

VI

Environmental compatibility of cement and concrete

The significant rise in the environmental awareness of the general public has conferred ever greater importance on the environmental compatibility of construction materials over the past years. Decisions in favour of certain building materials and types of construction are influenced not only by technical and economic aspects, but increasingly also by ecological aspects these days. The aim behind this is to erect a structure tailored to the needs of its user which incurs as little cost as possible and causes only a slight overall environmental impact from its erection via its utilisation and up to its dismantling. The environmental compatibility of the construction materials used constitutes a crucial prerequisite for this.

Cement and concrete have proved their excellent suitability for structural elements that get in contact with soil, groundwater and drinking water for decades. Extensive investigations substantiate that the quantities of trace elements or critical organic substances present are extremely small and correspond to the input via raw and process materials. Given the high binding capacity for trace elements of the hardened cement paste and the encapsulation into the solid and dense microstructure of the hardened cement paste, the release of such trace substances during use of the structures is very low and ranges frequently around the detection limit of modern, highly sensitive analytical methods.

Reliable and durable concrete structural elements and structures, such as sewage and waste water treatment plants, contribute to environmental preservation. Direct environmental benefits are derived from the use of secondary raw materials and fuels in clinker manufacture and the utilisation of appropriate residuals in cement production. Utilisation is on principle restricted to secondary materials that do not have an adverse effect on emissions, the homogeneity and construction properties of the cement, and its environmental compatibility.

The growing importance of environmental legislation for construction is also reflected in regulations and standards. In addition to national regulations, which for example lay down the hygienic and environmentally relevant specifications for cement-bound construction materials that get in contact with soil, groundwater and drinking water, corresponding European provisions are currently being elaborated. By cooperating in the corresponding bodies, the Research Institute pursues the aims of ensuring that existing favourable experiences with the environmental compatibility of cement-bound building materials are enshrined in the regulations, and of limiting the scope of testing to the actually necessary degree.



Environmental criteria for cement-bound construction materials ■

The clinker burning process is characterised by the strong alkaline reaction of the kiln feed, high kiln feed temperatures, and intensive contact between the solids and the kiln gas, which reaches temperatures of up to 2000 °C. The rotary kilns of the cement industry thus afford excellent conditions for the reliable and environmentally harmless utilisation of a large variety of residuals.

Through its use of suitable residuals, the German cement industry makes a vital contribution to reducing environmental pollution. This helps save primary energy sources, ease the waste-disposal burden of industry and municipalities, and preserve natural raw material resources. Utilisation is on principle restricted to materials that do not have an adverse effect on emissions, the homogeneity and construction properties of the cement, and its environmental compatibility.

Secondary materials and fuels

In the year 2003, 38% of the primary fuels in clinker production were substituted for by secondary fuels in Germany. Reprocessed fractions of industrial and commercial waste, used tyres, waste oil, meat and bone meal as well as animal fat, and scrap wood are most important in this context. The recovery in clinker manufacture of the thermal content of residuals containing energy contributes to CO₂ abatement without any additional product-specific residues being generated. Given the very high temperatures prevailing in the rotary kiln firing unit, organic substances are almost completely converted to carbon dioxide and water. For that reason, the emission concentrations of dioxins and furans in particular are very low. This is true irrespective of the fuels utilised.

In addition to secondary fuels, suitable secondary by-products, such as industrial lime, used foundry sand, roasted pyrite, fly ash and residuals from the iron and steel industries, can be used as raw material constituents or corrective materials for the raw mix, respectively, in an environmentally compatible manner depending on the raw material situation of a cement works.

Trace element contents in the cement

Like all building materials made from natural raw materials, cement contains

small quantities of trace elements that enter the production process via the raw materials and the fuels. Depending on their volatility and the process conditions, these are bound in the clinker to varying degrees. For that reason, the trace element content of secondary raw materials and fuels is an important criterion for evaluating their environmentally compatible utilisation. It has to be taken into consideration, however, that these secondary materials merely substitute for a corresponding proportion of primary feed materials which contain trace elements as well.

All investigations carried out to date substantiate that the utilisation of secondary materials common in the German cement industry today does not entail any sizeable change in the trace element contents in the product. Overall, the trace element contents of German cements range in the same order of magnitude as the contents in natural rock, soil and clay, regardless of whether or not secondary materials are used in cement manufacture.

Release of trace elements

Just like cement, also aggregates and concrete additions contain small quantities of trace elements. It is, however, not the content of trace elements contained in a building material that counts in assessing its environmental compatibility, but merely the proportion that can verge into the environmental media water, soil and air during production and use. The factor decisive for release is the proportion of trace elements dissolved in the pore water. Numerous investigations confirm that most trace elements, such as antimony, arsenic, lead, cadmium, vanadium, zinc, etc., are present in almost insoluble form in fresh mortar and concrete and are released in tiny quantities only. In contrast to the trace elements enumerated before, the alkali and chromium compounds contained in the cements can be more readily soluble in the pore water. For that reason, the quantities of these substances that can be released from mortar and concrete had to be determined. Intense research activities at the Institute for Construction Research (ibac) confirmed the Research Institute's investigations on the release of alkali and chromium compounds from fresh concrete. Accordingly, chromium is the only trace element investigated that may be released from fresh concrete on a scale of environmental relevance. The investigations further showed, however, that elevated chromium contents exclusively occur in the immediate contact zone and for a short time only. The fact that release is reduced

appreciably by the dense, solid hardened cement paste matrix formed as hydration progresses is applicable to all substances. With chromium, this effect is intensified by the dissolved proportion being combined chemically in the chromate ettringite, thus verging into a virtually water-insoluble compound after a time lag.

