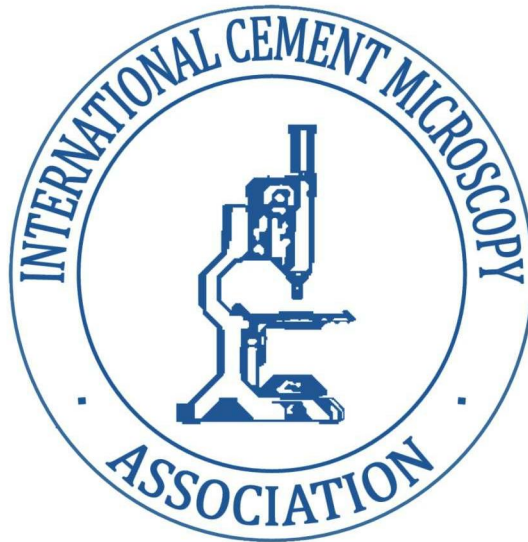


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SILICA-STABILIZED CALCIUM SILICATE HYDRATES AT ELEVATED TEMPERATURE

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ABSTRACT

Cements used in zonal isolation for oil and gas wells can be subjected to a wide range of cure conditions where temperatures in permafrost regions can be as low as -10°C and for geothermal wells can exceed 300°C . Pressure in these wells can range from about 1.38 to 138 MPa. At temperatures above 120°F normal, Portland cement systems start to show strength retrogression over time. The retrogression is considered to result from formation of lime-rich calcium silicate hydrates, notably α -dicalcium silicate hydrate ($\alpha\text{-C}_2\text{SH}$), hillebrandite (C_2SH) and β -tricalcium silicate ($\beta\text{-C}_3\text{S}_2\text{H}_3$), the stability field of which is dependent on the temperature and pressure. Typically, this form of strength retrogression is overcome by addition of excess silica to the system, which results in formation of silica-rich crystalline phases such as gyrolite ($\text{C}_2\text{S}_3\text{H}_{-2}$), tobermorite ($\text{C}_5\text{S}_6\text{H}_5$), truscottite ($\text{C}_7\text{S}_{12}\text{H}_{-3}$), and xonotlite ($\text{C}_6\text{S}_6\text{H}$).

It is generally considered that the silica-rich crystalline phases will coexist stably in aqueous solution with silica in the silica-rich part of the $\text{CaO-SiO}_2\text{-H}_2\text{O}$ system if the total lime to silica (C/S) ratio is ≤ 1.0 and that strength retrogression will not occur. Although the C/S ratio plays a significant role in phase stability, it is not the only factor involved and results of the present investigation show that metastable phases formed in the early stages of reaction modify the long-term stability and phase equilibrium. Source of silica, whether as predominantly pure SiO_2 or alumino-silicate, the particle size of the silica source and localized C/S ratios within the cement matrix all influence the initial phases produced as well as crystallite size and morphology. At 180°C and 20.7 MPa pressure, cured up to 25 days, the stable phases with quartz flour ($\text{SiO}_2 > 98\%$) as the silica source, are tobermorite and/or xonotlite, both of which give good compressive strengths. On the contrary, silica fume ($\text{SiO}_2 > 93.8\%$) (1) gives a number of crystalline metastable phases that have so far not been identified, (2) gives lime-rich $\alpha\text{-C}_2\text{SH}$, and (3) shows severe strength retrogression. Class F fly ash used as an alumino-silicate source formed hydrogrossular ($\text{Ca}_3\text{Al}_2(\text{SiO}_4)(\text{OH})_8$), a calcium aluminum silicate hydrate, as the primary stable phase with some $\alpha\text{-C}_2\text{SH}$ and aluminum substituted tobermorite as secondary phases. The compressive-strength development at 1, 3, 7, and 25 days also showed a good correlation with the obtained stable or metastable phase equilibrium composition. Good compressive strengths and no strength retrogression were only evidenced when quartz flour was used as the source of silica, whether on its own or in combination with silica fume or fly ash. Silica fume or fly ash, when used as the only source of silica, both showed severe strength retrogression to occur within 3 to 7 days.

