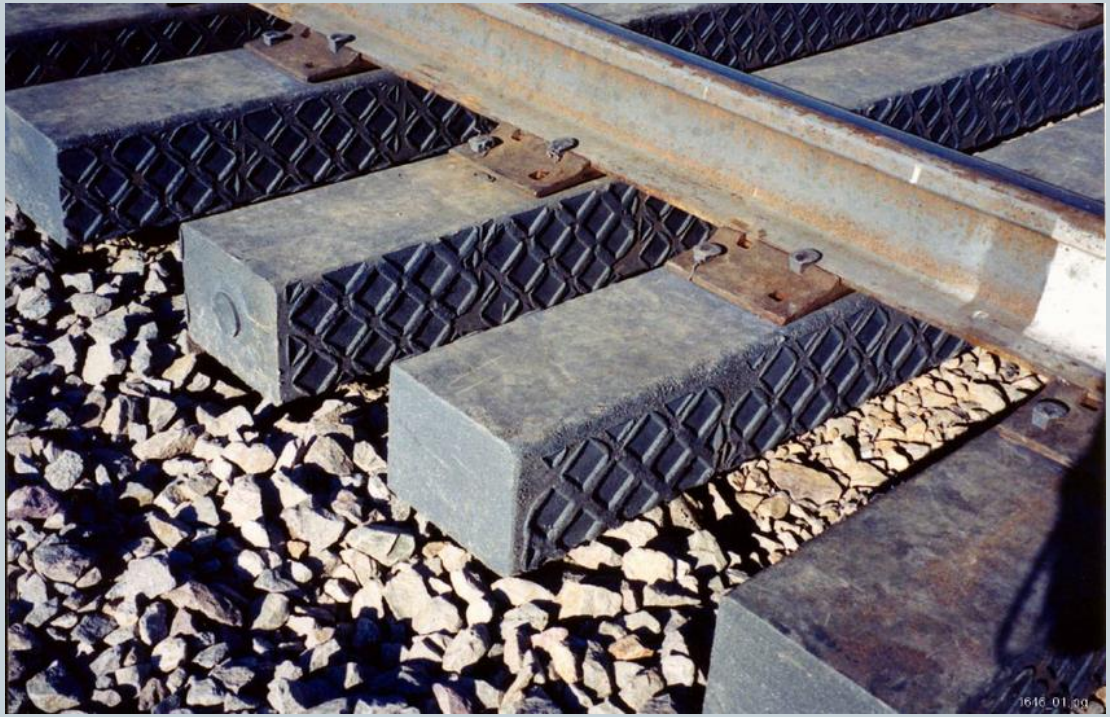
Composite Railway Crossties Status & Developments



Updated 18.10.2022

Markku Vilkki, Conenor Ltd

Railway Crossties
(known also as ”Sleepers”)

references from one US manufacturer Axion

- OVER THE PAST 20 YEARS PLASTIC SLEEPERS MADE FROM RECYCLED PLASTICS HAVE BECOME COMMON STANDARD PRODUCTS
- SEVERAL MANUFACTURERS ALL OVER THE WORLD INTHE USA,RUSSIA,CANADA,JAPAN,UK, GERMANY,INDIA,TAIWAN, AFRICA, THAILAND, NETHERLANDS AND AUSTRALIA
- PLASTIC RAILWAY SLEEPERS ARE REPLACING EXISTING CONCRETE, STEEL AND, PARTICULARLY, TIMBER ONES IN BOTH MAINLINE AND HEAVY HAUL RAIL NETWORKS

Benefits of Plastic & Composite Sleepers

Composite Ties Stacked High at the Marshall, Texas Manufacturing Plant

- **ENGINEERING**
  - MEET AND EXCEED NATIONAL STANDARDS
- **MORE DURABLE**
  - RESISTANT TO ROT, FUNGUS, INSECTS, AND MOISTURE
- **EASY-TO-INSTALL**
  - INSTALLS USING TRADITIONAL WOOD-TIE EQUIPMENT
- **ENVIRONMENTALLY SAFER & CLEANER**
  - INERT MATERIAL AND CONTAINS NO TOXIC MATERIALS
- **GREEN SUSTAINABLE PRODUCT**
  - MADE FROM 100% RECYCLED MATERIAL AND ARE 100% RECYCLABLE AT THE END OF THEIR LONGLIFE
- **PROVEN LONGER LASTING**
  - RESIST PLATE WEAR, HOLD SPIKES, AND MAINTAIN GAUGE ACCUMULATING WELL AXLE LOADS
- **LOWER LIFE CYCLE COSTS**

