Decarbonising and Enhancing Sustainability in Cycling Infrastructure:

Applications of Tyre-Derived Materials in Urban Environments

List of materials used in cycling furniture

Plastics & Polymer

(1/6)

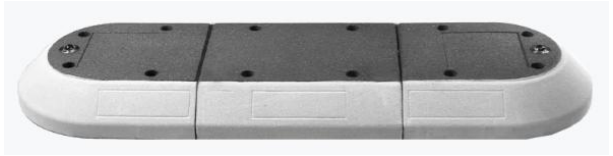
- Polyethylene (PE – HDPE / LDPE)
  - Where used: Flexible bollards, Modular lane separators, Cable-protected kerb units, Recycled-plastic benches
  - Why used: impact resistance, UV stability, lightweight, corrosion-proof
- Polypropylene (PP)
  - Where used: Modular traffic separators, Base elements for reflective posts
  - Why used: fatigue resistance, chemical resistance
- Polyurethane (PU)
  - Where used: Flexible delineator posts, Impact-absorbing separator elements
  - Why used: high elasticity, returns to shape after impact
- PVC (Polyvinyl Chloride)
  - Where used: Reflective sleeves, Sign housings
  - Why used: cost-effective, weather resistant

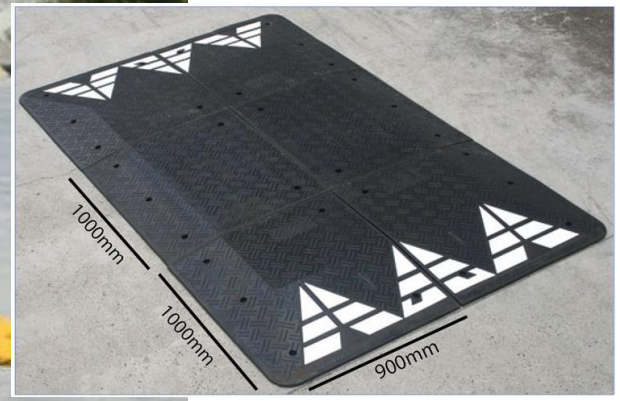
List of materials used in cycling furniture

Rubber & Elastomers

(2/6)

- Recycled Rubber (SBR)
  - Where used: Bolt-down lane separators, Speed cushions, Impact bases for bollards
  - Why used: shock absorption, skid resistance
- EPDM Rubber
  - Where used: Colored safety surfacing, Protective edging
  - Why used: UV resistance, weather durability
- Thermoplastic Elastomers (TPE)
  - Where used: Flexible separator modules, Anti-slip surfaces





List of materials used in cycling furniture

Metals

(3/6)

- Carbon Steel (Galvanized / Powder-Coated)
  - Where used: Bollards, Bike racks, Guardrails, Barriers
  - Why used: strength, structural performance
- Stainless Steel (AISI 304 / 316)
  - Where used: Premium bollards, Bike stands, Coastal installations
  - Why used: corrosion resistance
- Aluminum
  - Where used: Sign poles, Lightweight bollards, Shelter structures
  - Why used: lightweight, corrosion-resistant
- Cast Iron
  - Where used: Decorative bollards, Heritage areas
  - Why used: durability, traditional aesthetics
- Weathering Steel (Corten)
  - Where used: Architectural separators, Planters along cycle paths

List of materials used in cycling furniture

Concrete & Mineral Materials

(4/6)

- Reinforced Concrete (Precast)
  - Where used: Fixed bollards, Raised cycle-track kerbs, Traffic islands
  - Why used: mass, anti-ram resistance, durability
- Polymer Concrete
  - Where used: Modular separators, Drainage-integrated units
  - Why used: higher strength-to-weight ratio
- Fiber-Reinforced Concrete (GFRC)
  - Where used: Lightweight architectural elements
- Natural Stone (Granite / Limestone)
  - Where used: Historic city bollards, Kerb stones

List of materials used in cycling furniture

Wood & Engineered Timber

(5/6)

