

Non structural precast elements from recycled aggregates

Final Conference Meeting

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- A) **European Standards for concrete precast product**
- B) **Application on concrete precast product for pilot project in Seraing**
- C) **Application on concrete paving blocks**
- D) **Conclusion**

A) European Standards for concrete precast product

- Existing standards for the specific product

EN 1338 – Paving blocks

EN 1168 – Hollow core slab

EN ...

⇒ Specific requirements and test methods

- No existing standards for the Product

EN 13369 (Precast concrete) and EN 206-1(ready-mix concrete)

⇒ Common requirements with exposition classes

XC - Corrosion by carbonation

XD – Corrosion with chloride

XS – Corrosion with chloride from sea water

XF – Freeze/thaw with or without de-icing slat

XA – Chemical attack

Target

Use the highest percentage
of recycled aggregates

Go beyond the Standards

B) Application on concrete precast product for Pilot project in Seraing

According to EN 13369 and EN 206-1

Exposition classes XC4, XD2, XF4 – (Environnement class-EE4) = Outside conditions, rain, freeze – thaw and de-icing salt

- ⇒ **W/C ≤ 0,45**
- ⇒ **Cement Quantity = min 340 kg/m³**
- ⇒ C35/45 -> Fck (compressive strength on cube) = 45 MPa -> **Fmean : 50-55 MPa**

⇒ **Water absorption (NBN B15-001 et NBN B21-600)**

- Max aggregate size(20mm) > 16 mm : ≤ 5,5 %**
- 16 mm >= Max aggregate size > 8mm : ≤ 6,5 %
- 8 mm >= Max aggregate size > 4mm : ≤ 7,5 %

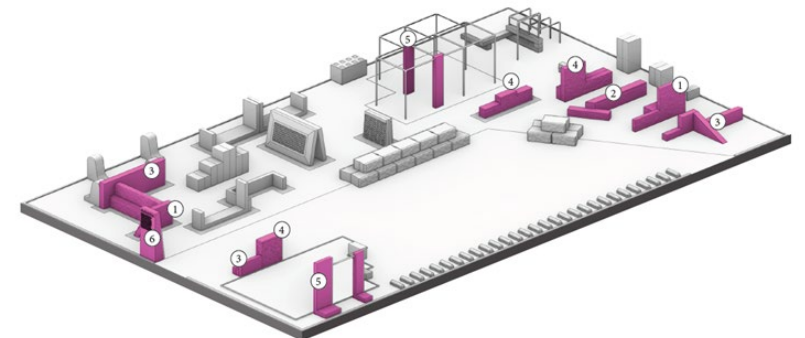
Targets

Fmean : 50-55 MPa

W/C ≤ 0,45

Cement ≥ 340 kg/m³

Water absorption ≤ 5,5%



Concrete mixes

Test results (S2)

RA from Tradecowall – unknown origin

Targets reached with Crushed Concrete RA (40% - 25% including sand)

Tests results		Crushed concrete aggregates (Type A - EN12620)		Mixed aggregates (Type B - EN12620)	
		M50-80CC-D20	M25-40CC-D20	M50-80MA-D20	M25-40MA-D20
Cement	[kg]	400	400	400	400
Weff/C (water on cement Ratio)	[-]	0,45	0,45	0,45	0,45
W/C (water on cement Ratio)	[-]	0,54	0,50	0,56	0,51
% of Recycled aggregates including Sand	[-]	50%	25%	50%	25%
W/C mesured (water on cement Ratio)	[-]	0,43	0,42	0,46	0,46
Slump test (Abrams cone) EN12350-2	[-]	S4(20cm)	S2(8cm)	S3(14cm)	S2(7cm)
Fresh raw density	[kg/m ³]	2306	2315	2226	2335
Compressive Strength at 7 days	[MPA]	50,3	56,7	51,7	56,0
Compressive Strength at 28 days	[MPA]	63,8	69,3	59,9	71,4
Tensile splitting Strength at 28 days	[MPA]	4,6	4,1	4,4	4,6
Water absorption	[%]	6,6	5,5	7,2	6,0
Hard dry raw density	[kg/m ³]	2225	2293	2154	2216

What about durability ? Is-it enough ?

