Durability models

Decision-making tools that compare your project's requirements with corrosion protection solutions

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More owners are demanding structures with longer lives at lower costs. In response, project engineers and builders are focusing more attention on corrosion resistance technologies for exposed structures to address these seemingly contradictory requirements.

Structural engineers have known for many years about systems that combat corrosion; however, most have not been able to quantify the usefulness of the various systems for two reasons.

First, they lack an overall understanding of the various corrosion protection products. In the past, the efficacy of calcium nitrite-based corrosion inhibitors, silica fume, and sealers, was not effectively demonstrated and compared to the more traditional, epoxy-coated reinforced steel solution.

Second, no tools were available to help the engineer predict the benefit of the various combinations of new materials and processes.

Recently, the industry has developed software programs, that weigh the time-sensitive relationships among corrosion inhibitors, structure life, and costs. These provide the engineer with an unbiased, scientific procedure to evaluate and compare the costs and effects of all of the available corrosion protection systems.

Pressured to extend the usable life of new structures and to improve overall return on investment, the industry is refining modeling approaches to predict the costs and benefits of protecting projects from salt-induced corrosion. Concurrently, it is developing less invasive deicing compounds and improved corrosion additives to concrete mixtures.

Durability is an important consideration for projects subjected to harsh environments.

Modeling capabilities

Several years ago, Grace Construction Products introduced DuraModel™, the first software to couple service life prediction with life cycle cost impact, discounted to present value dollars. The motivation to develop such a model was based on Grace's belief that a non-biased tool of this type would consistently highlight the cost effectiveness of DCI technology relative to other available corrosion protection systems. From the beginning, the engineering community embraced DuraModel and provided feedback, which Grace has used to upgrade the scope, versatility, and functionality of the software.

The current version uses a scientifically based evaluation method, along with data from specific projects, to compare performance and costs of all corrosion protection products and systems. This provides the design community and owners with data they need to make more informed decisions.

Alan Simon, principal at Hybrid Parking Solutions of Massachusetts, finds that DuraModel saves significant time and money for his company and for his clients. "We are able to help our clients quickly evaluate a wide range of alternative corrosion solutions," he said. "The DuraModel quantifies the

alternatives, providing a foundation for decision making."

Input requirements and output

The input information for DuraModel includes: concrete quality (to determine diffusivity), environmental conditions, concrete cover over reinforcing steel, service life requirements, an assumption of repairs (if needed), assumption of an appropriate discount rate, and the cost and performance characteristics of all the corrosion protection systems evaluated. Many of these inputs have default values, but they can be changed suit the specific project requirements.

The model provides output that reflects mathematical calculations and economic analyzes of various systems. It indicates ranking of systems based on initial costs of construction, time to repair, present values of future repair costs, and total life cycle cost expectations. For example, running DuraModel for a hypothetical bridge structure might show an expected time-to-repair of 20 years using the standard concrete mix. The addition of five percent silica fume and 20 liters of calcium nitrite per cubic meter could extend the time-to-repair to more than 70 years. Only the total number of protective system options available to the design team limits the permutations and combinations that DuraModel can calculate.

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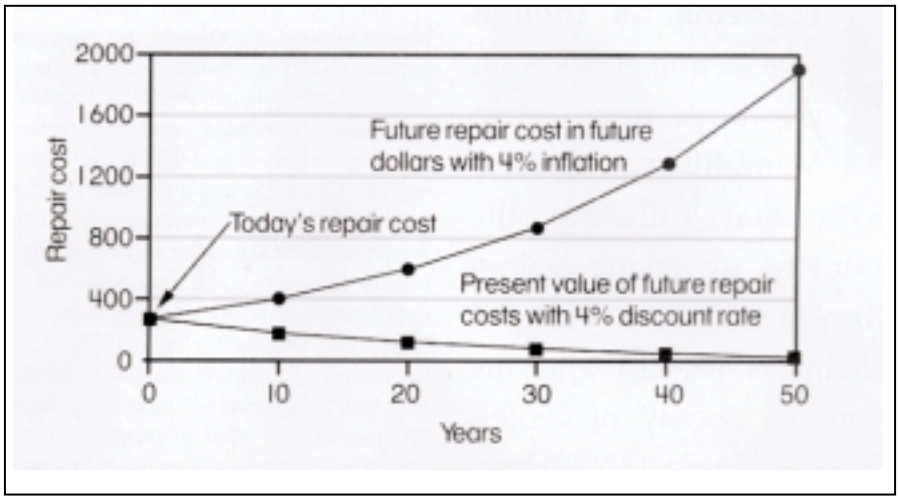
Explaining the life cycle cost analysis

Once the model has determined the time-to-repair for the different options, the next step is to determine the present value of the projected future repairs. The present value of the projected repairs can then be added to the up-front cost to yield the present value life cycle cost (LCC). In order to estimate the present value of a future expense, the owner must calculate a discount rate. The discount rate is essentially the difference between an owner's cost of capital and the projected inflation rate. The graph (top right) shows the compounding effect that four percent inflation has on future repairs, but also the minimizing effect that a four percent discount rate has on repairs that are expected to take place many years hence.

This particular example of four percent inflation and four percent discount rate would only be appropriate for an owner with an eight percent return on capital. Although the discount rate is not exactly equal to cost of capital minus inflation rate, it is a close approximation. For an owner with a cost of capital of 10 percent, the appropriate discount rate should be six percent. For owners such as public agencies with relatively low discount rates, life cycle costs are minimized by investing in preventative measures that substantially delay needs for repair. Private firms with higher discount rates would see less present value impact for a distant repair, and would reasonably invest somewhat less in preventative measures.

When considering the cost of repairs, it is important to consider the collateral costs and loss of income, as well as the actual structure repair cost. For a parking garage, this could represent loss of income while the garage or a portion of it is out of service. For a bridge, agencies should (and commonly do) look at the costs to the public in terms of traffic delays, and wear and tear on autos as the bridge deck deteriorates and is then taken out of service for repairs. As these collateral costs and/or lost income values are incorporated into the analysis, the return on investment of preventative measures rises dramatically.



Note: Values for inflation and discount rate chosen for illustrative purposes only.

Advancements in modeling

Several major efforts are underway to develop the next generation of models and introduce a broader array of intelligence into the evaluation process. For example, a coalition formed through the efforts of the American Concrete Institute Strategic Development Council (ACI SDC) has been actively developing a new industry standard Service Life Prediction Model for the last 18 months. This model, developed by the University of Toronto with funding and guidance provided by Grace Construction Products, Master Builders, and the Portland Cement Association (PCA), is entering into a beta test phase and is expected to be released in the second half of 2000.

In addition, the Concrete Corrosion Inhibitor Association (CCIA) was formed to promote the understanding and use of corrosion inhibitors in concrete. The association is made up of Master Builders, Grace Construction Products, ASIM Concrete Technologies, Inc., Sika Corp., and Cortec Corp. Their goal is to announce its initial modeling recommendations in the second half of 2000. ■

For further information and a demonstration of DuraModel, visit Grace Construction Products' Web site at ***www.graceconstruction.com*** *or call 1-888-432-6491.*

Models consider the environment.