Bridging the Gaps:
One Concrete World - Multiple Standards

Unification of Standards - An Industry Goal

Vojtech Tauber
Sika Corporation
Lyndhurst, New Jersey, USA

Agenda:

- Czech Republic vs USA
- Selected standards
- Industry challenges
- Conclusions

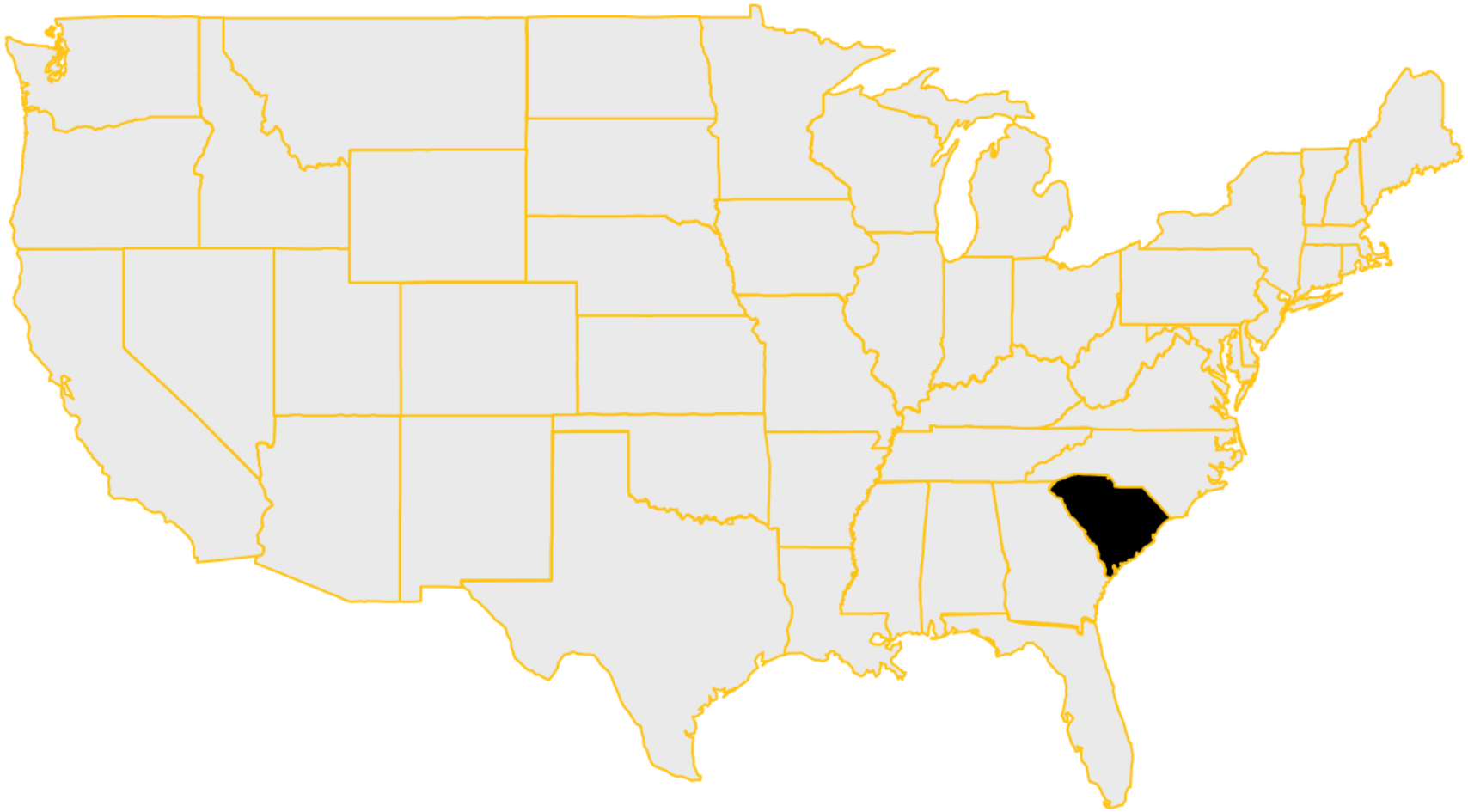

2005
2013
2023

Czech Republic

What is the Czech Republic most known for?

