

Large scale uses for Polymer Composites made from post use mixed plastics.



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Composites 
Trade Association
Industry Award Winner 2016 - Environmental/Sustainability

businessGreen
**TECHNOLOGY
AWARDS 2016**
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Aims and Objectives realised

For the past 30 years composite products made from mixed plastic waste have been marketed at prices considerably higher than the concrete & wood products they replace. The markets therefore have remained “niche” at best relying on the environmental & maintenance free durability they offer. **We therefore set out and have achieved:**

- ✓ An efficient, fully automated safe process to manufacture a wide range of composite products made from mixed polymer waste arising from household, industrial & commercial arisings presently consigned to landfill;
- ✓ Determined the validity of the products in terms of their physical & environmental performance to meet structurally loaded applications
- ✓ Proven the fully automated process technology & the products in field trials;
- ✓ **Enabled products to be marketed at prices that compare and in many cases undercut those paid for the concrete & wood products they replace.**
- ✓ Provide considerable whole life performance savings in both cost and environmental impact.

Re-Formative engineering technology

developed from:

- A project started in the 1990's to manufacture composite cross ties for TieTek in the USA, which in the UK led to sample edge kerbs being made and used successfully in field trials together with major house builders;
- Extensive market research showed potential for a wide variety of composite products could be made from post use mixed plastics packaging in place of concrete, hardwood and treated softwood, where given their superior effective longer maintenance free service life offered whole life environment and economic performance benefits;
- It was clear that achieving initial cost parity with these traditional materials would remove price as a major obstacle;
- Successful trials proved the validity of the process with its ability to produce 6-8 times faster than existing systems.

Composite product applications:

Rail sector:

- ✓ **Rail sleepers** in place of creosote treated wood sleepers and bearers;
- ✓ **Noise barriers** for HS2 and the whole of the rail network;
- ✓ **Cable troughs** in place of concrete reducing carbon emissions by 95%;
- ✓ **Fencing**, long lasting, maintenance free.

Marine and fluvial:

- ✓ **Reinforced composites** designed to match and better the physical performance of tropical hardwood and concrete against catastrophic weather affecting coastal erosion and improve resilience from floods to homes, road and rail infrastructure.

Telecommunications, Power and roads:

- ✓ **Composite cable poles** in place of short service life wood poles as a solution to the forthcoming EU ban on use of creosote as a preservative;
- ✓ Composite road kerbs, 60% lighter than concrete, saving 95% carbon emissions, delivery and installation costs.

Realising the potential

- ✓ Many of the composite product applications do not require the need for reinforcement. Where products are not subjected to high structural loads, as in the case of kerbing, fencing, cable troughs, experience has shown that consistent quality in terms of toughness and resistance to weathering is achievable using 100% mixed recovered polymers that are presently mostly landfilled. Examples have been in use for more than 40 years in a wide variety of climatic conditions and therefore Revaluetechnology formed a partnership with Reluma GmbH in Germany to introduce their composites to the UK market.
- ✓ The need to reinforce the mixed plastics to be used in structurally loaded applications, as in rail sleepers and groyne construction was a missing factor in Revaluetechnology development. In 2013 collaboration with Univ. of Sheffield was initiated to find ways in which use could be made of their previous composite rail sleeper research programme.
- ✓ It is from this that earlier this year our “step change” occurred when Professor Alma Hodzic agreed to work directly with ourselves, having left the University where she had successfully led the Composites Engineering function for nine years. Alma will explain how and why the combination of her formulations knowledge combined with Revaluetechnology processing technology provides the means to avoid destruction of tropical rain forests and reduce carbon emissions associated with concrete manufacture.

Sources of Polymer Recyclates

Polymer Recyclates

Manufacturing waste

Contaminated process scrap and purgings
Rejected parts: incorrect colour, faulty printing, incorrect contents
Excess product/end of lines

Post industrial waste

End of life products: wheelie bins, sharp containers, barrels and bulk containers, astroturf, exhibition carpet, coat hangers

Industrial and commercial packaging

Plant pots, bottle and bread crates, agricultural film stretch-wrap films and returnable transit packaging such as pallets, crates

