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Waste Materials in Construction: Putting Theory into Practice

RECYCLING FOR ROAD IMPROVEMENTS

Presentation by Charles J. Nemmers, P.E.
at the WASCON '97 Conference
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Einstein once said "The significant problems we face cannot be solved by the same level of thinking that created them."

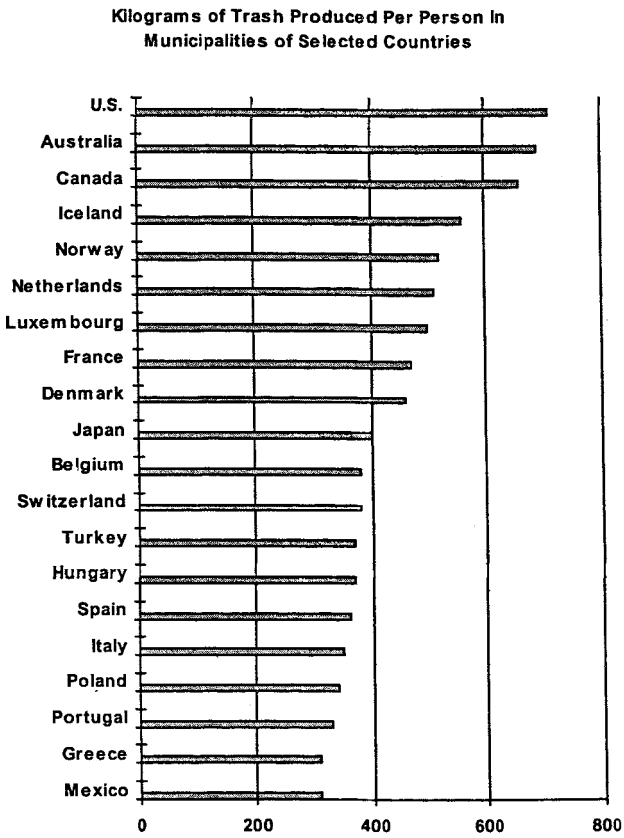
These words challenge us to think anew how we use and reuse materials for the construction and reconstruction of transportation facilities, especially highways and other roads. The Road Transport Research Program Steering Committee of the Organization for Economic Cooperation and Development (OECD) headquartered in Paris, formed a Scientific Expert Group to review the issue of recycling in road building and I will be reporting on what we did. But it is the need to do our work at a different level (i.e., Einstein quote) that made our collective work both challenging and productive.

Fifteen nations plus two Asphalt associations were involved in our study group, a survey of recycling in methods, products, laws, and procedures in these countries was conducted and a state-of-the-practice report was prepared. Several of my colleagues on this report are with us here today and I trust that what I say will be close enough to what we wrote that they will be able to identify it.

Recycling is now a well proven technology, often a preferred choice for construction, a backbone for an entire equipment industry, and a requirement, if not a necessity, in many countries. Since 1977 - the year of publication of the first OECD report on the *Use of Waste Materials and By-Products in Road Construction* - both the volume and quality of the recycling of road by-products in the road sector have increased significantly in OECD countries. However, the generation of waste remains high as shown in the chart below.

Amounts of Municipal Trash in the World

The world's most industrialized nations produced an estimated 450,000,000 metric tons of municipal trash in 1992. This figure shows kilograms of trash produced per person per year in the urban areas around the world in selected countries



(Source: Washington Post, 23 November 1996)

In 1995, the OECD Road Transport Research Program Steering Committee determined that the advances in recycling called for the Scientific Expert Group on *Recycling for Road Improvements* to take a new look at this important subject area. The primary goal of the Group was to generate information that would describe the state-of-the-art in recycling and promote recycling of waste and by-product materials, especially those generated in the road sector, in road construction. It was anticipated that the Group's efforts would help to: establish or change policy in Member countries; support improvements in current specifications; identify workable technologies; and identify needed research and knowledge transfer initiatives with the expectation of increasing recycling efforts and discovering more innovative and efficient solutions.

