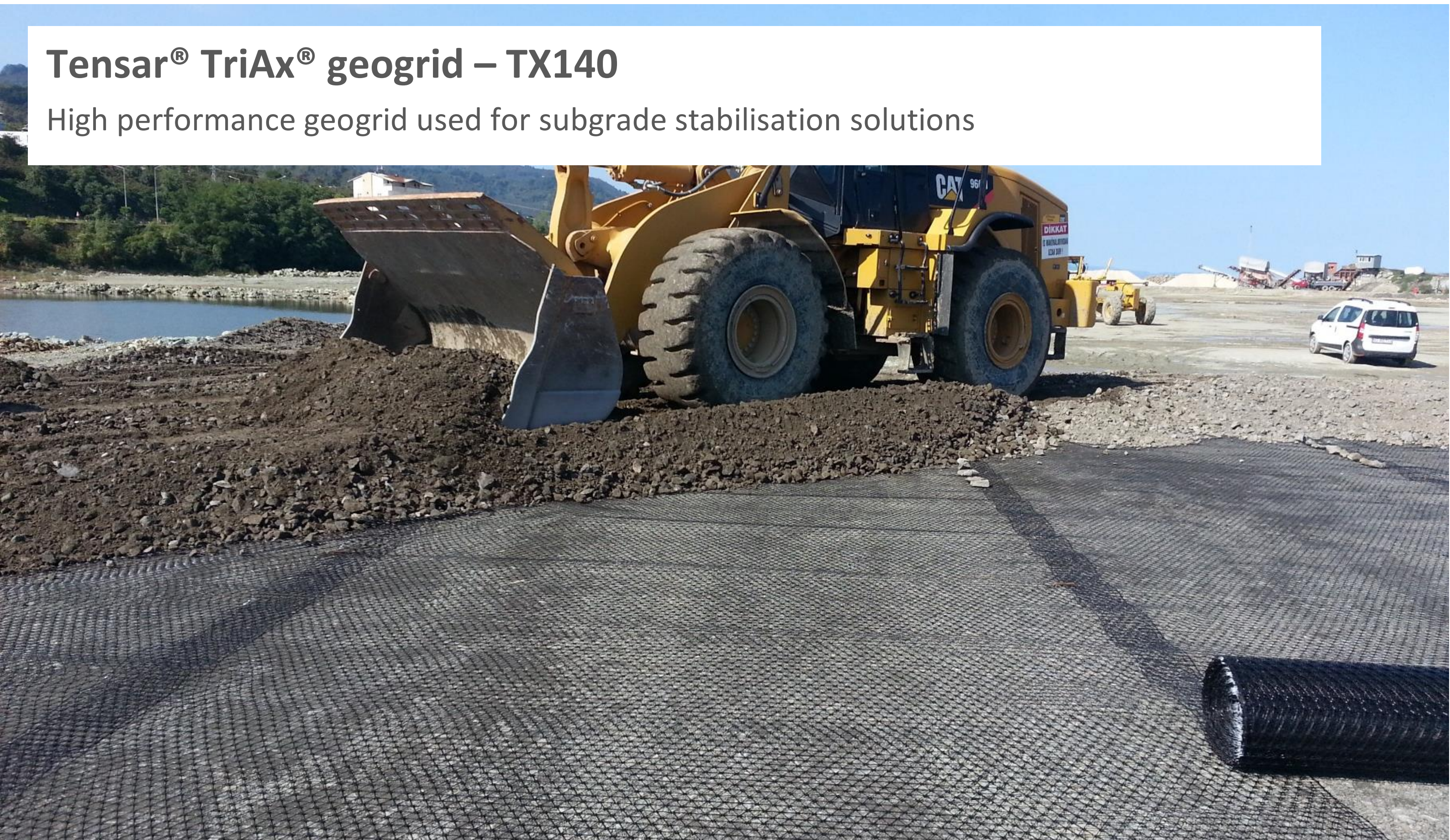
Environmental Product Declaration

as per ISO 14025 and EN 15804+A2

Owner of the declaration:	Tensar International Limited
Publisher:	Kiwa-Ecobility Experts
Programme operator:	Kiwa-Ecobility Experts
Registration number:	EPD-TENSAR-143-EN (Rev.1_20.05.2022)
Issue date:	14.01.2022
Valid to:	14.01.2027

Tensar® TriAx® geogrid – TX140

High performance geogrid used for subgrade stabilisation solutions



1. General information

Tensar International Limited	Tensar® TriAx® TX140
Programme operator Kiwa-Ecobility Experts Voltastr. 5 13355 Berlin Germany	**Owner of the declaration** Tensar International Limited Units 2-4 Cunningham Court Shadsworth Business Park Blackburn, United Kingdom
Registration number EPD-TENSAR-143-EN (Rev.1_20.05.2022)	**Declared product / declared unit** 1 m^2 geogrid
This declaration is based on the Product Category Rules PCR B - Geosynthetic products 2022-02-08 (draft) **Issue date** 14.01.2022 **Valid to** 14.01.2027	**Scope** Tensar® TriAx® TX140 geogrid is a product of the product series TriAx TX100. It is produced and distributed by Tensar International Limited, located in Blackburn (United Kingdom). The EPD refers to the specific product. EPD type: Cradle to grave with options, and with modules C1-C4 and module D. Kiwa-Ecobility Experts shall not be liable with respect to manufacturer information, life cycle assessment data and evidence.
Frank Huppertz (Head of Kiwa-Ecobility Experts)	**Verification** The European standard EN 15804+A2:2019 serves as the core PCR. Independent verification of the declaration and data according to ISO 14025:2011-10 ☐internal ☒external
Prof. Dr. Frank Heimbecher (Chairman of the independent expert committee – Kiwa-Ecobility Experts)	Anne Kees Jeeninga - Advieslab V.o.f. (Third party verifier)

