



# Composites for Hydraulic Structures

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## Terms of Reference

### 1. Background

Composites have evolved over the years and dominate the marine, aviation, and auto industry. Composites offer many and varied material properties, some are strength-to-weight ratio, corrosion resistance, ease of construction, etc. Civil Works engineers have been reluctant to take advantage of these properties, partially due to the lack of well documented success stories and the absence of an accepted design code.

### 2. Objectives

The main objectives is identifying "Best Practices" of how to use composites for hydraulic structures, summarize case studies with pros and cons, and to compile guidance documents to aid engineers when using composites in the demanding environment of hydraulic structures.

### 3. Earlier reports to be reviewed

The working group will gather any applicable guidance documents available, including vender brochures, research reports, conference papers, case studies, etc.

### 4. Scope

To compile available documents where composites provide a benefit over conventional materials for hydraulic structures and to define best practices to aid engineers when using composites for hydraulic structures.

### 5. Intended Product

The intent will be to provide a summary of current best practices and guidance of composites.

**History:** Provide a brief history of composites describing how and why these materials are being investigated and implemented.

**Terminology:** Provide clarity on the use and misuse of names and definitions related to alternative materials/composites. Inventory alternative materials - list and define the most widely used composites for structural applications.

**Applications:** Identify applications involved in large scale marine and civil works projects. These projects involve the construction of facilities such as locks, dams, levees and pump stations. These projects are comprised of various elements such as valves, gates, walls, piling, mooring facilities, etc.

These elements can be broken into three major categories as shown below for possible composite applications:

- A. Structural Elements/Systems – These would be items fabricated from various composite shapes to erect a larger composite structure. These would be items such as gates, miter gates and valves. These items would be operable structures subject to large loads, submersion and extreme climate and environmental conditions.
- B. Hybrid Structural Elements/Systems – These would be items similar to Structural Elements/Systems but would be a combination of traditional materials and composite materials.
- C. Coatings – These would be items sprayed or glued to usually steel structures inhibit corrosion.
- D. Miscellaneous Items – This would be items such as railings, gratings, ladders, etc. These items are not subject to extreme loadings but are subject to submersion and extreme climate and environmental conditions.

This WG report should focus primarily on Categories A, B, and C. Provide recommended materials and/or material combinations that could potentially be used for these categories. Provide repair schemes for damaged portions of composite structures.

### **Pros and Cons**

List the major pros and cons of using composite materials. Provide examples and comparisons as needed to justify the pros and cons. Provide insight to the following topics:

- Durability
- Weight
- Strength
- Hardness
- Friction and Wear Resistance
- Chemical Resistance
- Fire Resistance
- Impact Resistance
- Long Term Water Submersion Resistance
- Ultraviolet Resistance
- Fatigue Resistance
- Cavitation Resistance
- Cost
- Thermal Properties
- Moisture Uptake
- Methods of repair (Minor/Major)
- Material Advantages/Disadvantages
- Any other physical properties relevant to the products use in the marine/civil industry

### **Fabrication**

Describe how the composite materials are fabricated and assembled. Discuss and describe the methods of material fabrication. Elaborate on the relevance of strand orientation. Describe the various connections between members. Elaborate on the advantages and disadvantages of the various connections.

## **Inspection**

The engineering and fabrication industry has a wealth of knowledge and guidance pertaining to the inspection and acceptance of structures fabricated from traditional materials. These inspections range from visual inspections all the way to Infrared Thermography, Tap Hammer, Ultrasonic, X-ray with metallic particles, etc. Describe the various processes for inspecting structures fabricated with composite materials. Provide more emphasis in the testing of the various connections. Describe the industry standards for testing of composite materials for both destructive and non-destructive testing for Quality Assurance.

## **Design Guidance**

List relevant codes or guidance for the design and construction of composite structures. Provide a review and comment on the relevance and applicability of the document.

## **Case History**

To achieve large scale acceptance composites will need prototype testing. Provide a plan of "Lessons Learned" from the bridge composite industry for ways to improve acceptance from designers for integration of composites. Provide discussion on type of structures that may be advantageous to use composites. Discuss how to move composites from minor uses such as guides and other appurtenances, to using composites for major structural components of structures. Include discussion on "ease of construction". For this review there is an important need to ensure that proven design concepts move forward and make recommendations for best practices, also Lessons Learned from Failures associated with composites. Provide relevant case histories.

## **6. Working Group Membership**

The background and experience may include the following:

- A. Academia/educators
- B. Operators and managers of existing waterways
- C. Consultants and navigation engineers
- D. Representatives of regulatory bodies
- E. Promoters of improvement or new navigation schemes
- F. Manufacturers and fabricators
- G. Resin and fiber/fabric suppliers

## **7. Relevance for Countries in Transition**

The results will help to designers and promoters of new or existing navigations throughout the world and provide guidance to develop and operate safe and economically viable waterways. This working group can be useful for all countries developing hydraulic structure infrastructure by providing a relevant design experience for using composites for new or to extend the life of existing hydraulic structures.

## **8. Sustainability**

Provide a discussion on climate change issues when deciding to use composite materials. How does using composites over conventional materials impact greenhouse gases, improve adaptation of existing infrastructure to cope with climate change, etc.