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Waste Materials in Construction: Putting Theory into Practice

Research and Standardization Programme for Determination of Leaching Behaviour of Construction Materials and Wastes in the Netherlands.

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1. Background.

In 1980 a study group (**'SOSUV'**) was formed in the Netherlands with the aim to develop a set of standard laboratory tests for the determination of the leaching behaviour of solid combustion residues. The SOSUV group drafted test procedures to simulate leaching under different field conditions for both granular waste materials and monolithic waste matter. After the early work of the SOSUV group a substantial research programme supported by the government was launched to test a great variety of other bulk waste materials with potential for utilization (**'Mammoth-project'**). As a reference also natural construction materials (e.g. cement, sand, gravel, concrete) were included within the project.
During the course of the Mammoth-project two national standards were published:

- **NVN 2508** 'Determination of leaching characteristics of combustion wastes'
- Draft-**NVN 5432** 'Determination of the maximum leachable quantity and the emission of potentially hazardous components from products in which combustion wastes are incorporated'.

In recent years a many other granular waste materials and waste-derived products have been studied. It was observed that the leaching behaviour of a great many substances could be interpreted on the same basis as used for the characterization of combustion residues. The standard methods NVN 2508 and NVN 5432 for combustion residues apparantly also apply for many other waste materials.

In 1990 a special task group was asked to extend the scope and applicability of NVN 2508 and NVN 5432 to comparable materials and to develop additional standards necessary for detailed characterization of other construction materials and wastes. With support of the Netherlands Standardization Institute (**NNI**) and the Netherlands Agency for Energy and the Environment (**NOVEM**) an ambitious multi-year project programme was started [TSP 90]. The leading role in the execution of this programme is performed by a newly established standardization committee (**NNI-Committee 390 011**).

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Apart from the national research and standardization programme a variety of **field studies** was launched by several interested parties in order to obtain direct leaching information from specific road construction projects, ground works, and waste deposits. In part these field experiments were also ment to link the measured contaminants diffused in the soils around the constructions with predictions based on the results of standardized laboratory experiments with the applied materials.

2. Scope and contents of the Research and Standardization Programme.

For the environmental characterization of construction materials and wastes several tools are needed:

- a classification system based on the most important physical and chemical characteristics;
- standardized test methods for the determination of the chemical composition and the leaching properties;
- guidelines for the interpretation of test results in relation to the proposed end use;
- legal acceptability criteria and procedures.

In order to make such tools available for all relevant materials a step by step standardization programme was prepared along the following lines:

- the programme must result in a complete set of standards and guidelines based on a sound scientific understanding of potential environmental impacts;
- the programme must be supported by all relevant parties from government, building industry, and advisory bodies;
- for a priority list of constructiom materials and waste products the most important standards need to be available within a period of 2-3 years (see appendix);
- all standard procedures have to be screened with respect to practical consequences and costs.

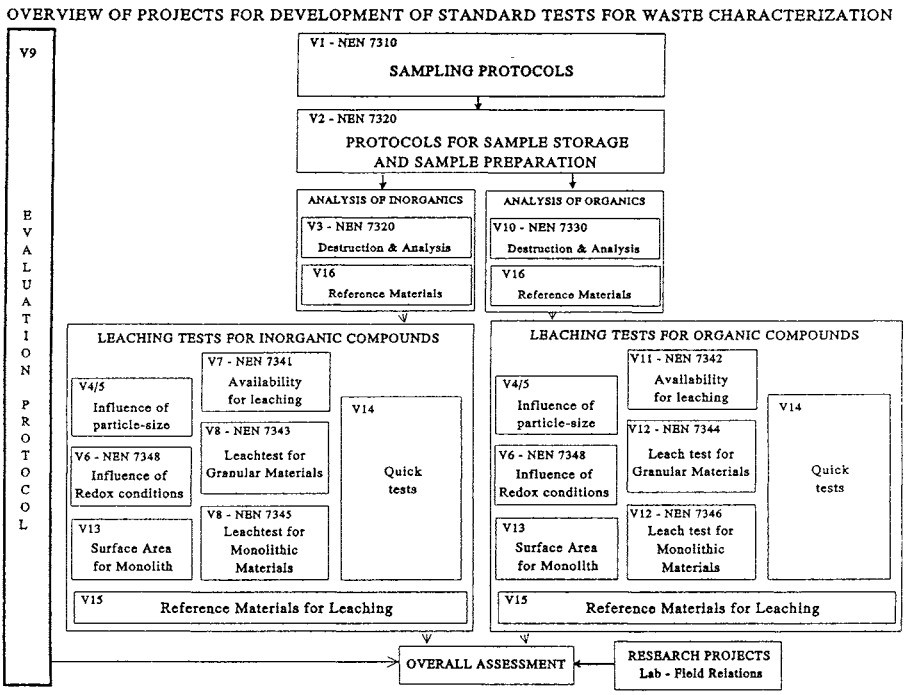
With the above mentioned guidelines in mind a Standardization Programme was started with the intention to prepare as a first step all readily obtainable standards on the basis of existing knowledge. The standardization programme consists of 15 projects on the subjects:

. Sampling protocols and techniques
. Protocols for sample storage and pre-treatment
. Destruction and chemical analysis of the solid phase
. Leach tests for inorganic and organic compounds
. Analysis of the leachate
. Influence of reducing conditions
. Influence of particle size distribution
. Geometry aspects in leaching of monolithic matter

- Reference materials
- Interpretation of test results

The interrelations between the projects (indicated as 'V-projects') are shown in Fig. 1:

Fig.1:

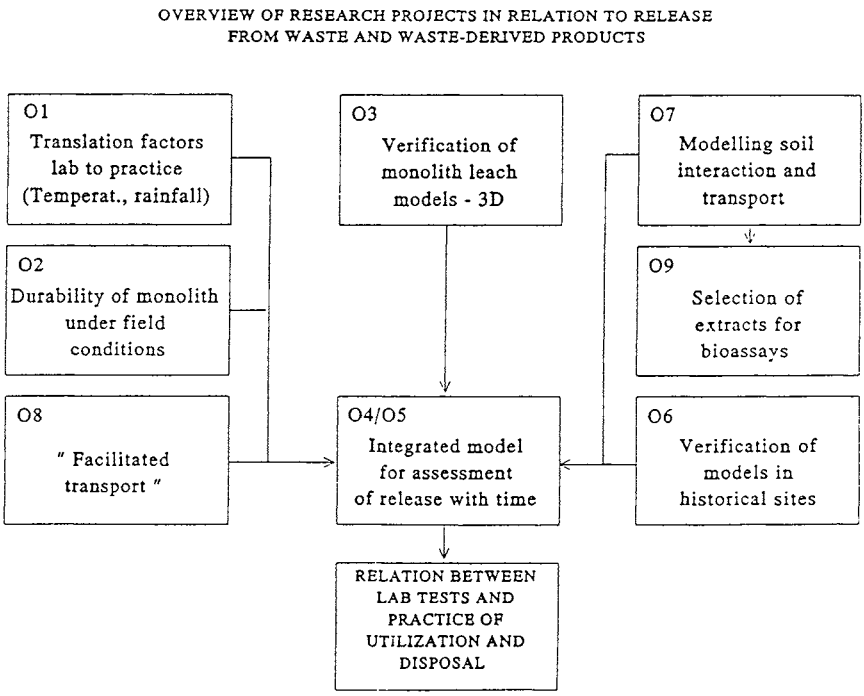


In the same time a coherent Research Programme was started in order to solve practical and scientific problems with respect to possible future standards on material characterization. This part of the programme consists of 9 projects on the subjects:

- Translation of laboratory results to practice
- Durability of products under field conditions
- Modelling of long-term leaching behaviour
- Interaction of leached contaminants with soils
- Enhanced leaching of non-mobile components by dissolved organic matter and particulates ('facilitated transport')
- Selection of extracts for bioassessment

The coherence of the research projects (indicated as 'O-projects') is shown in Fig. 2.

Fig.2:



The main results of the entire Research and Standardization Programme are summarized in the Handbook on Leaching [HBU 94][HBU 97] prepared under supervision of the Netherlands Foundation for Legislatation and Research in Ground Work, Water, and Road Constructions and Traffic Control Techniques (**C.R.O.W**). In part I of this handbook general guidelines for the characterization of leaching behaviour are presented, together with a survey of the developed standard test procedures. In part II of the handbook for some 50 building materials and waste materials the physical properties, leaching characteristics, and most relevant aspects from an environmental point of view are highlighted.

3. Scope and contents of the individual field experiments.

The third series of activities on leaching concerns individual field studies launched by several interested parties in order to obtain direct leaching information from specific road and building construction projects, ground works, or waste deposits. The field experiments

were primarily ment to check wether or not contamination would occur due to leaching of the used materials. Some field tests were focussed on this primary goal but other experiments were more comprehensive and focussed also on the understanding of the leaching mechanisms and the chemical interactions with the surrounding soils. From the results of the latter field studies the relation between the observed leaching in the real world and the results of standardized laboratory tests on the materials used may be derived.
The results of the 6 most interesting field studies are summarized in part III of the Handbook on Leaching [HBU 96] prepared under supervision of **C.R.O.W**. It concerns the following cases:

a Use of granular material (MSWI bottom ash) in an embankment to support a motorway
b Road foundation with compacted granular materials (sand, pulverized coal bottom ash, concrete granulate)
c Road foundation with cement-bound granular materials (pulverized coal fly ash)
d Concrete sluice construction in and above surface water
e Riverbank protection with granular material (steel slag)
f Road surface with paving-stones.

Two of these cases are presented in more detail elsewhere in this Proceedings (case c: by Schreurs and Van der Sloot; case e: by Sonneveldt e.a).

