Environmental compatibility of cement and concrete

Water sampling tower of the drinking water barrage Frauenau
Environmental criteria for cementitious building materials

In industrial nations cementitious building materials play an extremely important role as regards construction of reliable and durable building components and buildings. Accordingly, environmentally compatible manufacture and use of cement is also very important. The cement industry was and is conscious of its responsibility towards the environment and for many years has been working towards assessing and improving the environmental compatibility of cementitious building materials in all phases of their lives. This includes cement manufacture and processing, the use of mortar and concrete as well as disposal.

The clinker burning process is a material conversion process that is characterised by the strong alkaline reaction of the kiln feed, high kiln feed temperatures of approx. 1450 °C, and intensive contact between the solids and the kiln gas, which reaches temperatures of up to 2000 °C. Thus, the rotary kilns in the cement industry present excellent conditions for the reliable and environmentally compatible utilisation of many residual materials. However, on principle the German cement industry uses only residual materials that do not have any adverse effect on emissions, the homogeneity and the structural properties of the cement as well as its environmental compatibility.

Extensive investigations carried out by the Research Institute corroborate that the utilisation of alternative materials common in the German cement industry today does not significantly change trace element contents in the product. Overall, the trace element content of German cements is within the same order of magnitude as the contents of natural rocks, soils or clays. This applies regardless of whether or not alternative materials are used in cement manufacture.

Use of alternative materials

Given its process-specific conditions, the clinker burning process is very well suited for energetic and material recycling of numerous alternative materials. In 2008, about 54 % of fuel energy consumption in the German cement industry was covered by alternative fuels. The most important fuels are processed fractions of industrial and commercial waste, used tyres, waste oil, bone meal and animal fats as well as scrap wood.

**Fig. VI-1** summarises the trend in the use of alternative fuels in the German cement industry. Energy recovery contributes towards CO₂ reduction without generating production-specific residual materials. The high temperature in the rotary kilns ensures that organic substances are almost completely converted to carbon dioxide and water. The emission concentrations of organic compounds, such as dioxins, furans, etc., are therefore very low. This applies regardless of the fuels that are used.

Depending on their chemical composition secondary raw materials can replace raw material components and are also suitable as corrective materials for the raw mix. Depending on their main constituents, they can be divided into calcium, silicon, iron, aluminium, sulphur or fluorine agents. In clinker production, fly ash, used foundry sand, lime residues and waste from the iron and steel industries are primarily utilised. The materials chiefly used in cement grinding are granulated blastfurnace slag as well as gypsum from flue gas desulphurisation.

Trace elements in cement

Like all building materials derived from natural raw materials, cement contains small quantities of trace elements. The trace element content in the clinker is substantially influenced by the trace element contents of the raw materials used in clinker production, which may differ considerably depending on the geochemical composition of the raw material source.

During the clinker burning process the physical/chemical properties of the trace elements determine the evaporation and condensation behaviour. Non-volatile elements, such as arsenic, beryllium, chromium, copper, nickel, vanadium and zinc, as well as low-volatile elements, like lead and cadmium, are almost completely discharged from the kiln system with the clinker. The highly volatile element thallium is retained in the preheater which results in an internal recirculation system being formed. In the exhaust purification systems, at temperatures below approx. 120 °C the highly volatile element mercury can condense on dust particles and be separated with these particles.

If natural feed materials are replaced by suitable alternative fuels or raw materials, their trace element content is an important assessment criterion. It must be remembered that alternative materials replace only a corresponding amount of primary materials, which also contain trace elements. With the amount of alternative materials used these days in the German cement industry, minor increases or decreases of trace element content in the cements can occur. However, these changes are normally covered by the natural variations in the concentrations of the primary feed materials.

Back in 1995, the Research Institute first investigated around 100 Portland cements from the 1994 inspection period for 10 trace elements. In 1999 and 2002, all cements manufactured in Germany and inspected by the Research Institute from the test periods 1998 and 2001 were analysed as regards the elements referred to in the German Technical Instructions on Air Quality Control (TA Luft) and the 17th Federal Immission Control Ordinance (17. BImSchV) and also for beryllium and zinc. In order to expand and update this data base, during the period under review all cements from the 2005 test period were analysed again. **Fig. VI-2** shows the average values of trace element contents in the investigated standard cements for the four manufacturing periods. As the figure shows, trace
element contents have not changed significantly, although the use of alternative fuels increased more than fivefold between 1994 and 2005 (see Fig. VI-1).

