A STUDY ON HIERARCHICAL FRAMING AND STANDARDIZATION OF LEACHING TESTS FOR WASTE UTILIZATION IN JAPAN

H. SAKANAKURA*, M. OSAKO*, K. MIYAWAKI°, S. SAKITA°°, Y. TOJO[#], H. SAKAMOTO[##], K. ENDO*, T. TANOSAKI[+], A. KIDA* AND S. SAKAI[++]

**National Institute for Environmental Studies, 16-2, Onogawa, Tsukuba-city, Ibaraki 305-8506, Japan*
°Meisei University, Japan
°°Hiroshima Prefectural University, Japan
[#]Hokkaido University, Japan
[##]Kanagawa Prefectural Environmental Science Research Centre, Japan
[+]Taiheiyo Cement, Co., Japan
[++]Kyoto University, Japan

SUMMARY: A Study on hierarchical framing and standardization of leaching tests for recycled products are in progress under a research project "Studies on methodology to set environmental safety quality level based on standardization of the testing system for secondary recycled products". The aim is focused on the risks for soil and groundwater caused by leaching of contaminants. The proposing evaluation frame will provide appropriate method for a variety of recycled products. The frame comprises several exposure tests and leaching tests, being scheduled for standardization in Japanese Society of Waste Management Experts Standards (JSWMES) through examination of the test validity using actual recycled products.

1. INTRODUCTION

Setup of environmental safety levels for a variety of recycled products is not a simple problem. For a contribution of establishing sustainable waste management, most prefectural governments in Japan have been introducing accreditation systems for recycled products. However, in most cases, environmental criteria for soils by a batch leaching test "JLT-46" (Japanese Environmental Agency, 1995) is substituted, despite the wide-ranging types and lifecycles of recycled products involved. Such inappropriate testing system may lead to both sides of environmental problems: a certain recycled product containing toxic substances may causes environmental pollution **(**Miyawaki K., Osako M. & al, 2007**)**, or, overestimated requests for the environmental safety may inhibit rational waste utilization. An appropriate evaluation guideline for environmental safety levels of different recycled products is awaited urgently for those prefectural accreditation systems.

Proceedings Sardinia 2007, Eleventh International Waste Management and Landfill Symposium
S. Margherita di Pula, Cagliari, Italy; 1 - 5 October 2007

Our research aims to propose a hierarchical testing and evaluation system for recycled products used in construction sites; focusing on the risks for soil and groundwater caused by leaching of contaminants. The proposing evaluation frame will provide appropriate evaluation steps of a broad range of shapes and utilization environment of recycled products. The frame comprises several exposure tests and leaching tests. Some tests have been standardized by special organizations such as Japanese Industrial Standards Committee (JISC), European Committee for Standardization (CEN) and Nederlandse Norm (NEN). In this research project, test methods are scheduled for standardization in Japanese Society of Waste Management Experts Standards (JSWMES), after trial runs and validation tests on actual recycled products.

2. EVALUATION FRAME

2.1 Overall structure

Our original evaluation frame is schematically shown in Figure 1. The frame consists of two main parts – for feed waste material and for recycled products. Each part comprises two steps respectively – characterization step (rhombus in Figure 1) and compliance step (squares in Figure 1). Characterization step is designed with relatively detail evaluation for the purpose of, for example, accreditation of recycled products by a local government. Here, feed waste material that was not accepted in the first rhombus will be scrutinized in the second rhombus on the recycled product. For the accepted materials or products in the characterization step, compliance step will serve periodical monitoring using simple batch leaching test such as JLT-46.

2.2 Evaluation on feed waste material

In the initial step (STEP 1 in Figure 1), the feed waste material itself will be evaluated from a safety perspective. If the material is determined as environmentally safe as, for example, non-polluted soil, the waste material will be available in any utilization situation.

In this step waste material is size-reduced and examined by two kinds of leaching test; immediate short-term and potential long-term leachability.