Manufacturers of Plastic Sleepers

EXAMPLES

- HTTP://WWW.AXIONSI.COM/
- INTEGRITIES — INTEGRICO COMPOSITES
- HTTP://WWW.TIETEK.NET/PRODUCT.ASP
- HTTP://WWW.SICUT.CO.UK/
- HTTP://WWW.ICSSERVICES.COM.AU/WKG/PDFS/CARBONLOCMANUALGENERAL5.PDF
- COMPOSITE SLEEPERS | JSC «FIRMA TVEMA»

Manufacturing Process of Plastic & Composite Sleepers

MANUGACTURING OF POLYMERIC SLEEPERS IN THREE STEPS;

1. PROCESSING PROPER PLASTIC WASTE
2. PRODUCTION OF POLYMERIC MATERIAL FORMULATION WITH OR WITHOUT REINFORCEMENTS
3. PRODUCTION OF SLEEPERS
   - by intrusion method (plastic)
   - by extrusion method (composite)

Manufacturing Process of Plastic Sleepers

VIDEO IN YOUTUBE FROM INTEGRICO

HTTPS://WWW.YOUTUBE.COM/WATCH?V=8TZNUV-OWLS

Different Types of Plastic & Composite Sleepers

- ***TYPE-1 SLEEPERS WITH SHORT OR NO FIBRE REINFORCEMENTS***

  SLEEPERS THAT CONSIST OF RECYCLED PLASTIC (PLASTIC BAGS, SCRAPPED VEHICLE TYRES, PLASTIC COFFEE CUPS, MILK JUGS, LAUNDRY DETERGENT BOTTLES ETC.) OR BITUMEN WITH FILLERS (SAND, GRAVEL, RECYCLED GLASS OR SHORT GLASS FIBRES < 20 MM)

- ***TYPE-2 SLEEPERS WITH LONG FIBRE REINFORCEMENT IN THE LONGITUDINAL DIRECTION***

  TYPE-2 SLEEPERS ARE SLEEPER TECHNOLOGIES REINFORCED WITH LONG CONTINUOUS GLASS FIBREREINFORCEMENT IN THE LONGITUDINAL DIRECTION AND NO OR VERY SHORT RANDOM FIBRE IN THE TRANSVERSEDIRECTION

- ***TYPE-3 SLEEPERS WITH FIBRE REINFORCEMENT IN LONGITUDINAL AND TRANSVERSE DIRECTIONS***

  TYPE-3 SLEEPERS HAVE LONG REINFORCEMENT FIBRES IN BOTH LONGITUDINAL AND TRANSVERSE DIRECTIONSAND CONSEQUENTLY BOTH THE FLEXURAL AND SHEAR BEHAVIOUR ARE DOMINATED BY FIBRES.

Different Types of Plastic & Composite Sleepers

Comparison of different types of composite sleeper

Properties and performances	Type-1	Type-2	Type-3
Flexural strength and stiffness	Low	Good	Good
Shear strength	Low	Medium	Good
Anchorage capacity	Low	Good	Good
Drilling and cutting	Easy	Easy	Moderately easy
Price	Low	High	High

Source: Composite Railway Sleepers – Recent developments, challenges and future prospects / Article in Composite Structures · August 2015

Comparing Advantages and Disadvantages of Type-1 and Type-2 Sleepers

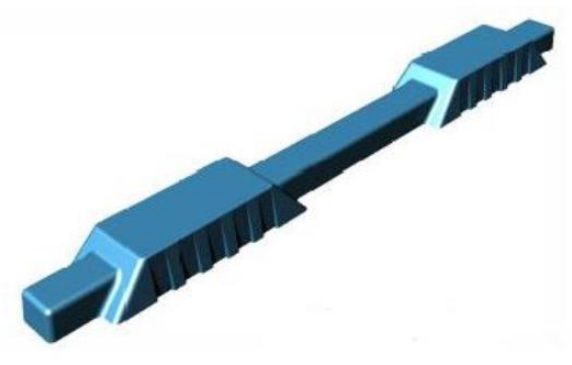


Table 1 Advantages and disadvantages of Type 1 sleeper

Advantages	Disadvantages
Easy to drill and cut	Low Strength
Good durability	Low Stiffness
Recycled material	Limited design flexibility
Reasonably priced	Temperature sensitive
Tough	Creep sensitive
	Low fire resistance

Table 2 Advantages and disadvantages of Type 2 sleeper

Advantages	Disadvantages
Easy to drill and cut	Average shear strength
Good durability	Average Shear Modulus
Good flexural strength	Expensive
Good Modulus of Elasticity	Limited design flexibility
	Marginal fire resistance

