THE GREEN CONSTRUCTION BOARD

REPORT 019

Precast Concrete Resource Efficiency Action Plan

October 2013

A contribution to delivering the targets in the joint government and industry Strategy for Sustainable Construction and the ambitions of the Green Construction Board

WRAP

mpa British Precast

Precast Concrete: a Resource Efficiency Action Plan

October 2013

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WRAP is a not for profit, government funded company, recognised in the UK and internationally as experts in resource efficiency and product sustainability.

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Executive summary

This Resource Efficiency Action Plan (REAP) for the precast concrete sector has been developed to assist the supply chain, which ranges from raw material extraction to the demolition/deconstruction of buildings, in identifying and creating an actionable strategy for improving resource efficiency within the supply chain. The plan identifies the key challenges and actions that the precast concrete sector and its associated supply chain need to address in order to make improvements in resource efficiency in the sector.

This REAP addresses a wider range of issues than previous REAPs. It tackles a much wider scope of resource efficiency and covers the main impact indicators of waste, water, carbon (energy usage and emissions), materials (primary raw materials and secondary/recycled materials) and biodiversity. It is in accordance with the current resource efficiency, low carbon and general sustainability themes being promoted by the Green Construction Board (GCB) and Construction 2025 Industry Strategy: government and industry partnership, and the Construction Products Association (CPA).

This plan has been developed in association with two other action plans, for Clay Bricks and Clay Blocks and Ready Mix Concrete, sharing a Joint Project Management Team, and it underpins the approach these related heavyweight construction materials sectors are taking to address sustainability issues and the provision of resource efficient products and solutions to the construction sector in the UK.

It has been put together *by* the supply chain *for* the supply chain, and has benefited from the input from a stakeholder group formed of a wide range of professionals drawn from the precast concrete supply chain, including raw material suppliers, precast concrete manufacturers, logistics and packaging suppliers, designers and architects, builders' merchants, house builders and main contractors, and demolition and recycling contractors. In addition to providing the funding for this project, WRAP has supplied valuable links with other sectors and other REAPs and its contribution is duly acknowledged.

In the UK, precast concrete is one of the main construction product sectors, with an annual turnover that exceeded £2 billion in 2008, and has more than 10,000 people in full-time employment working in well over 500 production sites. It is estimated that around 20 million tonnes of precast was manufactured in 2011, using millions of tonnes of aggregates and other natural resources, emitting 2.8 million tonnes of CO_2 and generating around 665,800 tonnes of process and factory waste (of which 90% is recycled). Resource efficiency is therefore a major issue for precast concrete manufacturers.

British Precast has been running a sustainability strategy scheme since 2008, which looks at a wide range of sustainability principles and measures the industry performance against a number of KPIs. The scheme set targets to 2012 and now proposes targets and objectives to 2020 and beyond. It allows the industry to collect information on resource efficiency and waste generation but no detailed information beyond the factory gate, or detailed analysis of the drivers and implications of product use, wastage or end of life, has ever been conducted.

One of the beneficial outcomes of this REAP is therefore in addressing this shortfall in the data collection and evaluation process. Through the 'actions' presented here, the aim is to develop a way of setting objectives and reporting progress against 2020 targets annually.

During the development of this REAP, more than 70 challenges and potential actions were identified by the stakeholder group, encompassing all aspects of the supply chain. These preliminary actions were subsequently reviewed and prioritised, resulting in 25 'SMART' high priority actions. When put into practice, it is believed that these actions will bring about measurable improvements in resource efficiency, not only when first instigated but continuing over time.

The actions generated provide a range of approaches to addressing continual improvement of the sector. These include the need to transfer knowledge in the form of formal Continual Professional Development (CPD) programmes, guidance documents and training packages, in order to change resource inefficient practices in the production, specification, distribution and use of precast concrete products. Other actions relate to the assessment and, where appropriate, investment in equipment and infrastructure that will deliver resource efficient improvements.

The basic concept of the action plan is that this report is just the start of a journey towards continual improvement in the sector, resulting in resource efficiency improvements in the manufacture, supply, construction and reuse, or recycling, of precast concrete products in the UK, thus contributing to the UK Government's requirements for a low carbon, sustainable construction sector.

The development of the plan will enable the precast concrete sector and supply chain to develop and deliver the most appropriate actions to improve resource efficiency across the precast concrete sector's supply chain.

Summary of actions

The following is a summary of actions within the report, including information regarding the lead on action delivery and the timescales proposed.