All investigations boil down to the result that elevated element concentrations in the groundwater solely occur in the immediate vicinity of the structural element and only for brief periods of time when the concrete is placed in the saturated soil zone. Given the very low quantities, they do not durably or significantly affect the groundwater and are thus irrelevant under environmental protection aspects.

In order to gain more profound understanding of the release of trace elements from cement-bound building materials and derive criteria for assessing the environmental compatibility of mortar and concrete, a European consortium tackled the "Environmental Criteria For Cement Based Products" (ECRICEM) research project several years ago. The partners involved in this project are the Energy Research Centre for the Netherlands (ECN), Holcim Group Support Ltd., Ciments d'Obourg, Norcem A.S. and the German Cement Works Association. The main focus of research work was initially placed on characterising the leaching behaviour of cement-bound building materials, which had been made from worldwide purchased Portland cements with the highest possible trace element contents. Furthermore, two laboratory-made cements having an artificially increased trace element content were used. In this process, the leaching methods most frequently applied in Europe at present were employed. All investigations revealed that the release of trace elements from cement-bound building materials did not have any adverse effects on the environment under usual application conditions even when the trace element portion in the cement had been increased significantly by purposeful doping.

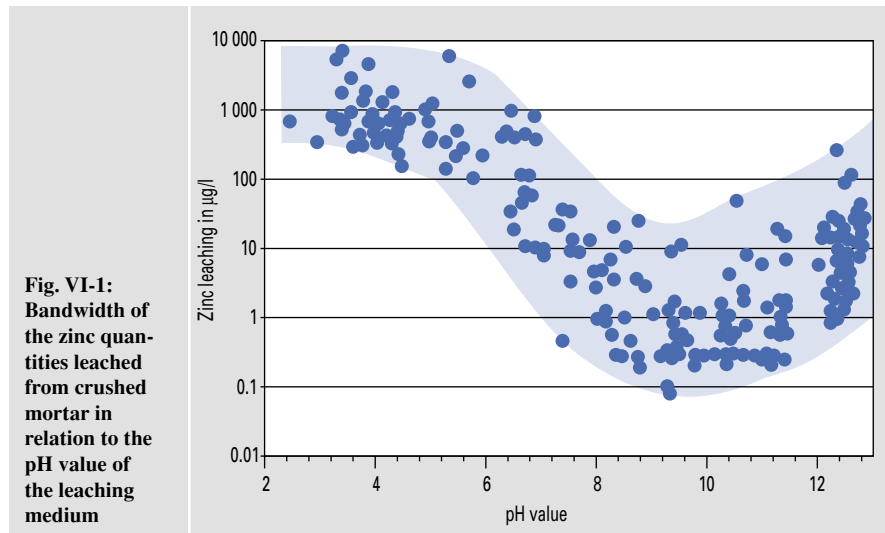
The first part of the ECRICEM project, which chiefly concentrated on trials using Portland cements, was completed at the end of 2001. In the period under review, cements with several main constituents were thoroughly investigated as part of phase two (ECRICEM II). The results of the leaching tests conducted confirmed the favourable environmental behaviour of cement-bound materials. They further showed that mortars made from cements

with several main constituents generally have the same characteristics regarding trace element release as mortars made from Portland cements.

For example, **Fig. VI-6** illustrates the bandwidth of the zinc quantity leached from crushed mortar as a function of the pH value of the leaching medium. Mortars (particle size < 2 mm) made from more than 40 different cements (CEM I to CEM V) were used in these investigations. It becomes apparent from the Figure that a comparative relation of zinc leaching to the pH value exists in spite of the considerable bandwidth. It has to be taken into account in evaluating the zinc quantities released that these leaching tests were carried out using crushed mortar and covered a wide range of pH values. Under usual application conditions, the leaching behaviour of cement-bound building materials is determined by the natural alkalinity and the density of the hardened cement paste. Zinc release is therefore not environmentally relevant. The element chromium was found to be an exception with regard to general release characteristics. Mortars made from cements containing blastfurnace slag turned out to release only very small quantities of chromium which were even appreciably lower than the values of chromate-reduced Portland cements. The results suggest that the low release is attributable to the reducing constituents contained in blastfurnace slag.

In addition to the leaching tests, the modelling of chemical reactions in cement-bound building materials formed a key subject in the period under review. Understanding of these reactions, which determine the solubility of the corresponding substances in the pore water and thus diffusion-controlled leaching, too, forms the basis for describing the long-term behaviour of cement-bound materials in contact with drinking water, groundwater and soil. This modelling can further serve to better describe criteria for the environmentally compatible utilisation of secondary materials in the cement industry.

The work performed further covered potential release scenarios and modelling of the leaching and spreading of substances in soil and groundwater. Laboratory results can only be assessed appropriately on the basis of a given soil and groundwater quality at a certain distance from the structure, in combination with suitable standardised release scenarios. The results of the ECRI-CEM project will leave their mark on the scheduled European standardisation work.



