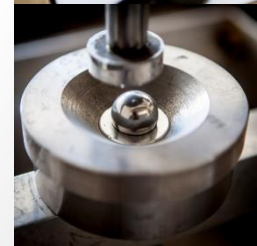
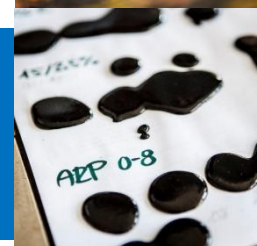
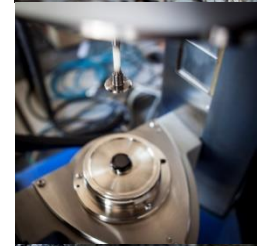
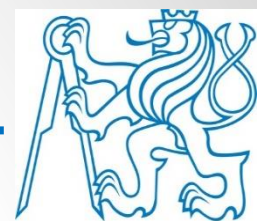


30 years of cold recycling in CZ – daily business and challenges

JAN VALENTIN

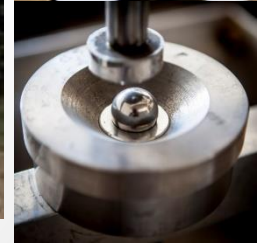
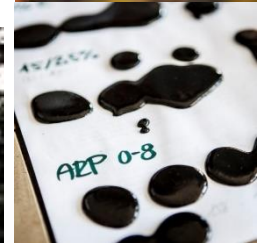
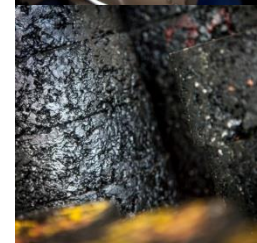
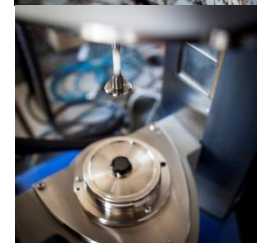
Faculty of Civil Engineering, Czech Technical University in Prague

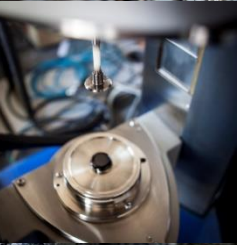




How did it start ?

- ➔ Introduced to the Czech market in late 90s;
- ➔ Basic concept used bituminous emulsion and hydraulic binders, beginning of millennium foamed bitumen was introduced as well;
- ➔ We learned from German experience and way the technology was used;
- ➔ ROADTEC machine set-up tested in first decade of 21st century as well;
- ➔ Pioneers: Baltom and SAT CZ.

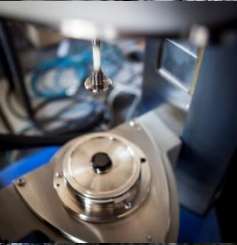


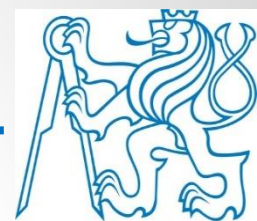




When is cold recycling used in CZ and is considered suitable?

- ➔ if serious structural pavement problems occur (in-depth corrosion, large cracking, increased number of potholes) – for most pavement types;
- ➔ if lost in bearing capacity is evident – mainly for regional or low volume roads;
- ➔ if local repairs are anymore economic and reasonable;
- ➔ if tar was used in the past in base layers (especially macadam layers built in 60s to 80s).





Technical specifications

- ➔ First generation 2000-2009: technical specifications of the Ministry of transport (cold in-situ, foamed bitumen cold technology; in-plant solutions)
- ➔ Second generation 2009-2022: technical specification TP 208 (we put several into one)
- ➔ Third generation 2022-...: technical standard CSN 73 6147

Basic facts:

- ➔ three types of cold recycling based on binder used
- ➔ indirect tensile strength or compressive strength
- ➔ moisture susceptibility or freezing-thawing resistance

Technický dokument je obsahově identický s oficiální úřední verzí. Buďte včasně v systému TP online a v Zásadách úsporné operace s ITMou verzí.

TP 208

MINISTERSTVO DOPRAVY
ODBOR SILNIČNÍ INFRASTRUKTURY

RECYKLACE KONSTRUKČNÍCH VRSTEV NETUHÝCH VOZOVEK
ZA STUDENA

TECHNICKÉ PODMÍNKY

Schváleno MD - Odbor silniční infrastruktury č. 554/09-910-IPK/1 ze dne 10.7.2009
s účinností od 1. srpna 2009

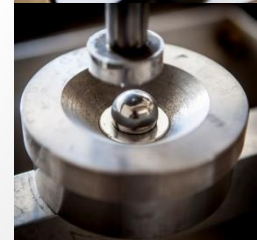
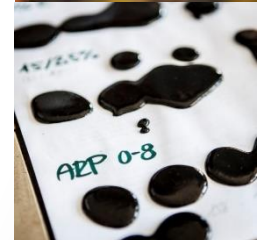
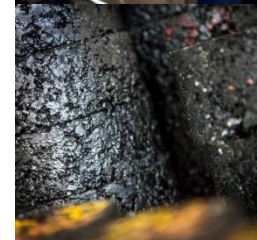
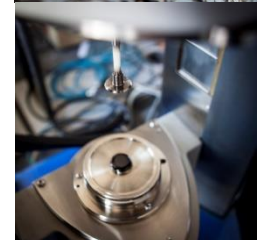
Současně se ruší a nahrazují v celém rozsahu
TP 111 schválené MDS-OPK č. 28913/98-120 ze dne 9.11.1998,
TP 126 schválené MD-OI č. 68/07-910-IPK/1 ze dne 16.1.2007,
TP 134 schválené MD-OPK č. 20326/00-120 ze dne 16.5.2000,
TP 162 schválené MD-OI č. 69/07-910-IPK/1 ze dne 16.1.2007.

