AGENDA
ACI SUBCOMMITTEE 562-0F

ACI Fall 2016 Convention
Philadelphia, PA

Saturday, October 22, 2016
6-9 pm, Room 404

1. Call to Order
2. Self-Introductions and Membership Update
3. Approval of Agenda
4. Discussion of new work
    a. Comments received as part of ICC process (attached)
        i. "shall be considered"
        ii. "earthquake cracks"
    b. Other new topics
        i. Service Life Prediction?
        ii. Limit states for durability?
5. Adjournment

CHAPTER 8—DURABILITY

8.1—General

8.1.1 Durability of materials incorporated into a repair shall be considered for individual repairs, the overall durability of the repaired structure, and the interaction of the repair system with the structure.

8.1.1C *The durability of materials incorporated into a repair depends on their ability to withstand the environment where they are installed. The durability of repairs is dependent on the compatibility between repair materials, the structure, and the surrounding environment. To achieve compatibility, the repair and the structure need to interact on several levels without detriment, including chemical, electrochemical, and physical behavior.*

8.1.2 Repair materials and methods shall be selected that are intended to be compatible with the structure, and are durable within the service environment. Anticipated maintenance shall be considered in the selection.

8.1.2C *The design service life of a structure and repaired members is established by the licensed design professional in consultation with the Owner to achieve an economical repair that satisfies strength, safety, and serviceability requirements. Only through satisfactory repair construction practices, including application of the specified repair materials, is it possible to achieve the design service life. The design service life of the structure and repaired members, including maintenance requirements, should be estimated by considering the durability of the materials. Such design service life should be reflected in the repair design and maintenance requirements, as well as be incorporated into the construction documents. A repaired section is considered to be the combination of the installed repair material(s) and the substrate material(s). Service life is discussed in ACI 365.1R.*

poor code language

Some examples of end-of-service life include:

a) Structural safety is unacceptable due to material degradation or the nominal strength is less than the required strength.

b) Maintenance requirements exceed resource limits.

c) Aesthetics become unacceptable.

d) Structural functionality is no longer sufficient.

e) Deformation capacity of the structure has been degraded due to a seismic event.

The cause of degradation should be determined as a first step in predicting each type of service life. Causes of degradation include:

a) Mechanical (abrasion, fatigue, impact, overload, settlement, explosion, vibration, excessive displacement, loads, or ground motion from a seismic event) *b) Chemical (alkali-aggregate reaction, sulfate attack, acid dissolution, soft water leaching, or biological action)*

c) Physical (freezing and thawing cycles, scaling, differing coefficients of thermal expansion, salt crystallization, radiation exposure [ultraviolet light], fire, or differential permeability between materials)

d) Reinforcement corrosion (carbonation, corrosive contaminants, dissimilar metals, stray currents, or stress corrosion cracking)

Preparation methods, materials, placement, and installed systems should be defined in the construction documents to reflect the design intent and requirements to achieve compatibility.

Repaired sections should be resistant to expected service conditions that can result in degradation, including the causes of degradation listed previously within the design service life, and combinations of these causes.

Repaired sections should be resistant to:

a) Chlorides and other corrosive contaminants that are present in the concrete or the penetration of corrosive contaminants into the concrete (such as chlorides) that lead to corrosion of reinforcement or other embedments (8.4).

b) Thermal exposure and cycles.

c) Freezing-and-thawing damage if subject to saturation and a freezing-and-thawing environment. ASTM C666 may be used to define a durability factor. A durability factor exceeding 80 percent has generally been found to be acceptable in many locations for resistance to freezing and thawing for cementitious materials (refer to ACI 546.3R).

d) Scaling if exposed to salts.

e) Exposure to ultraviolet or other radiation degradation within the repair environment unless other means are provided to address such degradation.

f) Fatigue resulting from loading cycles and load reversal. For example, fatigue resistance may be needed in repair areas subject to many cycles of repeated loading.

g) Impact, erosion, and vibration effects if exposed to conditions causing deterioration by these mechanisms.

