FYFE®

TYFO® FRP SYSTEMS

Advanced Composite Solutions for Structural Strengthening

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Over time, the stresses of daily wear take its toll on pipelines, bridges, tanks, buildings and other structures. Fyfe® FRP develops and designs materials that strengthen, repair and restore these deteriorating structures—sometimes to better-than-new condition.

Founded in 1988 to strengthen failing bridge columns using aerospace materials, Fyfe is a pioneer in the fiber-reinforced polymer (FRP) structural strengthening industry. Today we are a world leader in designing and manufacturing Tyfo®, a system of specialized carbon and glass fabrics, which we combine with polymers to strengthen a wide range of masonry, concrete, steel and timber structures. The Tyfo FRP system is also be used to rehabilitate piping systems.

Our staff include engineers, designers, material specialists, material manufacturers and project support personnel who work together to develop and design turnkey solutions for structural problems and provide technical support to engineers, contractors and owners in the pipeline, building and bridge rehabilitation markets.

CONTENT:

FYFE TYFO FRP SYSTEMS

Tyfo® systems are used to strengthen existing structural members.

Tyfo Composite Systems are advanced composite systems are fiber reinforced polymer (FRP) products specifically made to strengthen structural components.

The primary systems are composed of high-strength carbon fibers combined with Tyfo polymers. A variety of unidirectional and bidirectional products are available to optimize the performance provided to each structural element.

Tyfo Polymer Systems are polymers combined with reinforced fabrics to form advanced composite systems used for structural strengthening. Tyfo® polymer systems are specially formulated to be used in conjunction with the various Tyfo fabrics and prefabricated systems.

Our polymers have been optimized to provide convenient working times, excellent indoor air quality, and long-term environmental durability. The type of polymer needed addresses general applications, high-temperature exposure, underwater conditions, and structural strengthening preparation and detailing.

Tyfo Coatings & Finishings - When engineering a repair, rehabilitation, or maintenance project, engineers and designers must consider a range of issues alongside the required final texture and color, such as exposure to elevated temperatures, potable water, and, in some cases, aggressive chemicals that could come into contact with the system.

Our range of Tyfo® finishes is designed to provide the appropriate detailing and additional protection that may be required on your projects.