SEM STUDIES OF THE FIRST USA CONCRETE PAVEMENT

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ABSTRACT

A section of the first USA concrete pavement, cast in 1891 in Bellefontaine, Ohio, was studied by using a scanning electron microscope (SEM). The pavement had been placed in two layers: a dark, top “wearing course,” and a bottom, light-color “base course.” Many locations of well-hydrated, relatively dense cement paste contain monosulfate. The concrete predominantly contains dolomitic aggregate particles. The “wearing course” has a thin top layer of dolomite particles underlain by a very thin layer of clay and then by a layer of hydrated cement paste. Some cracks parallel to the exposed surface occur in this paste layer. Both courses contain a few shrinkage cracks. The concrete, after more than 100 years of weather exposure and service, does not contain ettringite, and does not show any sign of deterioration or distress.

Key Words: concrete pavement, scanning electron microscopy

UTILIZATION OF SULFO-CALCIC FLY ASH AS AN ALTERNATIVE TO GYPSUM FOR CEMENT CLINKER

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ABSTRACT

The amount of fly ash generated from electrical power plants in Turkey is about 13 million tones per year. Therefore, there is a great need to investigate alternatives on how to utilize fly ash more effectively. In Turkey, around half of the total amount of fly ash produced belongs to the high calcium class. Some of them do not completely comply with the relevant standards having high sulfate contents (more than %10 SO₃). Hence, a study was undertaken to investigate the ways to utilize sulfo-calcic fly ashes as an alternative to gypsum as a setting regulator in cement clinker. For this purpose, cement pastes were prepared from portland cement clinker ground with high calcium fly ashes containing different amounts of sulfate (11-24 % SO₃). The amount of addition of a given sulfo-calcic fly ash was adjusted according to the optimum SO₃ content. This usually led to the production of CEM II portland fly ash cements without using separate calcium sulfate addition. Setting behavior of cement pastes and morphology of hydrates formed at hydration times corresponding to the setting and hardening periods of hydration were investigated through scanning electron microscopy studies. Also, effect of high calcium fly ash substitution of gypsum on microstructure and compressive strengths of cements were determined at 2,7 and 28-days.

CaCO₃ PRECIPITATION BY SIRANTM-IMMOBILIZED *BACILLUS PASTEURII*

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ABSTRACT

Bacillus pasteurii ATCC 11859 cells were immobilized on SiranTM, porous glass beads, allowing surface immobilization. Kinetic studies on microbiologically induced calcium carbonate precipitation (MICCP) by free and SiranTM-immobilized *B. pasteurii* showed that the overall performance of SiranTM-immobilized *B. pasteurii* in MICCP was better than that of free cells. Substrate inhibition was observed in the free cell system, but not in the immobilized. The presence of ammonium chloride lowered the initial pH of medium, showing its buffering capacity. The absence of NH₄Cl from the CaCO₃ precipitation reaction mixture resulted in increase in pH, inducing additional chemical precipitation of CaCO₃ and consequently decreasing in K_m values. The V_{max} values of both free and SiranTM-immobilized *B. pasteurii* increased in the presence of NH₄Cl.

Scanning electron micrographs (SEM) provided evidence of MICCP on SiranTM beads and energy dispersive X-ray (EDX) analysis further identified the chemical composition of calcite crystals on the beads.

ELECTRON MICROSCOPY DURING EARLY CEMENT HYDRATION

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ABSTRACT

Crystal sizes of early hydration products originated from CAC or OPC hydration are commonly too small for optical microscopy. But electron microscopy can be applied for observation of crystals in the scale of some decades of nm to a few μm . Unfortunately none of the different electron microscopy techniques are able to work under ambient conditions concerning cement hydration.