They can contribute to affording a scientifically secured basis for the discussions on enshrining the essential requirements for hygiene, health and the environment in the harmonised European product standards.

European Construction Products Directive ■

The European Construction Products Directive was adopted in the year 1989. It stipulates that the construction products traded in the European domestic market be such that the structures made from them comply with all major requirements, e.g. for stability, fire resistance, fitness for use, and durability. In addition to these requirements traditionally enshrined in building legislation, the European Construction Products Directive purposefully refers to the protection of hygiene, health and the environment.

Standards harmonised for the purposes of the European Construction Products Directive are required to comprise the provisions necessary to ensure the protection of the immediate vicinity of a structure. The elaboration of such provisions presupposes, however, that the corresponding building regulations in the EU member countries include qualitative and, if necessary, also quantitative specifications. An analysis of the specifications existing in the member countries revealed that quantitative specifications for construction products obviously exist in only two member countries – Germany and the Netherlands – at present. These pursue the goal of limiting the release of hazardous substances from construction

products to the environmental media water, soil and air during the use of structures.

As a result of this low number of corresponding national regulations, the harmonised European product standards adopted to date, which include the European cement standard EN 197-1, exclusively comprise general references to existing national specifications so far. A concept for attestation of conformity and pertinent conformity attestation instruments, such as methods of testing and analysis, are to be worked out for the future compilation and revision of harmonised technical specifications now. To that end, the EU Commission drafted a mandate entitled “Development of horizontal standardized assessment methods for harmonized approaches relating to dangerous substances under the construction products directive”. The “Standing Committee on Construction (SCC)” agreed to the mandate at the end of 2004.

Conformity attestation concept

With the involvement of the interested parties, a multistage concept for attestation of conformity could be asserted with the EU. Acting as representatives of the European building materials industry, employees of the Research Institute took an active part in the corresponding consultations. The multistage concept is to ensure that conformity attestation is only required when it is actually necessary upon assessment of the potential hazards which the respective building material may cause to the environmental media water, soil and air. In detail, the three following options for conformity attestation have been provided for:

- Attestation of conformity without testing, so-called “WT products”
- Attestation of conformity without further testing, so-called “WFT products”
- Attestation of conformity with further testing, so-called “FT products”.

To assess potential environmental hazards by building products, the release of hazardous substances to the interior air of structures (liberation of gases) and the release of hazardous substances to the soil and the groundwater (leaching) are examined. The liberation of hazardous substances in the form of gases should be irrelevant for purely inorganic cement-bound building materials.

Conformity attestation instruments

In order to be able to assign the construction products to the types of conformity attestation described above, the required instruments are to be harmonised throughout Europe by establishing corresponding European standards. Prior to their application, it must be ensured that practical experiences gathered from the application of the respective construction products are incorporated appropriately. This is particularly important when conformity attestation does not imply testing (WT product).

When tests are required to classify a construction product as WFT product, characterisation tests have been provided for. These tests serve to assess both the content and the release of hazardous substances. In the case of products to be tested to evaluate conformity, these are called initial and routine tests. To that purpose, standardised methods of testing which are largely horizontal, i.e. basically independent of the individual products, have to be worked out.

According to the ideas of the EU Commission, the decision on the attestation of conformity required for a construction product is to be made by the member states, which are represented by the “Standing Committee on Construction”. This applies to the exemption from testing for WT products in particular. The EU Commission will set up the “Dangerous Substances” expert group to prepare these decisions. If possible, the expert group is to refer only to drafts that have been drawn up by the European standardisation and approval institutions CEN and EOTA, respectively, i.e. by the competent product committees. FIZ representatives are involved in the crucial product committees and will introduce their positions into the competent expert group

via the Association of European Building Material Manufacturers (CEPMC).

Effects on cement-bound building materials

Cement-bound building materials have proved themselves in structural elements that get in contact with soil and groundwater for decades. Extensive laboratory investigations substantiate that trace elements or critical organic compounds are present only in trace amounts that correspond to the input via raw and process materials. Under the use conditions of the structures, the release of such trace substances is very low, often ranging around the analytical detection limit. This statement can be corroborated by extensive investigations that also covered cements made using secondary raw materials and fuels (see section on “Environmental criteria for cement-bound building materials”).

From the cement industry’s perspective, the present investigation results afford the basis for the use of cements according to EN 197-1 in the manufacture of construction products and structural elements in contact with soil and ground water without testing (WT product). More specifically, this classification will have to be argued in member countries where construction products have to meet requirements regarding the protection of the soil and the groundwater. This currently applies to the Netherlands and Germany.

DIBt Guideline „Assessment of the effects of construction products on soil and ground water” ■

The corresponding approval tests for those construction products which require building inspectorate approval also have to take into account potential hazards to soil and ground water. The Guideline „Assessments of the effects of construction products on soil and ground water” issued by the German Institute for Building Technology (DIBt) summarises the corresponding scientific, technical and legal fundamental principles. This general evaluation concept, which is effective for all construction products in contact with soil and ground water, was published in the version of November 2000 and is currently being revised.

