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Editorial

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There is an established tradition for salvaging and recycling building and construction materials. For hundreds of years after the end of the Roman Empire, later groups plundered Roman buildings as a source for new materials; often skilfully worked stone masonry and fired clay products were thus incorporated into altogether cruder new buildings. Demolition waste has long been broken down and used as foundations and subbases for new construction, roads and other pavements. There is now a movement towards, and encouragement for, recycling old concrete as crushed aggregate for new concrete, although there can be legitimate concerns and certainly more caution must be exercised with respect to fine aggregate.

More valued building elements, such as ashlar blocks, bricks, roofing slates or tiles, lintels, flooring tiles and various decorative items, have long been recovered and re-used. In recent times, as we have become ever more sensitive to the need to minimise waste and maximise re-use, this trade has organised itself into centres where these items can be sold, sorted and purchased. In some cases, certain materials are only available on a second-hand basis, including natural stone varieties that are either worked out or no longer viably quarried; an example would be natural roofing slate from Scotland. Indeed, such is the quality reputation of indigenous UK slates, it is often considered preferable to undertake visual assessment and expert selection for re-use of second-hand slates from these sources, rather than importing new materials or employing manufactured products.

Alongside this admirable recovery and re-use of earlier construction materials, there has also been a gradually increasing role for finding gainful re-employment by the construction industry of redundant or waste products. A familiar, but not always recognised, early example was the use of former ship's timbers for buildings, explaining the quaintly curved members that characterise many country cottages and attractive old pubs. A more recent such adventitious re-usage involved large residual stocks of tubular steel produced during the Second World War that found a new use in the post-war rapid rebuilding programme for various system-built housing types; unfortunately, in some cases early corrosion meant that this re-use was not always a lasting success. Large quantities of industrial wastes and by-products, such as various slags, have found extensive and largely beneficial uses in construction and this trend is increasing. In the middle part of the last century, much clinker from coal-burning furnaces was routinely used as aggregate in concrete with variable success, and today waste ashes from furnaces and incinerators are common components of especially precast units. A by-product of the china clay extraction industry in south-west England comprises mostly quartz grains and is extensively used as an aggregate for concrete in the region. In Germany, calcium sulfate that is available as an industrial by-product is used to make gypsum plaster, by careful factory blending with inert fillers and other constituents, and competes on an equal basis in the UK market place with the familiar pink gypsum plaster that is processed from a natural deposit.

Readers will be aware of many other examples of this happily growing endeavour to consume waste or previously-used products as an alternative to extracting or making new construction materials. However, it is a constantly changing situation, partly because the availability of wastes or by-products might fluctuate. A now-famous London landmark set out, as far as possible, to use recycled materials or innovative products made from otherwise useless waste; in this way, the architect was keen to use floor tiles made from expired cathode ray tubes, of which there was a growing unusable 'mountain' in the pre-flatscreen era. In the end they could not be used because the glassy product was too slippery, but in any case the otherwise admirable initiative was soon compromised by the rapid demise of the cathode ray tube. Two extremely popular construction materials in common usage worldwide, blastfurnace slag by-product from the iron and steel industry, in its ground granulated form, and fly ash waste (including pulverised-fuel ash) from coal-burning furnaces, might also face at least regional supply shortages going forward. Some of the former large producers of iron and steel, including the UK, are increasing focusing on specialist rather than bulk production, with consequently reduced slag outputs, although interestingly and relevantly, there could soon be a new lease of life from the processing of recycled iron and steel materials (Allwood, 2016). In the case of fly ash and other types of produced ash (such as rice husk ash), this possible shortage could be more profound worldwide as there is a global move away from coal and other carbon-burning for environmental reasons.

The group of seven papers in this themed issue on recycled construction materials present a varied insight into the topic. Fittingly, the scene is set by an opening overview article by a specialist consultant, who recently retired after many years with the Waste Resources Action Programme in the UK (Barritt, 2016). He explains that the UK construction industry is in the vanguard of countries exceeding the 70% target set by the European Commission for preventing resources being lost to

landfill and has now moved its focus from improved recycling (now leading in Europe with 27% of supplied aggregate in 2012 being recycled) to prevention of waste. Barritt reviews the factors that have influenced this progress in the UK.

Two further papers consider the use of recycled concrete aggregate. Soutsos & Fulton (2016) report on the extensive regeneration that has occurred in Merseyside since about 2000, combining the availability of construction and demolition waste (C&DW) with extensive new development. In particular, they describe laboratory research and factory trials into the use of C&DW in a relatively high-value use: the precast concrete block and paving industry. Success is claimed for these products, containing levels of replacement of newly quarried aggregate by C&DW-derived aggregate that did not necessitate any increase in cement content. A concise paper by Fox (2016), based on actual commercial case studies, identifies the risk of asbestos contamination in some forms of recycled building material. Helpfully, Fox provides brief background to the mineralogy and usage of asbestos in buildings and explains how suspect materials can be investigated with reference to the UK's Control of Asbestos Regulations 2012 (licensing regulations were first introduced in 1983). Crucially, concern is indicated over some of the man-made mineral fibres that have replaced asbestos in construction products, especially the refractory ceramic fibre.

Different aspects of concrete made using recycled aggregates are addressed in the next two papers. Hassan *et al*. (2016) address the situation in Qatar, where structural concrete has typically been made using imported aggregates of proven quality, but where demand is increasing as infrastructure is developed ahead of the 2022 World Cup. Their programme has been assessing both C&DW generated within Qatar as old buildings are demolished in readiness for redevelopment and excavation waste of mainly limestone rock that can be processed as aggregate. These recycled aggregates were trialled in various concrete mixes and some actual monitored buildings, indicating that, when properly specified, processed and controlled, the local recycled aggregates performed comparably with the established imported materials. Badr (2016) set out to fill a gap in the literature on concrete repairs, questioning whether standard repair techniques were equally effective with recycled-aggregate concrete. Badr experimented with deliberately deteriorated and damaged recycled-aggregate concretes and found that the standard repair techniques successfully returned them to a monolithic condition.

The penultimate paper (Ellis *et al*., 2016) is a valuable and exemplary case study of a major structure (the Bermondsey Dive-Under – 'BDU' – scheme in south-east London), in which a major (900 m) brick viaduct was demolished and the bricks innovatively recycled in a crushed engineering fill for the replacement works. A practical research programme is described, in which two types of brick deriving from the demolition (yellow and red) were found to perform differently, but that overall the crushed brick could be successfully used as a (non-metallic) reinforced-earth fill material.

Finally, Andiç-Çakir *et al*. (2016) are concerned about how to utilise some 12–13 million tonnes of glass waste material generated annually worldwide, especially as it might not be possible to consume it in concrete or other cementitious materials, owing to possible resultant alkali–silica reactivity (ASR). They propose using some of the glass as aggregate within polymer concrete, when ASR is not an issue, and their tests indicated that this would be feasible, when the concrete could also employ glass fabric reinforcement.

I hope you will enjoy reading the above papers as much as I have enjoyed preparing this Editorial, including my preliminary ramblings around the subject of recycled construction materials and my short snapshots of the excellent contributions.

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