Standard SEM techniques are operating under a system pressure of down to $1 \cdot 10^{-4}$ Pa pressure which is only one part per billion of the ambient atmosphere. Hydrated phases which are present before transferring the sample into the vacuum of the SEM chamber are completely dehydrated but may remain mainly stable in their morphology. Mix water is removed completely.

Cryo SEM technique which allows to freeze the sample very rapidly in liquid nitrogen is able to fix the water in the frozen hydrated phases and the system vacuum will not lead to a water depletion in the crystal structure. The liquid water of the cement paste is transformed during nitrogen freezing into an amorphous solid. The influence of the freezing and preparation procedure (manipulation of the surface) as well as the low temperatures in the vacuum chamber and the sublimation of mix water on cement hydration are able to produce artifacts which have to be considered.

The ESEM technique allows a partial pressure of about 500-1500 Pa during examination and needs no sputtering of the surface. Using a temperature of 3°C leads to a relative humidity of nearly 100%. Even under this conditions the loss of mix water can not be avoided completely. Precipitation of salts may occur as artifacts. Hydration is stopped after transfer of the sample into the vacuum chamber. Really in situ examination of hydration is not possible this way. The water/cement ratio of the observed specimen can not be defined. Main advantage of the method is the absence of the sputter layer on the sample which might cover very small early hydration products.

Oilwell Cements and Calcium Hydroxide Formation Part II

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ABSTRACT

This paper continues the study of calcium hydroxide in oilwell cements. Samples of hydrated cements cured at elevated temperatures and pressures were examined with the environmental scanning electron microscope (ESEM). Other samples with various chemical admixtures were also examined with the ESEM to attempt to determine their possible stimulation or retardation effect on calcium hydroxide formation.

INTRODUCTION

The study of calcium hydroxide crystals and their effect on oilwell cements is continued from the paper "Oilwell Cements and Calcium Hydroxide Formation," published by the ICMA in the

Properties of artificial slags produced by the ZEWA process

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ABSTRACT

Treatment of steel-making slags, EAF dusts, fly ash, car shredder residue, under reducing conditions by means an electric arc furnace (**ZEro WAs**te process) produces iron alloy that can be recycled by the steel industry and a mineral having the same chemical composition (main oxides, CaO, Al₂O₃, SiO₂, MgO) and the same mineralogical composition (% glass) as an industrial blast furnace (BF) slag.

Utilization of these new materials as cementitious additives requires an evaluation of their properties. In this study, we compare the reactivity (reactivity index) and the durability (carbonation) of these materials to the equivalent BF slag. Comparisons are carried out with mixture 50/50 of slag, ground at 4500 cm²/g and Portland cement type 1.

Results show that the main properties of these artificial slags are in the same range as those found with industrial BF slag and thus can be used as cementitious replacement.

RESUME

Le traitement de laitier d'aciérie, poussières de four électrique, cendres volantes, ou résidus minéraux de voiture au moyen d'un four électrique, dans des conditions réductrices produit un alliage de fer qui peut être recyclé par l'industrie sidérurgiste et un produit minéral qui a la même composition chimique (principaux oxydes, CaO, Al₂O₃, SiO₂, MgO) et minéralogique (% verre) qu'un laitier de haut fourneau industriel (**ZEro WAs**te process)

L'utilisation de ce nouveau matériaux comme additif au ciment nécessite une évaluation de ses propriétés. Dans cette étude, nous comparons la réactivité (indice de réactivité) et la durabilité (carbonatation) de ces laitiers artificiels aux laitiers de haut fourneaux industriels. Les comparaisons s'effectuent sur des mélanges 50/50 de laitier broyé à 4500 cm²/g et de ciment Portland type 1

Les résultats obtenus montrent que les principales propriétés de ces laitiers artificiels sont dans la même gamme de valeur que celles des laitiers de haut fourneau industriel et donc peuvent les remplacer dans leurs applications de substitution.

