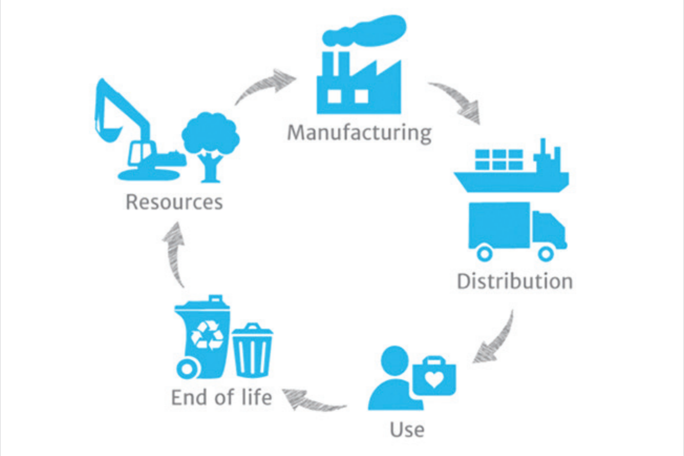
Environmental Impact and Embodied Energy

Sustainable Construction

The construction industry consumes more resources taken from the Earth (up to 50%) than any other industry. The construction, operation and subsequent demolition of all built facilities account for 40 –45% of the global energy use. FRP materials are light weight and have proven to provide longer lifespans than traditional construction materials, such as concrete, steel, and timber. Owing to these inherent characteristics FRP is a sustainable construction material. It is anticipated that FRP structures have less environmental impact than those made of conventional constructional materials.



Material Embodied Energy

The energy consumed by the production of FRP materials, also referred to as material-embodied energy, can vary significantly according to the type of the fibres and the manufacturing processes. The embodied energy increases as the percentage of resin in the composites increases. If the desire is to make the product greener based on embodied energy of the material, increasing the fibre volume fraction would be an option. It is should be noted that a high fibre volume fraction also makes the composite stronger and stiffer, thereby providing further opportunity for the optimal use of the material. CFRP has a higher embodied energy than most other construction materials, however, the embodied energy of GFRP composites, which are often used in the construction industry, is compatible with other materials. Amongst the widely used construction materials timber has a clear advantage as a low energy material. However, the need of a less total volume of GFRP materials together with its excellent durability characteristics mean GFRP is likely to have a less total embodied energy impact compared to most other construction materials.

Life Cycle Assessment

A reliable investigation of the impact of embodied energy in a given structure is not trivial; for instance, transportation can affect the embodied energy. A comprehensive life cycle assessment would have to be performed to determine the final comparative impact assessment of the construction. Life Cycle Assessment is a tool for the systematic evaluation of the environmental impacts of a structure over its life cycle from extraction of raw materials through end-of-life product disposal. Results of case studies of footbridges made of pultruded GFRP profiles highlight the environmental advantage of composites in terms of energy consumption compared to structural steel and reinforced concrete.

It should be noted that, however, the implementation of a life-cycle environmental analysis strongly depends on the availability of data for the various impacts and consistent evaluations of such impacts on the construction materials during the life-cycle. The existing methods have primarily been developed to investigate environmental impact of relatively simple units for which the techniques and service conditions are well determined. The real-life structures are more complex and the conditions are also very vague determined. For instance, life-cycle analyses strongly depend on the assessment of the deterioration of the structure and the evaluation of its actual service life. It should also be noted that every construction project is different, and a material or a system which offers the best environmental solution in one project, does not necessarily do it in the other. Clearly, major research is still needed in this area. However, this should not refrain the engineers from investigating the life cycle assessments of FRP structures.

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Sustainability

Recent reports from the industry suggest that FRP has been the most cost effective solution at “first installed” cost in a few recent structures. Even if the “first installed’ cost of FRP solutions in not favourable compared to equivalent concrete/steel structures the life cycle cost and life cycle assessment analyses could be used to demonstrate cost and sustainability benefits of FRP structures. For instance, FRP bridge decks have advantages, such as controlled off-site fabrication, high strength, high fatigue and corrosion resistance, light weight, easy transportation, faster on-site assembly, minimisation of traffic disturbances, etc.; these could be used to off-set the initial cost, and to exploit the sustainable solutions offered by FRP materials.

Mitigation of Environmental Impact

The following measures may be undertaken to mitigate the environmental impact of FRPs whilst improving the sustainability benefits:

1. Reduce the amount of materials used and minimise the waste.
2. Use of less impact materials and less energy intensive manufacturing methods.
3. Use of good environmental management methods including reuse and recycling of the materials.

The future FRP designs should contribute to optimal performance, the efficient use of resources, and minimum embodied energy, carbon emissions, minimised on-site activities, etc.

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