Proposed action	Deliverable action
Manufacturing	
SG2.1 Use the scoping study baseline data to identify which sub-sectors within Precast have the largest range of energy per tonne usage rates, development of case studies and best practice guides to help manufacturers to reduce overall energy consumption.	**A2.1a** Targets to be developed in line with the industry KPIs annually and longer term for energy efficiency in line with the British Precast 2020 targeting. **A2.1b** Case studies of best practice to be promoted through award winners over the past five years. Website to be hosted by British Precast and links provided to the Green Construction Board (GCB) and Mineral Products Association (MPA).
SG2.2 Development of a target of zero waste to landfill	**A2.2a** British Precast to promote 100% diversion of process waste to landfill with a target of 100% compliance. **A2.2b** Target of 95% of all waste generated diverted from landfill and to alternative uses against the 2012 British Precast baseline, with an intention to achieve by 2020.
SG2.3 Promotion of capture and storage of rainwater on all production sites. Evaluate the potential for harvesting from roofs over a certain size.	**A2.3a** British Precast to develop, publish and promote case studies as and when available of water management and water recycling and rainwater harvesting. **A2.3b** Development of a rainwater harvesting tool to calculate the potential harvested volumes.
SG2.4 Project needed to calculate the breakpoint where it becomes more economical to add cement rather than heated curing and vice versa.	**A2.4a** British Precast to undertake a study to determine at current costs the benefits of each approach and develop a tool to calculate the breakpoint between the different approaches.
SG2.5 Review all questionnaires and guidance in respect of the data capture in association with KPI data annual surveys. Focus on energy, waste, water, recycled aggregates and binders.	**A2.5a** British Precast to review all questionnaires and data collection processes associated with the annual KPI data surveys.
Logistics and packaging	
SG4.1 To increase the efficient utilisation of the logistics fleet for precast concrete and assess the benefits of extending the pick-up and delivery to site periods within the day.	**A4.1a** The Chartered Institute of Logistics and Transport (CILT) with member companies to develop and undertake a study programme with site operators to identify the potential efficiencies in extending the delivery to site periods to later in the afternoon (to 5pm or 5.30pm).
SG4.2 Undertake an industry study to evaluate whether 'brand miles' are a real issue and identify the scale of additional mileage incurred as a result of the use of branded vehicles for specific deliveries.	**A4.2a** The CILT, the Brick Development Association (BDA) and British Precast to devise, and seek support for, a survey of its members into the issues relating to brand miles. The aim is to quantify the scale of the problem and identify any additional inefficiencies it imposes on the supply chain – and then work to remove them.
SG4.3 Continue to undertake driver awareness training and promote fuel efficient driving techniques.	**A4.3a** The CILT and its member companies to continue to promote driver awareness and training in relation to fuel efficient driving techniques.

Proposed action	Deliverable action
SG 4.4 Pallets have been a potential opportunity for increased efficiency within the logistics and packaging sector for many years, through pallet return and reuse schemes. However, there is a wide range of pallets currently in use, not all of which are regarded as being fit for purpose in the context of reuse. The aim is to establish whether the pallet sector, manufacturers of pallets and users, should resurrect the Construction Products Association (CPA) Pallets Group and reinvestigate a number of possible resource efficiency opportunities, by modifications to site practice and/or pallet specification and standards.	**A4.4a** Assessment of the merits of the CPA Pallets Group being resurrected. If the assessment recommends the resurrection of the Pallets Group, a first meeting is to be held. **A4.4b** Establishment of a small working party to review the merits of developing the specifications for a small range of standardised pallets with agreed minimum specifications, and to circulate and promote the outcomes.
Design for use and reuse	
SG5.1 Development of a standardised Building Information Modelling (BIM) compliant resource efficiency data set including how to incorporate the key elements of Environmental Product Declaration (EPD) data.	**A5.1a** British Precast to promote the use of the standard formats for resource efficiency BIM data (and, where appropriate, EPD data sets) through guidance notes to members.
SG5.2 There is a need to manage client expectations better in respect of the aesthetics of products. Continual Professional Development (CPD) training to improve the education of the client base, through the Royal Institute of British Architects (RIBA). British Precast to create a workmanship guide based on the contents of PAS (Publically Available Specification) 70, as a British Precast technical guidance note to architects and the design community.	**A5.2a** British Precast to develop CPD presentations and general practical guidance notes to promote good workmanship and manage customer expectations, including refinement and redrafting of the existing PAS 70 as a British Precast technical guidance document.
SG5.4 Promotion of responsible sourcing, aims and objectives, through engagement with the customer base via CPD activities, and guidance on how to maximise the benefits of applying BES 6001 to the supply chain and links with the UK Contractors Group (UKCG) and its register of BES 6001 certificated products and suppliers.	**A5.4a** Responsible sourcing guidance document to be developed by British Precast, including it within CPD. The document is to incorporate guidance to manufacturers on how to maximise the benefits of having BES 6001 in respect to BREEAM and the Code for Sustainable Homes (CSH). The document will also link with the UKCG and signpost links to BES 6001 certificates. A second document is to be developed in relation to the promotion of benefits of responsible sourcing to the client base.
Construction process	
SG6.1 Development of better awareness of the actual value of the materials and how site management and best practice can be used to minimise wastage of materials on site. General support of existing actions in other sectors for the promotion of best practice in terms of site management and education of the workforce.	**A6.1a** Identification of the training and guidance needed for different target audiences in relation to waste minimisation through on site actions. **A6.1b** Development of CPD and other training package content by British Precast to promote best practice on site, especially when bringing innovative products to market. Links to be established with other interested parties such as the RIBA, UKCG, Royal Institution of Chartered Surveyors (RICS) and Construction Skills.
SG6.2 Investigate the benefits of using site-based pallets for off-loading and site handling of void packs and storage.	**A6.2a** Development of a case study to look at the potential benefits and reduction in site-sourced waste generation and losses of materials through storage and handling of void packs on site-based pallets.

