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DESIGN OF REINFORCED CONCRETE FLOOR SLABS WITH THE CONTENT OF THE PLASTIC AGGREGATES

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Working characteristics of personal computers – (working/disabled)

Computing power of the processor.

Capacity and velocity of the computing memory.

Capacity and velocity of the hard disk.

Presence/absence of the interfaces for the internal and external peripheries.

Mechanical properties: Bulk density
Cube and prism strength
Modulus of elasticity
Flexural strength
Bond strength

Physical properties: Characteristics of heat transfer
Characteristics of humidity transfer

Amendment of the draft bill no. 223/2001 on wastes

The acceptance of the regulation EP and CE nr. 2002/96 ES from 21.7.2003 on the wastes of the electric and electronic devices as amended in the regulation 2003/108/ES from 8.12.2003

Question: „ Elektronic waste and what about it? “

• **Waste storage –** non-recurring process of the mortification of the input energy. Since 1.1.2005 the electronic scraps must not be located on the waste storage**.**

• **Incineration** – non-permissible and therefore inapplicable process of the electronic scraps disposal.

• **Rational recycling** – the research results indicate the perspective of the utilisation of the original materials in new substitute products, in this case – buildings products.

Characteristic of PA = material PC/TV (Personal Computers/TV screens)

PA contains following plastics:

•Polyethylene (PE) – belongs to the group of thermoplastics and elastomers. It grows softer under heat, remaining chemically constant. Its modulus of elasticity is E_{PE} < 1000 MPa, ductility δ > 25%. In the stabilised form it may be used in the temperature range from 80°C to 100°C.

•Polystyrene (PS) – belongs to the group of thermoplastics and plastomers – E_{PS} > 1000 MPa and δ < 25%. It withstands the heat stress up to approximately 90°C.

• Acrylonitrite–butadiene–styrene (ABS) – belongs to the group of thermoplastics and plastomers – E_{ABS} > 1000 MPa, δ < 25%. The polymers ABS are characterised by the markedly higher chemical resistance and toughness compared to the polystyrene. Permanency of form remains from 80°C to 105°C according to the type.

•Epoxy resin (EZ) – belongs to the group of the thermosets. It hardens under heat and acquired its properties by the chemical reaction. It may be used up to temperatures between 100°C and 105°C depending on the type of resin, hardening agent and filler .

Specification of the composite mixtures containing PA (CPA) – PC/TV

• **The mixture A –** it is the reference basic mixture comprising untreated PA. The binder was the Portland blended cement Holcim – CEM II/B–M (S–V) 32.5 N according to EN 197-1. The ratio PA/cement was 4:1 in vibrated volume at cement-water ratio *w*/*c* = 0.62. The working characteristics have large scatter, which is related to taking of samples. In the real conditions, the supposed continuous taking of samples is almost impossible.

•**The mixture B** – it is the pure mixture of PA in connection with the cement as in the case A. However, the fractions, inclusive the lower fractions of PA correspond to the common mixtures used in ÚSTARCH SAV. The cement-water ratio is approximately *w*/*c* = 0.62. The treatment of mixture was made by vibration .

•**The mixture C** – it is the composite mixture as in the case B. The lower fractions up to the grain diameter of 2 mm were substituted with the gravel fractions of the gravel deposit Košarisko, i.e. river Danube gravel, The fraction PA of 4/8 mm has been used as the filler. The cement-water ratio was approximately *w*/*c* = 0.62. The treatment of mixture was made by vibration.

Specification of the composite mixtures containing PA (CPA) – PC/TV

•**The mixture D** – it is the composite mixture of the type C with the additive of the super-plasticizer "STACHEMENT NN", cement-water ratio *w/c* = 0.53. The mixture was worked out by needle punching. The advantage of this mixture is the relatively low bulk density, strength characteristics markedly above the characteristics of the aerated concrete and ceramic products.

•**The mixture E** – it is the composite mixture of the type B with the additive of the super-plasticizer „STACHEMENT NN", the water-cement ratio *w/c* = 0.53. The mixture was worked out by needle punching. The advantage of this mixture is the relatively low bulk density, strength characteristics markedly above the characteristics of the aerated concrete and ceramic products.

• **Mixtures F, G** – correspond to the mixture D. In order to simplify the technological requirements the river gravel fraction up to 1 mm was replaced by the pit sand fraction from the locality Lozorno (sieve analysis confirmed 97 % presence of the fraction up to 1 mm). Cement CEM II/B-M (S-V) 32.5 N was applied for mixture F, for the mixture G it was the cement CEM I 42.5 R. The ratio (plastic crushed material + sand)/cement) was (3.75:1). The advantages are the high working characteristics in compression and tension and thereby the possibility of application as the structural material in undemanding structures.