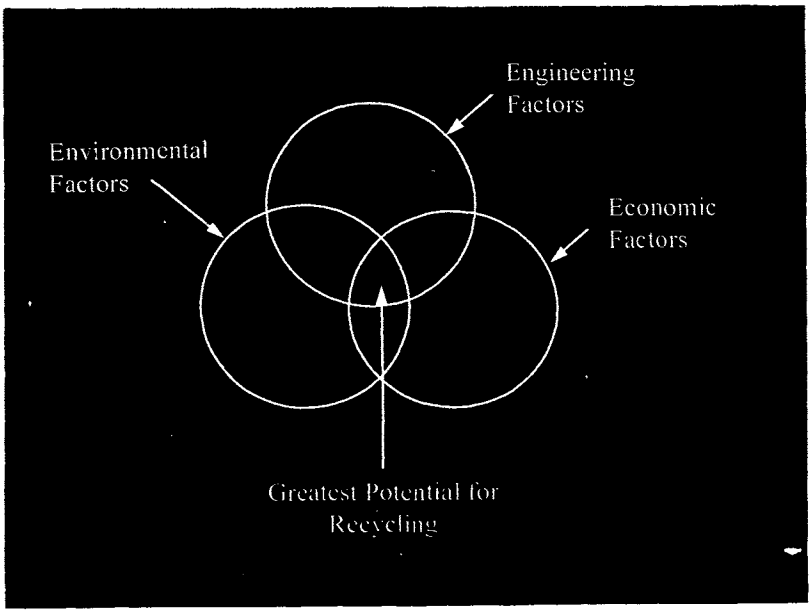
SUCCESSFUL RECYCLING REQUIRES LEADERSHIP

While addressing the recycling of both road by-products and non-road by-products in this report, it is agreed that recycling of road by-products takes precedence in order for the road industry as a whole to take responsibility and demonstrate leadership to the fullest extent possible. The principle of "cleaning up own house first" must apply. The responsibility for road by-products belongs to the road sector.

The following general hierarchy for waste management was adopted (applicable to any industry; in this case, applied to the road construction industry):

- Minimise waste production.
- Recycle in parent industry.
- Recycle in other industries.
- Incinerate.
  - Incinerate with energy recovery;
  - Incinerate to reduce volume.
- Dispose of in a landfill.

Following this hierarchy, an industry (i.e., road construction) not only sets an example for recycling in general, but takes responsibility for reducing its own by-product disposal problems by first attempting to recycle *within* the industry itself. In the case of the highway industry, it certainly makes sense to recycle road by-products in roads. Not only will this reduce costs of disposal during construction, but the material similarities suggest that such uses would be technically feasible as well. It also makes sense to use by-products from other industries, when appropriate. In fact, the report shows that in some cases (e.g., fly ash in cement concrete) certain by-products may actually benefit road construction by improving the materials.



From information supplied by the participating countries, the Group identified three areas that must be jointly considered for successful recycling efforts. They are:

- engineering factors;
- environmental factors;
- economic factors;

Each of these areas contain elements - ranging from the political context to specific engineering risks - which have a significant bearing on the potential application of by-products.

SURVEYS ARE BASIS OF STATE OF THE PRACTICE

Two major surveys were conducted as part of this study.

1) Survey to assess the extent of current use of various by-product materials in Member countries.

   This assessment was accomplished by distributing survey questionnaires to OECD Member countries. Materials generated by road construction were considered separately from those generated by other industries.

   a) For road materials, the information requested in the survey included extent of use in various road applications, amounts available, a summary of important properties, test methods and guidelines and description of any new techniques being developed.

   b) For non-road materials, the information requested also included extent of use in

various road applications, additional information was requested on amounts, material tests and acceptance criteria, construction equipment and procedures, quality control tests, standard specifications and factors used in evaluating environmental and economic suitability.

2) Survey to assess waste management and recycling policy in Member countries, especially in regard to road building.

Information requested here dealt with official policy, organisation(s) responsible for policy, economic issues affecting policy, regulations, obstructions to implementation and technology transfer. These surveys gave us engineering environmental and economic input into our three circle model.

The first survey showed that in the 20 years since the last OECD report on recycling in road construction more countries are now recycling many different materials and much more of these materials as part of road construction. Recycling of asphalt pavement is being done in all of the countries surveyed. Nearly 100 million tons of RAP are being produced annually. Other waste materials from non-road industries are also being recycled into road construction and over twenty of these by-products were identified. These products ranged from old tires to various slags and ashes, to glass, paper and plastic. It is clear that the engineering properties, the environmental consequences and the economic possibilities of these non-road by-products need to intersect for them to be a useful recycled material.

Through our study we identified several road and non-road by-products that were clearly winners and these were:

- reclaimed asphalt pavement in new asphalt pavements;
- reclaimed concrete pavement in new concrete pavement;
- blast furnace slag as supplementary cementing material in concrete or stabilised base and subbase;
- steel slag used in base courses and asphalt pavements; and
- coal fly ash used in a highway embankment.