Proposed action	Deliverable action
SG6.3 Not applicable to Precast Concrete	
SG6.4 Agree the actual wastage rates and reasons why precast concrete products are wasted on construction sites, so that appropriate targets for waste reduction can be set.	**A6.4a** To agree wastage rates of products listed in the WRAP wastage rates report, to enable the publication and dissemination of the report and the use of the data set in tools and guidance.
Demolition	
SG7.1 Development of mortar specification and use guidance to allow for block recovery, while maintaining structural performance during service. Better understanding of the cost implications of block recovery from sites and the potential value of end product.	**A7.1a** British Precast to develop CPD and general guidance and produce supporting material, following consultation with the Mortar Industry Association (MIA). **A7.1b** Liaison with the NBS, structural engineers, the National House Building Council (NHBC) and MIA in order to develop support, if appropriate, for the redrafting of European Standards for Masonry Mortars in respect of mortar strengths for blockwork. **A7.1c** Case study to develop a better understanding of the practicality, processes and cost implications of the recovery of precast concrete products for reuse from demolition sites.
SG7.2 There is a need for the precast sector to work with the National Federation of Demolition Contractors (NFDC) in the development and updating of the Demolition Refurbishment Information Data Sheets (DRIDS). The DRIDS were launched in June 2013 but should be linked in with the REAP actions regarding updating and expanding the scope of products. Links to the construction education package from the sub-group. General lack of understanding of what is fit for purpose and what is appropriate when selecting recyclable or reusable materials. Design for reuse to be included as well as a link into the Green Construction Board objectives.	**A7.2a** British Precast to provide practical support and technical information in support of the updating of the DRIDS.
SG7.3 Development of appropriate best practice guidance based on the experiences of reuse and recycling of precast concrete products in Europe.	**A7.3a** British Precast to liaise with European sector bodies to identify best practice across Europe and potentially adopt the best ideas in the UK sectors. Initial survey and report to be completed.

Contents

1 Introduction

This Resource Efficiency Action Plan (REAP) for the precast concrete products industry and its supply chain identifies a set of actions that will result in a significant improvement of the sector's resource efficiency. In this report, resource efficiency covers aspects of operational impacts other than just the generation of waste, as has been the focus of previous REAPs for other sectors. In the context of this report, resource efficiency covers the following main areas:

- Water
- Waste
- Carbon (energy and greenhouse gas (GHG) emissions)
- Materials
- Biodiversity

The primary purpose of the REAP is to promote collaboration within the supply chain resulting in a beneficial outcome.

In doing so, the report presents the actions the precast concrete sector and the associated downstream supply chain are taking in response to the UK Government's July 2013 publication 'Construction 2025: industrial strategy for construction – government and industry in partnership'[1], and to the 'greening the industry' approach being developed by the Green Construction Board[2].

In addition, the action plan will help develop sector KPI targets/objectives for 2020 and align strategy to the Concrete Industry Sustainable Strategy[3], Cement Industry Carbon Strategy[4] and Green Construction Board's low carbon route map[5].

The original impetus for the action plan came from liaison between British Precast, the Construction Products Association (CPA) and the Waste and Resources Action Programme (WRAP), following the successful publication of REAPs for other parts of the construction materials sector – flooring[6], joinery[7], windows[8], plasterboard[9], insulation foam[10], and mineral wool ceiling tiles[11]. British Precast identified, through its Sustainability and Environment Committee, a need for a better understanding of the potential benefits of improved resource efficiency, other than those already within the existing annual sustainability KPIs, and thus better alignment with the wider UK construction sector's goals in achieving a more sustainable construction sector.

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[1] Construction 2025: industrial strategy for construction – government and industry in partnership https://www.gov.uk/government/publications/construction-2025-strategy
[2] Green Construction Board http://www.greenconstructionboard.org/index.php/working-groups/greening-the-industry
[3] Concrete Industry Sustainable Strategy (Concrete Centre – Mineral Products Association) http://www.concretecentre.com/sustainability/sustainable_strategy.aspx
[4] Cement Industry Carbon 2050 Strategy (Mineral Products Association) http://cement.mineralproducts.org/current_issues/climate_change/carbon_strategy.php
[5] Green Construction Board – Low Carbon Routemap for the Built Environment. http://www.greenconstructionboard.org/index.php/resources/routemap
[6] http://www.wrap.org.uk/sites/files/wrap/Flooring_REAP.pdf
[7] http://www.wrap.org.uk/sites/files/wrap/REAP_Joinery_Final.pdf
[8] http://archive.defra.gov.uk/environment/business/products/roadmaps/documents/windows101019.pdf
[9] http://archive.defra.gov.uk/environment/business/products/roadmaps/documents/plasterboard101019.pdf
[10] http://www.wrap.org.uk/sites/files/wrap/BIF.pdf
[11] http://members.ais-interiors.org.uk/assets/Uploads/Mineral-Wool-Ceiling-Tiles-A-Resource-Efficiency-Action-Plan.pdf

Resource efficiency for the precast concrete sector is therefore directly relevant to the consumption of raw materials, including energy and water, and the generation of emissions from combustion processes and the decomposition of the raw materials during the cement manufacturing process. It also relates to providing biodiversity and new habitats as part of the decommissioning process and the restoration of quarries and operational sites.

