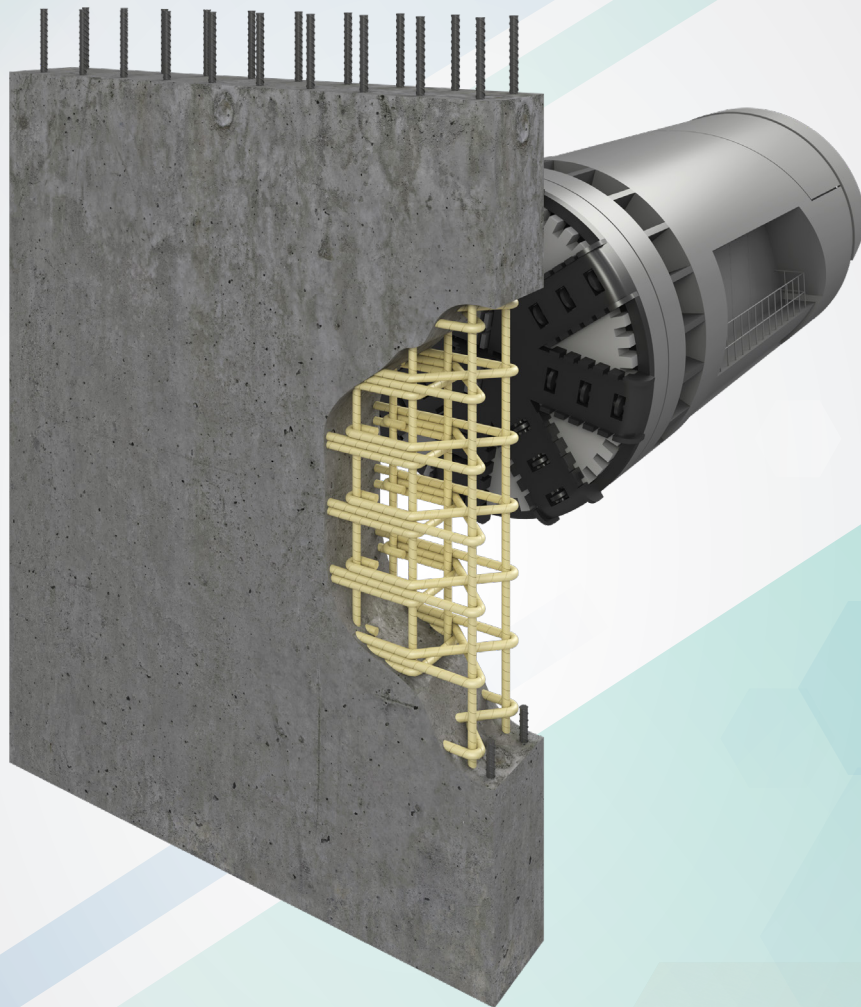


ASTEC

Soft-Eye

Turnkey solution for efficient boring of reinforced concrete structures



Dextra

www.dextragroup.com

Typical Soft-Eye locations

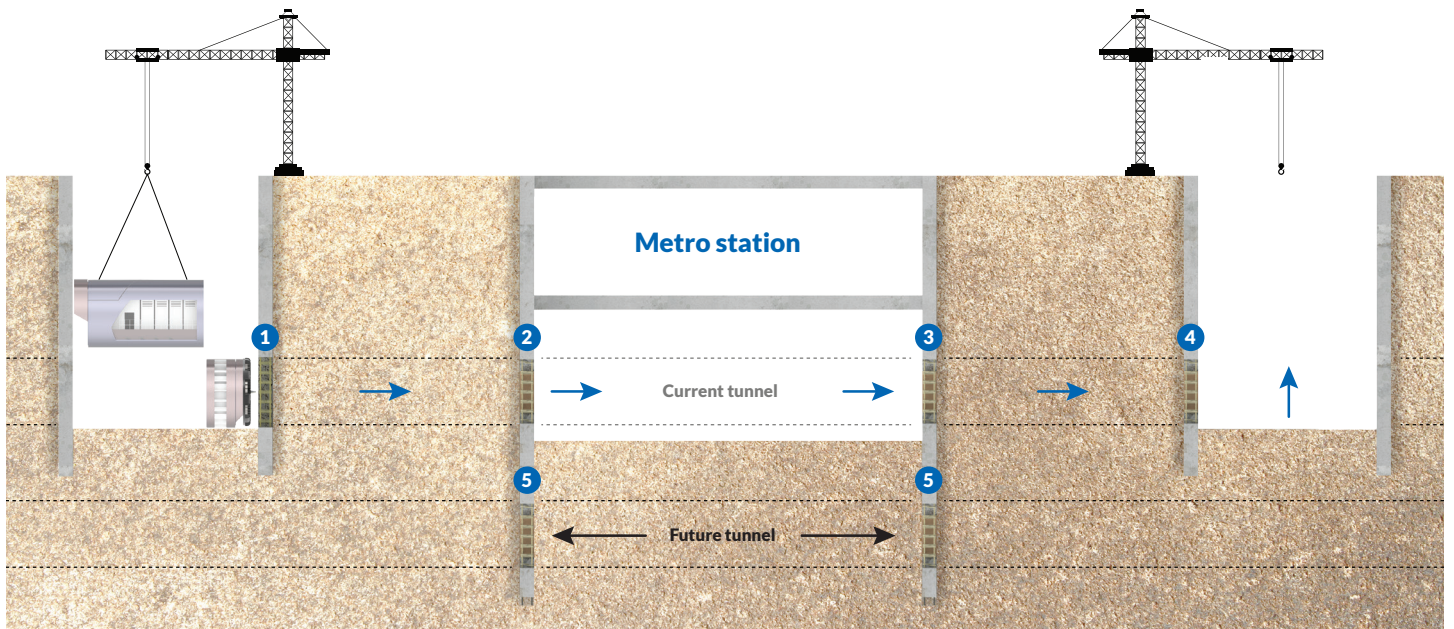
1 Soft-Eye at launching shaft

2 Soft-Eye at station break-in

3 Soft-Eye at station break-out

4 Soft-Eye at retrieval shaft

5 Soft-Eye for future extension



Without Soft-Eye

To create tunnel openings, the concrete and steel structures reinforcing the D-Wall have to be extracted at the entry/exit point. This is a tedious task that requires mobilization of additional heavy equipment. There is also a high risk of damaging the Tunnel Boring Machine (TBM). In humid soil environment, opening the D-Wall prior to TBM arrival may cause complications.