In order to take the material-specific properties of the different building materials into account in an appropriate manner, the general evaluation principles are specified for different construction products

in Part II. To that end, the DIBt set up the task forces

- concrete and cement-bound building materials,
- soil injection agents and
- agents for sewer renovation.

During the period under review, the “Concrete and cement-bound building materials” task force completed the evaluation concept for “Concrete and concrete constituents”. Although this evaluation concept has not been published yet, the DIBt is already applying it in approval testing.

The evaluation concept applies to cement, concrete additions, concrete admixtures and aggregates as well as to construction mortars and concretes which require general building inspectorate approval. The DIBt experts specify the tests to be carried out, making reference to the information on the construction product provided by the manufacturer. Different leaching methods are available to determine the release of substances.

For the rare cases of water-permeable concrete construction, the competent expert committee specifies the testing methods on a case-by-case basis. Water-impermeable construction above ground water level is generally regarded as uncritical, which is why leaching tests have been provided for in exceptional cases only. These have to be conducted in accordance with the trough method developed by the Research Association for Roads and Traffic (FGSV). Accordingly, the ingredients in the eluates are required to comply with the no effect levels laid down in the DIBt code of practice or the limit values of the drinking water ordinance or comparable values straight away.

Water-impermeable construction in the ground water is evaluated by referring to the contact ground water to assess the release from real structural elements. Model calculations serve to determine leaching from the building material by means of a diffusion model, and the dispersion of the substance in the soil / ground water by means of a geological flow and transport model. The combination of the two models allows to predict substance concentrations in the ground water in relation to time for defined framework conditions (Fig. VI-2).

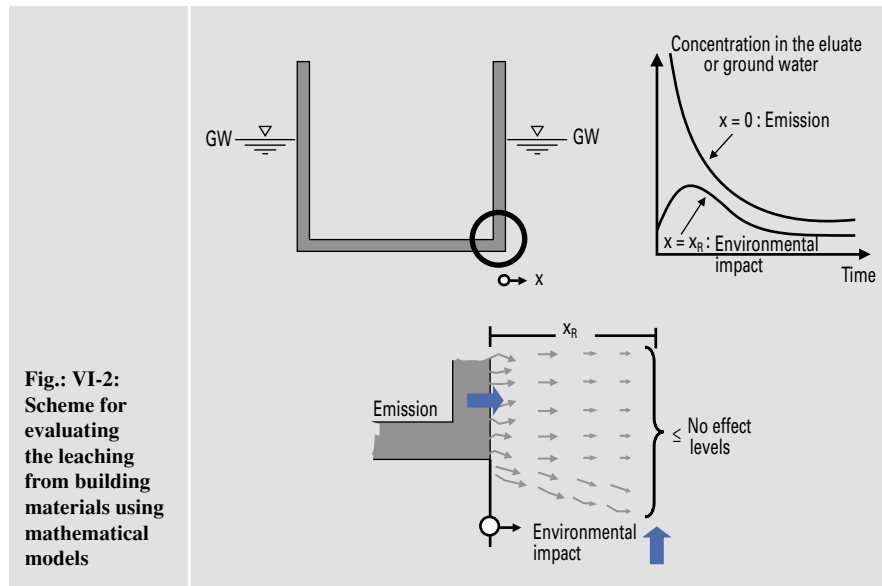
The calculation of release by means of the diffusion model can be performed based on the results of long-term tank leaching tests.

A working group of the German Committee for Reinforced Concrete (DAfStb) prepared the standardisation of a corresponding test for hardened concrete in cooperation with the Research Institute. It includes leaching tests of concrete cubes ($10 \times 10 \times 10 \text{ cm}^3$) and the extraction of six eluates obtained after different testing times. The total test duration is 56 days.

The framework conditions for model calculation specified in Part II of the DIBT Guideline “Concrete and concrete constituents” are a structural element surface of 400 m^2 , a permeability factor of the soil of 10^{-4} m/s , an effective porosity of 0.1, and a hydraulic gradient of 10^{-3} . The layer of the contact ground water (X_R) applied for small-scale averaging is 0 to 0.3 m thick. The period of time for which the average is determined is 6 months. A soil temperature of $10 \text{ }^\circ\text{C}$ is assumed. Retardation, chemical or biological decomposition must not be taken into account in the calculation. These tight framework conditions were set deliberately in order to ensure that a large variety of application areas are covered by conventional conformity attestation.

On the basis of these model parameters, the maximum permissible release quantities to be complied with during the 56-day tank leaching test can be calculated by means of the release model with reference to the respective no effect levels specified for the various substances. **Tab. VI-1** summarises the trace elements to be investigated in cement-bound building materials at present, and the permissible release quantities.