2. Product

2.1 Product description

The geogrid is comprised of multiple hexagons formed by equilateral triangular apertures. These apertures are defined by a structure of monolithic, multidirectional tensile elements of defined orientation, size and shape.
The hexagonal geogrid is manufactured from an extruded polypropylene sheet, which is then punched and orientated in three equilateral directions so that the resulting ribs of the triangular apertures have a high degree of molecular orientation which continues through the mass of integral node.

2.2 Application

The intended use of the geogrid is to stabilize granular layers in order to minimize deformations during trafficking, to improve the load bearing capacity and to increase the design life of the granular layer in or under a construction in roads, railways and other trafficked areas, taking into account prevailing national regulations on design methodologies. The stabilising geogrid is installed within or directly under unbound granular layer to increase its stiffness. The combination of the geogrid and the aggregate creates a mechanically stabilized composite layer with significantly improved properties and performance capabilities in response to dynamic and static loading compared with aggregate layers alone. When installing, the manufacturer's installation procedures shall be observed, as well as the respective national practices.

2.3 Technical data

Name	Value	Tolerance	Unit
Weight of product /TR 041 B.3/	175	-35	g/m^2
Radial Secant Stiffness at 2% strain /TR 041 B. 1/	215	-65	kN/m
Radial Secant Stiffness at 0,5% strain /TR 041 B.1/	300	-75	kN/m
Radial Secant Stiffness Ratio /TR 041 B.1/	0.8	-0.15	-
Junction Efficiency /TR 041 B.2/	100	-10	%
Static Puncture Resistance /EN ISO 12236/	n.r.	-	kN
Characteristic Opening Size /EN ISO 12956/	n.r.	-	mm
Water Permeability/EN ISO 11058/	n.r.	-	Velocity Index (VIH50) ms^{-1}
Chemical Resistance	n.r.	-	-
Hexagon Pitch /TR 041 B.4/	80	±4	mm
Resistance to weathering /EN 12224/	Maximum time for exposure after installation of 1 month		
Resistance to oxidation and to acid and alkali liquids /EN ISO 13438/ and /EN 14030/	Resistant for 50 years when used in soil temperature of 15°C and 100 years when used in soil temperature of 15°C for soils with pH between 4 and 9		
Specific dimension of the finished rolls (width x length)	4 x 75		m x m

2.4 Placing on the market/ Application rules

For quality assurance the geogrids TriAx TX100 series are regulated in accordance with the European Technical Assessment (ETA) 12/0530 and marked with a CE mark (or UKCA mark for the UK market) by the manufacturer. In the EU/EFTA (excluding Switzerland) the placing of geogrids on the market is covered by Regulation (EU) No. 305/2011 of 9 March 2011. For the product use the respective national provisions shall apply. The product is packed and transported as roll and mainly marketed in Europe.

2.5 Base materials / Ancillary materials

TriAx geogrids are manufactured from a homopolymer or a copolymer of Polypropylene (PP). PP is a thermoplastic polymer. It belongs to the group of polyolefins and is partially crystalline and nonpolar. PP is prepared by polymerisation of propene. It is rugged and unusually resistant to many chemical solvents, bases and acids.

Raw material	Unit	Value
Polypropylene granules/pellets (PP)	%	94
Masterbatch granules/pellets	%	6

There is no biogenic carbon in the products.

The product is not included in the "Candidate list of substances of very high concern for authorisation" (SVHC).

2.6 Manufacturing

The manufacturing is located at Tensar Manufacturing Limited, 2 Sett End Road West, Blackburn, Lancashire, BB1 2PU, United Kingdom. The geogrids are made from PP granulate. In the first step granulate is melted and then extruded. After this the extruded sheet passes the punching process. Depending on the specific product the punches differ in size. The punched sheet is then stretched. The result is the specific triangular structure of each geogrid. The products are rolled and then packaged.