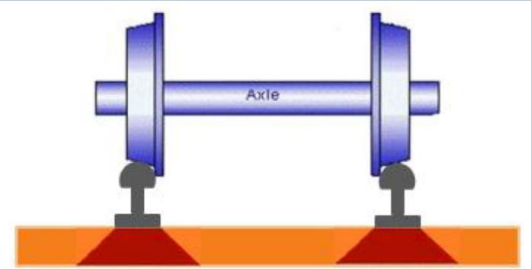
Source: Composite Railway Sleepers – Recent developments, challenges and future prospects / Article in Composite Structures · August 2015

Summary of Plastic Type-1 Sleepers

- The most common composite sleeper material, Type-1 sleepers offer a range of benefits including ease of drill and cut, good durability, consumption of waste materials, reasonable price, and tough.
- However, it suffers from low strength and stiffness, limited design flexibility, temperature and creep sensitivity, and low resistance to fire.
- Notable sleepers in this category Type-1 are TieTek (USA), Axion (USA), IntegriCo (USA), Woodcore (USA). I-Plas (UK), SICUT (UK), Tufflex (S-Africa), Natural Rubber (Thailand), Kunststof Lankhorst Product KLP (Netherlands), Mixed Plastic Waste MPW (Germany) and TVEMA (Russia)

Source: Composite Railway Sleepers – Recent developments, challenges and future prospects / Article in Composite Structures · August 2015

How to Improve Strength of Plastic Type-1 Sleepers



- Because of no or the short length of the fillers, they do not have a major reinforcing effect and the failure behavior of these sleepers is mainly polymer driven.
- Due to the lack of any long reinforcement fibres these sleepers are flexible and expand and contract significantly with temperature.

However, as stronger Type-2 and Type-3 composite sleepers become very expensive up to 10x more compared to wood sleepers, there is an incentive to develop further the low cost Type-1 plastic sleepers to become stronger and more durable !

Comparing the Performance of Composite Sleepers to AREMA (USA) Specification Requirements

Performance measurement	AREMA specification					
	Oak	Softwood	Glue Lam	Type-1	Type-2	Type-3
Density, (kg/m^3)	1096	855	960	850-1150	740	1040-2000
Modulus of elasticity, (GPa)	8.4	7.4	12.0	1.5-1.8	8.1	5.0-8.0
Modulus of rupture, (MPa)	57.9	49.3	66.9	17.2-20.6	142	70-120
Shear strength, (MPa)	5	4	4	4	10	15-20
Rail seat compression, (MPa)	4.6	3	3.9	15.2-20.6	28	40
Screw withdrawal, (kN)	22.2	13.3	N/A	31.6-35.6	65	>60

Source: Composite Railway Sleepers – Recent developments, challenges and future prospects / Article in Composite Structures · August 2015

ISO 12856

Plastics — Plastic railway sleepers for railway applications (railroad ties) — Part 1: Material characteristics

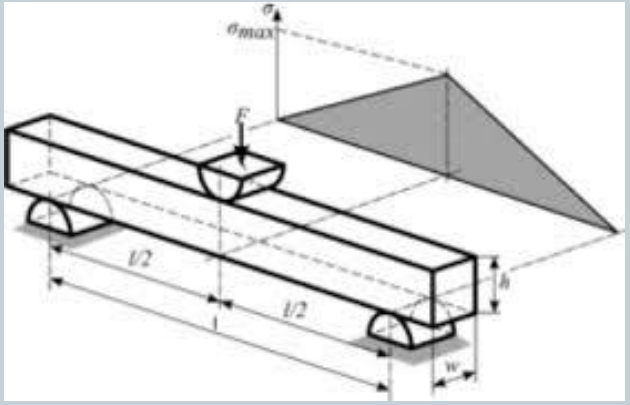
The part of ISO 12856 specifies the characteristics of plastic and reinforced plastic materials to be used in the manufacturing of railway sleepers.

It is applicable to the sleepers and parts of sleepers to be installed in tracks with or without ballast. Examples of different types of plastic and reinforced sleepers are given in Annex B.

In view of the facts that the types of plastics and manufacturing processes can have various effects on the in-service performance, this part of ISO 12856 covers the general characteristics of materials which plastic/composite sleepers are made from, in order to specify their performance.

The part of ISO 12856 will be used in conjunction with ISO 12856-2 to be developed in the foreseeable future.
The part of ISO 12856 applies to sleepers made from plastic materials, including reinforced plastic materials.