Concrete admixture - D max 14 mm (S3)

Concrete mixes		Test series n°3 - CEM I 52 R LA						
		REF - 0 %	Crushed concrete aggregates (Type A - EN12620)			Mixed aggregates (Type B - EN12620)		
		M0 - D14	M65-100CC-D14	M50-75CC-D14	M25-40CC-D14	M65-100MA-D14	M50-75MA-D14	M25-40MA-D14
Water	[kg]	180	180			180		
Soaking water	[kg]	9	50	40	25	53	41	26
Cement	[kg]	400	400			400		
Weff/C (water on cement Ratio)	[-]	0,45	0,45			0,45		
W/C (water on cement Ratio)	[-]	0,47	0,57	0,55	0,51	0,58	0,55	0,51
Sand 0/2	[kg]	615	615	615	615	615	615	615
CC 2/6 - Limestone	[kg]	273	-	273	273	-	273	273
CC 6/14 - Limestone	[kg]	909	-	-	454	-	-	454
RA aggregates 2/6 - Tradecowall	[kg]	-	237	-	-	216	-	-
RA aggregates 6/14 - Tradecowall	[kg]	-	791	791	395	723	723	362
RA aggregates 14/20 - Tradecowall	[kg]	-	-	-	-	-	-	-
% of Recycled aggregates	[-]	0%	100%	77%	38%	100%	77%	38%
% of Recycled aggregates including Sand	[-]	0%	65%	50%	25%	65%	50%	25%
Superplastizer	[%]	0,5%	0,5%	1%	1%	1%	1%	1%

What about durability ? Is-it enough ?

Tests results (S3) Freeze thaw test with de-icing agents (XF4,XC2,XF4)