The manufacturing process is shown in the following figure:

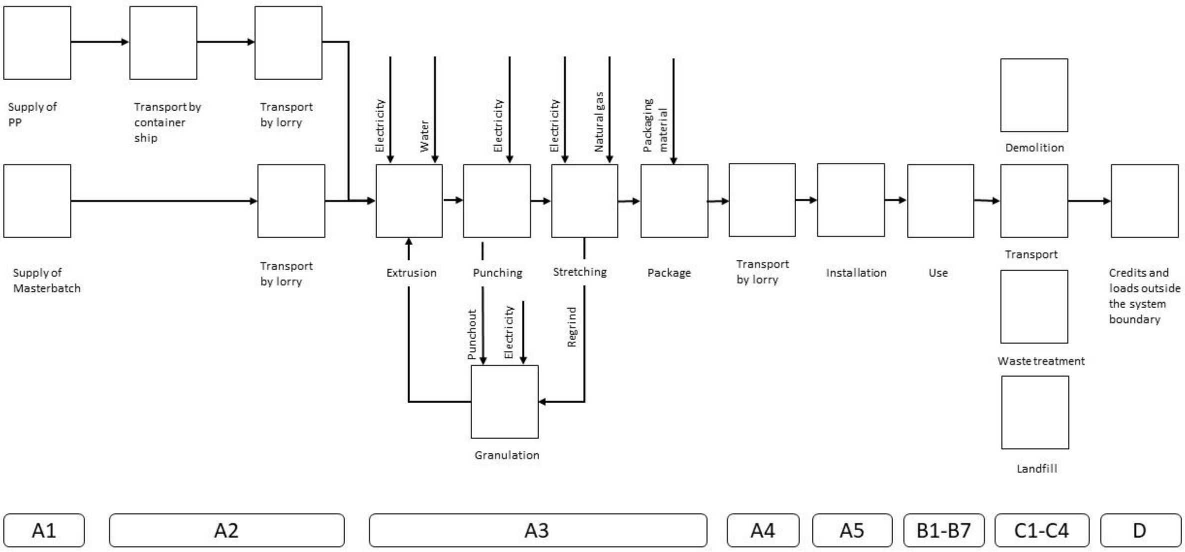


Figure 1: Process flow chart of the production of Tensar® TriAx®

2.7 Packaging

Geogrids are rolled and banded twice with PP banding tape.

2.8 Reference Service Life (RSL)

The RSL of the stabilisation geogrid depends on the service life of the roadway or platform it is included in. This is dependent on both the exact roadway structure and the intensity of usage. The stabilisation geogrids can be used in both temporary and permanent roadways and platforms. For temporary applications, service life would be measured using anticipated trafficking or imposed loading and would typically last for time durations measured in days, weeks or months. For permanent roadways, the stabilisation geogrids will be required to provide a service life of around 20 years. According to the manufacturer the reference service lifetime of the TX100 series is in excess of 120 years.

2.9 Other Information

For further information on TriAx TX100 products please visit the official Tensar International Limited webpage under the following link: www.tensar.co.uk

3. LCA: Calculation rules

3.1 Declared unit

In accordance with the PCR B 1 m^2 geogrid is chosen as the declared unit.

Product	Unit	Value
Declared Unit	m^2 geogrid	1
Unit weight	g/m^2	175
Conversion factor to 1 kg	-	5.71

3.2 System boundary

The Environmental Product Declaration is a complete life cycle with a functional unit. It considers all potential environmental impacts of the product from the cradle to the end of life.
The manufacturing phase includes the production or extraction of the source materials, the transport to the respective production plant and the production of the geogrids. All inputs (raw materials, pre-cursors, energy and auxiliary materials) as well as the by-products and waste are considered for all life cycle phases. Finally, only production-related energy consumption (excluding administration and social rooms) is considered.

It is assumed that no activities for maintenance, repair, transport and replacement, refurbishment or other material and energy flows take place during the useful life of 20 years (RSL). Modules B1 to B3 are therefore assumed to be zero. Product replacement (B4) and renovation (B5) only apply when the product is considered in a lifespan (of a building, work, etc.). Operational water and energy use are not considered.

The year 2020 represents the time reference for raw materials and electricity consumption. Due to the production location United Kingdom is considered as the geographical reference area. Since the Dutch NMD method has been applied, the product is also considered representative for Netherlands. However, environmental effects such as the greenhouse effect can occur with a strong spatial and temporal offset.

The following production steps are considered during the manufacturing phase:

- Extraction and processing of the raw materials (PP, Masterbatch)
- Transport to the production site
- Processing of the geogrids (extrusion, punching, stretching)
- Packaging (including packaging material)
- End-of-life (including transport)

Secondary fuels are not included in the production process and are therefore not considered. The waste materials and quantities produced are included in the respective modules.

3.3 Estimates and assumptions

Almost all datasets chosen for the LCA refer to the EU as the geographic reference. Transport distances for all raw materials used (raw materials, operating materials, packaging) could be recorded. A payload factor of 50% was used for all truck transports (suppliers, disposal transports and internal transports), which corresponds to a full delivery and empty return trip. A data set for a non-specific truck was used.

The distance to the construction site (A4) was calculated according to the NMD method. Accordingly, the distance between the production site in Blackburn and Utrecht was considered (900 km). As the mean of transportation truck (unspecified) was chosen.

Tensar International Limited switched in 2020 to a 100 % renewable wind energy. According to a wind electricity portal, windbranche.de, 50% of wind power in UK is generated from onshore and 50% from offshore wind parks. Based on this assumption an electricity data set was generated for the LCA calculation. No CO_2 certificates were considered.

3.4 Cut-off criteria

All flows which influence the total mass, energy or environmental impact more than 1% are included in the LCA. It can be assumed that the neglected processes would have contributed less than 5% to the impact categories considered.