MOR- and MOE-values of Plastic Type-1 Sleepers



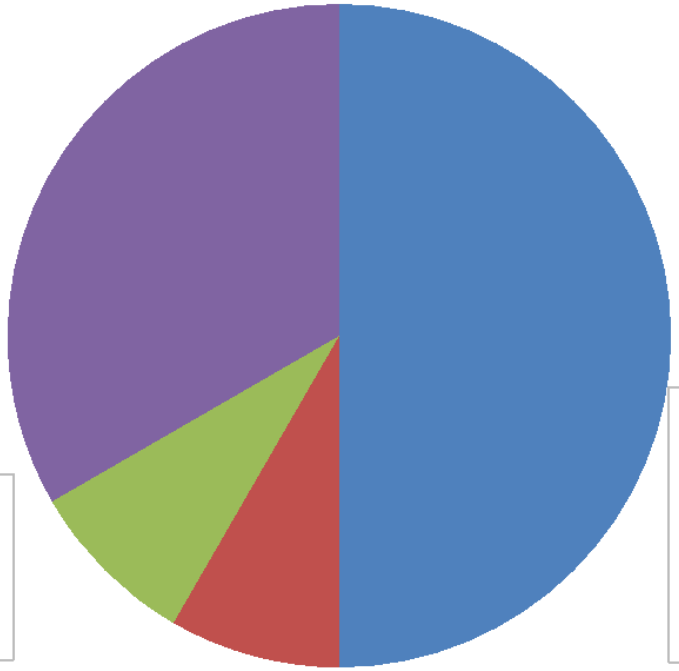
- Modulus of Rupture (flexural strength) and Modulus of Elasticity (stiffness) values for composite materials are defined in 3-point bending test in laboratory conditions
- The minimum values stated in AREMA (USA) specification (MOR @13.8 MPa and MOE @1.2 GPa) represent those levels typical for polyethylene (PE) polymer – and this is obvious because Type-1 composite sleepers are made mainly from this waste material

When producing the composite material formulation one may combine other stronger waste materials in the PE-waste polymer for improving the mechanical performance of Type-1 sleepers into much higher level without increasing costs !!

Choice of Materials for Type-1 Plastic Sleepers

THERMOSET PLASTICS WITH FIBRES FOR REINFORCEMENTS
(EPOXY / POLYESTER / +GF / +CF)

- PROFILES
- SHEETS
- BOATS
- WIND TURBINE BLADES
- VARIOUS FROM TRANSPORTATION
- ETC.



THERMOPLASTICS FOR POLYMER MATRIX
(PE / PP / PVC / ABS)

- PIPES
- TANKS & DRUMS & CONTAINERS
- BOTTLES & CANISTERS
- FILMS
- CAR PARTS (bumpers etc.)
- PACKAGING (crates etc.)
- HOUSEHOLD GOODS
- ETC.

MIXED PLASTICS FOR MATRIX/FILLER
(PE / PP / PVC / PET / EVOH / ALU / LBP)

- POUCHES
- SACHETS
- FILMS
- LIQUID PACKAGING (TetraPak)
- OTHER FOOD PACKAGES
- ETC.

THERMOPLASTICS FOR FILLER
(PS / PC / PA / PU / PET / etc.)

- TECHNICAL PARTS
- WEEE
- ETC.

