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Case Study

Corrosion condition evaluations of historic concrete icons[☆,☆☆]

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ABSTRACT

Corrosion condition assessments of historic concrete structures can provide the owner with invaluable information regarding the current condition of the structure, the factors contributing to the corrosion damage, and can also project when the structure may exhibit further material loss. This information is vital to be proactive in the repair process which is imperative to minimize loss to the structure. When dealing with a highly significant concrete structure, the investigative team is often faced with restrictive parameters limiting the amount of data which can be collected. This paper discusses challenges in preserving 'historic concrete' and provides four case studies of predictive corrosion condition assessments which were carried out to help in the decision making process.

1. Introduction

1.1. Survey approach

A corrosion condition evaluation of a concrete structure identifies the conditions which affect the long-term behavior of the concrete's performance over time within its given environment. The aim is to create a lifetime model of when the building will reach critical deterioration limit states and when the structure will require repairs. The analysis can also allow owners to plan for service life extension and obsolesce if necessary. With historic concrete buildings, the intended design life and desired service life are often many years apart. Historic buildings, defined in the United States as being 50 years or older (National Register of Historic Places), are almost always functioning beyond their intended service life.

A detailed corrosion condition evaluation is a significant part of the evaluation process for aging concrete. The assessment procedure identifies deterioration factors, including physical, chemical, structural, mechanical and electrochemical damage, to incorporate into a risk matrix.

This holistic survey approach is multifaceted with a long term view on building performance. The final analysis includes the use of durability models to provide an understanding of future behavior, projected time frames to reach limit states and when the structure will see an increase in deterioration. This methodological approach allows owners to make informed decisions on the best repair choice for the life extension of the buildings.

☆ This paper was presented at Concrete Solutions, the 5th International Conference on Concrete Repair. It can be found in the conference proceedings: Michael Grantham, P.A. Muhammed Basheer, Bryan Magee, Marios Soutsos, Concrete Solutions 2014, CRC Press, 2014.
☆☆ All data presented within the case studies is from the authors' site investigations.
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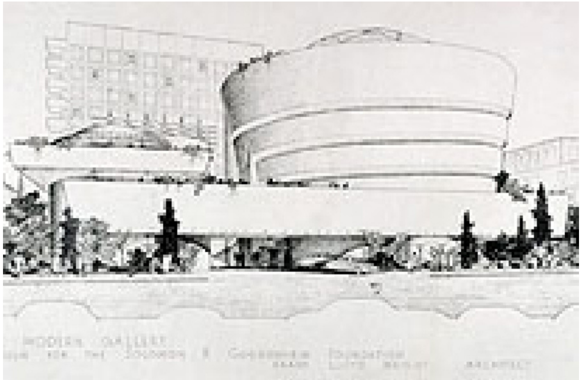

Fig. 1. Rendering of the Guggenheim Museum, FLW. Credit Cohen.

Four case studies are used to illustrate the results of recent corrosion condition evaluations and durability models. Each structure assessed has historical relevance in American architectural history, each is a different form of construction, and designed by prominent American architects.

1.2. "Preserving concrete"

Reinforced concrete revolutionized construction of the 20th century. The material is ubiquitous and was at the forefront of modern technological advancements within the construction industry on an international platform. Structures once recognized as innovative and new, from beautiful in form, to brutalist and offensive, are now pending landmark designation. As concrete buildings begin to age, structures greater than 50 years old which have been deemed architecturally significant now require conservation (Fig. 1).

Particular challenges with historic buildings include landmark restrictions, such as minimizing interventions, preserving historic fabric, reversibility, and replacing materials in kind. This philosophy of minimal intervention is prevalent throughout the conservation community which is not in agreement with the general concrete repair industry. Industry professionals are challenged when treating landmark concrete as repairs do not follow a conservation philosophy.

Architectural concrete of the modern movement comprises individual structures to planned cities. The design, construction method, materials used and standards of workmanship employed in the creation of a concrete structure will vary enormously according to its date of construction. All these factors will affect the durability of the structure (Macdonald, 2003). Additionally, the location, climate, will play a part in the deterioration and subsequent repair. The ephemeral nature of the structure, the transitory attitude of the designer and the inextricable links between material, fabric, integrity and structure will need to be considered in the repair.

Current 'traditional repair' methods generally conflict with conservation standards. The attitude of treating 'historic' concrete structures as unimportant and disposable is all too prevalent. The requirements to provide interventions which may be invasive yet preserve the integrity of the structure create complex physical and philosophical challenges. The balance of conservation, authenticity of the original fabric, code compliance and minimizing deterioration must all be addressed. The final aim of an intervention should be to preserve the structure for future generations while minimizing impact and not compromising safety of the users or the stability of the structure.

Arguably the most detrimental mechanism of deterioration to concrete is corrosion of the reinforcing steel. It is not a question of if a concrete structure will corrode; it is a question of when it will corrode.

2. Corrosion condition assessments

2.1. Testing an icon

Dealing with degradation and corrosion of concrete requires a multifaceted, holistic approach. Understanding concrete composition, material properties, additives, aggregates, types of reinforcing steel and construction details are key factors in the assessment. The corrosion evaluation process for historic, iconic concrete should embrace the tenets of the Secretary of the Interior Guidelines, English Heritage, Historic Scotland or the governing conservation body of the respective country. While standard practices outlined by the American Concrete Institute, the Corrosion Prevention Association, or the Concrete Society provide a baseline for surveys, they do not address the sensitivity required to assess historic concrete.

"The corrosion process for steel reinforced concrete can be simplified into a two-stage process namely, the 'initiation phase' and the 'propagation phase'. By definition the initiation phase is the time taken for conditions to become conducive to corrosion and the propagation phase is the period in which the accelerated corrosion of the steel reinforcement ultimately leads to rust staining, cracking and spalling of the cover concrete (BRE)." Once the structure has been evaluated and the team