

125 Years of Research for Quality and Progress

Jubilee of joint research forms high point of the International VDZ Congress

In a ceremony on the occasion of the 5th International VDZ Congress „Process Technology of Cement Manufacturing“ the German Cement Works Association is celebrating the 125th anniversary of its foundation. The beginnings of the cement research in 1877 were already a milestone in quality awareness, which runs like a golden thread through the history of the Association. Today also, the VDZ and its Research Institute are a guarantor for practical and quality-oriented joint research. And since the sphere of the Association’s work is becoming increasingly internationalised, the Research Institute will in the coming years increasingly be expanded into a European research platform.

With the start of industrial cement production in Germany, in January 1877 the founding members of the „Association of German Cement Manufacturers“ joined together into an independent common interest group. The main focus of the joint work, even in the initial years, was already on technical questions. The essential motivation of the cement producers in joining together into an association was however the hitherto inconsistent quality level of the cement. At that time, there were no consistent standard testing procedures.

The composition issue

In the first years of its existence, the „Association of German Cement Manufacturers“ was already working out guidelines for the testing and delivery of Portland cement. As early as 1878, the first Cement Standard was published on this basis. Very rapidly, Portland cement became an established term. It stood for quality and was priced accordingly.

Through the constant improvement of the production process, as the years passed cement of ever higher quality was produced. It exceeded the strength requirements of the standard to an ever greater degree. At the same time, experiments showed that as well as the clinker, the granulated blast furnace slag also influences the hardening of the cement. The question of the composition of the cement arose from this. It formed the basis of a controversy within the cement industry that lasted for

several decades. In the end, however, these differences in opinion spurred the research on considerably. In particular, the foundation of the Association made it possible to bear jointly the substantial costs of the registration tests required by the state and of wide-ranging studies. In fact the evaluations showed that iron Portland cement and blast furnace Portland cement were equivalent to Portland cement. Nonetheless it would take until 1948 before all research studies could be brought together under the roof of the „Verein Deutscher Portland- und Hüttenzementwerke e.V.“ (Association of German Portland and Slag Cement Works).

1950s reconstruction euphoria

In May 1949, the first members’ meeting of the Association founded again after the war took place. At the same time, the work in the partly destroyed Research Institute was taken up again. In accordance with the statutes, the Association undertook the monitoring of its members’ cements according to the German cement standard DIN 1164.

After four years of successful joint work, the new Association changed its name to „Verein Deutscher Zementwerke e.V.“ (German Cement Works Association). The purpose of this was to highlight the successful merging of the different fields of interest. The board members now no longer came proportionately from the different branches of the cement industry but instead represented the cement-producing regions of Germany.

In 1948, the work of the Association was subdivided into the following working committees: the laboratory committee, responsible for test procedures and cement processing, the raw material committee with the fields raw materials and hydraulic additives, and the technical committee. At the members’ meeting in 1954 it was decided also to establish the concrete technology committee. The involvement of the factories in the studies is to this day an essential feature of the joint work.

In 1958, at the members’ meeting in Baden-Baden, the Association celebrated the 10th anniversary of its refoundation. In April 1973, 25 years had passed since the Association had founded itself again after the war. This 25-year reunion provided an occasion to look back on a remarkable reconstruction achievement.

From upswing to recession

In the 50s and 60s, the construction boom in Germany led to a continual rise in cement shipments. Tough



Fig. 1: On 1 June 1956 the Research Institute started operations in the newly erected VDZ building. Since 1998 the concrete steles stand in front of the newly designed entrance hall.



Fig. 2: In 1952, at the 75-year jubilee, the Association was renamed „Verein Deutscher Zementwerke e.V.“ (German Cement Works Association).

market confrontations in the Westphalia region, the two so-called Westphalian cement wars, and the recession that set in with the 1973 oil crisis, reduced the number of cement companies in Germany. As a consequence, the number of members in the Association fell from 70 in 1966 to 49 in 1975.

At this time a major focus of the joint work concerned the reduction of the energy consumption during cement manufacture. Kilns operating by the wet process were closed down in the 1960s and 70s. In the 1970s, the kiln capacity was increased from 350 to 2400 tons/day on average. In 1977, at a South German works, Europe's largest suspension type preheater until then came on stream at 4000 tons/day. Today, clinker kilns mainly operate by the dry process. New installations are constructed exclusively as cyclone preheater kilns with calciner, tertiary air duct and grate coolers.

Environmental protection as Association objective

As early as the 1930s, the dust committee was founded in the Association. In 1950, a dust measuring station was set up, from which the so-called emissions monitoring department subsequently derived. Also among its responsibilities was noise abatement and questions relating to vibrations after explosions in quarrying operations.

In 1950, the dust emission from rotary cement kilns was still about 3 - 5 percent of production. In the subsequent decades, the dust emission was drastically reduced. By now, the daily average emission level for dusts in the exhaust gas from rotary kilns is down to 10 - 30 mg/m³.

Today the Research Institute is available to the cement factories and other industries for the testing of environmental legal conditions right up to complete environmental impact

audits. The institute is recognised as a notified monitoring body according to the Federal Ambient Pollution Protection law. The scope of the notification covers all fields relevant to the cement industry. This includes the determination of the emissions of inorganic gases, dusts, dust components and chemical compounds adsorbed on dust, and also the emissions of organic chemical and highly toxic organic chemical compounds in extremely low concentrations (dioxins and furans); also the determination of noise emission and pollution, and of vibrations due to blasting. Likewise, emission measuring instruments can be calibrated and their functioning checked.

Control is better

As evidence of conformity with the European cement standard EN 197-1 and as a precondition for free trade in Europe, manufacturers label their cements with the European CE mark.

The VDZ Quality Surveillance Organisation is notified in accordance with the Construction Products Directive. Hence the VDZ can offer its services as a notified body throughout Europe. The accreditation of the laboratories as well as the notified body was successfully concluded in 2002. At present, over 500 cements and cement-like binders from 67 factories are tested in accordance with German and to some extent also with foreign rules. Of these, by now about 330 cements have received certificates in accordance with EN 197-1.

Safety at work

In 1968, an accident prevention commission was formed, which could be called upon by the factories for advice free of charge. A safety at work study group dealt with safety instruction leaflets. It also organised competitions which singled out the three companies with the lowest

accident figures and distribute plaques. The result of this Association activity was plain to see. In the course of 30 years, the accident frequency rate and the mean annual capacity loss sank by about two thirds. Furthermore, there were intensive courses for industrial foremen so that these could properly fulfil their role in setting a good example as regards safety at work.

Scholarships for young people

The long-standing chief executive of the VDZ, Prof. Dr.-Ing. Gerd Wischers succeeded in forging a link between the chemical-mineralogical and physical behaviour of cement paste and hardened cement paste and the usage properties of concrete.

One year after the death of Prof. Wischers, the Association created the Gerd-Wischers Foundation. Since 1995, it has been nurturing young scientists as new blood for the cement industry. Among the first research topics was a diploma study on the effect of cement kiln dusts on strength and phase development in cement hydration. Other studies were concerned with self-compacting concrete and the alkali balance of the pore solution in the hardened cement.

In 2002, the first scholar did a doctorate on the use of cement-bound mortar systems in the drinking water field. The funding is open to young people from this country and abroad, who wish to work on a research topic in the field of cement manufacture or cement utilisation.

Tradition-conscious and modern

The research studies of the VDZ have always commanded great respect in the industry and also in the specialist world, throughout the many years of the Association's history. Today in the Research Institute in Düsseldorf, the Association has available a renowned and internationally recognised scientific establishment.

At the start of 2002, the VDZ defined its previous objectives afresh, and with the European Cement Research Academy has created the basis for a European research platform. Through the foundation of the European Cement Research Academy, the VDZ retains its well-established form, while at the same time it is emphatically adopting a European orientation. The independence of the Academy ensures the equal treatment of all its members.

At the start of the 21st century, the VDZ is both tradition-conscious and modern. It is well equipped to face the demands of the future.

Cement Research: from Limestone to High Quality Concrete

The Research Institute of the Cement Industry: joint research over the years

In 1901 - about 25 years after the foundation of the Association of German Cement Manufacturers - the first Association laboratory started its work in Berlin-Karlshorst. At this time, the influence of the raw materials and the production process on the cement properties was largely unknown. Hence the most urgent research projects were devoted to the constituents of the cement clinker. Since the number of Association members grew strongly in the initial years, the laboratory increasingly turned into a central test authority for the cement from the factories. Today with its Research Institute in Düsseldorf, the German Cement Works Association has available a renowned and internationally recognised scientific establishment. This covers all aspects of cement production and use.

The building of the first Association laboratory was in itself a real joint achievement. The Association members drew up the building plans and delivered cement and marble slabs, and also stone and steps. On 1 December 1901 the laboratory in Berlin-Karlshorst was ready for business. Later, the Association members little by little funded the laboratory equipment and the library.