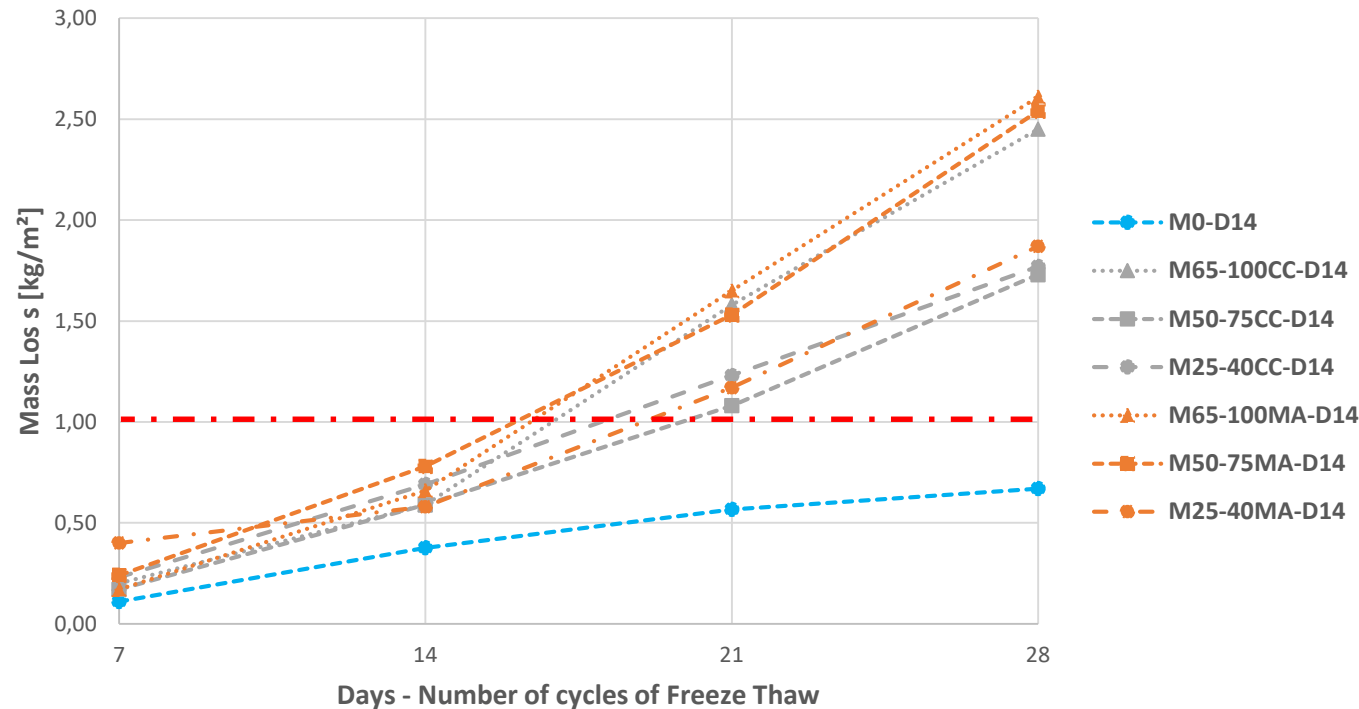
Targets

Fc : 50-55 Mpa Cement >= 340 kg/m³
 W/C <= 0,45 Water abs. <= 6,5%

Tests results		REF - 0 %	Crushed concrete aggregates (Type A - EN12620)				Mixed aggregates (Type B - EN12620)		
		M0 - D14	M65-100CC-D14	M50-75CC-D14	M25-40CC-D14	M65-100MA-D14	M50-75MA-D14	M25-40MA-D14	
Cement	[kg]	400	400	400	400	400	400	400	
Weff/C (water on cement Ratio)	[-]	0,45	0,45	0,45	0,45	0,45	0,45	0,45	
W/C (water on cement Ratio)	[-]	0,47	0,57	0,55	0,51	0,58	0,55	0,51	
% of Recycled aggregates including Sand	[-]	0%	65%	50%	25%	65%	50%	25%	
W/C mesured (water on cement Ratio)	[-]	0,42	0,44	0,41	0,44	0,42	0,41	0,44	
Slump test (Abrams cone) EN12350-2	[-]	S4(21cm)	S3(10cm)	S4(18cm)	S4(21cm)	S3(10cm)	S4(18cm)	S4(17cm)	
Fresh raw density	[kg/m ³]	2433	2254	2319	2229	2299	2261	2326	
Compressive Strength at 7 days	[MPA]	67,8	54,6	58,5	59,6	50,5	53,4	54,6	
Compressive Strength at 28 days	[MPA]	80,0	59,9	74,3	72,4	59,0	69,6	75,8	
Tensile splitting Strength at 28 days	[MPA]	5,0	4,0	5,1	5,6	4,4	5,1	5,0	
Water absorption	[%]	5,0	6,7	5,6	5,9	7,1	6,0	5,5	
Hard dry raw density	[kg/m ³]	2432	2167	2195	2282	2071	2195	2234	
Freeze-thaw test at 28 days - Mass Loss	[kg/m ²]	0,67	2,45	1,73	1,77	2,61	2,54	1,87	

Freeze thaw test with de-icing salt after 28 cycles (S3)

Freeze Thaw Cycle with de-icing salt
Mass Loss during time



Target
 Mass Loss mean < 1kg/m²
 with max individual value <1,5 kg/m²

Freez thaw test

M0-D14 (Ref)

