-oxidation is the primary long-term degradation mechanism for polypropylene.

Assessment by KIWA GmbH (Greven)

Tensar International has been assessed and registered as having a Quality Management System that complies and meets the requirements of BS EN ISO 9001:2015 for a number of activities, its ISO9001 auditing body being the BSI UK. Among these activities is the manufacture of polymeric grids for civil engineering applications. The InterAx geogrids referred to within this document fall within this activity. The documented ISO9001 quality management system forms the foundation of the systems assessed in the Factory Production Control audit for CE marking.

Tensar International has obtained the relevant CE marking approval for all their products that fall within the Construction Products Regulations (CPR). The notifying body carrying out Factory Production Control surveillance auditing for Tensar International products under the CPR is KIWA GmbH (Greven). The relevant Certification Number is 0799-CPR-110. Whilst the CE mark for InterAx is under EAD 080002-00-0102, the durability Annex of the geosynthetic hEN's also provides useful reference.

Reference Standards

The following reference standards are relevant to the use of Tensar InterAx products:

PD ISO/TS 20432:2022	Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement
PD ISO/TS 13434:2020	Geosynthetics. Guidelines for the assessment of durability
EAD 080002-00-0102	Non-reinforcing hexagonal geogrid for the stabilisation of unbound granular layers by way of interlock with the aggregate
EN 13249:2016	Characteristics required for use in construction of roads and other trafficked areas (excluding railways and asphalt inclusion)
EN 13250:2016	Characteristics required for use in construction of railways
EN 13251:2016	Characteristics required for use in earthworks, foundations and retaining structures
EN 13253:2016	Characteristics required for use in erosion control works (coastal protection, bank revetments)
EN 13254:2016	Characteristics required for use in the construction of reservoirs and dams
EN 13255:2016	Characteristics required for use in the construction of canals
EN 13257:2016	Characteristics required for use in solid waste disposals
EN 13265:2016	Characteristics required for use in liquid waste containment projects

Reference Publications

The following reference publications may be relevant to the use of Tensar InterAx products:

BRE 255	Performance of Building Materials in Contaminated Land

Durability Aspects

The durability aspects of CE marking are given in Section 2 of the EAD and Annex B of the relevant hEN harmonised standards EN 13249:2016 to EN 13265:2016. Additionally PD ISO/TS 20432:2022 and PD ISO/TS 13434:2020 provide valuable guidance on durability assessments beyond the basic Annex B index/screening tests. Annex B.1.1 makes clear the index/screening tests are not appropriate for setting reduction factors.

Weathering

- PD ISO/TS 20432:2022 9.3, PD ISO/TS 13434:2020 8.3, reference hEN standards Annex B.2
- Tensar NX750 has passed the accelerated weathering test according to EN 12224:2000
- The "index" standard for these tests is a retained strength of >80%. Accordingly, a maximum exposure time of up to 1 month after installation can be quoted for CE marking purposes on a Declaration of Performance (DoP) as a result of this test, on the basis of a retained strength of >80%. Testing has been carried out and the results reported. (Reference 1):

Retained strength (MD & CMD) = >98% (Reference 1)

- The acceleration of weathering performance according to EN12224 is based on a radiant exposure of 50MJ/m2, equivalent to approximately 1 month in Southern European latitudes. PD ISO/TS 13434:2020 Table 4 note a indicates that an exposure of up to 4 months may be acceptable depending on season / location for a retained strength >80% in EN12224 testing.
- Additionally, an on-going long-term exposure trial at Atlanta, Georgia (140 kiloLangley/year or 1700kWh/m2) provides a high degree of confidence based on results of NX750 geogrid that exposure durations in excess of a year will result in less than a 10% reduction of tensile properties for the Tensar InterAx product family **(Reference 2).**
- **Whilst regional UV levels will be an influence, Tensar is confident that the effect of exposure for periods well beyond 1 month after installation will be negligible, and would expect no loss of in-situ performance when exposed up to a period of one year.**

Resistance to chemicals

- PD ISO/TS 20432:2022 9.4, PD ISO/TS 13434:2020 8.5.3.5.3, no longer referenced in hEN's Annex B
- Tensar NX750 has passed the screening test for resistance to acid and alkaline liquids according to EN 14030:2001, which was previously referenced in Annex B of the CE marking hEN's

The "index" standard for these tests is a retained strength of >50%. Tests have been carried out and the results reported (Reference 1):

Retained strength (MD & CMD) = Acids >99% , Alkalis 100% (Reference 1)

- However, the EN14030 test is of a relatively limited duration of only 3 days. Additionally, the temperature maintained in the test is only 60°C, providing no great time acceleration according to the Van't Hoff or Arrhenius principles.