The laboratory in Karlshorst

The equipment of the laboratory in Berlin-Karlshorst was at first very modest. The engineering laboratory was established on the ground floor. The physics laboratory, the board-room and the office were located on the first floor. Under the stairs there was a darkroom. The laboratory worker was given a dwelling in the attic. The caretaker acted as an additional laboratory assistant.

F. Framm, head of the institute since 1902, devoted himself especially to the establishment of a consistent analytical procedure for Portland cement. He was also involved in the work of the seawater committee and in the establishment of the standards for the consistent delivery and testing of Portland cement.

Under the management of G. Haegermann (1923-1945) the team at the Karlshorst laboratory initially grew to five employees. In 1925, it was augmented by a mineralogist. The tests which the laboratory undertook included the general cement testing of samples from 83 Association factories, the weekly testing of the standard sand and the random testing of foreign cements.

Haegermann's main interest was in all questions relating to standards testing. He was especially interested in the determination of strength on hardened test specimens from standard mortar, and also the change in the technical mortar properties through the individual clinker phases, the addition of salts or surface-active substances. His numerous publications were concerned with the control of the concrete at the construction site, with the application potential and the properties of natural cement, added bitumen in concrete, and screening results from the 4900-mesh screen. Haegermann pursued the question as to whether the mixing water could be the cause of a setting failure. In addition, he studied the resistance of the cements to corrosive solutions. His work should be of particular benefit to producers and

users. He therefore strictly refrained from any advertising.

At a later period, the laboratory building was augmented by a concrete technology department, and from 1928 to 1935, A. Hummel took over the management of the department. Apart from this, an experimental plant for the production of Portland cement was set up. The firm G. Polysius-Dessau funded the experimental rotary kiln for this and the firm F. Krupp-Grusonwerk a ball-mill. A further room was provided for a collection for teaching and learning purposes. The theme of the collection was the historical development of the test apparatus and the mineral binders and also their production.

In 1943, the research laboratory in Karlshorst was damaged by bombs. The work of the institute was not resumed until after the war, in Düsseldorf.

Düsseldorf and Hamburg-Blankenese

Because of the disputes over the composition of the cement, the manufacturers of cements containing blast furnace slag founded the Association of German Iron Portland Cement Works e.V. in 1901 and set up a laboratory in Düsseldorf for standards testing.

In 1913, the Association of German Blast Furnace Cement Works e.V. was formed. At the same time the „Chemical Technical Testing Institute“ of H. Passow in Hamburg-Blankenese was renamed the „Laboratory of the Association of German Blast Furnace Cement Works“. Later, this Association moved to Düsseldorf as well. A for-



Fig. 1: The Association's first laboratory in Berlin-Karlshorst



Fig. 2: Cement testing laboratory in the institute on the Roßstrasse

mal contract between the Iron Portland and the Blast Furnace Associations provided for bringing the two association laboratories into a common building. Possibly a fruitful cooperation would have come into being, had there not been personal differences between the managers of the two research institutes, directors Grün and Guttman. By 1926, the association boards had to end the stressful cooperation. Both institutes worked in their own buildings. The Association of German Iron Portland Cement Works moved into the house at 17 Eckstrasse. In 1937, F. Keil took over the management of the institute.

After the war, the work in the partly destroyed institute in the Eckstrasse in Düsseldorf was gradually taken up again. This took place first in the three important work fields to which the division into departments corresponded. From 1948, the chemical mineralogy department concerned itself with the further study of the properties of cement and with its assessment. In line with its statutes, the Association undertook the monitoring of its members' cements in accordance with the German cement standard DIN 1164. Other experiments were concerned with cements which had been swelled by means of gypsum and the addition of aluminat. The research plan also included a review of American experience with „aerated“ concrete, the air void content of which had been artificially increased. This concrete was more resistant to frost and thawing salts. A test of the cements for plasticity and the testing of hardened concrete in buildings with the ball hammer rounded off the research programme.

New building in Tannenstrasse

Quite soon, the rooms in Eckstrasse were no longer adequate for the extended work programme. Hence in 1954 the VDZ decided also to buy

the plots of land adjacent to the site on which the former research institute of the blast furnace cement industry had stood. In the first phase of building, a four-storey main building with a lecture room, a workshop and a dwelling house for employees was built. On 1 June 1956, the new building was formally opened.

After just five years, a first extension became necessary. By creating a cellar under the courtyard, urgently needed work and storage rooms were gained. In 1965, it was possible to move into the first three floors of the extension in the Roßstrasse. In addition, in 1972 the Association bought a further 160 m² strip of land behind the institute. On this plot of land, it extended the concreting hall to double the ground area. In the cellar of the new building, several large frost chambers accessible to vehicles and a separate insulated room for storage at +40 °C and 100% atmospheric humidity were built. Then in 1992, the extension was enlarged to the originally planned height of six storeys.

Research from limestone to concrete

Today, with the Research Institute in Düsseldorf, the German Cement Works Association has available a renowned and internationally recognised scientific establishment. This covers all aspects of cement production and use. The Institute has a modern equipment park and is also optimally equipped for sophisticated, pure research.

Research on the performance of the cements has always been a central task of the Research Institute. Today a major focus of the Institute's work concerns the interplay of the main and minor constituents of the cement. Depending on the area of application, individual performance features can deliberately be influenced. Here, the reactivity of the

main components is of decisive importance. Also, the grinding fineness of the individual constituents can be deliberately coordinated by separate grinding.

The main constituents blast furnace slag, limestone, fly ash and burnt shale in particular make a considerable contribution to the reduction of the CO₂ emissions from cement works. The studies on Portland composite cements at the Research Institute concentrate on the granulometry of the main cement constituents. Apart from their strength-forming capacity, the long-term durability of the concretes produced from these cements is decisive for their market success.

In the concrete building technology field, the technical and economic principles for concretes with special performance features are being further developed in laboratory studies and practical applications. Among these are for example concretes with high acid resistance or self-compacting concrete.

For high-strength concretes, load-free deformation (contraction) and tensile strength and breaking strain were studied. In addition, there are wide-ranging research studies on transport construction, e.g. road construction, the products of road construction, and the ballastless track for the newly constructed stretches of the German Railways.

The optimal mode of production

The overriding aim of process technology research is to optimise the energy consumption and the use of the workforce during cement production, and also the quality and uniformity of the cement. The Research Institute has extensive knowledge from wide-ranging and systematic studies on rotary kiln and grinding installations. The most recent measurements on kiln installations should above all clarify the question of how increased material cycles can be reduced by process technology, so that disturbing kiln coating and process breakdowns can be avoided. Here, the effects that the composition of the raw material and the operation of the rotary kiln and preheater can have on the SO₂ emissions were also investigated. A further major focus of the studies on precalciner plants concerns the possibilities for NO_x reduction by carrying out staged combustion in the calciner.

Industrial and semi-industrial grinding and classifier installations are also being studied by the



Fig. 3: Mill experiment for the optimisation of energy consumption and the particle size distribution of the cement



Fig. 4: The VDZ quality monitoring laboratory

Research Institute. Above all, the effects of the different grinding systems and the modern classifier designs and modes of operation are tested. These affect the energy utilisation, the operating performance of the plants and the product properties. Particularly interesting here is the question as to how through different grinding plant systems, by grinding plants with high-pressure grinding rolls and cage rotor classifier, with ball-mills and cage rotor classifier, or with roller mills and cage rotor classifier, products can be manufactured which have different, deliberately adjusted particle size distributions. For the grinding of dry grinding feedstock the state of the technology is that the lowest use of electrical energy can be achieved by the use of the high-pressure grinding rolls, or else the roller mill. For the grinding and drying of moist feed, the roller mill is an efficient alternative.

Emissions reduction as the aim

The testing of the environmental compatibility in the use of different secondary fuels and raw materials is in the forefront of many studies. The inputs of trace elements into the kiln system via secondary materials can increase or decline depending on the origin of the wastes. The trace elements are predominantly bound into the clinker. Only the highly volatile element mercury is relevant for emissions, and the input of this into the kiln system is limited by restricting the content in the materials used.

So that secondary raw materials can be used in an environmentally safe way in the cement industry, the effect of the raw materials and the mode of operation of the kiln on the emissions of individual organic compounds was investigated. The studies were performed inter alia with a continuously measuring mass spectrometer on kiln installations.



Fig. 5: Workability experiments on self-compacting concrete

They show that no marked changes in the quantity of individual organic compounds released occur as a result of the substitution of natural raw materials by secondary ones. Raw materials which contain a high proportion of volatile organic components can be added at higher temperatures such as in the region of the calciner or kiln inlet. In this temperature range, the organic compounds are fully converted.

European research platform

At the start of the new millennium, changes in the industry present the VDZ with new challenges. The regulations and the standardisation that relate to cement and concrete increasingly take place at European level. Hence in the future the VDZ no longer has to represent the technical and scientific interests of its members in the hydraulic binder field exclusively at the national, but increasingly at the European level. But the cement industry itself has also since the 90s been undergoing an increasing internationalisation process. Hence the institute increasingly receives requests from abroad; many international cement manufacturers wish to share in the research findings. For this reason, at the start of 2002, the VDZ defined its previous objectives afresh: It has created the basis for a European research platform.

