Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag

Forschungsnetzwerk
Mittelstand

Industrielle
Gemeinschaftsforschung

vdz

Research association:	VDZ Technology gGmbH (Cement plants)
Research organisation 1:	VDZ Technology gGmbH Research institute of the cement industry
Research organisation 2:	-
IGF project no:	22000 N
Authorisation period:	01.02.2022 – 31.07.2024
Published on the VDZ website:	https://www.vdz-online.de/en/knowledge-base/research-projects/suitability-of-recycled-gypsum-for-setting-control-of-cements-and-influences-on-cement-and-concrete-properties

Research topic:
Suitability of recycled gypsum for setting control of cements and influences on cement and concrete properties

1 Initial situation

The setting behaviour of cement is generally optimised by calcium sulphates. Large parts of the calcium sulphate quantities required are covered by gypsum from flue gas desulphurisation (FGD gypsum) in the coal-fired power generation industry. However, the availability of FGD gypsum is decreasing significantly as a result of the coal phase-out. In order to compensate for the decline in available quantities of FGD gypsum, more natural gypsum and anhydrite would have to be mined or corresponding calcium sulphates imported. Both contradict the resource and climate policy of the German cement industry.

An alternative in terms of the circular economy is the use of recycled gypsum (RC gypsum). With the long-term average quantities of recycled gypsum produced in Germany, not only could the loss of FGD gypsum available to the cement industry be compensated for by RC gypsum, but the amount of natural calcium sulphate used could also be further reduced.

2 Problem

Although the secondary sulphate source RC gypsum is generally considered to be very suitable, cement manufacturers have so far only been able to use it in very small quantities, if at all, as the known behaviour of natural calcium sulphates and FGD gypsum could not be transferred to RC gypsum without further ado. In particular, there was a lack of knowledge about the influence of other components in RC gypsum on the properties of cement, mortar and concrete.

3 Aim of research

Aim of the research project was to investigate the suitability of RC gypsum for use in the production of cement. To this end, the necessary influencing variables, parameters and value ranges were systematically determined in order to be able to use RC gypsum for cement production, so that the elimination of FGD gypsum can be compensated for, natural resources can be conserved and the amount of waste to be landfilled can be reduced.

4 Summary of the research results

The chemical-mineralogical compositions of the RC gypsum available in Germany at the start of the project did not differ significantly in most of the parameters tested. The trace element contents in the solids and the concentrations of the eluate parameters were far below the maxima specified in the standard DIN 4226-101. The batches of RC gypsum delivered during the test showed a high degree of uniformity. Overall, the RC gypsums corresponded to the natural gypsum analysed in terms of the main characteristic values.

Some of the RC gypsums exhibited very different moisture contents. The respective content of surface moisture must be taken into account when adding RC gypsum to the cement mill on a mass basis. The calcium sulphate dihydrate content of the RC gypsum was higher than in the natural gypsum used. The RC gypsum dehydrated more slowly than the natural gypsum. This means that RC gypsum can dewater in the cement mill to a lesser extent to easily soluble hemihydrate than natural gypsum at the same retention time or mill temperature. The solubilities of the RC gypsum dewatered to hemihydrates corresponded to the solubility of the correspondingly dewatered natural gypsum or were in line with literature data. The TOC content of the RC gypsum was higher than that of the natural gypsum.

Cements with different clinkers in different grinding fineness as well as a mixture of RC gypsum dehydrated to hemihydrate and anhydrite always met the requirements of DIN EN 197-1 in terms of the space stability and the onset of setting as well as the compressive strength of normal cement.

Some RC gypsum increased the air content of fresh mortar, in some cases significantly, depending on the TOC content. This led to softer mortar consistencies and lower bulk densities of fresh and hardened mortar. The reduced bulk densities and increased air contents are primarily attributed to the higher TOC content in RC gypsum.

The TOC content of RC gypsum could not be significantly reduced by leaching with hexane. The TOC content could be significantly reduced by tempering RC gypsum. Cements produced in this way resulted in normal fresh mortar air contents and normal compressive strengths. TOC-induced high air contents and lower compressive strengths could also be avoided by using an additive with a defoaming effect. An additive that accelerated hardening also increased the compressive strength of mortar with RC gypsum cement to the reference range and compensated for the TOC-induced influence of the higher air content on the compressive strength.

When using cement with RC gypsum dehydrated to hemihydrate, less natural or synthetic air-entraining agent was required for the same air content of fresh mortar than for cement with correspondingly dehydrated natural gypsum. The effect of polycarboxylate ether-based superplasticisers for ready-mixed concrete and for precast concrete products was not influenced by RC gypsum cement. However, in combination with RC gypsum cement, more acti-

ve substance had to be dosed in order to achieve a superplasticiser effectiveness comparable to that of the reference cement.

The release of substances from concrete with RC gypsum cement did not differ significantly from the release of substances from the reference concrete with natural gypsum in the cement. In some cases, significantly less than 10% of the permissible release was measured for both concretes. This underlines the fundamental suitability of RC gypsum for use in the cement production process.

Funding information

The IGF project No. **22000 N** of VDZ Technology gGmbH, Toulouser Allee 71, 40476 Düsseldorf was funded via the AiF within the framework of the programme for the promotion of joint industrial research (IGF) by the Federal Ministry of Economics and Climate Protection on the basis of a resolution of the German Bundestag.