Protection of Concrete Surface from the Canadian Standard, ICRI, and ACI Perspectives

Claudiane M. Ouellet-Plamondon

Abstract The Canadian standard CSA A23.1:19 on concrete materials and methods of concrete construction addresses the concrete surface treatment in chapter 7 placing, finishing, and curing concrete and in chapter 8 concrete with special performance requirements. The factors affecting the abrasion resistance are specified. The surface defects are named as honeycombing, sand streaking, lift lines, variations in color, soft areas, and large surface void. Special finish of architectural formed concrete must minimize texture and color variations. The standard does not mention specific organic coating material. The standard is clear on specific forbidden action that can affect the surface finish. The International Concrete Repair Institute (ICRI) has more specific guidelines on the types of product to apply. The sealers and coating recommenders are classified as high molecular weight methacrylic sealing compounds, low viscosity epoxy sealing compounds, silane and siloxane sealing compounds, and coating compounds for concrete. The causes of damage to concrete are explained. The American Concrete Institute has a number of committees addressing surface finishing. The ACI 546.3R-14 Guide to materials selection for concrete repair has tables for sealers and anti-carbonatation coating selection based on durability factors.

Keywords Protection of concrete surface · Canadian standard · ICRI · ACI

1 Introduction

Sealers and coating can increase the durability of concrete infrastructure repairs, when well applied. From the Canadian perspective, the guidelines on the application of the coating and sealer are available in the CSA standard, the guides from the International Concrete Repair Institute (ICRI), and the American Concrete Institute. The objective of this extended abstract is to report the key point on the protection

C. M. Ouellet-Plamondon (✉)
École de Technologie Supérieure, Université du Québec, 1100 Notre-Dame Ouest, Montreal, QC H3C 1K3, Canada
e-mail: Claudiane.Ouellet-Plamondon@etsmtl.ca

R. Gupta et al. (eds.), *Proceedings of the Canadian Society of Civil Engineering Annual Conference 2022*, Lecture Notes in Civil Engineering 363,
https://doi.org/10.1007/978-3-031-34593-7_58

of surface concrete from the Canadian standard CSA 23.1 [2], ICRI, and the ACI guides. The best practices aim to prevent the degradation of the surface treatment. Limited information is available on the degradation mechanisms. There is worldwide interest in the best practices for coating application to prevent their degradation, as demonstrated by the Rilem technical committee on the degradation of protective surface treatment. The first step is to summarize the relevant information in standard and guides.

2 The Canadian Standard

The Canadian standard on concrete materials and methods of concrete construction addresses the concrete surface treatment in chapter 7 placing, finishing, and curing concrete and in chapter 8 concrete with special performance requirements. It does not mention specific organic coating material. The standard is clear in specific forbidden action that can affect the surface finish (Table 1). The conditions for underwater concreting are explained. The anti-washout admixtures are recommended to prevent mass loss (7.5.5). Regarding abrasion and wear resistance, the owner shall specify the surface treatment to the intended use of the surface (7.7.5). The factors affecting the abrasion resistance are the hardness of the aggregates, surface compressive strength, water-to-cementitious material ratio, quality and duration of curing, and the type of final finish. The finishing of formed surface must happen as soon after stripping the forms (7.10). The surface defects are named as honeycombing, sand streaking, lift lines, variations in color, soft areas, and large surface void. Surface void and color variations cannot be patched, unless they are too different from the reference sample or if there are special specifications that they must be patched. Architectural concrete is specified in the contract document (8.3). Special finish of architectural formed concrete must minimize texture and color variations. The specific finishes are specified in ACI guides. The current standard does not have any consideration regarding freeze–thaw exposure.

Table 1 Forbidden action according to CSA 23.1

Actions	Example	Chapter section
Concreting underwater	Not under 5 °C, unless strength is sufficient; velocity of the current shall not exceed 3 m/min; maximum washout not greater than 8%	7.5.5
Finishing of formed surfaces	Surface void and color variations cannot be patched	7.10.2.4

3 The ICRI Perspective

The section on the ICRI perspective is based on guide to concrete repair second edition [3]. More guide is available on surface preparation prior to sealers and coatings applications.

3.1 Sealers and Coatings

Sealers and coatings are used reduced deterioration from corrosion of rebar, freeze–thaw, carbonation, and sulfate damage. They protect concrete and repair surface damage and small cracks. They are applied on dry and cure concrete as a maintenance and repair procedure of infrastructure in overall good conditions. Sealing cracks are important to reduce the permeability of the concrete connected to its durability. The concrete treatment methods are the surface treatment with coating, treatments that can fill surface voids and cracks, and surface sealers. The main chemical groups are reviewed.

3.1.1 High Molecular Weight Methacrylic (HMWM) Sealing Compounds

The HMWM sealing is made up of methacrylic monomer and a polymerization catalyst comparable to monomer systems used in polymer concrete. It penetrates to a depth of 1.6 mm in concrete and it is more effective at sealing fine cracks in the concrete surface. It is affected by solar radiation and it can disappear after 1–2 years.