Some mechanical properties of the mixtures with the content of PA / (PC, TV)

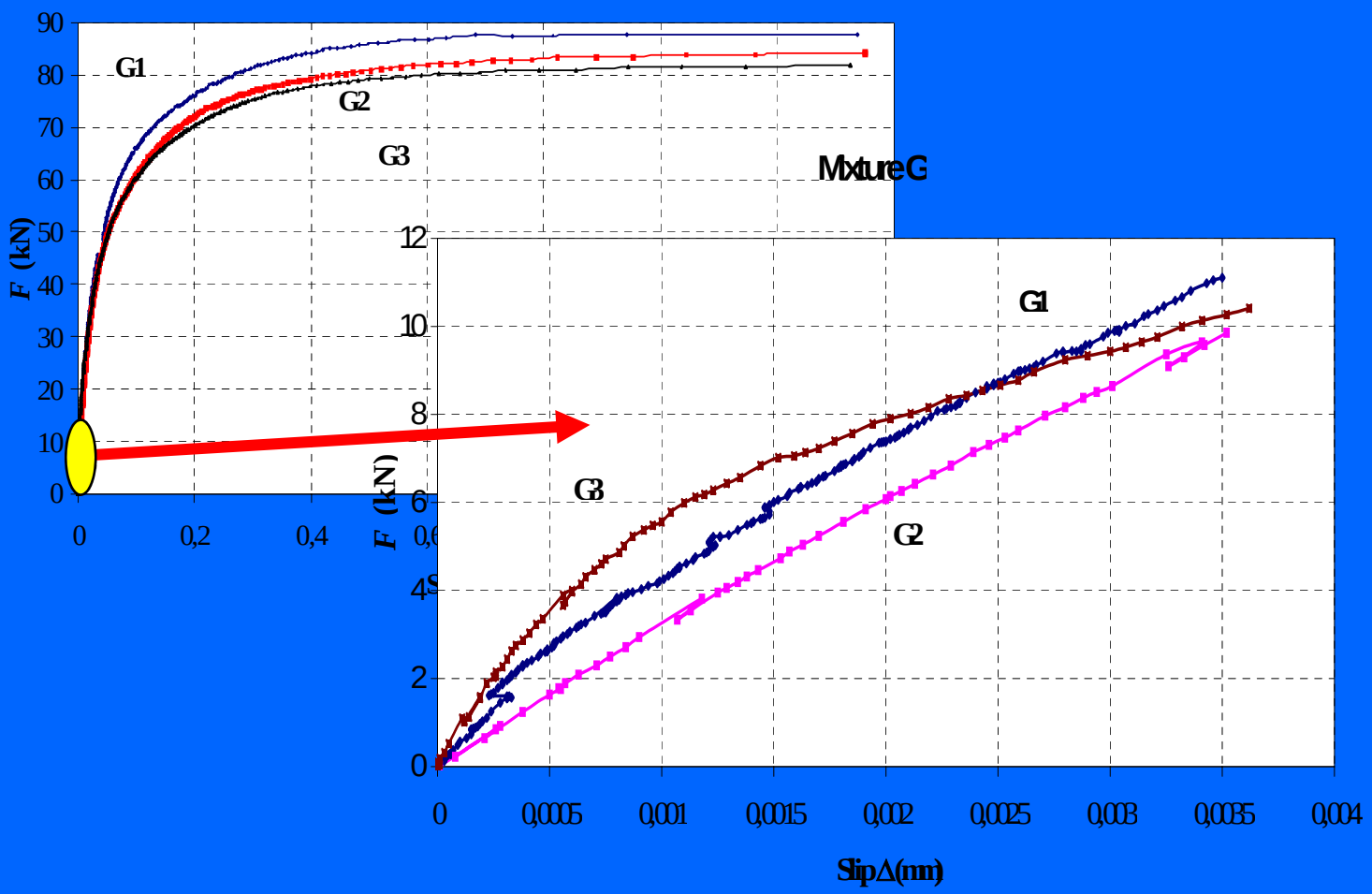
Average values of: the bulk density $\rho_{c,}$, cube strength f_{cc}, prism strength f_{cp}, modulus of elasticity E_c, flexural strength $f_{ct,f}$

Denotation of mixtures	ρ_c ($kg.m^{-3}$)	f_{cc} (MPa)	f_{cp} (MPa)	E_c (GPa)	$f_{ct,f}$ (MPa)
A	1044	5.32	3.71	2.23	1.23
B	1055	6.53	5.59	2.85	1.13
C	1523	10.31	9.67	6.07	1.57
D	1615	15.44	14.76	9.88	2.51
E	1250	7.42	7.20	3.25	1.72
F	1689	22.18	20.09	11.65	3.50
G	1792	29.19	20.40	12.32	3.44