Post-consumer packaging

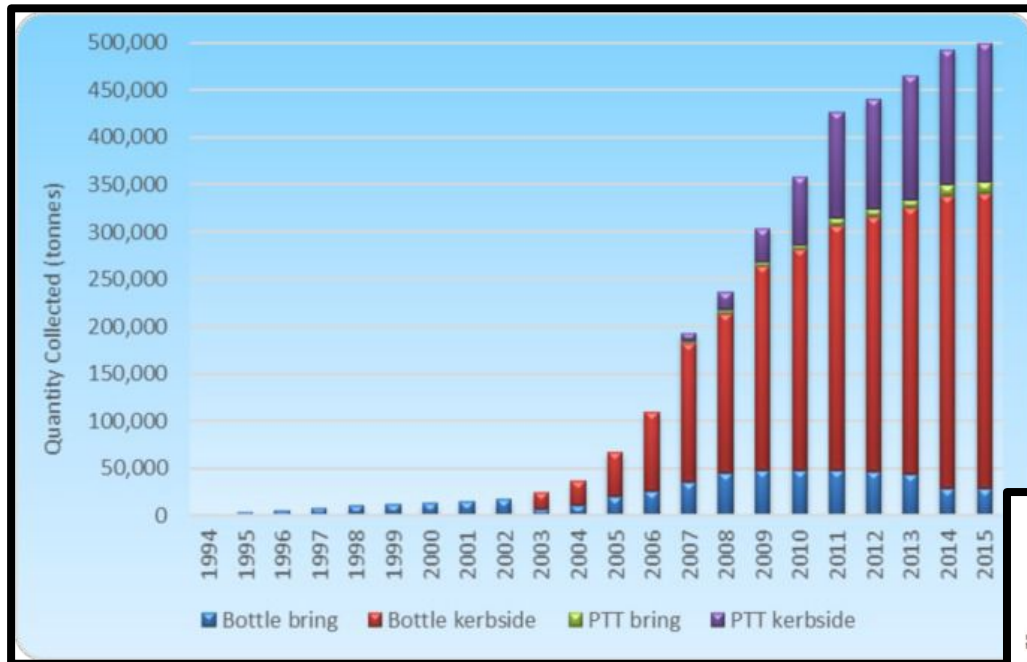
Plastic bottles
Rigid or flexible plastic: pots, tubs, trays
Films

Post-consumer waste

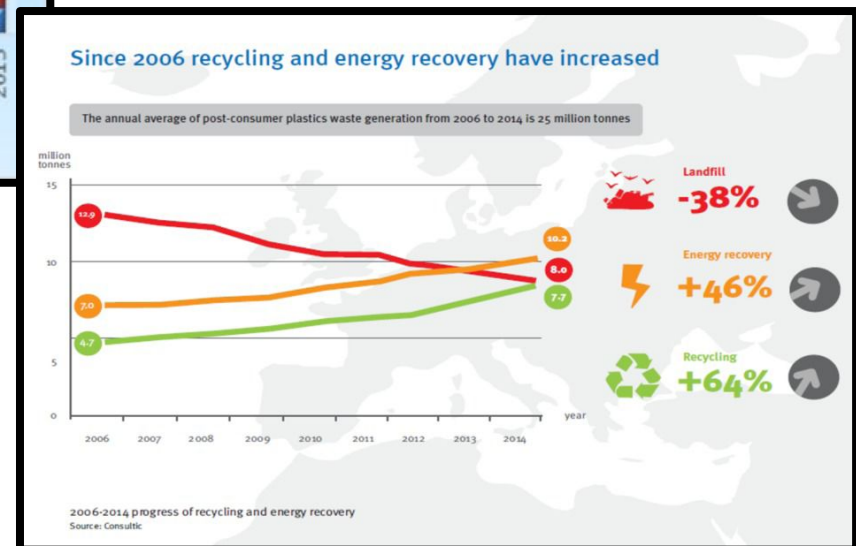
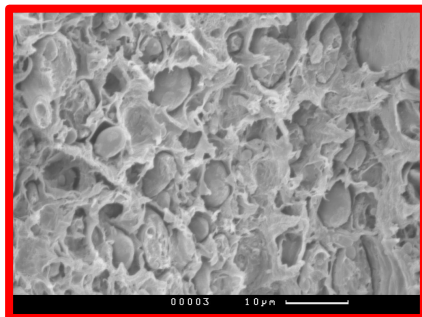
Fridges, TVs, electronics, electrical goods, carpets, cars, etc

