DISCUSSION WITH END-USERS REGARDING CEMENT/WASTE SYSTEMS DATABASE AND PREDICTIVE MODELS

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Introduction of impurities into cement is inherent to recycling of industrial by-products in building materials, and to treatment of industrial wastes by solidification prior to disposal. These impurities can cause problems with materials handling and durability. In this respect, 3-year project is funded under the European Commission's Brite-Euram III programme, on Neural Network Analysis for Prediction of Interactions in Cement/Waste Systems (NNAPICS).
This project applies neural networks to predict the physical and environmental properties of cement/waste systems. Existing data concerning solidified wastes and building materials containing industrial by-products are being collected into a database and analysed using neural networks, and supplementary data are being generated in a laboratory study. Thus, the main deliverables from the project will be: (1) a database containing information about cement/waste systems (the «CWS Database»), and (2) predictive models constructed using the information in the database.

L'introduction d'impuretés dans les ciments est inhérente au recyclage des sous-produits industriels en matériaux de construction ainsi qu'au traitement de déchets industriels par solidification avant mise en décharge. Ces impuretés peuvent engendrer des problèmes liés à la manipulation et à la pérennité des matériaux. Pour étudier et prévenir ces problèmes, le Programme Brite-Euram III de la Commission Européenne, finance un projet en 3 ans sur l'Analyse par Réseau Neuronal pour la Prévision des Interactions au sein des Systèmes Ciment/Déchet (NNAPICS).
Ce projet utilise les réseaux neuronaux afin de prévoir les propriétés physiques et environnementales des systèmes Ciment/Déchet. Des données déjà existantes sur les déchets solidifiés et les matériaux de construction contenant des sous-produits industriels sont collectées afin de constituer une base de données ; elles sont ensuite analysées en utilisant les réseaux neuronaux et complétées par les résultats d'une étude en laboratoire. Ainsi, les principales productions de ce projet seront : (1) une base de données contenant des informations sur les systèmes Ciment/Déchet (Cement/Waste Systems «CWS Database») et (2) des modèles de prévision construits à partir des informations de la base de données.

INTRODUCTION

A workshop was arranged to inform potential end-users about a 3-year project funded under the European Commission's Brite-Euram III programme, on Neural Network Analysis for Prediction of Interactions in Cement/Waste Systems (NNAPICS).
Introduction of impurities into cement is inherent to recycling of industrial by-products in building materials, and to treatment of industrial wastes by solidification prior to disposal. These impurities can cause problems with materials handling and durability. This project applies neural networks to predict the physical and environmental properties of cement/waste systems. Existing data concerning solidified wastes and building materials containing industrial by-products are being collected into a database and analysed using neural networks, and supplementary data are being generated in a laboratory study. Thus, the main deliverables from the project will be: (1) a database containing information about cement/waste systems (the «CWS Database»), and (2) predictive models constructed using the information in the database.
End-users of these deliverables are expected to include waste generators, waste treatment facilities, suppliers of construction materials, users of construction materials, regulators, and consultants to these sectors. The NNAPICS consortium is seeking participation from potential end-users to provide input and feedback regarding the project. In

particular, large data sets regarding the composition, engineering properties, durability and/or leachability of cement systems containing wastes or other impurities are needed. Assistance from the end-users is also needed to review the deliverables from the NNAPICS project and to plan a continued strategy for their use and exploitation.

The NNAPICS End-User Group has about 200 members, 24 of whom attended the workshop. The workshop started with presentations by members of the NNAPICS consortium (Imperial College, UK; British Nuclear Fuels, Ltd., UK; University of Surrey, UK; Universidad de Cantabria, Spain; Euroresiduos, Spain; Trinity College Dublin, Ireland; GESENU, Italy; and Universita di Roma «La Sapienza», Italy). These are summarized in the conference proceedings for the conference on Waste Stabilization and Environment.

