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Practical Utilization Findings of Concretes with Gypsum-Free Cements at Building of Concrete Pavements and Landing Ground

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Summary

The paper describes research findings and observations concerning practical application of concretes based on gypsum-free cements. Concretes made of gypsum-free cements feature short processing time and high initial strength over 1 to 3 days. Also, the article analyzes chosen factors impacting to fresh/hardened concrete – to begin with influence of mineralogical composition of aggregates, impact of water-cement ratio to initial setting time of fresh concrete as well as impact of water-cement ratio to concrete initial strength. The paper presents confrontation of concrete strengths using standard Portland cement with the same of concrete based on gypsum-free cement. Furthermore, described is experience in applied application of concretes based on gypsum-free cements. In view of short processing time as to concretes based on gypsum-free cements i.e. 25 to 50 minutes as a rule, these concretes are optimal in particular for small volume constructions or repair works requiring putting into operation as soon as possible as from casting, e.g. cement-concrete road carpets.

KEYWORDS: concrete, sclerometer, strength, analysis.

1. INTRODUCTION

There are different methods of how to reach initial high concrete strength values; one of them is utilization of special cements inclusively Portland gypsum free cements, i.e. those in which setting regulator – the gypsum – is replaced by another system of setting regulation. In the Czech Republic, manufactures have produced gypsum free cements (GFC) with specific surface of 400 – 600 $m^{2/}kg$ and setting regulation system Na_2CO_3 + additives based on sulphite extracts. An advantage of such cements was a high strength at the age of 1 to 3 days, which enabled producing of concretes with high initial strength. To reach a proper consistence

of fresh concrete, no plasticisation additives were necessary, as the gypsum free cement setting regulation system had a strong plasticisation effect due to sulphite extracts.

Such concretes, above all, have been used for slab constructions, most frequently for repairs of cement-concrete roads and airport runways.

This paper summarizes the research knowledge and practical experience in connection with application of the concretes using Portland gypsum free cements.

2. DEMANDS ON PARAMETERS OF GYPSUM FREE CEMENTS AND CONCRETES USING GFC

As concretes containing gypsum free cements have been used above all for repairs of roads and airport runways, which should be serviceable in a possibly short time after the repair, this precondition is reflected in demands on parameters of gypsum free cements and concretes produced by using thereof.

2.1 Gypsum Free Cement – Specification and Demands on Features

Typical features of gypsum free cement are:

- Short initial setting
- Short lag between starting and end point of setting
- High initial strength at the age of 1 to 3 days

The demands on parameters are shown in Table 1.

Table 1. Požadavky na vlastnosti bezsádrovcového cementu

Regulation system of setting time for cement			0,5 – 0,6% KORTAN FN + 1,8% Na_2CO_3 of clincer weight
Property		Unit	Desired Value
Specific Surface		m^2/kg	>425
Initial Setting Time		min	> 25
Period of Setting		min	< 90
Compression Strength	4 h	MPa	≥ 2
	24 h		≥ 35
	3 days		≥ 45
	7 days		≥ 50
	28 days		≥ 55

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Property		Unit	Desired Value
Flexural Strength	4 h	MPa	≥ 0.25
	24 h		≥ 6.0
	3 days		≥ 7.0
	7 days		≥ 7.5
	28 days		≥ 9.0

2.2 Concrete Using Gypsum Free Cement – Specification and Demands on Features

The concrete based on gypsum free cement represents an alternative material usable for repair of cement-concrete roads, namely for local repair as well as for total replacing of the single slabs.

Demands on concrete parameters for repair and renewal of cement-concrete roads are shown in Table 2. There are two different concrete types in relation to the slab thickness to be repaired:

- Mortar – aggregates, grain size D_{max} < 8 mm as a maximum. Recommended for slab repair thickness between 0.01 and 0.05 m. The values of compression and tensile strength have been measured on specimens (baby squares 0.04 x 0.04 x 0.16 m) in accordance with CSN EN 196-1.
- Concrete – aggregates, grain size $D_{max} \in (8; 32$ mm). Recommended for slab repair thickness > 0.05 m. The strength values have been measured on specimens in accordance with CSN EN 12390-3, resp. CSN EN 12390-5.