1.1 Precast concrete supply chain

For the purpose of this report, the precast concrete products supply chain was mapped out in order to create the basis for the formation of the stakeholder group. The main features of the supply chain are shown in Figure 1, which outlines the primary routes to market for precast concrete products and where some of the resource efficiency opportunities lie.

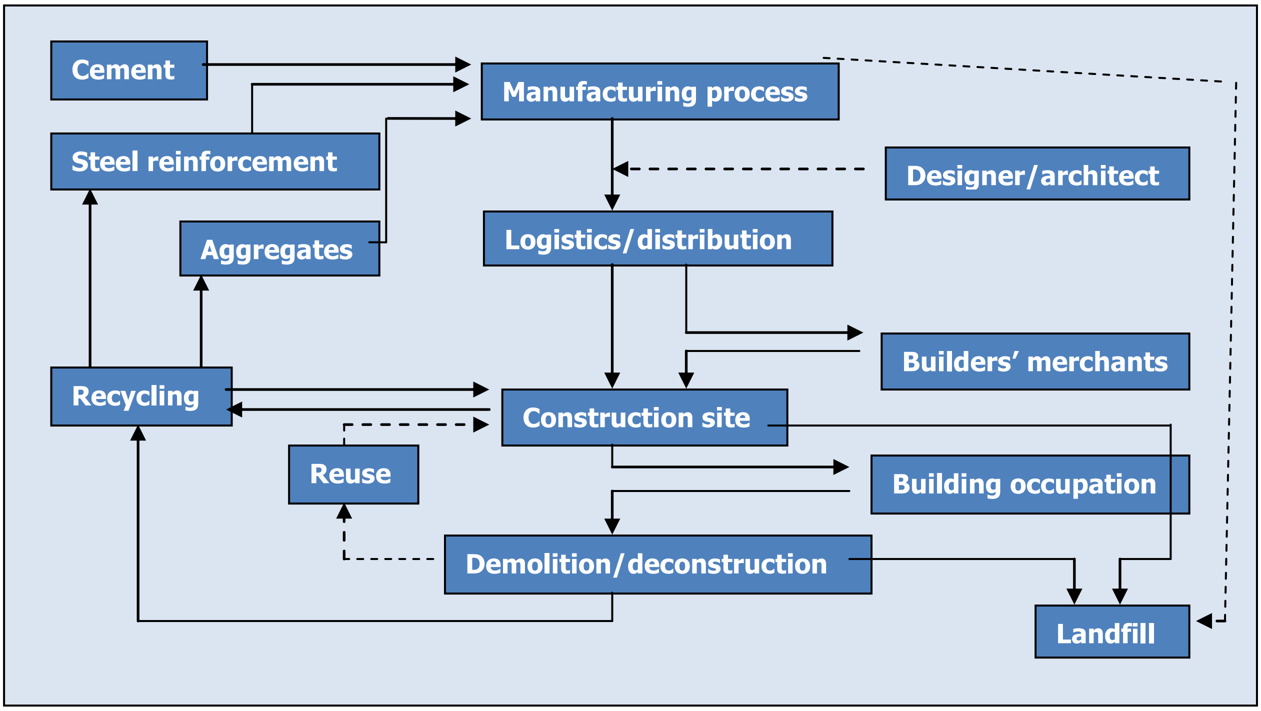

Figure 1: Schematic of the supply chain for precast concrete products

After the manufacturing process, the supply chain for precast concrete products is relatively simple. However, several routes to the end customer have evolved. As shown in Figure 1, depending on the type of precast concrete product in question, not all are supplied direct to the customer. Products such as dense aggregate blocks may be supplied via builders' merchants. In the case of builders' merchants, the blocks can be sold by the merchant and delivered directly from the manufacturer or via the merchant's yard.

The supply chain is therefore represented by the following sub-groups that form the stakeholder group for the Precast Concrete REAP (Table 1).

Table 1: Sub-group structure of the supply chain for the Precast Concrete Resource Efficiency Action Plan

Sub-group	Supply chain segment served
SG1	Clay Bricks and Clay Blocks manufacturing and raw materials (not included in this report)
SG2	Precast Concrete manufacturing and raw materials
SG3	Ready Mix Concrete manufacturing and raw materials (not included in this report)
SG4	Logistics and packaging (including builders' merchants)
SG5	Design for use and reuse
SG6	Construction
SG7	Demolition

1.2 Resource efficiency impact indicators

Following the publication of Environmental Product Declaration standard BS EN 15804 2012[12], there is a standardised assessment methodology for the measurement of resource efficiency and environmental impact indicators for construction products. Where possible, the resource efficiency indicators and principles of BS EN 15804 have been used in identifying relevant factors in assessing the resource efficiency and measurement methodologies adopted in this REAP. This is specifically the case for the development of targets and assessment of progress towards them.