PET	HDPE	PP	PS	PE
Bottles	Bottles	Frozen/tubs	Punnets	Films
Pots	Cleaning items	MW trays	Trays	Foams
Tubs		Punnets	Pots	Bubble wrap
Punnets		Trays		Pipes
Trays		Cleaning items		
		Pots		
		Films		

The growing problem: synthetic polymer waste



Recoup UK Household Plastics Collection Survey 2016



Immiscible polymer blends with GF

Progress of recycling & energy recovery in the EU (source: plastics: the facts)



Plastics PACKAGING has the highest recycling and energy recovery rates

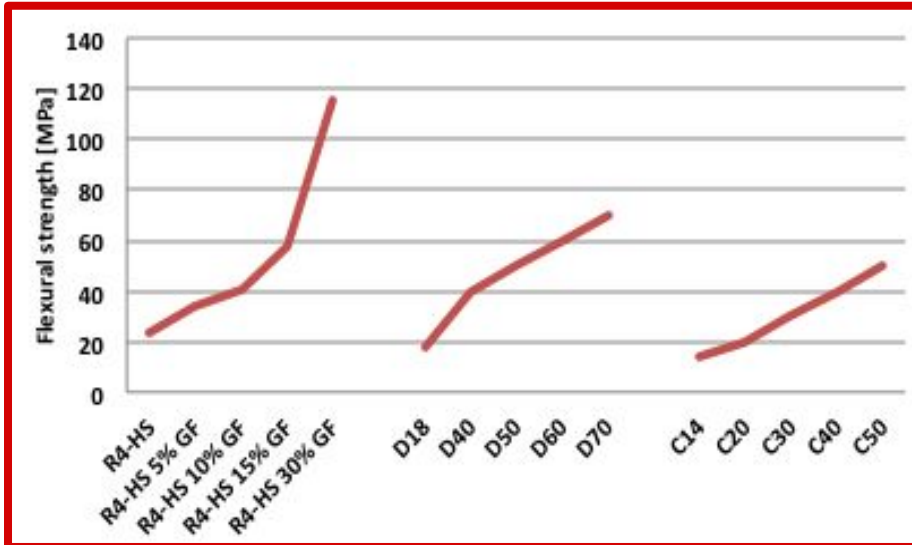


Packaging recycling and energy recovery rate by country 2014

(Referred to post-consumer plastics waste)

Source: Consultic

Replacing hardwood and softwood



Recycled polymer composite strength is the main design criterion in meeting the properties of the hardwood & softwood structures. Stiffness can be adjusted by changing profile dimensions.

Selected Materials	Strength [MPa]	Modulus [GPa]	Potential Replacement
D70 Hardwood	70	20	-
D60 Hardwood	60	17	-
D50 Hardwood	50	14	-
C50 Softwood	50	16	-
C40 Softwood	40	14	-
C30 Softwood	30	12	-
R4-HS with 30% Glass Fibre	116	5.35	All D and C classes
R4-HS with 20% Glass Fibre	77	3.5	D18-D60, all C classes
R4-HS with 15% Glass Fibre	58	2.7	D18-D50, all C classes

Strength and elastic modulus values of the optimised recycled polymer composites vs. softwood and hardwood benchmarks used in civil engineering structures such as railway sleepers and coastal groynes.