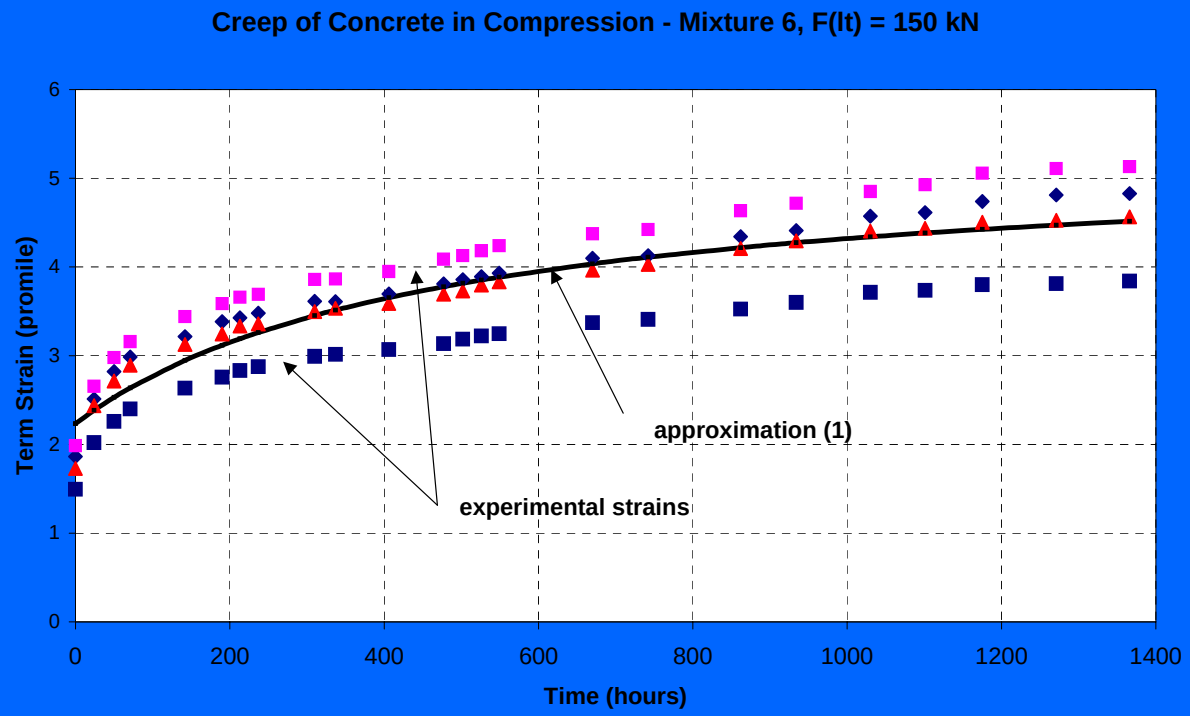
CENTRAL EUROPE
TOWARDS
SUSTAINABLE BUILDING
2010

Examination of bond between reinforcement ΦV 16 (10 425) and CPA on prisms (STN 73 1328)


CENTRAL EUROPE
TOWARDS
SUSTAINABLE BUILDING
2010
CESB 10
PRAGUE


Mixture G
F (kN)
G1
G2
G3
Mixture G
Slip Δ (mm)

CPA – some results of the long-term tests – frames - γ = 0,7 / 0,8

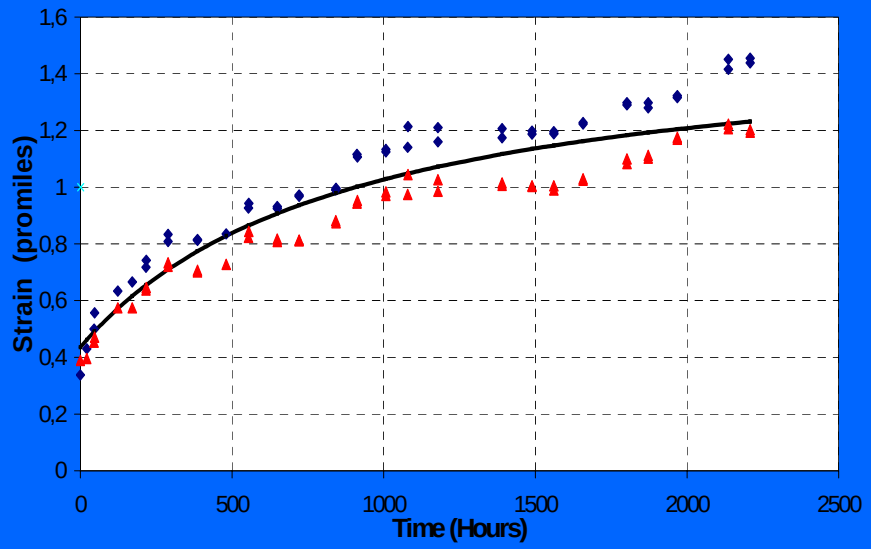


$\varepsilon(\Delta t) = b + (c \,.\, \Delta t) / ((c \,.\, \Delta t) + d)$, $b + c = 5{,}3$ prom., ε(zost) = 2,74 prom, $d = 470$