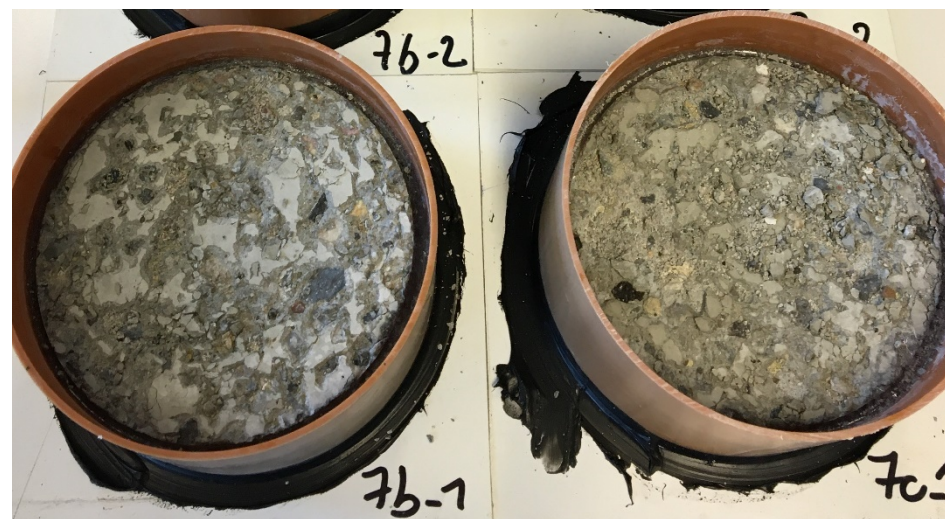
0,72 kg/m²

0,43 kg/m²



M50-75CC-D14

1,27 kg/m²



M25-40CC-D14

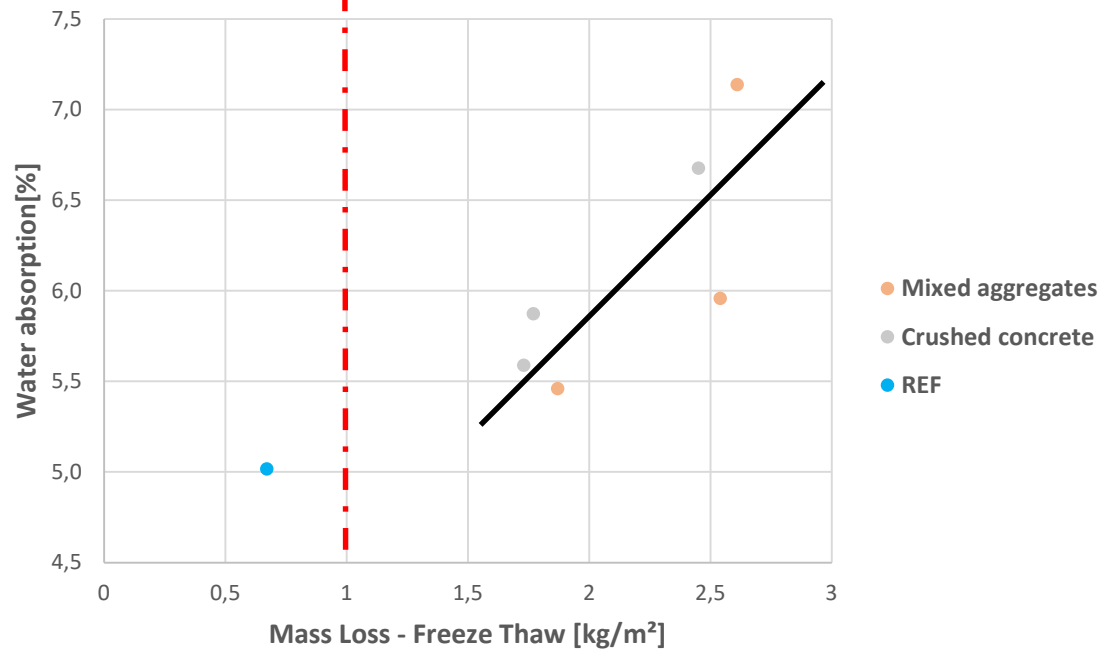
2,15 kg/m²



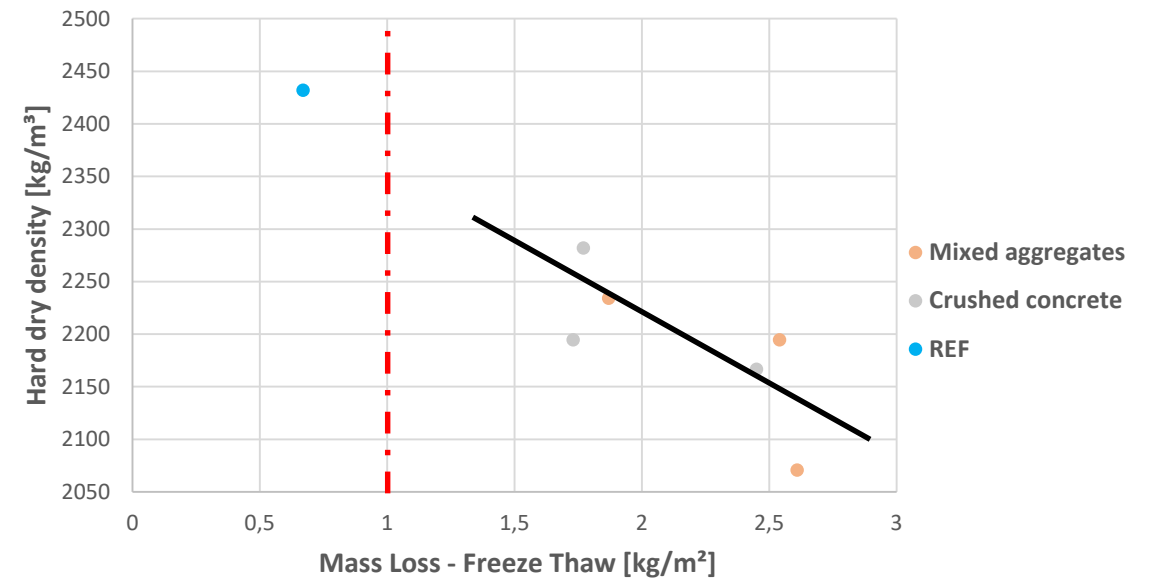
M50-75MA-D14

1,96 kg/m²

Water absorption / Mass Loss



Hard dry Density / Mass Loss



C) Application on concrete paving blocks

EN 1338 - Requirements		
Water absorption	[%]	≤ 6
Mass loss after freeze-thaw test	[kg/m ²]	≤ 1 as a mean with no individual value > 1,5
Tensile splitting strength	[MPa]	≥ 3,6 with no individual value < 2,9
Tensile splitting [N/mm]	[N/mm]	≥ 250

		Mix - Natural	Mix - Recycled
Cement	[kg]	340	340
Type of cement	[-]	CEM III A 42,5 N LA	CEM I 52,5 N - Vicat
W/C (water on cement Ratio)	[-]	0,5-0,6	0,5-0,6