- PD ISO/TS 20432:2022 and PD ISO/TS 13434:2020 both advocate accelerated testing using an Arrhenius approach to gather data beyond the screening tests where appropriate. Tensar therefore commissioned EdifERA to carry out more extreme accelerated testing using an Arrhenius approach based on using a 90°C test temperature for specimens maintained in acid solution pH 2.3 to 3.0 and alkaline solution pH 12.5 to 13.0, with specimen retrievals at intervals of 3 months, 6 months and 12 months. This study covered both HDPE and PP geogrids – as outlined above InterAx is >85% polypropylene and this study is therefore a relevant indicator. **(Reference 3)**
- Quoting from Reference 3

  *Neither the HDPE or PP samples showed any clear degradation over the twelve month ageing period and the results from both materials were slightly erratic. It appears unlikely that acidic conditions as low as **2.3 to 3 pH**, or alkaline conditions as high as **12 to 12.5 pH**, would have any long term adverse effects upon the tensile properties of the materials. A lack of deterioration prevented extrapolation from an Arrhenius life prediction being carried out. However, using the same model, an estimate of a minimum of 64 years at 30oC, 128 years at 20oC and 256 years at 10oC with no deterioration was made.*

Microbiological

- PD ISO/TS 20432:2022 9.5, PD ISO/TS 13434: 2020 8.5.3.5.4, no longer referenced in hEN's Annex B
- Both PD ISO/TS 20432:2022 9.5 and PD ISO/TS 13434: 2020 8.5.3.5.4 make clear that biological degradation is not a serious factor in the service life of geosynthetics. Polymers like polypropylene from which InterAx is manufactured are not easily broken down by bacteria and fungi.
- However, historically Tensar has carried out some tests for polypropylene products using an index test for microbiological resistance according to EN 12225. Tests have been carried out and the results reported (Reference 4):
- **Retained strength (MD & CMD) = 97.4% & 103.0% (Reference 4)**
- This variation is likely to be due to natural variation in the tensile test results between the exposed specimen and the control rather than any real microbiological degradation.
- **Tensar does not expect InterAx geogrids to be adversely affected by microbiological attack.**

Oxidation

- PD ISO/TS 20432:2022 9.4, PD ISO/TS 13434:2020 8.5.4.5, EAD 080002-00-0102 2.2.5, reference hEN standards Annex B.4.2.2
- Tensar NX750 has passed the screening test for resistance to oxidation according to EN ISO 13438 as modified in Annex B.4.2.2
- The "index" standard for these tests is a retained strength of >50%. Tests have been carried out and the results reported (Reference 5):
- **Retained strength (MD & CMD) = >97% & >95% (Reference 1)**
- In addition, EAD 080002-00-0102 2.2.5 outlines a more aggressive modification of the EN ISO 13438 oxidation test, using a higher oven temperature.
- The "index" standard for these tests is a retained strength of >50%. Tests have been carried out and the results reported (Reference 5):

Retained strength (MD & CMD) = 100% & >92% (Reference 5)

- However, both the EN13438 test and the EAD 080002-00-0102 2.2.5 are "index" or "screening" tests and the standard of >50% retained strength is of limited value.
- PD ISO/TS 20432:2007 and PD ISO/TS 13434:2008 both accept for accelerated testing using an Arrhenius approach to gather data beyond the screening tests where appropriate.
- Tensar therefore commissioned RINA to carry out more extreme accelerated testing using an Arrhenius approach based on an "Oven aging" program using 110°C, 120°C and 130°C test temperatures for the specimens with specimen retrievals at intervals up to 160 days. (Reference 6)
- Quoting directly from Reference 6

Predicted lifetime to 80% retained strength of Tensar NX750 at 20 ºC is ~398 years

On the basis of this result, Tensar is confident that no loss of performance is likely to occur as a result of oxidation degradation for a period in excess of 120 years. Oxidation is the primary mode of degradation of a polypropylene based geogrid like InterAx.