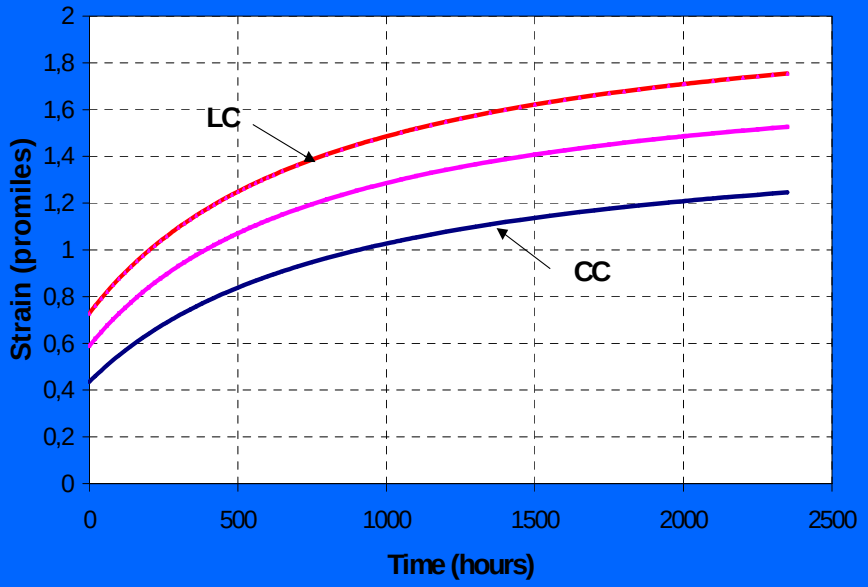
6,9 3,66 472

CPA – some results of the long-term tests – cages - γ = 0,2

Carbonation chamber - mixture F, No 6 - F(lt) = 45 kN



Comparison of mixtures F - CC/EC/LC



Envir	*Mixture*	*(b + c)*	*d*	*f cp)*
LC	**F**	2,12	837	20,85
	G	1,86	812	25,87
NC	**F**	1,85	805	23,40
	G	2,00	850	24,61
CC	**F**	1,58	885	27,20
	G	1,60	770	31,00

T18-20/σ10/CO215/w60

Characteristics of CPA - material PRC

Variation in the shape of aggregates for the mixtures A - G and for the mixtures H(i)

Distribution of the fractions PRC: fraction 0/1 mm – 9 %, 1/2 mm – 18 %, 2/4 mm – 32 %, 4/8 mm – 41 %.

Specification of the composite mixtures CPA containing PRC

- **The mixture H1** – the fraction 0/1 mm – 50 % the pit sand from the locality Lozorno, 50 % plastic, the fraction 1/8 mm – plastic, the fraction 8/16 mm – 30 % plastic, 4/8 mm the river gravel from the Danubian locality, water cement ratio w/c = 0,35, cement CEM II/B-M (S-V) 32,5 N, the plasticizer Stachema NN at the rate of 1.7 % to the mass of cement. The mixture was worked out by needle punching.

- **The mixture H2** – corresponds to the H1 with the following variations – the fraction 0/1 mm – 100 %, the pit sand, working out by needle punching, suggested vibration .

- **The mixture H3** – corresponds to the H1 with the following variations – the fraction 0/1 mm – 100 %, the pit sand, working out by vibration .

- **The mixture H4** – corresponds to the H1 with the following variations – the fraction 0/1 mm – 100 % the pit sand, the fraction 8/16 mm – 100 % river gravel, working out by vibration .

Some mechanical properties of the mixtures containing PA / (PRC)

Average values of: the bulk density ρ_c, cube strength f_{cc}, prism strength f_{cp}, modulus of elasticity E_c, flexural strength $f_{ct,f}$, tensile strength f_{ct}

Denotation of mixtures	ρ_c ($kg.m^{-3}$)	f_{cc} (MPa)	f_{cp} (MPa)	E_c (GPa)	$f_{ct,f}$ (MPa)	f_{ct} (MPa)
H1	1931	15.67	10.53	7.33	2.50	1.62
H2	1861	14.67	9.67	4.46	2.34	1.52
H3	**1863**	**15.90**	**11.90**	**12.83**	**3.89**	**2.53**
H4	2019	17.32	11.44	9.67	2.14	1.40

Examination of bond between CPA and reinforcing bars

Average experimental values of *F(m)*, *τ(m)* and of normative design and characteristic values *f(ct, i)*