**Release of trace elements**

Like all building materials that come from natural raw material sources, cementitious building materials contain small concentrations of trace elements that are input via the cement, the aggregate and any concrete additions. Experience has shown that the trace element content of the mixing water and concrete admixtures is negligible and can be ignored in the overall consideration. However, to assess the environmental compatibility of a building material it is not the content of potentially unsafe substances that is decisive but rather the proportion that can be released to the environmental media, water, soil or air during the manufacture, use and, possibly, demolition or recycling of the respective materials.

Cement undergoes a series of complex chemical reactions immediately upon its first contact with the mixing water, during which calcium sulphate and a small proportion of the tricalcium aluminate (C₃A), for example, are dissolved and the resulting action products such as calcium hydroxide and trisulphate (ettringite) are formed. After a few minutes the cement paste suspension has a pH of 12.7 to 12.9. As a result of this high alkalinity, numerous metal ions, such as cadmium, mercury, manganese, cobalt and nickel, which might possibly be dissolved once the cement comes in contact with the mixing water, are immediately precipitated again as insoluble hydroxides. Trace elements, such as arsenic or molybdenum, which form oxyanions, are precipitated as insoluble calcium compounds. Other trace elements are absorbed on the cement phases formed or incorporated in their crystal lattice as hydration progresses further.

The leaching behaviour of environmentally relevant constituents from hardened concrete has been well researched and numerous reliable scientific results are available. On the whole, the investigations have shown that it is not the detectable quantity of trace elements in a cementitious building material that is decisive for any release but only the small amount that is dissolved in the pore water of the hardened cement paste.

Besides the chemical interactions of the trace elements with the hydration products, another factor is that during the hardening of cementitious building materials a solid, largely water impermeable structure forms. For instance, the rate of diffusion of a substance in a correctly manufactured concrete can be reduced by a factor of up to 5000 compared to free diffusion in water. Therefore, leaching of substances dissolved in the pore water of hardened mortar or concrete is possible only via diffusion processes in the liquid-filled pores. Because of the low concentrations of constituents in the pore water, the rate of diffusion is very low and the released volumes are reduced very quickly. On the whole, it can be said that cementitious building materials have no negative effect on the environment under common conditions of use.

During the period under review the research project started many years ago by a European consortium, “Environmental Criteria for Cement Based Products (ECRICEM)”, was completed. The research partners were:

- the Energy Research Centre for the Netherlands (ECN),
- the Holcim Group Support Ltd,
- Holcim Belgium,
- NORCEM, HEIDELBERGCEMENT Group,
- and the German Cement Works Association (VDZ).

Initially, the main focus of the research work was to determine the release behaviour of cementitious building materials that were manufactured with cements available worldwide (Portland cement and cements containing several main constituents) with high contents of trace elements. The results of the investigations substantiated the environmentally favourable performance of cementitious building materials. They also demonstrated that in general all the cements that were investigated – regardless of the cement type – have similar release characteristics. For example, the bandwidth of leaching results in the trough procedure for many elements was only a factor of 2.5 above or below the average.

Table VI-1 contains average values of leached trace elements in relation to the respective total content in the mortars that were investigated, which were manufactured with twenty different cements containing several main constituents. The following three leaching methods were used:

- The Dutch availability test (NEN 7341) on ground samples with a particle size < 125 µm and pH values of 4 and 7 and leaching times of three hours for each pH value as a digestion process,
- A batch procedure on crushed samples with a particle size < 2 mm and a pH value of 8 and a leaching time of 48 hours,
- A trough procedure (based on the Dutch diffusion test NEN 7345) on mortar prisms (16 x 4 x 4 cm³) with no artificial pH adjustment over a total leaching time of 64 days – as the basis for calculating the quantity of leached substances over 100 years.

Table VI-1 shows that the released quantities of trace elements differ by orders of magnitude in the three methods. But it must be remembered that in the last-mentioned trough procedure the leached quantities of elements relate to a period of 100 years. The results show that the release of trace elements from cementitious building materials has no environmental relevance under common conditions of use. It is also clear that test procedures in which specifically manufactured, largely dense mortars
or concrete structures are destroyed again during the investigation are not suitable for a practical assessment of cementitious building materials.