Throughout the supply chain, the principal resource impact areas fall within the following:

- **Materials** – including recycled materials (aggregates and cement replacements) used in the manufacturing process.
- **Carbon (energy and GHG emissions)** – covering both direct and indirect energy consumption associated with the manufacture, transportation and installation/demolition of the products, as well as natural gas, electricity and other fuel oils and gas. In addition, the GHG emissions associated with the use of fuels are a particular area of interest because cement manufacturing falls within the Energy Intensive Users Group in the UK and is thus required to report annually on GHG emissions through the EU ETS (European Union Emissions Trading Scheme) or the UK Small Emitters Scheme and additionally through the CCA Climate Change Agreement (CCA) process.
- **Water** – consumption of water within the process, either through the use of mains (potable) water or, in the case of the manufacturing process, via abstraction from lagoons or boreholes on site as well.

[12] BS EN 15804 2012 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

- **Waste** – covers waste generation either through the manufacturing process, waste as a result of the transportation and storing of products before use, handling and storage of materials on the construction site, pallets and packaging wastes, and waste either recovered or recycled through recycling schemes (typically, the packaging wastes) and materials sent to landfill.
- **Biodiversity** - mineral workings, including quarries, lagoons and decommissioned production facilities, can provide the opportunity to develop and enhance the biodiversity of a site following its restoration. Such actions are usually identified within the restoration plans for all the mineral industries' extractive and production operations.

Conserving the UK's biodiversity is an essential requirement for sustainable development. Precast concrete sector stakeholders expect the industry to reflect this in the way it carries out business. At the same time, the industry increasingly recognises the importance of its role in conserving biodiversity, with the mineral industries being among the leaders in demonstrating how it can be done through the implementation of Biodiversity Action Plans (BAPs). The most exciting opportunities lie in quarry management and restoration, where there is great scope to recreate habitats and encourage species that were once more common in the wider countryside and are targeted in the UK BAP.

Built environment assessment schemes such as BREEAM and CEEQUAL are also helping to raise awareness of this topic with clients, architects and contractors and to ensure that opportunities are taken to integrate biodiversity into the built environment.

Biodiversity is a developing area, in particular with the work being done on ecosystem services, which assign a financial benefit to natural resources. Also, there are future opportunities for a biodiversity credit scheme, where the impacts of development are offset at another location. Biodiversity will be revisited at the annual review stage of British Precast's Sustainability Charter, allowing progress of these developments to be monitored and reported.

Table 2: British precast average resource efficiency indicators for the period 2007-2011 (weighted average for all sub-groups)

		2007	2008	2009	2010	2011
Resource	**Estimated UK Total:**	**38.0mt**	**28.5mt**	**20.0mt**	**20.0mt**	**20.0mt**
	Sector Association representation:	**43.66%**	**42.08%**	**34.17%**	**51.18%**	**56.32%**
Production	Annual Output (tonne):	16,589,763	11,992,540	6,834,380	10,235,952	11,263,656
Energy	kWh / tonne product:	52.90	62.70	89.82	71.71	49.63
Emissions	kg CO_2 / tonne using current conversion factors:	13.50	17.37	23.93	19.95	13.96
Binder	pfa / GGBS substitute (% of total cementitious materials):	n/a	n/a	30.9%	24.2%	23.6%
Aggregate	tonne of all aggregate / tonne product:	0.754	0.832	0.876	0.800	0.814
	Secondary aggregate (% of total aggregate used):	16.5	22.6	19.2%	20.3%	21.0%
Packaging	kg all packaging / tonne product:	2.50	4.90	4.93	4.93	3.75
Water	litres mains water / tonne product:	110.4	113.5	126.9	99.4	84.19
Waste	waste to landfill (%) of total waste:	12%	15%	9.47%	5.50%	5.83%
	waste recycled off site (%):	71%	49%	69.46%	53.10%	44.41%
	waste recycled on site (%):	17%	36%	21.07%	41.20%	49.71%
	material diverted from LF for use as fuel (%):	n/a	n/a	0.05%	0.15%	0.06%
Delivery	average Lorry load (tonne product / delivery):	28.0	18.6	21.7	21.8	22.06
	average delivery distance by road (km / delivery):	160.00	203.00	81.48	119.0	107.00

Within the raw materials supply and manufacturing segments of the supply chain, the UK precast concrete industry has sustainability related KPIs that are measured and reported on annually through British Precast's Sustainability Charter (Table 2). One of the actions already achieved as a result of the development of the REAP is the review and refinement of the sustainability KPIs being measured. The structure of the questionnaire and the scope of the data requested have been modified to be more specific and allow for better reporting against resource efficiency targets in future.