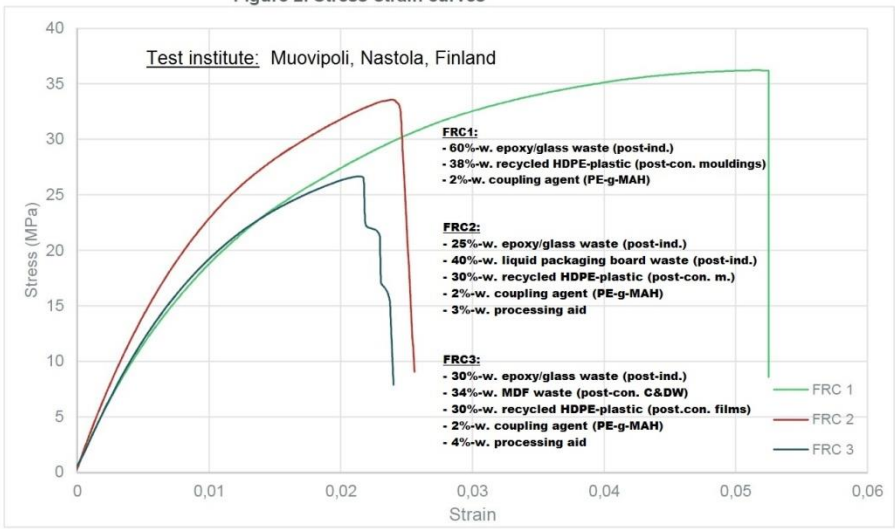
POSSIBLE USAGE OF DIFFERENT PLASTIC WASTE MATERIALS IN COMPOSITE MANUFACTURING

MOR- and MOE-values of Conenor Developed FRP-Waste Reinforced HDPE-Waste Plastic

Table 1. Flexural properties, EN ISO 178

Sample	Maximum Load (N)	Flexural Strength σ_{Max} (MPa)	Strain at flexural strength ε_{Max}	Stress at Break σ_B (MPa)	Strain at Break ε_B	Flexural Modulus E_f (MPa)
FRC 1	170 ± 14,6	36,2 ± 2,34	0,052 ± 0,003	20,40 ± 16,10	0,053 ± 0,003	2410 ± 145
FRC 2	157 ± 3,2	33,6 ± 0,81	0,024 ± 0,001	15,40 ± 10,70	0,025 ± 0,001	2970 ± 50
FRC 3	135 ± 4,3	27,0 ± 0,55	0,022 ± 0,002	10,50 ± 7,17	0,023 ± 0,002	2530 ± 155

Figure 2. Stress-strain curves



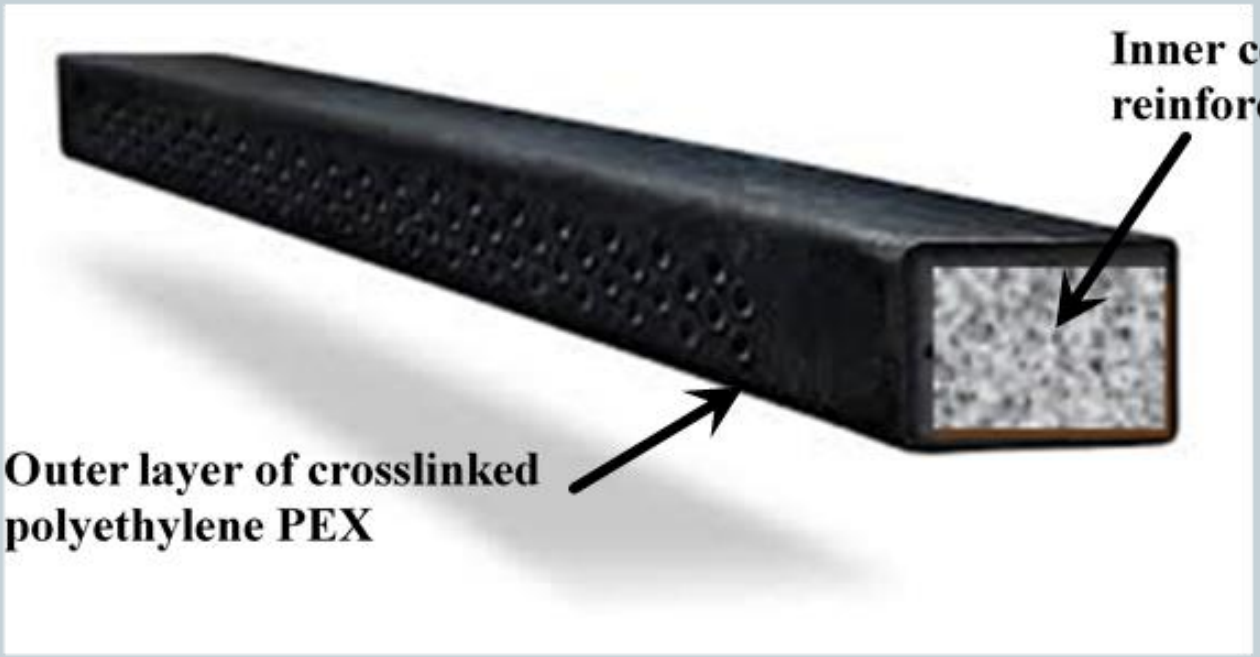
MOR-values up to 36 MPa !

MOE-values up to 3 GPa !