Case study: Qatar

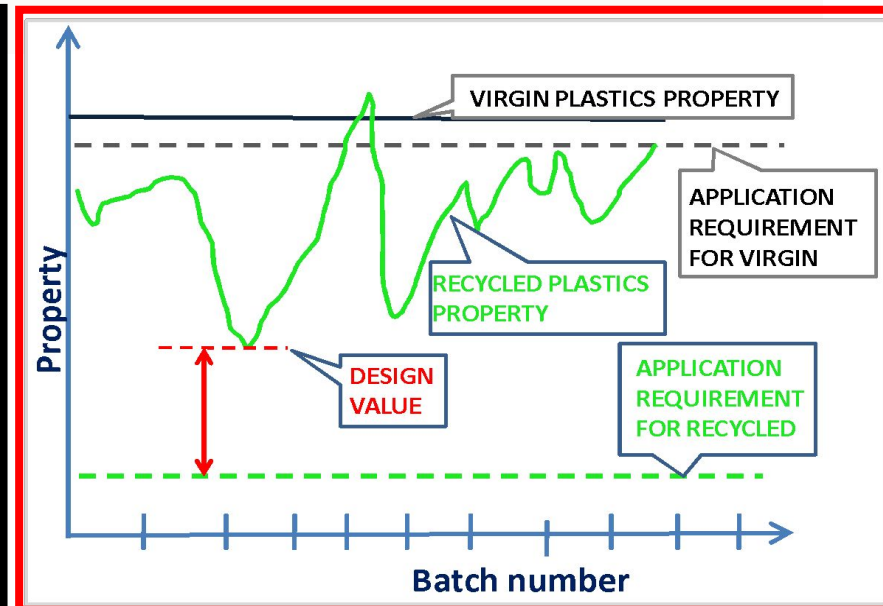
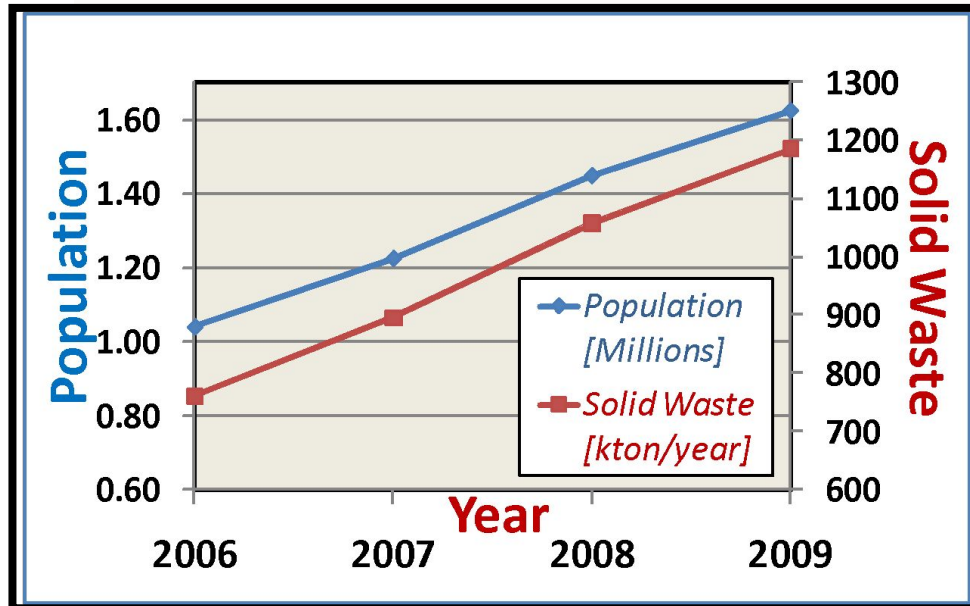
Industrial waste

- a viable feedstock for developing a product with consistent performance

Post consumer waste

- uncertain supply of raw materials
- lack of certifiable performance
- change of composition of waste with time and residential area

