Upgrading the use of recycled aggregates

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Abstract
Use of crushed concrete and masonry in the UK is mainly for lower grade applications and its resource potential (as measured by its position in the marketplace) is frequently undervalued. In recent years there have been moves to demonstrate its wider potential eg in ready-mixed concrete for the new Environmental Building at BRE. This paper describes progress in collaborative programmes with UK industry to improve guarantees of quality for use in concrete blocks, precast concrete, and by the introduction of a pilot scheme for quality control. This paper also introduces new work to improve the availability of information and in particular the establishment of an internet-based materials information exchange. This is designed to be attractive by being simple, quick and self-maintaining.

Concrete blocks were made with up to 75% recycled aggregate on a full-scale industrial plant and tested in beam-and-block test floors. All performance indicators were exceeded by a very wide margin. With regard to precast concrete, no effective difference was found in initial tests with the replacement of up to 20% of coarse aggregate or 10% of fine aggregate with reclaimed product. Quality control of recycled aggregates for these construction products should not need to be very onerous - with floor infill blocks because of the massive safety margin, and with reclaimed product in precast because this is already a much better controlled source than demolition waste. The prospect for some utilisation of fine recycled aggregates in higher-grade applications is considered possible both in the precast application and for cement manufacture.
Keywords: cement, concrete blocks, demolition, flooring, internet, precast, quality control, readymix, recycled aggregates

1 Introduction

Worldwide demand for aggregates is on an increasing trend and long-term projections indicate that the UK is no exception. As in the UK, there is an increasing commitment to the principles of sustainable development, with an emphasis on the need to make greater use of waste and recycled materials and use primary aggregates more efficiently. Although waste and recycled materials already account for about 10% of the aggregates used in the UK, there is a considerable potential to increase this level of usage and it is UK Government policy to promote this where this furthers aims of materials conservation and environmental protection.

Many countries, including the UK, already have a substantial use of recycled aggregates in road construction, where fairly large quantities of low-specification aggregates have traditionally been required. While attempts are being made to increase this usage in the UK, it must also be borne in mind that the construction of new roads on virgin land is not a sustainable activity and that already this is losing its importance with respect to road maintenance and the construction of high-speed rail networks and urban transit systems. All of these activities generally require a greater proportion of materials produced to higher specifications. It is against this background, and the decreasing availability/increasing cost of landfill, that efforts have been made towards putting in place higher-grade outlets for recycled aggregates.

2 Specifications for recycled aggregates

European standards for all types of construction aggregates are currently being prepared and are intended to include the use of recycled aggregates, provided, of course, that they meet performance requirements for the intended end-use. An ad hoc group of the relevant Technical Committee (TC 154) has prepared a technical report on the specification of recycled aggregates from which specification clauses will be drafted for inclusion in the product standards. Unfortunately this will not be ready in time for the projected implementation date (the year 2000) for the first package of aggregates standards. Thus implementation of European (CEN) specification requirements for recycled aggregates may have to wait for the first revision of these standards, or at least until amendments are issued.

Specifications for recycled aggregates in concrete prepared in the Technical Report of the ad hoc group for recycled aggregates are based on the RILEM Recommendation [1]. Additional recommendations made by the ad hoc group include additional quality control procedures - rates of testing, and very importantly, the input control of materials entering recycling plants.

3 Recycled aggregates in ready-mixed concrete

The RILEM Recommendation was used as a basis for the specification of recycled aggregates in ready-mixed concrete in BRE's new Environmental Building [2] and in the construction of a strong floor facility at BRE's Cardington Laboratory [3]. The use of this specification in conjunction with the British Standard for concrete (BS5328) had

already been explored as a permissible within the UK Building Regulations as part of a study carried out by BRE for UK Government Minerals Planning [4]. Quality control procedures relating mainly to input control and frequency of testing were put in place for each of these projects.

A new project to assist a more general application of recycled aggregate in ready-mixed concrete has been started at BRE. This involves partnerships of demolition firms, recycling plants, readymix companies and clients. The clients in the first instance will be Local Authorities in which there are various pressures to promote recycling - these are applied by Central Government and relate to permissions for mineral extraction and the provision of landfill space. Naturally, Authorities in urban areas, particularly in SE England are under the greatest pressure. The aim of the project is to put in place quality control procedures to allow a more general use of recycled aggregates in higher grade applications. This may not just be for structural concrete, but could also be used, for example, for cement-bound sub-base materials in roads - a use which was introduced in the Highways Specification in 1991 [5], but not, as far as it is known, taken up.

It is intended that the quality control procedures will be backed up by a BRE Digest to be published in 1998. This Digest will bridge the gap between specifications as drafted for CEN and current UK practice.

4 Recycled aggregates in manufactured products

In the BRE study on specifications [4] another route for the application of recycled aggregates was identified and this is potentially simpler to implement. Manufactured products should be guaranteed by the manufacturer as fit for purpose. Thus, in principle, the quality control of any input of recycled material needs to be verified only by the manufacturer of the product. In practice, however, not all products are specified purely on performance and standards often contain both recipes and performance requirements. In these circumstances, proof may be required to the satisfaction of the user that a recipe can be varied without detriment to the product.

4.1 Concrete blocks

Another partnership project led by BRE has concentrated on the use of demolition waste in precast concrete blocks. The intended use for these blocks was for beam-and-block flooring systems. This was considered to be a fairly non-onerous end-use since there are no weathering requirements and the general experience with loading tests on floor is that the margins of safety are very large (at least a factor of 10).