4. Results obtained to date.

To date the Research and Standardization Programme has resulted in a series of new national standards for leaching tests with respect to inorganic compounds (NEN 7340, 7341, 7343, 7345, and 7349) as well as organic compounds (NVN 7344 and 7350). Also protocols for sampling (NEN 7300 and NVN 7301, 7302, and 7303), sample storage and pre-treatment (NEN 7310 and NVN 7311, 7312, and 7313), and standards for the destruction and analysis of both inorganic compounds (NEN 7320 and NVN 7321, 7322, 7323, and 7324) and of organic compounds (NVN 7330) were developed. Additional tests for the assessment of the influence of specific material properties or conditions such as pH, redox, and dissolved organic matter are well underway [NOR 95].

For validation of the new leaching standards a comprehensive round robin test programme has been executed. Also the standards for the destruction and analysis of both inorganic and organic compounds have been validated in a round robin test for a variety of important building materials. For the sampling and pre-treatment protocols a validation programme is in preparation.

The research programme has given first results with respect to the derivation of factors for the 'translation of laboratory test results to practice'. Also basic insight has been obtained in the factors that complicate the material characterization such as durability, facilitated transport in the surrounding soil, and biodegradation. Together with the information obtained from the individual field experiments (see section 3) a fair degree of quantitative understanding of the leaching and diffusion mechanisms has been reached for most currently used building materials in ground works and road or embankment constructions.

The analysis of the 6 cases mentioned in part III of the Handbook on Leaching has learned that to date it is possible:

- to generate basic leaching insight in the majority of chemically stable materials which is suitable to assess (at least qualitatively) the environmetal consequences of the commonly used applications with these materials;
- to assess quantitatively the environmental consequences in a number of specific field situations by applying semi-empirical 'translation factors' to the results of standard laboratory tests;

For materials applied under conditions where the infiltration of water is more or less inhibited (highly unsaturated conditions) and for materials that change strongly under the infuence of air and water (e.g. materials with reducing properties or biologically active materials) it is not possible to predict the leaching behaviour on the basis of the present standard tests. For these circumstances only with the help of additional characterization tests and the application of suitable calculation models a more quantitative assessment of the environmetal consequences is possible. In both areas progress is being made through projects presently underway.

A recent overview of the results obtained to date and the progress made in Dutch legislation with respect to leaching was presented during the symposium 'Secundaire materialen primair toepassen'. The proceedings of this seminar also contains a comprehensive literature survey [SYM 96].

5. References

[TSP 90] Taakstellend Plan ter ondersteuning van normcommissie 390 011 'Uitloogkarakterisering van bouwmaterialen en afvalstoffen', NOVEM B.V., Utrecht (1990).

[NOR 95] Normcommissie 390 011 'Uitloogkarakterisering van bouwmaterialen en afvalstoffen', Jaarverslag 1994, doc. 390 011/95-08, NNI, Delft (1995).

[HBU 94] Uitlogen op karakter, Handboek Uitloogkarakterisering, I Testmethoden en II Materialen, C.R.O.W, Ede (November 1994).

[HBU 96] Uitlogen op karakter, Handboek Uitloogkarakterisering, III Praktijk, C.R.O.W, Ede (May 1996).

[HBU 97] Uitlogen op karakter, Handboek Uitloogkarakterisering, Aanvulling op delen I en II, C.R.O.W, Ede (January 1997).

[SYM 96] Symposium 'Secundaire materialen primair toepassen', gebruik van uitloogproeven in de praktijk, C.R.O.W, Ede (8th May 1996).

Appendix

List of materials treated within the Netherlands Standardization Programme:

Classification (grain size)		Species	Priority list	Other materials
1	Powders and sludges			
	Category a	Conventional materials	Cement Lime	
	Category b	Fly ashes	Pulverized coal fly ash MSWI fly ash	FBC fly ash
	Category c	Gypsum	_	Phospho gypsum FGD-gypsum
	Category d	Sludges	_	Sewage treatment sludge Waste water treatment sludge Drinking water purification sludge River sediment Dredge material
2	Fine-granular materials (0-4 mm)			
	Category a	Soils	Clay Sand Peat Decontaminated soils	
	Category b	Fine-granular	Construction debris sand Pulverized coal bottom ash Blast furnace slag Coal gasification slag	FBC bottom ash Sand blasting waste
3	Course-granular materials (0-60 mm)			
	Category a	Natural materials	Gravel Lava	Crushed rock
	Category b	Course-granular	PC fly ash aggregates Concrete granulate Coal mine waste Asphalt concrete granulate	Masonry granulate Construction debris
	Category c	Slags	Blast furnace slag Phospho slag LD steel slag MSWI bottom ash	Metallurgical slags
4	Monolithic matter and products			
	Category a	Hydraulic products	Concrete Concrete products Asphalt concrete	Stablized wastes Bituminous mixes
	Category b	Autoclaph products	Calcium silicate bricks Light-weight concrete	
	Category c	Baked products	Masonry bricks Paving-stones	Waste derived masonry bricks Waste derived ceramic products
	Category d	Monolithic slags	Monolithic blast furnace slag phospho slag LD steel slag	Monolithic metallurgical slags