Ing. Jan Zajíček – APT SERVIS
červenec 2009





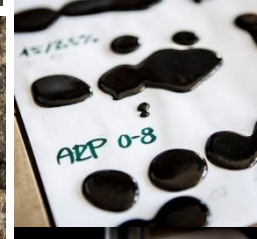
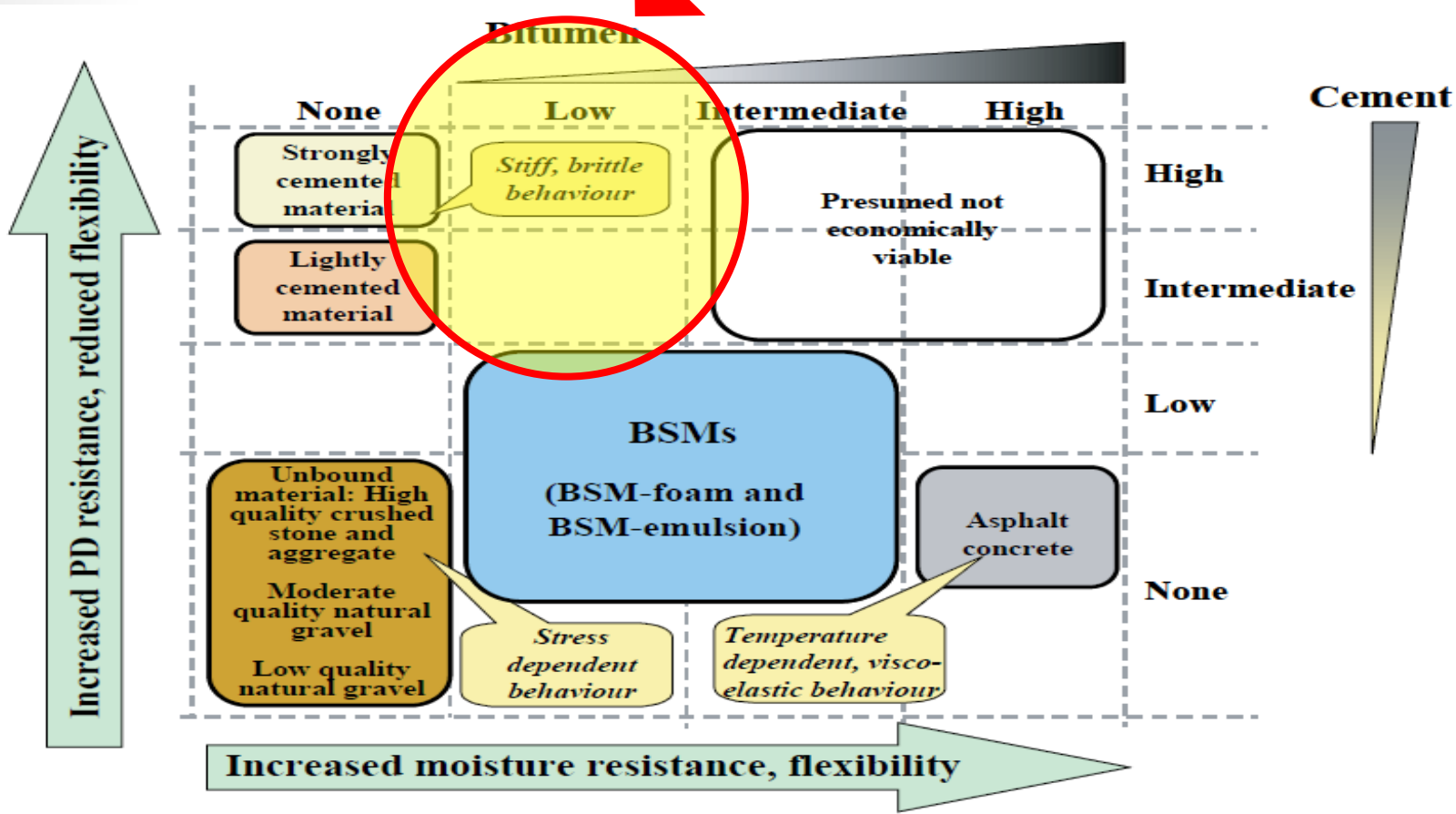
Vlastnost		Požadavky pro směsi s použitím pojiva		
		cement nebo jiné hydr. pojivo	cement + asfaltová emulze nebo zpěněný asfalt	asfaltová emulze nebo zpěněný asfalt
Označení směsi	recyklace na místě	0/32; 0/45		0/32
	recyklace v centru	0/16; 0/22; 0/32; 0/45		0/16; 0/22; 0/32
Požadavky na zrnitost směsi ^{1) 2)}		Příloha A, tab. A.1	Příloha A, tab. A.1	Příloha A, tab. A.2
Laboratorní srovnávací objemová hmotnost a optimální vlhkost		deklarovaná hodnota		
Vlhkost ³⁾		-3% až +2%		
Min. pevnost v tlaku R_c po 28 dnech		$C_{3/4}$ ⁴⁾ nebo	—	—
Min. pevnost v příč. tahu R_{it} po 7 dnech		0,30 až 0,70 MPa	0,30 až 0,70 MPa	0,30 MPa
Odolnost proti mrazu a vodě :		85% pevnosti R_c nebo 70% pevnosti R_{it}	—	—
- min. pevnost v tlaku				
Odolnost proti vodě :		70% pevnosti R_{it}	70% pevnosti R_{it}	60% pevnosti R_{it}
- min. pevnost v příčném tahu				
Mezerovitost		—	8% až 15%	6% až 14%
¹⁾ Doporučené požadavky pro směs kameniva před přidáním pojiva				
²⁾ U složky R-materiálu se uvažuje kusová zrnitost.				
³⁾ Doporučené max. odchylky od deklarované hodnoty.				
⁴⁾ Třídy pevnosti podle ČSN EN 14227-1				

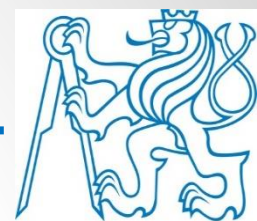




What is common in CZ with respect to binders?