Table 2: Demands on Composites Using Gypsum Free Cements

Parameter		Unit	Motrar	Concrete
Initial Setting Time		min	≥ 20	≥ 40
Sample		m	0.4.x 0.04 x 016	0.1 x 0.1 x 0.4
Compression Strength	3 days	MPa	≥ 45	≥ 30
Flexural Strength	3 days	MPa	≥ 5,0	≥ 4,0
Concrete Surface Scaling	7 days	g/m^2	≤ 1000 afret 75 cykles	
	28 days		≤ 1000 after 100 cykles	

3. FRESH CONCRETE STARTING POINT OF SETTING

BSPC concretes may be characterized as composites with short starting point of setting. However, the main problem of utilization thereof is, to ensure an adequate

time of processing. The research results and pieces of knowledge based on practical application have shown that fresh concrete using GFC (GFC-FC) starting point of setting is influenced especially by:

- Gypsum free binder features (granulation finesse, number of additives regulating the starting point of setting, clinker chemical composition);
- Mineralogical and chemical composition of the compact natural aggregates;
- Cement-water ratio (W/C).

3.1. Mineralogical Composition of Aggregates

The foregone research has shown a solid evidence of greywacke mineralogical composition influence on the GFC-FC starting point of setting. Upon greywacke selection, the exploited aggregates should be preferred; sands with high content in quartz should be used; sands with high content in feldspar are not convenient. The type of used coarse aggregates has not any distinguished influence on the hardened concrete strength.

3.2. Cement-Water Ratio

The starting point of fresh concrete setting delays in dependence on the cement-water ratio increase. However, this fact, above all, negatively influences initial strength values of the concrete hardening.

3.3. Supposed Starting Point of Fresh Concrete Setting

On the base of test results [1, 2], an empiric relation (1) for an informative fresh concrete starting point of setting IST_{FC} derived from the cement slurry starting point of setting IST_{CP} was calculated as follows:

$$IST_{CP} = a.IST_{FC} \quad \text{pro W/C} \leq 0.40 \quad a \in (0.4;0.6) \tag{1}$$

4. STRENGTH OF CONCRETE USING GYPSUM FREE CEMENT

4.1. Concrete Strength Influenced by Cement-Water Ratio

- The Cement-Water Ratio (W/C) mostly influences compression strength and tensile strength under flexure of the concrete at the age of 1 day.
- A W/C value of 0.38 as a minimum is necessary for reaching high initial strength values with concrete of the age of 1 – 3 days. Any exceeding

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values will result in an aqueous deceleration accompanied with a retard of strengthening process.

- Concentration of setting regulator admixtures (0.5; 0.6 % KORTAN FN + 1.8 % Na_2CO_3 of the clinker weight) enables it to reach the supposed high initial strength values of BSPC-B with regard to the recommended W/C value.
- KORTAN FN additive having besides retardation ability also strong plasticization effects enables processes reaching to 20 – 150 mm cone shrinkage under the low W/C values.

Graphs in Figures 1 and 2 illustrate the W/C impact on GFC using concrete.