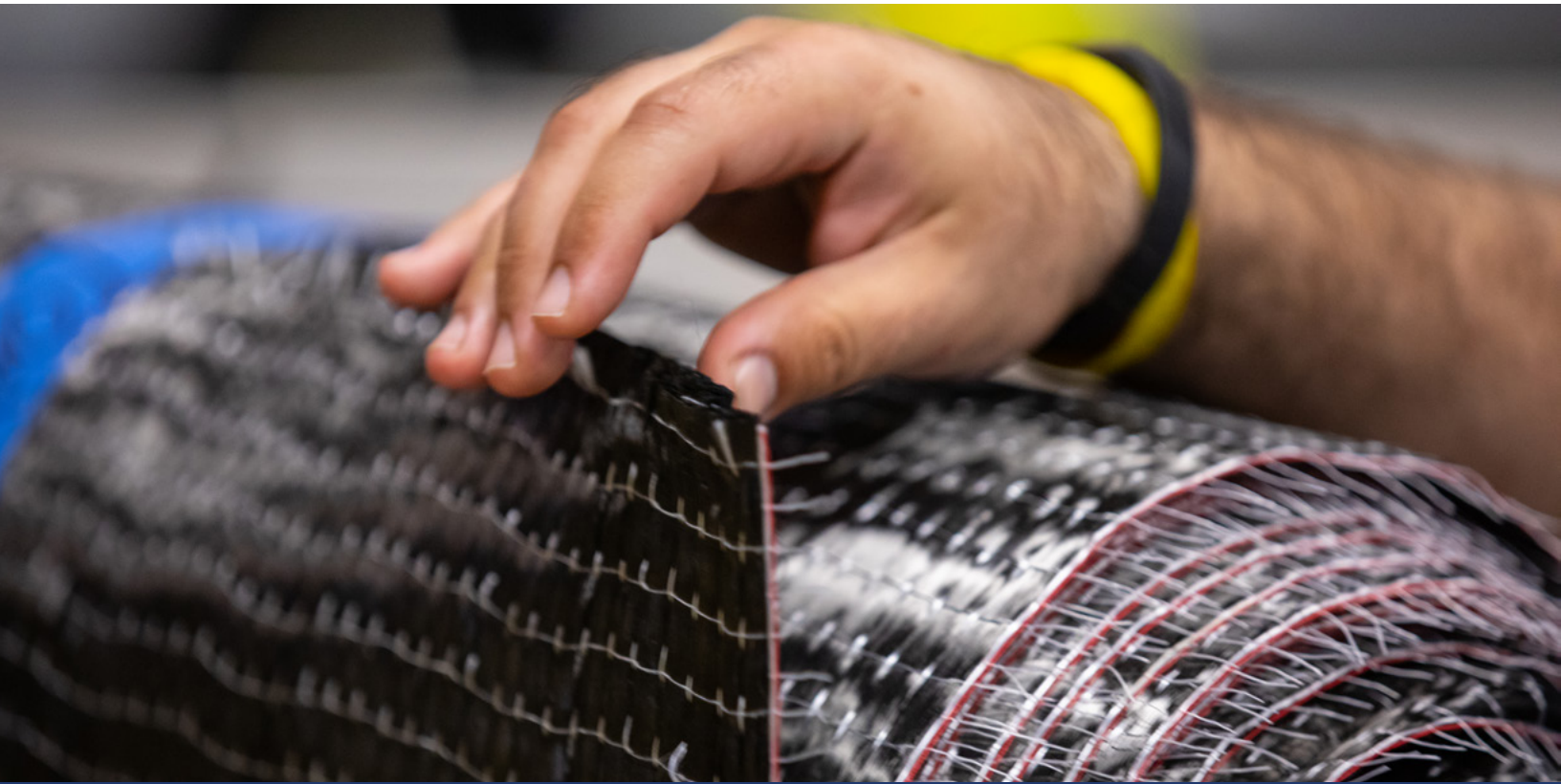
We have developed a variety of coatings to address the above-mentioned conditions and are available to offer support in your decision-making process.

PRODUCT SELECTOR GUIDE

Product	Tyfo SCH-41	Tyfo SCH 41S	Tyfo SCH 41-2X	Tyfo SCH 41S-2X	Tyfo SCH-11UP	Tyfo BCC	Tyfo SEH-31A	Tyfo SEH-51A	Tyfo SEH-81A	Tyfo WEB	Tyfo BC
Fiber Type	Carbon Fiber						Glass Fiber				
Orientation	Unidirectional (0°)					Bidirectional (± 45°)	Unidirectional (0°)			Bidirectional (± 90°)	Bidirectional (± 45°)
Tensile Strength*	131 ksi				121 kis	81 ksi	71 ksi	66 ksi	88 ksi	35.8 ksi	32.4 ksi
Tensile Modulus*	14.6 Msi				11.9 Msi	5.9 Msi	3.2 Msi	3.73 Msi	4.3 Msi	2.24 Msi	2.16 Msi
Gross Laminate Ply Thickness	0.040”		0.080”		0.020”	0.034”	0.030”	0.050”	0.080”	0.010”	0.034”
Max Suggested Exposure Temperature**	140F with the Tyfo S Epoxy 170F with the Tyfo S-T Epoxy						140F with the Tyfo S Epoxy 170F with the Tyfo S-T Epoxy				

*Strength is defined as the mean strength minus 3 standard deviations. Modulus is defined as the reported mean modulus, and elongation is defined as the calculated strain from the derived strength and modulus. Note that the suggested design value for the tensile chord modulus is reduced if calculated as per ASTM D7290.

**Exposure temperature is reported as 40F below the Tg



ENGINEERING SERVICES

In pioneering this industry, Fyfe FRP has more experience and a longer track record than any other FRP suppliers. Our **engineering services** are designed to support civil and structural engineers considering the use of this technology. The following typical engineering services are provided:

- Preliminary design to determine feasibility and cost savings compared to other technologies
- Material takeoff support
- Formalized design calculations and shop drawings
- Project specific detailing and specification writing
- Field quality control and site engineering support
- Assistance with plan check activities and jurisdiction approval
- Design training and document review
- Structural observation and inspection support and training

Most of these services are at no cost and no obligation.