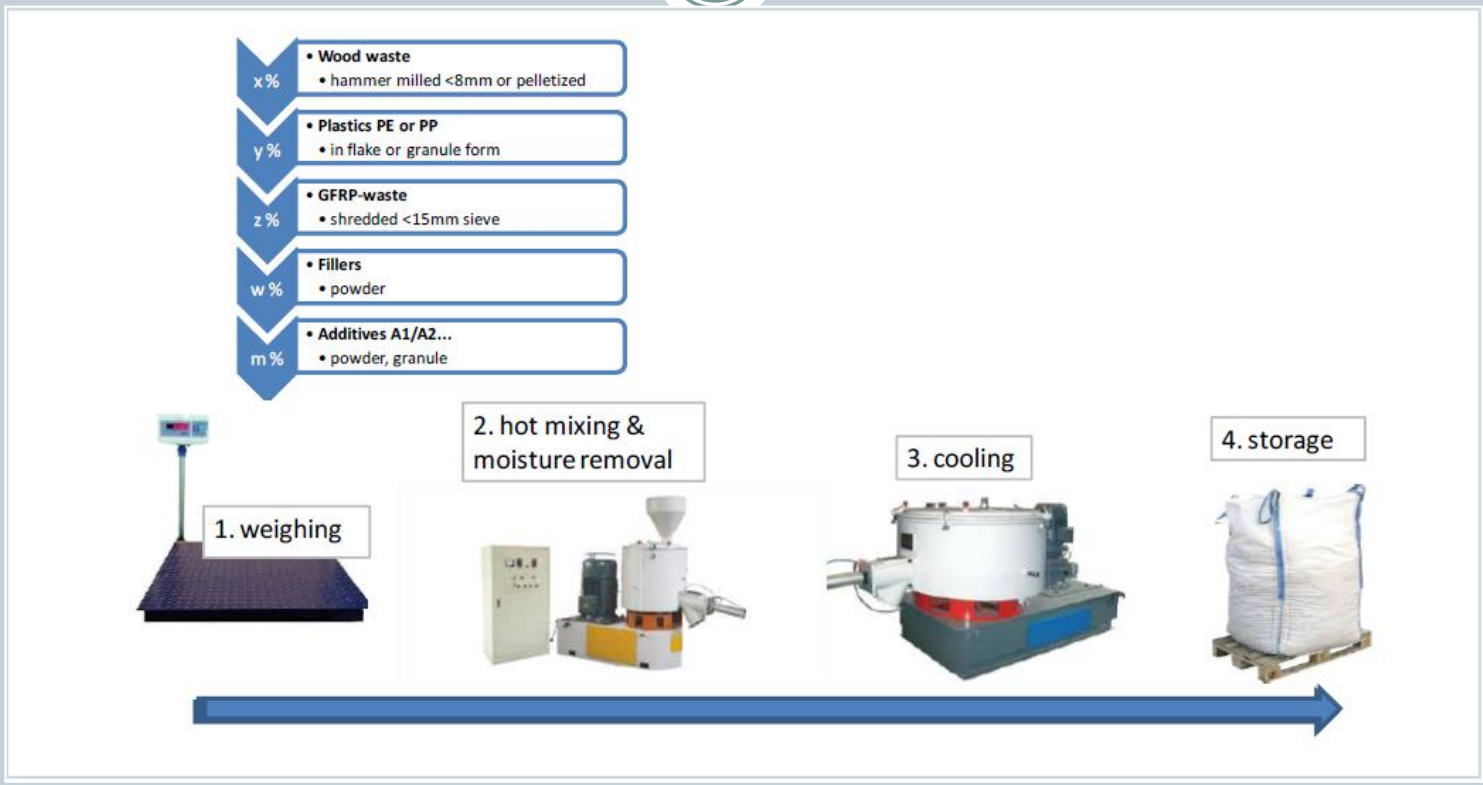
Mechanical properties of ”FRC”-material from waste exceed AREMA requirements by 2,5 times and outperform those existing Type-1 composite sleepers in the market

Ideal for stronger Type-1 Plastic Sleepers !