This solution do the Czechs „love“ / prefer

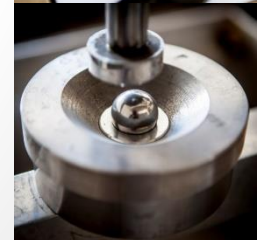
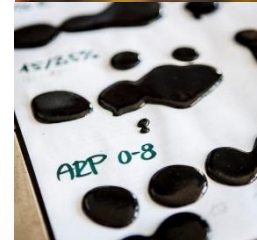
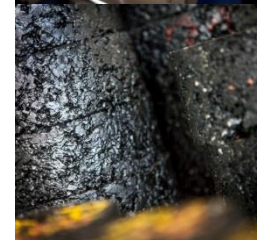
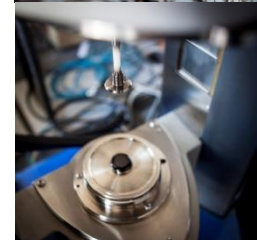


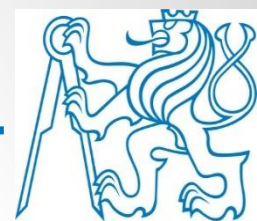


Common practice today (I)

- ➔ the whole family of cold recycling technologies since 2023 regulated by national technical standard (CSN 74 6147)
- ➔ cold recycling for unbound and bound layers possible

Co se recykluje ^a			Pojivo	Srovnatelná vrstva ^b
Hutněné asfaltové vrstvy ^b	Penetrační makadam, nátěry	Vrstvy bez asfaltového pojiva		
NESTMELENÉ VRSTVY – RECYKLACE BEZ POUŽITÍ POJIVA				
max. 30 %	BEZ OMEZENÍ		—	MZ ^c ČSN 73 6126-1
STMELENÉ VRSTVY – RECYKLACE S POUŽITÍM POJIVA^d				
max. 50 %		BEZ OMEZENÍ	cement / hydraulické silniční pojivo	SC C _{3/4} ČSN 73 6124-1
min. 50 %		max. 50 %	cement / hydraulické silniční pojivo + asfaltová emulze / zpěněný asfalt	SC C _{3/4} ČSN 73 6124-1
min. 80 %	max. 20 %		asfaltová emulze / zpěněný asfalt	SC C _{1,5/2} ČSN 73 6124-1



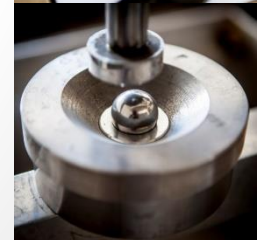
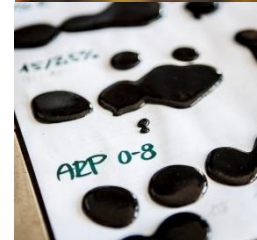
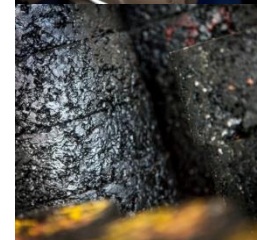
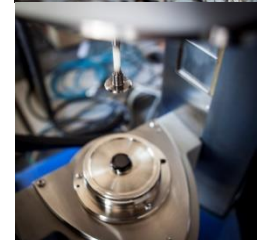


Common practice today (II)

Vlastnost		Požadavky na směsi s použitím pojiva			
		C	CA	A	C, CA
Označení směsi		0/32, 0/45		0/32	0/63
Laboratorní srovnávací objemová hmotnost a optimální vlhkost		Deklarovaná hodnota			
Dálnice	Min. pevnost v tlaku R_c po 28 dnech ^a Odolnost proti mrazu a vodě	$C_{3/4}$ 85 % pevnosti R_c	–	–	–
	Pevnost v příčném tahu R_{it} po 7 dnech ^b Odolnost proti vodě min.	–	0,30 až 0,70 MPa 75 % pevnosti R_{it}	–	
Ostatní komunikace	Pevnost v příčném tahu R_{it} po 7 dnech ^b Odolnost proti vodě min.	0,30 až 0,70 MPa 75 % pevnosti R_{it}	0,30 až 0,70 MPa 75 % pevnosti R_{it}	Min. 0,2 MPa 60 % pevnosti R_{it}	

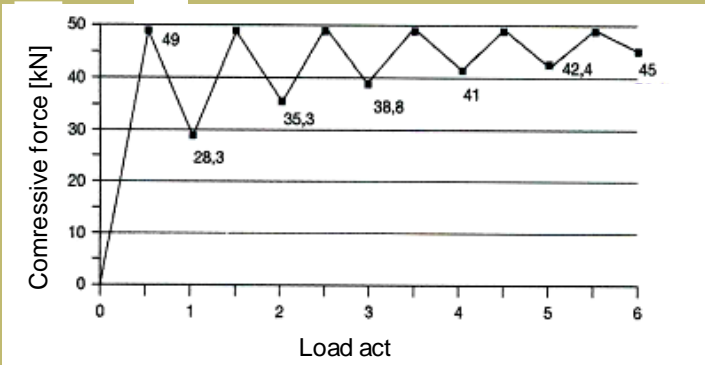
^a Zkouší se jako směsi stmelené cementem podle ČSN 73 6124-1. Platí i pro směsi 0/45 s maximálním podílem nadsítného 15 %.

^b Zkouší se podle Přílohy A. Platí pro směsi 0/32 a 0/45 s maximálním podílem nadsítného 15 %.

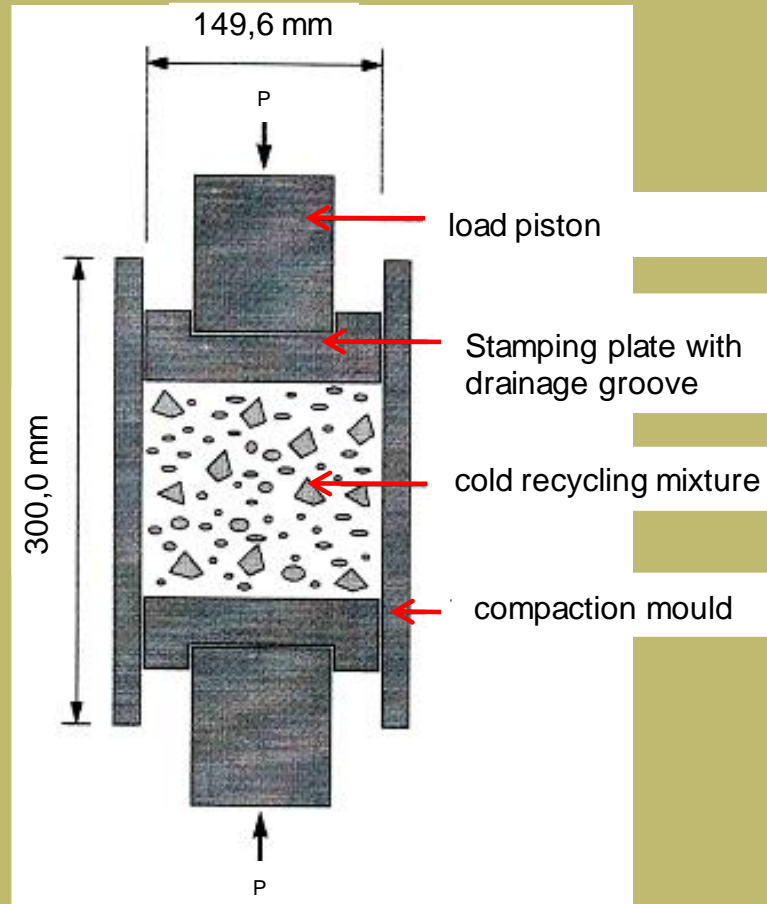




Common practice today (III)