Variability Assessment - Availability, Collectability and Recyclability

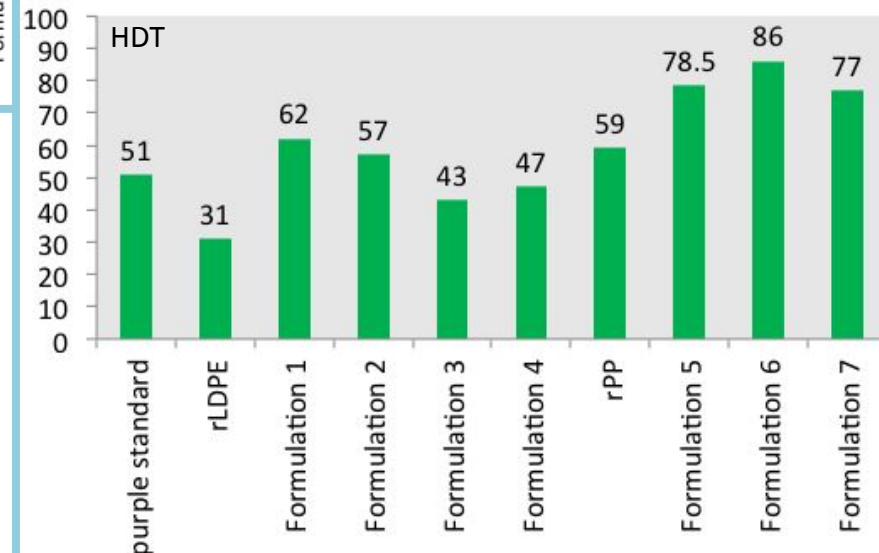
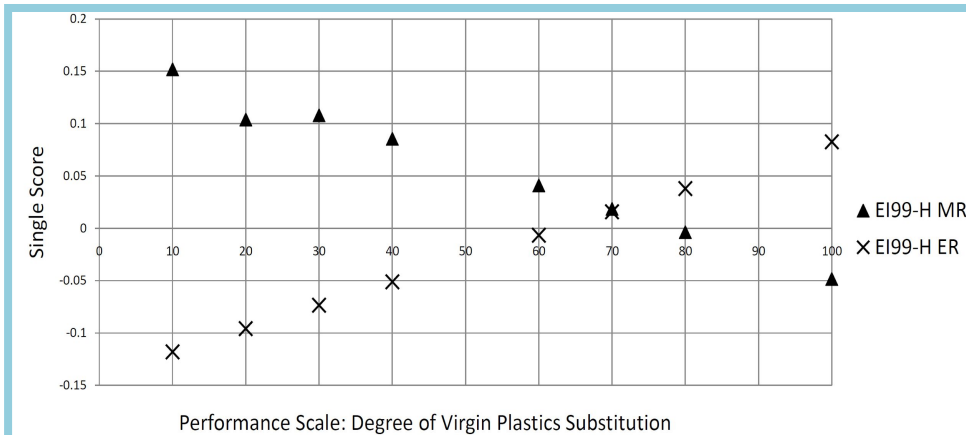
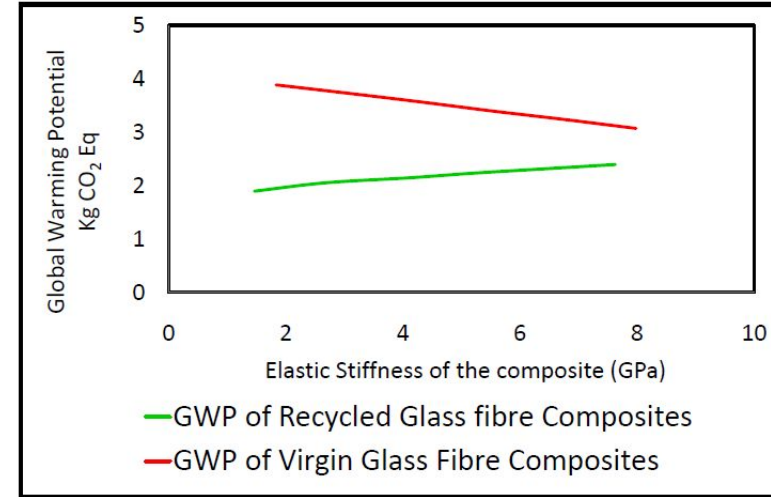
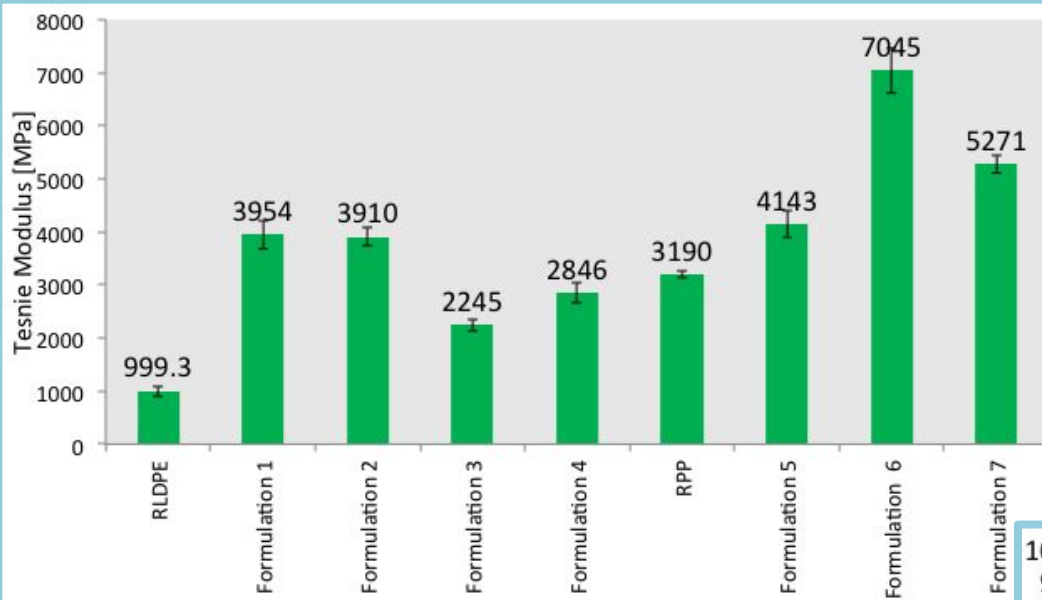