The positive experiences with the joint research at the national level form the basis for the development of this European research platform, the „European Cement Research Academy“. Founded in summer 2002 as an independent company, the Academy will begin its actual work in 2003. There, as an additional offer, research results will be more extensively communicated to the participants in seminars and conferences. The Academy is organisationally separate from the VDZ and is open to all cement manufacturers. Here it is immaterial whether or not these are regular members of the VDZ. The independence of the Academy ensures the equal treatment of all its members. All members have the same rights and obligations. The work of the Academy is decided by a Technical Advisory Board staffed at the European level.

Through the foundation of the European Cement Research Academy, the VDZ retains its well-established form. Its statutory activity remains the same. However, through the foundation of the Academy, the VDZ is emphatically adopting a European orientation, without throwing past achievements overboard in the process.

Standardisation of Cement - Basis for Quality Standards - a golden thread through the 125-year history of the VDZ

Because of its many, almost unlimited possible uses, cement has during the past 125 years won its place as the important building material of modern times. Consistent standards and norms are an essential precondition for this success. Thus the most important motive leading to the foundation of the Association of German Cement Manufacturers in 1877 was the creation and testing of such quality standards.

The standard developed in the very first year of the Association's history laid down requirements for the most important performance features of cement: setting time, constancy of volume (soundness), grinding fineness, and tensile and compressive strength. For dispatch and use, consistent guidelines on packaging and weight were created. Equipment and procedures for the testing of the requirements were described in detail in notes to the definitions in the standard. In 1878, the Royal Prussian Ministry of the Interior, by publication in the ministerial gazette, decreed that this industry standard should be the basis for cement deliveries.

Definition of Portland cement

The revised standard introduced in 1886 for the first time contained a definition of Portland cement as a product „formed by calcination of an intimate mixture of lime and clay-containing materials as essential components until sintering and subsequent pulverisation to the consistency of flour“. The struggle for consistent quality standards called for a still more precise definition. The revised standard published in 1909 for the first time contained quantitative data on the content of the most important clinker minerals. At the same time, the MgO content was for the first time limited to max. 5%, the sulphate content to 2,5% and additives to 3%.

Cements containing granulated blast furnace slag

The latter definition resulted from the demarcation from blast furnace slag-containing cements. A vehement

stand was taken against cements to which granulated slag was added during or after calcination. However, this could not halt the development and standardisation of blast furnace slag-containing cements. The standard for iron Portland cement developed by the Association of German Iron Portland Cement Works appeared in 1909. In this, the proportion of „granulated blast furnace slag“ was limited to max. 30%. In 1917 there appeared the standard for blast furnace cement, which „consists mainly of basic blast furnace slag with a minimum content of 15% parts by weight of Portland cement“ issued by the Association for German Blast Furnace Cements. The three standards essentially differed only in the first paragraph in each case, which contained the definition of the terms Portland, iron Portland, and blast furnace cement.

First joint standard

In 1927 there appeared the first joint standard for Portland and iron Portland cement, and in 1932 the first German cement standard under the designation DIN 1164, in which all three cements were for the first time covered together.

The updating of the three cement standards up to the publication of this first joint standard was marked by the precise statement of the test procedures and test equipment and by the definition of the duties of the test station in the required ongoing monitoring of the cement works. In addition, the strength classes defined in the standard bore witness to the improved cement quality. While the standard introduced in 1886 required

a minimum compressive strength of 160 kg/cm², the first DIN standard introduced in 1932 already provided the strength classes Z275 and Z400.

Updating after the war

After the war, work on the cement standard again came back to the centre of the Association's work as early as the 1950s, and led in 1958 to a new edition of the standard, essentially unchanged since 1932, and to a fundamental new version in 1967. In this, the standard was for the first time introduced in separate sheets, which respectively dealt with the definition and specifications, the proof of compliance and also the individual test procedures.

First European cement standard

During the past 30 years, the work on the cement standards was characterised by the goal of uniform definitions throughout Europe. The Research Institute played a decisive part in making it possible to achieve this goal with the publication of the test standard DIN EN 196 as of 1994 and through the adoption of the product and conformity certification standard DIN EN 197-1 and -2 in 2001.

Fig. 2: European standards for cement and cement-like binders

DIN EN 197-1/2	Common cement
EN 197-1:2000 prA1:2002	Low heat common cement
EN 197-x	Low early strength blast furnace cement
DIN EN 14216	Very low heat special cement
EN xxx	Calcium aluminate cement
EN 413-1	Masonry cement
DIN EN 459	Building lime
DIN V ENV 13282	Hydraulic binder for road bases

In the future also, the work of the Research Institute will be characterised by the updating of the standards mechanism. As well as the classical physical, mechanical, and chemical mineralogical performance features, data on the environmental compatibility of cements are coming into the field of view of standardisation. Jointly with its European partners, the Research Institute will make a formative contribution to the discussion of the questions connected with this and, in line with its 125-year tradition, be a guarantor for practical standards with regard to the cement producers, users and all fields concerned under public and private law.



Fig. 1: Bending tensile test device of 1875

Accident Rate Continually Reduced in the Cement Industry

VDZ working group has been making an important contribution for many years

The promotion of safety at work is among the designated duties of the German Cement Works Association. For over 40 years, the working group „Safety at Work“ has been making an important contribution to this.

The common aim of the VDZ safety work is to motivate employees in the cement works to safety-conscious working, regularly to inform them of possibilities for improvements in safety at work and to exhort them to constant checking of safety at their workplace.

Among the duties of the working group „Safety at Work“ are the analysis of the occurrence of accidents at member factories, the determination of statistical parameters, the development and recommendation of measures for the improvement of safety at work and the development of safety leaflets and check-lists.

Since 1965, the numbers of notifiable operating and road accidents at the German member works have been collected by the Research Institute and statistically evaluated. In the last 30 years, the incidence of accidents has fallen by ca 70% and is now at a very low level (Figure 1). Thus the

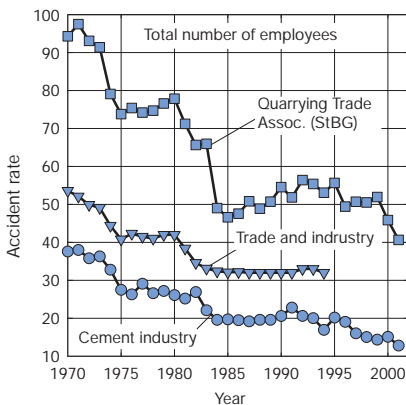


Fig. 1: Accident rate (number of accidents per million working hours) compared to the firms in the Quarrying Employers' Liability Insurance Association (StBG) and to the whole of trade and industry

accident figures of the cement industry lie about 68% below the accident rate of all member companies of the Quarry Employers' Liability Insurance Association (StBG) and about 35% below the average accident rate of all trade and industry.

For 24 years, the factories with clinker production have year by year been distinguished by the lowest accident rates. The recognition of this performance is expressed by the presentation of a plaque at VDZ's Annual Meeting (see box).

For the promotion of safety at work, each year three safety leaflets with the description of especially noteworthy accidents and also three safety check-lists for the checking of safety equipment and measures in different work areas

are made available to the cement factories.

Apart from this, on behalf of the VDZ, safety at work seminars for bosses and foremen are given by the Quarry Employers' Liability Insurance Association, for which the „Safety at Work“ working group defines the teaching content and provides assistance during the drafting of training documents.

Safety at Work Competition



At VDZ's Annual Meeting in Berlin, the awards were presented to the winners of the VDZ safety at work competition.

In those Days They Drank Incredibly

A look back at the early days of industrial safety in Germany

In 1891, an industrial safety law was introduced in Germany, in which a factory regulation was for the first time made mandatory. Factory regulations governed the working hours and laid the foundation stone for the virtues later described as typically German, such as punctuality, order and enthusiasm for work. Grounds for dismissal were disobedience to superiors, unauthorised desertion of work with endangerment of colleagues, careless handling of inflammable materials, disrespectful behaviour even towards members of the employer's family, repeated unpunctuality, drunkenness and embezzlement. Damaged tools or glass panes had to be replaced. If the culprit could not be identified, the whole department paid. If a worker left work after a dismissal without completing the time period, then the outstanding wages went to the factory health insurance. At one factory the unpunctual worker lost some of his wages, at another he had no right to

employment for the rest of the day.