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Installation damage

PD ISO/TS 20432:2007 8., PD ISO/TS 13434:2008 6.4.4, reference hEN standards Table 1`

Tensar NX750 has been subjected to the installation damage test EN ISO 10722. The tests carried out and the results reported (Reference 4):

Retained strength (MD) = >94% (Reference 7)

Additionally, a full scale site damage test as suggested in PD ISO/TS 20432:2022 8.2 has been carried out on NX750 and this exhibited less than a 10% reduction in retained mechanical properties following exhumation. **(Reference 10)**

Immersion in Water/Seawater

- Polyolefins such as polypropylene are not susceptible to hydrolysis and as such extended immersion testing is not mentioned in either PD ISO/TS 20432:2007 or PD ISO/TS 13434:2008. A limited pre-leaching test in water is now part of the hEN Annex B.4.2.2 oxidation test to check for any tendency for the long-term anti-oxidant packages to leach from the product
- However, Tensar have had requests for information about the durability of polypropylene geogrids when fully immersed in fresh water or seawater for extended periods of time.
- Tensar therefore commissioned EdifERA to carry out a lifetime assessment to establish the durability of polypropylene geogrids when fully immersed in seawater (seawater being chosen as a "worst case" scenario). The lifetime assessment was based on an "Oven aging" program using 70°C, 80°C and 90°C test temperatures for the specimens with the specimens immersed in "Instant Ocean" artificial seawater, with specimen retrievals at intervals between 1 month and 12 months **(Reference 8)**
- Quoting directly from Reference 8

  The polypropylene samples exhibited possible slight degradation, however this degradation was inconsistent and wasn't deemed significant. ***Using the Arrhenius model estimated that the polypropylene geogrid would last a minimum of 64 years at 30°C, 128 years at 20°C, 169 years at 16.1°C (average sea surface temperature) and 256 years at 10°C without deterioration.***

Effect of Land Contaminants

- The increasing scarcity of building land and the need for redevelopment has led to widespread re-use of former industrial land. Although not covered explicitly in either PD ISO/TS 20432:2022 or CR ISO 13434:2020, or in the reference hEN standards which specifically reference natural soils between pH 4 and pH 9. However, some relevant publications are concerned with this topic, for example BRE 255 "Performance of Building Materials in Contaminated Land"

- Tensar have seen an increasing number of projects either built on former industrial sites, including some projects that require the use of locally reclaimed fill materials
- It is impossible to test construction products for durability relative to every combination of chemicals that may be present on a former industrial site, Tensar therefore commissioned RINA Tech to carry out a literature survey and study of the effect of chemicals found in a series of typical "Environmental Site Assessment" reports. (Reference 9). This survey took account of the wide range of residual chemicals typically found on these sites, for example: total petroleum hydrocarbons (TPH's), volatile organic compounds(VOC's) and polycyclic aromatic hydrocarbons (PAH's)
- Quoting directly from **Reference 9**

  The polymers used in InterAx are highly resistant to hydrocarbons and the concentrations measured in the three environmental reports reviewed will not affect the life expectancy of InterAx.

Durability statement

From the comprehensive data referenced above it is apparent that the statement that Tensar is allowed to make for CE Declaration of Performance purposes is somewhat limited compared to the actual demonstrable performance of the product in a much wider range of conditions.

The durability statement of Tensar InterAx products appearing on the relevant CE Declaration of Performance, is the maximum allowed under the terms of Section 2 of the EAD and Annex B in the relevant hEN standards. The durability statement for the purposes of CE marking has to follow the set form of text outlined in Annex B.4.1 as follows

"*The minimum working life is assumed to be 100 years in natural soils with a pH value between 4 and 9 and in soil temperatures less than 15°C and is expected to be 50 years in natural soils with a pH value between 4 and 9 and in soil temperatures less than 25°C, when covered within 30 days.*"

From the various data sets referenced above we can make the following additional statements about the durability of the InterAx series of geogrids, above and beyond the limited statement allowed for CE marking purposes.

Weathering

Tensar is carrying out an on-going real-time assessment of weathering resistance at our facility in Atlanta, Georgia (140 kiloLangley/year or 1700kWh/m2) and no significant loss of mechanical properties have been reported after an exposure time in excess of one year.