2 The action plan

The development of the Resource Efficiency Action Plan for precast concrete products has been undertaken in consultation with a wide range of interested parties from within the supply chain, from raw material suppliers to demolition contractors. The establishment of the stakeholder group has enabled an open and wide-ranging discussion and analysis of each stage in the supply chain, and of the current resource impacts on efficiency and the actions that could be taken to improve the overall resource efficiency of the supply chain.

Following the initial stakeholder group meeting, it was clear that, to engage with all members and particularly to capture all the salient information to enable the development of the REAP, it would be more efficient to create specialist interest sub-groups. These sub-groups were also given the task of helping with the REAP for clay bricks and clay blocks, being developed in parallel.

The primary aim of the action plan is to identify, clarify and define actions that will improve the resource efficiency of each of the segments in the supply chain for precast concrete products. These actions need to be defined in such a way as to make things happen. To this end, the actions have been developed as 'SMART actions' – specific, measurable, achievable, realistic and time-bound to enable periodic review and refinement of performance against the actions.

This allows actions to be developed and managed with clear and meaningful outcomes, which in turn will have a beneficial impact on resource efficiency throughout the supply chain.

2.1 Manufacturing

Sub-group SG2 involved the main manufacturing members of the stakeholder group and thus included representatives of the key precast construction products producers. Within the manufacturing process and the supply of raw materials, the main focus on resource efficiency fell on the use of the physical resources, energy, materials, water and the waste generated as a result of the manufacturing process.

- **SG2.1 Energy (and associated emissions)** – How to drive down the energy usage in the sector and also in manufacturing in specific precast sub-sectors; it also covers the development of targets for 2020 based on analysis of the 2007-2011 data, with a 2010 baseline.

- **SG2.2 Waste** – Waste generation in the manufacturing process is still recognised as an area where there can be continued improvement throughout the sector. The aim of the associated action is to reduce waste to landfill produced on site of manufacture. It also looked at the development of targets for 2020 based on analysis of the 2007-2011 data, with a 2010 baseline.

- **SG2.3 Mains water** – Although water is a monitored raw material, there is a need for a better understanding of its use in the sector, and ultimately to reduce mains water consumption (from public supply) and maximise recovery and recycling of water from the process. This sub-group also developed targets for 2020 based on analysis of the 2007-2011 data, with a 2010 baseline.

- **SG2.4 Raw materials: binders** – There is a split in current production activities regarding the use of more cement versus longer and/or heated curing in the manufacturing process. Analysis of the existing data suggests that, within specific sub-sectors of the precast concrete industry, some manufacturers increase throughput by modifying the curing conditions for the products, typically by adding heat, whereas others use higher cement contents in the mix. So there is a requirement to understand the resource efficiency impacts of each of these and to examine whether one approach is more efficient than another.

- **SG 2.5 Data** – This sub-group looked at the refinement of the way data is requested and guidance given in order to maximise the accuracy of annual data collection for the KPIs. This data refinement will be used in the development of targets for 2020, based on the analysis of the 2007-2011 results, with a baseline year of 2010.

The resulting actions (Table 3) provide the structure of interventions identified by the members of the manufacturing sub-group that were deemed high priority.

Actions **A2.1a and b** are aimed at addressing the measured differences in the energy efficiency in the sub-sectors of precast concrete products. The primary aim is to reduce the average energy consumption of the sector by targeting those currently operating at above average energy consumption. This is to be achieved by a combination of better data collection and the promotion of best practice guidance for the sector, and specifically case studies within sub-sectors where energy reduction can be shown to be possible.

Actions **A2.2a and b** relate to the desire to minimise process waste generation sent to landfill on production sites as far as practically possible, and thus increase the resource efficiency associated with the whole of the manufacturing process. Action **A2.2b** is specifically aimed at the reduction of all types of waste generated on production sites and the setting of a target of diverting 95% of all waste generated from landfill and into recycling schemes.

Table 3: Actions identified relating to the supply of raw materials and the manufacturing process for precast concrete products

Proposed action	Lead	Deliverable actions
SG2.1 Use the scoping study baseline data to identify which sub-sectors within Precast have the largest range of energy per tonne usage rates, developing case studies and best practice guides to help manufacturers to reduce overall energy consumption.	British Precast	**A2.1a** Targets to be developed in line with the industry KPIs annually and longer term for energy efficiency in line with the British Precast 2020 targeting. **By Dec 2013** (development of targets). **A2.1b** Case studies of best practice to be promoted through the award winners over the past five years. Website to be hosted by British Precast and links provided to GCB and MPA. **By Dec 2013** (started).
SG2.2 Development of a target of zero waste to landfill	British Precast	**A2.2a** British Precast to promote 100% diversion of process waste to landfill with a target of 100% compliance. **By Dec 2013** (promotion to have started). **A2.2b** Target of 95% of all waste generated diverted from landfill and to alternative uses against 2012 British Precast baseline, with an intention to achieve by 2020. **By Dec 2013** (establish target).
SG2.3 Promotion of capture and storage of rainwater on all production sites. Evaluate the potential for harvesting from roofs over a certain size.	British Precast	**A2.3a** British Precast to develop, publish and promote case studies, as and when available, of water management and water recycling and rainwater harvesting. **By Dec 2014** (completed). **A2.3b** Development of a rainwater harvesting tool to calculate the potential harvested volumes. **By Dec 2014** (started).
SG2.4 Project needed to calculate the breakpoint where it becomes more economical to add cement rather than heated curing and vice versa.	British Precast	**A2.4a** British Precast to undertake a study to determine at current costs the benefits of each approach and develop a tool to calculate the breakpoint between the different approaches. **By Mar 2014** (started).
SG2.5 Review all questionnaires and guidance in respect of the data capture in association with the annual KPI data surveys. Focus on energy, waste, water, recycled aggregates and binders.	British Precast	**A2.5a** British Precast to review all questionnaires and data collection processes associated with the annual KPI data surveys. **By Dec 2013** (completed).