- Hardwood (Oak, Robinia, Tropical Hardwoods)
  - Where used: Natural bollards, Edge barriers, Benches
  - Why used: aesthetic integration in parks/greenways
- Softwood (Pressure Treated Pine)
  - Where used: Rural path edging, Rail barriers
- Glulam / Engineered Timber
  - Where used: Bike shelters, Covered rest areas

List of materials used in cycling furniture

Composites & Advanced Materials

(6/6)

- Fiberglass (GFRP / FRP)
  - Where used: Lightweight flexible bollards, Corrosion-free posts
- Carbon Fiber (rare, premium use)
  - Where used: Lightweight structural elements
- Wood-Plastic Composite (WPC)
  - Where used: Benches, Decking along cycle paths

Performance goals & SMILE CITY project

Performance Goal	Typical Materials	SMILE CITY specific contribution
Flexible impact absorption	PU, PE, rubber	PE/PP/HDPE & *ELT powder* Rubber & *devulcanised ELT rubber* Rubber & *ELT textile fibres* PE/PP/HDPE & *ELT textile fibres* PU glue & *ELT crumb (cold and hot molded)*
Heavy vehicle protection	Reinforced concrete, steel	
Coastal corrosion resistance	Stainless steel, aluminum, FRP	
Sustainable / recycled	Recycled plastics, rubber, WPC	PE/PP/HDPE & *ELT powder* Rubber & *devulcanised ELT rubber* Rubber & *ELT textile fibres* PE/PP/HDPE & *ELT textile fibres* PU glue & *ELT crumb (cold and hot molded)*
Natural / park environments	Hardwood, glulam, corten	

Benefits & Key performance indicators

Base materials	ELT derived components		
	Fibres	Powders	Devulcanised rubber
Thermoplastics	Eco-filler Cost saver **Performance enabler**	**Charpy impact** Eco-filler Cost saver	**Charpy impact** Eco-filler Cost saver
Rubber compounds	Eco-filler Cost saver **Cut-through protection** **Mooney regulation** **Hardness regulator**	**Processing add** Eco-filler Cost saver	Eco-filler **Cost saver**

What is possible (1/4)

Recycling technology	Sample composition	Recycled content	Mechanical properties		
			Tensile strength (MPa)	Elongation at brake (%)	Charpy V-notch (kJ/m^2)
Reactive sintering	Crumb <3.5 mm without any additives	100%	0.6-1.1	22-84	
Actualy performs well	Crumb 2-3 mm + polyurethane binder (up to 30 wt%)	>70%	0.4-1.2	3-62	
	Powder 0.18-0.38 mm + sulfur-based curing system	~100%	6.7-9.5	160-240	

What is possible (2/4)

Recycling technology	Sample composition	Recycled content	Mechanical properties		
			Tensile strength (MPa)	Elongation at brake (%)	Charpy V-notch (kJ/m^2)
Reclaiming & Devulc.	Reclaimed powder <0,6 mm and molded without additives	100%	3.2-5.1	135-160	
	Reclaimed powder 0.25 mm + sulfur-based curing system	~100%	4.2-8.1	109-202	
	Reclaimed powder <1.5 mm (mix of tyres) + sulfur-based curing system	~100%	4.1-6.9	187-310	
	Reclaimed powder (whole PC tyre) + sulfur-based curing system	~100%	5-8	<200%	
	Reclaimed powder (TT treads) + sulfur-based curing system	~100%	6.0-16.5	355-400	

