A decade of design and practice using GFRP : current and future trends

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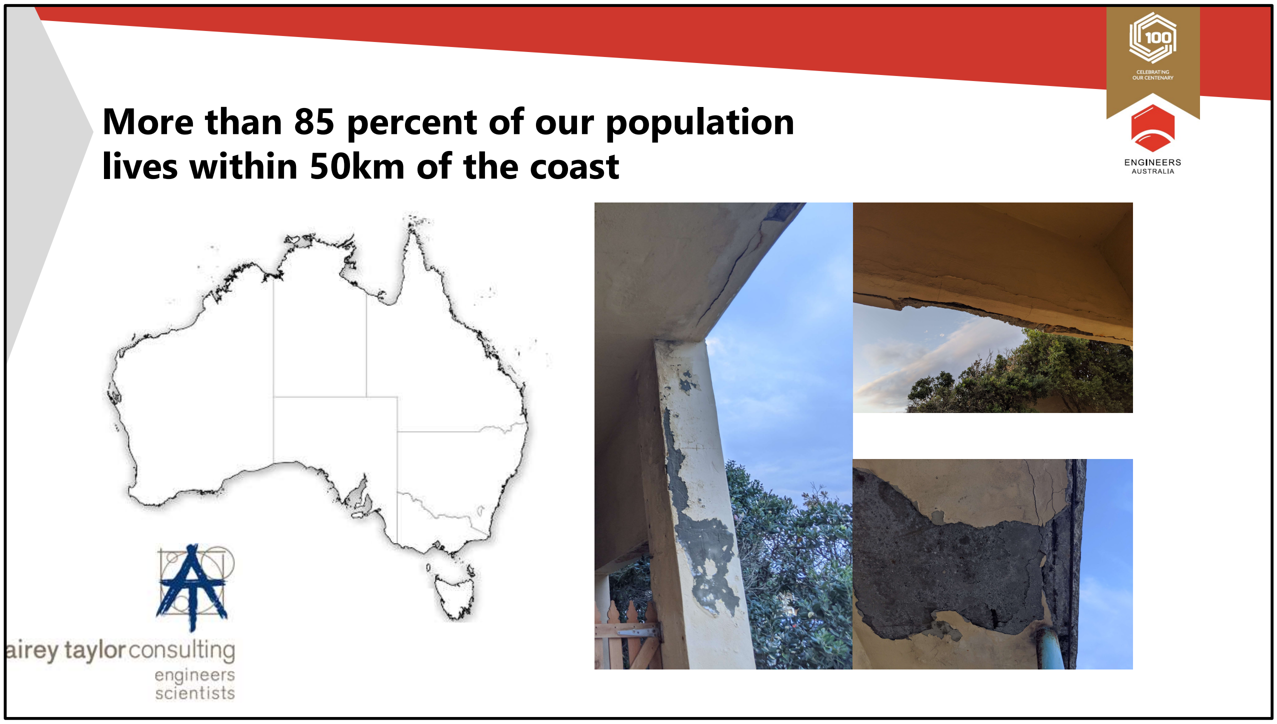
Ladies and Gentlemen, my name is Peter Airey. I am an Honorary Fellow of Engineers Australia and practice as Managing Director of Airey Taylor Consulting in Perth, Western Australia.

My firm almost uniquely matches Structural and Civil Engineering expertise with in-house Materials Science capability. After a decade of research and use, my company remains at the leading edge of research and application of Glass Fibre Reinforced Polymer rods as concrete reinforcement.

I am here to share my experience of working with Glass Fibre Reinforced Polymers in the last decade and my view of its current and future applicability to real world projects.



Ladies & Gentlemen, Australia is the largest island in the world. As our National Anthem states : “Our land is girt by sea.”

Most of our nation’s development is in coastal areas; fringing the various oceans; where the higher presence of salt accelerates the concrete degradation process colloquially known as “concrete cancer.”

The balcony you can see is one we investigated in Cottesloe, a coastal suburb of Perth, and these photos show this process in full swing. We need to have infrastructure that resists this process.

Overseas experience

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I became interested in this matter over ten years ago, looking overseas for experience with better options to protect structures in high salinity environments. This was because galvanising, cathodic protection or integral waterproofing agents in the concrete, high cover to bars and high strength concrete all have a downside.

