Composite Products of Waste Materials for Roads and Civil Engineering

Per TYLLGREN[1]

[1]*Svenskt VägCentrum, Södertorpsvägen 116, SE-215 65 Malmö, Sweden, per.tyllgren@vagcentrum.se*

Abstract

Making high-quality gravel from waste by combining selected materials is similar to making ordinary gravel. The extra work is to produce suitable components from the waste before completion. Thus waste products replace the corresponding amount of exclusive natural resources, although it might be in a secondary function. Waste of special interest is reclaimed asphalt pavement, reclaimed concrete, blast furnace slag and MSWI bottom ashes.

After clearing away contents for other use or disposal, the material is crushed and screened to a suitable particle size gradation. This is carried out either at the origin site of the waste or at a storage area arranged for this purpose. These raw materials or components are then added to proper rock gradations, which could take place at an ordinary quarry.

Composite materials are intended for the same use as conventional unbound materials. Therefore the quality assurance focuses on such properties. Cohesiveness, low density or hardness are useful properties in some cases but they are not necessary to perform in this context. It could be as simple as adding a sand fraction from incinerator slag to open-graded macadam to accomplish a graded gravel material. Conventional crushed rock and certified composite products must be fully interchangeable.

Keywords: waste; gravel; mixes; recycling; roads

1 Introduction

For obvious reasons owners of granular waste try to find better use of their materials than disposal. To those not involved in the gravel business on a daily basis, it could be hard to find the right steps to make it happen. The environmental objections are apparent in some cases but most often it is the wrong material, at the wrong place at the wrong time. The rock is not blasted and crushed until there are deliveries in the near future. Waste is not produced because there is a demand for it. Without a strategy to balance demand and supply there will be logistical problems, besides those of quality nature. The customer also wants to see his needs in focus and not just being regarded as an opportunity to avoid the landfill.

A good way to learn how to introduce waste products into civil engineering is to study the rock material industry to see what needs to be done to fit in on that great potential market. Some outlets are in the covering of landfills or on odd construction projects surrounded by expensive special arrangements. The large volumes, however, result from a constant flow of material, although seemingly small and slow, into products of general use. In order to succeed in this effort there are questions to sort out and actions to take. This is what the concept of composite products of waste materials is all about.

2 Materials

To catch the interest of the market, waste or surplus materials need to be of some volume and produced relatively continuously or at least in annual cycles. Materials of special interest are reclaimed asphalt pavement, concrete from demolition, slags from the metal industry and bottom ashes from MSWI. Others are replaced railway embankment macadam, collected gritting sand and sand fractions from various industrial processes. Mixes of dug up materials like sand, gravel, asphalt pavement and walking path tiles are useful as raw materials. Granulates of bricks and tiles often come along with demolished concrete. Household waste frequently contains porcelain, fuses, ceramics and glass. These materials are far from strong as rock materials but pre-treated properly they can all be of some use. Especially in combination with crushed aggregate, which can also be a surplus material.

3 Methods

Each category of waste needs different kinds of processing in order to become a certified component: separation, crushing, screening or washing. The quality and function of the combined end product is based on three key elements: amount and properties of the fines, the hardness of the coarse aggregate and the gradation. Silty materials should be avoided, common rock hardness is enough and the Fuller distribution is the target. The environmental aspects are considered in each case.

These general processing steps involve a number of variations, e.g. magnetic separation of ferrous materials, wind screening of light materials or flotation. Flotation and washing could be performed simultaneously. The purpose of washing is to remove the silty fines and soluble substances as salts. Crushing and screening shapes the particles to a suitable gradation for the intended use, e.g. a sand like fraction combined with a coarse aggregate.

The rock material is crushed just enough, like a graded macadam, to make room for an added sand fraction. This offers several advantages: a simple, quick and cheap crushing of rock without grinding a high quality material into a simple component as sand. Such grinding also produces harmful silt. The sand fraction doesn’t have to be made of strong particles. The important thing is that the content of silt is low.