Sand 0/2	[kg]	600	600
CC 0/4 - Limestone	[kg]	600	600
RA crushed concrete 2/6 - Tradecowall	[kg]	-	600
CC 2/6 - Limestone	[kg]	600	-
% of Recycled aggregates	[-]	0%	100%
% of Recycled aggregates including Sand	[-]	0%	35%



Paving blocks

Tests results

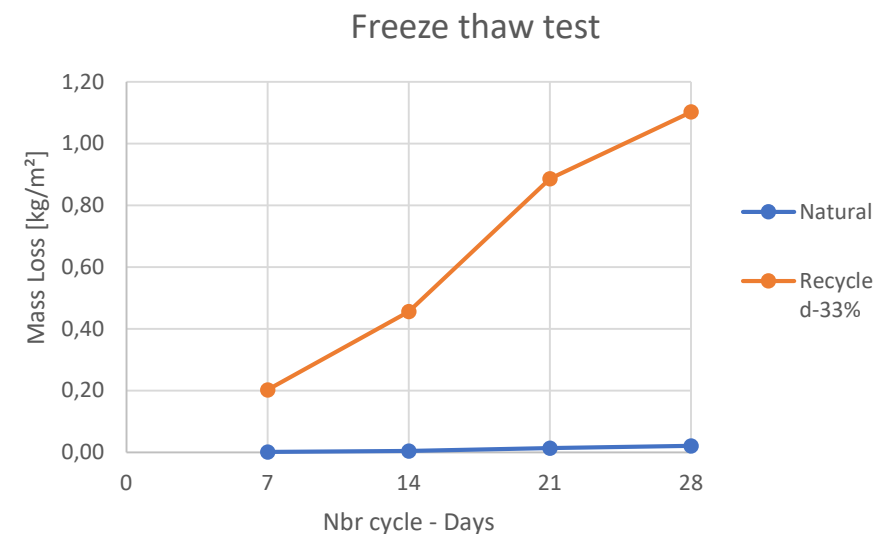
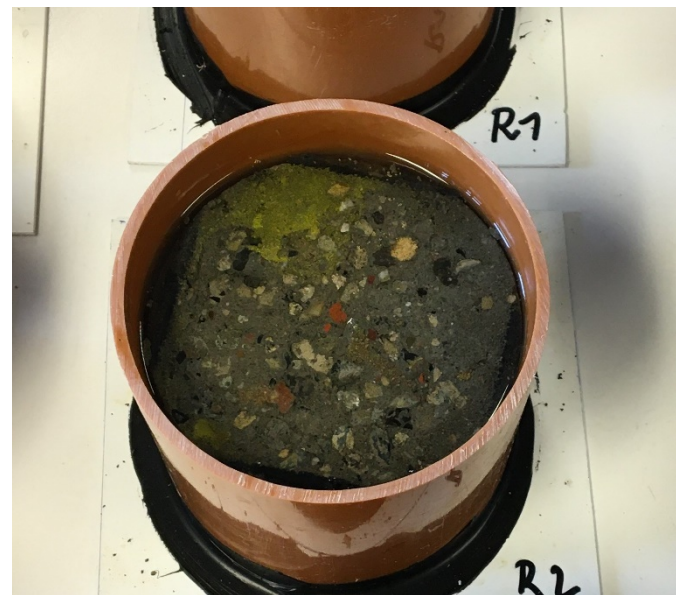
Paving blocks	Dimensions [cm x cm x cm]	% of recycled aggregates	Hard density [kg/m ³]	Dry density [kg/m ³]	Tensile splitting strength [MPa]	Tensile splitting [N/mm]	Water Absorption [%]
Natural	22x11x7	0%	2321	2206	4,69	550	5,9
Natural	11x11x7	0%	2306	2223	4,69	599	5,6
Recycled	22x11x7	35%	2198	2045	3,18	371	9,2
Recycled	11x11x7	35%	2153	2075	2,47	325	10,2