Static pressure compaction



Indirect tensile strength test (destructive) @15°C





Common practice today (IV)

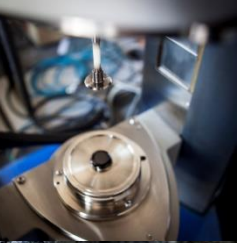
Typically used binders:

- ➔ cationic slow-breaking bituminous emulsion C 60 B10 or C 65 B10 **(2-3.5% binder)**
- ➔ foamed bitumen made from paving grade 70/100 or 50/70 **(1.5-3% binder)**
- ➔ Portland cement CEM I/32.5, CEM II/32.5, CEM I 42.5 **(2.5-5 % binder)**
- ➔ Commercial road hydraulic binders (SM, GEOROAD, DROHART etc.)

Typical mix requirements by road administrations and designers:

- ➔ recycle 17 to 20 cm of base or base and binder layer
- ➔ use 4 % cement and 1.5% emulsion or 4 % cement and 0.9% foamed bitumen

WHY? and WHAT IS TRICKY ABOUT THESE DESIGNS?

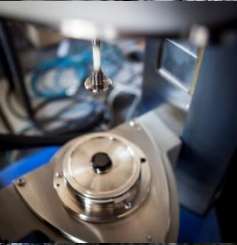




Tar – specific troublemaker

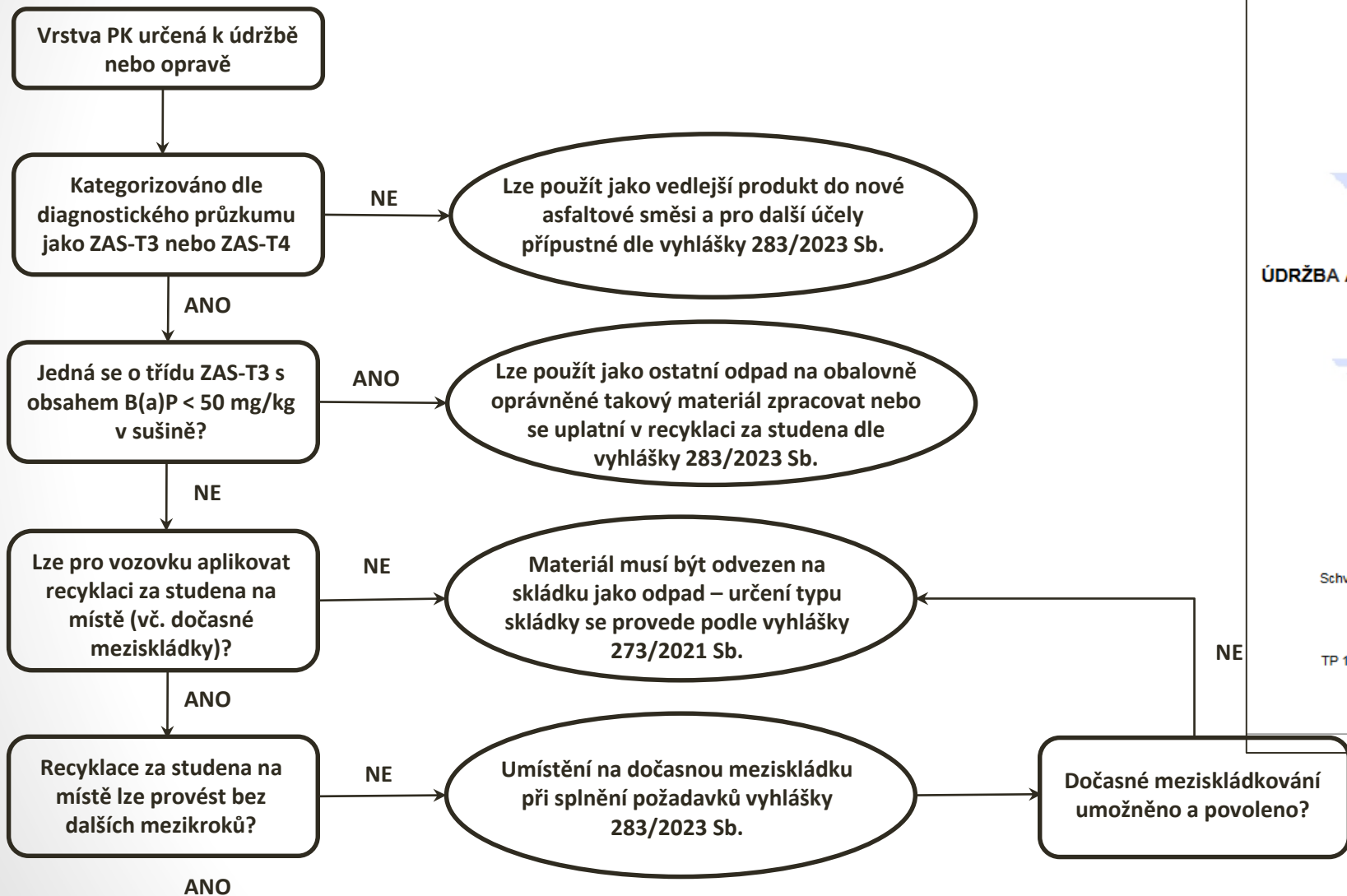
Typically used binders:

- ➔ regularly used between 60s and 80s for base layers
- ➔ banned around 1989
- ➔ but about 30 % of regional or county roads contain this material
- ➔ PAHs really very high as we all know





Tar – procedure used in CZ



TP 150

MINISTERSTVO DOPRAVY
Odbor silniční infrastruktury

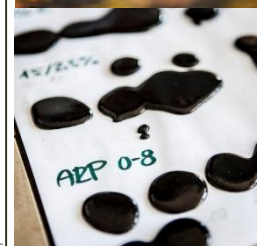
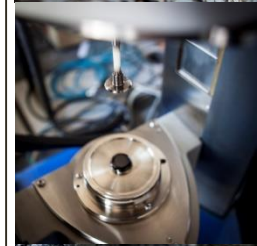
TECHNICKÉ PODMÍNKY