The Czech Republic lies in Central Europe and is known for its **rich history, stunning architecture, delicious cuisine, and vibrant culture**.

Czech Republic vs. USA



- 125 times smaller
- Equal to South Carolina

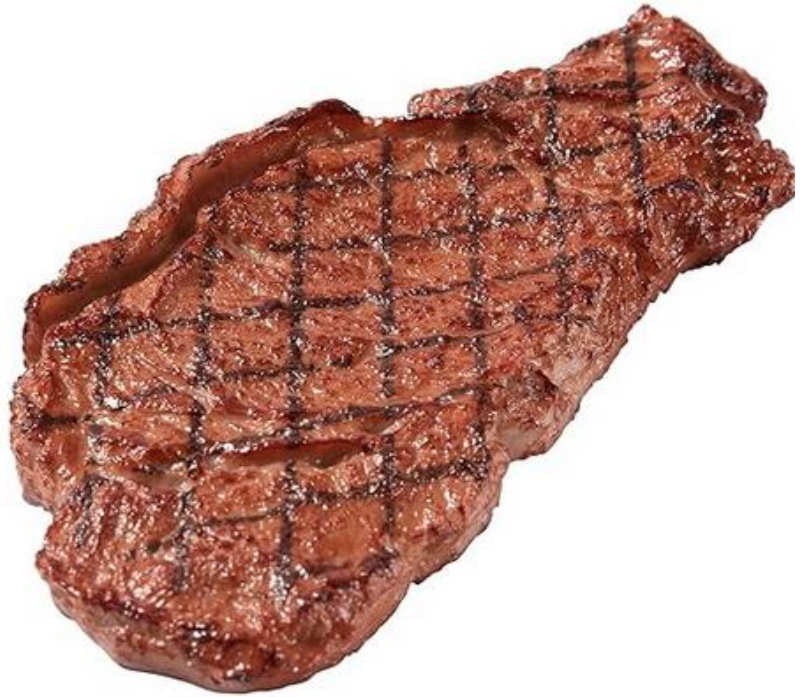
2022 Population:

USA: **333,287,557** million

South Carolina: **5,1** million

Czech Republic: **10,5** million

Differences



Weight: kg/lb, **Temp.**: C/F, **Strength:** MPa/psi, **Volume:** m3/yd3


w/c

=

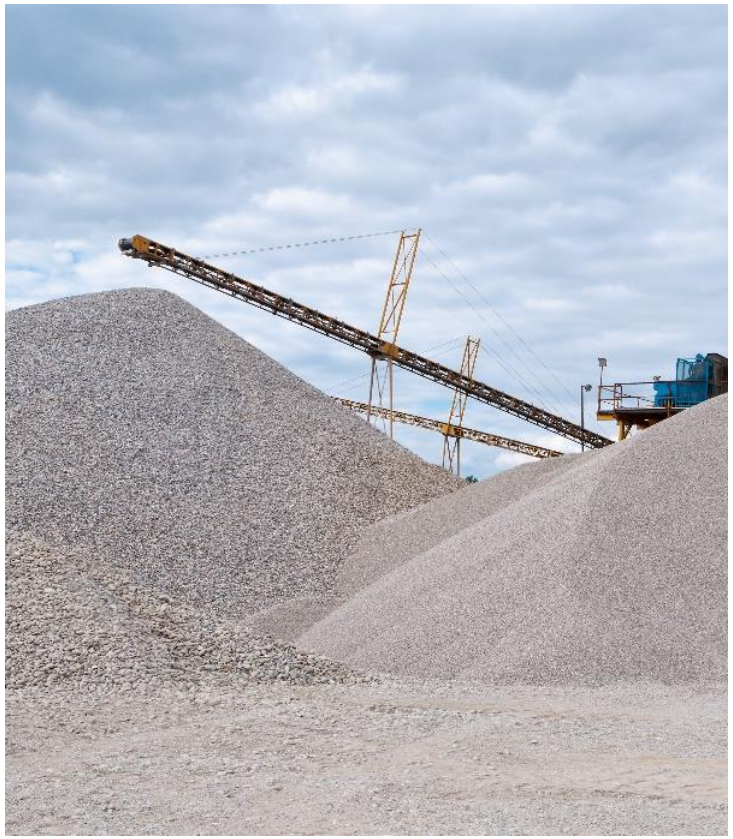

w/c

- 450 RMC plants / 7.5 mil. m3
- 2 cement types
- 1-2 SCM’s
- 2 fine aggregates
- 3 coarse aggregates