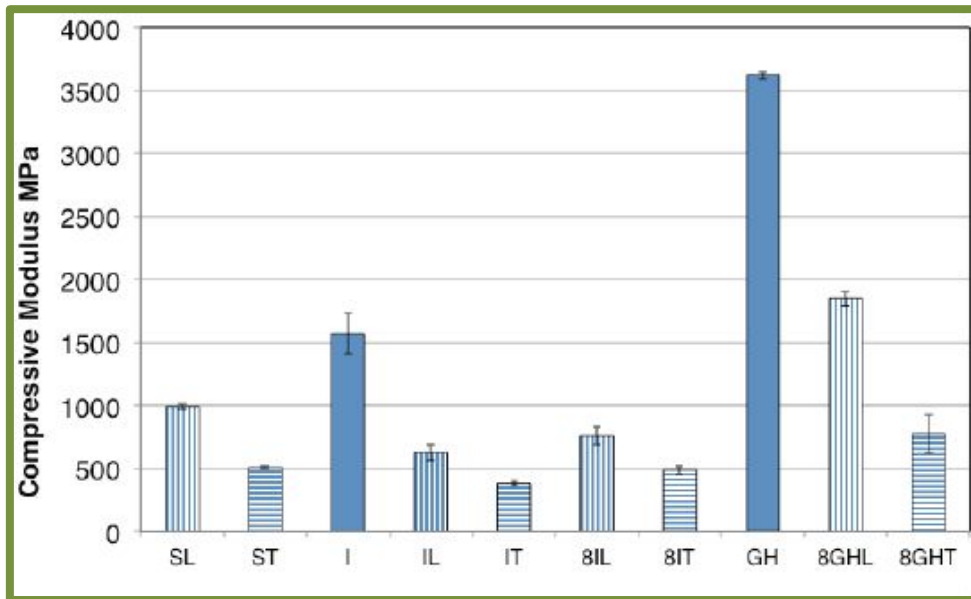
Revaluetech

Polymer Re-Formative Engineering

Case study: Qatar

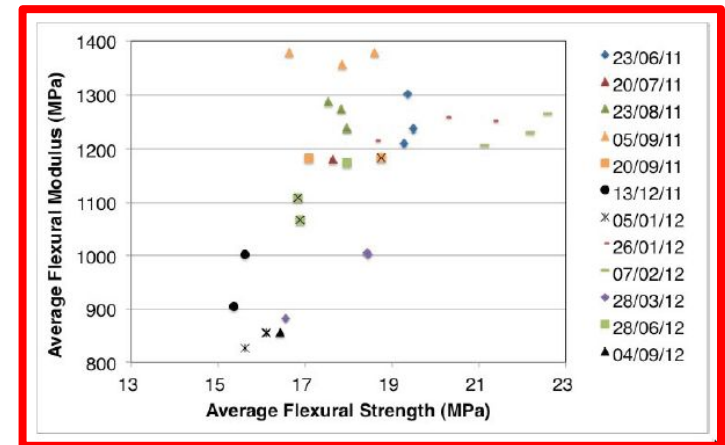


Case study: Railway sleepers

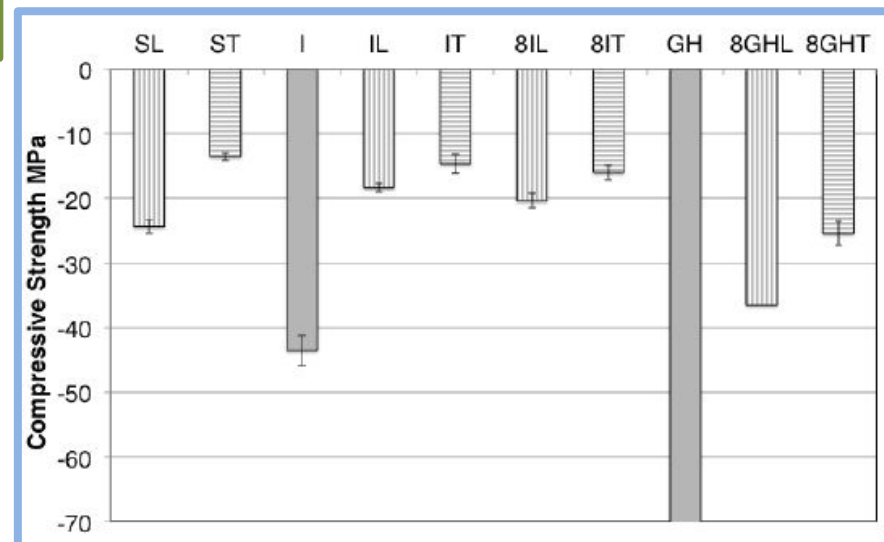


Average compressive modulus measured longitudinal (L), transverse (T) and indentation of a metal 80x40.5 mm block on the wide face of a profile (solid blue). Grades: Standard (S), Impact (I), Glass reinforced (GH). $\pm$ standard deviation is plotted. No prefix 100x100 mm profile, 8 = 80x80 mm profile.

Average compressive strength of a range of profiles with $\pm$ standard deviation.



Variation between different production unreinforced batches in 50x125 mm profiles.



Case study: Railway sleepers

✧ Challenges

- ✧ Manufacturing consistency due to polymer blend shrinkage in mould.
- ✧ Selection of 2-3 compatible polyolefins limited the recycling options.
- ✧ Tg of polymers was found to be dominant parameter in the fatigue test – should be kept as low as possible.
- ✧ Weight and cost of the product should not be prioritised over increased durability and lower maintenance cost, however the cost was found to be dominant.

✧ Improvements

- ✧ Immiscible polymers found to be beneficial in this application due to the increased energy dissipation.
- ✧ Hyperstatic system of sleepers and rails was not affected by the sleeper modulus reduction compared to wood.
- ✧ Reinforcement had to be added to maintain the properties and to minimise the recycle fluctuations.
- ✧ Despite the full test protocol being co-developed and approved by the Network Rail, the cost of the sleeper buried the project, due to industrial waste cost dependency.



Challenges with the use of recycled polymers