3.1.2 Low Viscosity Epoxy (LVE) Sealing Compounds

The LVE sealing compound is easier to use than HMWM, but they have a higher viscosity and they do not penetrate in cracks as much. The epoxy is made of epoxy resin with an appropriate catalyst of hardener. It better seals the cracks on the surface. LVE is also deteriorated with solar radiation in 1–2 years. In the typical Western United State climatic conditions, it is expected to last 10–20 years. Afterward, it must be reapplied.

3.1.3 Silane and Siloxane (SS) Sealing Compounds

The SS is effective and easy to use. They are used to seal concrete surfaces and cracks thinner than 0.005 mm, and they reduce water penetrated of treated concrete. For that efficiency, the sealing compound must contain 20% solid and the crack cannot

be larger than 0.25 mm. The SS is suspended in water, alcohol, or mineral spirits that evaporate after the application. Solvent-based tends to work better than water-based. Silanes cure at a high pH, while siloxanes do not need. The water beads at the surface when wet and the concrete does not change color. This sealing does not protect against prolonged inundation. They can be applied afterward. They have a limited service life of 5–7 years.

3.1.4 Coating Compounds for Concrete

The surface treatment is usually with epoxy, polyurethane, or polyurea. There are four reasons to apply coating: (1) waterproofing to prevent water flow in the concrete, (2) damp proofing can seal the porosity of the concrete and prevent the absorption of the water, (3) decorative concrete is used to enhance the aesthetics, (4) barrier coating protects the concrete from the exposure to chemicals or from contamination.

3.2 The Damage to Concrete

The cause of the damage to concrete is the excess concrete mix water, faulty design, construction defects, sulfate deterioration, alkali-aggregate reaction, freeze and thawing, abrasion–erosion damage, cavitation damage, and corrosion of reinforced steel, acid exposure, cracking, structural overload, and other multiple causes of damage. The organic coatings are used in crack and water leak repairs. Resin injection works with epoxy resins, polyurethanes, and methacrylic acrylates. Epoxy can rebound structural cracks still relatively dry. The polyurethanes and methacrylic acrylate can seal cracks and water leaks. To rebound a structural crack, it must be dry and exempt of dirt. Resin injection is used to seal deep cracks, while shallow cracks with sealers.

4 The ACI Perspective

The ACI has a number of technical committees with mixed members from the industry, academia, and the government providing the best practices for concrete finish and repair. This article report Tables 2 and 3 adapted from the ACI 546.3R-14 Guide to materials selection for concrete repair [1]. Sealer and elastomer coatings prevent water penetration into the concrete, and elastomer coating is more efficient. They improve the durability of concrete repair. They also limit the ingress of water-soluble chemical like chloride ions into the concrete. Anti-carbonation coatings limit air and carbon dioxide penetration in the concrete and slow down the carbonatation process. They also limit water penetration, but it is not their main purpose. They

Table 2 Materials' selection guide for surface sealers (adapted from ACI 546.3R-14)

Durability factor	Silane	Siloxane	Acrylic	Epoxy	Linen seed oil
Limit water absorption	Good	Good	Good	Good	Bad
Water vapor transmission	Good	Good	Good	Fair	Fair
Penetrates concrete	Yes	Yes	No	No	No
Clear or tinted	Clear	Clear	Both	Tinted	Clear
UV resistance	Good	Good	Moderate	Moderate	No data
VOCs	Broad range	Broad range	Broad range	High	No data

Table 3 Material selection guide for anti-carbonatation coatings (adapted from ACI 546.3R-14)

Durability factors	Acrylic	Methacrylate	Polymer-modified cementitious
CO_2 screening	Good	Good	Very good
Vapor transmission	Good	Good	Good
Water, chloride ion screening	Yes	Yes	Yes
Elasticity	Yes	No	No
Color	Tinted	Clear	Gray or white
Weathering resistance	Good	Good	Good
Primer	Yes	Yes	No

are used on vertical and horizontal surfaces not exposed to pedestrian and vehicular traffic.

5 Conclusion

This conference article presented the material selection of coatings and sealers, as well as the best practices to prevent their degradation. The ACI guide is clear on the durability factors of the sealers and coatings. The exposure to freeze–thaw is not yet considered clearly in the standard and guidelines.

References

1. ACI (2014) 546.3R-14. Guide to materials selection for concrete repair. ACI, Farmington Hills, MI
2. CSA (2019) A23.1:19/CSA A23.2:19. Concrete materials and methods of concrete construction/test methods and standard practices for concrete. CSA, Toronto, Canada
3. Fay KFV (2015) Guide to concrete repair, 2nd edn. U.S. Department of the Interior Bureau of Reclamation