



## To repair or replace a bulkhead: that is the question

*New steel sheet pile bulkhead under construction, Grove Harbor Marina (Dinner Key Boatyard Marina) Miami, Florida*

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The most common form of shoreline stabilization at marinas is a bulkhead. The bulkhead provides an economical shoreline interface between the upland marina area and wet slips. For some marinas, the bulkhead also serves as a source of revenue, whether it be parallel docking or perpendicular mooring. Marina management is faced with the maintenance of marine structures, and a proper assessment of the bulkhead with estimated remaining service life is essential for budgeting repairs and/or replacement. In addition, there are safety concerns relative to loads behind the bulkhead such as forklifts, vehicles, and marina customers.

Assessing the condition of bulkheads on a regular basis can extend the service life of a structure. Performing preventative maintenance or minor repairs as a result of a bulkhead condition study can be completed before they become major concerns. Often times, bulkhead problems do not "surface" until it is too late. Sinkholes or bulkhead failure can have a substan-

tial economic impact on marina operations. Underwater bulkhead deterioration or other problems such as undermining due to propeller scour are not visible above water and cannot be monitored on a regular basis.

This article will explain the difference between a seawall and bulkhead, introduce elements of bulkhead design, present bulkhead materials of construction, and discuss bulkhead evaluation methodology.

### Seawall vs. bulkhead?

Many people refer to all vertical shoreline structures as "seawalls," but there is a difference between a seawall and a bulkhead:

**Seawall:** structure that provides shoreline protection from waves but also retains soil.

**Bulkhead:** vertical shoreline stabilization structure that primarily retains soil, and provides minimal protection from waves.

Seawalls are typically located on the coast fronting beaches, and are subject to storm surges with pounding surf, eroding shorelines and wave overtopping from

coastal storm events. Some localized waterfront properties may be subject to significant wave activity, even though they are not exposed to ocean waves. The "rule of thumb" in bulkhead design is to account for wave impacts if the significant wave height at a project site is expected to be in excess of three feet (1 meter).

### Elements of bulkhead design

The following design considerations need to be addressed to properly assess the condition of a bulkhead.

- Topography: elevations, grading, etc.
- Soil Properties: unit weight of soil, clay vs. sand, etc.
- Embedment/Stability: depth of bulkhead for stability
- Water Table: differential water levels behind and in front of walls can introduce additional loading on the wall
- Exposure: climate and saltwater vs. freshwater
- Material Properties: strength and performance in the marine environment
- Surcharge: live loads behind the wall



Replacement steel sheet pile bulkhead under construction, Bahia Mar Yachting Center, Ft. Lauderdale, Florida

such as vehicles

- Ice Loads: in northern climates
- Prior Maintenance
- Changes in use

Original or “as-built” plans can provide a wealth of information including the age of the structure and many of the design elements listed in the above paragraphs. The deteriorated condition of a bulkhead be an indication that the bulkhead is either in need of maintenance, or that it has fulfilled its service life. In some cases, the bulkhead may be damaged due to loads in excess of loads it was designed to withstand.

## Materials of construction

The material of the bulkhead must be

properly identified during the assessing. The condition. The following table presents common wall construction materials with comments regarding availability, construction issues, and general performance in the marine environment:

### Concrete

Pile/panel and sheet piling configurations provide a service life of 30+ years if correct mix design and proper marine structural design implemented. Sheet piling can be difficult to install in hard substrates, and concrete pile/panel walls can be subject to undermining.

### Steel

Steel sheet piling commonly used for bulkheads. The material provides excellent strength characteristics for high wall exposure applications. has an interlocking seal, and is generally easy to install, even in harder substrate. It must be properly coated and maintained for long service life of 25+ years.

### Aluminum

Sheet piling provides good corrosion resistance, but lighter sections allow for minimal exposed wall height. It is important to recognize corrosion potential of dissimilar metal hardware, do not use in waters with low backfill with clay-mucky soils. It is difficult to install in hard substrates.