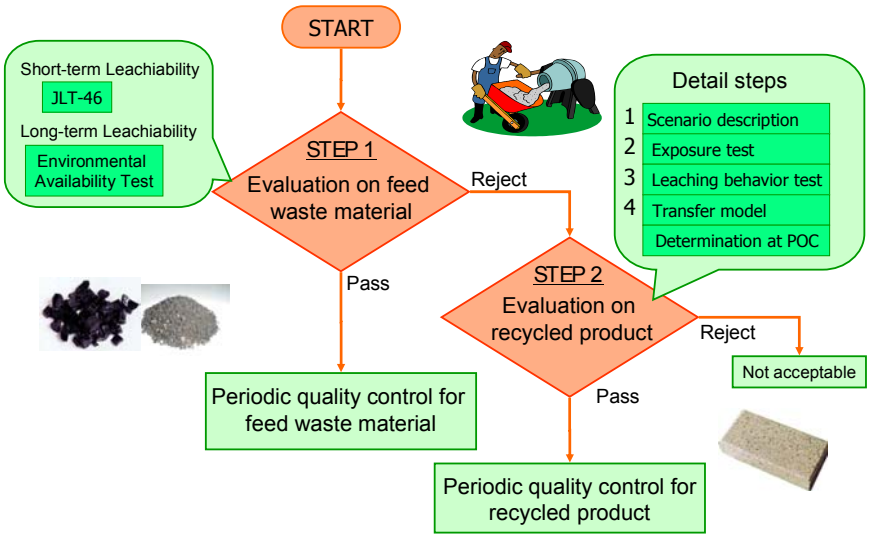

Figure 1. Evaluation frame for utilization of recycled products

Short-term leachability will be investigated on <2 mm-sieved sample by JLT-46: a single batch leach test of 10 liquid to solid ratio, 6 hours contact time and 0.45 μm membrane filtration. JLT-46 guarantees consistency with environmental standard for soils.

Long-term leachability will be evaluated on <125 μm-ground sample by environmental availability test. The prototype test is NEN 7371 availability test (NEN, 2004). The test is modified for the estimation of environmental impact especially by the effect of pH that is well known to have the most critical effect of inorganic toxic substances, in not only acidic condition (pH 4) but also basic (pH 12), neutral (pH 7) and the natural pH conditions. Size-reduction aims to test the effect of exposure of specific hard conditions, such as repeat utilization and/or grinding environment of road surface. Detail of the environmental availability test will be shown later in this paper.

2.3 Evaluation on recycled product based on utilization scenario

It is reasonable to provide evaluation methods for not only feed waste material but also recycled product. As the utilization situation is limited, evaluation test methods will be able to optimize in detail for respective recycled products. Depends on the utilization situation, even if a recycled product contains toxic substance in certain quantity (e.g. not acceptable level by foregoing feed waste material evaluation), the environmental impact might be estimated to be "acceptable". Thus evaluation on recycled product based on utilization scenario will broaden the utilization chance for the recycled products. However, it should be noted that control of the products while utilization is strictly required, as the evaluation results here do not guarantee the other utilization scenarios.

The second step (STEP 2 in Figure 1) gives the indication. Here, a recycled product using feed waste material which was not accepted in the initial step will be scrutinized along with an assumed utilization scenario. This step was developed partly in reference to a report on EU construction products directive (Dijkstra J.J., van der Sloot H.A. & al, 2005). Uniqueness of this research will be described as below.

A brief example of utilization scenario is shown in Table 1. Characteristics of the product and assumed scenario, i.e. physical and chemical characteristics, and utilization site conditions, including long-term climatic effects are described. In the scenario, information on recycled product such as shape (monolith or granular) and blending condition with other materials as well as length of in-service term are stated. Environmental conditions such as pH, water flux, dry-humid cycle, freezing-melting cycle, contact phase, redox conditions are defined.

