MPA Cement Fact Sheet 7

Alternative fuels and raw materials in cement kilns: Cement quality and concrete performance

Introduction

A major priority for cement makers is the safe manufacture of high quality cement. The UK cement industry is committed to achieving this in a sustainable way: environmentally, socially and economically. To achieve greater sustainability of its manufacturing process it is essential that all available resources are used efficiently and effectively. Many wastes from within the industry or from external sources have potential for use within cement manufacture, either as fuels or replacement raw materials, and the industry is actively pursuing their beneficial use within its processes. The UK Government has committed itself to the EU Landfill Directive and other international agreements that aim to reduce disposal of wastes to landfill and to recovering energy and materials from used tyres, packaging wastes, solvents and many other waste streams. The UK cement industry is, therefore, playing a vital role in helping to achieve the UK's environmental objectives by utilising appropriate wastes as alternative fuels and raw materials in the manufacture of cement.

Which wastes are used as alternative fuels?

Traditionally, fossil fuels [coal, pet coke as well as a limited amount of gas and oil] have been burnt to generate the temperatures of around 1450ºC needed to produce cement. World-wide, waste-derived fuels have been used for many years to partially replace fossil fuels in cement manufacture. In the UK, waste-derived fuels are rigidly specified and sourced from amongst: used tyres (whole or chipped), secondary liquid fuels (recycled inks, solvents, thinners, oils and residues), wood, packaging wastes (non-recyclable paper, cardboard and plastics), sewage sludge (pellets), residual household waste, commercial and industrial waste and meat and bone meal (MBM). On a mass basis, fuel accounts for only 10% of the 'throughput' of a cement kiln; the rest comprises raw/mineral materials. On a thermal basis, the level of replacement of fossil fuels by waste-derived fuel is around 40% (2010) averaged over the UK whereas it is up to 70% in some EU countries. Waste-derived fuels, like fossil fuels, are predominantly hydrocarbons which, when burnt during cement manufacture, are almost entirely decomposed to carbon dioxide and water with insignificant amounts of more complex carbon-based compounds [1]. A very small residue or ash is formed from liquid fuels, larger quantities are formed from solid fuels but all are chemically bound in cement clinker. As an example, tyres burn to give a residue that is mainly iron, thus reducing the need for additional iron ore to be added as a raw material component.

Which wastes are used as alternative raw materials?

Portland cement is made from mixtures of mainly natural mineral materials, principally chalk/limestone and clay/shale. These raw materials can be partially replaced by wastes, tertiary materials and by-products from other industries in order to 'fine tune' the overall

chemical composition. The proportion of raw materials comprising waste is around 7% by mass (2010) conversely additional/equivalent amounts of natural minerals would have to be added to achieve this same 'fine tuning'. Replacement raw materials currently in use include: cement kiln dust, construction waste, ceramic moulds, refractory bricks, road sweepings, power station fly ash, foundry sand, mill scale (steel production) and iron from used tyres. Less commonly, china clay wastes and colliery shale have been used. Work is also underway to introduce wastes rich in silica, iron, alumina and lime minerals from, for example the water and automotive industries. The wastes used are mainly inorganic in nature, carefully sourced and subject to specifications to which suppliers must comply. These replacement raw materials are processed through the high temperature kilns (solids at 1450ºC, flames at 2000ºC) in exactly the same way as are natural materials.

How are waste-derived fuels in cement manufacture regulated in the UK?

The cement industry is primarily regulated by the Environmental Permitting Regulations (EPR) for England and Wales [2] and Pollution Prevention and Control (PPC) Regulations for Scotland, together with the Waste Incineration Directive [3]. The Environment Agency is responsible for issuing licences or 'permits' to cement kilns in England and Wales whereas the Scottish Environment Protection Agency (SEPA) is responsible for Scotland. In order for a 'permit' to be granted for burning a non-fossil fuel the EA/SEPA requires an 'environmental assessment' to be carried out to demonstrate that the impact of the factory when using the waste will be no greater (and in reality less) than when using traditional resources.

How is stakeholder dialogue undertaken in the UK?