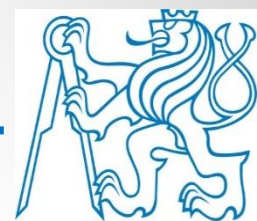
ÚDRŽBA A OPRAVY VOZOVEK POZEMNÍCH KOMUNIKACÍ
OBSAHUJÍCÍCH DEHTOVÁ POJIVA

Schváleno MD – Odbor silniční infrastruktury č. j. 26/2011-910-IPK/1
ze dne 10.01.2011 s účinností od 01.02.2011

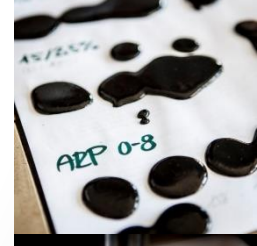
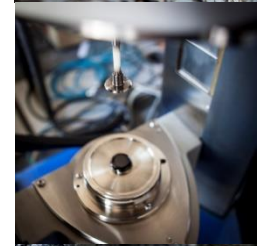
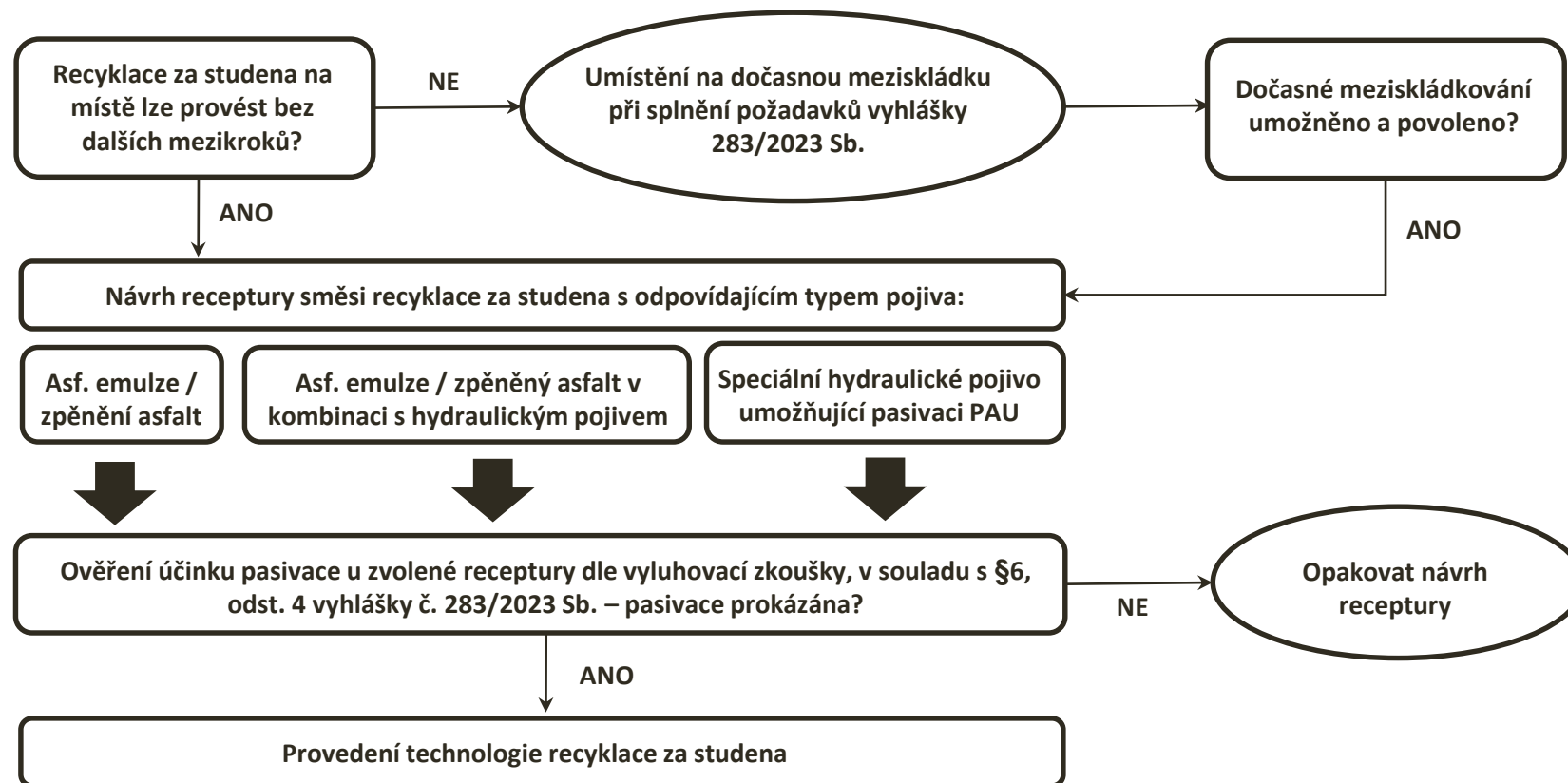
Současně se ruší a nahrazují v celém rozsahu
TP 150 schválené MDS-OPK č. j. 27755/01-123 ze dne 15.10.2001.

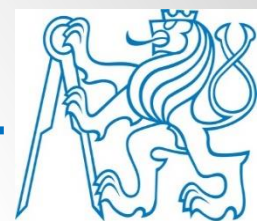
Fakulta stavební ČVUT v Praze





Tar – procedure used in CZ





Alternative pozzolana or alkali-activated binders

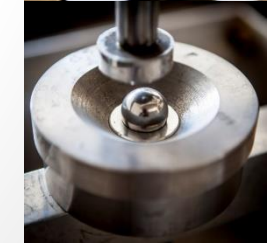
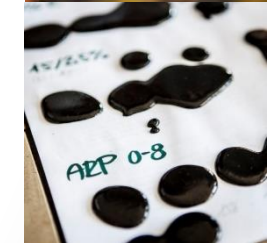
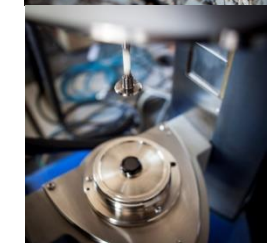
What sources do we have?