ADDING SCMs TO PORTLAND CEMENT: IMPACT ON OILWELL CEMENTING ADDITIVE PERFORMANCE

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ABSTRACT

The manufacture of Portland cement involves the heating of limestone and other materials to approximately 2800° F to form new compounds. One of the major chemistry changes that occurs during this process is the reduction of limestone to calcium oxide and CO₂ ($\text{CaCO}_3 = \text{CaO} + \text{CO}_2$).

Cement plants are under pressure worldwide to lower emissions of CO₂. One simple and inexpensive way to lower CO₂ emissions is to add supplemental cement materials (SCMs) to the produced cement clinker. Because these SCMs do not go through the kiln, the end result is a reduction in CO₂ for equivalent tons of final product. SCMs include silica-rich materials such as fly ash, silica fume, blast furnace slag, and metakaolin. These materials readily become part of the chemical matrix and impart advantageous properties to the hydrating cement, such as reduced permeability, enhanced compressive strength, and increased sulfate resistance.

Another additive, raw limestone, is becoming increasingly popular in many parts of the world. Limestone is usually added in small amounts (less than 5%) and ground with the clinker. Limestone added in this manner is considered inert and appears to have little effect on the properties of the hydrated cement.

Many companies that produce oilwell cements are considering the addition of small amounts of raw limestone to their products to reduce CO₂ emissions. The concept is appealing because limestone is inexpensive and readily available and because its addition could reduce production costs. Limestone is available at every cement plant in the world because it is the primary material in Portland cement. The addition of limestone can save money because less energy would be required for pre-heaters and kilns.

Nevertheless, it is not currently known how the addition of SCMs and/or raw limestone will affect the performance of fluid-loss control additives, dispersants, and retarders. This investigation seeks to determine whether SCMs and/or raw limestone will affect the performance of these oilwell cementing additives.

**AN UPDATE ON APPLICATION OF A FLAT-BED SCANNER FOR
PERFORMING ASTM C 457**

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ABSTRACT

Determination of the air-void system parameters of hardened concrete is generally performed using an optical microscope and procedures outlined in ASTM C 457. This process is tedious and the results dependant upon the operator performing the analysis. Recently, an approach to performing this analysis has been developed using a high-resolution flat-bed scanner. The developed approach provides a complete analysis including aggregate and paste fractions based upon image analysis techniques. This paper presents recent developments at streamlining this analysis process to provide fundamental analysis of the air-void system parameters assuming aggregate and paste contents from mix design data. Additionally, the results obtained from the high-resolution scanner are compared with results from the same specimens obtained from a conventional office flat-bed scanner.

DEVELOPMENT OF CONCRETE PRODUCTS INCORPORATING WASTE RUBBER AND PLASTIC AGGREGATES.

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ABSTRACT

It is widely acknowledged that the use of waste plastic aggregates in construction products will contribute to more sustainable construction and has the benefit of reducing; the extraction of primary aggregates, the amount of disposed waste materials and the associated environmental social impacts.

The principle objective of this paper is to evaluate the potential use of waste plastic and rubber as alternative aggregates in concrete, one of the major construction products and to explain the change in the properties of the concrete contains waste plastic aggregates.

The results presented in this paper form a part of a project research work prepared in 2004 for the Department of Trade and Industry (DTI), UK, Project Record; F-02-TAR1: Alternative Aggregates in Asphalt and Concrete.

The sources of the waste processed plastic were characterised prior to the production of lightweight concrete blocks, normal concrete, floor screeds and foamed concrete.

Increasing plastic content was found generally decreasing compressive strength and reducing the flexural, indirect tensile and shears strengths of the concrete products. The greatest reduction in the strength properties was obtained from the shear strength results.