Slip *Δ* (mm)	Mixture F				Mixture H3			
	F(m) (kN)	*τ(m)* (MPa)	*f(ct,d)* (MPa)	*f(ct,k)* (MPa)	*F(m)* (kN)	*τ(m)* (MPa)	*f(ct,d)* (MPa)	*f(ct,k)* (MPa)
0,001	3,32	0,58	0,90	1,40 (B20)	1,44	0,25	0,75	1,15 (B15)
0,0015	4,60	0,80			1,66	0,29		
0,002	5,91	1,03			2,41	0,42		

PRELIMINARY RESULTS

Actual results of the short-term tests indicate that the mixtures B to E may be applied as thermo insulating or soundproofing material. The mixtures F, G and H3 are comparable with the corresponding mixtures for structural elements according to STN 73 1201/1993.

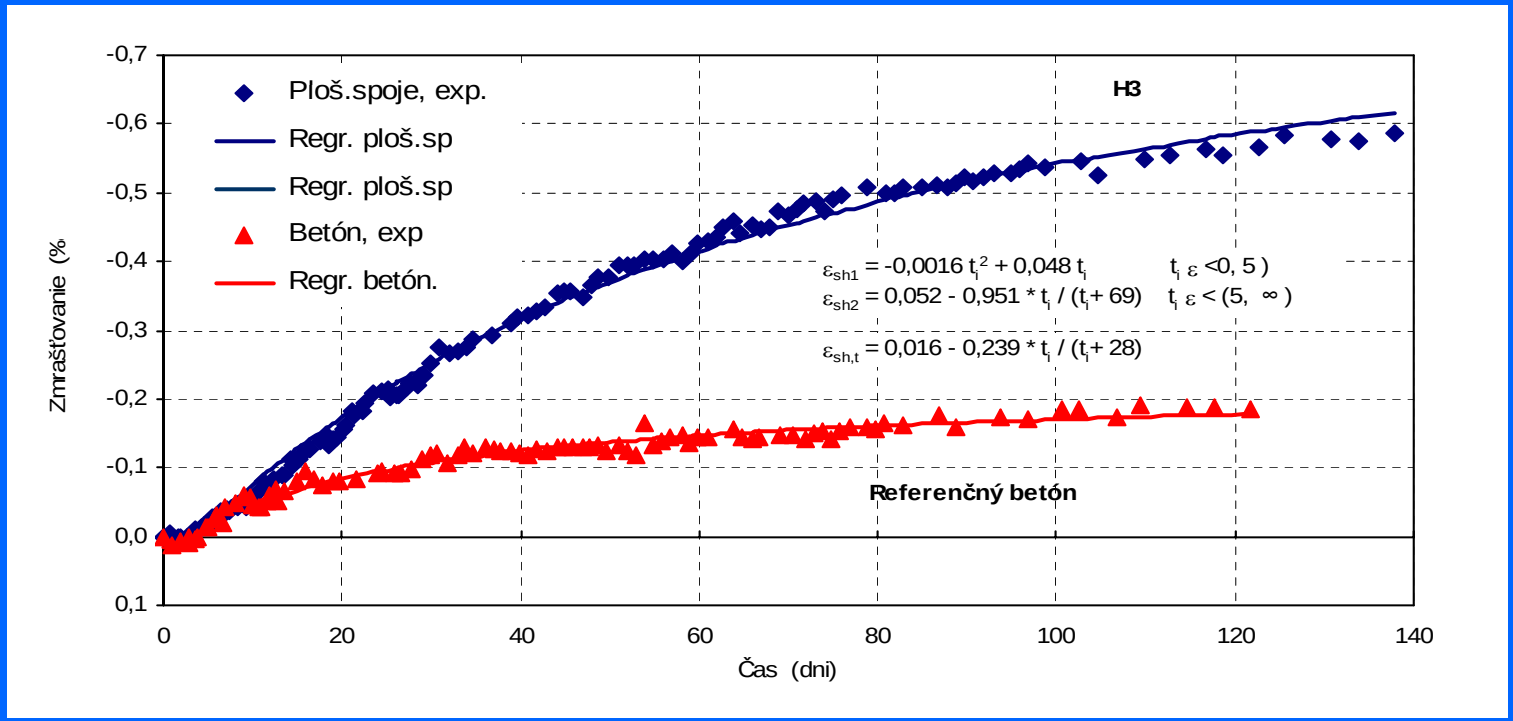
In all cases the problems of the bond between the reinforcing rods and composite should be dealt with.

The behaviour of the composites with the content of the plastic crushed material under long-term load should be verified for all mixtures, particularly in the special ambience. The reference values according to the valid normative regulations are only informative.

The problems of the effects of carbonation on the mechanical and physical properties of the composites containing plastic crushed material is open, actual and require appropriate consideration. The problems are under research and will be presented in a separate paper.