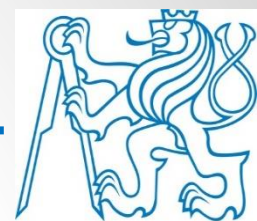
- ➔ cement kiln dust or lime production dust
- ➔ traditional silica fly-ash
- ➔ fly-ash from fluidized combustion
- ➔ bottom ash from fluidized combustion
- ➔ blast furnace slag incl. granulated
- ➔ pan slag and BOF slag (steel production slag)



- ➔ binders to fulfill EN 13282-1 -2
- ➔ geopolymers
- ➔ active admixtures based on principles known from concrete mixtures

Side effect

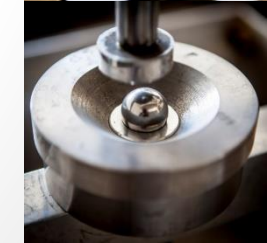
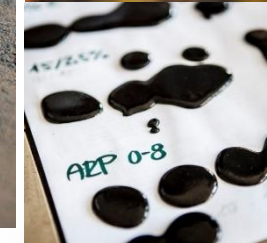
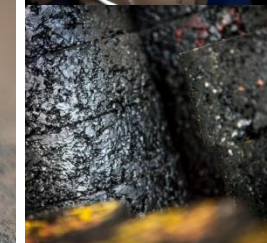
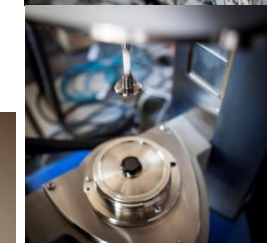


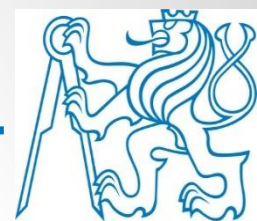


Czech-based alternative binders

TFA – ternary fly-ash-based binder

- ➔ binder based on sulfate-calcium CFBC fly ash from a brown-coal power plant.
- ➔ fly ash arising from the fluidized coal combustion process with ground limestone. mixed with water containing plasticizing additives for improvement of the rheological properties.
- ➔ subsequently mechanically activated together with ground limestone and other additives to achieve specific refinement.
- ➔ several development generations of TFA tested and used since 2018.
- ➔ beside cold recycling or hydraulic bound granular mixtures used in concrete and for shotcrete of Prague subway.

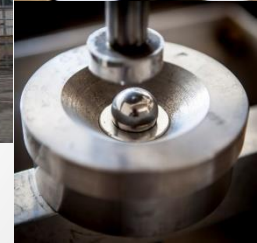
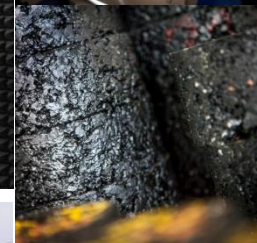


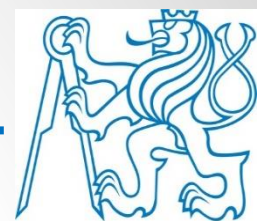


Czech-based alternative binders

AFFA - mechanical-chemically activated fluidized bed combustion fly ash

- ➔ Produced by using high-speed grinding (HSG) in special disintegrators
- ➔ HSG leads to finer pulverization, homogeneous particle distribution, higher surface area and increase amount of internal energy in the material which chemically activates pulverized fly ash
- ➔ Material is getting pozzolanic properties with limited occurrence of unwished minerals like ettringite
- ➔ The activation during milling is reached by adding small controlled amount of Portland clinker, lime hydrated or gypsum
- ➔ It can be used as alternative binder, active filler or admixture for blended binders.



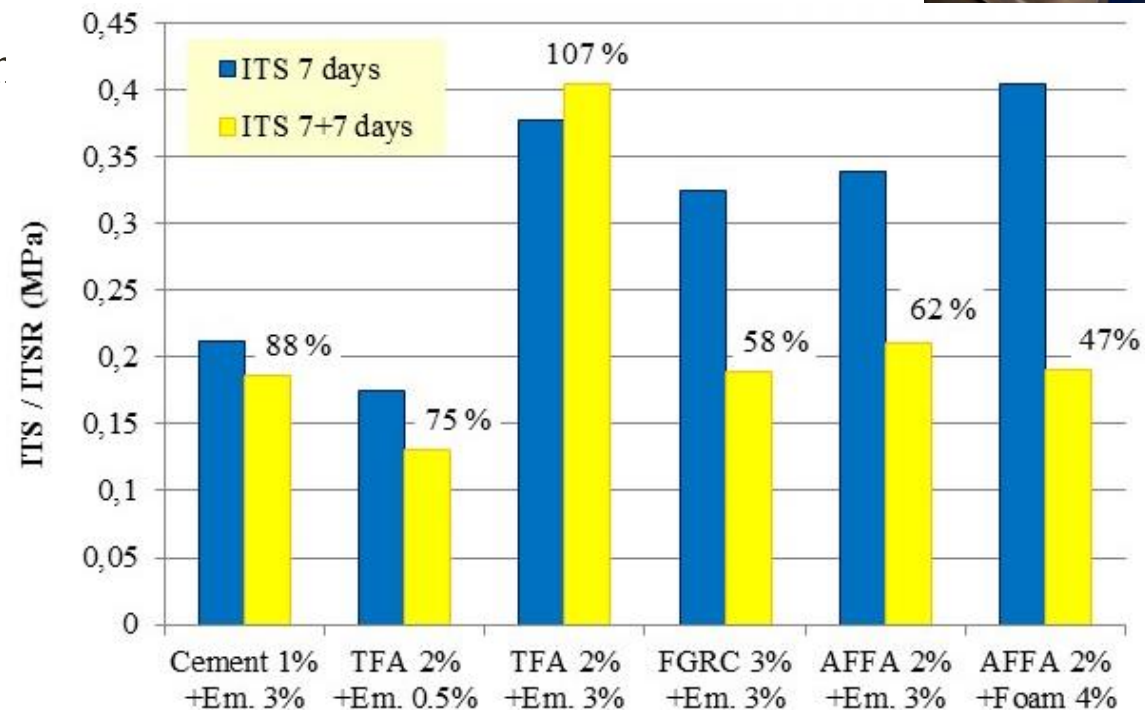


Czech-based alternative binders



- ➔ Significantly lower ITS for the mix with only 0.5 % of bituminous emulsion.
- ➔ Surprisingly, also the reference mix (3 % bit. emulsion, 1 % cement) did not even come close to the minimum value (ITS 0.3 MPa).
- ➔ Only mixtures with cement or TFA meet the moisture susceptibility limit (75 %).