Alcohol abuse was particularly mentioned in all factory regulations, since it markedly increased the risk of accident. Nevertheless, wine and beer were allowed with meals. However, the factory regulation evidently was not sufficient to remedy the abuses. A written record from Züllchow reads: „(...) There were old Berzelius lamps which I had to keep a close eye on, since denatured spirit was not yet in fashion, and I still believe to this day that many molecules of $C_4H_6O_2$ found their way not into the lamp, but into the throats of the workers bringing samples. For in those days they drank an incredible amount. Not only the mill workers needed 1/2 pound (ca 225 ml) of schnapps daily to wash the dust down, but also the coopers and fitters very much needed a minimum amount such as this to fortify them-selves. Admittedly, they worked 11 hours a day, and mostly Sunday mornings as well. (...)“

Qualification through Knowledge Transfer

European Cement Research Academy starts as European platform

As indeed in the past, steadily increasing demands on the employees in cement works will also in future require an above-average and expert knowledge level. For 44 years now, the VDZ training system has successfully offered courses and seminars at the highest level in support of the training and further training of the employees at the member factories. At the start of 2003, the European Cement Research Academy begins its activity as a European platform for knowledge exchange.

Since 1958, the VDZ professional development programme has been true to its well-established tradition in its courses and seminars, in its teaching programme and in its mode of working: always up-to-date and flexible in subject matter, and always oriented towards the training needs of the cement works.

Hassels training site modernised

Courses for industrial foremen have been given by the VDZ for many years. The industrial foremen's course „Cement and Limestone“ is the only one of its kind in the entire German-speaking area. It is recognised as an official training syllabus by the chamber of trade and industry in Düsseldorf. The practical basis of the courses, the mutual exchange of experiences as well as the use of modern learning materials and aids guarantee an efficient communication of knowledge. So far, 780 works' employees have successfully taken part in the 27 completed foremen's courses. With the passage of time, the teaching content is continually adjusted to the requirements of the obligatory teaching plan, but also to the requirements of the real world.

The courses consist of teaching blocks of up to 7 months' duration. They all take place at the Hassels training site (Fig. 1) in the South of Düsseldorf. In order also to adapt to meet modern requirements, the training site was last year thoroughly modernised with resources of the

VDZ professional development programme, regarding both sanitary installations and technical equipment. At present, 15 employees from different cement factories are being trained in the 20th course at Düsseldorf-Hassels.

Courses also for control-room operators

In order to accommodate the increasing requirements for the qualification of control-room operators, the VDZ had in 1990 decided, in addition to the industrial foremen's courses also to give production controller courses at the training site in Hassels. The participants are informed of the current state of knowledge in the process technology of cement production as well as the measurement, control and regulation technology at the cement works. By now, 194 employees have successfully taken part in the 8 production controller courses to date. At present, 16 participants are taking part in the 9th production controller course.

Professional development programme expanded

In addition, since 1998, one-day or several-day seminars for various interest groups – from laboratory employees to works managers – have been given in the Research Institute itself.

Key points are chemical analysis, antipollution and environmental technology, the process technology

of cement production, the monitoring of cement quality, and the principles of concrete technology. In addition, seminars for industrial foremen in the field or for young process engineers are offered, in order to deepen and refresh their knowledge level. The content deals with current themes relating to the cement production process.

European Cement Research Academy founded

Alongside the already well-proven professional development scheme the VDZ offers, by the beginning of 2003 the „European Cement Research Academy“ (ECRA) will start its work. In this the participants are more extensively informed of research results in the form of an additional offering of seminars and conferences. In the initial period, the research findings of the Research Institute form the basis for the deeper communication of knowledge in the Academy. For it is precisely the findings from the work of the Institute which are much sought after by representatives of the cement industry and the technical public, since they as a rule bring with them a direct economic benefit to the user. Moreover, the Academy offers the participants a major opportunity for mutual exchange on important technical and scientific questions.

The Academy will be an independent European institution. All its members have the same rights and obligations. Members of the VDZ are not automatically members of the Academy. The Academy will rather be organisationally separate from the VDZ and will be open to all cement producers (Fig. 2). The Technical Advisory Board ensures that the Academy programme includes interesting topics of European interest.



Fig. 1: The training site in Düsseldorf-Hassels

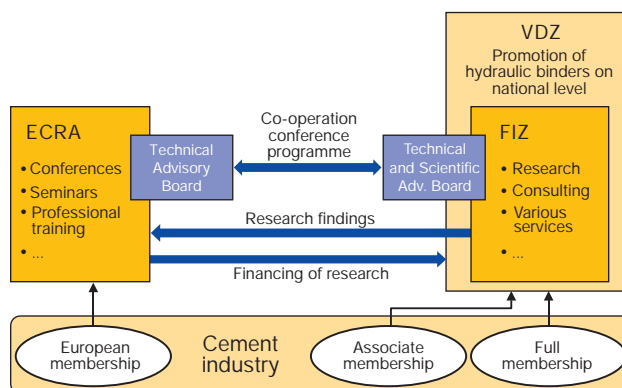


Fig. 2: Organisation of the European Cement Research Academy (ECRA) as European research platform

The VDZ has Successfully Undergone Independent Inspection

Laboratory accreditation and certification of management system were successfully completed

At the beginning of July 2002, the laboratories of the Research Institute were successfully accredited. At the same time, the integrated management system received its certification. After intensive preparation, all the requirements of the standards ISO 9001-2000, ISO 14001, ISO 17025 and EN 45011 are now fulfilled. This independent, private certificate underlines the high degree of reliability of the work at the Institute. Prominent in the certification are the highest possible efficiency and transparency of the procedures at the Institute. The lean, EDP-backed management system ensures minimal administrative costs and hence provides the basis for effective use as a management tool.

The accreditation of the laboratories of the Research Institute was necessary so that the VDZ will also be able to offer its services to the full extent nationally and internationally in the future. In particular, in future the accreditation will be required as a precondition for the notification of the Research Institute as emissions and ambient pollution monitoring body. Also, in other European countries, product certification is increasingly linked with successful accreditation. In order to make the procedures in the Institute lean and efficient, the VDZ management required a management system that can be efficiently used, and does not quickly degenerate into a „paper tiger“.

The result that is now in place is an organisation-wide, integrated management system. It is based on a „paper-free“ database, in which all documents are managed. From his workplace, every employee has at any time access to the information he needs via the Intranet.

Laboratory accreditation

The standard ISO 17025 is the successor of EN 45001 and is the highest private quality certificate for testing laboratories. In contrast for example to DIN EN ISO 9001, system and management aspects are less prominent here. The emphasis is rather on the performance of the measurements and the reproducibility and accuracy of the measurement results thus obtained.

Hence an essential component of the requirements of ISO 17025 are measures that ensure that only suitable procedures are used, and that they are correctly performed. In addition, it must be demonstrated, for example by participation in inter-laboratory tests, that the results obtained also correspond to the actual conditions - a practice which is already of long standing in the Research Institute.

Overall, the successful accreditation vouches for the good quality of the test results obtained

in the laboratories of the Research Institute.

Product certification

For about 100 years, the quality surveillance organisation of the VDZ has been carrying out regular audit testing on cements. The testing was at first carried out on the voluntary initiative of the cement industry and was only later carried out because of building inspectorate's requirements. Through changes in the monitoring standard in 1970 and 1996, the manufacturer's quality assurance measures were systematically included in the inspection. In 2000,

the notification as a testing laboratory, inspection body and certification body was extended to construction products in accordance with the EU Construction Products Directive. On the basis of this, EU conformity certificates for cements were for the first time issued in April 2001. These are valid throughout Europe, and the manufacturer can label his cements with the European CE mark.

In most countries in the EU, private accreditation of certification bodies under EN 45011 has a status that goes beyond this, and forms the definitive basis for assessment of the competence and independence of such a body. In these countries, there is often also a tendency to give out private „quality marks“ in addition to the CE mark. To create a comparable basis for the activities of the quality surveillance organisation of the VDZ, this surveillance organisation – in addition to the existing notification – was also privately accredited under EN 45011.

Fig. 1: Paper-free design of the VDZ/FIZ integrated management system

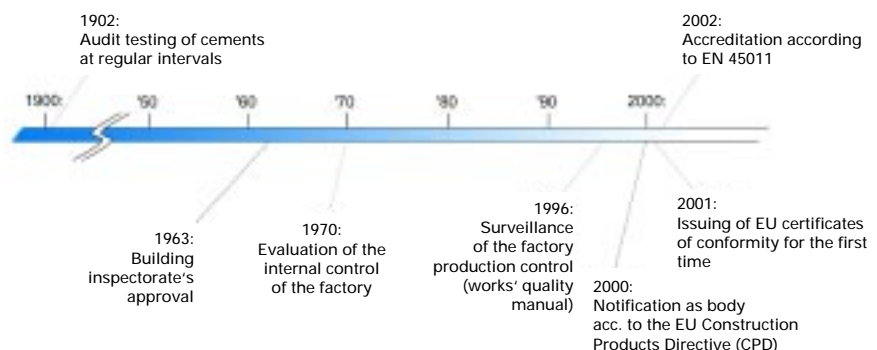
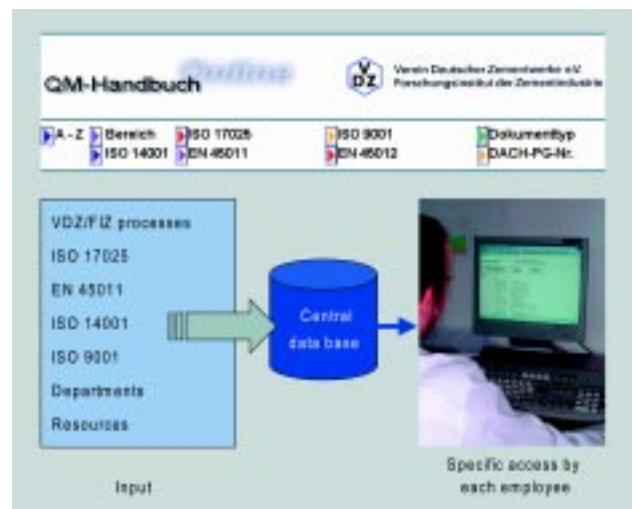


Fig. 2: Milestones in product certification and inspection by the quality surveillance organisation of the VDZ

Voluntary Agreement on CO₂ Reduction Continues to be Successful

The EU Directive on emissions trading cannot be accepted by the cement industry at present

While the introduction of an EU-wide CO₂ emissions trading scheme is under discussion in Brussels and Strasbourg, German industry is going ahead with its voluntary agreement for climate protection. The cement industry's current monitoring data show that it is demonstrably well on the way to fulfilling its reduction commitment.