Table 1. Brief examples of utilization scenario

Feed waste material		Waste-molten slag	Waste-molten slag	Blast furnace slag (air-cooled)
Recycled product	Product type	Precast concrete	Ballast	Ballast
	Application	Gutter	Frost heave prevention	Asphalt pavement
Form	Granular / Monolith	Monolith	Granular	Monolith
	Single / Mix with other materials	Mix	Single	Mix
Environmental condition	Duration of service	20 years	20 years	10 years
	pH	7 – 12	4 – 7	4 – 7
	Water flux	Surface wash off	Inner space dropping	Surface wash of
	Dry-wet cycle	Yes	Yes	Yes
	Freeze-melt cycle	Depend on the area	Yes	Depend on the area
	Contact phase	Outer air, soil	Soil	Outer air, asphalt
	Redox	Both	Reductive	Oxidic
	Sunshine	Upper side	No	Upper side

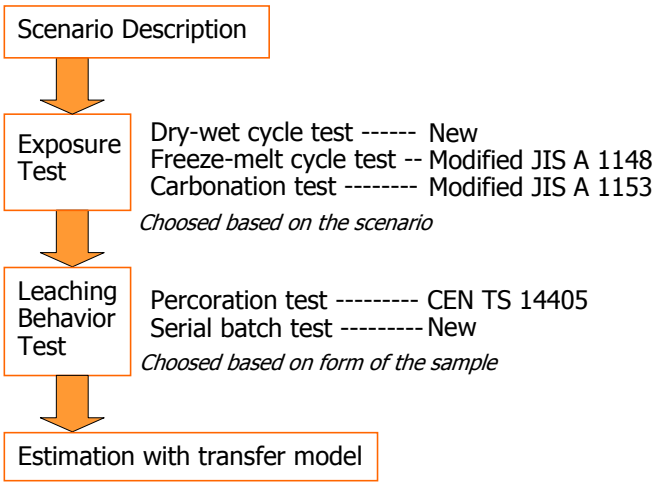

Figure 2. Adaptation of exposure test and leaching behavior test

As shown in Figure 2, exposure tests and leaching tests are subsequently selected based on the scenario. The most critical exposure test among e.g. freezing-melting cycle test, dry-humid cycle test and carbonation test will be assigned. Some of these exposure tests will be diverted from JIS exposure tests for the effect on concrete strength. After the exposure test, the sample will be subjected to the following leaching behavior test. Leaching behavior test will be selected from a serial batch test or an up-flow percolation test. Serial batch test is now developing in this research project that can be used for both monolithic and granular product. Up-flow percolation test is basically CEN/TS 14405 (CEN TC 292, 2004) column test, available for <10 mm granular. Compatibility between serial batch test and up-flow percolation test is now examining.

Through the leaching behavior test, the leaching mechanism will be determined on the basis of release flux slope in order to estimate the long-term leaching behavior. Environmental impact will be estimated by a contaminant transfer model through soils and groundwater. The model is also developing now, planning to introduce the leaching behavior data as boundary conditions.

Besides leaching behavior test and transfer model, a chemical speciation method using pH-dependence test – basically, CEN/TS 14429 (CEN TC 292, 2005) or CEN/TS 14997 (CEN TC 292, 2006) and a single batch test with specific solvent such as high-DOC concentration will be prepared for chemical speciation to reinforce the leaching test results.

2.4 Periodic quality control tests

In the case that the feed waste material or recycled products passed the evaluation in the initial or second step respectively, it means that they are recognized to be environmental safety material or product in certain scenarios. Then it is required to investigate the compliance of the accreditation for subsequently produced lot periodically by means of a simple compliance leaching test.

In the proposed evaluation frame, we suggest JLT-46 for feed waste material, and JIS K 0058-1-5 (JISC, 2005) agitation test for recycled products from slag as compliance test, respectively.

3. STANDARDIZATION OF TEST METHODS

3.1 Exposure tests and leaching tests

More detail of the evaluation frame with the test methods is shown in Figure 3. As was

mentioned above, the proposed frame comprises several exposure tests and leaching tests, some of which have already been standardized by special organizations such as Japanese Industrial Standards Committee (JISC), European Committee for Standardization (CEN) and Nederlandse Norm (NEN).

These tests are scheduled to ensure the confidence of the accuracy by executing the tests with actual feed materials and/or recycled products. As the need arises, some tests will be modified and then make validation test among several laboratories. Then the tests are going to be published as Japanese Society of Waste Management Experts Standards (JSWMES). As for newly proposing tests, standardization are planned in almost similar steps as the existing test methods. Current situation of the standardization process on the test methods are listed in Table 2. Note that not all the leaching test are required, but a part of the tests are efficiently adopted depends on purposes and requirements.