Removal of concrete and steel structure

With Soft-Eye

The Tunnel Boring Machine (TBM) simply breaks through the station's D-Wall by cutting the FRP reinforcement and crushing the concrete. Thanks to the design of the Soft-Eye, the margin of error can be controlled. This method is the fastest, simplest and safest way to create tunnel openings.



Structure of concrete & FRP bars crushed by TBM

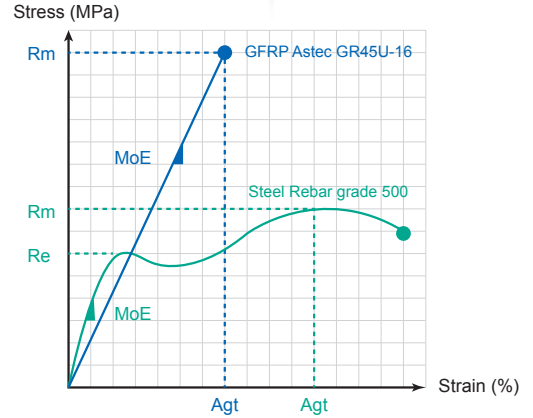
FRP material

Mechanical properties: Steel vs FRP

Conventional steel rebar is characterized by a ductile behavior: it deforms significantly beyond its yield point (plastic deformation).
 On the other hand, GFRP rebar has purely brittle behavior: its deformation is proportional to the load applied (elastic deformation).



