



Recycling of Fibre Reinforced Polymer (FRP) Composite Materials

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2nd National Civil Engineering Symposium 14-15 Sep 2022

Outline

- Background
- Global market share
- FRP waste disposal methods
- Cost of Recycling methods
- Conclusions



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LABORATORY STRESS
STRENGTH TESTING OF
GEO MATERIALS



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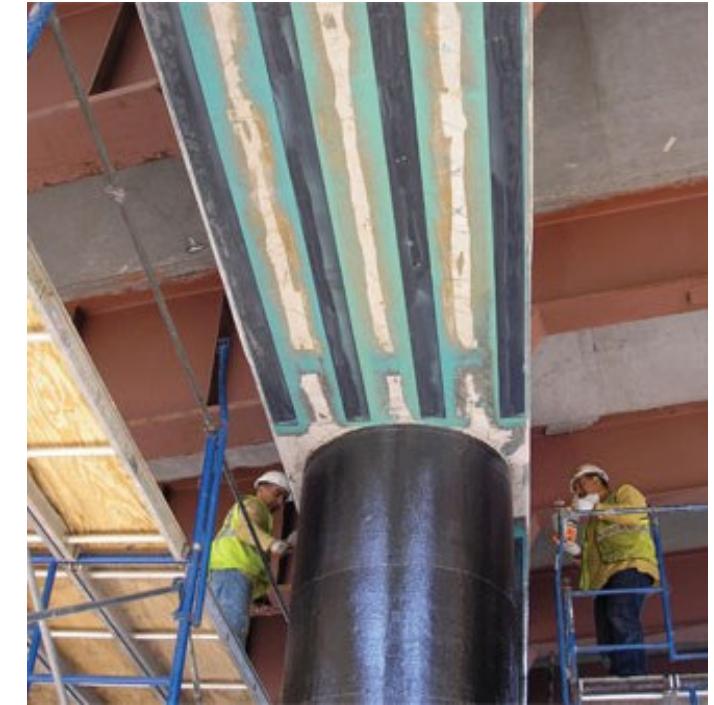
Background



FRP profiles



FRP rebars



FRP strengthening

Background

Dawlish footbridge Devon UK

All composite FRP footbridge spanning a coastal railway line



Old rusty steel bridge reconstructed in 1937



New All-FRP bridge 2011 – **no corrosion**

Global Market share

- As per JEC group – FRP production value of USD 100 billion and a volume of more than 12 million metric ton (Mt) in 2021
- FRP applications in more than 15 industries
- For next five years, FRP industry set to grow 2-9%
- 95% Glass FRP, of which 75% use thermoset resin



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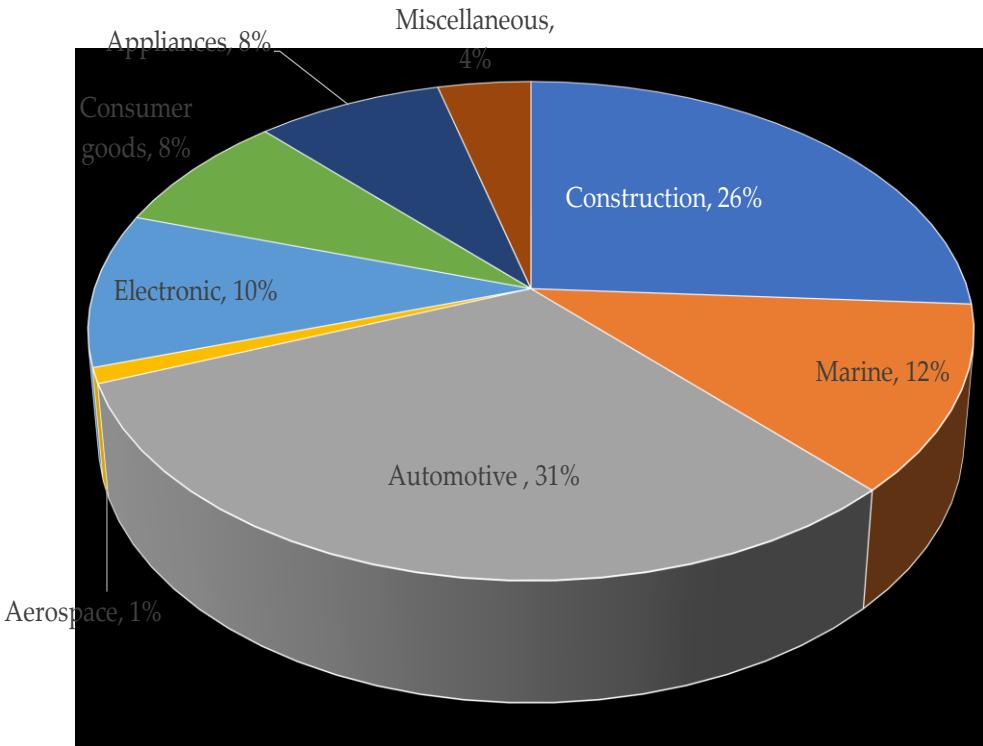