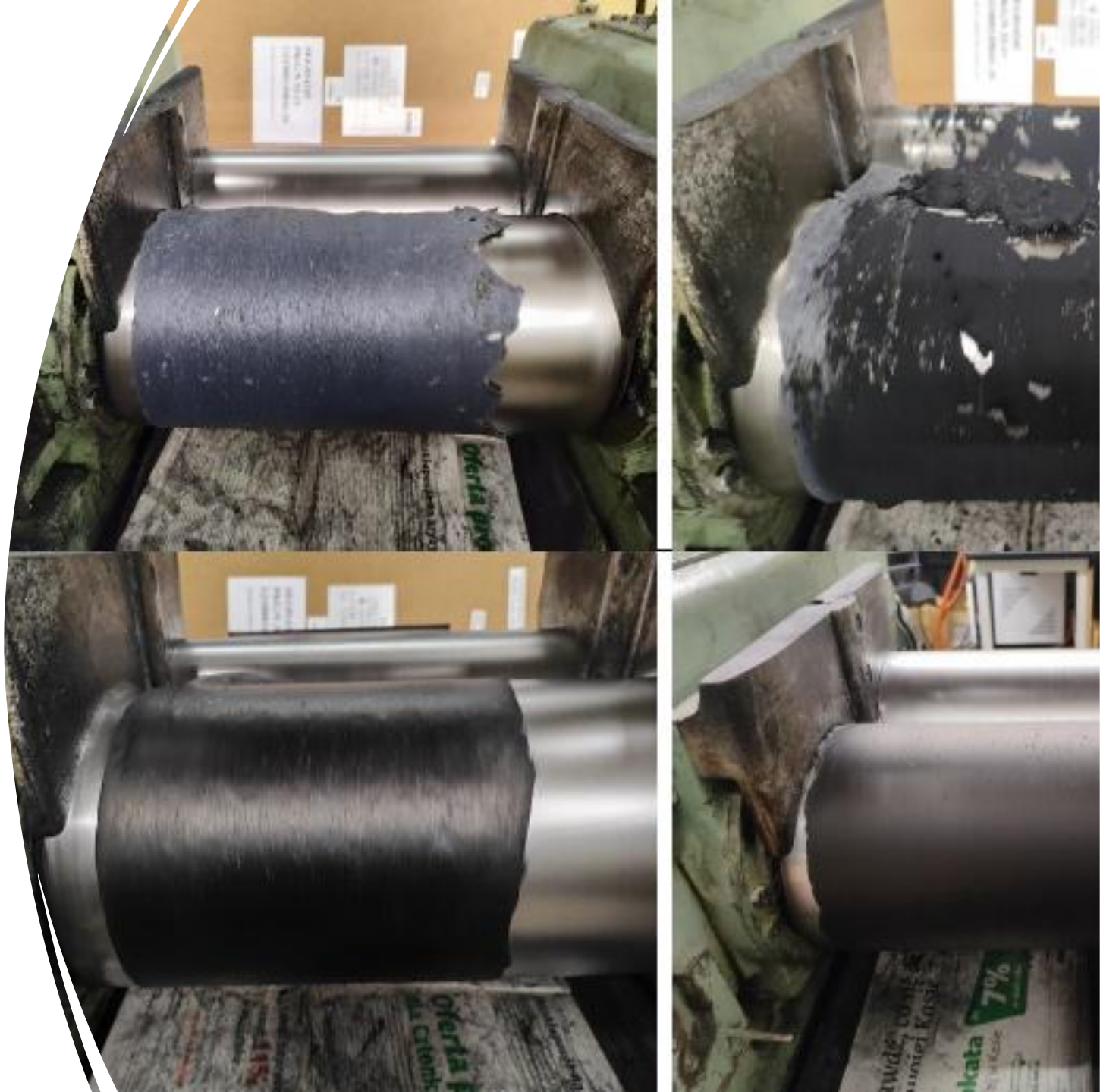
What is possible (3/4)

Recycling technology	Sample composition	Recycled content	Mechanical properties		
			Tensile strength (MPa)	Elongation at brake (%)	Charpy V-notch (kJ/m^2)
Rubber compound.	Devulc + SBR or NR (0-20 wt%) + sulfur-based curing system	>80%	3.1-6.0	100-200	
	Devulc powder <0.595 mm + NR (0-30 wt%) + sulfur-based curing system	>70%	8-9	400-575	
	Devulc powder mix of tires <0.6 mm + elastomers: SEBS, SBR or EOC (2.5-15 phr) + peroxide-based curing agent	>70%	5.2-8.1	113-136	
	Textiles + SBR + sulfur-based curing system	5-50%	12-20 (50-83%)	300-650 (41-90%)	