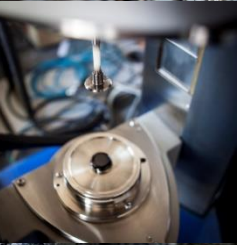
Hydraulic binder	Content	Bituminous binder	Content	Indirect Tensile Strength (MPa)	Moisture susceptibility (%)
Cement	1.0%		3.0%	0.21	88%
TFA	2.0%	Bituminous emulsion	0.5%	0.18	75%
TFA	2.0%		3.0%	0.38	107%
FGRC	3.0%		3.0%	0.32	58%
AFFA	2.0%		3.0%	0.34	62%
AFFA	2.0%	Foamed bitumen	4.0%	0.40	47%





Trial section with 1st application of AFFA in Europe

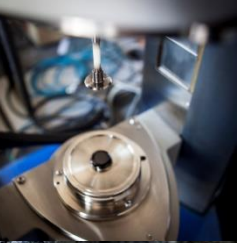
Quality	Unit	Reference mix (4 % cement)	Alternative 1 (1 % cement + 4 % AFFA)	Alternative 2 (2 % foamed bitumen + 3 % AFFA)	Requirement for production control test
ITS after 7 days	MPa	1.00	0.39	0.25	0.25 MPa
ITS after 7+7 days	MPa	1.25	0.42	0.18	-
Moisture susceptibility	%	125.7 %	108.8 %	74.0 %	min. 75 %

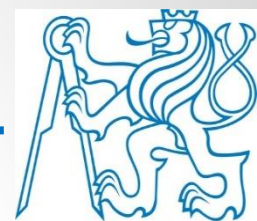


- ➔ Simple 1:1 substitution of standard cement with an fly-ash based alternative binder is not possible, but... there are effective options
- ➔ To combine AFFA with limited amount of cement
- ➔ Add higher amount of AFFA and avoid cement => technical problems: necessary to apply thick layer (small density of AFFA)
 - threatened by wind
 - the recycler rolls the AFFA in front of it – potential reduction of the actual binder content in the final mix



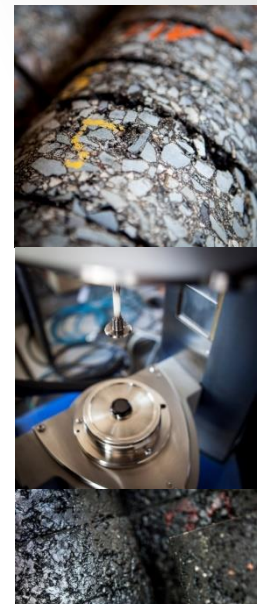
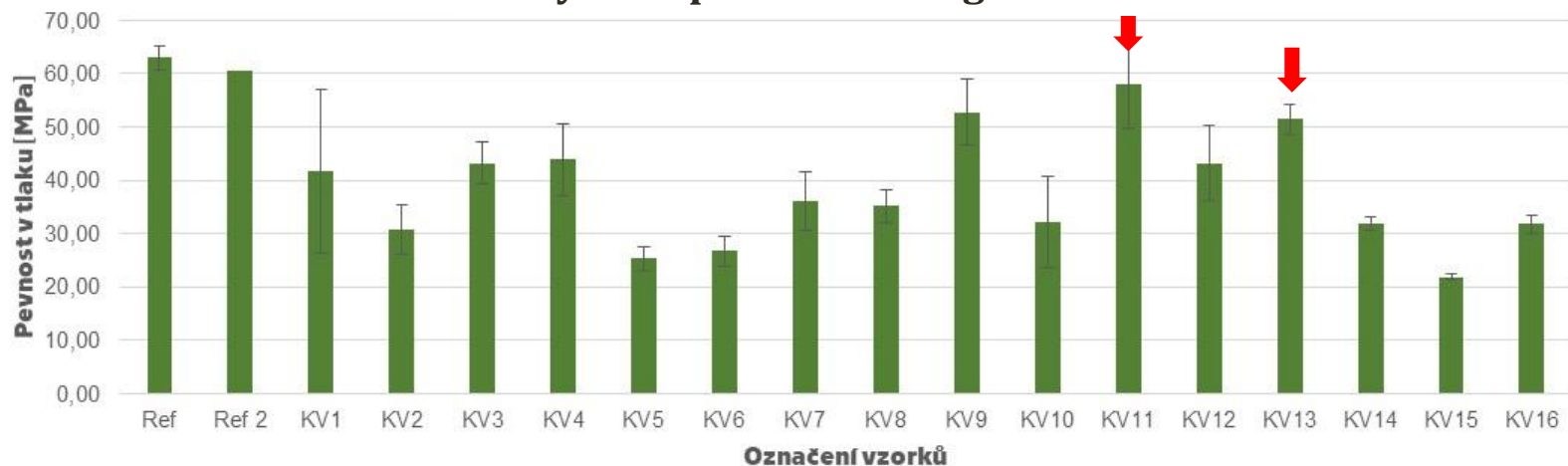
Trial section with 1st application of AFFA in Europe