Whilst regional UV levels will be an influence, Tensar are confident that the effect of exposure for periods well beyond 1 month after installation will be negligible, and would expect no loss of in-situ performance when exposed up to a period of one year.

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Resistance to chemicals

An Arrhenius type lifetime assessment has been carried out to explore the likely service life of Tensar polypropylene geogrids in extreme acid and alkali conditions. InterAx is of the same basic polymer recipe.

This study suggested that following 64 years in these conditions, at 30°C, no deterioration would occur. This would become 128 years at 20°C and 256 years at 10°C

Microbiological

Microbiological tests have been carried out and demonstrate a very high-retained strength (~100%). In addition, the "state of the art" is that polypropylene is not likely to be affected by microbiological attack.

Tensar do not expect biological degradation to have any effect on the long-term performance of InterAx geogrids.

Oxidation

Oxidation is the principal cause of long-term degradation in polyolefin based products like Tensar InterAx. Beyond the basic CE screening/type testing Tensar has undertaken Arrhenius type lifetime assessments using oven aging methodology which is currently accepted as "state of the art".

The study performed according to this method predicted that the geogrid would last at least 120 years before any significant reduction of properties began.

Installation damage

Tensar has carried out bot Tensar has carried out both basic index testing to EN ISO 10722 and a full scale site damage test.

Full scale site damage testing shows a very high degree of retained mechanical property (89 - 96%). h basic index testing to EN ISO 10722 and a full scale site damage test.

Immersion in Water/Seawater

An independent Arrhenius type lifetime assessment has been undertaken on Tensar polypropylene geogrids. InterAx is of the same basic polymer recipe. **It is estimated that InterAx geogrids would last a minimum of 64 years at 30°C, 128 years at 20°C, 169 years at 16.1°C (average sea surface temperature) and 256 years at 10°C without deterioration.**

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Effect of Land Contaminants

An independent study of the likely effects of land contaminants, as represented by a number of typical Environmental Site Assessment reports has been undertaken.

A review of the concentration of compounds from typical environmental site assessment reports suggests that the hydrocarbon levels are too low to affect InterAx

Evidence of Service Experience (PD ISO/TS 20432:2007 9.4.2, PD ISO/TS 13434:2008 8.5.2)

Tensar InterAx have been manufactured and has been commercially available for the past three years, but biaxial and other multi-axial geogrids of comparable mass per unit area, polymer recipe and manufacturing process have already been in service in a wide range of environments for periods of around 35 years in many installations worldwide. There are no reports of deterioration due to conditions of extreme pH or temperature. Previous Tensar installations where no issues occurred have included applications like landfills and heap leach sites, where both high temperature and extreme pH are likely to exist in combination.

Extended Durability Statement

Taking into account all the evidence outlined above, Tensar is confident in making the following extended durability statement, that goes beyond the one made for basic CE marking purposes.

Tensar are confident that no deterioration in geogrid properties will occur for a period in excess of 120 years in soil conditions between pH4 and pH 9 at a temperature of 20°C and would expect no loss of in-situ performance of the geogrid when stored outdoors for a period of 1 year prior to installation.

References

(1) BTTG Report 10/24415 dated December 2021
(2) Tensar internal test results dated August 2023
(3) Edif ERA Report "Aging Geogrid in High and Low pH Conditions", report reference 2016-0211 EPD2729001 dated April 2016
(4) BTTG Report 10/16857 dated June 2012
(5) KIWA Report 1.1/29173/0108.0.1-2022 dated March 2022
(6) RINA Tech UK Report "Life Prediction of InterAx Using Oven Aging", report reference 2022-0718 EDP47327-001, dated November 2022
(7) BTTG Report 10/25030 dated March 2024
(8) Edif ERA Report "Geogrid Ageing in Seawater", report reference 2016-0210 EDP2728001 dated April 2016
(9) RINA Tech UK Report "Environmental Assessment of InterAx", report reference 2022-0719 Rev. 2 EDP47321-001, dated January 2023
(10) Tensar internal report: "2021 Cumbria Site Damage Trial" dated June 2021

Note: over a number of years the UK based independent materials testing/research agency currently known as RINA Tech, based at Leatherhead in Surrey has undergone a number of changes of ownership and name. In this document references to ERA Technology Limited, Cobham ERA, and Edif ERA all refer to the same entity.

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