All process specific data could be determined and modelled by the use of generic data (EcoInvent 3.6) The PP is bulk delivered in 24 tons batches – the pellets is blown into the silo. Therefore, there is no packaging waste for the PP.

The masterbatch is delivered in octabins made of cardboard and a thin polythene liner. Cardboard and liner are recycled afterwards. As the amounts for the masterbatch packaging are quite small referred to the overall mass flow this packaging was neglected. It is assumed that the residues of the extrusion, punching and stretching processes are less than 1% of the total mass, energy or environmental impact. Therefore, these residues are within the cut-off criteria and were neglected.

3.5 Period under review

The production data applies to the operating year 2020.

3.6 Data quality

For all processes primary data was collected and provided by Tensar International Limited. The primary data refers to year 2020. For the data, which is not influenced by the manufacturer, generic data was used. The secondary data was taken from the database EcoInvent (version 3.6). The database is maintained on a regular basis and thus meets the requirements of EN 15804 (background data not older than 10 years). The power sources were chosen from data for the UK in 2020, in accordance with the geographical and time representativeness. The data quality is very good, because all process specific data could be documented and modelled by using the generic data.

RETHiNK EPD web application from the company NIBE was used to model the life cycle for the production and disposal of the declared product systems. To ensure that the results are comparable, consistent background data from the international database EcoInvent was used in the LCA (e.g. data records on energy, transport, auxiliary materials and supplies). Almost all consistent data sets contained in the EcoInvent database are documented and can be viewed online.

3.7 Allocation

Allocations were avoided as far as possible. Tensar uses PP for several products as a raw material and all PP residues, which occur during the manufacturing, are recycled. The residues are not mandatorily used again for the product from which they originate. The recycled residues might be used for products from another PP based series.

For example: 5% residues of PP occur during the manufacturing of geogrid A. These 5% are recycled, but due to operating conditions, it is possible that 4% is reused for geogrid A and 1% for geogrid B.

For this calculation it was assumed, that the generated punchout and the regrind material of a specific geogrid is reused in a closed loop recycling for the analysed geogrid. This was done to avoid product specific shifts of potential environmental impacts. It was also assumed that the recycled PP substitutes virgin PP after a regranulation and that this does not imply any quality losses.

3.8 Comparability

In principle, a comparison or assessment of the environmental impacts of different products is only possible if they have been prepared in accordance with EN 15804. For the evaluation of the comparability, the following aspects have to be considered in particular: PCR used, functional or declared unit, geographical reference, definition of the system boundary, declared modules, data selection (primary or secondary data, background database, data quality), scenarios used for use and disposal phases, and the life cycle inventory (data collection, calculation methods, allocations, validity period). For further guidance see EN 15804+A2 (5.3 Comparability of EPD for construction products).

4. LCA: Scenarios and additional technical information

When installing stabilising pavement optimisation geogrid, it is simply unrolled by hand on prepared subgrade or capping layer. Apart from rolling out, no further installation measures are necessary, which would otherwise be required during road construction. A reject or unused portion of 5% of the pavement optimisation geogrid is assumed during the installation process.

For C1 the process and amount of the generic dataset 'Polyester weefsel' (EN: polyester fabric) out of chapter 22.46 Grondwapening en grondscheiding (EN: 22.46 Soil reinforcement and soil separation) of the program DuboCalc with database version NMD version 1.8 - 5.01.14052018. In this generic dataset 0.0013 hrs of the process Gr.mach.hydr. (gemiddeld) (EN: Hydraulic excavator (average)) are stated for module C1 (demolition).

For the end-of-life the NMD szenario PE/PP soil reinforcement (geotextile and geogrid) was chosen. This scenario assumes that 25% of the geogrid remains in the subground, 70% are incinerated and 5% are recycled. In the scenario the original waste scenario for benefits from recycling "Polyethylene, HDPE, granulate | production (EU)" were substituted by the "Polypropene, granulate".

Note: The transport distances of the waste are based on the standard waste scenarios of the NMD Determination Method (SBK 2019): incineration 150 km/ recycling 50 km / landfill 100 km; vehicle: truck, unspecific. For energy recovery, it is assumed that only fossil raw materials are substituted, considering the calorific values of the raw materials of the declared product and energy and thermal efficiencies of 18% and 32%. According the EN 15804, loads are credited in A3 or C3 to C4 and benefits are credited in module D.

For all transports, the environmental profile of a non-specific truck transport was used (conservative assumption): The vehicle operates with diesel, and it provides a fleet average that includes different lorry classes as well as EURO classes. This environmental profile contains data for transport, which is calculated for an average load factor, including empty return trips (EcoInvent 3.6).

5. LCA: Results

The following tables show the results of the impact assessment indicators, resource use, waste and other output streams. The results presented here refer to the declared specific product.

Disclaimer on ADP-e, ADP-f, WDP, ETP-fw, HTP-c, HTP-nc, SQP: The results of these environmental impact indicators must be used with caution, as the uncertainties in these results are high or as there is limited experience with the indicator.

Disclaimer on IR: This impact category mainly addresses the potential effect of low dose ionizing radiation on human health in the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents and occupational exposures, nor does it consider radioactive waste disposal in underground facilities. Potential ionizing radiation from soil, radon, and some building materials is also not measured by this indicator.