BUILDING REHABILITATION

Tyfo systems are most applicable to reinforced concrete, reinforced and unreinforced masonry buildings. However, there are unique applications that have been developed for both wood and steel structural elements.

Typical strengthening applications include:

- Adaptive reuse
- Seismic retrofit
- Strengthening due to deterioration or corrosion
- Strengthening due to new openings
- Force protection and blast mitigation
- Historic preservation

Tyfo can strengthen columns, walls, beams, diaphragms and connections. Almost all of the applications conducted in the field were first justified through structural testing and many are not reflected in published design standards.

The use of **composite anchors** enables the strengthening and detailing of structural elements that otherwise would not be achievable with Tyfo systems. Additionally, composite anchors enhance the performance of Tyfo systems on many kinds of applications to make them more efficient or more cost effective.

BRIDGES AND TRANSPORTATION

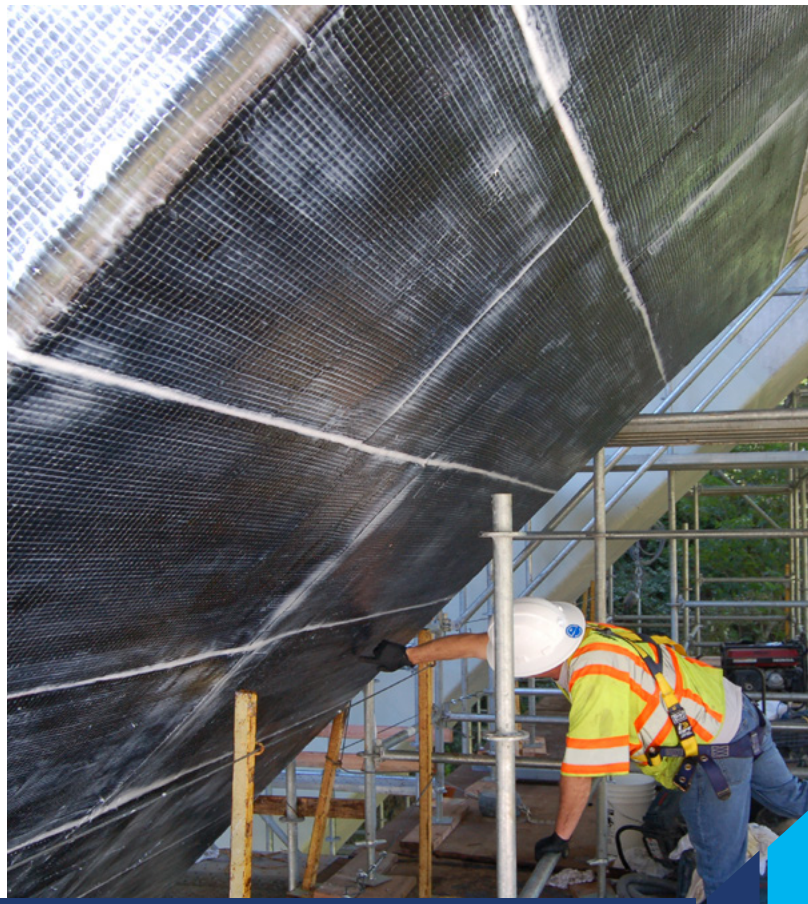
Initially developed for seismic strengthening of bridge columns, Tyfo systems have since been used to strengthen and protect bridges across the world. Tyfo systems have undergone rigorous structural and durability testing to gain acceptance by transportation departments and ministers world-wide.

Tyfo systems may be applied on bridges to provide the following performance:

- Bridge seismic retrofits
- Increase load rating capacity of bridge elements
- Regain strength due to section loss
- Regain strength and stiffness due to impact damage
- Protect elements from future exposure to the environment

The following elements may receive Tyfo systems for strengthening and protection:

- Columns, piles or piers
- Beams, AASHTO girders, box girders
- Bent caps, pile or pier caps
- Bridge decks



PIPELINES, WATER & WASTEWATER

When a large-diameter pre-stressed concrete cylinder pipe (PCCP, LCP and ECP), reinforced concrete pipe (RCP), steel, ductile iron, cast iron, FRP or other types of pipe suffer from corrosion or another form of decay, they can experience significant structural loss. Tyfo system strengthens structurally deficient pipes and enables them to accommodate all internal loads (i.e. operating, transient, thrust and vacuum pressures) and all external loads (i.e. traffic, soil, groundwater and temperature).