Actions **A2.3a and b** are aimed at the development of case studies and guidance for the precast sector in the reduction of usage of mains water. Water remains a vital and critical component in the production of precast construction products, not least because it is the 'activator' of the cement that results in the setting and curing process. So water is needed as an active ingredient of all the product mixes, and thus issues with supply and water quality are of significant interest to the sector.

The ability to recycle and/or harvest rainwater within production sites is therefore a potential route to minimising the need to take water from the mains drinking water system. Although not economically justifiable with the current relatively low cost of water in the UK, the benefit to the sector in pursuing this approach is more strategic and forward-looking with a view to safeguarding production on sites that may be in water-stressed locations and thus subject to limitations on either borehole abstraction or mains supply.

Action **A2.4a** relates to the need for a better understanding of the benefits of achieving curing in a timely manner during the manufacturing process. As with all cement-based products, after adding water to the mix, a chemical reaction between the cement and the water takes place resulting in physical bonding of the concrete. There are two ways of accelerating the ultimate strength and the rate of strength gain resulting from this curing process – adding more cement to the mix or curing in moist warm curing chambers.

Historically, the precast concrete sector, depending upon the nature of the products being produced, has opted for one route or the other. Accordingly, there is need to understand if, within a particular sub-sector of precast concrete or between sub-sectors, there is an opportunity for greater efficiency in materials or energy consumption by changing to a different curing regime.

Action **A2.5a** is a general action to review the quality and quantity of data captured. The aim is, where appropriate, to provide clearer guidance on the submission of data to industry questionnaires. Data quality and completeness have been identified as critical to the validity of the target-setting objectives for the precast sector, both in the short and medium term, not least in the ability to chart accurately progress towards these targets.

2.2 Logistics and packaging

Sub-group SG4 contained representatives from the logistics and packaging part of the supply chain. Their role relates to the packaging and transportation of the precast concrete products either to a construction site or, in some cases, to a builders' merchant, DIY chain or similar.

The sub-group identified a number of opportunities to undertake actions that would result in resource efficiencies (Table 4). These predominantly relate to energy conservation in the logistics sector and to the reduction of damage from handling through the distribution process or on site, with the use of appropriate packaging and/or palletisation of products.

- **SG4.1 Extended pick-up and drop-off times** – The sub-group identified that currently the working day for most sites is from 7am to 5pm. But scheduling of deliveries is dominated by morning requests, and deliveries after 3pm are very limited. In addition, many works usually only operate a limited loading period, again foreshortened in the late afternoon. Extending pick-up and drop-offs by a couple of hours per day would, it is thought, increase the efficiency of the logistics fleet significantly.

- **SG4.2 Brand miles** – The sub-group highlighted an activity that significantly affects the fuel consumption and thus the energy efficiency of the delivery of certain branded products to the client. Some manufacturers or merchants will only deliver products on similarly branded delivery vehicles, even if this increases the distance travelled to make the delivery. It would therefore appear that non-branded vehicles or interchangeable branding for delivery vehicles would provide the best solution and offer more flexible fleet utilisation.

- **SG4.3 Driver awareness/training and fuel efficiency** – Many of the logistics operators already work with a fuel efficient fleet. However, there are perceived to be significant benefits to continued driver awareness and training in order to optimise fuel efficiencies. Some companies, in addition to training, offer financial rewards to drivers for achieving defined targets.

- **SG4.4 Pallets** – The use and type of pallets in the construction and retail sector have been a topic of debate for many years. In addition to the general potential opportunities in respect of limiting pallets to a small number of standard sizes and specifications, opportunities for resource efficiency have been identified, including the use of site-based pallets (see SG6.2) for product storage and handling.

Sub-group SG6, which focused on the construction process segment of the supply chain, identified that the assessment of the use of appropriate packaging and the potential application of site-based palletised storage of 'void packs' of pavers and blocks (SG6.2) represented a key action. Packaging therefore has a role in optimising the protection of the product during transportation, handling and storage, and thus in minimising the potential for damage or rejection of pavers and blocks as a result of contamination during storage.

Packaging also has a significant role in the health and safety implications of the supply chain logistics and safe handling of the packs. Although this issue is very important, the sub-group concluded that current guidance and requirements for safe handling were robust and would not warrant further consideration in this REAP.