Recycling materials considering the engineering properties and the environmental consequences is good business but this is not the only way to encourage recycling. This is where our second survey comes into play. Here we asked for the policies that were being utilized to increase recycling. It is clear that many countries are using policies (that is incentives and disincentives) to effect an outcome favoring recycling.

It is possible for governments to influence the free market by tax enforcement or subsidy strategies that are designed to promote recycling and the use of recycled by-products. All market parties are encouraged to act in a market-conforming manner by actions such as: providing sufficient information on the long-term performance of by-products, stimulating test or research projects, implementing a waste tax, providing recommendations and requirements for the use of by-products or subsidising recycling and reproduction facilities. Similarly "Restrictive"

regulations can be used to reduce the production of waste and to control its disposal. These regulations must often be balanced, however, with additional policies that encourage sorting, recycling, and reuse.

In several countries, government takes the responsibility for increasing recycling and reuse of by-products. It also works to develop a system of laws and regulations that will restrict the construction industry in how they deal with wastes and encourages the use of by-products. In order to monitor results, most countries set recycling goals for the future. Before a new by-product is accepted for use, it may be necessary for this by-product to undergo research or a period of testing and evaluation that validates its quality and reliability.

A combination of government incentives (subsidies, research) and disincentives (taxes, dumping fees) done co-operatively with industry seems to offer a good formula for success.

To further the advancement of recycling world-wide, all countries - regardless of their current good practices in recycling - should continue to explore new recycling opportunities, advance technical knowledge, and design increasingly effective programs.

Keeping in mind that Einstein is calling us to move to a higher level of thinking, our group identified an Implementation Plan for Recycling and provided a model partnering agreement that illustrates the importance of co-operation and outlines the philosophies, roles, and broad-based implementation responsibilities of each partner in carrying out recycling.

Individual Partner	Implementation Item
By-Product Supplier	Specifies product names and characteristics. Develops quality plan to ensure product consistency. Produces product to meet specifications and quality plan requirements. Defines cost and sale parameters.
Environmental Authority	Specifies general environmental regulations. Defines pollutants and risks of pollution. Defines appropriate contamination limits. Defines methods to study pollution and specifies associated tests. Proposes taxes or specific incentives to facilitate the use of by-products.
Engineering Authority (Road Administration Agency)	Determines suitability of by-products which can be used in road construction and rehabilitation. Undertakes documentary research reviews and data base and supplier information. Considers technical/economical feasibility for each application. Proposes combination of by-product use, technical processes and cost considerations to owner agency and co-operating partners. Conducts any necessary research and demonstration sites on selected options with owner agency and co-operating partners. Develops specifications for project applications and proposes standards.
Owner Agency (Road Administration Agency)	Defines performance requirements or technical needs. Selects by-products and techniques according to program needs/economies. Reviews research results and selects demonstration sites in conjunction with engineering and environmental authorities. Adopts technical regulations and standard documents for contracts.
Contractor	Proposes specific techniques on projects in conjunction with suppliers. Carries out construction activities using by-products according to standards and specifications set forth by owner agency, environmental and engineering authorities. Defines techniques as incorporated in technical proposals and requirements for future applications.

SIX RECOMMENDATIONS

This Recycling for Road Improvements report recognises that the use of by-products in road construction is contingent upon the technical, engineering, value of the material. However, this contingency is viewed not as an excuse so as to not recycle, but rather as a need to disseminate good information and examples as well as a larger call for continued research into the prudent use of by-products.

There is a definite governmental role in this sector. It is suggested that measured public sector involvement can accelerate this adoption of much recycling technology.

From the investigation and analysis of the current state of recycling, a series of recommendations are identified that could help to keep pace with increasing global stores of by-products and decreasing space for landfills.

1. Test materials before recycling.

The results of the survey on the use of recycled road materials, shows a significant growth in the quantity, diversity and quality of recycling over the past 20 years.

The most commonly used road by-products continue to result from recycled asphalt pavements. The scale of using recycled concrete pavement by-products is less significant than that for asphalt concrete but is developing.

The effectiveness of recycling clearly requires one to test the road material *before recycling* so as to:

- Identify the engineering factors that are critical.
- Determine the highest level of recycling that is possible.
- Assure that recycling this time will not foreclose recycling options in the future.
- Avoid recycling materials that have serious health consequences - i.e., pavements, containing coal tar - or accommodating other materials that have health and safety consequences, i.e., lead-based paints, asbestos in demolition waste.