Tyfo systems can be bonded to either the inside or outside of pipes, has a design life of 50 to 100 years, and is an accepted structural rehabilitation method in the municipal, oil & gas and power industries.

Tyfo systems provides solutions for:

- Structural strengthening/pipeline renewal
- Leak repair
- Joint rebuilding and repair
- Operating pressure increase
- Corrosion mitigation

It can be used across a range of industries including municipal, industrial, power generation, oil & gas and penstocks.

WATERFRONT & MARINE STRUCTURES

The corrosive nature of marine environments can severely damage waterfront structures, destroy their aesthetics, and render them unable to support the loads they were designed to carry. Fyfe is a leader in rehabilitating and preserving existing reinforced concrete, wood, and steel structural elements using Tyfo Systems.

Tyfo Systems have been applied on piers, wharves and bridges to provide the following:

- Repair and strengthen corroded elements
- Increase load rating capacity of structural elements
- Protect elements from future exposure to the environment
- Pier or wharf seismic retrofit

Fyfe offers products that cure under water which allow for use in and around the tide zone. Waterfront structures are uniquely challenging due to the working conditions, salt or fresh water exposure, wave impact, and UV exposure. Advanced composites may be used in conjunction with cathodic protection systems to help preserve a structure.

Fyfe's sister company **Geotree** has complementary products that support bridge and waterfront applications.

SILOS, STACKS & CHIMNEYS

This infrastructure can often be found in harsh environments such as near the ocean and can be subjected to high levels of damaging chemicals. Silos must also withstand high-pressure variants as they are filled and emptied - this pressure can cause structural weakening. Fyfe's Tyfo range of products has proven itself to offer second-to-none structural strengthening properties to silos, stacks and chimneys around the world.

INDUSTRIAL FACILITIES & POWER GENERATION

The Tyfo System is ideal for strengthening industrial structures and tanks as it can easily be installed around existing equipment and instrumentation. Its ease of constructability can be achieved in extreme working conditions with industrial processes remaining operational significantly reducing repairs during shutdown and turnaround periods.

Tyfo systems cater for a range of Industrial applications including:

- Seismic retrofitting
- Structural element strengthening
- High temperature environments
- Concrete repair
- Corrosion repair
- Blast mitigation

Project examples include:

- Oil and gas facilities
- Support structures
- External pipelines
- Pipe rehabilitation
- Chimney structures
- Tank reinforcing

TRAINING

Our certified applicators have completed structural retrofits, strengthening, and repairs on more than 25,000 applications on commercial, industrial, and government facilities around the globe. Fyfe's world-class training services include training for third-party contractors, third-party deputy construction inspectors, consulting structural engineers, third-party materials laboratories, university laboratories, and owners.

Fyfe's training services include the following:

- Certified applicator installation training
- Design, detailing, and specification writing training
- Installation inspection and structural observation training
- Materials testing training
- University research consulting
  - Test setup
  - Data acquisition
  - Material installation
  - Material design and detailing on full- and large-scale test specimens

CERTIFIED APPLICATOR AND INSPECTOR TRAINING

Fyfe's certified applicator training reflects the know-how and experience of an advanced composites company that started the niche market 1988, and developed the market alongside the engineering community every year since. Fyfe's certified applicator program coveys technical information through classroom teaching as well as hands-on training.

The comprehensive training program includes:

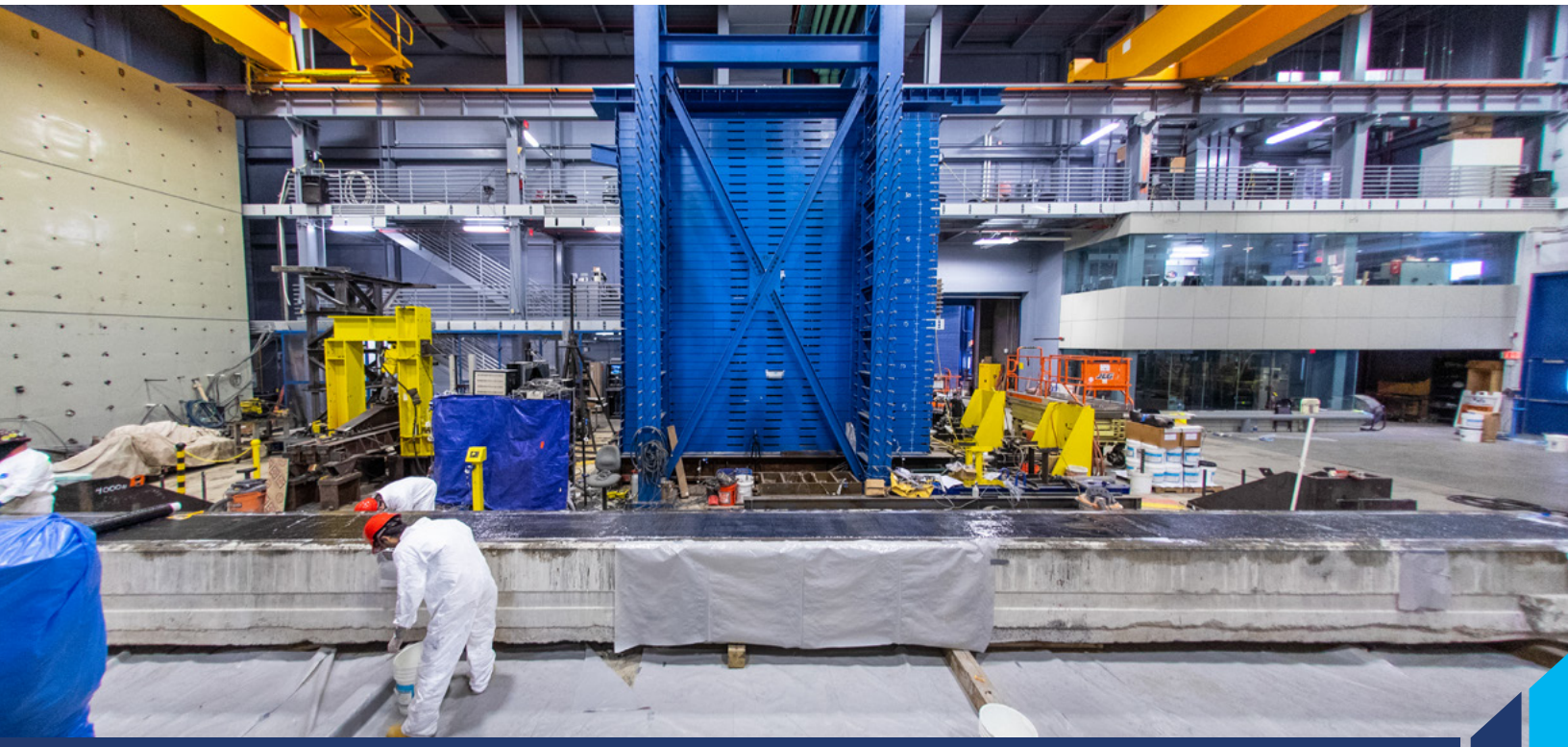
- Industry terminology
- Jobsite essentials
- Installation methods
- QC testing procedures
- Inspection procedures
- Hands-on training activities include:
  - Mixing, saturating and installation
  - Mechanical anchorage installation
  - Specialty finish application
  - Quality control testing and equipment

TESTING, R&D, INNOVATION

Tyfo system has undergone more than 500 structural and material tests to prove its effectiveness and durability since 1988.

Our products have been **tested and proven** at hundreds of independent universities and accredited labs throughout the world. These tests include structural, durability, corrosion, blast mitigation and fire-resistance studies along with valuable environmental durability research to simulate the effect of 50 to 100 years of service life. In addition to these extensive laboratory tests, Tyfo systems have performed as designed in major urban earthquakes in Taipei, Los Angeles, Seattle, San Salvador and China. The result is reliable composite strengthening systems that have demonstrated intended design performances time and time again.

Fyfe FRP continues to innovate and develop products to meet the needs of the markets and clients we serve. Our in-house research and development team is committed to leading and improving the structural strengthening market.



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