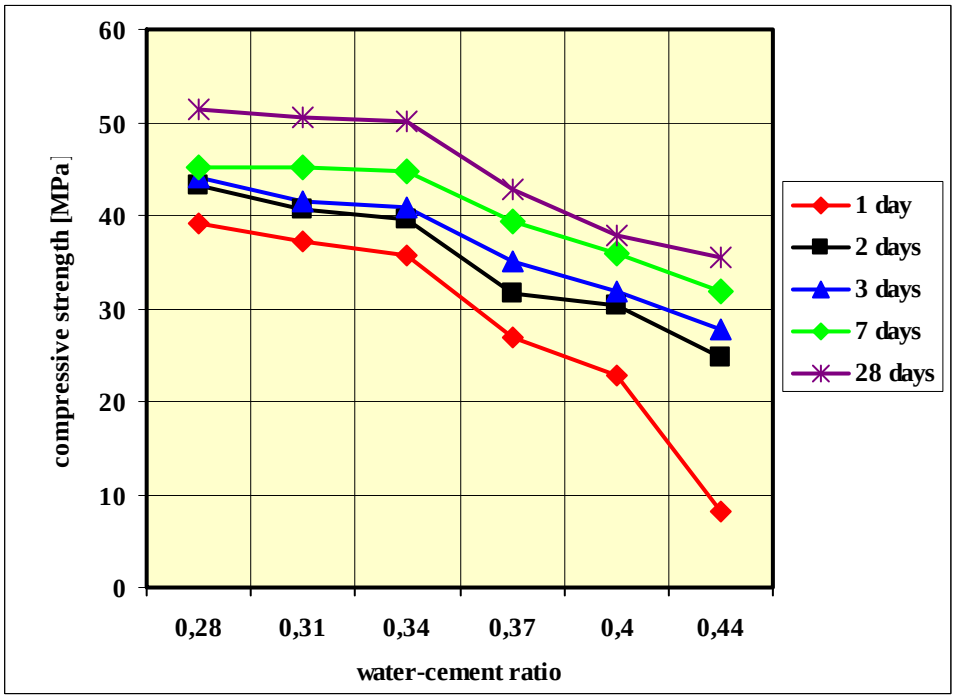

Figure 1: W/C Impact on GFC-C Compression Strength

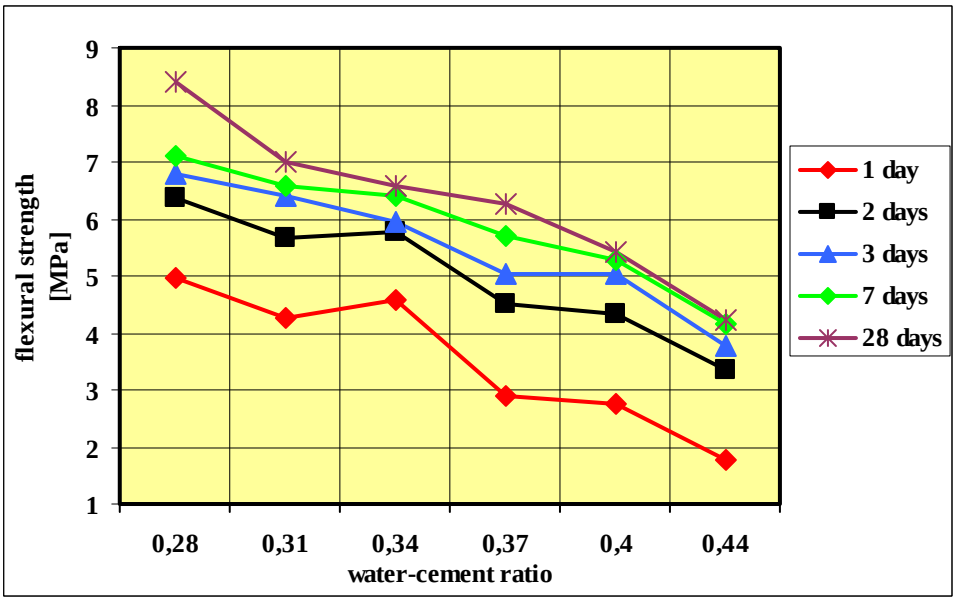

Figure 2: W/C Impact on GFC-C Tensile Strength under Flexure

4.2 GFC Using Concrete Strength Progression in Time

GFC-C compression strength progression in time in comparison with strength progression of concrete using a normal Portland cement is graphically demonstrated in the Figure 3. To generalize the results, the compression strength absolute values are given in % - 100%; the concrete age is 28 days. For concretes using normal Portland cements, the compression strength was calculated from the relation 2 as per the CSN 73 1201,

$$f_{c,cu,t} = f_{c,cu,28}\left(\frac{1.36t}{t+10}\right) \qquad (2)$$

where:
$f_{c,cu,t}$ – concrete cube strength at the age of "t" days,
$f_{c,cu,28}$ – concrete cube strength at the age of 28 days,
t – age of concrete for which the strength has been determined.

The GFC-C compression strength and tensile strength under flexure progression in time is shown in the Figure 5. The strength of concrete at the age of 3 days is considered as 100%. An evaluation of 1 day strength values has shown that at this age, BSRVC-B compression strength has been distinctively influenced by cement-

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water ratio. It is not efficient to produce concretes with W/C > 0.38, as an exceeded value of W/C > 0.38 causes deceleration of hydration process and retardation of the concrete strength growth.

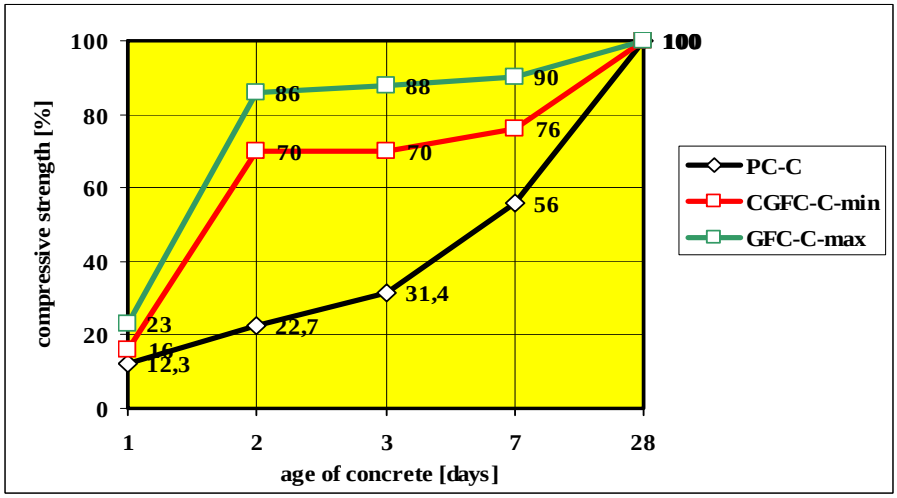

Figure 3: GFC-C Compression Strength Progression Depending on Time in Comparison with Concrete Using Standard Portland Cement