Crushed asphalt should if possible be recycled into new asphalt mixes again. Significant volumes, however, cannot be used that way because of difficulties in logistics or poor quality. In some cases contaminations prevent RAP from being heated up. It could still be used in cold processes and embedded in other materials. RAP brings several benefits to these non-cohesive materials. It prevents segregation, catches dust, keeps coarse aggregate in place and makes the mix less water sensitive.

The concrete particles are not strong enough to be placed in base layers and the curing ability of crushed concrete is double-edged. Too close to the road surface the brittle cohesion could cause reflective cracking. Added aggregate reduces these adverse effects while the benefit of the curing remains.

An unlikely mix of crushed RAP and concrete has proven versatile for many purposes. For high performance roads, however, it has to be mixed with a good part of coarse aggregate.

How waste becomes end products for general use via certified components.												
Examples of waste materials	Optional processing steps to a certified component					Examples of combinations for technically unrestricted use						
	Assessment of waste	Separation	Crushing	Screening	Washing							
Reclaimed As-phalt Pavement	o	o	o	o		x	x				x	
Demolished Concrete Boul-ders	o	o	o	o		x		x				
Misc. metal slags	o		o	o	o							x
MSWI bottom ashes	o	o	o	o	o					x	x	
Gritting sand	o	o		o	o				x			
Misc. surplus non silty sand like materials	o								x			
Replaced railway embankment macadam	o	o	o	o	o				x			
Crushed Rock Gravel						x	x	x		x	x	x

4 Examples from a case study

Figure 1. The SYSAV sorting facility for bottom ashes in Malmö.

Figure 2. Screening shapes the SLAGsand to fit the other components.

Figure 3. A prepared blend of SLAGsand and ASPHALTgravel on top of ROCKgravel before mixing it all together.

Figure 4. The test road in Malmö comparing virgin base gravel (light brown area) with SLAGASPHALT*base*.

The pictures show a case study on combined MSWI bottom ashes, RAP and crushed rock for a test road in Malmö, Sweden. This version of the composite concept is described in a handbook for MSWI, based on a general technical description /see References/. It was reported that 30 % of a prepared blend of processed SLAGsand and ASPHALTgravel mixed with ROCKgravel could replace conventional crushed base gravel made from virgin rock material in a high performance construction.

5 Discussion

The main purpose of the composite concept is to make the best use of each material and to help correcting any apparent deficiencies, e.g. lack in particle hardness, by adding ordinary crushed rock. It doesn't stop certified components from being used solely without any rock aggregate involved if the result is satisfactory without it. And there are enough of reclaimed and surplus rock to go around and some metal slags with great hardness not to bring virgin crushed aggregate into the mixes at all times.
The prerequisite for this way of working is acceptance among producers, suppliers and clients. It takes a convincing and transparent quality assurance programme to achieve that. Still, profit is not guaranteed. As experienced players know recycling is often more expensive than new production unless helped by regulations, fees, taxes or active working of the market. Those responsible for generating waste must contribute financially to the downstream activities to ensure a successful recycling.

6 Conclusions

If intentions are to make serious steps towards recycling of waste in large quantities there are some basics to consider:

- There is a continuous demand for base and sub-base gravel all year around and everywhere. That is why they are suitable as end products for waste components.
- With few exceptions waste in its original form work without restrictions in high performance constructions. However, in composites with crushed rock any waste will do after proper processing and in due quantities.
- The key to success is proper processing of waste to a certified component. Once that has been achieved the rest is processing as usual.
- Products containing certified components from waste must be fully interchangeable with the ordinary range on the market. Only then the market value of gravel can be fully exploited.
- Dust shall at all times be avoided or immobilised, for reasons of convenience and health in some cases. Besides this it is always unwanted from a geotechnical point of view.
- Processing of waste will cost. Funding should come from those causing the waste situation. It is common practice in all other recycling cases.
- The ordinary gravel producers are seldom interested in recycling without proper tives. Since they possess all means necessary it would be worth the effort to catch their interest. In principle, raw materials can be of any kind, even certified components from waste.
- Key players are customers with the opportunity to favour or require the use of recycled materials in their procurements.

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