Mechanical properties	Steel Rebar Grade 500	GFRP ASTEC GR45U-16
Yield Strength (Re)	500 MPa	/
Tensile Strength (Rm)	600 MPa	980 MPa
Strain at Rm (Agt)	5.0%	2.18%
Modulus of Elasticity (MoE)	205 GPa	45 GPa



Benefits of FRP



The anisotropic property of FRP ensures that it can easily be cut by common excavation and piling equipment, as well as by Tunnel Boring Machines (TBM). FRP solutions are the best alternative to removable anchors, as they can be left in place.

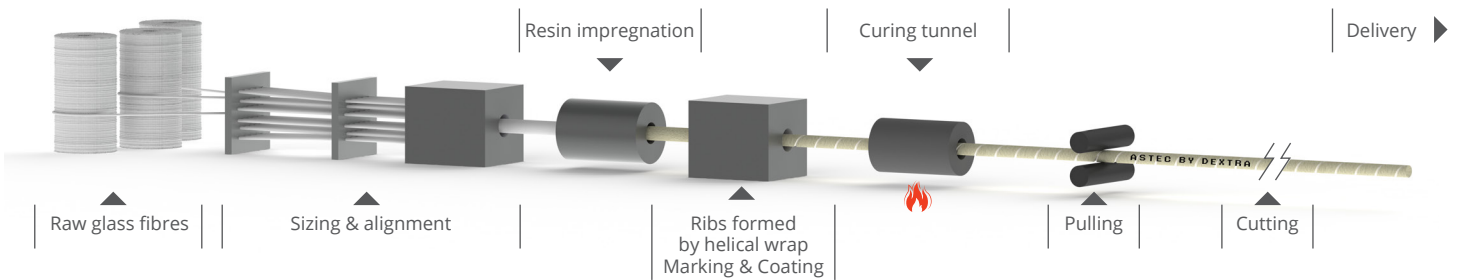


The FRP is suitable for both permanent and temporary applications. The material alleviates all concerns about corrosion: FRP profiles are available in formulations that are resistant to acidic and alkali environments.



A clear advantage of FRP bars is the strength-to-weight ratio: eight times higher than steel. Indeed, FRP profiles are twice stronger than steel in tensile for only 25% of its weight.