- 7500 RMC plants / 400 mil. yd3
- 1 cement
- 1 SCM
- 1 fine aggregates
- 1 coarse aggregates

Industry challenges

- Quality aggregates
- Cement availability
- Availability of SCM’s
- Durability of the concrete
- Raw material shortages
- Sustainability
- Experienced and qualified labor
- Trucking issues



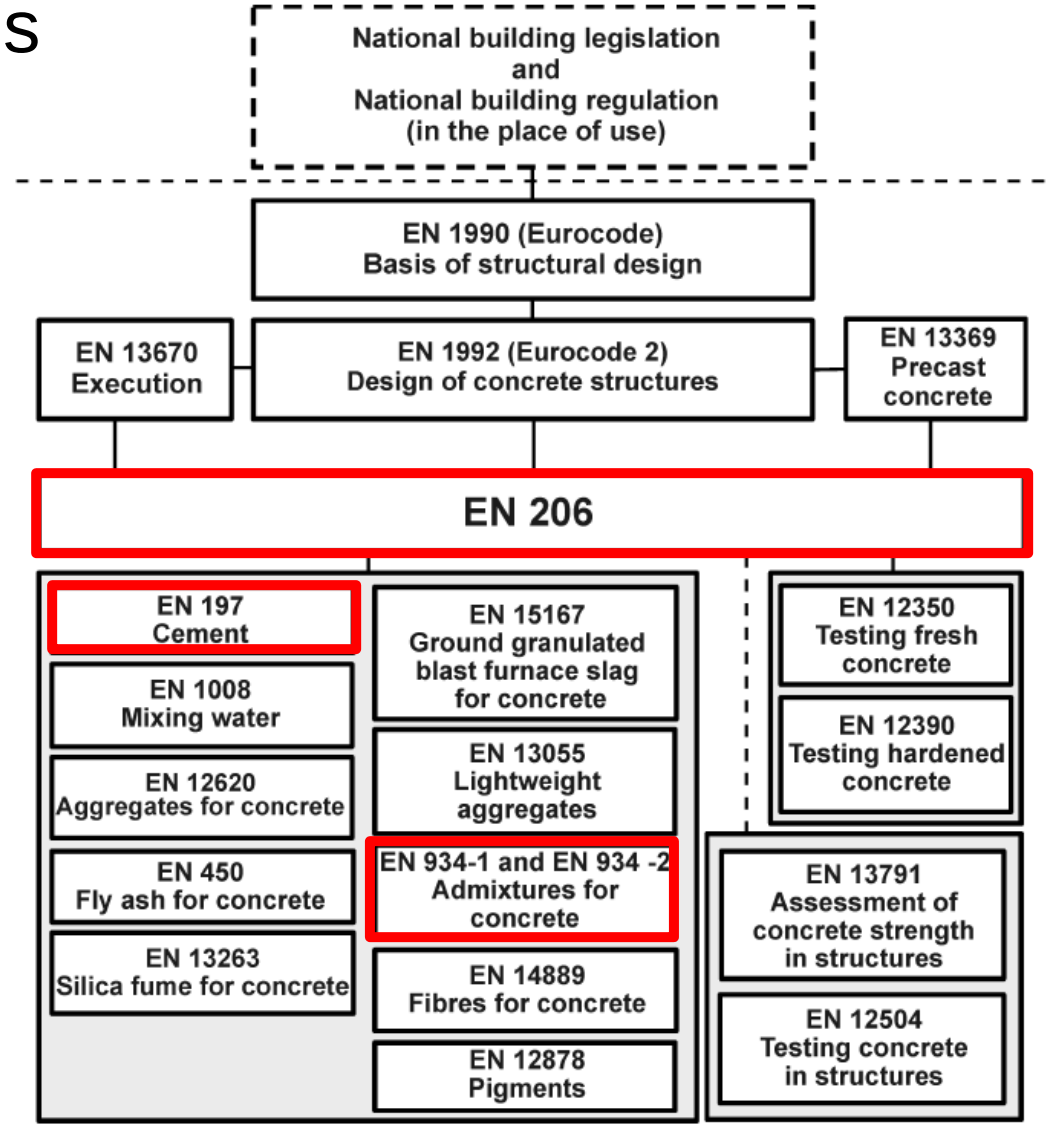
Key Observations – Concrete industry

- **Go big or go home!**
- Production volume & typical project size
- Mix designs
- Selection of the raw materials
- Setting characteristics
- Durability of the concrete
- Industry cooperation
- Standards

USA vs European standards

- **ACI / ASTM / ASSHTO…**
  - ACI 318, ASTM C150 …
- **EN**
  - *Germany*
    - **DIN** - DIN EN 197
  - *Czech Republic*
    - **ČSN** - ČSN EN 197

European standards



Cement manufacturing locations in Czech Republic

CEM I - Portland cement
CEM II - Portland-composite cement
CEM III - Blast furnace cement
CEM IV - Pozzolanic cement
CEM V - Composite cement

- **5** cement plants
- **4.5** million metric tons
- **27** types of cement

Cement Specification – ČSN EN 197

Main types	Notation of the 27 products (types of common cement)		Composition (percentage by mass[a]) Main constituents										Minor additional constituent
			Clinker	Blast-furnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
						natural	natural calcined	siliceous	calca-reous				
			K	S	D[b]	P	Q	V	W	T	L	LL	
CEM I	Portland cement	CEM I	95-100	–	–	–	–	–	–	–	–	–	0-5