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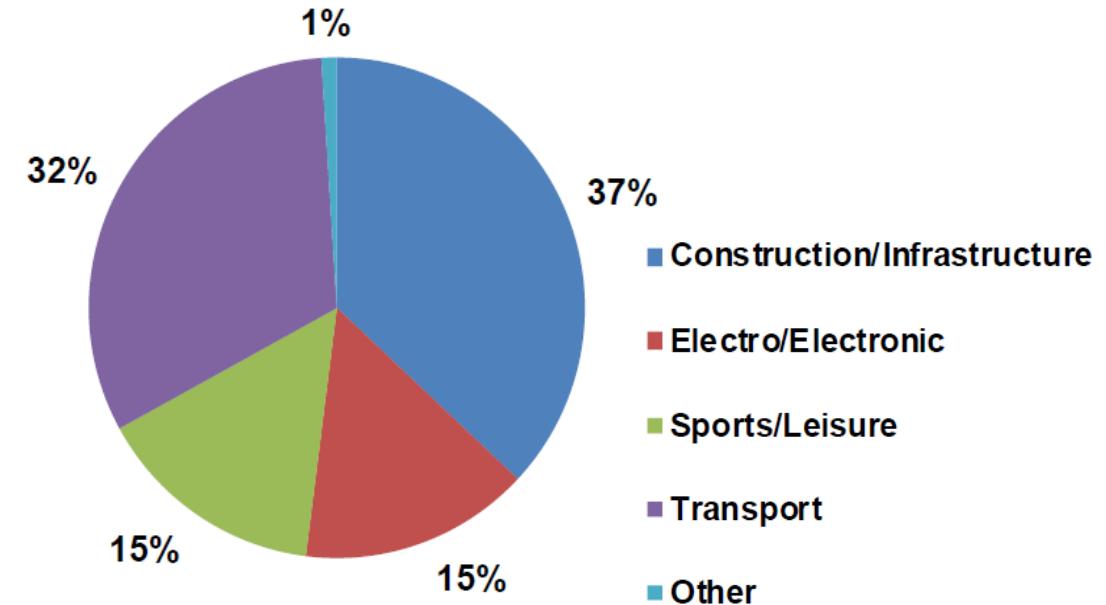
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Global Market share



