ERA-NET Plus Infravation

SEACON

AN INDUSTRY PERSPECTIVE - ASTALDI

(SEACON Forum/HRB Workshop)

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Outline

- Astaldi's Experience with FRP
- Construction Considerations
  - Procurement & Lead times
  - Site Storage and logistics
  - Construction Challenges
  - Advantages/Disadvantages – Contractor's View
- Halls River Bridge Project
  - Comparison HRB GFRP – Black Steel
- Vision for deployment of innovation

Astaldi's Experience with FRP

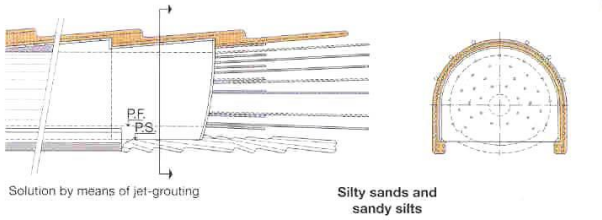
- More than 20 years using FRP:

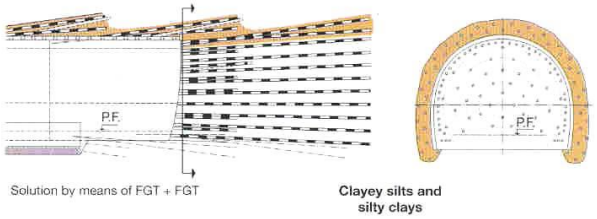
Astaldi's Recent Projects using FRP	
Metro Copenhagen,Phase 1 & 2 - Denmark	Metro Milan Line 5 Bignami - Garibaldi, Italy
Metro Brescia. Italy	Metro Naples Line 1, Piscinola - Centro Direzionale, Italy
Metro Genoa, Italy	Metro Rome Line C, Italy Phase 1 and Phase 2
Metro Milan Line 4, Italy	Metro Warsaw, Poland
Metro Milan Line 5, San Siro - Garibaldi, Italy	Rome-Naples HSR, Italy

Astaldi's use of FRP, has been predominately for **mechanized tunneling**, and **NATM works**.

Astaldi's Experience with FRP

- Use of 'Soft Eye' in breakthroughs of Tunnel Boring Machines (TBMs) in stations/shafts.
- Use of Glass FRP reinforcements for tunnel face strengthening in soft ground NATM tunnels works.





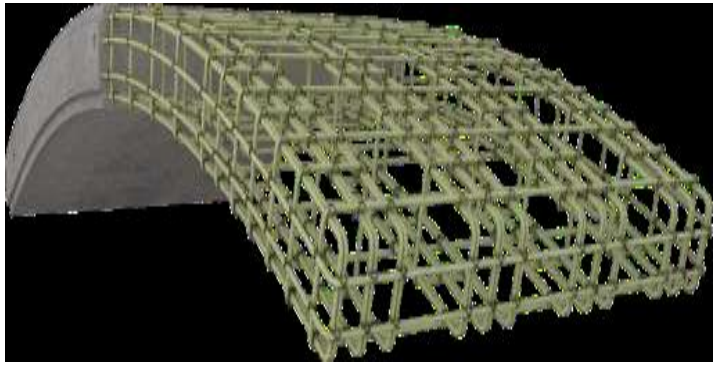
Astaldi's Experience with FRP

In recent years, the improvement in materials and testing have allowed FRP to make the jump from '***temporary works***' to '***permanent works***'.

- *Concrete Tunnel Linings/Segments with FRP.*
- *LRT Track Beds - Mitigation of Stray Current Corrosion*
- *Reinforced Concrete Structures in marine environments.*
- *Reinforced Structures subject to harsh environment – cold weather climates.*

Astaldi's Experience with FRP

- Less reinforcements requirements due to reduced concrete cover.
- Higher durability - no issues with spalling caused by oxidization of steel rebar.
- Higher durability - no corrosions caused by stray currents from DC distribution lines, railway systems, substations, among other sources
- Normal Concrete Mixes Designs- no specific requirements for specialized mixes and relevant testing



Construction Considerations

Procurement & Lead Time

- Procurement must consider lead time for manufacturing and shipping.
- Design becomes critical
- Procurement of additional quantities of FRP bars to ensure immediate replacements in case of damages on site.
- QA/QC - additional verifications at manufacturing plant needed prior to shipment to mitigate risk of delays due to non compliances of materials arriving on site.