A subcommittee of the Federal State Water Consortium (LAWA) has been concerned for quite some time with revising the existing no effect levels and deriving new values for further parameters. These include barium and vanadium, for example. The Conference of the Ministers for the Environment gave the go-ahead for publishing the revised and supplemented no effect levels at the end of 2004. DIBt can be assumed to incorporate the new values and parameters in the code of practice. Which of the new parameters will be relevant to the specific Part II “Concrete and concrete constituents” is still open to discussion. **Tab. VI-2** lists the new no effect levels laid down by LAWA opposite the DIBt values currently in effect. It becomes obvious from the Table that the values were lowered drastically in some cases. This applies to cadmium and zinc, for example. The new value for vanadium was set very low, too. Application of the no effect level for vanadium has been suspend-



Tab. VI-1: Maximum permissible release from cement-bound building materials in the long-term tank leaching test after 56 days according to the DIBt Guideline Part II

Element	Maximum permissible release in the long-term tank leaching test after 56 days in mg/m^2
Arsenic (As)	5
Lead (Pb)	12
Cadmium (Cd)	2,4
Chromium (total Cr)	24
Chromium (Cr(VI))	4
Cobalt (Co)	24
Copper (Cu)	24
Nickel (Ni)	24
Zinc (Zn)	150

ed until December 31, 2007, however, in order to enable industry to complete the incomplete data base on toxicity to humans and ecology and to furnish proof that a higher value is justified under scientific aspects.

The new no effect levels and parameters and the associated considerable reduction of the permissible rates of release are emphatically questioned by the parties in building practice concerned. Moreover, it appears to be unusual and astonishing that industry has to furnish the proof required for appropriate classification.

To gather more profound experiences with the DIBt evaluation concept for cement-bound building materials, the Research Institute produced 13 concretes in accordance with the concept and tested them in long-term tank leaching tests in the period under review. In order to get a bandwidth of trace elements in standard cements manu-

factured in Germany that is as large as possible, cements having the highest content possible of one or several trace elements were deliberately employed in concrete production. **Tab. VI-3** lists the maximum values of the 13 cements investigated opposite the average values of German standard cements (VDZ: Trace elements in German standard cements 2001).

Tab. VI-2: Comparison of the DIBt values currently in effect and the new LAWA no effect levels for inorganic parameters for evaluating locally restricted ground water pollution

Inorganic parameter	No effect level in µg/l	
	DIBt code of practice	LAWA value
Antimony (Sb)	10	5
Arsenic (As)	10	10
Barium (Ba)	-	340
Lead (Pb)	25	7
Boron (B)	-	740
Cadmium (Cd)	5	0.5
Chromium, total (Cr)	50	-
Chromate (Cr)	8	7
Cobalt (Co)	50	8
Copper (Cu)	50	14
Molybdenum (Mo)	50	35
Nickel (Ni)	50	14
Mercury (Hg)	1	0.2
Selenium (Se)	10	7
Thallium (Tl)	-	0.8
Vanadium (V)	-	4*
Zinc (Zn)	500	58
Tin (Sn)	40	-
Chloride (Cl ⁻)	-	250 000
Cyanide, total (CN ⁻)	50	50
Cyanide, easily releasable (CN ⁻)	10	5
Fluoride (F ⁻)	750	750
Sulphate (SO ₄ ²⁻)	-	240 000

*Application of the no effect level for vanadium has been suspended until December 31, 2007.

Tab. VI-3: Comparison of the maximum trace element contents in the cements used for concrete production and the mean values of German standard cements (VDZ: Trace elements in German standard cements 2001)

Element	Maximum value of the cements in mg/kg	Mean value of German cements in mg/kg
Antimony (Sb)	23.1	2.9
Arsenic (As)	37.5	7.0
Barium (Ba)	14 990	No information
Lead (Pb)	34.4	17
Cadmium (Cd)	1.0	0.4
Chromium (Cr)	118	41
Cobalt (Co)	13.1	8.7
Copper (Cu)	108	31
Manganese (Mn)	4 503	759
Molybdenum (Mo)	14.2	No information
Nickel (Ni)	44.3	23
Mercury (Hg)	0.08	0.06
Thallium (Tl)	1.8	0.4
Vanadium (V)	190	50
Zinc (Zn)	303	192
Tin (Sn)	5.4	3.6

The results of the long-term tank leaching tests show that the majority of eluate values for the various trace elements were below the determination limit of the highly sensitive detection methods applied. The tests did not yield measurable values for the elements arsenic, lead, cadmium, thallium and tin. All the elements investigated fell short

of the DIBt values currently in effect (Tab. VI-1). With regard to the new no effect levels and parameters laid down by LAWA, the situation was slightly different. When the permissible rates of release in long-term tank leaching tests were calculated on the basis of the existing model and the framework conditions presently specified, the

leaching of barium, chromate, nickel and vanadium turned out to exceed the limits in some cases.

The considerable lowering of the no effect levels is not acceptable to building practice. From the industry's point of view, LAWA did not furnish the required proof that precaution on such an extensive scale is necessary. With the exception of vanadium, however, LAWA is not willing to drop these values. They indicated, however, that the framework conditions applied in model calculation might possibly be adapted. For example, an increase from the current 0 to 0.3 m to a range from 0 to 1.0 m or 2.0 m (i.e. still the immediate vicinity of a structure) in the thickness of the layer (XR) for small-scale averaging would somewhat alleviate the impact of the tightened requirements. It is to be hoped that a solution satisfactory for both sides will be found in the scheduled discussions.