Initial studies in this project were concerned with the requirements for recycled aggregates to be used in conventional blockrnaking plant. These plants rely on the free fall of materials in hoppers etc and thus a sufficient proportion of fines must be removed from the recycled aggregate to ensure that clogging of the plant does not occur. The grading of the recycled aggregates thus needs to be coarser than that needed to produce dense, well-compacted blocks. Some natural sand needed to be added to the recycled aggregate at the mixer ie it was not possible to produce good blocks containing 100% recycled aggregate with conventional plant. Blocks with up to 75% recycled aggregate could be made with no difficulty. (ARC Conbloc using materials supplied from Pinden

Plant & Processing). Floor loading tests were carried out by Kingsway Technology on blocks from 3 trial runs containing between 50% and 75% recycled aggregates. Beam-and block floors 2.9 x 3 metres were constructed for each trial run and finished with a 50mm thick 3:1 sand:cement screed which was left to cure for 28 days. Each floor required the use of 6 beams and 70 blocks. Floors were loaded centrally via a 100mm square plate. Results for ultimate load gave safety factors of between 33.7 and 39.0, and deflection was well within limits given in BS8 110 for the structural use of concrete.

4.2 Precast structural concrete

A further partnership project led by BRE in association with members of the Precast Flooring Federation, Leeds, Nottingham Trent and Sheffield Universities is concerned with the recycling of rejected precast elements within precast works. Wastage of concrete within precast works due to a number of factors such as breakage, poor compaction, malformation and off-cuts can sometimes approach 10%. Although some materials have been crushed and used as hardcore rather than landfilled, there would be further advantages if the material could be fed back into the production line. Use of reclaimed product in precast is already practised in some countries where this is allowed in the specifications. The challenge in the UK where current specifications preclude its use is to produce an industry code of practice/industrial standard that will be acceptable within the construction industry as a whole.

Trials are being carried out at 4 precast works, and initial tests on various levels of replacement should be complete early in 1998. Initial results indicate that there is little if any effect from the replacement of 20% of the coarse aggregate and 10% of the fine aggregate by reclaimed product. Reclaimed product is a purer and more consistent material than recycled aggregates from demolition waste and thus requirements for quality control are very much reduced. The incorporation of a small percentage of fine material without detriment also illustrates the purer nature of reclaimed product - most research workers have found the fine material from demolition waste to be too contaminated for very successful use in concrete.

When the use of reclaimed product in precast works is well established as routine within the construction industry, it may be possible to consider an extension to this practice. If buildings were "deconstructed" rather than "demolished" then precast elements could be retrieved and returned to the manufacturer for recycling.

4.3 Cement manufacture

Demolition materials can form a source of raw materials for the preparation of raw feed to cement kilns producing Portland cement. This forms part of a Brite-Euram project "Construction recycling technologies for high quality cement and concrete" led by the Spanish cement company Lemona of Bilbao with Labein also of Bilbao. BRE is part of the consortium which also includes work on concrete technology by Holzmann, Prüftechnik and BAM of Germany and Taywood Engineering (UK). It is hoped that cement manufacture will be able to cope with the higher level of pollutant found in the fines derived from crushed demolition material, and thus, together with the use of recycled aggregate in concrete, offer the potential of high grade applications for all size fractions.

5 Materials Information Exchange

One of the key restraining factors which prevents the more effective use of demolition materials and surplus construction materials is lack of timely information on arisings and information regarding potential construction projects or production processes where such waste could be utilised. A potential user of waste needs to know what waste is becoming available and when (or for how long), in what quantity, where, and what cost. Conversely, a producer of waste, whether construction, demolition or at a materials production site will ask similar questions in relation to potential disposal routes. Timely notification of material availability and future sources will facilitate advance planning and greater take-up of material.

In response to these requirements BRE, with support from the UK Department of the Environment, Transport and the Regions have developed an intemet-based Materials Information Exchange. This consists of four parts:

- A 'board' showing materials for free collection or sale, with text and menu boxes for nature of arising, quantity, location, cost and timing
- A category of unutilised materials, for example, over-ordered stock available
- A 'Materials Wanted' board with text and menu options similar to above
- An 'up and coming' demolition board to notify potential users of future sources.

The system is available to any operator who has an internet connection. In operation the exchange is not complex and relies on a series of predesignated 'click' boxes giving options relating to most of the details required. The operator generally only needs to input contact point of the supplier or user. The system will automatically search all input data to match the search commands. The time for both inputting and extraction of information is measured in seconds rather than minutes. Furnished with the contact information, the operator is then free to negotiate for the use of the material.

The Materials Information Exchange is designed to be self-maintaining and users are free to enter or extract information directly from the system without the need to contact a third party. The self-maintaining nature of this system means that there are no subscriptions or user fees. It is considered that the simplicity, speed and cost-free nature of the system will provide an attractive package to the industry and ensure take-up and use of the system. The address of the system on the internet is:

http://helios.bre.co.uk/waste

BRE are about to commence an integrated awareness, consultation and review exercise with potential users, industry trade associations, Local Authorities etc., targeted initially on London and SE England. This aims to encourage take-up of the scheme and, in the light of consultation, to identify improvements that will increase the effectiveness of the exchange.

6 Future developments

BRE, Construction Directorate of the UK Department of the Environment, Transport and the Regions, the UK Environment Agency and Hertfordshire County Council intend to establish a Sustainable Building Network aimed primarily at Local Government which has a crucial role to play in developing and implementing ways of promoting sustainable practice in industry on a local and regional basis. They act as clients in specifying construction projects, as influencers through environmental fora such as Local Agenda 21 and as enforcers in planning and building control.

As well as providing information on current best practice, and facilitating the building of partnerships to achieve these aims, it is intended that the Network will provide a positive feedback of new ideas and experience eg Hertfordshire County Council anticipate undertaking a study of reuse and recycling of materials in the construction of schools and are willing to share their information through the forum.

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