Description of the system boundary

Product stage			Construction process stage		Use stage							End of life stage				Benefits and loads beyond the system boundaries
Raw material supply	Transport	Manu-facturing	Transport from manu-facturer to place of use	Construction -installation process	Use	Main-tenance	Repair	Replacement	Refur-bishmen	Operational energy use	Operational water use	De-construction / demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
X	X	X	X	X	X	X	X	MND	MND	MND	MND	X	X	X	X	X

X=Module declared | MND=Module not declared

Results of the LCA – Environmental impact: 1 m² Tensar® TriAx® TX140 (EN 15804+A2)

Parameter	Unit	A1	A2	A3	A4	A5	B1	B2	B3	C1	C2	C3	C4	D
Core environmental impact indicators (EN 15804+A2/NMD set 2)														
ADP-mm	kg Sb-eqv	2,99E-06	1,41E-07	1,28E-07	5,39E-07	2,15E-07	0,00E+00	0,00E+00	0,00E+00	1,04E-07	6,43E-08	4,21E-07	4,96E-09	-2,09E-07
ADP-f	MJ	1,26E+01	1,01E-01	9,25E-01	3,21E-01	7,14E-01	0,00E+00	0,00E+00	0,00E+00	9,37E-01	3,83E-02	2,56E-01	1,10E-02	-3,96E+00
AP	mol H^+ eqv.	1,22E-03	9,41E-05	7,42E-05	1,23E-04	8,43E-05	0,00E+00	0,00E+00	0,00E+00	7,12E-04	1,47E-05	1,48E-04	4,05E-06	-2,25E-04
EP-fw	kg PO_4 eqv.	4,82E-06	5,86E-08	7,33E-07	2,15E-07	3,44E-07	0,00E+00	0,00E+00	0,00E+00	2,48E-07	2,56E-08	9,90E-07	8,32E-09	-4,69E-07
EP-m	kg N eqv.	2,02E-04	2,47E-05	1,71E-05	4,35E-05	1,68E-05	0,00E+00	0,00E+00	0,00E+00	3,14E-04	5,19E-06	4,05E-05	2,45E-06	-5,90E-05
EP-t	mol N eqv.	2,23E-03	2,74E-04	1,87E-04	4,79E-04	1,85E-04	0,00E+00	0,00E+00	0,00E+00	3,45E-03	5,72E-05	4,51E-04	1,49E-05	-6,49E-04
GWP-b	kg CO_2 eqv.	1,52E-03	1,06E-06	3,37E-05	9,82E-06	8,12E-05	0,00E+00	0,00E+00	0,00E+00	1,89E-05	1,17E-06	4,76E-05	5,00E-06	-1,34E-04
GWP-f	kg CO_2 eqv.	3,47E-01	7,02E-03	5,72E-02	2,13E-02	3,88E-02	0,00E+00	0,00E+00	0,00E+00	6,81E-02	2,54E-03	3,29E-01	6,49E-03	-2,16E-01
GWP-luluc	kg CO_2 eqv.	8,39E-05	3,69E-06	6,25E-06	7,79E-06	6,50E-06	0,00E+00	0,00E+00	0,00E+00	5,37E-06	9,30E-07	2,67E-05	2,29E-07	-1,01E-05
GWP-total	kg CO_2 eqv.	3,48E-01	7,02E-03	5,72E-02	2,13E-02	3,89E-02	0,00E+00	0,00E+00	0,00E+00	6,81E-02	2,54E-03	3,29E-01	6,49E-03	-2,16E-01
ODP	kg CFC-11 eqv.	1,03E-08	1,50E-09	7,14E-09	4,69E-09	1,74E-09	0,00E+00	0,00E+00	0,00E+00	1,47E-08	5,60E-10	1,00E-08	1,43E-10	-2,60E-08
POCP	kg NMVOC eqv.	1,06E-03	7,45E-05	6,70E-05	1,37E-04	7,44E-05	0,00E+00	0,00E+00	0,00E+00	9,49E-04	1,63E-05	1,21E-04	5,69E-06	-2,32E-04
WDP	m^3 world eqv.	2,40E-01	3,07E-04	2,57E-02	1,15E-03	1,43E-02	0,00E+00	0,00E+00	0,00E+00	1,26E-03	1,37E-04	1,68E-02	4,70E-04	-2,72E-02
Additional environmental impact indicators (EN 15804+A2/NMD set 2)														
ETP-fw	CTUe	1,77E+00	8,33E-02	2,07E-01	2,86E-01	3,30E-01	0,00E+00	0,00E+00	0,00E+00	5,65E-01	3,41E-02	4,13E+00	1,17E-02	-2,77E-01
HTP-c	CTUh	6,86E-11	3,57E-12	2,07E-11	9,28E-12	8,40E-12	0,00E+00	0,00E+00	0,00E+00	1,97E-11	1,11E-12	6,29E-11	3,06E-13	-1,60E-11
HTP-nc	CTUh	2,06E-09	8,59E-11	2,57E-10	3,13E-10	2,05E-10	0,00E+00	0,00E+00	0,00E+00	4,85E-10	3,73E-11	1,31E-09	7,60E-12	-2,84E-10
IRP	kBq U235 eqv.	7,35E-03	4,24E-04	5,35E-04	1,34E-03	5,47E-04	0,00E+00	0,00E+00	0,00E+00	4,02E-03	1,60E-04	1,05E-03	4,30E-05	-1,39E-03
PM	disease in-cidence	1,14E-08	4,96E-10	5,03E-10	1,91E-09	7,90E-10	0,00E+00	0,00E+00	0,00E+00	1,89E-08	2,28E-10	1,20E-09	7,63E-11	-1,01E-09
SQP		3,67E-01	6,59E-02	5,16E-02	2,78E-01	4,60E-02	0,00E+00	0,00E+00	0,00E+00	1,20E-01	3,32E-02	9,43E-02	2,60E-02	-6,52E-02