DVGW worksheet W 347 ■

Due to the great importance of drinking water being supplied in perfect condition, all materials, which get into direct contact with the drinking water during its production or storage or during its transport from the producer to the consumer, are subject to strict hygiene specifications. Cement-bound materials have proved themselves in all domains of drinking water supply for decades. The Worksheet W 347 "Hygiene requirements applying to cement-bound materials in the drinking water sector – testing and evaluation" (issue of October 1999) by the German Gas and Water Engineering Association (DVGW) is the first regulation ever established to take into account the specific properties of cement-bound materials in contact with drinking water in an appropriate manner. The Worksheet is currently being revised at the instigation of the DVGW. This measure was prompted by the introduction of the European standards for cement, aggregates, concrete admixtures etc. and the work of AHG 6 "Influence of cement-bound products on water intended for human consumption" of CEN/TC 164 "Drinking water supply".

In the current draft of the Worksheet, the pretreatment of the specimens and the composition of the testing water were adapted to the draft of the European test standard entitled "Influence of factory-made cement-bound products on organoleptic parameters". According to the research results available to date, however, this will have hardly any influence on the evaluation of cement-bound materials with

regard to drinking water hygiene. Given the favourable experiences gained with the existing Worksheet, a number of tests were dispensed with in the new draft. For example, testing of TOC release is no longer required for structures located in drinking water protection zones, and testing of taste was cancelled from the organoleptic parameters.

An essential conceptual modification of Worksheet W 347 was prompted by the harmonised European cement standard EN 197. German drinking water hygiene specialists were not willing to accept the range of European cement types, which was extended considerably in comparison to the range included in DIN 1164, without additional specifications for the drinking water sector. They first stipulated to limit the total content of certain trace elements in the cement. The result achieved in intense discussions was that the trace element contents in the cement are not specified as absolute “limit values”. Instead of that, the permissible contents listed in **Tab. VI-4** were laid down for some elements. If these values are complied with, no separate leaching tests are required. If these contents are exceeded, leaching tests must be carried out to verify that the maximum permissible release quantities of the corresponding elements, which are given in the Table as well, are observed. Lithium release only needs to be tested when lithium compounds are utilised as concrete admixtures.

The cements manufactured in Germany meet the total contents and the permissible release quantities given in **Tab. VI-4**. The new issue of Worksheet W 347 is expected to be completed and adopted in the year 2005.

European Acceptance Scheme for construction products in contact with drinking water

Drinking water hygiene specialists authorised by the EU member states have been working on a “European Acceptance Scheme (EAS)” for construction products in contact with drinking water in the “Regulators Group for Construction Products in Contact with Drinking Water (RG-CPDW)” since 1999. The EAS is to apply to all construction products that get in contact with drinking water, such as plastics, metals, cement-bound materials, etc. Based on an EU mandate referring to the European Drinking Water Directive and the Construction Products Directive, attestation of conformity and the specific material requirements are to be harmonised. The European acceptance scheme

Tab. VI-4: Total trace element contents in the cement the transgression of which requires a leaching test, and the corresponding permissible release quantities

Element	Total content in cement in wt.%	Release quantity in mg m ⁻² d ⁻¹
Arsenic (As)	0.01	0.05
Lead (Pb)	0.05	0.1
Cadmium (Cd)	0.001	0.05
Chromium (Cr)	0.05	0.3
Nickel (Ni)	0.05	0.2
Lithium (Li)	No requirement	0.3

to be worked out is to be based on the following principles:

- Preservation of the respective national consumer protection levels in place
- Guarantee of possible application for all common materials
- Compilation of a comprehensive acceptance system
- Guarantee of transparency and confidentiality

Regulators group “Cement”

While the work on plastics and metals in the drinking water sector was commenced in the immediate aftermath of the establishment of the regulators group, cement-bound materials were dealt with only marginally for a long time. At the end of 2003, a RG-CPDW subgroup “Cement” was set up, which is to work out proposals for positive lists, proven constituents and acceptance criteria. The subgroup is made up of regulators and experts, respectively, from Belgium, France, Germany, the Netherlands, Spain and the United Kingdom as well as a delegation of CEN/TC 104 “Concrete and associated products”, which is in charge of concrete standardisation. The Federal Ministry for Health and Social Security appointed an employee of the Research Institute as the expert who is to represent Germany.

Discussion of the concept of an Approved Constituent List (ACL), i.e. a list that comprises the constituents that may be used in in-situ concrete with subsequent drinking water contact without testing, which was proposed by the CEN/TC 104, will represent a major aspect of the work to be performed. The ACL currently is a list of constituents, such as cements, concrete additions, concrete admixtures, etc., that have a tradition of use in the drinking water domain and are approved for that purpose in at least one member state. Furthermore, the starting materials for concrete admixtures have to be included in a positive list to be drawn up, which serves as an attestation of the substances’ toxicological suitability

for application in the drinking water sector. The data and information, respectively, which will be required for this initial list to be accepted for the purposes of the EAS in the future is not foreseeable yet. Moreover, the committee or expert group, respectively, that will have the say over the ACL has not been determined yet.

It is the objective of the ACL to reduce the scope of testing for products in contact with drinking water to the extent that is actually necessary. It is helpful for the classification of substances in the ACL when the requirements of the drinking water domain are already included in the pertinent product standards. Drinking water hygiene specialists take a very critical stance towards organic additives (in cement), for example. For that reason, a reduction in the maximum permissible input quantity of such substances from the current 0.5% to 0.2%, for example, is being discussed as part of the scheduled revision of the harmonised cement standard EN 197-1. If this value is exceeded, it has to be declared.