Market share of **Fibre Reinforced Polymer (FRP)** by application

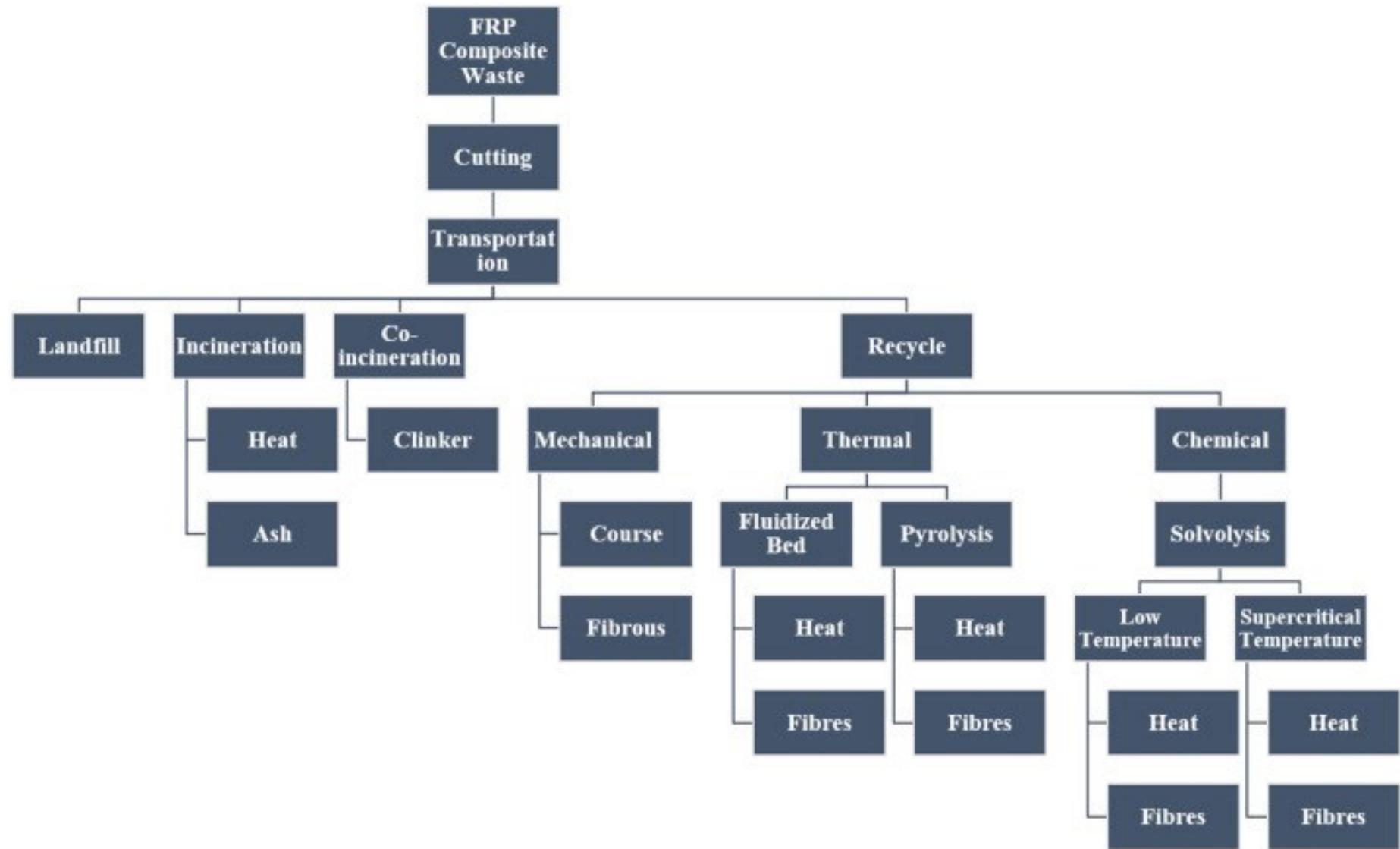


Europe GFRP market share by application in 2020

FRP composite waste

- Waste generated from production (scrap) and end-of-life usage
- 40% waste from production- dumped as scrap or defective parts
- Landfill & incineration are traditional ways for waste disposal
- US – almost all landfill; strict laws in Europe for dumping
- GFRP waste in Europe is 304 kt by 2020 (1/3 of production)





Vo Dong *et al.* (2015)



Landfill

- Pros:
 - Cost efficient technique
- Cons:
 - Pollution to the local environment
 - Creates greenhouse gases i.e. methane
 - Spreads infectious diseases

Incineration and co-incineration

- Pros:
 - Convert solid waste into ash, gas and heat
 - Landfill space is reduced
- Cons:
 - Expensive to build, maintain and operate
 - Skilled labour required
 - Generate toxic gases harmful to people

Recycling

- Pros
 - Helps to protect the environment
 - Reduce processing raw materials and energy consumption
 - Reduce pollution
 - Reduce greenhouse gases emission and global warming
- Cons
 - Required high capital cost
 - Products of recycling waste may not give same property as a virgin product

Gharde and Kandasubramanian (2019)



