12. Analyze Wave Transformation

Understanding the mechanics and theories used in describing wave transformation is necessary for the proper design of coastal structures. Carefully interpret these wave theories for application to the site-specific features of the coastal environment.

12.10 Refraction

Refraction occurs when bottom friction slows a portion of the wave causing it to bend. Refraction can either disperse the energy causing attenuation in wave height, or focus the energy causing amplification.

Consider REFRACTION ANALYSIS when:

1) The water depth is less than half the design wavelength, and
2) Offshore bottom contours are irregular and/or mildly sloping

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Note 1. Refraction is generally necessary when designing for long period swell.

Note 2. In areas of high tidal range, low tide usually produces the greatest refraction.

Note 3. Long waves refract more than short waves. Therefore, include a range of wave periods in the analysis to bracket the worst condition.

REFERENCES:

1. U.S. Army Corps of Engineers. Department of the Army, 1984. *Shore Protection Manual.* Coastal Engineering Research Center: Vicksburg, Mississippi. Vol. 1. Pg.2-602.

2. Resio. Computer Numerical Model. *"STWAVE."* Coastal Engineering Research Center (CERC).

12.20 Diffraction

Diffraction occurs when a wave passes an abrupt object such as a rubble breakwater, or an island with steep shorelines. Diffraction consists of wave energy spilling along the wave crest into the lee of the barrier. Unlike refraction, diffraction is a two-dimensional phenomenon. Diffraction and refraction are both present where there are intermediate or highly irregular slopes. These complex conditions can usually be handled with unified numerical models.

Consider DIFFRACTION when:

1) The harbor or area of concern is in the shadow of a headland, island, breakwater, or other coastal feature that partially blocks a major wave exposure

2) The measure of a breakwater's effectiveness is evaluated using predetermined criteria for inner harbor disturbance

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Note 1. Wave energy that diffracts around the ends of floating breakwaters and wave barriers needs to be recombined with the energy that passes under or through.

Note 2. When diffracting around a land mass, always check whether refraction should also be considered.

REFERENCES:

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* Coastal Engineering Research Center: Vicksburg, Mississippi. Vol.1. Pg. 2-75.
2. Resio. Computer Numerical Model. *"STWAVE."* Coastal Engineering Research Center (CERC).

12.30 Reflection

Reflection occurs when a wave encounters a flat solid object such as a vertical wall or side of a large ship. Long period swells also reflect much of their energy off rubble-mound breakwaters or steep rocky shorelines.

Consider REFLECTION when:

1) A reflected wave may combine with the incident wave. Therefore, avoid structures with vertical walls in, or near, navigation channels.

2) A reflected wave may impact adjoining properties causing increased erosion or otherwise limiting their use

3) Reflected wave energy within the harbor basin may lead to resonance, seiche, or similar undamped oscillations

4) Reflective structures that do not absorb energy will often have more runup and overtopping

Note 1. A rule of thumb is that features with a width less than 1/4 of a wavelength will not reflect energy.

REFERENCES:

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* Coastal Engineering Research Center: Vicksburg, Mississippi. Vol.1. Pg.2-109.

12.40 Shoaling and Breaking

Shoaling occurs when waves move into shallow water. When the wave slows due to bottom friction, the wavelengths are compressed (shortened) and the wave height increases. The wave period remains the same.

Consider SHOALING when:

1) A breakwater or similar structure is constructed where the toe is in water depth less than about ½ wavelength

2) When a structure is fronted by a mildly sloping beach

Note 1. Shoaling is more pronounced with long period waves.

Note 2. For irregular shorelines, always combine shoaling with refraction. Though concave shorelines may cancel each other out, while on convex shorelines they may be additive.

Note 3. For design conditions in shallow water, always check for the maximum depth limited height.

REFERENCES:

1. U.S. Army Corps of Engineers. Dept. of the Army. 1984. *Shore Protection Manual.* Coastal Engineering Research Center: Vicksburg, Mississippi. Vol.1. Pg.2-109.
2. ASCE Manual No.50. Task Committee on Marinas 2000. 1982. *Planning and Design Guidelines for Small Craft Harbors.* New York. Pg. 65, 81.