The Research Institute is intensely involved in the work regarding the drinking water sector, since the regulations laid down for this particularly sensitive domain might possibly become relevant for other areas of application for cement-bound materials as well. The ACL might, for example, serve as a model for establishing criteria governing the classification as a so-called WT product (attestation of conformity without testing) for the purposes of the Construction Products Directive.

Sustainable building ■

Sustainable building is defined as the erection of a structure tailored to the needs of its users which causes low overall costs and environmental impacts from its erection via its useful life, and up to its dismantling. The environmental compatibility of the building material, i.e. its completely harmless use in direct contact with water, soil and (interior) air, constitutes a fundamental prerequisite for this goal. In addition to that, the environmental impacts associated with the erection, such as the consumption of energy resources or air-borne emissions, are included in the integrated assessment of the structure, as is the cost of production. However, assessment invariably has to cover the costs accrued and environmental impacts caused throughout the service life. For that reason, the decisive contribution a building material makes to sustainability is inherent in its potential to be used in erecting a structure that simultaneously serves its purpose and saves costs as well as the environment.

Round table on sustainable building

The Federal Ministry for Transport, Building and Housing (BMVBW) set up a "Round table on sustainable building" in which the interested parties, i.e. building material manufacturers, the construction industry, architects and public-sector clients are represented. The objective of the round table is to find a consensus on the fundamental principles of sustainable building and their practical implementation. These are to be applied in building projects commissioned by the federal government in particular at first. In this way, the BMVBW continues the development of sustainable building, which was begun by the issuance of the guidance paper "Sustainable building" in March 2001.

The question about the distinctive features of sustainable building is a central topic of discussion at the round table. In the meantime, the round table specified indicators that are to be tested under practical conditions in construction projects commissioned by the federal government for a trial phase once some detail questions still open at present have been clarified. The list of indicators for example comprises parameters of life-cycle analysis. These include the greenhouse potential as well as construction costs and the costs incurred for use of the structure. Thermal comfort was proposed as an indicator for cosiness and may serve as an example for a parameter from the social dimension area.

A consensus on an appropriate parameter for the description of some special facts, such as the utilisation of non-calorific raw materials, has not been reached yet. Furthermore, capturing special aspects by a characteristic value will prove difficult in some cases. This is true for cosiness, for example. Purely verbal description could be more appropriate in these cases. Moreover, the extent to which computer models may be applied in the integrated assessment of the sustainability of structures in the future will have to be examined. The decisive criterion for such software will be that it supports the consensus on the course of action reached at the round table, instead of the implementation being adapted to existing programmes.

The useful life of a structure has vital influence on its sustainability rating. In this context, the BMVBW has tried to replace the tabular summary of the service life of structural elements, which is considered too general on the whole, by a more differentiated approach. To that purpose, it must be possible to take into account the increases in durability achieved in the respective building tasks as a result of planning and execution. It will have to be checked whether this way of proceeding will do justice to the individual types of construction, such as concrete construction, for example.

The further activities of the BMVBW relate to the development of a guidance paper on sustainable construction for existing buildings, and to giving prominence to exemplary structures. VDZ attends this work in collaboration with the Federal German Cement Industry Association and the German Building Materials Association (BBS) through participation in the round table and its working groups.

Environmental labelling

Environmental declarations serve to document the environmental impacts ensuing from the manufacture of a product, thus creating the preconditions for the ecological assessment of its life cycle. In contrast to ordinary environmental labels, these environmental declarations do not comprise product evaluation. Much rather, they document the environmental impacts associated with the manufacture and – as far as known – with the use of a product.

Environmental impacts are determined by life cycle assessment; they are essentially based on the consumption of raw materials and energy as well as the emissions and the waste generated by production. In this

context, the environmental impacts caused by the previous history, e.g. in the generation of the fuels required in the production process or of the electrical power consumed, are taken into consideration as well. In the field of construction, this information on construction products contributes to an integrated assessment of the life cycle of structures, provided that it is available for all major construction products. Proper evaluation, however, invariably has to include the environmental impact caused by the use of the structure, too, which is often significantly higher than that ensuing from the manufacture of the construction product.

Even the "Integrated assessment of building materials and structures (GaBi)" project, in which the cement industry was involved, already developed a building material profile that pre-empted the crucial elements of such a declaration (see Activity Report 1996 – 1999). The information contained in an environmental declaration for cement that is listed in **Tab. VI-5** largely corresponds to the data categories established in the GaBi project and has come to be generally regarded as a major constituent of a declaration in the European cement industry. The declaration can specifically refer to the cement manufactured at a certain plant. It may as well reflect the environmental impact for a generic cement, such as an assumed national or European average cement. In practical application, generic data will usually suffice as information for assessing a structure in order to incorporate the environmental impact associated with a construction product in the planning process.

The environmental declarations that the Consortium for Environmentally Compatible Construction Products (AUB) established for other construction products in Germany contain comparable information. If applicable, these environmental declarations additionally indicate the immediate environmental impacts on the media water, soil and, most particularly, interior air. Since these approaches are comparable, it may be possible to establish environmental declarations for cement which correspond to the declarations for other building materials issued in Germany, and which are largely understood and accepted in Europe at the same time.