The presentations by the NNAPICS consortium were followed by presentations by 4 members of an industry panel (K. Bradshaw, Blue Circle Cement; J. Frenay, ENCI; Marie-Claire Magnie, Intertec; and R. Vogels, Intron), who led a discussion regarding the following questions:

– What do end-users want the CWS Database to do?
– How will the CWS Database be used?
– Can the CWS Database improve the business of end-users? How?
– What cement/waste product properties are of greatest interest?
– Which waste types are most important?
– What cement/waste product properties are useful to predict?
– Will information such as that from the project increase the amount of waste that can be utilised in construction?
– In what ways can end-users help the project?

The discussion centred around 8 main topics, which are discussed below.

THE DIFFERENCE BETWEEN A «WASTE» AND A «PRODUCT»

Several workshop attendees raised the issue of the importance of terminology, because there are negative associations with the term «waste», which can have serious economic implications.

In fact, the NNAPICS project is trying hard to avoid labelling materials in ways that have negative or positive connotations. There are materials which are mixed with water, and perhaps with each other, to create new materials. The former are called «mix items» in the CWS Database, and the latter are called «products». «mix items» include materials which are commonly called «cements» or «binders», and also materials which may be classified as different categories of «wastes» (depending on the jurisdiction), but they are not identified as such in the database, although «wastes» may have a number associated with them if they can be found in the OECD or European waste catalogues. The philosophical basis for this approach is that material properties form a continuum; some materials may be inert (this could mean that they are not cementitious, or that they do not contain environmentally hazardous components), some may be reactive (again, in several ways), some are in between. It is the objective of the project to catalogue and examine relationships between the properties of the various materials, not to make judgements about whether the properties or materials are good or bad, or where the line between «non-wastes» and «wastes» should be drawn. It is hoped that one of the uses for information from the project will be to make it easier for the appropriate authorities to make these distinctions in a sensible way, in order that more «waste» materials will be utilized, conserving natural resources and minimizing landfill while protecting the environment.

WHAT KIND OF DATA IS BEING COLLECTED?

The relationships of initial interest for the project are those between cement/waste product composition, and setting, strength, pH and acid neutralisation capacity. Composition may be expressed simply as the formulation, or in more detail, as the elemental, oxide, or phase analysis. pH and contaminant concentrations are being collected for different types of single batch extractions; acid neutralisation capacity is being collected for continuous, incremental and batch titrations. These properties are being collected for the raw materials, as well as the final products.

An example of the CWS Database (in Access) can be downloaded from the project web pages (http://concrete-www.cv.ic.ac.uk/iscowaa/nnapics/intro.html). The example contains the full literature list, and data for 10 sample references. However, the field headings and pull-down menus show most of the parameters being collected. It should be noted that additional refinement of the database is on-going, and the final product will be considerably more user-friendly, but the current version serves to show the type of information that the project is collecting.

The project is collecting information about cement products made with all materials, including manufactured cements, which may contain no other additives, commercial accelerators and retarders, and/or industrial by-products of varying environmental concern at a variety of different addition ratios. Industrial by-products may be added as cementing materials, inert filler, or aggregate. As much detail as possible regarding the characteristics of the materials, including particle size and pre-processing, is being collected. However, only those parameters for which a lot of information is available will be useful for predictive modelling.

The project has been limited to cementitious systems, because it is expected that there will be trends in their physical and chemical effects. Immobilisation mechanisms in other systems (e.g. sulphur, organic polymers) would likely be entirely different, and other materials have therefore been excluded.

COMPLEXITY OF MATERIALS AND TEST METHODS

The materials which go into a cement/waste product are

highly complex and there were questions as to whether the database will be able to take this complexity into account. Also, there are many different test methods, with different parameters, many of which have changed substantially over the past 20 years.
The project has tried to deal with this issue by including a large number of parameters for the raw materials, the cement/waste products, and also the test methods in the CWS Database format. Not all of the parameters targeted for collection are reported in the literature, but initial analysis of the data has shown that even when little information is available about composition, some valuable analysis of the data is possible. The more information that is available, the more sophisticated and sensitive the analysis can be.
For the test methods, collecting detailed information regarding the test parameters allows results from different tests to be analysed together. For instance, in a leaching test, the contaminant concentration will be dependent on the liquid-to-solid ratio, contact time, and leachant characteristics, as well as upon the composition of the sample being tested.