### Timber

A timber pile/wale/sheet system is a common structural configuration. It is generally economical material, but has limited strength characteristics for high wall heights. Preservative treatment is essential for marine organisms. Service life is generally less than 25 years. It is difficult to install in hard substrates.

### Vinyl/F.R.P.

This is a relatively new, economical product with service life of 50+ years (based on manufacturer warranties) It's available in different colors. Strength characteristics are limited for high wall heights. It is difficult to install in hard substrates.

## Structural evaluation

The American Society of Civil Engineers (ASCE) *Underwater Investigations Standard Practice Manual* was released in 2001 and provides guidance for the evaluation of marine structures including bulkhead.

The following topics are covered related to structural bulkhead evaluation:

- Qualifications of inspection personnel
- Types and methods of inspections
- Typical forms of deterioration
- Condition Rating
- Frequency of Inspection

Marina management should retain the services of a consulting engineering firm that provides above/below water inspection services.

A comprehensive report is essential to document a proper bulkhead evaluation. The report should reference procedures and guidelines from the associate manual. All of the above items should be included along with photographs and sketches of the observed configuration with notes regarding deterioration. Comparison of previous reports provides an indication of the rate of deterioration.

Repair recommendations, along with construction cost estimates, should be included to provide marina management with sound engineering advice so they can plan of maintenance/repairs as necessary. Even though a bulkhead is deteriorated, it may not require immediate replacement. The report should be sealed by a registered professional engineer experienced in



Two examples of typical concrete bulkheads: Eleuthera, Bahamas





*Deteriorated concrete pile/panel bulkhead. Note the storm sewer outfall through the bulkhead.*

the evaluation of in-service marine structures. The engineer is required by law to provide independent un-biased advice.

### **FAQ regarding bulkheads**

#### ***Can I raise the grade of my property with the existing bulkhead?***

The bulkhead must be evaluated by an engineer to determine if the structure can withstand the additional loads from fill and structural modifications. Deterioration can severely weaken the structural capacity of the bulkhead, and the bulkhead was most likely designed for the existing conditions.

#### ***What is the best material for bulkheads?***

Material selection is site-specific and depends on design conditions. Concrete (if designed appropriately) generally provides a long service life, but it is not favorable from a first-cost basis. Vinyl sheet piling and other composite materials, where applicable, should be considered due to their resistance to the harsh marine environment.

#### ***How long can I expect my wall to last?***

Answers to this question are generally

subjective. An experienced marine structural engineer can also provide an indication of material performance. Certain non-destructive and/or partially destructive Materials testing can provide additional information for the assessment.

#### ***What regulatory permits are required?***

Bulkheads typically require an environmental resource permit from several agencies including local and state environmental resource management agencies and U.S. Army Corps of Engineers. The contractor must secure a permit from the building department.

#### ***How often should I inspect the wall?***

The ASCE Manual provides guidance for the frequency of inspections. Generally, seawalls and bulkheads should be evaluated every 5 to 6 years.

#### ***How are bulkheads repaired?***

A qualified marine structural engineer should be consulted to evaluate the existing wall and to determine if rehabilitation or replacement is required. Options can generally be provided to provide an economical approach to meet budget constraints.

#### ***Who can build a bulkhead?***

Bulkheads are specialized structures, often requiring water-based construction equipment and techniques. The costs for waterfront construction are generally higher than for upland structures such as buildings. Bulkhead or seawall work should be reserved for a qualified and experienced marine contractor.

#### ***How much does Bulkhead construction cost?***

Depending on the local construction market and bulkhead design requirements, repairs may cost \$100-\$400 per linear foot of wall. Bulkhead replacement may cost \$500-\$1,000 per linear foot.

### **Conclusions**

1. Bulkhead design is site-specific and the design elements of a particular structure should be understood prior to evaluation.

2. Bulkhead materials of construction exhibit various forms of deterioration in the marine environment. Proper material identification is essential to assess structural performance.

3. ASCE recently released a standard practice manual to provide guidance for the above/ below water assessment of marine structures.

4. Bulkhead evaluations should be conducted by qualified personnel under the supervision of a licensed professional engineer

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