CEM II	Portland-slag cement	CEM II/A-S	80-94	6-20	–	–	–	–	–	–	–	–	0-5
		CEM II/B-S	65-79	21-35	–	–	–	–	–	–	–	–	0-5
	Portland-silica fume cement	CEM II/A-D	90-94	–	6-10	–	–	–	–	–	–	–	0-5
	Portland-pozzolana cement	CEM II/A-P	80-94	–	–	6-20	–	–	–	–	–	–	0-5
		CEM II/B-P	65-79	–	–	21-35	–	–	–	–	–	–	0-5
		CEM II/A-Q	80-94	–	–	–	6-20	–	–	–	–	–	0-5
		CEM II/B-Q	65-79	–	–	–	21-35	–	–	–	–	–	0-5
	Portland-fly ash cement	CEM II/A-V	80-94	–	–	–	–	6-20	–	–	–	–	0-5
		CEM II/B-V	65-79	–	–	–	–	21-35	–	–	–	–	0-5
		CEM II/A-W	80-94	–	–	–	–	–	6-20	–	–	–	0-5
		CEM II/B-W	65-79	–	–	–	–	–	21-35	–	–	–	0-5
	Portland-burnt shale cement	CEM II/A-T	80-94	–	–	–	–	–	–	6-20	–	–	0-5
		CEM II/B-T	65-79	–	–	–	–	–	–	21-35	–	–	0-5
	Portland-limestone cement	CEM II/A-L	80-94	–	–	–	–	–	–	–	6-20	–	0-5
		CEM II/B-L	65-79	–	–	–	–	–	–	–	21-35	–	0-5
		CEM II/A-LL	80-94	–	–	–	–	–	–	–	–	6-20	0-5
		CEM II/B-LL	65-79	–	–	–	–	–	–	–	–	21-35	0-5
	Portland-composite cement[c]	CEM II/A-M	80-88	<---------- 12-20 ---------->									0-5
		CEM II/B-M	65-79	<---------- 21-35 ---------->									
CEM III	Blast furnace cement	CEM III/A	35-64	36-65	–	–	–	–	–	–	–	–	0-5
		CEM III/B	20-34	66-80	–	–	–	–	–	–	–	–	0-5
		CEM III/C	5-19	81-95	–	–	–	–	–	–	–	–	0-5
CEM IV	Pozzolanic cement[c]	CEM IV/A	65-89	–	<---------- 11-35 ---------->					–	–	–	0-5
		CEM IV/B	45-64	–	<---------- 36-55 ---------->					–	–	–	0-5
CEM V	Composite cement[c]	CEM V/A	40-64	18-30	–	<------- 18-30 ------->			–	–	–	–	0-5
		CEM V/B	20-38	31-49	–	<------- 31-49 ------->			–	–	–	–	0-5