Production process: Pultrusion

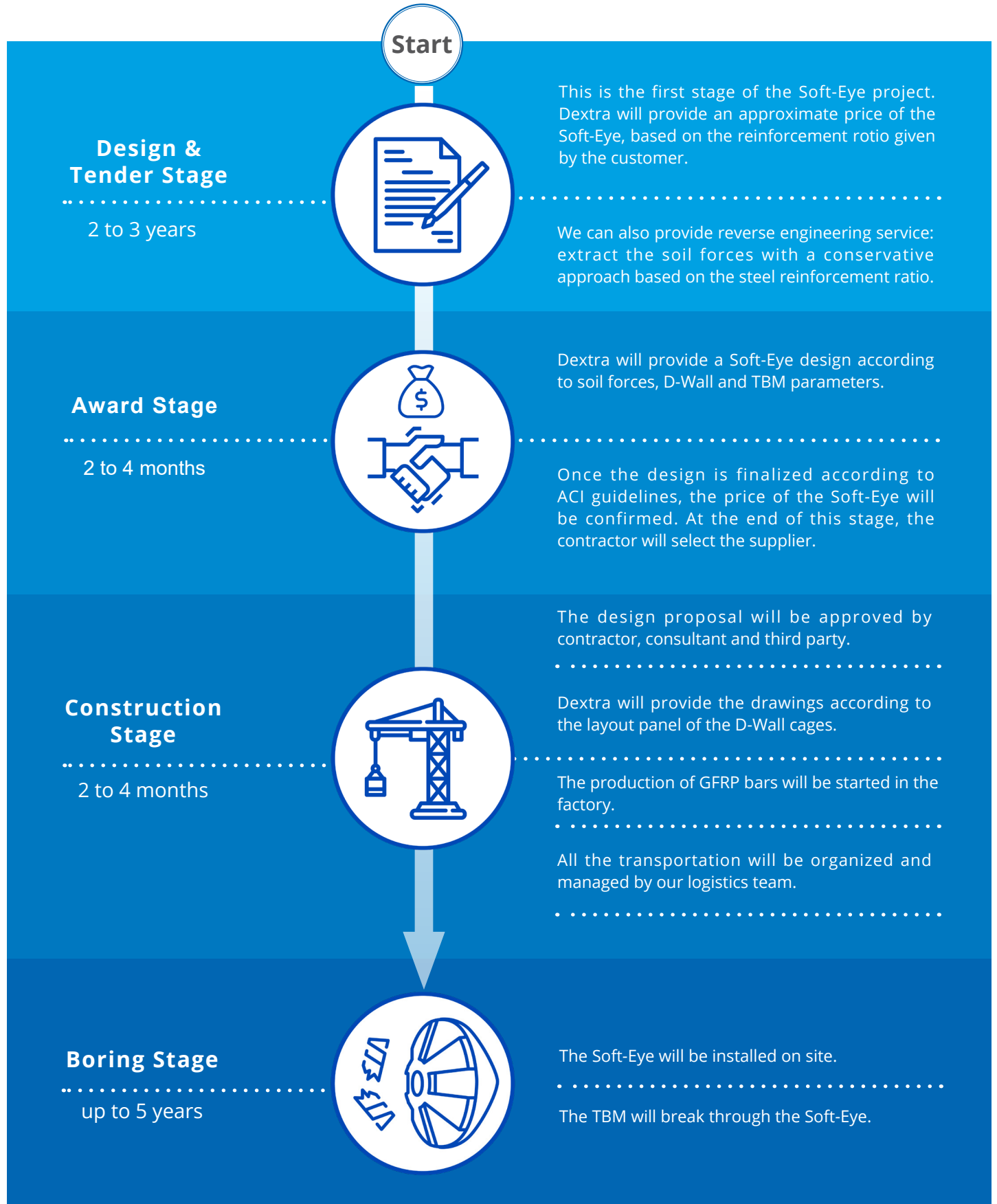


Conventional shapes

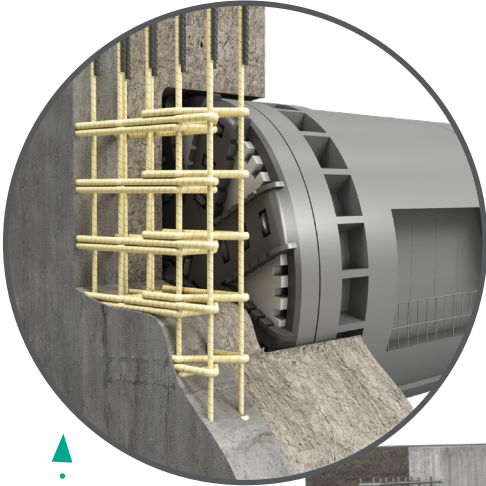


Timeline: a long-term project for a temporary solution

Dextra offers an integrated turnkey solution, from the design to the delivery on site. The supply chain of a Soft-Eye project is divided into 4 main parts. At every step, Dextra provides expertise and knowledge to consultants and contractors to help them achieve the quality, time and budget objectives of the project.



Design concept & lifetime



Temporary

The typical Soft-Eye application. The cage is made of GFRP bars, which will be cut by the TBM during breakthrough.