As early as 1995, German industry entered into its voluntary agreement with the Federal government, in which it committed itself to reduce its energy consumption. The German cement industry contributed to this with its own commitment to reduce its specific fuel energy consumption by 20% from 1987 to 2005. At the end of 2000, the agreement was adapted to general international conditions and converted to the basis of CO₂ and greenhouse gas emissions. In its current agreement, the cement industry promises to decrease its specific energy-related CO₂ emissions by 28% in the

energy consumption compared to the previous year from 2835 to 2790 kJ/kg cement. Analysis of the data shows that this reduction is attributable to the increased production of cements with several main constituents as well as the increased use of secondary fuels. The average clinker content in the cement, for example, declined from 81 to 78%. In spite of the markedly decreased cement production, the production of Portland limestone cements in particular increased clearly, while the production of cements containing granulated blast furnace slag slightly declined for market reasons. The use of secondary fuels compared to the previous year increased from 25.7% to 30.3% now.

Since the specific electrical energy consumption fell to 99.8 kWh per ton of cement now, the specific energy-related CO₂ emission declined from 0.263 to 0.246 tons of CO₂ per ton of cement. This corresponds to a reduction of 30% compared to 1990.

These figures show that the voluntary agreement between industry and Federal government is a suitable instrument for the reduction of industrial greenhouse gas emissions. Fundamental here is the joint approach of the industrial sectors and also the flexibility to reduce emissions with the most efficient measures. The introduction of an emissions trading scheme such as the European Commission has proposed would, however, take the ground from under the voluntary

Compromise proposals of the rapporteur of the European Parliament

To take account of the concerns of some member states (among them Germany and Great Britain) with regard to the Draft Directive on the introduction of an EU emissions trading scheme, the rapporteur of the European Parliament da Silva presented compromise proposals in early July. The first reading in the European Parliament is planned for September 2002.

- Temporary exclusion of certain installations from emissions trading until the end of 2007, if these enter into comparable reduction commitments („Opt out“)
- Option for inclusion of additional sectors and installations into the emissions trading scheme by the member states („Opt in“)
- The emission trading scheme may only be linked to credits from CDM or JI which involve renewable energy and demand-side energy efficiency improvements
- Inclusion of all „Kyoto gases“, provided that the quality of data is satisfactory
- Allocation of 85% of the emission allowances free of charge, auctioning of the remaining 15% and cost-neutral redistribution of the revenues

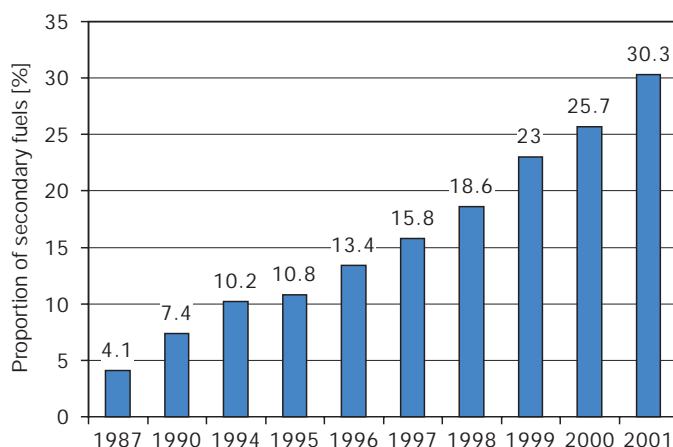
CEMBUREAU postulations with regard to emissions trading:

- First allocation of the emission allowances in all trading periods free of charge
- No additional constraints due to other political instruments for climate protection (e.g., CO₂ / energy taxes) for participants in the emissions trading scheme
- Possibility of reduction commitment on the basis of specific targets
- Allowance for CO₂ reduction through the use of secondary fuels („CO₂ neutrality“)
- Member states should be enabled to take appropriate measures to the advantage of firms/sectors which are placed at competitive risk by emissions trading („Safeguard clause“)

period from 1990 to 2012. Essential measures for the implementation of its agreement are the – since then largely completed – process technology optimisation of the kilns and the grinding plants, the reduction of the clinker content in the cement by increased production of cements with several main constituents and the increased use of secondary fuels.

In 2001, the German cement industry decreased its specific fuel

The use of secondary fuels in the German cement industry could be increased to ca. 30% in the last year



The Use of Smaller Grinding Balls Saves Grinding Energy

Ball-mills in combined grinding plants can be charged with smaller balls

At the Research Institute, the effect of the size of the grinding medium on the grinding energy requirement and the particle size distribution in the second grinding of a cement was studied on a semi-industrial grinding plant. It was found that with the use of smaller grinding media marked energy savings are possible, however narrower particle size distributions in the cement are produced.

While there was a steady rise in the average specific electrical energy consumption from 88 to 111 kWh/t in the period from 1960 to 1987, the average electrical energy consumption in Germany has since fallen again by ca. 10% to 101 kWh/t. Over 60% of the electrical energy requirement for cement production is caused by comminution processes. The saving of grinding energy has thus been at the centre of interest for many years.

Ball-mills in combination grinding plants

Because of their low grinding energy requirement, high-pressure grinding rolls are often used for cement grinding. However, cements which have been ground in a circuit of high pressure grinding rolls and separator as a rule display a narrower particle size distribution and thus a higher water requirement than a ball-mill cement. Therefore cements are often only preground to finenesses of 2000 to 3000 cm²/g in high-pressure grinding rolls. For the final grinding of the cements, ball-mills, which are operated both as continuous mills and also in a circuit with a separator, are still used. The downstream ball-mills are as a rule charged with grinding balls 25 to 12 mm in size.

Grinding tests with different grinding medium sizes

As grinding feed for the grinding tests, a clinker meal from a high-pressure grinding roll and separator cycle at a German cement factory was used. The clinker meal with a fineness of 2450 cm²/g was mixed with grinding additives and further ground in a semi-industrial continuous ball-mill with the dimensions 0.4 m x 1.2 m. As grinding media, both balls and also cylpebs were used, and both monodisperse and also polydisperse ball fillings were studied. With the grinding balls, ball sizes of 6, 8, 10, 13, 15 and 20 mm were used. Since the smallest grinding balls currently produced industrially have a diameter of 12 mm, reject balls from ball bearing production were used as grinding balls of the sizes 6, 8 and 10 mm.

In order to study the effect of the roundness and surface quality of the grinding media, the grinding tests were carried out on the 13 mm balls both with new, cast grinding balls and also with ball bearing balls. In all grinding tests, the grinding medium mass was the same, hence the power consumption of the mill also did not differ substantially. For every grinding medium filling, the continuous mill was operated with feed mass flows of 45, 35, 25 and 15 kg/h. With the grinding plant in the stationary state, specific surface area and particle size distribution were determined in each case.

Fig. 1 shows the results of the grinding tests with monodisperse grinding balls. As can be seen from the diagram, the highest specific

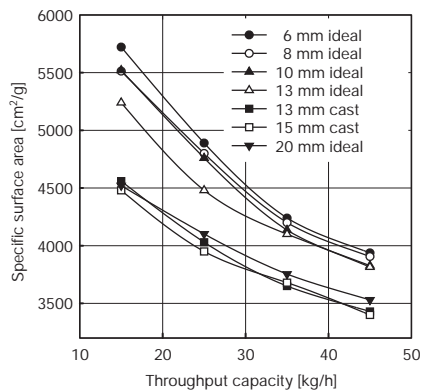


Fig. 1: Specific surface area in final grinding of a clinker meal in a ball-mill with different monodisperse grinding balls

surface areas were attained with the smallest balls. With the use of grinding balls with a diameter of 20 mm, the throughput capacity of the grinding plant is ca. 15 kg/h for a target fineness of 4500 cm²/g and the grinding energy requirement 47 kWh/t. With the use of 13 mm balls, a throughput of 25 kg/h can be attained, and here the power consumption for the final grinding is still only 30 kWh/t. On the other hand, if the mill is filled with 8 mm balls, a throughput capacity of ca. 30 kg/h with a power requirement of only

18 kWh/t could be attained. These results relate exclusively to ideally spherical balls.