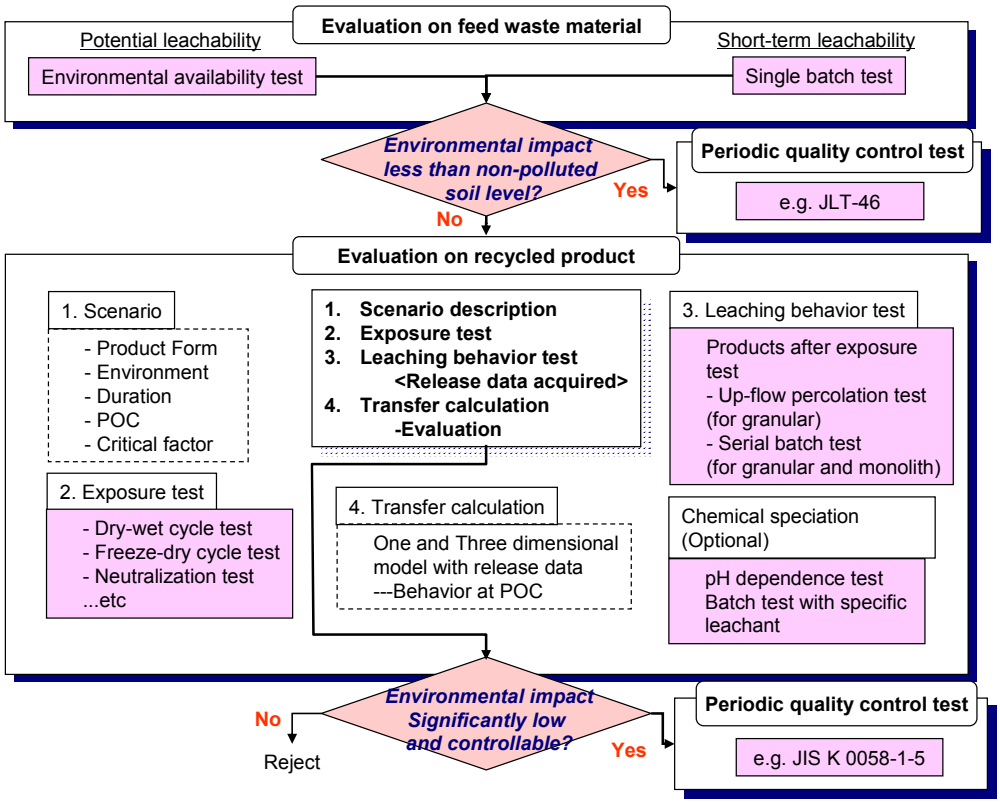

Figure 3. Detail version of the evaluation frame

Table 2. Current situation of the standardization progress of the assigned tests

	Prototype	2005-2006	2006-2007	2007-2008
Environmental availability test	NEN 7371	Trial	Validation	-
Dry-wet cycle test	New	Trial	Trial	Trial
Freeze-melt cycle test	JIS A 1148	Trial	-	-
Neutralization test	JIS A 1153	Trial	-	-
Percolation test	CEN TS 14405	-	Trial	Trial
Serial batch test	New	Trial	Trial	Validation
pH dependence test (Cont. Keep)	CEN TS 14429	Trial	-	-
pH dependence test (Initial add)	CEN TS 14997	-	Trial	Validation
Special solvent batch test	New	-	Trial	Trial

3.2 Development of environmental availability test

Among the test methods listed in Table 2, environmental availability test is foregoing on JSWME standard. The original availability test method is a Dutch standard NEN 7371 for assessment of maximum leachability by means of two leaching steps, the first step is under natural pH (or, pH 7) and the second is acidic environment (pH 4) on finely ground sample (<125 μm) at high L/S ratio (50 in each fraction).

In this research, NEN 7371 has been modified to be able to evaluate availability in not only acidic but also basic (pH 12) condition. Basic condition was introduced in order to characterize the available fraction in alkaline environment for the case that the material contacts with cement concrete leachate, for example.