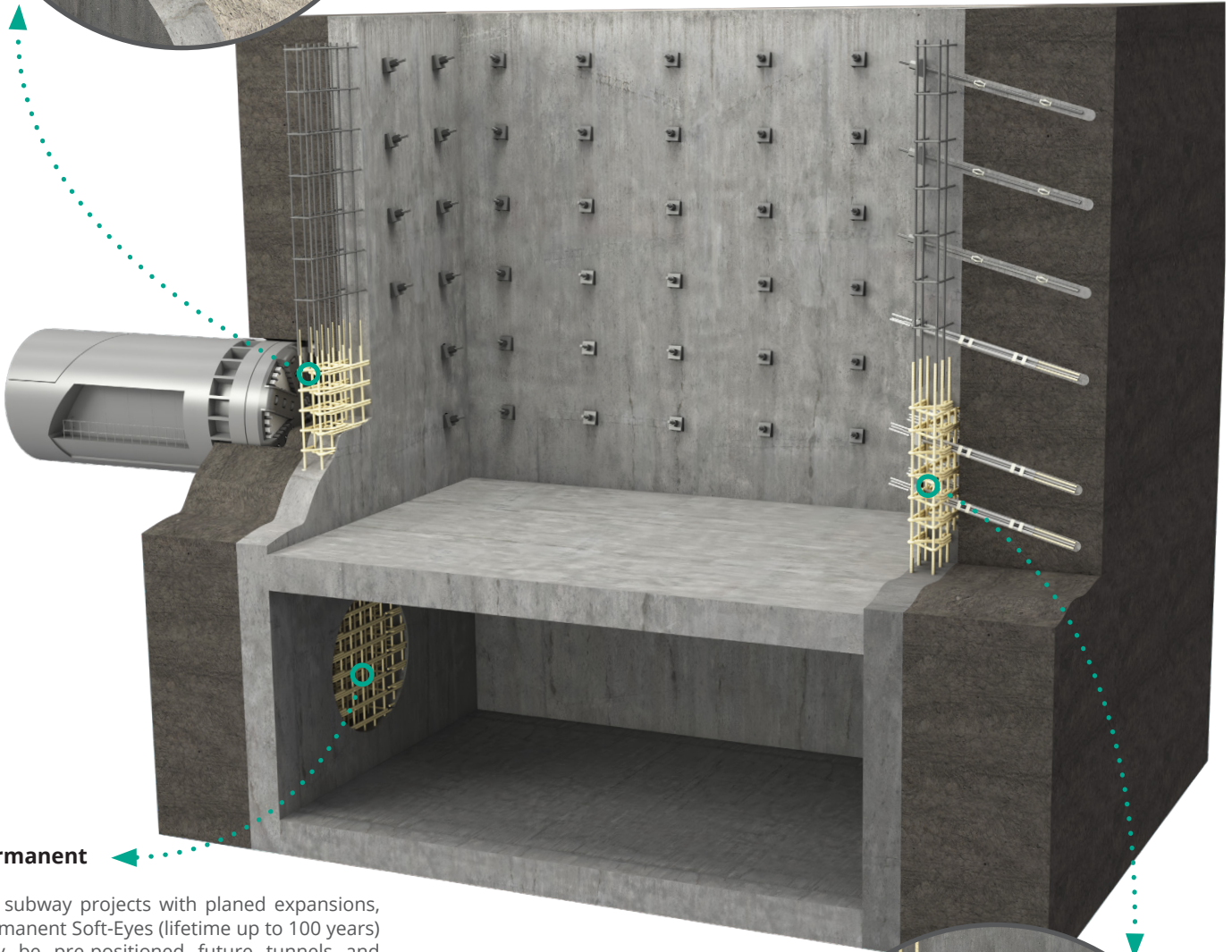
Guidelines

ACI 440.1R-15, 2015 : "Guide for the Design and Construction of Concrete Reinforced with FRP Bars," Published by the American Concrete Institute, Farmington Hills, MI.

ACI 440.3R-12, 2012 : "Guide Test Methods for FRP Composites for Reinforcing or Strengthening Concrete & Masonry Structures."

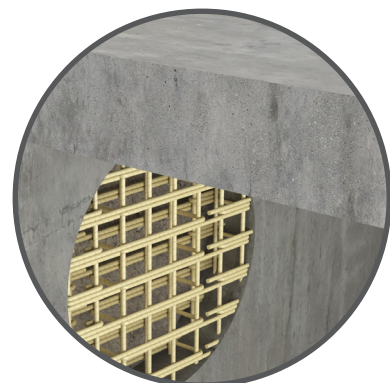
1. *Eurocode (EN 1990)* – "Basis of structural design."