h) Abrasion resistance of repaired sections subject to heavy traffic, impingement of abrasive particles, or similar conditions.

i) Chemical exposure may include sulfate attack, acids, alkalis, solvents, leaching of cementitious materials due to soft water, salt crystallization, and other factors that are known to attack or deteriorate the repair material or concrete substrate. Water penetration into concrete is associated with many types of chemical attack and other deterioration mechanisms.

j) *The carbonation susceptibility, depth, and rate of both the existing concrete and the repair material in repairs containing reinforcement or other embedments requiring alkaline passivation of the metal for protection from corrosion (refer to 8.4).*

k) *Alkali-aggregate reactions.*

l) *Differential permeability between the repair and existing concrete if the repair material or the substrate concrete is vulnerable to deterioration due to trapped moisture, such as freezing-and-thawing damage of saturated concrete, corrosion of embedded steel reinforcement, alkali-aggregate reactions, or sulfate attack (refer to ACI*

So if concrete cover violates code, you have to add cover?

8.2—Cover

8.2.1 Concrete cover shall be in accordance with the design basis criteria. For alternative materials and methods, an equivalent cover that provides sufficient corrosion protection shall be approved in accordance with 1.4.2. Sufficient anchorage and development for the reinforcement shall be provided regardless of methods used to provide corrosion protection.

8.2.1C *The code language is intended to allow materials that provide equivalent cover to be used if they can be demonstrated to be effective according to the approval procedure detailed in 1.4.2. If alternative methods of corrosion protection are used, anchorage and development lengths should be reviewed.*

8.2.2 *Corrosion*—Where concrete cover for existing reinforcement is insufficient to provide corrosion protection for the design service life of the structure, additional concrete cover or an alternate means of corrosion protection shall be provided to mitigate corrosion of reinforcement within the repair area.

8.2.2C *Alternative means of protecting reinforcement include the application of waterproof membranes (ACI 515.2R Guide to Protective Systems), corrosion inhibitors, and various forms of cathodic protection. Reinforcement corrosion, chloride contamination, and carbonation should be considered when evaluating the maintenance requirements and design service life of alternative methods for corrosion protection. Ongoing metal corrosion may create distress and deterioration beyond the limit of the repair area. The design service life requirements should be reviewed when widespread durability issues are considered. Issues related to concrete cover need to be addressed in a timely manner.*

8.3—Cracks

8.3.1 The cause(s) of cracks shall be assessed, and mitigating cracking shall be considered in the rehabilitation design.

So if an earthquake causes cracks, we need to mitigate the cracking in the future??

8.3.1C *Cracks can reduce the protection provided by the effective cover over steel reinforcement and lead to water and deleterious material ingress, which accelerates the deterioration of embedded reinforcement and can cause other concrete deterioration issues such as freezing-and-thawing deterioration, alkali-aggregate deterioration, and chemical attack. Identification of their cause(s) and evaluation of their impact on a structure or a concrete component is described in ACI 224.1R.*

As part of a repair design, cracking mitigation methods should consider the causes, movement, size, orientation, width, and complexity of the network of cracks. The characteristics of the substrate, location, and evidence of water transmission should be determined to assess the appropriate method of repair. Active water infiltration should be corrected as required for the durability of the structure.

8.3.2 The design of repairs shall consider the effects of cracks on the expected durability, performance, and design service life of the repair and structure as a whole.

8.3.2C *Not all cracks need to be repaired, however, all cracks have the potential to become active cracks. Cracks in concrete structures can be detrimental to the long-term performance of a structure if the cracks are of sufficient size to allow for the ingress of deleterious materials into the structure, and guidance for critical crack sizes is provided in ACI 224R, Table 4.1. Consideration should be given to post-repair cracking and the need for protection of the existing concrete and repair material from the ingress of deleterious materials. ACI 224.1R provides guidance for the prevention and control of cracks.*

There are a variety of different materials that have been used for crack repair, and their correct specification for a given application will govern the design service life of the repair. For cracks that are essentially acting as a joint or are active, one type of effective repair is to seal the crack with an elastomeric sealant. Materials used for crack injection include, epoxy, polyurethane, latex in a cement matrix, microfine cement, and polymethacrylate. For repair by crack injection, the process and material should be appropriate to the site conditions. Crack injection should not be used to repair cracks caused by corrosion of steel reinforcement and alkali aggregate reaction unless supplemental means are employed to mitigate the cause of the cracks.