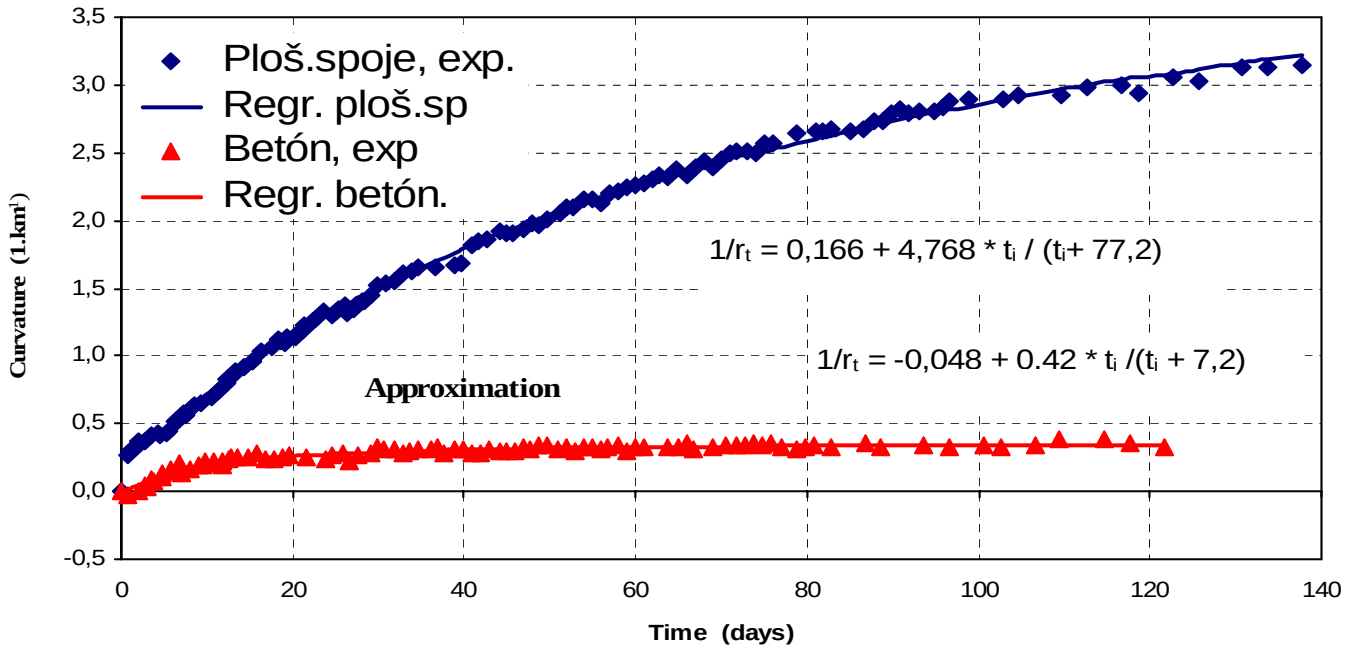
At present the tests of floor slabs made of the mixture H3 are in progress at the ICASA SAS. The short-term tests as well as the tests on the influence of the time factor are concerned – in this state the effects of the aggressiveness of the ambience will be not taken into account. With regard to the significant rheological deformations of the composite the tests are focused mainly on the verification of the results in respect of the criteria of the serviceability limit states.