After the experimental work was completed in 2004, intensive work was carried out on modelling chemical reactions in cementitious building materials. The LeachXS expert system was used for the model calculations (Fig. VI-3). To assess the long-term leaching behaviour of cementitious building materials it is vital to have an understanding of the “controlling” factors that determine the solubility of a trace element in the pore water and thus also the diffusion-controlled release. For example, one specific trace element cannot be considered on its own, but only in interaction with the other components in the pore water and with the cement hydrate phases. Consideration of these interactions, such as the formation of hardly soluble compounds, like lead chromate that can have a major effect on the release of the respective elements, is possible only with model calculations.

Effects such as carbonation, the formation of protective carbonate layers, etc. on the release of trace elements from concrete in contact with surface water, groundwater or the soil are also very difficult to simulate in laboratory experiments. In this case mechanistic model calculations can be used to provide at least an estimate of how these effects influence leaching of trace elements. Based on the results of experiments, for example with long-term leaching tests in a tank leaching test (Fig. VI-4), and corresponding model calculations, it is possible to determine the “source term” for the leaching.

On the whole, it can be said that the results of the ECRICEM projects offer a scientifically sound basis for the imminent European standardisation work to embed Essential Requirement No. 3 “Hygiene, Health and Environment” in the harmonised European product standards (see European Construction Products Directive).

**Table VI-1: Average quantity of leached trace elements in relation to the respective total content for three different leaching processes**

<table>
<thead>
<tr>
<th>Element</th>
<th>Quantity of leached elements as a % of total content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Availability test Particle size &lt; 125 µm pH = 4 and 7</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>2.0</td>
</tr>
<tr>
<td>Barium (Ba)</td>
<td>14</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>8.7</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>90</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>5.1</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>8.1</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>10</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>10</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>70</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>20</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>2.9</td>
</tr>
<tr>
<td>Antimony (Sb)</td>
<td>8.6</td>
</tr>
<tr>
<td>Vanadium (V)</td>
<td>1.0</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>15</td>
</tr>
<tr>
<td>Tin (Sn)</td>
<td>2.9</td>
</tr>
</tbody>
</table>

*) extrapolated to 100 years standing time

**REACH**

The new European Regulation 1907/2006, generally known as the REACH Regulation (Registration, Evaluation, Authorisation and Restriction of Chemicals), has been in force since 1 June 2007 (for the time schedule see Fig. VI-5). The associated annexes IV and V “Exemptions from registration obligations” were only passed in October 2008. Since then, it has been official that cement clinker is exempted from the REACH registration obligations. This applies not only to Portland cement clinker, but also to calcium aluminate and calcium sulfoaluminate clinker. Also exempted are natural substances like limestones and pozzolans as long as they are not chemically modified. All other manufactured and imported substances must be registered over the next few years. Extended registration deadlines can only be made use of if the substances have been preregistered. This was possible between 1 June 2008 and 1 December 2008. Of the substances normally used in cement manufacture, hard
coal fly ashes, blastfurnace slags, calcium sulphates and chromate reducers, among others, have been preregistered. Cement manufacturers may also have to register these substances if they manufacture or import them.

The bypass and kiln dusts that occur in cement works are covered by the REACH Regulation if they are declared as a product and not as waste. Because of the variable composition with high proportions of alkali salts and free lime, it may not be possible to classify all dusts as clinker dust. Separate registration is then necessary so that the dusts can continue to be marketed as a product or in products. This is why these dusts have been preregistered as flue dust, Portland cement under the EC number 270-659-9. The VDZ acts as a third party representative for many cement works during the pre-SIEF phase (Substance Information Exchange Forum). Together with other registrants, it is being clarified which dusts accrue and under which conditions these can be registered together.

The REACH Regulation demands a hazardous substance classification for every substance, and therefore also for Portland cement clinker, by the end of 2010, which must be submitted to the new European Chemicals Agency (ECHA).

The complex subject of the REACH Regulation and the many different requirements for cement manufacturers resulting from the regulation have been discussed over the last three years by the REACH Working Group within the VDZ – incorporated into the work of Working Group 4 of the CEMBUREAU.

European Construction Products Directive

The European Construction Products Directive (CPD) demands that only construction products that are suitable for their intended use may be traded in the Single European Market. In addition to the requirements traditionally embedded in construction law, such as stability, fire protection and safety in use, it specifically refers to hygiene, health and the environment (Essential Requirement No. 3). Currently, the Construction Products Directive is being revised and, in future, is to be transferred into a legally binding regulation called the Construction Products Regulation (CPR).