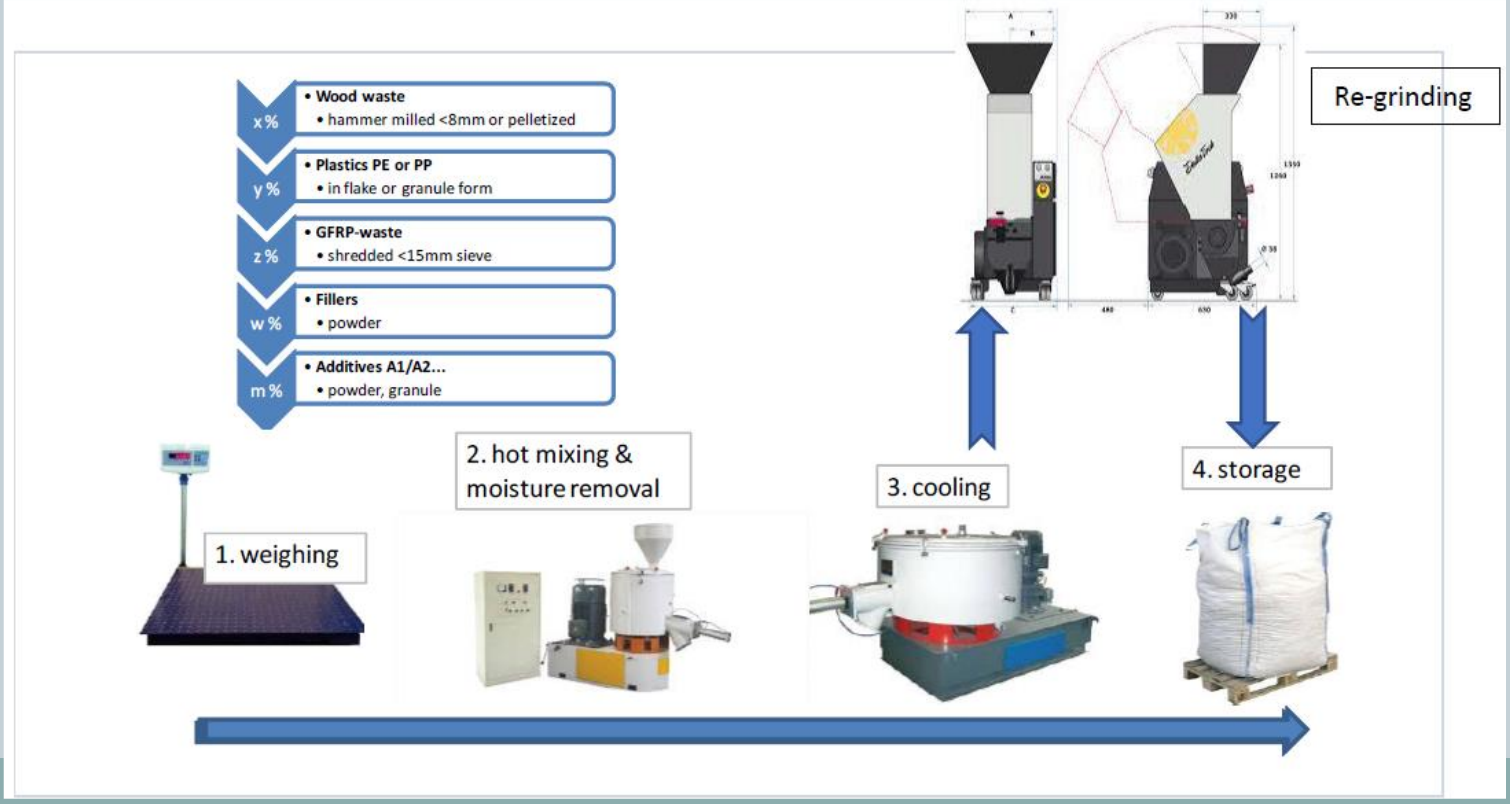
Conenor multilayer composite sleeper reinforced with FRP-waste