The studies with 13 mm balls further showed that better results were obtained with the ideally spherical grinding balls than with the cast balls, which because of their short use period still display a ridge on the ball circumference and a pouring nipple for production reasons. It can however be assumed that with a longer use period these balls are worn spherical and then behave like ball bearing balls.

In comparison with monodisperse ball fillings of the same average diameter, somewhat better grinding results were attained with polydisperse ball fillings. On the other hand, the grinding tests with cyppebs fillings led to markedly worse results than with ball fillings of comparable average diameter.

Effect on the particle size distribution

Fig. 2 shows the slopes of the particle size distributions of the ground clinker meals for the monodisperse ball fillings. As is clear from the figure, the slope of the particle size distribution of the

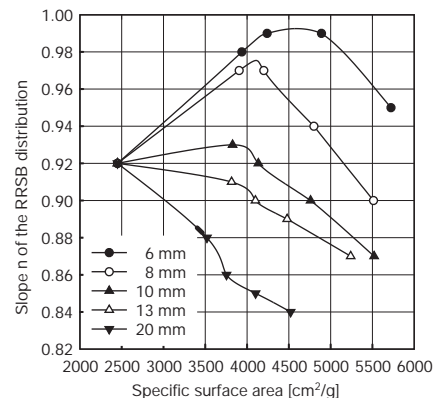


Fig. 2: Slope of the particle size distribution for final grinding of a clinker meal in a ball-mill with different monodisperse balls

cement decreased in the final grinding in the ball-mill, when relatively large grinding balls were used. With the use of smaller grinding balls, on the other hand, narrower particle size distributions of the cement were obtained, which resulted in an increased water requirement.

Research: Market-oriented CEM II Cements

Ternary cements tested – calcareous fly ashes with problems

The cement industry has committed itself to making a contribution to climate protection by reducing CO₂ emissions. For this, particular significance attaches to cements with several main constituents. These are under intensive study at the Research Institute as Portland composite cements. Cements containing at the same time granulated blast furnace slag and limestone appear very promising with regard to the strength development and durability of concrete. Calcareous fly ashes are only suitable to a limited degree.

In the years 1996 to 2000, the proportion of cements with several main constituents in the German domestic deliveries could markedly be increased. The voluntary agreement of the German cement industry to reduce CO₂ emissions renders it necessary further to increase the market share of these cement types.

Standardisation requirements

CEM II cements are standardised as Portland-composite cements in the European cement standard EN 197-1. Among these, on account of the raw material conditions, Portland-limestone cements with limestone contents up to 35 wt.% (CEM II/B-LL) and Portland-composite cements with up to 35 wt.% blast furnace slag and limestone (CEM II/B-M (S-LL)) are of particular interest in Germany. In addition, for example calcareous fly ashes could also be used as a main constituent. Since the said cements have not previously been produced in Germany, no experience with their application is available. Hence, in the German application rules for the European concrete standard EN 206-1, the use for building components exposed to freeze/thaw cycles and chlorides had to be excluded so far for these cements. Moreover, even with no frost or chloride exposure, these cements cannot be used in moderately moist reinforced concrete building components and building components that are subject to cyclic wet and dry conditions. For these applications, it has not hitherto been possible conclusively to assess the risk of reinforcement corrosion due to carbonation.

Nature of the task

In the production of these cements, the proportion and granulometry of the constituents must be suited to their reactivity. For this, the main constituents can be ground together or ground separately and then mixed. Both ways can be fruitful. In any case, material and process technology aspects must be taken into account. The strength development of the cements is of special

importance. In addition, questions of carbonation and chloride-induced reinforcement corrosion and resistance against freeze-thaw attack without and with de-icing salt must be clarified. In addition, with the use of calcareous fly ashes, the questions as to their homogeneity and soundness are of central importance.

Blast furnace slag / limestone

On the basis of present experience, concretes produced with Portland-composite cements CEM II/B-LL and CEM II/B-M (S-LL) with up to 25 wt.% limestone show adequately fast strength development for normal production processes in practice. Also, concretes containing such cements probably have adequate protection against carbonation and chloride-induced corrosion of steel in the concrete and, under the local climatic conditions, adequate frost resistance for vertical concrete surfaces exposed to rain and freezing. In the Research Institute of the Cement Industry, these assumptions are being checked with regard to cements with limestone contents > 25 wt.%. Fig. 1 shows initial results for cements with a limestone content of 30 wt.%.

Clinker and limestone were ground separately and then mixed. The fineness of the clinker was varied between 3000 and 4000 cm²/g according to Blaine. The limestone was ground to a fineness of 6000 cm²/g. The mechanical requirements of

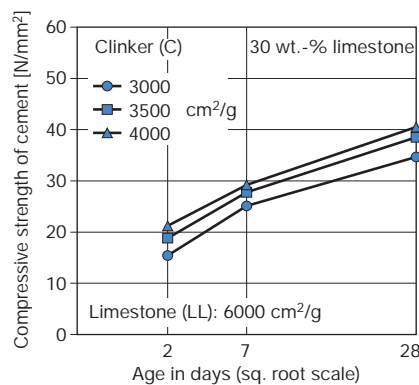


Fig. 1: Compressive strengths of Portland-limestone cements CEM II/B-LL with a limestone content of 30 wt.%

EN 197-1 for cements of the strength class 32.5 were fulfilled, however under the stated boundary conditions the strength level did not correspond to the requirements now usual in the German market. It will be necessary to grind the clinker component more finely.

Calcareous fly ash

Due to their chemical composition, German lignite fly ashes (BFA) fall into the calcareous fly ash category. The studies so far carried out at the Research Institute have shown that the requirements of EN 197-1 are not in all cases met by the examined fly ashes from the Rhine and the Lausitz coal deposits. In addition, the known low homogeneity of the ashes adversely affects their usability as a main cement constituent. One possibility for raising the strength of BFA-containing cements is the comminution of the BFA either by grinding together with clinker and calcium sulphate or by separate grinding and subsequent mixing. However, strength curves which approach those of Portland cements could only be attained at ash contents up to about 10 wt.%. For this, the respective ashes had to be separately ground to very high fineness. A limitation as regards the use of lignite fly ashes results from the expansion of the corresponding mortars. BFA cements with fly ashes with high free lime or periclase contents (e.g., BFA R1), which pass the expansion test according to EN 196-3, can exhibit considerable expansions in the autoclave test according to ASTM 151 C (Fig. 2).

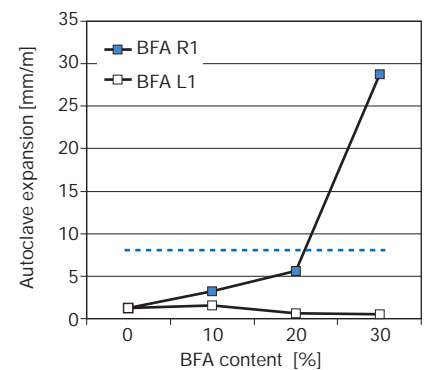


Fig. 2: ASTM C 151 autoclave test using BFA-containing cements

The limit of 8 mm/m specified in the American standard was exceeded by the cement containing 30% of Rhenish lignite fly ash. Moreover, length change measurements on mortar prisms with BFA cements after water storage revealed expansions some of which were considerably higher than those of the reference mortar with Portland cement.

Sulphate Resistance at Low Temperature Studied in Laboratory

Possible conclusions for practical application must be clarified in further investigations

Over 80 cases of harmful thaumasite formation in Great Britain prompted the Research Institute to carry out a comprehensive research programme two years ago. The results substantiate the high sulphate resisting property of the SR cements standardised under DIN 1164 even at low temperatures. The sulphate resisting property of cement-fly ash mixes under the selected test conditions could only be confirmed at the standard test temperature, but not at lower temperatures. The causes of this and possible conclusions for practical application must be clarified in further studies.

Alerted by the thaumasite damage to concrete structures noted in England in the 1990s, laboratory and field studies have been carried out in many places in recent years. At the Research Institute also, possible causes and preconditions for harmful thaumasite formation were more closely studied in a research project funded by the AiF (see VDZ Mitteilungen 109). The research project has since been completed, and the results were presented in June at the „First International Conference on Thaumasite in Cementitious Materials“ in Watford, England (see box).

Sulphate resistance

In the first part of the studies, the sulphate resisting property of mortars made from standardised SR cements and cement-fly ash mixes was determined at low temperature. For this, flat mortar prisms which had been produced according to the Wittekindt process were stored in sodium sulphate solution, and expansion tests were performed. In contrast to the usual procedure, however, the test pieces were subjected to sulphate attack at 8 °C and not at 20 °C. The SR Portland and SR blast furnace cements tested showed a high sulphate resistance even under these conditions. On the other hand, the test specimens of the cement-fly ash mixes showed markedly higher expansions at 8 °C than at 20 °C and at the same time higher expansions than the test specimens from the pure cements (Fig. 1). Even on replacing cement by fly ash at a conversion

factor of $k = 0.4$, no higher sulphate resistance could be substantiated for the fly ash-containing mixes. The fly ashes only showed an improvement regarding the sulphate resisting property in test series at low sulphate concentration (1500 mg/l). In comparison to the experiments with the pure cements, here the expansions of the test specimens decreased with increasing fly ash content.