I found that our Canadian cousins had big problems with their infrastructure due to their use of de-iceing salts on roads. These salts badly affect any infrastructure where cars enter with salt on their wheels and, of course, bridges, culverts and all associated concrete works.

They were using glass fibre reinforced polymer rods as a replacement for steel reinforcement in these settings; as these rods do not corrode with the ingress of salt into concrete. I thought this measure would potentially be a good option for our local salinity issues.

I looked for Code guidance on the design of columns using glass fibre reinforced polymer rods. I discovered there were none locally or in either the Canadian or American codes.

Together with the University of WA, my company initiated research into the ability of concrete columns to resist loads when reinforced with Glass Fibre Reinforced Polymers. The rods donated by Inconmat.

The results were published in a Paper sponsored by Airey Taylor Consulting on combined bending and axial loads in an Honours dissertation in 2012; seen on the left. A further Masters dissertation was published in 2015 (sponsored by Airey Taylor Consulting). We found to our surprise our research was leading the world in this area.

Our work was duplicated in 2016 and 2017 lead by the famous Dr Brahim Benmokrane at Sherbrook University, Quebec. This research provided confirmation of our core findings.

Majestic Point Pier review, Applecross (October, 2013)

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In August 2013 ATC received a commission from the City of Melville (in the South of Perth) to investigate a 600 metre long Boardwalk in the tidal part of the Swan River that has high salt levels during the summer.

The piles depicted were originally installed conventionally and treated using galvanising. After only 23 years they had lost up to 43% of their mass. This was clearly an appropriate case for substitution and application of our research using <u>glass fibre reinforced polymers for a practical setting.</u>

Majestic Point Pier, Applecross (2014)

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We proceeded to design and document the replacement piles of the piers using Cement Fibre Reinforced formers, Glass Fibre Reinforced Reinforcement rods and GFRP Holding Down bolts.

The steel deck of the 600 m long walkway was retreated and reused; and the original timber decking replaced with an Ultra Violet resistant composite decking.

The key issue for durability was the use of Glass Fibre Reinforced Polymer rods in the concrete. Upon completion the project was rated 75 years to first maintenance and set a benchmark for the use of the material in Western Australia.

Since this project was completed I am aware of two similar and significant projects in Western Australia which were designed by other Engineering firms; one being the jetty deck replacement in Wyndham and a single face of diaphragm walls in the Swan River at Elizabeth Quay in Perth.

Marine structures

The obvious usage for Glass Fibre Reinforced Polymers concrete is for structures in any marine environment. We were briefed to do an alternative design for a 2.25 kilometre deck for Point Wilson Jetty in Victoria for the Department of Defence. The design criteria was transient loading by mobile cranes.

The original design called for the use of steel reinforcement with high strength concrete. The precast deck units were coated with a finish selected to preclude (as much as is possible) ingress of salt and moisture. To make sure durability was achieved, cathodic protection was also specified.

Our alternative with glass fibre reinforced polymer used less rods bar-for-bar than the steel reinforcement and offered equal load capacity. It also has less concrete cover, lower strength concrete, no surface applications and no cathodic protection. It offered 75 years to first maintenance.

Aquatic Centres

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We have since started using glass fibre reinforced polymer rods in many applications. A good example is for Aquatic Centres. We have many commissions for these Centres and have completed nearly 50 to date.

The splash zones for pools (including the location of the scum gutters and balance tanks) is subject to exposure to the mix of oxygen and chlorinated water. The areas undergo accelerated corrosion of the steel reinforcement within the concrete due to this mix. Expensive repairs and even replacement of entire pools are required. Glass Fibre Reinforced Polymers are a clearly appropriate design solution for these settings.

We are using this material both for new Aquatic Centres and to rehabilitate those experiencing concrete cancer. Examples include Collie Aquatic Centre and LeisureFit in Booragoon.

In order to mitigate the price premium for Glass Fibre Reinforced Polymer rods over steel reinforcement, we have been using the rods only in the areas most vulnerable to accelerated corrosion.