2. Ensure that recycled by-products are used wisely.

Recycling is underway in all countries and will continue to increase as research and new technologies expand the opportunities. The OECD countries responding to the Group's survey clearly show that they are, in many ways, "cleaning up their own house first." It is clear that sometimes recycling (i.e., fly ash, slag aggregates) may offer a product that is better than virgin materials. But it is extremely important to review previous, related research and to test and evaluate as necessary to be sure that the by-product does perform acceptably. There are limitations in nearly all areas of by-product technologies and it is only worthwhile to recycle when you stay within the performance range of the material.

In using non-road by-products one must fully consider the acceptable boundaries of use. For instance, while steel slag is a good material in asphalt, it must not be used in concrete. Similarly, many of the applications of unbound by-products require that they not be used in areas close to a water table. Other by-products, such as scrap tires, offer some recycling potential. However, many countries are still researching the value of incorporating scrap tires into hot mix asphalt.

Although the road offers good opportunities to accept by-products from non-road sources, it should not serve as a "longitudinal landfill." In other words, the road must first and foremost serve its transport function. When compatible with the recycling of non-road by-products, the road can offer good, reasonable opportunities for governments and industry to recycle by-products from industries outside the road sector.

Continued research into recycling non-road by-products, by both the producers and users, holds promise to reduce global waste disposal and also to reduce the resulting stress that this places on the environment.

3. Promote the increased use of proven recycling solutions.

To show how recycling of road by-products and non-road by-products really works, "winners" were identified. Asphalt pavement and concrete pavement recycling are technologies that work, have significant environmental advantages and are economically attractive. The research, demonstration projects and equipment developed in response to these technologies shows that the road industry has done much to "clean up its own house first." These technologies are remarkably similar in all countries and their results are consistent. Similarly the recycling of non-road by-products, such as slags and coal fly ash/bottom ash, were explained through examples from several different countries. Interested individuals can now see a range of by-products from "very successful" to "offering good potential" and use this shared information to improve recycling techniques. We must share.

4. Support policies that foster recycling and discourage dumping.

As important as the engineering factors are to the use and recycling of road and non-road materials, other non-technical factors are also significant. Governmental laws, policies, and regulations can set restrictions so as to reduce the production of waste, control disposal and limit the use of new materials - or governmental regulations can be promotional and subsidise the use of recycled by-products, fund research, testing, evaluation and demonstration of recycled materials. What becomes clear as one reviews the survey responses is that a balance of regulations and policies is paramount to the success of a recycling program.

Within this regulatory environment there is a stronger emphasis on controls in those countries with denser populations and fewer available disposal options. Promotional options seem more effective in those environments where more options to recycling are available. It appears that increased support of research into better use of by-products was needed in all countries. This is especially true in countries that have established landfill restrictions. For

example, the European Community has strong landfill restrictions with a year 2002 compliance date. Most countries reported recycling goals, with many being over 50 percent recycling by the turn of the century.

In addition to the need to balance restrictive and promotional policies, it is clear from the information received that the success of any recycling program also depends on the involvement of the public and private sectors. The construction industry, the academic community, the owners of the roads, the recycling industries, equipment manufacturers and others can solve many more recycling problems by working together rather than in isolation. Pilot studies and test sections are strongly recommended.

5. Balance engineering, environmental and economic factors.

The central theme of this entire report is captured in the three overlapping circles where the best potential for recycling is defined by that area of overlap that occurs when engineering (technical), environmental and economic factors are properly balanced.

If these factors are not in balance, the result can be environmental requirements to use a recycled by-product that has not been proven, roads being built using structurally sound by-products but creating unacceptable side effects, or a serious underestimate of the economic effects of any of these strategies. The best solutions are those that balance all three factors in developing an informed judgement. Trade-offs will always need to be made. What is important is that these trade-offs be made with an understanding of all three factors and a concern for "the big picture."

6. Increase research and knowledge transfer.

The lack of adequate information on the long-term performance of by-products, standard specifications and testing requirements will continue to slow the recycling movement. The study team encourages: an increase in recycling research and demonstration projects; an increase in sharing recycling technology among countries; an increased use of incentives for recycling; creation of better devices to encourage recycling; and an effort to convince sceptics (through documentation and publication) of effective recycling. This report should help in this regard.