- ✧ The raw materials stream is already modified to the extent where it is not possible to identify the physical properties of the virgin polymers,
- ✧ The investigation into the variability of the recycled polymer stream has shown that the inconsistencies in the polymer properties can be used as the advantage as long as the basic mechanical properties and the glass transition temperature are maintained within the materials design & selection boundaries,
- ✧ The strength is the main property to be achieved as the stiffness can be improved by increasing the profile section dimensions,
- ✧ Glass fibre reinforced immiscible recycled polymer blends are capable of replacing hardwood with significant cost-effective benefits, and
- ✧ Softwood replacement requires carefully selected low-cost polyolefins from the post-consumer waste stream.

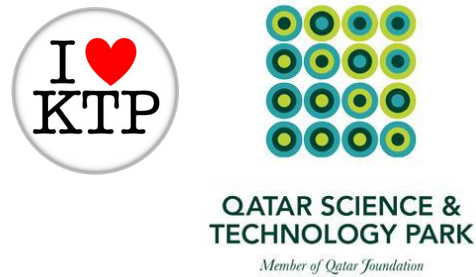
Lessons learned

- ✧ The variability in the recycled plastic price can cause detrimental financial consequences to the manufacturing of the final products due to the low profit margin,
- ✧ There is a massive difference between manufacturing of the commodity products versus highly tailored, consistent engineering structures capable of replacing coastal groyne timber structures and railways sleepers,
- ✧ The average R&D in recycled polymer composite structures is 3-5 years, including the systems tests,
- ✧ The research and engineering success criteria are highly dependent on the low cost materials selection and their consistent supply (management),
- ✧ Should the composition fall out of the low-cost boundary, it may result in the closure of the business,
- ✧ Composites are cost competitive with hardwood, treated softwood, concrete and therefore unaffected by oil or virgin polymer price fluctuations.

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