While the CPD concentrates solely on the usage phase of a building as regards “Essential Requirement No. 3”, the draft CPR envisages consideration of the entire life cycle; in other words, beginning with the construction, through the usage phase to demolition. The draft CPR also includes the new
substances from construction products” was formed to develop the test and assessment procedures required under mandate M/366. In accordance with the different intended conditions of use for the construction products, the two following working groups were established:

- Working Group 1: Release into soil and ground/surface water
- Working Group 2: Emissions from construction products into indoor air

To prepare for the actual standardisation, work was commenced on developing six Technical Reports (CEN/TR) on the subjects of barriers to trade, horizontal test methods and their use, WT, WFT/FT procedures, sampling, content and radioactivity. In the period under review, the reports on barriers to trade and WT, WFT/FT procedures were completed and published as prCEN/TR 15855:2008 (E) and prCEN/TR 15858:2008 (E).

The Technical Report on WT, WFT/FT procedures, which was compiled with substantial support from the Research Institute of the Cement Industry, envisages the general procedure presented in Figure VI-6 for the classification of construction products to the WT or WFT/FT procedures. These procedures apply to the release of regulated dangerous substances into soil, surface water and groundwater and also to emissions of regulated dangerous substances into indoor air.

A condition of classification to the WT procedure is that the existing long-term experience or available test results have shown that the product contains no significant quantities of regulated dangerous substances or releases them only in insignificant amounts that are below the limit values of all EU Member States. In addition, existing knowledge about the constituents, raw materials, the production process, etc. of the respective products are to be included in the assessment.

The WFT procedure, without regular testing, is envisaged for specific products or product groups on the basis of an initial type assessment. In this assessment, the constituents, raw materials, and the release behaviour of the products will be evaluated to see if there is a significant release of regulated substances. If substances could be released, an initial type testing with harmonised European test methods must be carried out to prove that the released quantities of regulated dangerous substances are below the limit values of all Member States of the EU.
If it is not possible to classify a product to the WT or WFT procedure, it is planned that specific products will subjected to further testing according to the assessment criteria defined in their technical specifications (routine tests). If the results of the further tests show that the specific product fulfills the assessment criteria for a WFT procedure, it is planned that the manufacturer can initiate a reclassification to the WFT procedure.

As regards the necessary harmonised European test methods, for the areas of soil and ground/surface water – indoor air has a subordinate significance for purely inorganic, cementitious construction materials – it is planned that a test leaching process (monolithic materials) and a column process (granular materials) will be developed. The first drafts for these test methods, based on existing methods used in the Netherlands and Germany, have already been proposed. When these drafts have been suitably reworked, it is envisaged to start with the necessary validity tests at the end of this year, so that the work on the test methods can be completed in 2010.

**Effects on cement and cementitious construction products**

The standardisation work in CEN/TC 351 as regards the test methods is progressing well; however, it will be a few years before the entire concept, such as the WT, WFT/FT procedures can be fully implemented. The Research Institute is represented in the respective important committees and contributes the favourable experiences with cement and concrete that it has gathered over many years for components that are in contact with soil, surface water and groundwater as well as drinking water to the standardization work. The cement industry believes that the scientifically-backed results of the investigations that are available form the basis for the continued use of cement according to EN 197-1 to manufacture construction products and building components that come into contact with the soil and surface water or groundwater without having to be tested (WT procedure).

**DIBt Guideline “Assessment of the effects of construction products on the soil and groundwater”**

In Germany, standardised construction products and products approved by the building supervision authorities meet all environmental protection requirements. In the case of new, unknown construction products that require building inspectorate approval, however, potential hazards to the soil and the groundwater have to be taken into account as well. In Germany, the German Institute of Structural Engineering (DIBt) drafted the guideline on “Assessment of the effects of construction products on soil and groundwater” to summarise the scientific, technical and legal fundamentals in one fact sheet. This general concept, which applies to all construction products that come into contact with soil or groundwater, was first published in the version of November 2000. In order to take the material-specific properties of the different construction products into account in an appropriate manner, the general assessment principles for different construction products were specified by the corresponding DIBt project groups in Part II.