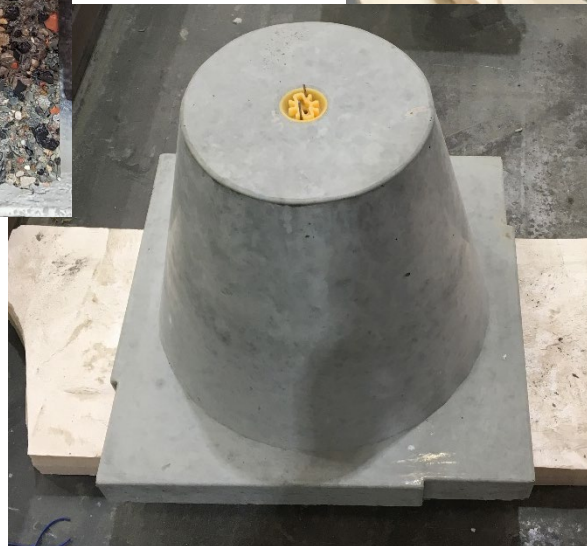
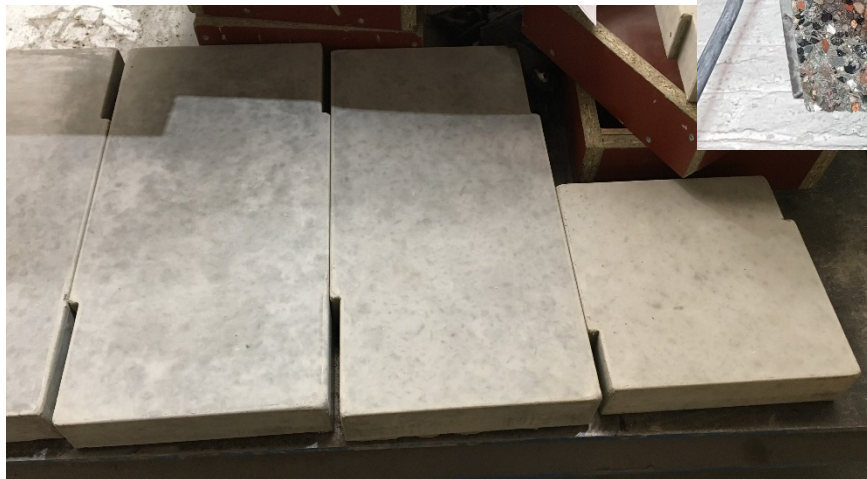
Paving blocks

Tests results – Freeze thaw cycle with de-icing agents

Paving blocks	% of recycled aggregates	Freeze-thaw test at 7 days [kg/m ²]	Freeze-thaw test at 14 days [kg/m ²]	Freeze-thaw test at 21 days [kg/m ²]	Freeze-thaw test at 28 days [kg/m ²]	Standard deviation
Natural	0%	0,00	0,00	0,01	0,02	0,02
Recycled	35%	0,20	0,46	0,89	1,10	0,82



WPT3- Prototypes



Non structural element from recycled aggregates

- Workability – ok
- Compressive strength and tensile strength - ok
- Water absorption – ok
- Durability
 - ⇒ Inside conditions – ok
 - ⇒ Outside conditions - Freeze-thaw cycle with/without de-icing agents
 - decrease W_{eff}/C -> water absorption to 4-5% and increase density
 - use Air entraining admixture
 - Freez-thaw cycle without de-icing salt

Questions ?