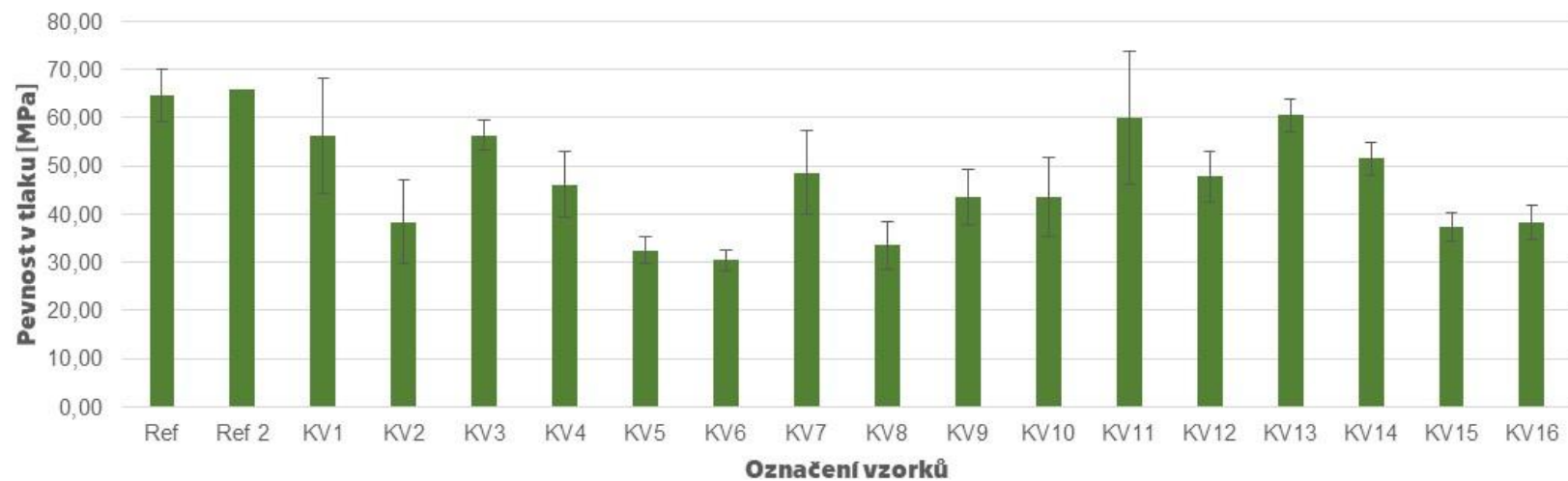


Some of the results from developments in CZ

7 days compressive strength



28 days compressive strength



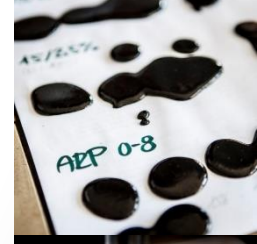
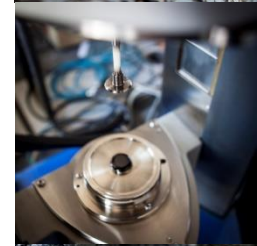
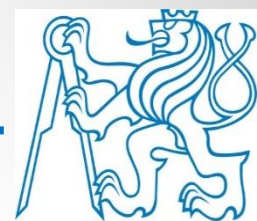
KV1: fluid + BFS 75:25 (50%)

KV3: GBFS Třinec (50%)

KV4: fluid + BFS 50:50 (50%)

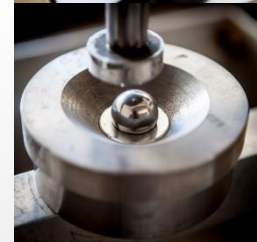
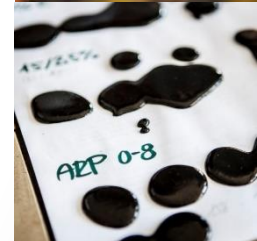
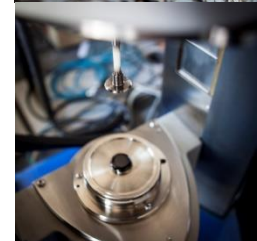
KV 11: fluid + BFS 50:50 (30%)

KV 13: GBFS Třinec (30%)



Složka směsi	E_01	E_02	E_03	E_04	E_05
Betonový recyklát (Eurovia) 0/32	45,0%	45,0%	46,3%	45,0%	45,0%
Asfaltový recyklát (Eurovia) 0/32	36,0%	36,0%	37,0%	36,0%	36,0%
Asfaltový odpad výroby	9,0%	9,0%	9,3%	9,0%	9,0%
Voda	4,0%	4,0%	3,5%	4,0%	4,0%
GVS EcoCoal (mletá)	4,8%	3,0%	3,2%	0,0%	0,0%
Fluidní popílek	0,0%	1,8%	0,0%	0,0%	0,0%
Cement CEM I 42,5R	1,2%	1,2%	0,8%	0,0%	1,2%
DestroCEM 8020	0,0%	0,0%	0,0%	6,0%	0,0%
VP struska Kladno (mletá)	0,0%	0,0%	0,0%	0,0%	4,8%

Varianta směsi	Objemová hmotnost	Sedmidenní pevnost v příčném tahu	Pevnost po uložení ve vodě	Odolnost proti účinkům vody	Modul pružnosti
	(g.cm ⁻³)	(MPa)	(MPa)	(%)	M _{dry} (MPa)
Mix E_01	1,880	0,26	0,27	103,8	13,50
Mix E_02	1,885	0,34	0,34	99,4	23,67
Mix E_03	1,933	0,17	0,16	94,1	12,68
Mix E_04	1,884	0,41	0,42	102,6	34,54
Mix E_05	1,915	0,17	0,13	76,7	11,79



Složení směsi	E_06	E_06A	E_07	E_08	E_08A	E_01A
Asfaltový recyklát (ČVUT) 0/32	44,4%	0,0%	46,2%	44,4%	0,0%	44,4%
Asfaltový recyklát (Eurovia) 0/32	0,0%	44,4%	0,0%	0,0%	44,4%	0,0%
ŠD 0/32 (Litice)	44,4%	44,4%	46,2%	44,4%	44,4%	44,4%
Voda	5,3%	5,3%	4,6%	5,3%	5,3%	5,3%
GVS EcoCoal	0,0%	0,0%	0,0%	0,0%	0,0%	4,0%
Cement CEM I 42,5	0,0%	0,0%	3,0%	0,0%	0,0%	2,0%
DASTIT 2022	0,0%	0,0%	0,0%	6,0%	6,0%	0,0%
DestroROAD 207010	6,0%	6,0%	0,0%	0,0%	0,0%	0,0%

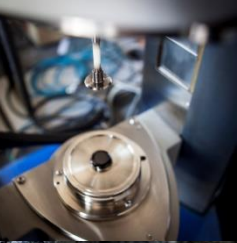
Varianta směsi	Objemová hmotnost	Sedmidenní pevnost v příčném tahu	Pevnost po uložení ve vodě	Odolnost proti účinkům vody	Modul pružnosti
	(g.cm ⁻³)	(MPa)	(MPa)	(%)	M _{dry} (MPa)
Mix E_01A	1,931	0,36	0,45	123,7	25,95
Mix E_06	2,080	0,41	0,42	102,7	41,74
Mix E_06A	1,928	0,32	0,32	99,4	28,44
Mix E_07	2,099	0,45	-	-	48,04
Mix E_08	2,068	0,38	0,28	72,9	44,42
Mix E_08A	2,079	0,29	0,21	72,4	17,07

„reference mix“ →



Some conclusions

- ➔ cold recycling is a long proven technology
- ➔ there are countries where road administrations have learnt to use it effectively
- ➔ effective, sustainable and improving pavement structures if wisely used
- ➔ potential for further fine-tuning or developments in used materials as well as knowledge about its long-term performance



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Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the HORIZON-RIA. Neither the European Union nor the granting authority can be held responsible for them.



There are always alternative ways....

**Thank you for your
attention.**

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