Thaumasite

In contrast to ettringite, thaumasite is a secondary phase which softens rather than expands the hardened cement. In addition to a sulphate attack at low temperature, the presence of carbonate and reactive silicic acid is also needed to cause the formation of thaumasite. Hence in the second part of the research programme, the material preconditions for the formation of thaumasite were systematically investigated. Carbonate was used in the form of various limestone meals together with cement in mortar experiments, and also in the form of limestone chips as aggregate in concrete experiments. Irrespective of the limestone used, in many test specimens after about half a year, in addition to secondary ettringite, thaumasite also formed as a result of sulphate attack (Fig. 2). Here, the silicate needed for the thaumasite formation derived from the calcium silicate hydrates of the hardened cement paste. In the damaged regions, complete softening of the structure occurred.

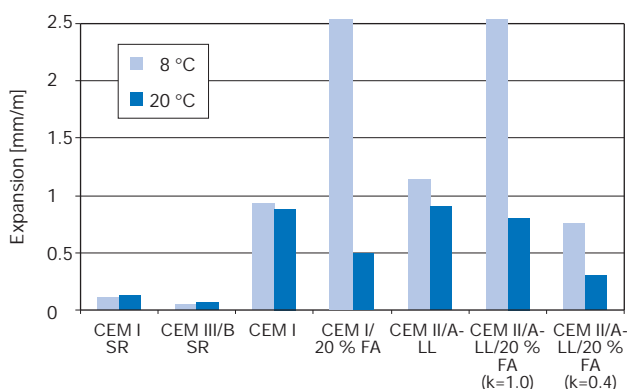


Fig. 1: Expansion measurements on various cements and cement-fly ash mixes after 56 days' storage in sodium sulphate solution (29800 mg sulphate/l) at 8 °C and at 20 °C

Conclusions

The studies confirm the high sulphate resisting property of DIN 1164 SR cements under the test conditions at 20 °C and at lower temperatures. SR cements continue to be suitable also for buildings which may be exposed to a sulphate attack (exposure class XA1 to XA3 acc. to DIN EN 206-1)



Fig. 2: Picture of a damaged concrete test specimen (standard prism) made of Portland cement with limestone chips as aggregate after 400 days' storage in sulphate-containing solution (29800 mg SO₄/l) at 8 °C

at temperatures below 15 °C. Further studies are being undertaken at the Research Institute of the Cement Industry in collaboration with the fly ash producers.

First Thaumasite Conference

From 19th to 21st June, the „First International Conference on Thaumasite in Cementitious Materials“ took place in Watford, England. In an intense and open exchange of expertise, about 120 participants from 16 countries attended a total of 61 lectures. These were predominantly concerned with the damages that had occurred in England. However, cases from the USA, Canada, South Africa, Scandinavia, Switzerland, and Germany were also presented. In none of the cases described an obvious sulphate attack had been expected.

Many lectures reported wide-ranging laboratory studies on the causes of thaumasite formation. In some of these contributions, harmful long-term formation of thaumasite was observed, even with the sulphate resisting Portland cements studied, if carbonate-containing aggregate had been used for the production of the concrete. In Great Britain, the findings to date on thaumasite formation were included in the new „BRE Special Digest 1“ and from 2003 will also be considered in the BS EN 206-1.

ASR Research – Long-term Focus of the Work of the VDZ

Many of the results from the research work passed into national guidelines and standards

In Germany, the Research Institute of the Cement Industry has had a decisive influence on research in the field of the harmful alkali-silica reaction (ASR). Many of the research results of the last 35 years passed into the national regulations for the avoidance of damage due to ASR. At present, the Institute is participating in a European project.

In an ASR, in the presence of moisture, reactive silicic acid in the aggregate reacts with the alkali hydroxide of the pore solution of the concrete to produce a swellable alkali silicate. Under unfavourable conditions, damage to the concrete can occur as a result.

Milestones of ASR research

Throughout Europe, until 1968 such damage was only considered possible in Denmark and England. However, damage to the Lachswehr bridge indicated that harmful ASR is also possible in Germany. As a result, under the leadership of the Research

Institute, procedures for testing the alkali sensitivity of North German aggregates, which contained opaline sandstone and flint, were developed. Almost simultaneously, requirements for cements with low active alkali content, so-called low-alkali cements, were defined. In 1974, together with the test procedures they were adopted in the first draft of the alkali guideline.

After the reunification of Germany, damage with other aggregates, e.g. greywacke, became known. In 1997, new research results led to the inclusion of the precambrian greywacke from the southern region of the new federal provinces in the alkali guideline and in 1999 to the extension of the range of low-alkali cements in DIN 1164.

Total Alkali Content on the Test Bench

Active alkali content is the decisive factor for harmful ASR

It is not the total alkali content of a cement, but rather the active alkali content in the pore solution of the concrete caused by it that is the decisive factor in triggering a harmful ASR. Hence the effect of main cement constituents on the active alkali content is being studied for the development of further cements with low-alkali properties.

Wide-ranging studies by the Research Institute contributed to the extension in 1999 of the range of low-alkali cements standardised in DIN 1164 to include the cements CEM II/B-S with a total alkali content ≤ 0.70 wt.% $\text{Na}_2\text{O}_{\text{eq}}$ and CEM III/A with a blast furnace slag content ≤ 49 wt.% and $\text{Na}_2\text{O}_{\text{eq}} \leq 0.95$ wt.%. These limit values determined on the basis of concrete tests are on the safe side.

It is known that the active alkali content of cements containing blast furnace slag is lower, even with the same total alkali content, than that of Portland cements. In order to determine how blast furnace slag influences the active alkali content, the pore solutions of concretes were analysed (Fig. 1).

On the left in the figure, the potassium concentration of a CEM I is shown, compared to cements in

which 20 or 40 wt.% of the Portland cement have been replaced by blast furnace slag. The concentration of the pore solution falls in proportion to the slag content. The decrease in the concentration is almost independent of the alkali content of the blast furnace slag used, as can be seen from the right-hand side of the figure.

The results show that the active alkali content of cements containing granulated blast furnace slag is influenced almost exclusively by the Portland cement content. Even though the total alkali content of slag-containing cements is no measure of the active alkali content, it has been proved for many years as the low-alkali criterion. The extent to which the active alkali content can also be taken into account in the assessments in future is the subject of the current studies.

Current questions

Across Europe, several other regulations and test procedures for avoiding a harmful ASR are in existence. So as to be able consistently to assess the alkali sensitivity of aggregates in the future, an EU-funded project, in



Fig. 1: Storage of concrete test specimens under practical conditions in the outside store

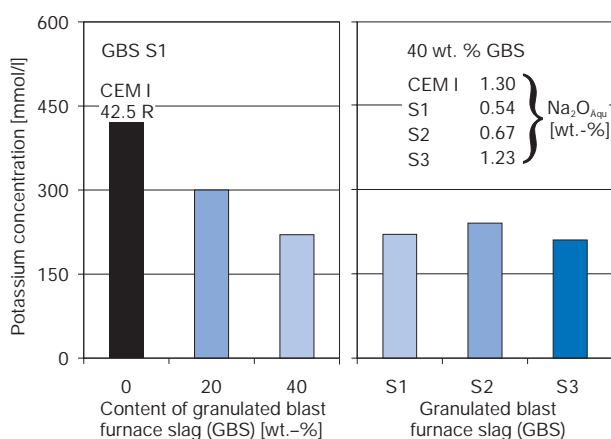


Fig. 1: Influence of blast furnace slag on the potassium concentration of the pore solution of concrete with alkali-sensitive aggregate (age: 28d)

which alkali-sensitive aggregates from the whole of Europe are to be characterised and catalogued, was initiated in 2002. In this, the Institute is above all involved in outside storage experiments (Fig. 1) in order to check laboratory results under practical conditions.

Further, the development of new low-alkali cements is being speeded up at the Institute. For this, fundamental studies are in progress at present which aim in particular at the reduction of the active alkali content in the pore solution of the concrete.

Sustainability in the German Cement Industry

Unions and management are continuing the process of sustainable development by specific projects

The sustainable development described 15 years ago by the World Commission for Environment and Development is increasingly gaining significance for all branches of the economy. Alongside the work of the World Business Council for Sustainable Development (WBCSD), unions and management in Germany have made this model a reality for the cement industry. Building on this, further projects are in preparation within a sustainability initiative.

Sustainable development aims to meet the needs of the present without compromising the ability of future generations to meet their own needs. In order to translate this model into specific steps, all players in the economy and in society must scrutinise the situation and their own opportunities for action.