Standardisation

The international standards organisation ISO has been working on a set of standards on sustainable building for several years already. The basic idea behind this broadly based set was to assess all structures throughout their life cycle. In this process, the construction products required for erection and the vicinity of a structure are taken into account (see Fig. VI-3). The potential parameters of sustainable building will be summarised in a draft standard that shows the ecological, economic and social aspects to be considered in general and illustrates them by parameters used as examples. The environmental evaluation of structures as part of sustainability assessment will be further specified in a separate draft standard, which will assess both parameters of life cycle assessment and indoors factors, such as noise, emissions to interior space, or light quality. Most progress has been made on the draft standard covering the environmental declaration of construction products, which goes beyond provisions regarding the content of the declaration. This draft standard for example also deals with aspects such as verification of the declaration, or the way of proceeding in deriving data inquiry rules specific to construction products. In many aspects, it follows standard ISO 14025, which is being revised at the same time and gives a general description also of the environmental declaration of products that do not belong to the construction sector. According to what is known, the building trade is thus the first sector in which the vision of sustainability has found explicit expression in standardisation projects.

In spite of that, the approach pursued by the ISO does not go far enough in the European Commission's opinion. It fears that the diverging national trends regarding the construction product declarations in particular may result in trade barriers that cannot be countered adequately by ISO standardisation. As a consequence, CEN was given the mandate to develop more specific standards both for evaluating the environmental performance of structures and for the environmental declaration of construction products. This European set of standards is to comprise a standard on the life cycle assessment of construction products and a standard on summarising life cycle analysis data at structural level as well. As these standards will not be sub-

Tab. VI-5: Data categories in a potential environmental declaration for cement

Raw material consumption	<ul style="list-style-type: none"> • Primary raw materials • Secondary raw materials
Water consumption	
Energy consumption (including electrical power)	<ul style="list-style-type: none"> • Primary energy sources • Secondary energy sources (each subdivided into renewable and nonrenewable sources of energy)
Potential environmental impact due to gaseous emissions	<ul style="list-style-type: none"> • Greenhouse potential • Acidification potential • Ozone depletion potential • Photo-oxidant potential (summer smog) • Nutrification potential
Waste for landfilling	<ul style="list-style-type: none"> • Non-hazardous waste • Hazardous waste

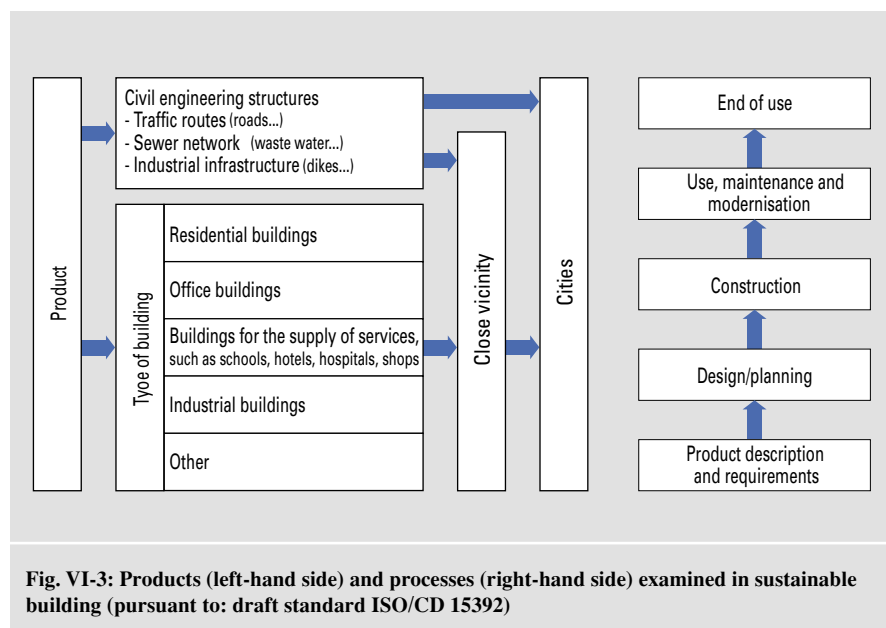


Fig. VI-3: Products (left-hand side) and processes (right-hand side) examined in sustainable building (pursuant to: draft standard ISO/CD 15392)

ject to the Construction Products Directive, they will remain voluntary. It is foreseeable all the same that these standards will have great influence on the environmental declaration of construction products in Europe.

Sustainable concrete construction

Implementation of sustainable building in practice presupposes the existence of specific aids for the individual types of construction. The German Committee for Reinforced Concrete (DAFStb) set itself the goal to compile a paper on the general principles of sustainable building with concrete in the medium run that is to close this gap. In order to achieve this aim, DAFStb prepared a research project the first phase of which is to be started in the year 2005, provided that the Federal Ministry for

Education and Research grants sponsorship. Among other topics, the project is to examine the question of how sustainability evaluation can be adapted specifically to concrete construction. In addition to that, it will address central issues of building material technology, design and life cycle management. VDZ is involved in the planning of this project via the Research Institute. In case of the project being approved, it will contribute to the research activities by compiling a study on the potential of secondary material utilisation in concrete construction.