The corresponding DIBt project group developed an assessment model for concrete and concrete constituents that allows the results of laboratory investigations (DAfStb Guideline: Determination of the release of inorganic substances through leaching from cementitious construction materials) to be transferred to the actual groundwater impact in the immediate vicinity of a structure. The evaluation model is based on the combination of a diffusion model for leaching from the building material and a geological flow and transport model for the dispersion of the substance in the soil and the groundwater. This combination allows the concentration of a substance in the groundwater in terms of time and space to be calculated. Figure VI-7 shows an example of the calculated chromium concentrations at different distances from the concrete structure. The substance concentration in the groundwater forecast on the basis of the assessment model has to comply with the corresponding limit values (insignificance threshold). Investigations that the Research Institute carried out on concretes made specifically from cements from German cement works with high contents of trace elements showed that they all meet these requirements. However, the values were, for example, only slightly below the insignificance levels for chromium where the cement contained high levels of chromium.

In 2004, a subcommittee of the German Working Group of the Federal States on Water Issues (LAWA) revised and in some cases drastically lowered the insignificance levels laid down in the DIBt guideline of November 2000. In addition, new levels were set for other parameters, such as barium, boron, thallium and vanadium. The Conference of Ministers for the Environment gave the go-ahead for the publica-
tion of the revised and supplemented insignificance levels, which led to a situation where even concretes manufactured with conventional cements did not meet some of the parameters. However, LAWA was not willing to change these levels – with the exception of vanadium, which was suspended until 31 December 2008 after pressure from the affected building industry. They did, however, agree to a change in the underlying conditions of the DIBt assessment approach. For example, the distance from the structure for which the assessment is made was increased from the original 0.30 metres to 2.0 metres. This change somewhat cushions the effects of the tightened requirements. However, the suspension of the insignificance level for vanadium was not extended after the end of 2008, which could lead to severe restrictions for some construction materials. It can be assumed that concretes manufactured using commercial cements will, in some cases, not comply with the levels for vanadium.

The DIBt guideline also serves to argue a common German position in the European discussion on the implementation of Essential Requirement No. 3 of the European Construction Products Directive on “Hygiene, health and the environment”. The DIBt had agreed not to initiate the notification procedure until a version agreed to by the industry was available. Violating this agreement, the procedure was initiated at short notice in early 2006. As the submitted “Principles for assessing the effects of construction products on the soil and groundwater” refer to the new LAWA insignificance levels, the industry unanimously rejected this procedure. In spite of this, the notification procedure was concluded in 2008. The final version of the principles Part I and Part II (concrete and concrete constituents) can be found on the Internet via the European Commission’s Technical Regulations Information System (TRIS).

The new insignificance levels and parameters and the associated considerable reduction in permissible release rates are still emphatically rejected by the affected construction industry. This applies especially to levels that are below the limit values of the German drinking water regulations. From the industry’s point of view LAWA did not furnish evidence that such precautions, which could represent considerable limitations for building practice, are necessary. On top of this, the new insignificance levels, which were previously only recommendations by LAWA for downstream authorities, are now included, for example, in § 48 of the new draft water management law and would for this reason legally enforceable. The German Building Materials Association (Bundesverband Baustoffe - Steine und Erden e.V.) commissioned expert legal advice on § 48, which came to the conclusion: “It is not the insignificance level itself that is unconstitutional because it is based on an ideal and utopian purity requirement for groundwater; however, an emission limit that drastically overweights the degree of groundwater protection that is actually achievable and implementable is unconstitutional”.

Cementitious materials in the drinking water area

European Acceptance Scheme (EAS) for construction products in contact with drinking water

Due to the fact that it is extremely important to ensure a supply of clean drinking water, strict hygiene demands are made regarding all materials that come into contact with drinking water. The European Drinking Water Directive defines minimum requirements for all Member States. Because of this, it was also self-evident to harmonise the requirements for materials that come into contact with drinking water throughout Europe. To this end, from 1999 to 2004 drinking water hygiene experts authorised by the Member States worked in the Regulators Group for Construction Products in Contact with Drinking Water (RG-CPDW) to establish a uniform European Acceptance Scheme (EAS). The EAS was intended to apply to all materials that come into contact with drinking water and ensure that the existing consumer protection level was maintained and that it would be possible to continue using all the tried and tested materials with no restrictions.