Current Pricing (Late July, 2021; SRC Malaga, WA)

Product Equivalence	Steel Reinforcement price	GFRP price
N10 6m / #3 MST bar 5.9m	$9.50	$10.00
N12 6m / #4 MST bar 5.9m	$12.00	$16.00
N16 6m / #5 MST bar 5.9m	$20.00	$23.00

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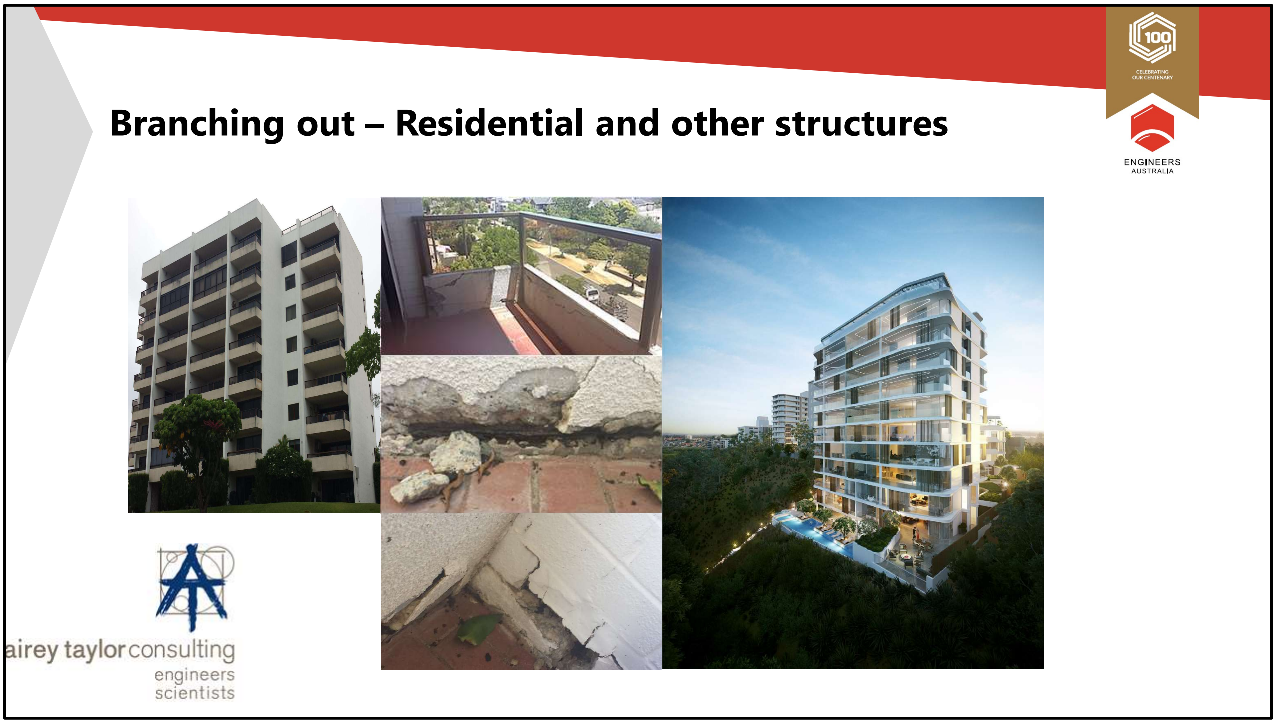
As the price of steel reinforcement has doubled since November 2020, use of Glass Fibre Reinforced Polymers for all reinforcement for aquatic centres is now viable and attractive.

I draw your attention to the rod for rod comparison on-screen. These prices were sourced from late July 2021 from SRC Malaga, a local distributor.

The costs are comparable and almost reaching parity, and when paired with the elimination of costs of less effective anti-corrosive treatments; offer a very happy solution indeed.

