REHABILITATION OF MANHOLES WITH FRP COMPOSITES

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Carbon and glass fiber reinforced polymers (FRP) have been used for infrastructure for more than three decades, and applications in pipeline and other below ground infrastructure rehabilitation has gained momentum in recent years. The advantages of these systems include high strength, corrosion resistance, light weight, and the ability to be installed on essentially any type of structure, size, and geometry.

Fiber reinforced polymers are generally defined as carbon and glass fiber fabrics saturated with engineered epoxy to meet the needs of each application. Properties of these materials vary in a wide range depending on the fabric type, weight, and orientation of the carbon or glass fibers in the fabric. FRPs can be uniaxial, biaxial, or triaxial with respect to the directions in which they provide strength. For instance, a biaxial fabric in a manhole can withstand stresses generated by loads in the circumferential (hoop) or longitudinal (axial) directions.

Figure 1. Carbon fabric being saturated with epoxy resin through a saturating machine.

FRP has been used successfully in infrastructure rehabilitation, including manhole rehab applications. FRP materials are high-strength (ultimate tensile strength of CFRP can be three times greater than that of average steel) and corrosion resistant. Special types of resins may be needed for manhole applications mainly due to the release of hydrogen sulfide in sanitary and combined sewers.

The objective of an FRP design is to ensure the FRP liner will remain functional when subjected to service loads over its design life and have the necessary strength, reliability, and durability.

While some design equations are provided in AWWA and ACI standards for FRP design, semi-structural rehabilitation, in particular, can be complex and may require computational modeling with the finite element method as well as testing for particular loading conditions on different FRP configurations. Stress concentrations are possible at seams, joints, cracks, and other surface irregularities. The design of an FRP system must be conducted by a licensed engineer that is competent in underground infrastructure and rehabilitation design with FRP.

Installation

FRP materials can be applied in two ways for manhole rehabilitation:

1. Wet-layup:

This is the conventional way of applying FRP on any type of infrastructure. The process essentially is comprised of saturating FRP fabrics with epoxy (preferably with a saturating machine), and then applying each layer upon completion of surface prep. This type of application is bond critical; and therefore, surface prep is important. The spacing between the rollers is calibrated to the fabric being used, and the spacing between the rollers is verified as part of the quality assurance/quality control (QA/QC) process. The saturated fabric is rolled up in a reel that can be taken off the machine and transported to the point of installation. The fabric saturated with epoxy (ideally using a mechanical saturator shown in Figure 1) is hand-pressed against the manhole wall to eliminate entrapped air pockets (or blisters). The joints and terminations of repair must be detailed to prevent the water from penetrating between the FRP laminae and substrate.

Figure 2. A prefabricated FRP system (Stifpipe) being inserted into a vertical access hole.

2. Prefabricated Inserts

Alternatively, an FRP system can be factory made (or cast on-site) to the dimensions of the manhole to be rehabilitated (Figure 2). This method requires accurate measurements of the structure to be rehabilitated, and the annular space between the manhole and FRP insert must be filled with cementitious or polymeric grout to ensure stability of the insert in addition to sealing the annular space. The grout can be factored into the design of the FRP, but in that case, the minimum grout thickness specified must be achieved in the field by using spacers.

A project-specific QA/QC plan is recommended, and thorough inspection is required before, during, and at the completion of an FRP installation. Particularly for wet layup applications, the surface conditions must be compatible with manufacturer's specifications. For instance, for concrete surfaces, the surface profile should conform to International Concrete Repair Institute (ICRI) CSP 2/3. It is recommended that all necessary repair and restoration of the substrate be approved by the project engineer prior to application.

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