a The values in the table refer to the sum of the main and minor additional constituents.

b The proportion of silica fume is limited to 10 %.

c In Portland-composite cements CEM II/A-M and CEM II/B-M, in pozzolanic cements CEM IV/A and CEM IV/B and in composite cements CEM V/A and CEM V/B the main constituents other than clinker shall be declared by designation of the cement (for examples, see Clause 8).

Strength class	Compressive strength MPa				Initial setting time	Sound-ness (expan-sion)
	Early strength		Standard strength			
	2 days	7 days	28 days		min	mm
32,5 L[a]	-	≥ 12,0	≥ 32,5	≤ 52,5	≥ 75	≤ 10
32,5 N	-	≥ 16,0				
32,5 R	≥ 10,0	-				
42,5 L[a]	-	≥16,0	≥ 42,5	≤ 62,5	≥ 60	
42,5 N	≥ 10,0	-				
42,5 R	≥ 20,0	-				
52,5 L[a]	≥ 10,0	-	≥ 52,5	-	≥ 45	
52,5 N	≥ 20,0	-				
52,5 R	≥ 30,0	-				

a Strength class only defined for CEM III cements.

Cement in Czech republic

< 2008	> 2010
CEM I 42,5 R	**CEM I/A-LL 42,5 N**
95-100% clinker	80-94% clinker 6-20% limestone
CEM II/A-S 32.5 N	**CEM II/B-S 32.5 R**
80-94% clinker 6-20% slag	65-79% clinker 21-35% slag

CEM I to **CEM I/A-LL** challenges

- Concrete workability
- Quality and the stability of the air
- Setting characteristic (cold weather)
- Pumpability, finishability and stickiness of the concrete
- Early strength & Late strength of the concrete
- Blending options with SCM’s
- Durability of the concrete
- Grinding Aids & Quality Improvements
- Etc.

Cement manufacturing locations in USA

- **95** cement plants
- **95** million metric tons
- **10** types of cement

ASTM C150 - Portland Cement Spec.

Type I - special properties specified
Type II - moderate sulfate resistance
Type III - high early strength
Type IV - low heat of hydration
Type V - high sulfate resistance

ASTM C595 - Blended Hydraulic Cements Spec.

Type IS - Portland blast-furnace slag cement
Type IP - Portland-pozzolan cement
Type IL - Portland-limestone cement
Type IT - Ternary blended cement

Concrete Specification – ČSN EN 206

Compressive Strength

Max Cl content

Concrete Slump

C 30/37 XF4 (CZ) – Cl 0,20 – Dmax = 16 – S4

Exposure Classes

Max size of aggregates

ACI 318-19 - Durability Requirements

Concrete Specification – ČSN EN 206

Compressive strength class	Minimum characteristic cylinder strength $f_{ck,cyl}$ N/mm^2	Minimum characteristic cube strength $f_{ck,cube}$ N/mm^2
C8/10	8	10
C12/15	12	15
C16/20	16	20
C20/25	20	25
C25/30	25	30
C30/37	30	37
C35/45	35	45
C40/50	40	50
C45/55	45	55
C50/60	50	60
C55/67	55	67
C60/75	60	75
C70/85	70	85
C80/95	80	95
C90/105	90	105
C100/115	100	115

Concrete use	Chloride content class [a]	Maximum Cl^- content by mass of cement[b] %
Not containing steel reinforcement or other embedded metal with the exception of corrosion-resisting lifting devices	Cl 1,00	1,00
Containing steel reinforcement or other embedded metal	Cl 0,20	0,20
	Cl 0,40[c]	0,40
Containing prestressing steel reinforcement in direct contact with concrete	Cl 0,10	0,10
	Cl 0,20	0,20