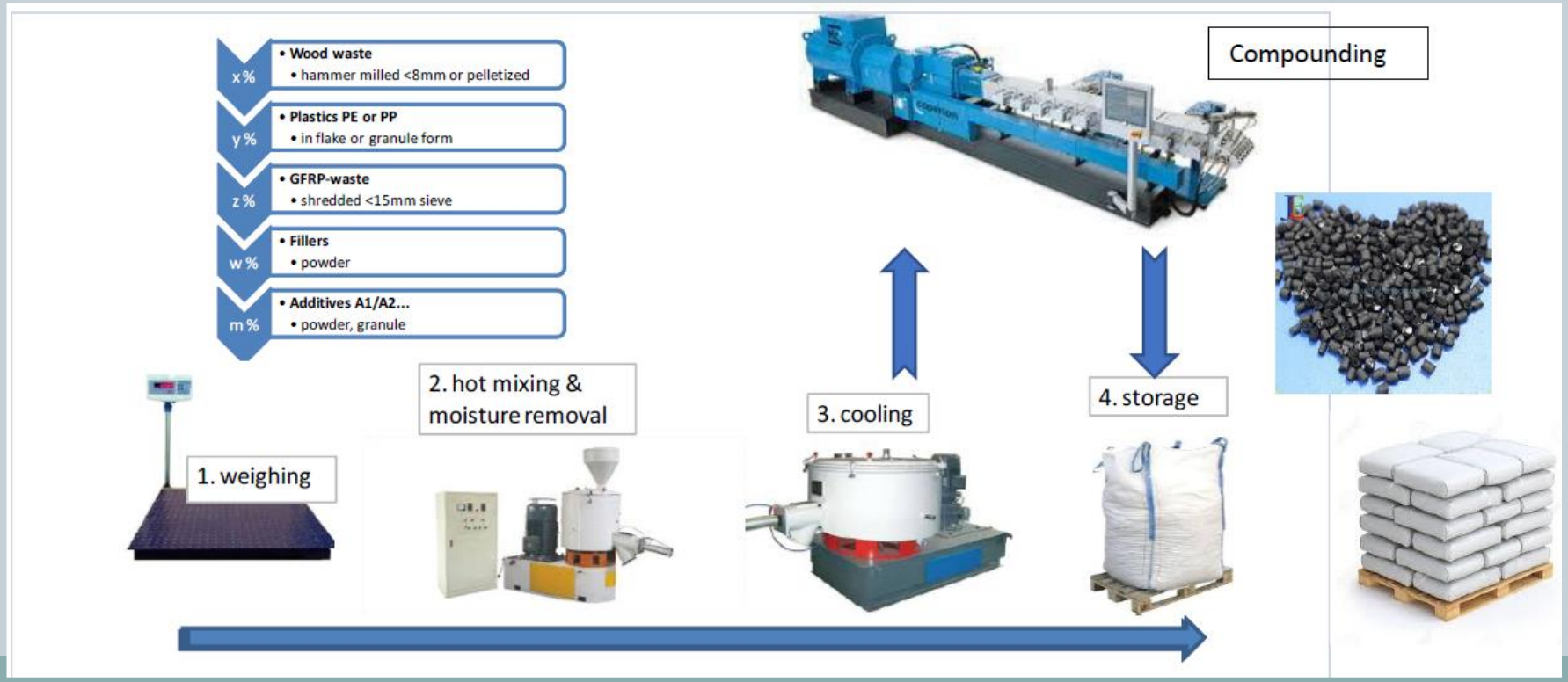
Production of random sized agglomerates reinforced with FRP-waste



Production of sized re-grinded agglomerates reinforced with FRP-waste



Production of compounded granules (*rSFT*) reinforced with FRP-waste



FRP-Waste Reinforced Material is an Invention by Conenor Ltd

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 159 127 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
15.07.2020 Bulletin 2020/29

(21) Application number: **17155520.4**

(22) Date of filing: **10.02.2017**

(51) Int Cl.:
B29B 7/00 *(2006.01)* ***B29B 7/10*** *(2006.01)*
B29B 7/90 *(2006.01)* ***B29B 9/08*** *(2006.01)*
B29K 105/24 *(2006.01)* *B29K 101/12* *(2006.01)*
B29K 105/06 *(2006.01)* *B29B 9/16* *(2006.01)*

(54) **METHOD FOR MANUFACTURING A PLASTIC COMPOSITION COMPRISING THERMOPLASTIC AND THERMOSET MATERIAL**

VERFAHREN ZUR HERSTELLUNG EINER KUNSTSTOFFMISCHUNG ENTHALTEND THERMOPLASTISCHES UND DUROPLASTISCHES MATERIAL

PROCÉDÉ DE FABRICATION D'UN MÉLANGE PLASTIQUE COMPORTANT UN MATÉRIAU THERMOPLASTIQUE ET UN MATÉRIAU THERMODURCISSABLE

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(43) Date of publication of application:
26.04.2017 Bulletin 2017/17

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(56) References cited:
EP-A1- 0 401 885
US-A- 5 861 117
US-B1- 6 497 956
WO-A1-01/08862
US-A1- 2003 125 399

Patent valid in the EU, USA, CAN and China

- Simple and Low Cost Thermo-Mechanical Process
- Using Commodity Existing Equipment
- No Processing Waste
- Applicable Stronger Material for Plastic Processing (injection, extrusion, intrusion)
- Technology Available on License Basis
- see http://www.conenor.com/s/EOLIS-final.pdf

Conenor Ltd – a Private Development Company in Waste Composites

CONENOR

www.conenor.com

- **SME founded 1995 specialized in composites from waste**
- **Inventor of unique CONEX®-Extrusion Technology**
- **Participation in EU-Commission co-funded R&D-projects;**
  - https://cordis.europa.eu/project/id/265212
  - https://cordis.europa.eu/project/id/609067
  - http://www.hiserproject.eu/
  - https://www.ecobulk.eu/
- **Outsourced client R&D-projects from waste composites for major corporations (including among others);**
  - UPM Group
  - StoraEnso
  - Kuusakoski / Metsähallitus
- **Licensing its patented technologies worldwide**