

Tomasz Piotrowski, Ph.D, Eng.^{1*)}
 Wioletta Jackiewicz-Rek, Ph.D, Eng.¹⁾
 Piotr Prochoń, Eng.¹⁾
 Prof. Luc Courard, D.Sc. Eng.²⁾
 Alain Jeanpierre³⁾

Special requirements for freeze-thaw resistance of concrete in PWR nuclear civil works

Dodatkowe wymagania dotyczące mrozoodporności betonu przy budowie elektrowni jądrowych typu PWR

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Abstract. The authors describe the additional requirements to ensure freeze-thaw resistance of concrete resulting from the French Rules for Design and Construction of PWR nuclear civil works RCC-CW. Since these requirements are based both on European standards and the French experience they are not fully compatible with the conditions and requirements in other countries, including Poland. The article seeks therefore to be an introduction to the discussion on adapting the guidelines for the freeze-thaw resistance of concrete from RCC-CW to Polish conditions.

Keywords: freeze-thaw resistance of concrete, requirements, nuclear power plant.

Streszczenie. Autorzy artykułu przedstawili dodatkowe wymagania dla zapewnienia mrozoodporności betonu wynikające z francuskich wytycznych do projektowania obudowy reaktora elektrowni jądrowej RCC-CW. Ponieważ wymagania te bazują zarówno na normach europejskich, jak i doświadczeniu francuskim, to nie są one całkowicie kompatybilne z warunkami i wymaganiami obowiązującymi w innych krajach, w tym w Polsce. Artykuł może być zatem wstępem do dyskusji na temat dostosowania wytycznych dotyczących mrozoodporności betonu RCC-CW do warunków polskich.

Słowa kluczowe: mrozoodporność betonu, wymagania, elektrownia jądrowa.

Freeze-thaw attack is the main corrosion process of concrete in Poland. It is a progressive phenomenon increasing with the number of frost cycles. Moreover, in connection with de-icing salt, the frost attack is much stronger. Only 50 years of durability of concrete is assured by PN-EN 206:2014, but the PWR nuclear structures life is extended to 80 and even 100 years. Therefore the RCC-CW *Design and construction rules for civil works in PWR nuclear islands* [17] is more restricted. It is based on French experience and technical measures that are defined for different frost exposure classes (requirements for concrete composition and performance). In many countries, including Poland, the conditions and experience (especially the test methods and qualification procedures) are different [6] so it is worthy to present these regulations.

Freeze-thaw durability according to PN-EN 206:2014

In PN-EN 206:2014 if concrete is exposed to significant attack by freeze-thaw cycles whilst wet, the environmental ac-

tion is classified as XF1 to XF4 exposure classes for risk of freeze-thaw attack:

- **XF1 Moderate water saturation, without de-icing agent**, e.g. vertical concrete surfaces exposed to rain and freezing;

- **XF2 Moderate water saturation, with de-icing agent**, e.g. vertical concrete surfaces of road structures exposed to freezing and airborne de-icing agents;

- **XF3 High water saturation, without de-icing agent**, e.g. horizontal concrete surfaces exposed to rain and freezing;

- **XF4 High water saturation, with de-icing agent or sea water**, e.g. road and bridge decks exposed to de-icing agents; concrete surfaces exposed to direct spray containing de-icing agents and freezing; splash zones of marine structures exposed to freezing.

Due to this classification the recommended limiting values for composition and properties of concrete are specified in Annex F. In RCC-CW these values are more restricted:

- for XF2: w/c ratio decreased from 0,55 to 0,50 and minimum strength class increased from C25/30 to C30/37;
- for XF4: minimum strength class increased from C30/37 to C35/45.

Additional requirements are given in PN-EN 206:2014 as well:

- **for all XF classes: an aggregate** should be in accordance with PN-EN 12620+A1:2010 with sufficient freeze/thaw resistance;

- **for XF2, XF3 and XF4:** minimum air content is limited to 4,0% and where the concrete is not air entrained, the performance of concrete should be tested according to an appropriate test method in comparison with a concrete for which freeze-thaw resistance for the relevant exposure class is proven.

In the bibliography of PN-EN 206:2014 there are two standards given for this purpose.

In PKN-CEN/TS 12390-9:2007 [15] it is recommended the use of „slab test” (based on the Swedish standard SS 13 72 44 [18], so-called Borås method) as a reference. The other two methods: one taken from RILEM-CF/CDF and the other „cube test” – based on original cube German method, are also contemplated for use as alternatives.

In CEN/TR 15177:2006 [2] there are presented three methods of testing internal frost resistance of concrete, i.e. test beam, slab test and CIF.

Requirements for aggregates in Poland

Actual requirements for freeze-thaw resistance of aggregates in Poland are

¹⁾ Warsaw University of Technology, Faculty of Civil Engineering

²⁾ University of Liège, ARGenCo

³⁾ EDF Ceidre

^{*)} Adres do korespondencji: t.piotrowski@il.pw.edu.pl