Flow chart is shown in Figure 4. Acidic side test is similar to NEN 7371. Modified points from NEN 7371 are; two subsamples are need to prepare, one for acidic and the other for basic side test. The basic side test is just reverse type of the acidic condition. All of the four extractants are going to be analyzed separately in order to determine which pH condition gives significant effect on metals.

Preliminary test trial was carried out having six participants of analyzing laboratories. Based on the results, test equipments (Figure 5) and procedures are decided in further details. At the moment, validation test is carrying out among 18 laboratories.

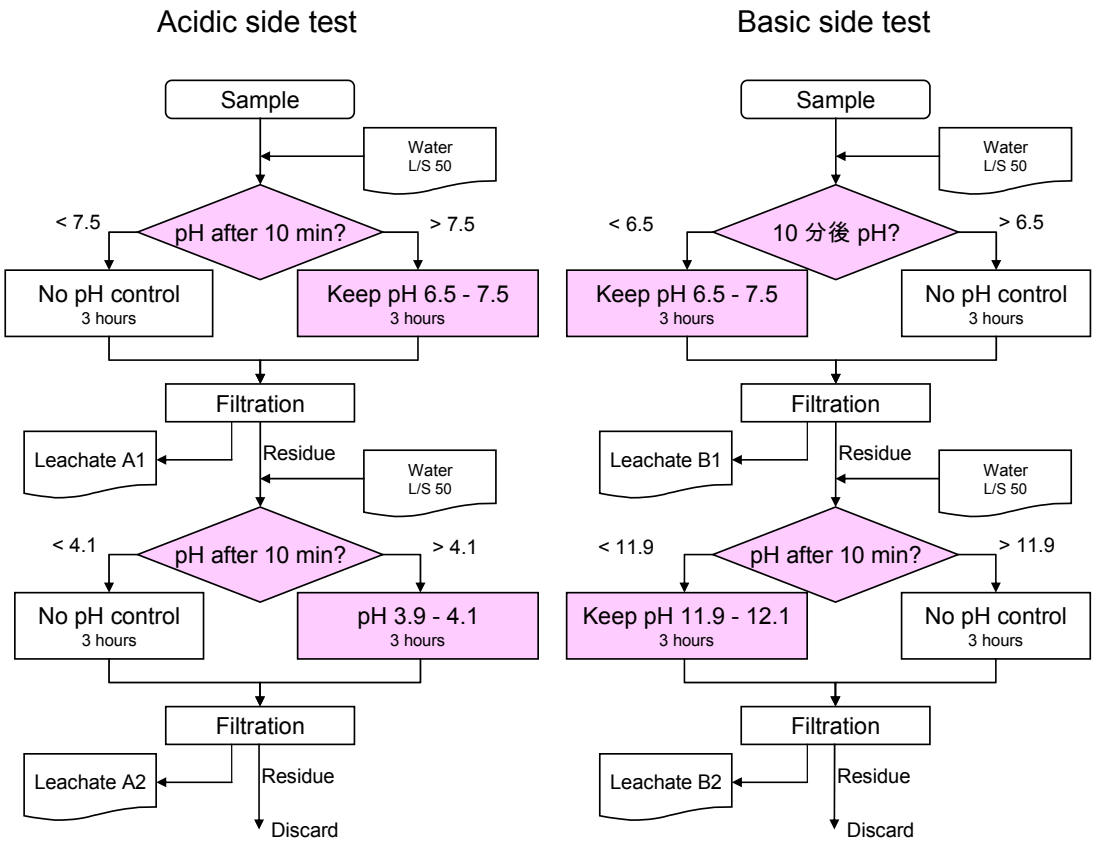

Figure 4. Flow chart for environmental availability test

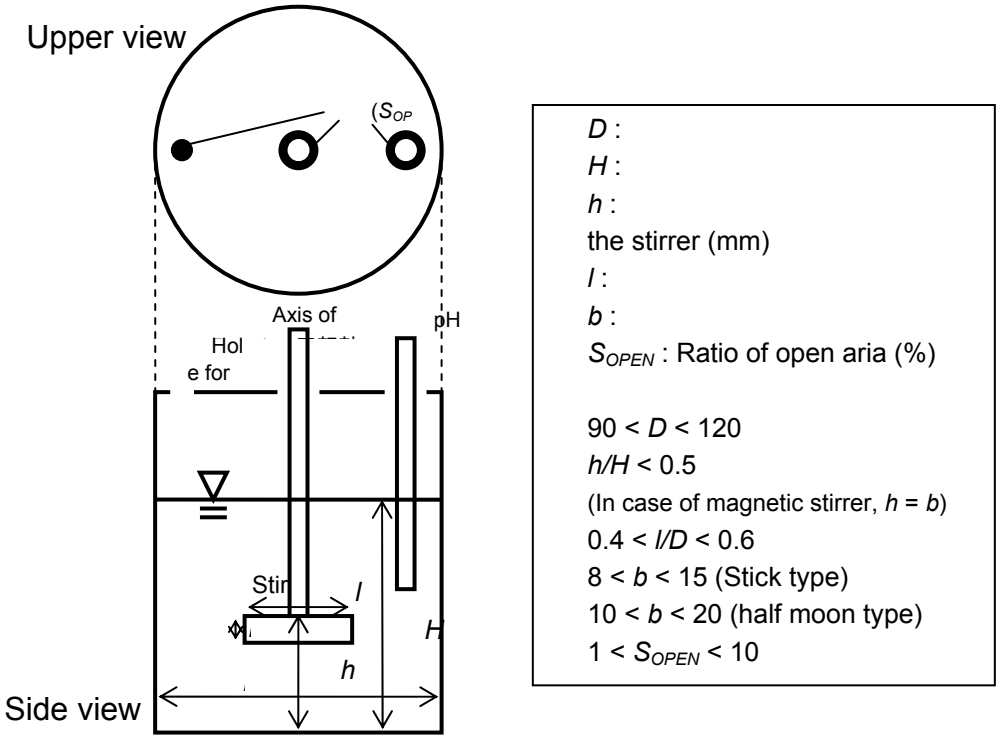

Figure 5. Test equipments for environmental availability test

4. CONCLUSIONS

Lack of evaluation system which accounts for environmental safety of recycled product limits the promotion of recycling. In this paper, a hierarchical testing and evaluation system for recycled products used in construction sites were introduced; focusing on the risks for soil and groundwater caused by leaching of contaminants. An evaluation frame was proposed that provides appropriate evaluation steps for a broad range of shapes and utilization environment of recycled products. The frame comprises several exposure tests and leaching tests. Some of these test methods are scheduled for standardization in Japanese Society of Waste Management Experts Standards (JSWMES), after examination of test validity using actual recycled products.

ACKNOWLEDGEMENTS