2. *Eurocode 2 (EN 1992-2)* – "Design of concrete structure - Concrete bridges - Design and detailing rules." published by the Europeans Committee for Standardization.



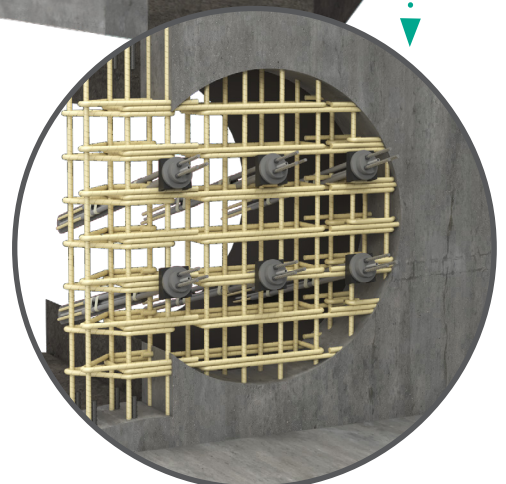
Permanent

For subway projects with planned expansions, permanent Soft-Eyes (lifetime up to 100 years) may be pre-positioned future tunnels and stations.

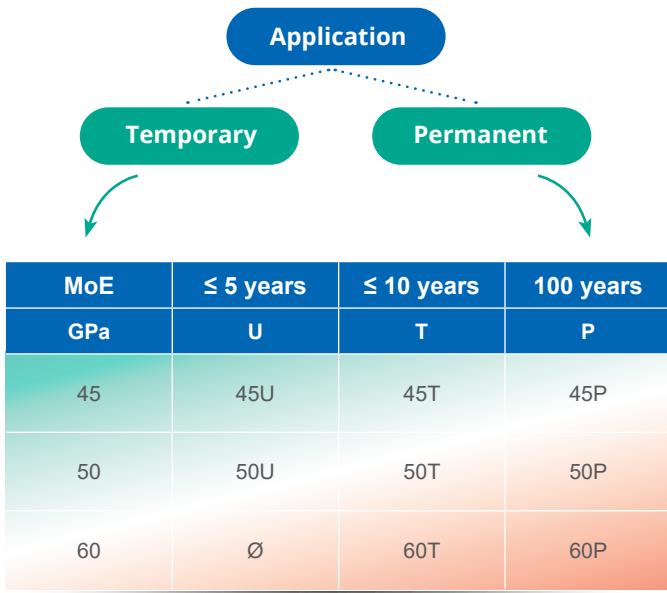


Temporary + Astec Active Anchor

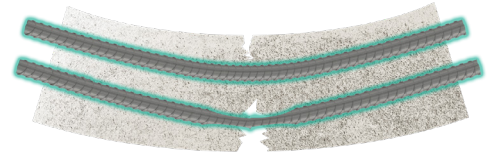
When strong soil forces require retaining wall to be anchored with post-tensioned anchors, Dextra recommends the use of Fully Cut-able ASTEC Active Anchors (AAA). Those will also be cut during TBM break through.



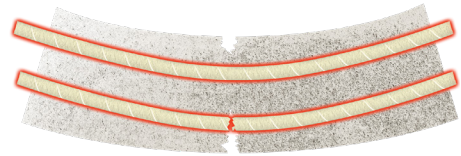
Selection tree



Different material, different behavior



Steel design = Rebar **Ductile Failure**



FRP design = Balance **Brittle Failure**

Quality assurance

Item	Test method ACI 440.3 R- 12
Cross Sectional Area, mm ²	Water displacement as per ACI 440.3R-04-B1
Diameter, mm	
Ultimate Tensile Load, kN	
Ultimate Tensile Strength, MPa ^①	ACI 440.3R-12 ASTM D7205-11
Modulus of Elasticity, GPa ^②	
Ultimate Strain, % ^②	
Fiber Content, %	ASTM D2584-11

Dextra follows ACI 440.3 (Revision 2012): Guide Test Methods for FRP Composites for Reinforcing or Strengthening Concrete & Masonry Structures.