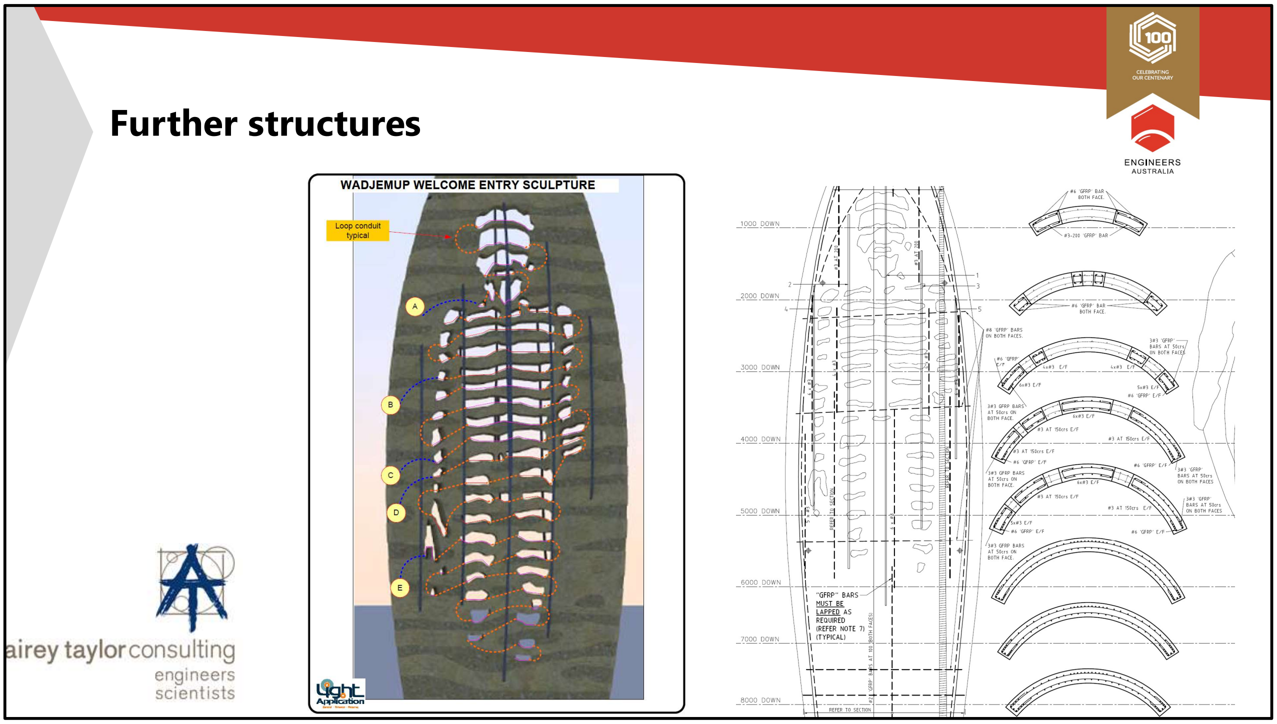


With pricing so attractive to clients, we are starting to use the material more and more for both remedial and new structures of all types.

One example is the remediation of damage due to rusted reinforcement at Swan Street in South Perth (see on the left). The damage is apparent on the balconies of all units (seen in the central images) and has a remediation budget of $1.5 million.

Replacement with GFRP will permanently prevent the re-occurance of damage to this riverside property.

On the right is the artists impression of 8 Parker Street, a project currently under construction less than 100 metres away from the property at Swan Street. The balcony, pool areas and other external facing areas susceptible to corrosion have been designed with GFRP to prevent similar requirements for expensive and troublesome maintenance.



Glass Fibre Reinforced Polymers are an appropriate design solution for many coastal and exposed structures.

Our current commission for the entry statement of Rottnest Island jetty landing area is at the forefront of the use of the material in Australia.

It is a 9 metre high sculpture with double curvature using custom shaped rods as lateral "ribs" to satisfy the artist's intent. The rods are held in place within the concrete, minimising the requirement for external cover. This allows an aesthetic result of very narrow sections the striking, tall sculpture.

This entry statement will endure the salinity of the beachfront for visitors to the island for generations to come.

It is a pleasure to see, after a decade of enquiry and development, the evolution of the use of this material to meet the needs of our coastal nation.

At the biennial Concrete 2021 National Conference in September this year, our firm will be presenting design outcomes addressing the structural considerations of the use of Glass Fibre Reinforced Polymer. Extracts of that paper and presentation can be seen. We will continue to use this superior technical response on all suitable projects to create lasting infrastructure to the benefit of the Nation… ourselves included!

I welcome your questions and thank you for your time.


Q&A

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