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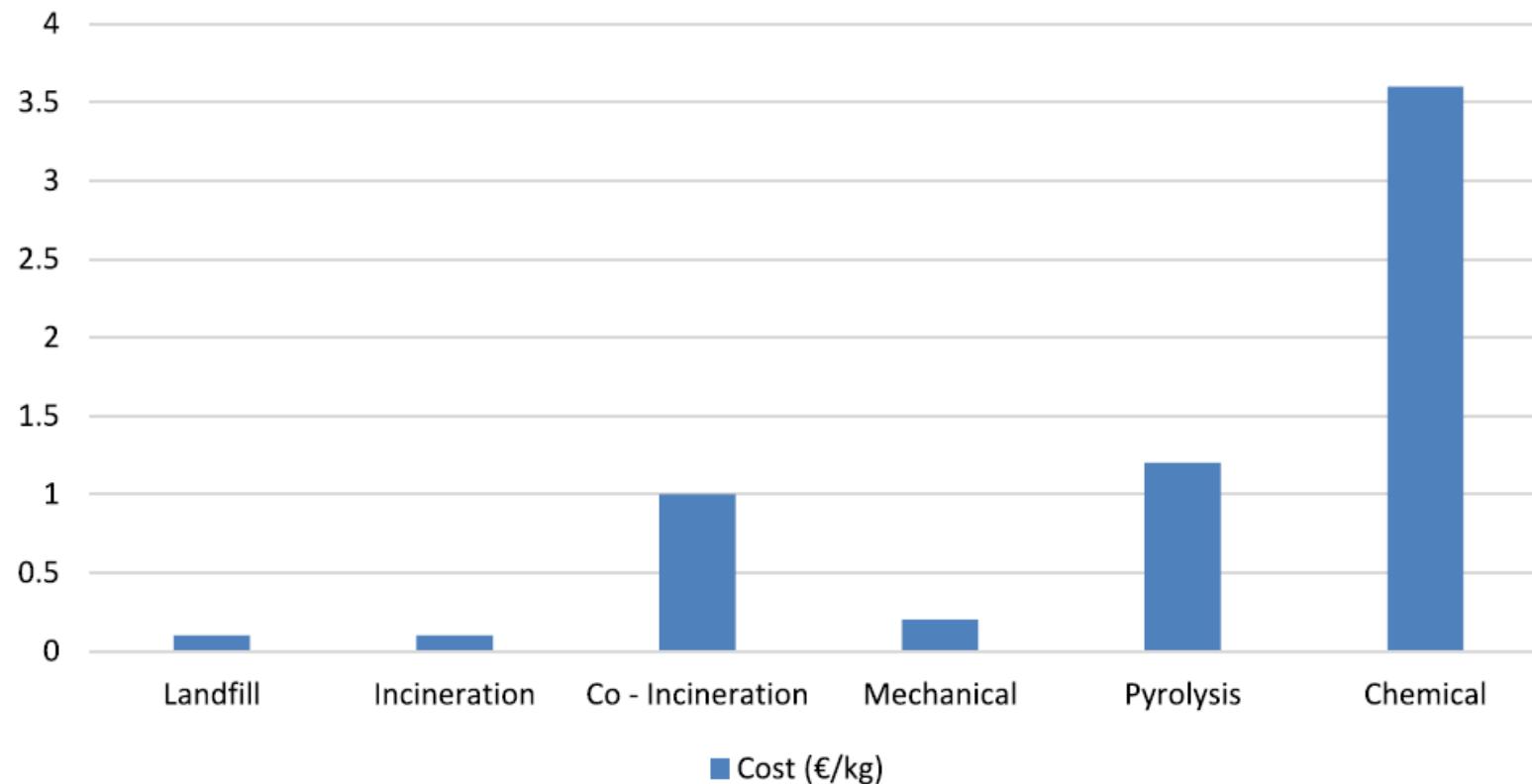


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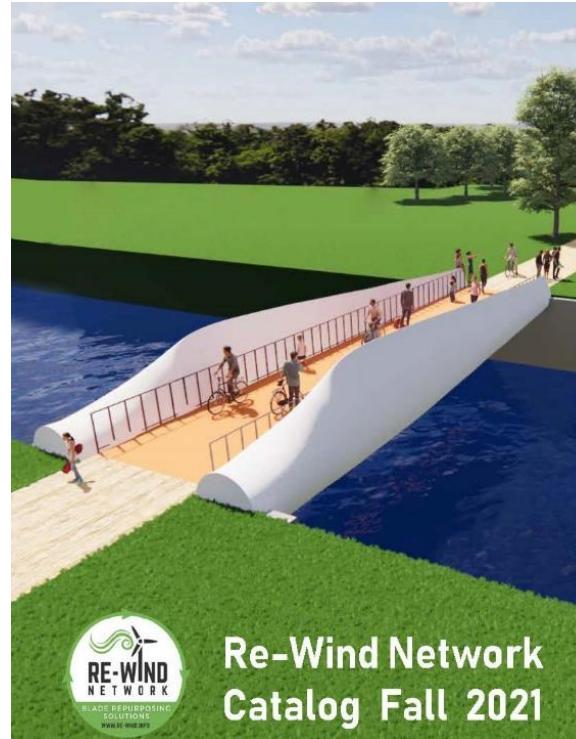
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Cost of FRP recycling/disposal



Average cost of FRP waste disposal technique per unit mass of waste in 2018 (Gharde and Kandasubramanian, 2019)