8.4—Corrosion and deterioration of reinforcement and metallic embedments

8.4.1 The corrosion and deterioration of reinforcement and embedded components shall be considered in the durability design. Repair materials shall not contain intentionally added constituents that are corrosive to reinforcement within the repair area.

8.4.1C *Untreated reinforcement corrosion limits the life expectancy of repair areas, repair materials, and repaired structures. ICRI No. 310.1R provides guidelines on removal of damaged concrete and cleaning of reinforcing steel. Repairs that do not address reinforcement corrosion may negatively impact the design service life and require more intensive monitoring. The structural design considerations for corroding reinforcing steel on repairs are described in 7.6.3.1.*

8.4.2 The impact on the design service life of the repaired structure shall be considered if it is anticipated that corrosion products cannot be removed during repair

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8.4.2C *Ideally corrosion products should be removed from reinforcing steel in repairs. In some situations, due to congestion of steel reinforcement, access limitations, load considerations, or other factors, it is not possible to remove corrosion products from the steel reinforcement. Situations exist where corroding reinforcement that cannot be adequately cleaned or repaired will remain in the repaired structure.*

The effects of uncleaned reinforcing steel on the long-term durability of the repaired structure should be considered in these situations. Supplemental corrosion mitigation strategies may be needed in these situations.

8.4.3 The quality of existing concrete and its ability to protect reinforcement from corrosion, fire and other forms of damage and deterioration shall be considered.

8.4.3C *Water and chemical penetration into the concrete can cause corrosion of metallic embedments and damage to nonmetallic reinforcement. Where concrete cover over reinforcement is insufficient to provide corrosion protection for the design service life of the structure, additional concrete cover or an alternate means of corrosion protection should be provided to mitigate reinforcement corrosion. The corrosion of embedded metals adjacent to the repair may be accelerated due to differing electrical potential between electrically continuous reinforcement in the repair area and external to the repair area. This form of corrosion is commonly referred to as the "anodic ring" or "halo effect", and is discussed in ACI 546R, ACI 364.3T, and ACI RAP BULLETIN 8 (Whitmore 2006). The rate of anodic ring corrosion depends upon the chloride content, internal relative humidity, and temperature.*

The anodic ring effect that can be induced by certain repairs should be addressed by incorporating appropriate corrosion mitigation strategies such as cathodic protection or corrosion inhibitors. ACI 222R, ACI 222.3R, ACI 364.3T, ACI 546R and the Concrete Society Technical Report 50 and FAQ sections from Concrete International (2002a, b, c) provide guidance for corrosion prevention, mitigation and inhibition. Both carbonation and chloride *contamination may require consideration and are discussed in ACI 546R.*

Aesthetics may be affected by different means of protection and may also require consideration. Damage due to fire and fire protection requirements are discussed in 7.9.

8.4.4 Existing steel reinforcement and added reinforcement shall be protected from corrosion, fire and other forms of damage and deterioration to satisfy durability requirements.

8.4.4C *Reinforcing steel in concrete construction is usually protected by concrete cover from deleterious materials and also provides fire protection. The minimum cover is typically required by the design basis criteria. Adequate protection may be provided by increased section thickness and appropriate coatings, such as sealers, intumescent coatings, or electrochemical methods.*

8.4.5 Galvanic corrosion between electrochemically dissimilar materials shall be considered.

8.4.5C *Reinforcement or metallic embedments in the repair area with differing electrochemical potentials, environments, or both, should be isolated from the existing reinforcement, or the existing reinforcement and metal embedments should be protected to minimize galvanic corrosion. For example, rail or post-pocket repairs that use dissimilar metals from conventional steel reinforcement could accelerate the deterioration of the installation (refer to ACI 222R).*

8.4.6 Corrosion protection of bonded and unbonded prestressing materials and prestressing system components shall be addressed during the repair design.

