Precast Polymer Concrete Segments

The development and innovations made in producing precast polymer concrete, also referred to as solid-cast-polymer or SCP, were developed for their superior corrosion resistance and physical properties. Polymer concrete/SCP structures (i.e. manholes, pipe, wet-wells) have been a standard-of-practice for the chemical processing, mining, and wastewater industries since 1985 (> 35 years). Interest in using precast polymer concrete/SCP for segmental tunnel linings has grown significantly in the last 15 years. Technological advancements in formulations, manufacturing, and design have made precast polymer concrete/SCP tunnel segments considerably more practical and cost-effective.

Fig. #1: 23' L x 25' D Wetwell

Fig. #2: 96" ID Manholes

Fig. #3: 120" ID to 78" ID Tunnel Shaft

Economic and Technological Challenges and Hurdles

Precast polymer concrete/SCP has been a consideration for tunnel segments based on its superior corrosion resistance and superior physical properties as compared to conventional cement concrete segments lined with thin-film, spray on polymer coatings, and mechanically or chemically bonded thermo-plastic sheet (e.g. PVC or HDPE) liners. Precast polymer concrete/SCP also offers additional benefits over thermal plastic liners, as select polymer concrete/SCP formulations are Class-A fire rated to replace less durable concrete railroad ties for the New York City Transit Authority subway system. However, polymer concrete/SCP, employing earlier and somewhat crude manufacturing methods, was about 10 times the cost of unlined conventional concrete segments. Even with the addition of coatings or plastic sheet liners, precast Portland cement concrete segments were less expensive than precast polymer concrete/SCP segments.

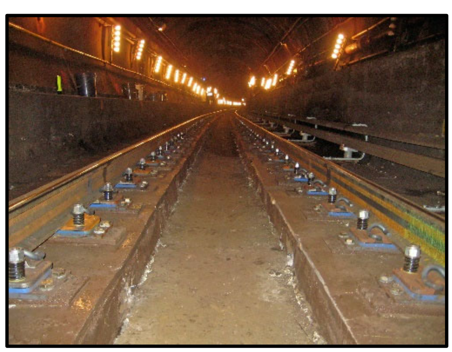

Fig. #4: NYC Transit Subway

In general, polymer concrete/SCP is approximately 4-6 times stronger than conventional concrete, such that precast polymer concrete/SCP segments could be produced as much as 50% thinner than conventional concrete segments. However, precast polymer concrete/SCP tunneling segments proved more expensive as they had to be produced at a minimum thickness (e.g. 7”) to incorporate rubber gaskets, bolts and/or dowels. As of 2018 there appeared to be no viable solutions to take advantage of the superior physical properties and corrosion resistance of polymer concrete/SCP in tunnel segments.

Precast Polymer Concrete/SCP VS. Conventional Concrete		
PRODUCT	**Average PSI**	**Average Mpa**
Compressive Strength (ASTM C-596)		
Conventional Concrete:	6,500	44.82
Polymer Concrete/SCP:	16,800	115.80
Tensile Strength (ASTM D-307)		
Conventional Concrete:	550	3.80
Polymer Concrete/SCP:	1,900	13.10
Beam Test (ASTM C-78)		
Conventional Concrete:	1,050	7.23
Polymer Concrete/SCP:	2,850	19.65
Shear Strength (ASTM D-732)		
Conventional Concrete:	870	6.00
Polymer Concrete/SCP:	5,000	34.47
Water Absorption %		
Conventional Concrete:	4.35%	
Polymer Concrete/SCP:	<0.1%	

Fig. #5

Polymer Matrix Formulations

Precast polymer concrete/SCP is made from various thermo-setting polymer binders such as polyester, vinyl ester, polyurea and epoxy resins, combined with inert aggregate fillers. Historically, some manufacturers have had issues with traditional binder systems. All resin systems are not the same and may contain volatile organic compounds (VOC’s) and hazardous air pollutants (HAP’s), making it difficult to permit and subject workers to occupational safety and health problems. Also, some resin systems having a high rate of shrinkage, elevated exothermic reaction, cannot integrate reinforcing steel because of incompatible thermal properties (thermal coefficient of expansion). Still, certain resin systems exhibiting VOC’s, HAP’s, thermal and shrinkage issues are designed such that these are not obstacles to polymer concrete/SCP production. However, unique technologically advancements offer certain resin systems more stability by removing harmful ingredients containing VOC's and HAP's, eliminating thermal, shrinkage and reinforcement concerns.