NEW

First Elitex then CB

- SBR_CB50EX50
- 50 phr N330 & 50 phr Elitex 4mm
- Flowing properly
  - Flows better than OKS
- Hard to cut through
  - Hint for applications



Processability

SBR_CB50EX2.5

SBR_CB50EX5

SBR_CB50EX10

SBR_CB50EX15

SBR_CB50EX25

SBR_CB50EX50

What is possible (4/4)

Recycling technology	Sample composition	Recycled content	Mechanical properties		
			Tensile strength (MPa)	Elongation at brake (%)	Charpy V-notch (kJ/m^2)
Melt-blending	Powder 0.315-0.630 mm + EVA 20-30 wt%	>70%	1.6-2.7	100-140	
	Powder mix of tires <0.6 mm + LLDPE, EOC, TOR, EVA (25 wt%)	75%	2.9-4.4	66-440	
	Powder truck tires + HDPE (20 wt%) + curing agents	80%	2.2-4.3	10-58	
	Powder treads and side walls 0.595 mm + PP (20 wt%) + curing agents	80%	1.5-2.5	15-38	
	Powder 0,4 mm + PP no curing agents	10-30%	18.5-28.2 (54-82%)	12.7-16.7 (2-3%)	**3.3-4.9 (110-163%)** **NEW**
	Powder 0,4 mm + HDPE no curing agents	10-30%	15.8-21.8 (63-87%)	34-54.1 (7-12.2%)	**4-6.4 (108-172%)**

European standards for cycling infrastructure (bollards, delineators, separators, kerbs, etc.) generally **do NOT** prescribe explicit material-level values such as minimum tensile strength or elongation at break for plastics or rubber.
Instead, they require **performance-based mechanical behavior,** verified **through product-level tests** (impact, deflection, durability).

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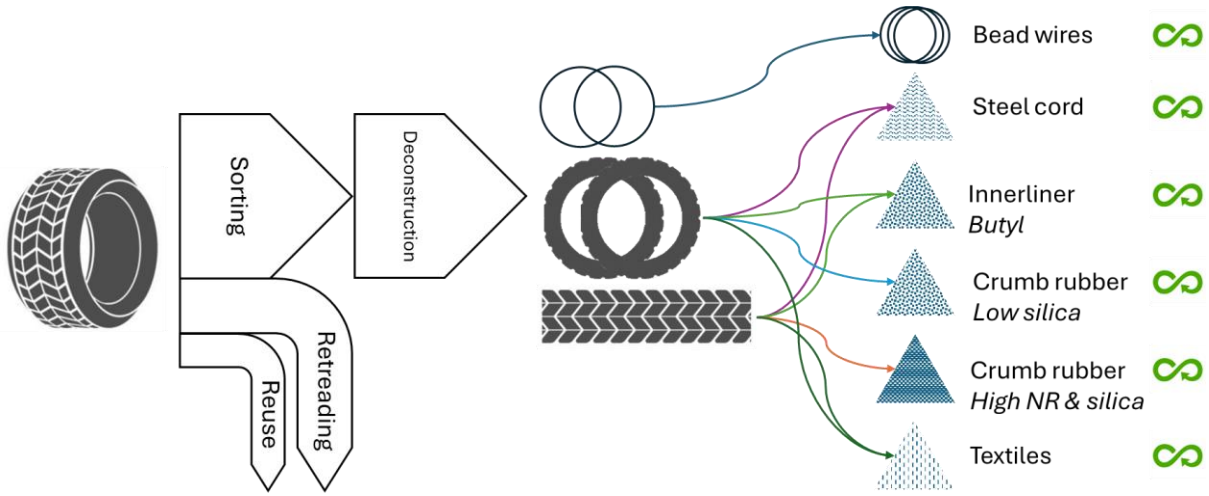
Recommendations – the recipe for success



- Consistency == sorting & deconstruction
- Performance == sorting & deconstruction & PSD & spec.surf.
- Processing cost (pressure, temp.) == PSD & specific surface
- Bankability == cost savings
- Bankability == performance
- Bankability == recycled content
- Bankability == low GWP (EPD, ISCC+)

See you at the next ETRA conference

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