ADP-mm=Depletion of abiotic resources- minerals and metals| **ADP-f**=Depletion of abiotic resources-fossil fuels | **AP**=Acidification of soil and water | **EP-fw**=Eutrophication, freshwater | **EP-m**=Eutrophication, marine | **EP-T**=Eutrophication, terrestrial | **GWP-b**=Global warming potential - biogenic | **GWP-f**=Global warming potential - fossil | **GWP-luluc**=Global warming potential - land use and land use change |**GWP-total**=Global warming potential |**ODP**=Ozone layer depletion |**POCP**=Photochemical oxidants creation | **WDP**=Water use | **ETP-fw**=Ecotoxicity, freshwater | **HTP-c**=Human toxicity, cancer | **HTP-nc**=Human toxicity, non-cancer | **IRP**=Ionising radiation, human health | **PM**=Particulate Matter | **SQP**=Land use

Results of the LCA – Resource use and environmental information: 1 m² Tensar® TriAx® TX140 (EN 15804+A2)

Parameter	Unit	A1	A2	A3	A4	A5	B1	B2	B3	C1	C2	C3	C4	D
PERE	MJ	1,72E-01	1,12E-03	8,32E-01	4,02E-03	5,18E-02	0,00E+00	0,00E+00	0,00E+00	5,07E-03	4,79E-04	2,59E-02	1,94E-04	-1,62E-02
PERM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	1,72E-01	1,12E-03	8,32E-01	4,02E-03	5,18E-02	0,00E+00	0,00E+00	0,00E+00	5,07E-03	4,79E-04	2,59E-02	1,94E-04	-1,62E-02
PENRE	MJ	7,07E+00	1,07E-01	9,55E-01	3,41E-01	4,42E-01	0,00E+00	0,00E+00	0,00E+00	9,95E-01	4,07E-02	2,72E-01	1,17E-02	-4,02E+00
PENRM	MJ	6,43E+00	0,00E+00	6,43E-02	0,00E+00	3,25E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-3,46E-01
PENRT	MJ	1,35E+01	1,07E-01	1,02E+00	3,41E-01	7,67E-01	0,00E+00	0,00E+00	0,00E+00	9,95E-01	4,07E-02	2,72E-01	1,17E-02	-4,37E+00
SM	Kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	M3	3,55E-03	1,05E-05	5,96E-04	3,91E-05	2,36E-04	0,00E+00	0,00E+00	0,00E+00	4,83E-05	4,66E-06	4,93E-04	1,15E-05	-3,81E-04
HWD	Kg	1,20E-06	2,09E-07	1,25E-06	8,13E-07	2,06E-07	0,00E+00	0,00E+00	0,00E+00	2,55E-06	9,70E-08	4,88E-07	1,67E-08	-4,23E-06
NHWD	Kg	1,03E-02	4,61E-03	3,77E-03	2,03E-02	4,60E-03	0,00E+00	0,00E+00	0,00E+00	1,11E-03	2,43E-03	6,31E-03	4,39E-02	-1,87E-03
RWD	Kg	7,33E-06	6,70E-07	6,89E-07	2,11E-06	6,04E-07	0,00E+00	0,00E+00	0,00E+00	6,51E-06	2,51E-07	9,21E-07	6,53E-08	-1,86E-06
CRU	Kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	Kg	0,00E+00	0,00E+00	8,75E-05	0,00E+00	4,47E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,75E-03	0,00E+00	0,00E+00
MER	Kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EE	MJ	0,00E+00	0,00E+00	2,21E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,32E+00

PERE=renewable primary energy ex. raw materials | **PERM**=renewable primary energy used as raw materials | **PERT**=renewable primary energy total | **PENRE**=non-renewable primary energy ex. raw materials | **PENRM**=non-renewable primary energy used as raw materials | **PENRT**=non-renewable primary energy total | **SM**=use of secondary material | **RSF**=use of renewable secondary fuels | **NRSF**=use of non-renewable secondary fuels | **FW**=use of net fresh water | **HWD**=hazardous waste disposed | **NHWD**=non-hazardous waste disposed | **RWD**=radioactive waste disposed | **CRU**=Components for re-use | **MFR**=Materials for recycling | **MER**=Materials for energy recovery | **EE**=Exported energy