Dextra Soft-Eyes are engineered and produced under a Quality Management System that complies with the requirements of ISO 9001 (Certificate CNBJ301191-US).

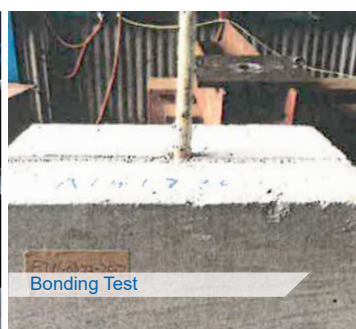
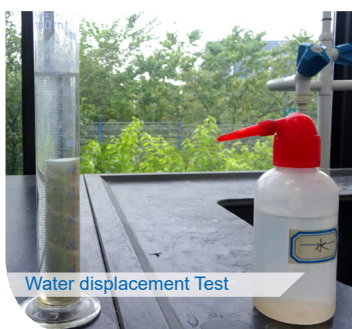


^① Data points are taken for from 0.001 to 0.003 strain as per item 13.3.1 of ASTM D7205-11

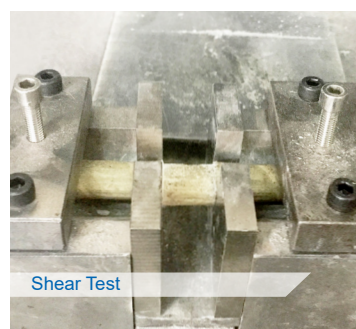
^② Calculated according to Standard Cross-sectional area as per item 11.2.5 of ASTM D7205-11