The work of the RG-CPDW was stopped in 2004 after the EU Commission decided that there was no legal basis for the group to exist. Because of this, the regulators group was changed into an experts group that has no regulatory or decision-making competence but only an advisory function for the Commission. It was further stated that the European Construction Products Directive only covers construction products that correspond to a harmonised technical specification and that the requirements to be placed on these products are left to the individual Member States’ discretion. Thus, it is only possible to harmonise the test methods for construction products in contact with drinking water.

Cementitious materials have been used safely in all areas of drinking water supply for many years (Fig. VI-8). Therefore, CEN/TC 104 “Concrete and related products” compiled an Approved Constituent List (ACL) for constituents that could be used without testing to manufacture concrete that came into contact with drinking water.

Fig. VI-8: Inside view of a concrete drinking water vessel.
water. This ACL contains a list of constituents, such as cements, aggregates, concrete additions, concrete admixtures, etc., that are traditionally used in the drinking water area and which are approved for this purpose in at least one of the EU’s Member States. The aim of this ACL concept is to reduce the scope of testing required for building products in contact with drinking water to the extent that is actually necessary.

The EU Commission approved the concept of the ACL. It was then summarised in a Commission paper together with similar lists for plastics (positive list) and metals (composition list) and submitted to the Standing Committee on Construction (SCC) for information. It is not yet foreseeable what status will be conferred on the ACL and the other lists in the future or which committee will decide on these lists. Currently, in the “4 Member States Group” drinking water regulators from France, Great Britain, the Netherlands and Germany are discussing how the work on the EAS can be continued.

The Research Institute’s point of view is that the ACL concept should be continued, as it is a good basis for future work in the field of drinking water. This concept might also serve as a model to develop criteria for WT procedure classification in the work of CEN/TC 351 – Emission of regulated dangerous substances in indoor air, soil, surface water and groundwater.

**DVGW worksheet W 347**

Worksheet W 347 “Hygiene requirements applying to cementitious materials in the drinking water sector – testing and evaluation”. Issued by the German Technical and Scientific Association for Gas and Water (DVGW) was presented and discussed in detail in the last Activity Report. The worksheet defines the hygiene requirements for cementitious materials that come into direct or indirect contact with drinking water or untreated water that is used to recover drinking water. In the May 2006 version of Worksheet W 347, changes were made to take account of the state of the art and the relevant European testing methods. In the period under review there have been no significant changes to the worksheet. However, the inclusion of new substances in the positive list has been discussed. It is planned that in future this list will be discussed each year by the DVGW Project Group 3.4.12 “W 347” and that the extended list will be published on the Internet. The project group is also intensively following the European activities in the drinking water sector. Since the European work is likely to go on for some time yet, in the coming years the May 2006 version of Worksheet W 347 will continue to provide a solid basis for assessing the hygiene properties of cementitious materials in the drinking water sector.

**Sustainable building with concrete**

In sustainable development the needs of the current generation are satisfied without jeopardising the future generations’ chances of living. The building industry follows this guiding principle when functional structures are built at low cost and with a low impact on the environment and when they are used durably.

**German Sustainable Building Certification**

In Germany, a Sustainable Building Certification was developed by the Federal Ministry for Transport, Building and Urban Development (BMVBS) in collaboration with the German Sustainable Building Council (DGNB). This will allow sustainability to be measured in the building industry in future. In principle, the assessment is based on the life cycle of the building – from the manufacture of the building material and construction of the building through its use stage to the demolition stage. The fundamental criteria were discussed with the participation of the German Building Materials Association (Bundesverband Baustoffe - Steine und Erden e.V.) and the VDZ at the BMVBS’s Sustainable Building Round Table.

Ecological, economic and social criteria were considered equally in the overall consideration (Fig. VI-9). One ecological criterion is, for example, the contribution of the building to the greenhouse effect on the basis of its construction and use. The key economic yardsticks are the life cycle costs which, in addition to the costs of construction, also include running and maintenance costs. The socio-cultural criteria take account of the effects that the structure has on the health and comfort of its users, among other things. In addition to these three dimensions of sustainability, the technical quality of the building involves, for example, an assessment of fire and noise protection. Although only to a lesser extent, process quality is also considered with criteria such as integral planning. At the end of this process, the structure has an overall score made up from the partial scores for ecological, economic and socio-cultural aspects, which also assesses the technical and design performance. The quality of the location of the structure is also taken into account, but this aspect is not included in the overall score. The certificate is awarded in gold, silver and bronze to provide a visual illustration of the assessment.

