15. Develop Inner Harbor Wave Criteria

The primary purpose for designing and constructing a harbor is to provide wave protection to moored vessels. What constitutes a protected harbor is somewhat subjective; however, there are minimum criteria that can assure owners that their boats can be left unattended without risk of damage during frequent storms or extreme events. Using agreed-upon criteria also ensures that the engineer designing the inner harbor floats and piles is in harmony with the engineer designing the protective structures.

15.10 Wave Disturbance

Excessive wave disturbance in a mooring basin will cause fatigue to the structural elements of a float system, and will accelerate wear on piling and pile guides. It also frays mooring lines, displaces fenders, and causes anxiety for boat owners.

Consider WAVE DISTURBANCE when:

1) Designing protective structures for new or existing harbors
2) Developing a float layout in a semi-protected wave environment
3) Designing the structural elements of a float system

Note 1. Protective structures and structural elements of the float system are normally designed for 50- to 100-year recurrence intervals of the largest waves. However, short-term events that may occur several times a year should also factor into consideration of wave disturbance in the mooring basin.

Note 2. When evaluating wave disturbance in the basin, you should consider the contribution of wave energy from all directions.

Note 3. Waves exceeding the design criteria can be generated within a mooring basin, if it has long, open channels or fairways.

Note 4. Wave energy can pass through a breakwater if the core is too permeable. This is especially true for long period waves, i.e. swell.

Note 5. Criteria for good wave conditions in a small boat harbor as defined in Table 2.5 (Reference 1) are generally recommended. Evaluate horizontal and vertical movement whenever a basin is exposed to long period swell.

REFERENCES:

1. ASCE Manual No.50. Task Committee on Marinas 2000. 1994. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 110-111.

15.11 Due to Harbor Resonance

Wave disturbance due to a standing wave in an enclosed body of water is called resonance. A harbor, with a nearly rectangular planform, is said to be “excited” when the wave entering the basin has a resonant period. Reflective boundaries exacerbate conditions, while sloping and porous boundaries such as beaches dissipate the energy. Long-period resonance in a large, enclosed water body is also called a seiche.

Consider HARBOR RESONANCE when:

1) Designing a small basin adjacent to a large water body where wave periods over ten seconds are common
2) Laying out the basin geometry and bottom elevations where long period waves are common
3) Designing or selecting the type of float system where long period waves occur

---

Note 1. The designer should be especially cautious where wavelengths propagating through the entrance channel are roughly equal to the basin length or width.

Note 2. Most harbor resonance is manifested in horizontal motions, which set up surge and sway response in vessels.

Note 3. Large vessels, due to their mass, are much more of a concern in basin resonance. Often their mooring system will have a similar response as the basin, and horizontal motions will amplify.

Note 4. Irregular energy-absorbing shorelines with uneven bottom elevations will usually help disperse the wave and dampen resonance. Vertical walls and uniform depths can exacerbate resonance.

REFERENCES:

1. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 110.

2. *Shore Protection Manual.* 1984. 4th ed., 2 vols. U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, U.S. Government Print. Off., Washington, D.C. Pp. 2-113 through 116.

15.12 Entrance Channel

Most wave energy that enters a basin will be from waves diffracted through the entrance channel. It is important to factor both wave attenuation and navigation safety into its design.

Consider ENTRANCE CHANNEL waves for inner harbor wave criteria when:

1) Designing protective structures that define the entrance width and orientation
2) Laying out floats that are affected by waves diffracting through the entrance

Note 1. If you can stand on a mooring float and see open water through the entrance, the float is probably not fully protected.

Note 2. Keep the entrance width as narrow as possible, while providing safe navigation, to minimize the amount of energy that can enter the basin. A narrow entrance will also improve circulation in most cases.

Note 3. Consider all fetches over about 1,000 feet when designing the entrance.

Note 4. One may consider mooring larger boats near the entrance where high waves occur, if they can be aligned with the wave *and* wavelengths are less than about half the boat length.

REFERENCES:

1. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 64-85, 110.

15.13 Breakwater Transmission

The primary purpose of a breakwater is to provide protected moorage and ensure the basin wave disturbance is within the acceptable criteria. In addition to waves diffracting around the ends and through the entrance channel, waves may be transmitted over, under, or through the breakwater.

Consider WAVE TRANSMISSION OVER, UNDER, OR THROUGH BREAKWATERS when:

1) Designing protective structures
2) Laying out mooring stalls behind a floating breakwater or wave barrier

---

Note 1. Rubble breakwaters are generally most practical for wave periods greater than about four seconds and water depths less than 30 feet. Be cautious of transmission through the breakwater when using a highly permeable core for long period waves.

Note 2. Floating breakwaters may be most economical for water depth over about 30 feet and wave period under three seconds. Floating breakwaters act as low-pass filters by attenuating the higher end of the frequency spectrum and transmitting the lower end. Consider incorporating the breakwater into the float system for transient moorage.

Note 3. Curtain wall, or vertical, wave barriers that only penetrate part of the water column have similar performance characteristics to floating breakwaters. Though they are typically designed with a gap at the bottom, it may be necessary to construct a full-depth wave barrier for periods greater than about four seconds. Evaluate curtain wall wave barriers for wave transmission during low tide and for structural and overtopping during high tide.

Note 4. It is often necessary to consider wave energy from several modes of transmission when evaluating inner harbor wave disturbance. As an example, waves passing under a floating breakwater can combine with those that diffract around the end.

REFERENCES:

1. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg.110.