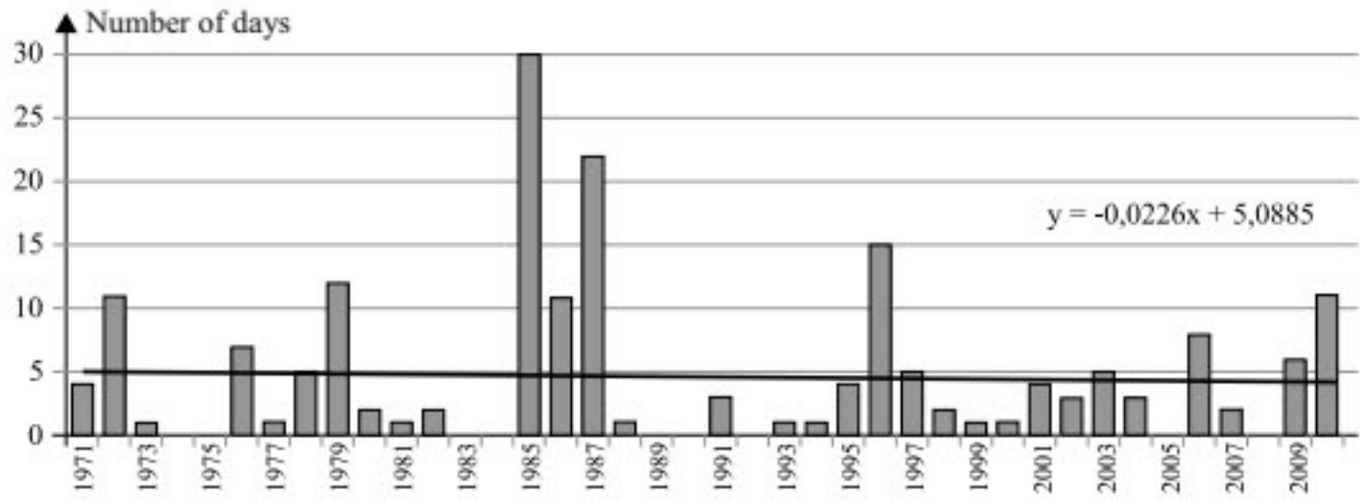

Fig. 2. Long-term variability of occurrence days with $T_{max} \leq -10°C$ at the Suwałki station in the period of 1971-2010 [4]

Rys. 2. Wieloletnia zmienność występowania dni z $T_{max} \leq -10°C$ na stacji Suwałki w okresie 1971 – 2010 [4]

Table 2. Exposure class description and performance test selection for specific conditions in France

Tabela 2. Dobór klasy ekspozycji i wybór badania mrozoodporności dla wybranych warunków we Francji

Exposure class	PN-EN 206:2014		NF EN 206/CN [12]		Performance test according to RCC-CW [17]
	Saturation	De-icing	Freezing zone	De-icing zone	
XF1	**Moderate**	No	Mild/Moderate	No-deicing/Not frequent	–
XF2	**Moderate**	Yes	Mild/**Moderate**	Frequent/Very frequent	NF P 18-425 [22]*
XF3	**High**	No	**Severe**	No-deicing/Not frequent	**NF P 18-424 [21]**
XF4	**High**	Yes	**Severe**	Frequent/Very frequent	**NF P 18-424 [21]**

* only for HPC

the specified maximum value of $\bar{L}$ is not respected, the concrete shall be subject to a performance test as follows (Table 2):

- NF P 18-424 [9] (freezing in water and thawing in water), for concrete subject to **severe freeze-thaw attacks** with a **high degree of water saturation** defined by PN-EN 206:2014– it means XF3 and XF4 – the limit value is $\Delta l/l < 400$ μm/m;
- NF P 18-425 [10] (freezing in air and thawing in water), for concrete subject to **moderate freeze-thaw attacks**, irrespective of the degree of water saturation of the concrete (in NF EN 206/CN there is no such case with high water saturation), or for concrete subject to **severe freeze-thaw conditions** with a **moderate degree of water saturation** defined by PN-EN 206:2014 (such case is not possible according to NF EN 206/CN) – the limit value is $(Fn^2/Fo^2)x100 \geq 75$. For high performance concrete subject to exposure classes XF2, XF3 or XF4, which are formulated with little or no air entraining admixture and do not contain the minimum air content the measurement of $\bar{L}$ is not relevant, so the qualification test shall include a performance test as well. HPC is differentiated from ordinary concrete by a compressive strength class of a High Strength Concrete (HSC – concrete with a higher strength than C50/60) and by one or more desired properties such as a higher level of compactness (for example for porosity or permeability requirements).

It is also acceptable to waive the requirement for the minimum air content for concrete exposed to frequent or very frequent attack from de-icing agents (XF2 or XF4) – in such case the scaling test according to XP P 18-420 [19] that is the same as „slab test" in PKN-CEN/TS 12390-9:2007 [15] should be performed. This procedure is also similar to the one expressed in PN-EN 1388:2005 except for number of cycles (increase from 28 to 56). The requirement is the mass of the scaling particles after 56 freeze-thaw cycles is $M \leq 600$ g/m^2. This value is different than the conformity criteria for concretes according to Borås method in Swedish Standard SS 13 72 44 [18] that are based on mass of scaling at 28 days (m_{28}), 56 days (m_{56}) and at 112 days (m_{112}) and are expressed as:

- very good: m_{56} average < 100 g/m^2;
- good m_{56} average < 200 g/m^2 or m_{56} average < 500 g/m^2 and $m_{56}/m_{28} < 2$ or m_{112} average < 500 g/m^2;
- acceptable: m_{56} average < 1000 g/m^2 and $m_{56}/m_{28} < 2$ or m_{112} average < 1000 g/m^2;
- unacceptable: the above not complied with.

Requirements for structural concrete in bridge construction in Poland

Additional requirements for freeze--thaw resistance of structural concrete in road infrastructure in Poland can be found in OST M-13.01.00 Structural concrete [14]. There is recommended that freeze-thaw resistance degree of structural concrete should be specified according to PN-B-06250:1998 and should be not less than: F100 for exposure class XF1; F150 for exposure class XF2 and XF3; F200 for exposure class XF4.

The required freeze-thaw resistance degree of concrete is achieved, if after the required number of cycles freezing on water saturated samples at -18 ± 2°C and thawing at +18 ± 2°C, the following conditions are met:

- the sample is not broken;
- total weight loss of concrete sample does not exceed 5%;
- reduction of the compressive strength is not more than 20% relative tothe strength of the reference samples.

Also an additional requirement for coarse aggregate is presented. There are given two limits for resistance to freezing and thawing in the presence of salt (NaCl) according to PN-EN 1367-6:2008 (F_{NaCl} = 6 and 2%) and resistance to fragmentation according to PN-EN 1097-2:2010 (LA_{25} and LA_{40}).

Requirements for pavement concrete in Poland

Concrete designed for concrete pavements in Poland despite the requirement for aggregate should meet the requirements of OST D-05.03.04 Concrete pavements [13] (Table 3) and corresponding to the exposure class chosen as follow:

- XF3 in the absence of the use of chemical winter maintenance of roads/ de-icing salts,
- XF4 for the use of chemical winter maintenance of roads.

Other requirements

In Lithuania where there are similar climate conditions to Poland and where Visaginas Nuclear Power Plant is a planned to be constructed, there is another sense of freeze-thaw resistan-