This research is financed by Japanese Ministry of the Environment as a part of research project "Studies on methodology to set environmental safety quality level based on standardization of the testing system for secondary recycled products".

REFERENCES

CEN TC 292 (2004) CEN/TS 14405 Characterization of waste – Leaching behaviour tests – Up flow percolation test (under specified conditions), British Standards (in English), 26 pages.

CEN TC 292 (2005) CEN/TS 14405 Characterization of waste – Leaching behaviour tests – Influence of pH on leaching with initial acid/base addition, British Standards (in English), 26 pages.

CEN TC 292 (2006) CEN/TS 14997 Characterization of waste – Leaching behaviour tests – Influence of pH on leaching with continuous pH-control, British Standards (in English), 31 pages.

Dijkstra J.J., van der Sloot H.A., Spanka G., Thielen G. (2005) How to judge release of dangerous substances from construction products to soil and groundwater, ECN-C—05-045

Japanese Environmental Agency (1995) Departmental notification No.46, 1995 on leaching test method for soils (in Japanese); Japanese official regulation.

JISC (2005) Test methods for chemicals in slags – Part 1: Leaching test method, Japanese standards association, 16 pages.

Miyawaki K., Osako M. & Sakanakura H. (2007) Present status of authorized systems for recycled materials by local government and its problems, Waste management research, 18(3) (In Japanese, printing).

NEN (2004) Nederlandse norm NEN 7371 Uitloogkarakteristieken – Bepaling van de baschikbaarheid voor uitloging van anorganische componenten – Vaste grond- en steenachtige materialen (Leaching characteristics – Determination of the availability of inorganic components for leaching – solid earthy and stony materials)