Manufacturing Advancements

Until recently, precast polymer concrete/SCP producers have been operating manually, culminating in increased handling, questionable QA/QC and increased manufacturing costs. However, polymer concrete/SCP producers are in the process of adapting to automated batching systems and RFID microchip technologies similarly used in conventional concrete production. These state-of-the-art manufacturing systems enhance productivity, quality, and worker safety.

Fig. #6: Automated Feed Mixing

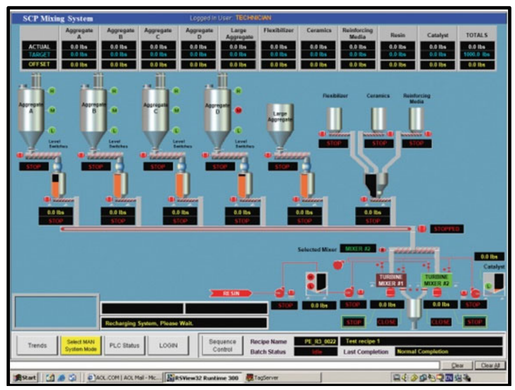

Fig. #7 PLC Control Panel

Design Improvements

As previously stated, earlier precast polymer concrete/SCP segmental tunnel designs were limited by thickness to incorporate gaskets, bolts, and dowels.

In the case of vehicular tunnels, where corrosion is not an issue, conventional concrete segments can be designed and manufactured using waffle designs, reducing the overall raw material volumes and cost of the Portland cement concrete tunnel segment system. However, waffled designs cannot be utilized in sanitary sewer tunnels due to sewage flow characteristics and turbulence created by waffle designs. A smooth internal surface is essential.

In the last several years a new and innovative precast polymer concrete/SCP segment design allows for a significant reduction in the volume and weight of polymer concrete segments, while still maintaining a smooth internal and external surface along with preserving superior physical and corrosion resistant properties. By integrating and positioning lightweight cores within the polymer concrete/SCP matrix and spacing the cores equal distance apart and on the same plane, the polymer concrete/SCP tunnel segment can carry virtually the same loads, as if it were a solid polymer concrete/SCP segment. The patented polymer concrete core-technology permits the design to achieve the desired segment thicknesses for incorporating gaskets, bolts and/or dowels. This new technology makes precast polymer concrete/SCP tunnel segments a cost-effective and superior corrosion resistant alternative to thin-film coated or sheet-lined conventional cement concrete segmental tunnel lining systems. Along with a significant raw material savings, the cost reduction assets are endless.

- Lower raw material costs
- Increased manufacturing productivity
- Lower freight costs
- Lighter-duty handling equipment (manufacturing & field)

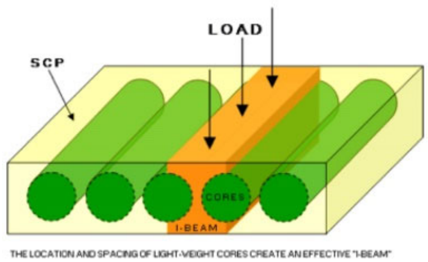

Fig. #8

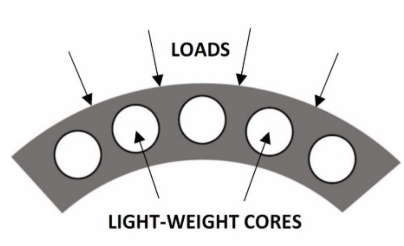

Fig. #9: Segmental Core Distribution

Installation Advantages

Large diameter sewer tunnels can be built with either a two-pass or one-pass lining polymer concrete segments to the protect the structural concrete from aggressive sewer gases and biologically induced corrosion, thereby extending the tunnels life cycle. The use of the one-pass system can significantly reduce the construction schedule and overall capital costs while improving the overall quality.

Carbon Footprint

Carbon footprint is a concern and challenge of the cement industry and conventional concrete. The conventional concrete industry has one of the highest carbon footprints of any industry in the world. An infant precast polymer concrete/SCP industry is currently undertaking and validating its presumed lower carbon footprint.

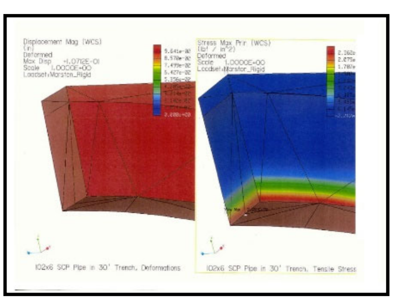

Fig. #10: FEA Modeling

Fig. #11: Gasket Test

Fig. #12: Segmental Tunnel