8.4.6C *The presence of prestressing force in the steel and the need to transfer the prestressing force into the concrete makes corrosion damage in prestressed concrete members more critical than traditionally reinforced structures (refer to ACI 423.4R). Section 7.6.4 addresses the structural requirements for the repair.*

The bonded or unbonded nature of the prestressing steel, the condition of the steel at the repair area, the attachment of the steel to the structure, the as-designed corrosion protection measures, the existing corrosion condition, and the continuity of the prestressing steel need to be considered to address corrosion protection of the structure. Refer to ICRI 320.4, and 222.2R.

Hydrodemolition and other types of material removal methods should be used cautiously if the structure contains unbonded prestressing steel reinforcement. In these situations, water can be introduced into the corrosion protection (sheathing) surrounding the steel (refer to ICRI No. 310.3), affecting the long-term durability of the prestressing steel reinforcement.

8.4.7 If electrochemical protection systems are used to protect steel reinforcement in repair areas and structures, the interaction of the protection system with the repaired elements, the entire structure, and environment shall be considered.

8.4.7C *Structures using impressed current electrochemical protection or mitigation systems should have continuous reinforcement, separate zones, or provisions should be made to make the steel electrically continuous. Impressed current electrochemical protection systems should be designed and maintained to not promote an alkali-aggregate reaction (AAR) and to avoid embrittlement of prestressing steel.*

Impressed current electrochemical protection systems should include a monitoring and maintenance plan developed by a licensed design professional specializing in the design of corrosion protection systems (refer to NACE SP0290, NACE SP0390, NACE 01105, NACE 01102, NACE 01101, NACE 01104, and NACE SP0107).

8.4.8 Repair materials and reinforcement shall be selected and detailed to be compatible such that the characteristics of each material do not adversely affect the durability of the other materials or of the existing concrete and reinforcement.

8.4.8C *Incompatibilities can arise from the use of inappropriate materials or components, or dissimilar electrochemical characteristics or physical properties, which can negatively impact the concrete and reinforcement. Some examples include:*

a) In certain situations such as exposure to high temperatures, polyvinyl chloride (PVC) and other polymer-based materials can deteriorate, releasing decomposition products found to cause corrosion.

b) Even if the conventional steel reinforcement becomes more noble in electrical contact with a dissimilar metal (for example, embedded aluminum conduit in the presence of chlorides), considerable concrete damage can arise (Monfore and Ost 1965).

c) Fiber-reinforced polymer (FRP) wrapping should not be used as a corrosion repair strategy on members experiencing corrosion of embedded reinforcement unless the concrete is repaired and corrosion mitigated. Appropriate sections within this code and referenced documents concerning FRP repairs should be consulted (refer to ACI 440.2R).

8.5—Surface treatments and coatings

8.5.1 Moisture transmission through the structure and the influence of the surface treatment on the durability of the structure shall be considered.

8.5.1C *Surface treatments, coatings, sealers, or membranes are commonly used to limit the ingress of deleterious materials and moisture into the structure to reduce future deterioration of the* *structure. Surface treatments, coatings, sealers, and membranes may have a shorter service life than the concrete and can be considered as consumable or requiring periodic replacement or repair to maintain effective protection of the concrete (ACI 515.1R).*

In some situations, encapsulation of moisture and deleterious materials by a surface treatment has been found to cause or accelerate deterioration. The condition of the concrete should be appropriate to receive a specific surface treatment, coating, or membrane (ICRI No. 310.2).

8.5.2 The selection of surface treatments applied to concrete surfaces shall consider concrete cracks and their anticipated expansion and contraction, or surface deflections on the repair system durability, the surface treatment, and the anticipated design service life of the structure.

8.5.2C *Crack development and propagation provide an accelerated mechanism for ingress of moisture and deleterious materials and may also cause a surface treatment to become ineffective.*