Construction Considerations

Site Storage and Logistics

- Transportation and storage usually in containers – avoids mishandling of rebar and protection from direct sunlight.
- Light weight of FRP rebar make it easy to man handle all sizes and lengths minimizing H&S issues.

Construction Considerations

Site Storage and Logistics

- Additional Storage requirements needed on site
- Specific lifting plans needed for large prefabricated cages.
- Weight of bars is ¼ of black steel, making it easy to handle and increases productivity rebar placing.

Construction Considerations

- Trained labor required to ensure correct fixing and minimize risk of damages and movement of reinforcements during concreting operations.
- Specialized lifting plans required for prefabricated cages.
- Splicing of FRP bars complicated and time consuming.

Construction Considerations

Construction Challenges

- Lift of prefabricated FRP cages
- Splicing of rebar to ensure safe lifting.
- Concrete issues due to light weight of rebar.
- NO FLAME – no heat sources allowed near FRP bars.
- Fragility of rebar

Construction Considerations

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Construction Considerations

Advantages:

- Highly resistant to corrosion
- Tensile strength greater than that of steel
- Weighs only one quarter as steel
- It is transparent to magnetic fields and radar frequencies
- GFRP has low electrical and thermal conductivity
- Reduced concrete cover requirements
- Labor Savings during Installation
- Concrete Properties less stringent

Construction Considerations

Disadvantages:

- Higher Costs of Materials
- Specific Storage and Site Logistics
- Additional Contingency Qty's required
- Specific lifting plans required
- QA/QC - additional verifications at manufacturing plant
- Risk of movement of GFRP during concreting
- Fragile – easily damaged. Specialized training of labor.
- Splicing details for prefabricated cages

Comparison HRB GFRP – Black steel

ALLOWABLE STRESS DESIGN

GFRP BARS	ALLOWABLE TENSILE STRENGTH (ksi) – HALLS RIVER BRIDGE BARS	VS	STEEL – GRADE 60	ALLOWABLE TENSILE STRENGTH (ksi)	K = (GFRP)/ (STEEL)
#4 (0.5 in)	143/2* = 71.5 ksi		#4 (0.5 in)	24 ksi	3
#5 (0.625 in)	140/2* = 70 ksi		#5 (0.625 in)	24 ksi	2.9
#6 (0.750 in)	146/2* = 73 ksi		#6 (0.750 in)	24 ksi	3
#8 (1 in)	123/2* = 61.5 ksi		#8 (1 in)	24 ksi	2.6

(*) minimum safety factor GFRP tensile strength: n = 2

Comparison HRB GFRP – Black steel

Cost expressed in terms of efficiency: $/K of the allowable tensile stress

GFRP BARS	Unite Price LF	Unite Price /K	VS	Grade 60 steel BARS	Unit price*
#4 (0.5 in)	1.00 $/LF	0.34 $/LF/K		#4 (0.5 in)	0.51 $/LF
#5 (0.625 in)	1.10 $/LF	0.38 $/LF/K		#5 (0.625 in)	0.79 $/LF
#6 (0.750 in)	1.40 $/LF	0.46 $/LF/K		#6 (0.750 in)	1.14 $/LF
#8 (1 in)	1.70 $/LF	0.66 $/LF/K		#8 (1 in)	2.03 $/LF

(*) unit price based on FDOT average prices

Vision for deployment of innovation

- University and Research to keep reporting and demonstrating the successful alternative to steel
- GFRP unit price must be competitive
- Designers/Clients have a key role as promoters
- Concrete Durability and Life Cycle Assessment have to be considered as driving input