Class	Slump tested in accordance with EN 12350-2 mm
S1	10 to 40
S2	50 to 90
S3	100 to 150
S4	160 to 210
S5[a]	≥ 220

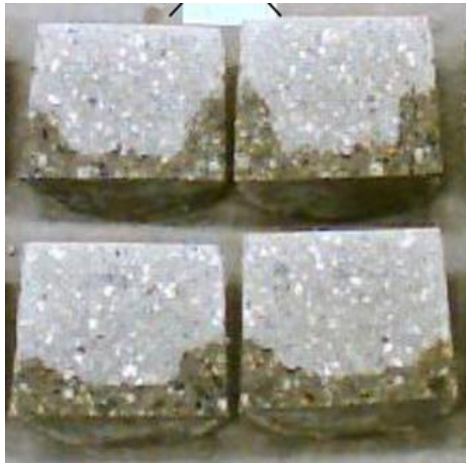
[a] See Note 1 to 5.4.1.

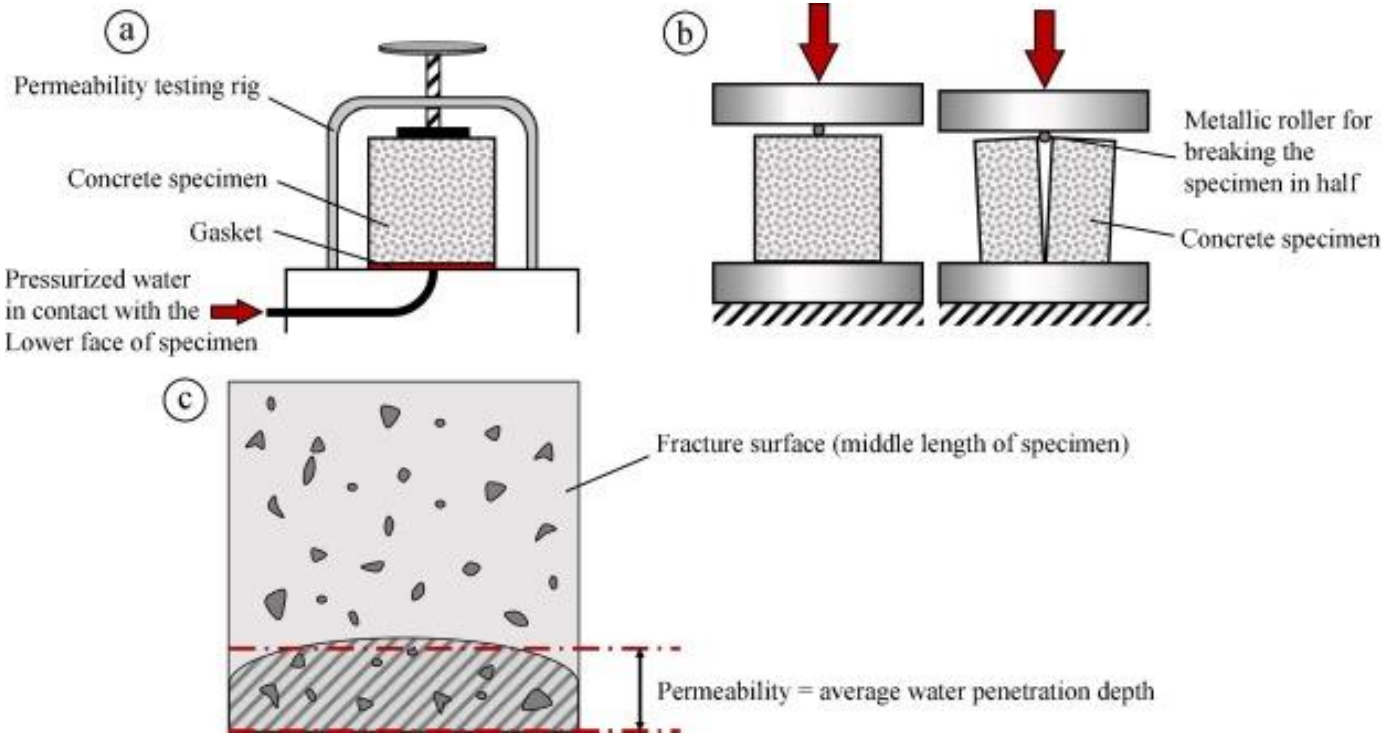
Concrete Specification – ČSN EN 206

Exposure Classes	Maximum w/c	Minimal cement content [kg/m3]	Minimal compressive strength of concrete [kg/m3]	Minimal content of the air [%]	Maximum water penetration [mm]	F/T durability [method /# of cycle]
XO	-	-	C 12/15	-	-	-
XC1	0,65	260	C 16/20	-	-	-
XC2	0,60	280	C 16/20	-	-	-
XC3	0,55	280	C 20/25	-	-	-
XC4	0,50	300	C 25/30	-	50	-
XS1	0,50	300	C 30/37	-	-	-
XS2	0,45	320	C 35/45	-	-	-
XS3	0,45	340	C 35/45	-	-	-
XD1	0,55	300	C 25/30	-	-	-
XD2	0,55	300	C 25/30	-	50	-
XD3	0,45	320	C 30/37	-	20	-
XF1	0,55	300	C 25/30	-	50	-
XF2	0,55	300	C 25/30	4,0	50	A/75 & C/50
XF3	0,50	320	C 25/30	4,0	35	A/100 & C/75
XF4	0,45	340	C 30/37	4,0	35	A/100 & C/75
XA1	0,55	300	C 25/30	-	50	-
XA2	0,50	320	C 25/30	-	35	-
XA3	0,45	360	C 30/37	-	20	-

XF - Freeze/thaw attack with or without de-icing agents

DIN 1048 - Depth of Penetration of Water Under Pressure





Admixture Specification - ČSN EN 934

Name of admixture
Water reducing/plasticizing admixtures