In contrast to other concrete products, the use of plastic and rubber in foamed concrete becomes less of a problem. Indeed, the low 28-day strength of a foamed concrete mix containing plastic or rubber could be seen as an advantage, particularly if the mixture has been designed with a high cement content to enable rapid early-age strength gain. A foamed concrete with a rapid setting character but low ultimate strength could facilitate faster trench reinstatement.

Whilst the low density of plastic aggregate caused segregation in normal density concrete, foamed concrete has a low density and this helped to maintain the integrity and cohesion of the mixtures containing plastic and rubber, even at high workability.

An experimental foamed concrete mixture was designed to achieve a rapid set within 8 hours and a 28-day strength of 3 N/mm². This mixture incorporated both a foaming agent and a superplasticiser, and exhibited the required flowing characteristics with no segregation of the plastic or rubber aggregates.

The paper also, explains the reasons for the poor bond between the smooth-surface plastic aggregate and the concrete matrix at the interface.

Key words: Lightweight concrete, plastic and rubber waste aggregates, Foamed concrete.

A NEW LOOK AT AN OLD CEMENT

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ABSTRACT

Current interest in the possibility of re-producing natural cement for historic restoration projects prompted a detailed study of concrete and mortar made with Rosendale cement. Samples used in the present study were taken from High Bridge, which was constructed ca. 1838 as part of the Croton Aqueduct system. The bridge spans the Harlem River at 173rd Street in Manhattan and is the oldest bridge in New York City. The construction of the Croton Aqueduct water distribution system was considered a major engineering achievement of the era. Records indicate that the concrete and the mortar for the stone masonry were made with Rosendale natural cement. This detailed study consists of analysis by petrographic microscopy, scanning electron microscopy, and X-ray diffraction. Archival research on the chemistry and performance of Rosendale cement is also presented.

Key Words: Natural cement, Rosendale, microscopy

The use of Mn-slags as an additive to OPCs

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Abstract

Ferromanganese - and Silicomanganese slags are waste products of the Manganese alloy production. Although a huge amount is used for road making, bigger quantities are deposited as waste material.

This pilot study should indicate whether Ferromanganese - and Silicomanganese slags can be used in cement industries as a raw material for cement production or if they can be used as admixture.

Mineralogically these slags are composed of glaucochroite (CaMnSiO_4), bustamite ($(\text{CaMn})_3[\text{Si}_3\text{O}_9]$), gehlenite $\text{Ca}_2(\text{Al,Mg})[(\text{Al,Si})\text{SiO}_7]$, quartz, amorphous phases and manganosite (MnO).

The bulk chemical analysis, determined by XRF and ICP-OES, is shown in Table 1:

Oxide	Concentration [wt-%]
CaO	18.3 – 30.0
Al_2O_3	5.0 - 6.0
MgO	5.0 - 7.0
Fe_2O_3	0.1-1.7
MnO	14.0-19.0
Na_2O	0 - 0.5
K_2O	0 – 0.3
SiO_2	30.0 – 33.0

Tab. 1 : Chemical analysis of manganese containing slags

Investigations on the reactivity with water were performed on 6 different European OPC types and two South African OPCs with different additions of 10-50% slag. A comparison of the mixtures with manganese-containing slags to the addition of blast furnace slags were performed. A comparison between interblending and intergrinding of the mixtures was also made. Some of the OPC/slag mixtures were homogenized by milling in a disc mill and the heat flow of these mixtures investigated by heat-flow calorimetry [Verryn, Pöllmann, Stöber].