DGNB wants the buildings to be assessed by suitably trained auditors. Initially, the certification is limited to newly constructed office and administrative buildings. The practicability of the system has been tested in some pilot projects. DGNB plans to establish the German Sustainable Building Certification outside Germany and thus compete with certificates that are already established there.
Standardisation regarding sustainable building

The European Committee for Standardisation (CEN), wants to build on the work of the ISO to establish clear guidelines for implementing sustainability in the European building industry. The general principles to describe buildings in the light of sustainability are to be described in the first of four framework documents. The three other parts will deal with the ecological, economic and social aspects. For the ecological dimension, the rules for calculating the environmental impact of a building and for drafting an environmental declaration for construction products will also be explained. Through its work in the DIN Mirror Committee, the VDZ ensures that the procedures established in Germany and accordingly regarded as practical are also incorporated into the European standards.

Sustainable concrete construction

Given its performance capacity, its wide range of applications and the large quantities of building materials used, concrete construction assumes a pre-eminent position in the building sector. This is why the development of rules and technical recommendations is of particular importance. The German Committee for Structural Concrete (DAfStb) is preparing the guideline “Basis of Sustainable Construction with Concrete (GrunaBau)”. To develop this guideline DAfStb has initiated a joint project which is funded by the German Federal Ministry for Education and Research (BMBF) and in which, under the auspices of the Research Institute, the potential for the use of alternative materials in cement and concrete manufacture will be investigated.

Ecological building material profiles

Information about the environmental effects associated with the manufacture of building materials is needed in the DAfStb project so that it can be used to calculate the sustainability indicators for a building. BMVBS also bases its sustainability assessments on suitable data. Ecological building material profiles summarise the environmental impacts related to the manufacture of a building material and provide these profiles for such calculations.

The updated building material profile for cement presents the contribution towards greenhouse potential and the contributions towards other environmental impacts for a cement that has been averaged for all the cements produced in Germany, and is based on the average proportions of cement clinker and other main constituents in 2006. The profile also takes account of the environmental impacts of upstream supply chains, for example the electricity used to produce the material. Considerable improvements have been made compared to the first calculation of the building material profile for cement ten years ago (see Table V-1). For instance, the specific contribution to the greenhouse effect has been reduced by 23 % and consumption of non-renewable energies has fallen by 38 %; contribution to other environmental impacts has also been drastically reduced. The reductions reflect the fact that in Germany more cement is produced with several main constituents but also the increased use of alternative fuels has a positive effect on many key values. The indicators determined for cement are also used as a basis for the building material profiles of cementitious building materials, such as concrete, and also for the ecological profiles of buildings constructed with these materials.
Measuring and testing methods

The Research Institute has had efficient analysis techniques to determine main, minor and trace elements at its disposal for many years. While in the past these techniques were used mainly in research projects and to clarify analytical issues, the Institute is now increasingly in demand as a service provider for these analysis tasks. As external customers need reliable investigation results quickly, the increased share of contract services demands analysis techniques that ensure high quality as well as rapid order processing. The Research Institute therefore strives to maintain state-of-the-art analysis equipment. For example, during the period under review the Institute acquired a high-performance carbon-hydrogen analyser and another ion chromatograph.

Focus on fuel analysis
For the cement industry, the steady increase in the use of alternative fuels has made reliable analysis of the carbon and hydrogen content in the fuels more important. In particular, this concerns determination of the biogenic carbon content according to the selective dissolution method and the determination of calorific values. The newly acquired carbon-hydrogen analyser is equipped with an autosampler for 50 samples (Fig. VI-10). This allows the carbon and hydrogen content of many different samples to be determined within a very short time. The standard deviations of repeatability are very low in spite of small sample weights of about 30 mg. The analyser also has very good long-term stability and only needs to be calibrated just once a year.

Due to the increase in fuel analyses, the number of fluorine, chlorine, bromine, iodine and sulphur determinations has also increased. The Institute thus acquired another ion chromatograph (Fig. VI-11) with autosampler. This allows parallel measurement of anions and cations. Both devices can cover all measurement tasks, which means that any downtime in one measuring system can be compensated for by the other. The new analysis devices have shortened testing times and increased sample throughput.