Concrete In The Marine Environment

Some of the first structures built by the Oil Industry offshore were made of concrete. Concrete seemed the natural material to use because of its proven durability in the marine environment. The first recorded maritime use of reinforced concrete was a boat built in France in 1858, and a substantial number of concrete ships were built during World Wars I and II. Also, many floating concrete drydocks and cargo barges are in service today, not to mention the thousands of bridges, piers, and other coastal structures built of steel reinforced concrete.

In the recent past (as little as 20 to 25 years ago) most concrete mixtures were low strength and quite porous, resulting in either cracks developing and/or sea water penetrating the concrete through its pores and corroding the reinforcing steel. Since that time, however, concrete technologies and materials have improved greatly due to experiences gained in the North Sea and studies undertaken by various agencies, including the U.S. Navy. In one study, the Navy sank a number of hollow concrete spheres into water depths up to 5,000 feet to determine if concrete would continue to maintain its strength and watertight integrity. The study showed that concrete was highly resistant to water penetration and, further, that the concrete's strength increased with age and submersion.

Cracks in concrete are obviously not desirable, since they can lead to reduced strength and corrosion of the reinforcing steel. In the marine environment, small hairline cracks at the surface (0.005 in.) will seal themselves with secondary crystallization. These type cracks have proven much less serious to the overall integrity of the structure than has the high permeability of improper concrete mixtures.

Corrosion of reinforcement steel in concrete due to a "porous" concrete mixture will appear in a very short period of time, usually within one year of service. Proper treatment methods, which include chipping off the bad concrete, patching with the correct concrete, and application of a suitable protective coating, will seal the structure and protect the reinforcement steel from further corrosion, and the concrete from future spalling.

To successfully use concrete in the marine environment, several criteria should be incorporated into the design to ensure a sound structure:

Design - Proper structural design to resist in-place, external and internal loadings should be performed.

Water-Cement Ratio - A low water to cement ratio should be specified.

Cement Factor - A minimum quantity of cement per cubic yard of concrete should be specified.

Calcium Chloride - The use of CaCl in mixing and curing water should be avoided.

Cover - Adequate cover over the reinforcing steel should be specified. The depth of the cover, however, is not as important as the general permeability of the concrete.

Dense Impermeable Concrete - This should be specified by (a) maintaining a low water-cement ratio, (b) requiring good consolidation (vibration) to eliminate voids near the reinforcing steel, (c) requiring good curing procedures, and (d) requiring a smooth surface finish.

Coating - In special cases it may be desirable to seal the surface with a protective treatment. Coatings alone are not a substitute for a good concrete mix. A good coating specified on bad concrete will not ensure a sound structure.

In conclusion, the technology associated with concrete structures purpose-built for the marine environment has advanced to such a degree that concrete provides a very viable, cost-effective alternative to other construction materials in many applications. As long as the proper practices are followed during design, construction, and maintenance of steel reinforced concrete in marine applications, a good, sound, long- lasting structure will result.

Corroded reinforcing steel in a concrete column exposed to salt water. Corrosion of the steel has caused severe spalling of the concrete.

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