Results of the LCA – Environmental impact,optional: 1 m² Tensar® TriAx® TX140 (set 1 of the NMD determination method (version 1.0; July 2020))

Parameter	Unit	A1	A2	A3	A4	A5	B1	B2	B3	C1	C2	C3	C4	D
ADP-e	kg Sb	2,99E-06	1,41E-07	1,28E-07	5,39E-07	2,15E-07	0,00E+00	0,00E+00	0,00E+00	1,04E-07	6,43E-08	4,21E-07	4,96E-09	-2,09E-07
ADP-f	kg Sb	5,99E-03	4,84E-05	4,91E-04	1,55E-04	3,43E-04	0,00E+00	0,00E+00	0,00E+00	4,45E-04	1,85E-05	1,36E-04	5,34E-06	-2,10E-03
GWP	kg CO_2 eqv.	3,32E-01	6,96E-03	5,64E-02	2,11E-02	3,80E-02	0,00E+00	0,00E+00	0,00E+00	6,74E-02	2,52E-03	3,28E-01	5,55E-03	-2,12E-01
ODP	kg CFC-11 eqv.	9,77E-09	1,19E-09	6,32E-09	3,74E-09	1,60E-09	0,00E+00	0,00E+00	0,00E+00	1,17E-08	4,47E-10	1,01E-08	1,15E-10	-2,29E-08
POCP	kg Ethene eqv.	2,77E-04	5,80E-06	1,26E-05	1,27E-05	1,62E-05	0,00E+00	0,00E+00	0,00E+00	6,86E-05	1,52E-06	1,17E-05	1,26E-06	-4,22E-05
AP	kg SO^2 eqv.	1,02E-03	7,45E-05	5,99E-05	9,27E-05	6,92E-05	0,00E+00	0,00E+00	0,00E+00	5,08E-04	1,11E-05	1,16E-04	3,07E-06	-1,78E-04
EP	kg PO_4^{3-} eqv.	8,97E-05	9,48E-06	8,60E-06	1,82E-05	7,44E-06	0,00E+00	0,00E+00	0,00E+00	1,15E-04	2,17E-06	1,88E-05	1,24E-06	-2,27E-05
HTP	kg 1.4 DB	4,89E-02	3,30E-03	1,28E-02	8,88E-03	4,99E-03	0,00E+00	0,00E+00	0,00E+00	2,50E-02	1,06E-03	2,39E-02	4,54E-04	-1,25E-02
FAETP	kg 1.4 DB	1,04E-03	7,90E-05	1,13E-04	2,59E-04	1,62E-04	0,00E+00	0,00E+00	0,00E+00	3,47E-04	3,09E-05	1,23E-03	4,73E-04	-1,52E-04
MAETP	kg 1.4 DB	3,20E+00	3,07E-01	3,25E-01	9,32E-01	4,49E-01	0,00E+00	0,00E+00	0,00E+00	1,21E+00	1,11E-01	3,58E+00	4,72E-01	-6,09E-01
TETP	kg 1.4 DB	1,84E-04	1,10E-05	4,19E-05	3,14E-05	1,68E-05	0,00E+00	0,00E+00	0,00E+00	4,11E-05	3,75E-06	6,12E-05	7,84E-07	-4,12E-05

ADP-e=Depletion of abiotic resources - elements | **ADP-f**=Depletion of abiotic resources - fossil fuels | **GWP**=Global warming potential | **ODP**=Ozone layer depletion | **POCP**=Photochemical oxidants creation | **AP**=Acidification of soil and water | **EP**=Eutrophication | **HTP**=Human toxicity | **FAETP**=Ecotoxicity fresh water | **MAETP**=Ecotoxicity marine water | **TETP**=Ecotoxicity terrestric

6. LCA: Interpretation

As shown in the figure below, raw material supply (A1) dominates in most environmental core indicators, often followed by the production process (A3). In some environmental core indicators demolition phase (C1) has a great impact. However, C1 is strongly dependent on the assumption (here diesel consumption of a construction site vehicle). The highest influence on the Global Warming Potential have row material supply (A1), waste processing (C3), and production process (A3). Transports (A2, A4, C2) have rather a minor impact within all core indicators.