Tensile & shear test

Testing

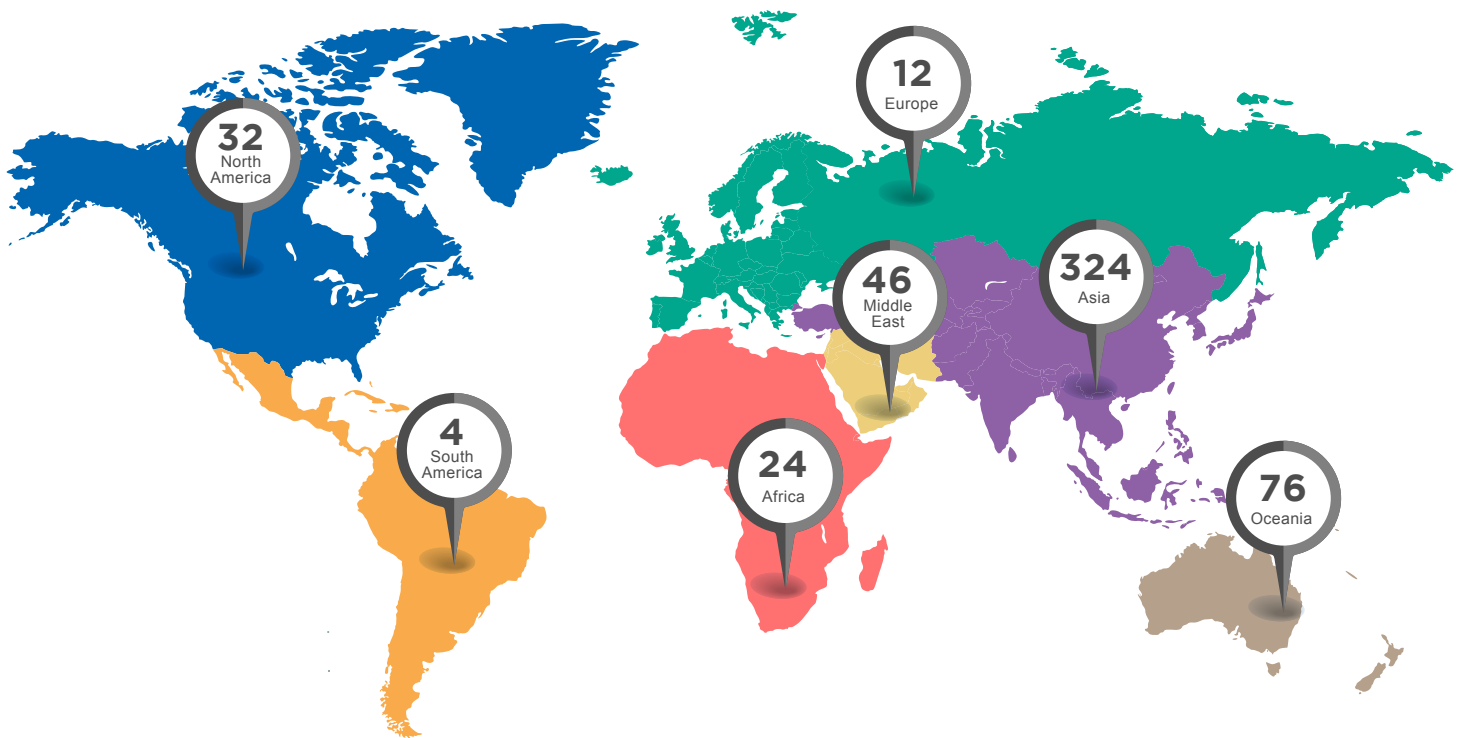


Typical failure mode



Worldwide references

Over 500 Soft-Eyes installed on all continents



Our iconic projects

North America

East Side and West Side CSO Tunnels, USA.
Beacon Hill Light Rail, USA.
Washington DC Subway, USA.
Airport LR, Minneapolis, USA.

Oceania

Forrestfield-Airport Link - Australia
Melbourne Metro Core Stations, Australia
Brisbane Airport Link, Australia

Asia

Bangkok MRT Orange line, Thailand
Bangkok MRT Blue line, Thailand
Chennai Metro, India
Delhi Metro, India
Tuen Mun-Chek Lap Kok Link (TMCLK), Hong Kong
Singapore Metro, Singapore

Europe

Brussels Metro, Belgium
Docklands Light Railway, England

Middle East

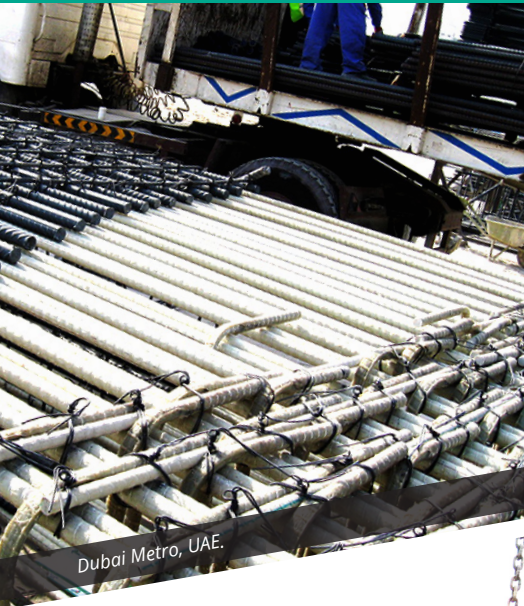
Doha Metro Major Station, Qatar
Doha Metro Golden line, Qatar
Dubai Metro (Route 2020), UAE.

South America

RIO Metro, Brazil
- Line 4 South Extension - Jardim de Alah
- Line 4 South Extension - Antero de Quental

Africa

Accra power station, Ghana
Cairo Metro Line 3, Egypt



Dubai Metro, UAE.



Doha Metro, Qatar



Bangkok MRT, Thailand



Singapore Metro, Singapore



Chennai Metro, India



Rio Metro, Brazil



Brisbane Airport Link, Australia



Doha Metro Msheireb Station, Qatar



Delhi Metro, India

Commercial presence
in more than
55 countries



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