The introduction of changes to long-established operations such as cement works can create interest, or sometimes concern amongst communities and other stakeholders. The cement industry engages with all interested stakeholders through regular, open communications about any aspect of its operations. The cement industry's key stakeholders include neighbours/local communities, employees, customers, shareholders, regulators, 'green' issue interests and those who depend on the industry for their livelihood. However, experience has shown that the stakeholders who become most involved are the local communities and the regulatory bodies.

For many years the cement industry has engaged with its local stakeholders in relation to the use of waste-derived fuels as well as on other issues of interest. MPA with its members has produced a Code of Practice relating to the use of waste-derived fuels. The Code sets out the minimum standards to which members adhere to before using new waste-derived fuels. The cement company will discuss the proposal for a new waste-derived fuel with local stakeholders prior to submitting the formal application for a variation, using the established site liaison committee, through local publications (such as newspaper or web site) and other means as appropriate. Stakeholders will be encouraged to comment throughout the process. Where appropriate, the company may additionally communicate its intent through community newsletters.

A technical evaluation of each new waste-derived fuel takes place for a set period, typically four weeks following commencement of use followed by continuous monitoring evaluation during normal operation. During the evaluation, continuous emissions monitors are used along with periodic extractive monitoring as required by the Waste Incineration

Directive. The technical evaluation will be agreed in advance with the Environment Agency.

At the end of the evaluation, the company submits a report to the Environment Agency. Copies of the report are provided by the company for interested parties upon request. The results of the trial are communicated to local groups through the site liaison meetings, via web sites etc.

Does using wastes as alternative fuels and raw materials have any effect on cement quality?

The main indicators of cement quality are the requirements for mechanical, physical and chemical properties which are standardised in *harmonised* European/national product specifications [4]. These requirements must be met regardless of either the type of fuel used or the nature of the raw materials. These properties are measured and monitored continually, under independent third party scrutiny, in order to ensure that cement conforms to its specification and can be legally placed on the market. The use of wastes has no effect on these major properties because any potential effects will have been accounted for by making compensatory adjustments to the chemical composition of the raw material fed to the kiln.

Does the cement industry go beyond regulation to ensure safety?

The UK cement industry goes beyond properties and characteristics that are specification requirements in order to fulfil its own commitments to health and safety. For example, where 'heavy metals profiles' are measured, the most sophisticated analytical instruments available are used (e.g. inductively-coupled plasma techniques such as ICP-MS and ICP-AES). Although the quantities of individual heavy metals contributed from different wastes and different traditional materials can vary, the levels in the cement are always in the 'parts per million' (ppm) to the 'parts per billion' (ppb) ranges and are of little consequence. In the case of any organic/carbon-based substances, there are no known compounds, whether present in fuels or as contaminants of raw materials, which can survive thermal decomposition at the temperatures of cement kilns and still be found in measurable amounts in the final cement.

Does using wastes as alternative fuels and raw materials have any effect on concrete properties?

Is the durability of concrete affected?

The recovery of wastes as waste-derived fuel and replacement raw materials in cement manufacture is a mature practice in many countries e.g. United States, Germany, Belgium, France, Switzerland and UK. There have been no problems of concrete performance related to their use. Indeed, it is extremely unlikely that any durability problems will ever emerge given the tight specification of 'kiln inputs' and 'kiln outputs' and the compositional congruence of cements made with or without waste materials. The UK cement industry is not, however, complacent and in any durability investigations that are undertaken, cements made using waste-derived fuels and replacement raw materials are included.

Does leaching from concrete occur?

Irrespective of the cement type or its process of production, the quantities of heavy metals, or organics, leached are generally at, or below, the limits of detection (LOD) of the sensitive analytical instruments used. Where they are detected, they are present at orders of magnitude less than any regulatory 'maximum admissible concentrations' [5]. Leaching tests, of various types, carried out on 'monoliths' (solid specimens with formed surfaces) of hardened mortar and hardened concretes in the UK [6], USA [5], and France [1] have shown that it is not possible to distinguish between cements made with traditional fuels and raw materials from those made with partial substitution of wastes.

Where can I find out more?

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References

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