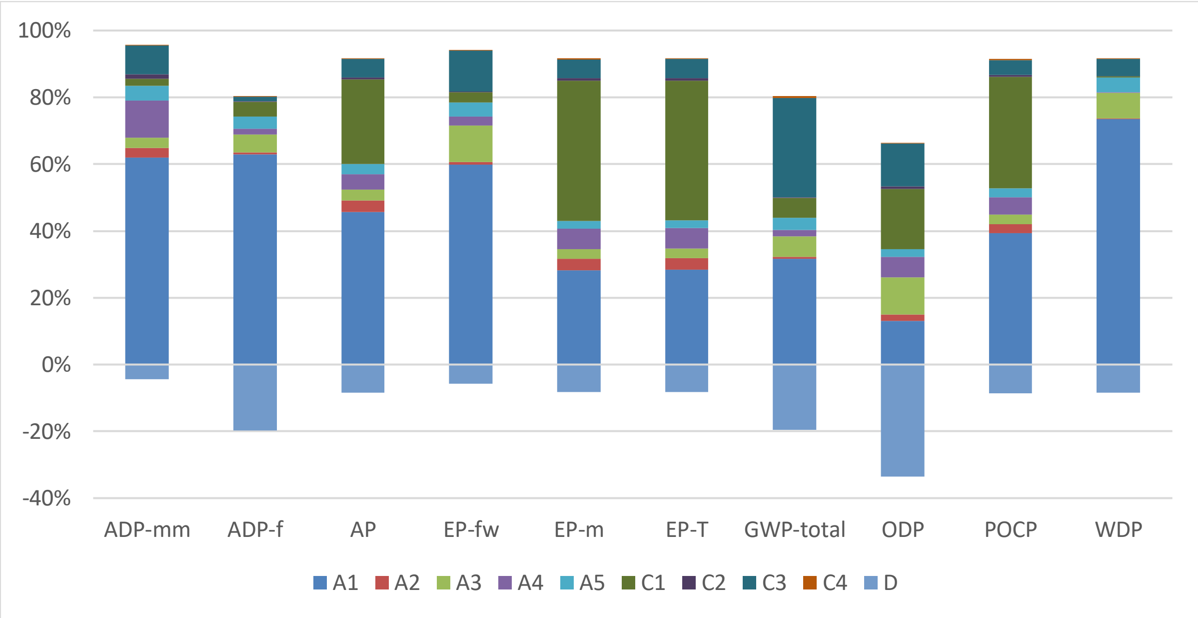


Figure 2: Tensar® TriAx® TX140 - Impact of the individual modules on the environmental core indicators

The MKI (Dutch: Milieukostenindicator) value calculated based on set 1 of the NMD determination method amounts to 0.055.

The data quality can be classified as good overall. All relevant process-specific data could be collected in the operational data collection. Consistent data sets from the EcoInvent database were available for almost all inputs and outputs. The background data meet the requirements of EN 15804, and the production data were recorded for the 2020 operating year. The quantities of raw materials and supplies used as well as energy consumption were recorded for the entire operating year.

7. Requisite evidence

In 2008 Tensar® TriAx® TX160 was tested concerning its leaching behaviour using the trough method. Due to this method the institute "PrüftechnikCDL" could determine the direct environmental impacts to the local environment (soil and groundwater). No parameters from the German Federal Soil Protection and Contaminated Sites Ordinance (BundesBodenschutz-und Altlastenverordnung: BBodSchV) were found in the 5. eluate, except from phenol. The analysed phenol concentrations are with 12 µg below the threshold value of the BBodSchV. In accordance with the criteria of the BBodSchVthe environmental soundness of the geogrid could be confirmed. This result can be transferred to all the other types of geogrids referring to the product series TX100, so as well to TriAx® TX140.

8. References

CML-IA April 2013 – Charakterisierungsfaktoren entwickelt durch Institut of Environmental Sciences (CML): Universität Leiden, Niederlande - http://www.cml.leiden.edu/software/data-cmlia.html

Donndorf, R., Kahle H., Müller, G., Philipp H-J., Taschow, H-J., Wolf, O. (1973): Werkstoffeinsatz und Korrosionsschutz in der chemischen Industrie. VEB Deutscher Verlag für Grundstoffindustrie Leipzig.

European Commission Joint Research Centre Institute for Prospective Technological Studies (JCR 2014): End-of-waste criteria for waste plastic for conversion, Seville, 2014, doi:10.2791/13033

Klöpffer, W., Grahl B.: Ökobilanz (LCA) – Ein Leitfaden für die Ausbildung und Beruf, Wily-VCH Ver-lag, Weinheim, 2007

Rosauer, V. (2010): Abschätzung der herstellungsbedingten Qualität und Lebensdauer von Asphalt-deckschichten mit Hilfe der Risikoanalyse (Estimation of the production-related quality and service life of asphalt wearing courses with the aid of risk analysis). Technischen Universität Darmstadt, 2010

Stichting Bouwkwaliteit (SBK) – Foundation for Building Quality; "Determination Method: Environmental Performance of Buildings and Civil Engineering Works"

Stichting Nationale Milieudatabase; Bepalingsmethode Milieuprestatie Bouwwerken; Version 1.0; July 2020; Berekeningswijze voor het bepalen van de milieuprestatie van bouwwerken ge-durende hun gehele levensduur, gebaseerd op de EN 15804.

Windbranche.de – Das Branchenportal rund um die Windenergie. Wind power and electricity generation in Great Britain: https://www.windbranche.de/wind/windstrom/windenergie-grossbritannien, last accessed 19 July 2021.

Standards and laws

ISO 14040:2006, Environmental management - Life cycle assessment - Principles and framework

ISO 14044:2006, Environmental management - Life cycle assessment - Requirements and guidelines

ISO 14025:2006: Environmental labels and declarations — Type III environmental declarations — Principles and procedures EN 13249

EN 15804:2012+A2:2019 Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products

PCR A: General Program Category Rules for Construction Products from the EPD program Kiwa-Ecobility Experts, R.0_2021-07-16

PCR B: Product Category Rules (PCR) from the Kiwa-Ecobility Experts EPD program: "Geosynthetic products", edition 2022-02-08 (draft)

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