PLASTER DURABILITY IN POOL ENVIRONMENTS

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ABSTRACT

An experimental investigation allowed the documentation of different stages in the progression of the deterioration of white portland cement plaster finish coats in swimming pool environments. This type of deterioration, termed “spot alteration” (SA) in this paper, involves a multitude of different chemical reaction mechanisms that typically lead to the development of progressively larger areas of softening, discoloration, microcracking, and loss of material. The experimental program involved the construction of four pools with each pool subdivided into four different quadrants. Each quadrant was constructed using different plaster mix designs and finishing techniques; the water chemistry was varied between the pools. The experiments investigated the following parameters of interest: w/c of the plaster mix, the use of calcium chloride as an accelerator, the use of supplemental water in the finishing of the plaster, the type of chlorine sanitizer used to control water chemistry, and exposure of the plaster to balanced or aggressive pool water. Analysis of the samples via reflected and transmitted light microscopy allowed the recognition of different stages or rankings of deterioration for samples after ~ six months of exposure. Observations obtained from this study suggest that SA of the experimental samples began with the dissolution of the calcium carbonate that coated finished surfaces within one month of placement of the plaster in service. The analysis indicated a progressive increase in the size of areas affected by SA, the depth of the pitting associated with SA, the thickness of paste affected by carbonation, and the thickness of paste depleted in portlandite. Advanced stages of deterioration involved both deposition of secondary calcium carbonate as well as etching of calcite aggregate particles and the onset of microcracking. Light microscopy and SEM/EDX analysis detected the presence of copper, barium, and phosphorous in a field sample and chloride enrichment at the finished surface of an experimental sample. Both samples showed a marked depletion of calcium at the finished surface.

Quantitative Phase Analysis of Synthetic CAC from Melts in the
System CaO-Al₂O₃-Fe₂O₃-SiO₂

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ABSTRACT

The article deals with the subject of establishing a quantification routine for **Fe-rich Calcium Aluminate Cements (CAFC)**. Two different synthesized **Fe-rich Calcium Aluminate Cements (SCAFC)** were produced according to the chemical composition of the “standard grade”-CAFC, but in the simplified system CaO-Al₂O₃-Fe₂O₃-SiO₂. From refined structure models, a single quantification routine (QXRD) was established. The amounts of phases and the chemical composition of major phases Monocalciumaluminate (CA), Ferrite phase and Gehlenite were determined by refining occupancy factors. The quantification result was calibrated by calculating the amounts of phases combined with their individual chemical compositions determined by QXRD and EPMA and shows the good accuracy of the established quantification routine. The flexibility of the routine makes it applicable to the industrial “standard grade”-CAFC.

TESTING THE IDENTITY OF CEMENTITIOUS MATERIALS BY TRACE ELEMENT ANALYSIS OF BELITE

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ABSTRACT

Testing institutes are sometimes asked whether two specimens made of cementitious materials are identical or of the same origin or not. It is very difficult to answer this question if the two specimens do not contain significantly different aggregates and do not contain characteristic differences in the major or minor components of the binder. Therefore a testing procedure based on the analysis of 14 trace elements in the residual belite was developed. By Kolmogoroff Smirnow tests it was possible to distinguish between specimens with the same cement and with different cements.

Materialprüfanstalten werden regelmäßig mit der Frage konfrontiert, ob zwei zementgebundene Materialproben identisch sind bzw. den gleichen Ursprung haben. Es ist sehr schwierig diese Frage zu beantworten, wenn die beiden Proben nicht deutlich unterschiedliche Gesteinskörnungen bzw. unterschiedliche Zementtypen aufweisen. Aus diesem Grund wurde ein Prüfverfahren entwickelt, das auf der Analyse von 14 Spurenelementen in den Belitrelikten beruht. Über eine Auswertung der Daten mittels Kolmogoroff-Smirnow-Tests war es möglich, zwischen Proben mit gleichem und mit unterschiedlichen Zementen zu unterscheiden.