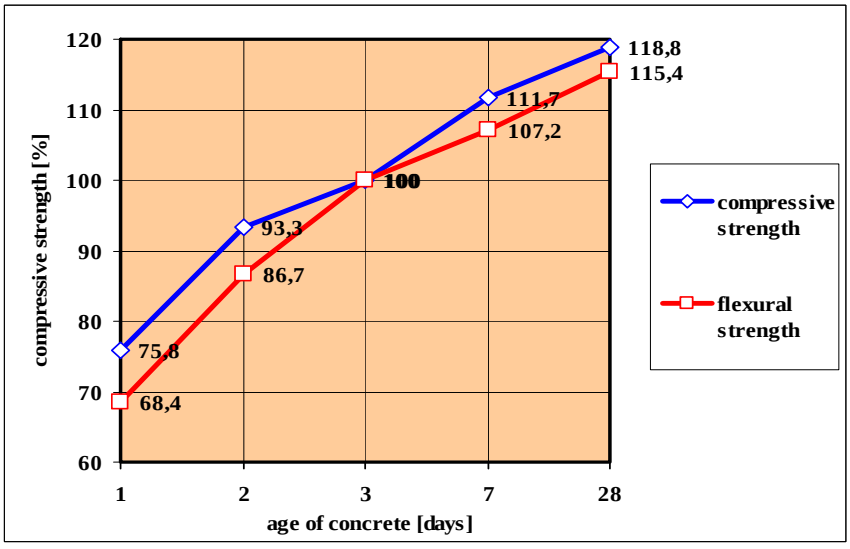

Figure 4: GFC-C Compression Strength and Tensile Strength under Flexure Progression in Time

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5. CONCRETE SURFACE RESISTANCE TO ALTERNATIONS OF FROST AND THAWING AND IMPACTS OF DEFROSTING CHEMICALS

This feature is very important in relation to concretes used for cement-concrete road and airport surfaces, which need to be treated with defrosting chemicals in winter, in order to ensure negotiability. Such testing lies in cyclic freeze and defrosting of a concrete sample dipped in a 5 % NaCl solution.

A waste volume (in g/m^2) as a consequence of the damaged surface scaling is an evaluation parameter for the concrete resistance to frost and thawing.

Concretes using gypsum free cements have shown scaling waste values of 220 to 620 g/m^2 after 100 test cycles. The mentioned values are valid for concretes free of aeration additives.

Concretes using gypsum free cements are, so to say, highly resistant to frost and defrosting chemicals.

6. PIECES OF KNOWLEDGE BASED ON PRACTICAL APPLICATION

Following pieces of experience are available due to the application of concretes using gypsum free cements in repairs of cement-concrete roads and airport runways:

- GFC-C using is limited by relatively short-time starting point of fresh concrete setting, i.e. by the period necessary for manufacturing, transportation and processing. The variation starting point coefficient of setting was ca 20%, however, the demanded starting point of setting was not reached in all cases. The necessary starting point of setting in duration of 40 minutes as a minimum brought about certain troubles at concreting. The lag of ca 5 – 10 minutes between the fresh concrete starting and end points of setting was too short.
- A utilization of such concretes is recommendable in cases supposing a high strength at the age of 3 days as a maximum. For constructions demanding high strength values after 7 days or more, the concretes using standard Portland cements and corresponding admixtures are more convenient.
- Concretes using gypsum free cement are suitable for small-volume-concreting, when the concrete is produced on the building site directly,

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whereas a concrete mixer batch covers a complete concreting of one element.

- A voluminous concreting, i.e. placing of more mixer batches into one element, proved to be very complicated.
- Upon GFC-C manufacturing, the fixed water portion is to be kept, otherwise a water overdose results in diminution of strength values, especially of those regarding the starting point of setting.

7. CONCLUSION

The results of research and experience from practical application have confirmed a suitability of concretes using gypsum free cements, especially for repairs of cement-concrete roads.

At the age of 2-3 days, concretes using gypsum free cements do reach strength values comparable with those of the concretes at the age of 28 days using standard Portland cement. The 28-days-strength-values of both concrete types are comparable.

GFC-C utilization is limited by relatively short-time starting point of fresh concrete, i.e. by the period necessary for manufacturing, transportation and processing.

A rigorous keeping of recommendation for concrete components, especially for water admixture is very important.

Acknowledgements

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