Free shrinkage – prisms (150 x 150 x 700) mm



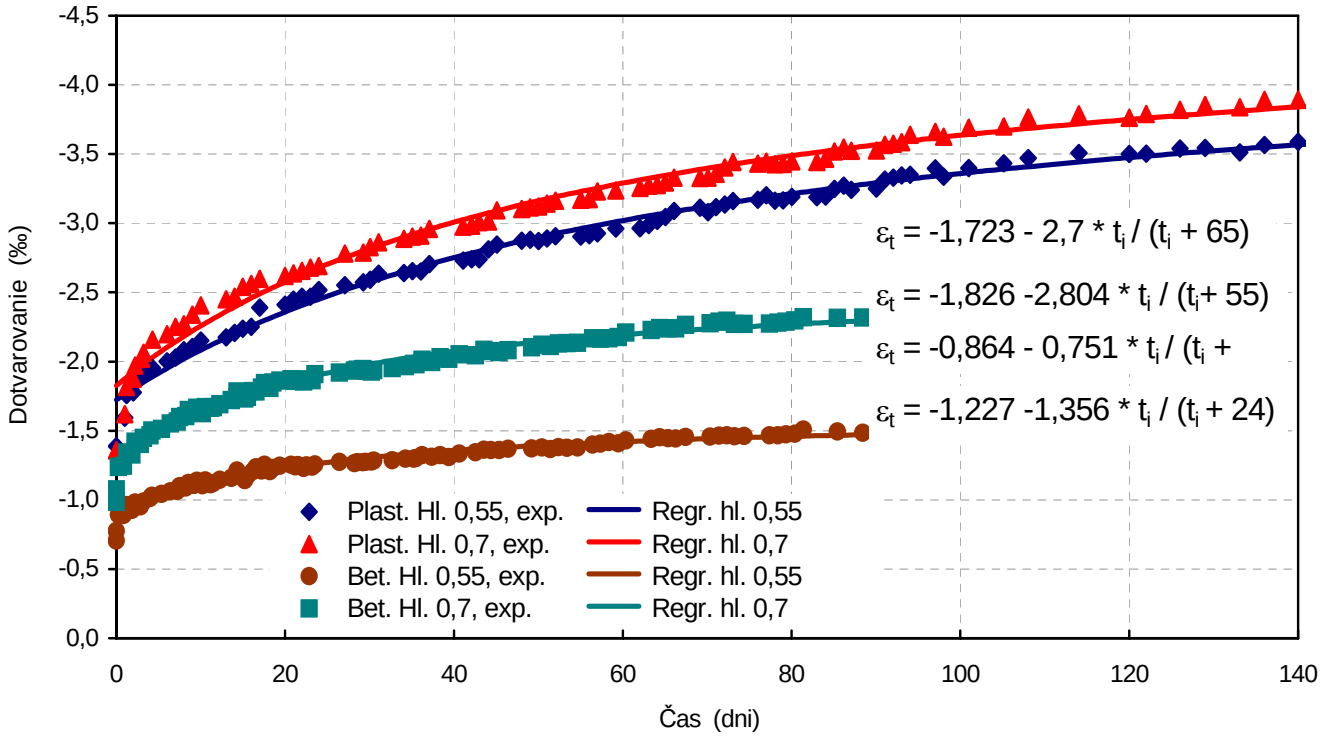
Ref. concrete $f_{(cc)}$ = 54.84 MPa, $f_{(cp)}$ = 44.35 MPa , $E_{(c)}$ = 40.674 GPa

Restricted shrinkage – prisms (150x150x680)mm



1 ϕ R10, cover 35 mm, l (gauge) = 580 mm

Creep induced deformations – RB, H3, γ = 0,55, 0,7



Conclusions and discussion 1

The results of the short-term tests indicate that the mixtures B to E may be applied as thermo insulating or soundproofing material. The mixtures F, G and H3 are comparable with the corresponding mixtures for structural elements according to STN 73 1201/1993.

In all cases the problems of the bond between the reinforcing rods and composite should be dealt with. The behaviour of the composites with the content of the plastic crushed material under long-term load should be verified for all mixtures, particularly in the special ambience. The reference values according to the valid normative regulations are only informative.

The problems of the effects of carbonation on the mechanical and physical properties of the composites containing PA is open, actual and require appropriate consideration.

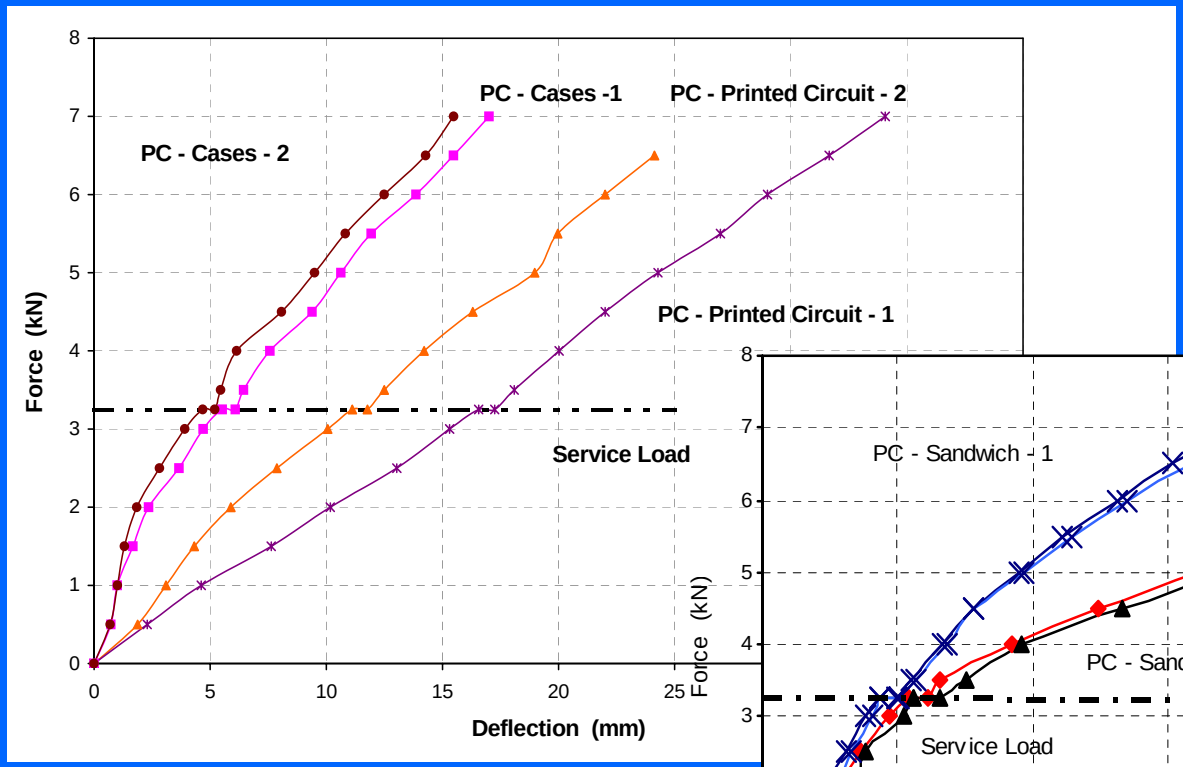
At present the tests of floor slabs made of the mixture H3 and of the mixture F are in progress. The short-term tests as well as the tests on the influence of the time factor are performed. With regard to the significant rheological deformations of the composite the tests are focused mainly on the verification of the results in respect of the criteria of the serviceability limit states. The results presented in this contribution made the relevant background for the design and the production of the floor slabs.