INFLUENCE OF THE CO₂ DISSOLVED IN PORE WATER ON THE STABILITY OF SULPHOALUMINATE HYDRATES: A CASE HYSTORY

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ABSTRACT

The present work found its origin in a case history we encountered in year 2004 with a fast hardening mortar. It is well known that the fast setting in this kind of products is due to a certain blend of ordinary portland cement (OPC), calcium aluminate cement (CAC) and a source of sulphate ions, which gives raise during the first part of hydration to calcium sulphoaluminate hydrates such as ettringite ($\text{Ca}_6\text{Al}_2(\text{SO}_4)_3(\text{OH})_{12}(\text{H}_2\text{O})_{26}$). In the job site under consideration we found that after 4 years since the installation the product was completely deteriorated and a large amount of hydrated product was still present. Performing a series of analysis such as powder X-ray diffraction (XRD), Thermo-Gravimetry (TG) and elemental analysis by Induced Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), we found that this hydrated product was not a sulpho-aluminate, but a carbo-aluminate. In fact we found a large amount of monocarbonate ($\text{Ca}_4\text{Al}_2\text{O}_6(\text{CO})_3(\text{H}_2\text{O})_{11}$) as described in literature [1] .

Object of the present work was the study of the genesis of this mineral in a simplified cement system. In order to do this we synthesized pure phases such as tricalciumaluminate ($\text{Ca}_3\text{Al}_2\text{O}_6$, or C_3A) and ettringite and we followed the different stages of transformation up to monocarbonate with Environmental Scanning Electron Microscopy beside all the previously cited analytical techniques.

MICROSTRUCTURAL INVESTIGATIONS ON EARLY HYDRATION PRODUCTS OF CEMENTITIOUS SYSTEMS IN COMBINATION WITH MODERN PCE-TYPE SUPERPLASTICIZERS BY ADVANCED CRYO-TRANSFER SEM

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Abstract:

Fundamental investigations on the influence of modern PCE-type superplasticizers on the morphology of the early hydration products of cementitious systems are a crucial element for understanding the basic mechanisms of action of this class of admixtures. It is believed that a more profound knowledge on the early stages of cement hydration in general and in the presence of high performance superplasticizers in particular can lay the foundation for development of tailor-made products of a new generation.

The cryo-SEM technique is well established for the investigation of biological systems. It has also already been applied successfully to cementitious systems in the past.

However in recent years most research groups were focused on the ESEM technique since it provides the possibility to study hydrating systems *in situ*. Advanced cryo-transfer SEM allows detailed examination of the microstructure at very high resolution even at very early hydration times almost free of any artefacts.

The present paper deals with time-resolved cryo-transfer SEM of cement paste and concrete in the presence and absence of selected PCE-type superplasticizers.

SYNTHESIS AND CRYSTAL CHEMISTRY OF MANGANESE CONTAINING PHASES IN CALCIUM ALUMINATE CEMENT.

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ABSTRACT

We report in this work the fixation of Manganese in two clinker phases C_2AS and CA . In order to obtain data on the newly synthesized crystal structures, the substitution processes $Mn^{2+} + Si^{4+} \Leftrightarrow 2Al^{3+}$ in Gehlenite and $Mn^{3+} \Leftrightarrow 2Al^{3+}$ in CA were investigated. Additionally, a sol gel route was applied to synthesize CA at low temperatures in order to stabilize trivalent Mn.

**ACID ATTACK IN A CONCRETE SEWER PIPE
- A PETROGRAPHIC & CHEMICAL INVESTIGATION**

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ABSTRACT

A 30-in. diameter steel cylinder reinforced concrete pipe (concrete pressure pipe, bar-wrapped, steel-cylinder type, AWWA C303) was investigated for deterioration by sulfuric acid generated inside the sewage force main. A section of the pipe from the crown region, containing a mortar coating, steel cylinder, and mortar liner, was examined. Results show an inherent dense, low-absorptive, and impermeable nature of the outer coating but a soft, porous, and absorptive nature of the inner liner. The latter was severely attacked by sulfuric acid, lost 25 percent of its thickness, and developed distinct compositional and microstructural features typical of a sulfuric acid attack. The study emphasizes the importance of a dense, low water-cement ratio (w/c), and impermeable liner material for resisting such an attack in sewer pipes.