High range water reducing/superplasticizing admixtures
Water retaining admixtures
Air entraining admixture
Set accelerating admixtures
Hardening accelerating admixtures
Set retarding admixtures
Water resisting admixtures
Set retarding/water reducing/plasticizing admixtures
Set retarding/high range water reducing/superplasticizing admixtures
Set accelerating/water reducing/plasticizing admixtures
Viscosity modifying admixture

Specific requirements for **water reducing admixtures** (at equal consistence)

No	Property	Reference concrete	Test method	Requirements
1	Water reduction	EN 480-1 reference concrete I	slump EN 12350-2 or flow EN 12350-5	In test mix ≥ 5 % compared with control mix
2	Compressive strength	EN 480-1 reference concrete I	EN 12390-3	At 7 and 28 days: Test mix ≥ 110 % of control mix
3	Air content in fresh concrete	EN 480-1 reference concrete I	EN 12350-7	Test mix ≤ 2 % by volume above control mix unless stated otherwise by the manufacturer

Cement: ČSN EN 197
- CEM I 42.5 or 52.5
- C3A & blain limitation

Aggregates: ČSN EN 12620

Reference concrete without admixture,

Concrete with admixture at equal slump,
- Cement content: 350 Kg/m3
- Air content below 2%,
- Slump – 70 mm
- Spread – 400 mm