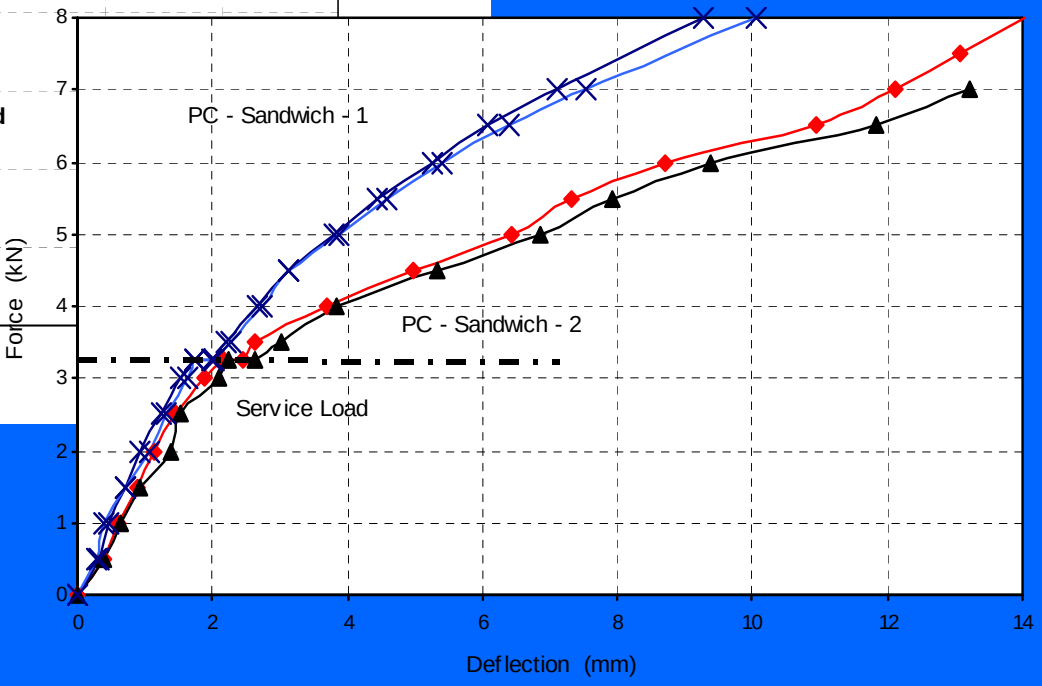
Conclusions and discussion 2

Undemanding structure
- technological discipline,
- bond,
- rheological properties.

Floor slabs:
- CPA, symmetric reinforcement,
- sandwich:
  CPA + bottom reinforcement
  upper part – reference concrete

Conclusions and discussion 2





GLOBAL CONCLUSION

At present the cement composite with the content of plastic – the mixture F is used for the foundation, vertical overground structures and construction of the ground floors. This material has specific properties in comparison with the standard concrete and the aim of this paper is to draw attention to them.

The results of the bond tests between the composite and the reinforcement, the results of the measurements of shrinkage and creep in compression make the relevant base for the design of the floor slabs. The results of the short-term tests suggest the real suitability of the application of the PC – sandwich floor slabs.

At present the other proving tests under long-term load are in progress for this type of slabs.

The obtained values of the working characteristics, inclusive of the stress-strain curves provide substantial input values for the substitutive theoretical models. The achieved working characteristics for other materials were applied e.g. in works [2], [7].

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THANK FOR YOUR ATTENTION