CEMENT/WASTE PRODUCT PROPERTIES

The end-users felt that properties related to handling, leachability and durability are all important. Leachability in regulatory tests is important for convincing regulatory authorities, and durability is particularly important for materials which will be utilised.

WASTE TYPES OF INTEREST

Waste types of particular interest are:
– wastes containing heavy metals,
– wastes containing very fine particles, and
– high volume waste materials.
Demolition wastes, dredge spoil, contaminated soils, and industrial ashes and sludges of many different kinds are of particular concern.

USES OF THE NNAPICS PROJECT DELIVERABLES

The panel members all mentioned that the database and predictive models must be highly user-friendly in order to find wide application. If possible, the predictive models should be transparent, e.g., it should be possible to interrogate the database for similar cases/references, in order to try to ascertain the background to a particular prediction by the models.
The end-users seemed to agree that one of the most basic functions of the CWS Database and the predictive models should be to answer the question of whether or not it is feasible to treat a particular waste type with cement. For common, well-characterised wastes, it may even be possible to eliminate treatability testing, although some level of laboratory testing will likely remain. The representatives from the cement industry present at the meeting were agreed that more information about the limitations of cement-based solidification is equally as valuable as information about successful applications.
Beyond answering this basic question, the CWS Database and predictive models could also be used to:
– choose the most effective binder (or develop pre-mixed multipurpose binders)
– avoid ineffective binders
– determine the highest proportion of waste that can be in the product
– determine optimal proportions of all mix components, taking into account both technical and economic factors
One of the most important applications of the NNAPICS database and predictive models will be in gaining public and regulatory acceptance of cement/waste products, either for utilisation or disposal. It was pointed out that ensuring the environmental acceptability of cement/waste products, and creating a positive image, is important for long-term commercial success.

CONFIDENTIALITY CONCERNS

A number of those present thought that commercial organisations will not provide data to the project because of concerns about confidentiality. The issue of data confidentiality appeared to centre around 2 aspects:
– special formulations/special additives, and
– business information.
With regard to (a), it is the position of the NNAPICS consortium that most successful solidification is performed using generic processes. Although there may be some cases where special additives are used for problem wastes, the majority of data is likely to concern simple formulations, e.g., portland cement or fly ash without any special additives. This data may be of limited usefulness to the organisation that has generated it, but it may complement the other data in the CWS Database to yield new and useful conclusions in the analysis. It is also worth noting that data for formulations which are not particularly successful are still interesting information for the database and for the analysis.
Furthermore, it is even possible for commercial organisations to provide only the final properties of their cement/waste products, without identifying the additives. If their formulations are particularly effective, the results will stand out to their advantage from the others in the database. Such data can be used to advertise the capabilities of the donor, or data can also be provided anonymously.
With regard to (b), it is not the purpose of NNAPICS to collect business information. Commercial data sets with all sensitive business information removed will still be useful.
Finally, the NNAPICS consortium can enter into confidentiality agreements under which donated data would not be made available to the public, but would be kept as a

confidential subset of the overall CWS Database.
Commercial organisations with suitable data should weigh whether their data can tell them everything they need to know on its own, or whether they will actually learn more by combining it with data from other sources.

LONG-TERM FATE OF THE CWS DATABASE AND PREDICTIVE MODELS

Development of a CWS Database and predictive models is an ambitious undertaking. While NNAPICS will give this undertaking a headstart, it is not a static enterprise, and consideration should be given to how the work will be continued at the end of the current 3-year project.
The current work is being funded as Brite Euram III basic research, which recognises that additional work will be necessary beyond the end of the current project for full commercialisation. Continued development and maintenance of the CWS Database and predictive models is dependent on demonstrating their usefulness to the end-users and thereby obtaining financial support.
Future Interaction between the NNAPICS Consortium and the End-Users
Offers to provide data to the project were made by 10 end-users at the workshop , as well as 5 others at the conference. In addition, the help of end-users will be sought for beta-testing the CWS Database and the predictive models, in the final year of the project.
It is expected that a second end-user workshop will be held before the end of the project. The tentative date is to coincide with WASCON 2000, which will be held from May 31-June 2, 2000 in Harrogate/Leeds, UK (http://www.efm.leeds.ac.uk/wascon2000).

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