Standard Specification for Chemical Admixtures for Concrete - ASTM C494

	Type A, Water-Reducing	Type B, Retarding	Type C, Accelerating	Type D, Water-Reducing and Retarding	Type E, Water-Reducing and Accelerating	Type F, Water-Reducing, High-Range	Type G, Water-Reducing, High-Range and Retarding	Type S Specific Performance
Water content, max, % of reference[A]	95	...	...	95	95	88	88	...
Time of setting, allowable deviation from reference, h:min:								
Initial: at least	...	1:00 later	1:00 earlier	1:00 later	1:00 earlier	...	1:00 later	
not more than	1:00 earlier nor 1:30 later	3:30 later	3:30 earlier	3:30 later	3:30 earlier	1:00 earlier nor 1:30 later	3:30 later	1:00 earlier nor 1:30 later
Final: at least	...	...	1:00 earlier	...	1:00 earlier	...	...	
not more than	1:00 earlier nor 1:30 later	3:30 later	...	3:30 later	...	1:00 earlier nor 1:30 later	3:30 later	1:00 earlier nor 1:30 later
Compressive strength, min, % of reference:[C]								
1 day	...	...	...	...	...	140	125	...
3 days	110	90	125	110	125	125	125	90
7 days	110	90	100	110	110	115	115	90
28 days	110 (120)[D]	90	100	110 (120)[D]	110	110 (120)[C]	110 (120)[D]	90
90 days	(117)[D]	n/a	n/a	(117)[D]	n/a	(117)[C]	(117)[D]	n/a
6 months	100 (113)[D]	90	90	100 (113)[D]	100	100 (113)[C]	100 (113)[D]	90
1 year	100	90	90	100	100	100	100	90
Flexural strength, min, % reference:[C]								
3 days	100	90	110	100	110	110	110	90
7 days	100	90	100	100	100	100	100	90
28 days	100	90	90	100	100	100	100	90
Length change, max shrinkage (alternative requirements):[E]								
Percent of reference	135	135	135	135	135	135	135	135
Increase over reference	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Relative durability factor, min % of reference[F]	80	80	80	80	80	80	80	80

Type A - Water-reducing
Type B - Retarding
Type C - Accelerating
Type D - Water-reducing and retarding
Type E - Water-reducing and accelerating
Type F - Water-reducing, high range
Type G - Water-reducing, high range, and retarding
Type S - Specific performance

Admixtures for concrete, mortar and grout - Test methods - ČSN EN 480

Specific requirements for **air entraining admixtures** (at equal consistence)

No	Property	Reference concrete	Test method	Requirements[a]
1	Air content in fresh concrete (entrained air)	EN 480-1 reference concrete III	EN 12350-7	Test mix ≥ 2,5 % by volume above control mix Total air content 4 % to 6 % by volume
2	Air void characteristics in hardened concrete	EN 480-1 reference concrete III	EN 480-11[b]	Spacing factor in test mix ≤ 0,200 mm
3	Compressive strength	EN 480-1 reference concrete III	EN 12390-3	At 28 days : test mix ≥ 75 % of control mix

[a] All the requirements apply to the same test mix.

[b] EN 480-11 is the reference method. Other methods of determining the spacing factor (e. g. modified point count method) may be used provided that they can be shown to give essentially the same results as the method in EN 480-11.

Cement: ČSN EN 197
- CEM I 42.5 or 52.5
- C3A & blain limitation

Aggregates: ČSN EN 12620

Reference concrete without admixture,
Concrete with admixture at equal slump,
- Cement content: 350 Kg/m3
- Slump – 30 mm
- Spread – 350 mm

Standard Specification for Chemical Admixtures for Concrete - ASTM C260

Air-Entraining Admixtures	
Time of setting, allowable deviation from control, h:min:	
Initial: not more than	1:15 earlier nor 1:15 later
Final: not more than	1:15 earlier nor 1:15 later
Compressive strength, min, % of control:	
3 days	90
7 days	90
28 days	90
Flexural strength, min, % of control:[B]	
3 days	90
7 days	90
28 days	90
Length change, max shrinkage (alternative requirements):[B,C]	
Percent of control	120
Increase over control, percentage points[D]	0.006
Relative durability factor, min	80
Bleeding of the net amount of mixing water, max percent over control[E]	2

Main Standard Differences

ČSN EN 934

- No laboratory limitations
- Completed after 28 days
- Testing at equal consistency
- w/c ratio freedom
- Limitation for the maximum air content
- Without testing and requirements:

- Freeze thaw
- Shrinkage
- Long-term strengths
- Setting characteristic
- Flexural strength

ASTM C494 / C260

- Complexity of the process
- Various test methods
- Limited options for testing
- More strict criteria requirements

- Plastic and hardened concrete properties
- Compressive and flexural
- Durability testing required

Conclusions

- Cooperation between the regions
- Unification of the standards
- Potential simplification of standards
- Sustainability
- **One Concrete World**

Thank you

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