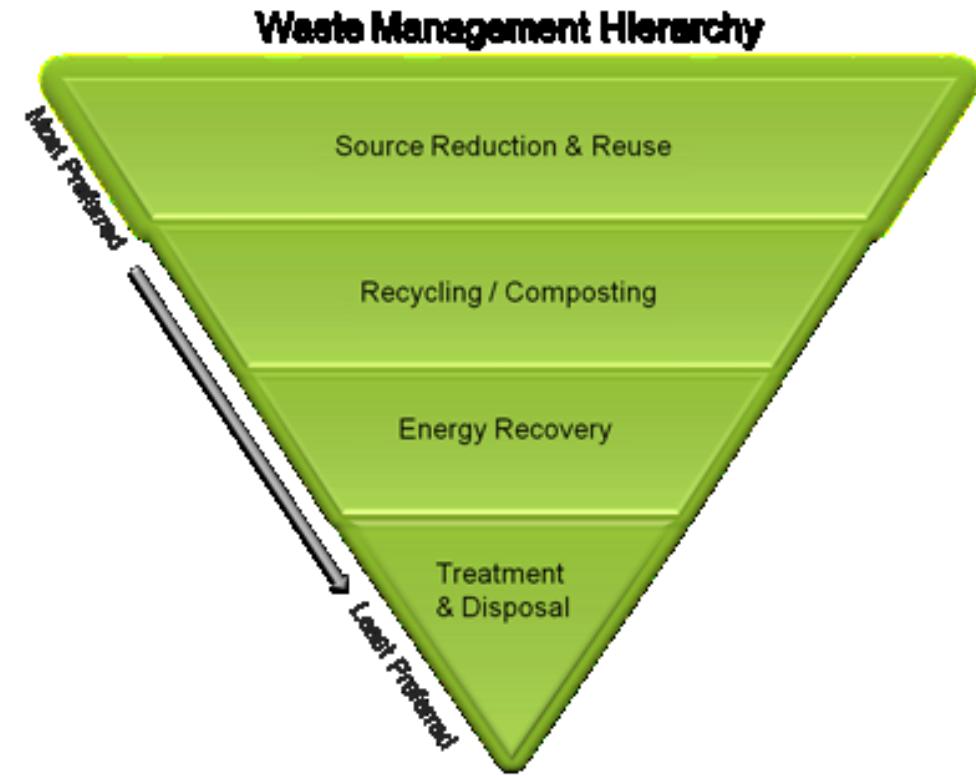
Reuse or repurpose



Graphics: A. McDonald, S. Kakkad, C. Kiernicki, A. Poff, T. Al-Haddad, M. Bermek, S. Li, J. Respert and C. Woodham, Georgia Tech, USA

End-of-Life of FRP composites

- Reuse
- Repurpose
- Recycle (mechanical)
- Recover (materials)
- Co-process (cement)
- Incinerate (energy)
- Landfill



<https://www.epa.gov/homeland-security-waste/waste-management-hierarchy-and-homeland-security-incidents>



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Conclusions

- Recycling of FRP is a major challenge
- Landfill is the most common and cheapest technique
- Mechanical recycling is the most economically viable
- Low-cost Glass FRP is most difficult to recycle
- Reusing or repurposing is the way forward



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Gharde, S. and Kandasubramanian, B. (2019) 'Mechanochemical and chemical recycling methodologies for the Fibre Reinforced Plastic (FRP)', *Environmental Technology & Innovation*, 14, p. 100311. doi: 10.1016/j.eti.2019.01.005.

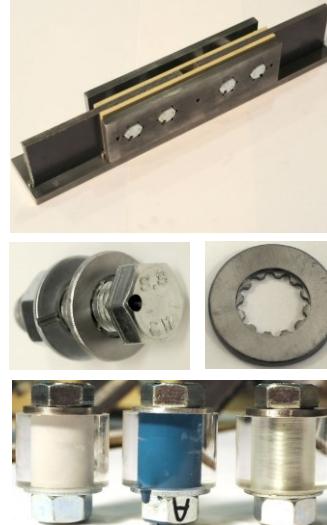
Vo Dong, P. A. et al. (2015) 'Modelling of Environmental Impacts and Economic Benefits of Fibre Reinforced Polymers Composite Recycling Pathways', in Gernaey, K. V, Huusom, J. K., and Gani, R. B. T.-C. A. C. E. (eds) *12 International Symposium on Process Systems Engineering and 25 European Symposium on Computer Aided Process Engineering*. Elsevier, pp. 2009–2014. doi: 10.1016/B978-0-444-63576-1.50029-7.



Thanks for listening.....Questions?

A recent review paper:

Qureshi J. 2022. A Review of Fibre Reinforced Polymer Structures.
Fibers. 10(3):27.



A copy of this presentation is available at bit.ly/JQ-NCE2022

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