Eco-efficiency

Firms can contribute to sustainable development in particular by an increase in eco-efficiency. This means the provision of a „rise“ in competitive goods and services with simultaneously lower environmental impacts. The World Business Council for Sustainable Development aims to promote the eco-efficiency thus defined. In the study „Toward a Sustainable Cement Industry“, among other things, measures and opportunities serving this aim are described. Some projects supporting this are for example devoted to the topics „Life Cycle Assessment“ or „Innovation“.

The social dimension

In the WBCSD, but also in the German cement industry in particular, as well as the economic and the ecological dimension, social aspects are also being considered. In a report „Sustainability and the Cement Industry“, employers and trade unions have also jointly addressed themes such as worker training or industrial safety in the context of sustainable development. Inexpensive building with

concrete, which supports the purchase of residential property, is also discussed as a social theme. Economic, ecological and social needs should be integrated in equal measure into the sustainable development and brought into balance.

Sustainability as process

The unions and management understand sustainability as a seeking and learning process, which is advanced in stages by investments and innovations. In this, the whole value-added chain from raw material extraction via cement production, concrete production and the use of cement-bound building materials through to concrete recycling, has to be taken into account. Often it is only by such comprehensive consideration as a whole that sensible solutions can be found and actual or supposed contradictions resolved.

Encouraging existing examples

In the report „Sustainability and the Cement Industry“, all aspects of sustainable development relevant to the cement industry are addressed, and the current status is defined. Here, many examples of advances in the process towards a „rise“ in sustainability can already be found today in all phases of the value-added chain. Thus the natural realm is admittedly severely stressed by raw material extraction in the cement industry quarrying sites. However, even in the operation of a quarry the living space

for many plants and animals can be favourably influenced. In addition, the quarrying is a benefit at a time when in Germany nature protection is the subsequent use in over 50% of the area. In recent decades, the emissions from cement production have been continually reduced, and the fuel energy consumption for clinker production is today already close to the process technology optimum. The accident rate in the German cement factories has fallen by two-thirds in the last 30 years. Through the development of new high-performance concretes, new possibilities for increasing eco-efficiency are opening up. The possibilities for concrete recycling, increased in recent years in Germany, are also contributing to this. The report also describes the high efficiency of concrete, which offers suitable lasting and environmentally friendly solutions both for building construction and for infrastructure measures in the construction business.

Sustainability initiatives

Following on from the report, the unions and management decided to carry out an initiative for sustainable development in the German cement industry. In addition to the further anchoring of the model in the firms and organisations of the German cement industry, the initiative will serve to intensify the dialogue with important discussion partners outside the sector. Further, projects in which ecological, economic and social aspects are interlinked will be carried out. In addition to the creation of information and training tools for the employees in the firms, these projects are concerned with the testing of innovative approaches in nature protection and raw material management, the use of secondary and possibly also renewable materials, and the possibilities for the creation of sustainable transport and logistical chains. Here on the one hand the project themes lie within the responsibility of the unions and management in the cement industry, and on the other hand, with their concern regarding the preservation of species diversity and climate protection and with ensuring sustainable mobility, fields of activity they relate to are also of considerable interest for external stakeholders. Thus, specific stimuli for the further process of sustainable development are meant to be provided.

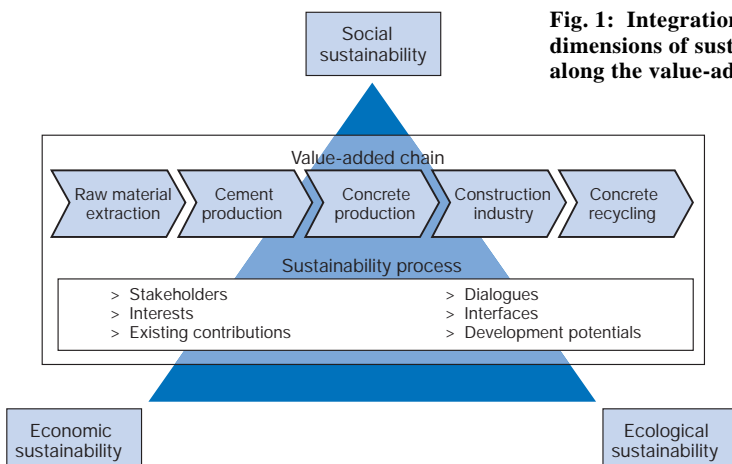


Fig. 1: Integration of the three dimensions of sustainability along the value-added chain

Current Publications from the Institute

Just under half of the budget available to the Research Institute is used for carrying out research work. Planning and direction of this work takes place in close coordination with the member companies of the VDZ. Below, some important publications of the last year are presented, which can be requested via the Internet at www.vdz-online.de.

Models for the clinker burning process

In 5 publications, G. Locher presents a comprehensive mathematical model, with which modifications to a rotary kiln installation can be studied in advance by computer. The aim of this work is the improvement of the mode of operation with regard to energy saving and environmental protection. The model considers both material and also process- and plant technology-related processes in the preheater, calciner, kiln, and cooler.

Low-chromate cements for improved industrial safety

In a review paper, the German „Trade Ruling“ on chromate is presented by M. Schneider and K. Lipus, and questions on chromate reduction and chromate analysis are answered.

Voluntary agreement of the German cement industry on climate protection

V. Hoenig and M. Schneider detail the voluntary agreement of the German cement industry on climate protection. Further, they discuss the effects on the cement industry that arise from the Draft Directive for an emissions trading scheme proposed by the EU Commission.

Possibilities and limits to NO_x reduction in the cement industry

V. Hoenig, H. Hoppe and N. Bodendiek describe the legal requirements applying in Germany to NO_x reduction and the present status of the process technology measures for meeting these requirements.

Conversion of the organic components of the raw material in the clinker burning process

In a dissertation prepared by U. Zunzer, the behaviour of organic components during clinker burning is examined. The results show that the organic compounds from up to 3% of the TOC are released as volatile organic compounds after the thermal decomposition in the presence of oxygen. A maximum of 26% of the TOC as residual coke is oxidised to carbon monoxide at temperatures below 700 °C and the remaining part

to carbon dioxide. Reduction of the organic or CO emissions by primary measures is possible only to a very limited extent, if at all.

Contributions at the DAfStb Research Colloquium on 11 and 12 July 2002

The contributions include reports on the work of the concrete technology and cement chemistry departments. In two contributions, Chr. Schneider reports on studies for the characterisation of main cement constituents and Ch. Müller on increasing the performance of Portland composite cements. Rules on the dispersion of silica dust in mortar production are described by V. Marchuk. M.T. Alonso reports on shrinkage, heat of hydration and strength development of high-strength concretes and the behaviour of such concretes under stress owing to temperature and shrinkage. V. Feldrappe devotes his contribution to the assessment of the frost resistance of high-strength concretes influenced by internal and external damage. Concrete technology approaches for the improvement of the acid resistance of pipe concretes are presented by W. Breit. E. Schäfer reports on studies on alkali binding by cement constituents, and J. Bokern on measures for the avoidance of harmful ASR in concrete. J. Rickert reports on studies on the mechanisms of action of retardants, S. Kordts on effects of the starting materials and the composition on the workability properties of self-compacting concretes. K. Lipus analyses the effect of the temperature on the sulphate resistance of concretes of differing composition, and P. Boos investigates the hydrolytic stability of coating mortars. Developments in low-noise durable concrete road pavings are described by E. Eickschen. G. Spanka presents the current situation concerning the emission of trace elements from concrete, and B. Hauer shows which measures can be taken to improve sustainability in construction with concrete.

Preparation of durable cement-bound surfaces in the drinking water field

In a dissertation prepared by P. Boos as a Gerd-Wischers scholar, the

hydrolytic behaviour of cement-bound mortars and concretes under the operating conditions of drinking water containers is analysed. Possible corrosion processes are studied in relation to the composition and porosity of the mortars. From the results basic concrete technology requirements for cement-bound coating systems in concrete drinking water containers could be derived.

New Cement Journal

The increased international orientation of the work at the Research Institute of the Cement Industry is reflected by the introduction of a new cement journal, which is to be first published, bilingually in German and English, under the title „Cement International“ by Verlag Bau und Technik at the 5th International VDZ Congress in September.

In a news section, „Cement International“ will report on developments in the cement industry and on important scientific work and government initiatives. Along with this, there will be brief technical articles. The major part of each issue will be devoted to several main contributions. Thus in the first issue three contributions from employees of the Research Institute of the Cement Industry will report on SO₂ cycles, on the sulphate resistance of mortars and concrete at different temperatures, and on the use of simulators in the training of production controllers. „Cement International“ is aimed at cement manufacturers, plant constructors, research institutes and interested specialists throughout the world. The first issue next year will appear in February.



VDZ-Mitteilungen

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Sie dienen ausschließlich der Information der Mitglieder des Vereins Deutscher Zementwerke e.V. und sind im Internet abrufbar unter: www.vdz-online.de (Mitgliederinformationen)