Action **A4.1a** relates to extending the period when the logistics fleet can pick up and drop off products during the working week. The sub-group highlighted that construction sites often request drop-offs between 7am and 3pm, or at the latest 3.30pm, while the site usually remains manned and operational up to 5pm or 5.30pm. The additional two hours at the end of the day for dropping off products would increase the efficient use of the logistics fleet. The sub-group also identified that extended pick-up (loading) times at the manufacturing sites would help, so overnight shipments for long haul could be utilised. Ideally, the logistics fleet would benefit from a 6am to 6pm loading time from manufacturing sites.

Table 4: Actions identified relating to the logistics and packaging aspects of the supply chain for precast concrete

Proposed action	Lead	Deliverable actions
SG4.1 To increase the efficient use of the logistics fleet for precast concrete to assess the benefits of extending the pick-up and delivery to site periods within the day.	Chartered Institute of Logistics and Transport and member companies	**A4.1a** The CILT with member companies to develop and undertake a study programme with site operators to identify the potential efficiencies in extending the delivery to site period to later in the afternoon (to 5pm or 5.30pm). **By Dec 2014** (study to be completed).
SG4.2 Undertake an industry study to evaluate whether 'brand miles' are a real issue and identify the scale of additional mileage incurred as a result of the use of branded vehicles for specific deliveries.	Chartered Institute of Logistics and Transport with the Brick Development Association and British Precast	**A4.2a** The CILT, BDA and British Precast to devise, and seek support for, a survey of its members on the issues relating to brand miles. The aim is to quantify the scale of the problem and identify any additional inefficiencies it imposes on the supply chain - and then work to remove them. **By Dec 2014** (study to be started).
SG4.3 Continue to undertake driver awareness training and promote fuel efficient driving techniques.	Chartered Institute of Logistics and Transport and member companies	**A4.3a** The CILT and its member companies to continue to promote driver awareness and training in relation to fuel efficient driving techniques. **By** (ongoing).
SG 4.4 Pallets have been a potential opportunity for increased efficiency within the logistics and packaging sector for many years, through pallet return and reuse schemes. However, there is a wide range of pallets currently in use, not all of which are regarded as being fit for purpose in the context of reuse. The aim is to establish whether the pallet sector, manufacturers of pallets and users, should resurrect the CPA Pallets Group and reinvestigate a number of possible resource efficiency opportunities, by modifications to site practice or by pallet specification and standards.	Chartered Institute of Logistics and Transport, manufacturers pallet suppliers and users	**A4.4a** Assessment of the merits of the CPA Pallets Group being resurrected. If the assessment recommends the resurrection of the Pallets Group, a first meeting is to be held. **By Mar 2014** (CPA to review if Pallet Group is to be re-established). **A4.4b** Establishment of a small working party to review the merits of developing the specifications for a small range of standardised pallets with agreed minimum specifications, and to circulate and promote the outcomes. **By Mar 2014** (working group to be established).

Action **4.2a** focuses on a known issue relating to the use of branded vehicles to carry competitor brand products or to deliver to certain customers. Many logistics companies have national relationships with the manufacturers but may work for more than one. Therefore, it is possible that products may be transported on competitors' branded vehicles. The key issue to be researched relates to specific delivery requirements and thus whether branded vehicles can be used to deliver competitor brand products to certain customers. A requirement to use same brand vehicles often increases the distance products are transported, if same brand vehicles are not available or appropriate for the pick-up, adding to the road miles. It is thus seen as a potentially significant inefficiency.

Action **A4.3a** reflects the support for driver awareness and training in respect of fuel efficient driving techniques. Most logistics companies already promote this and the action is intended to add additional support to this process.

Pallets are a regular topic for debate in the packaging sector. However, the sector has arrived at its current position by evolutionary processes and has become very diverse, both in products and the recycling schemes available and used.

Action **A4.4a** relates to assessing if there is merit in the resurrection of the CPA Pallets Group, which worked on similar issues in the past and brought together a wide range of interested parties from across the whole construction sector.

Action **A4.4b**, which could be dealt with by the Pallets Group, concerns the investigation into the benefits of a smaller number of standardised pallets with minimum quality specifications. The aim is to maximise the recovery of pallets within recycling schemes, and to promote pallets that are fit for purpose in terms of quality so they can be reused an extended number of times.

2.3 Design for use and reuse

Sub-group SG5 represented the interests of the designers of buildings and structures, and the specifiers, who utilise precast concrete elements and blocks in the fabric of the building. This segment of the supply chain can have a significant influence not only on the decision making process to use precast concrete products but also in the design of buildings that are 'precast element' compatible.

Blocks of all sizes are a very versatile medium to construct with and can be used in both traditional and contemporary architectural designs. However, there were some action points developed by the sub-group on potential improvements to resource efficiency at the design stage.

- **SG5.1 Building Information Modelling (BIM)** – The use of BIM with the latest generation of building design software is aimed at better development of a bill of quantities, and thus more accurate pricing for projects. BIM also allows for the inclusion of specific information relating to the environmental impact of the building materials in the database. Accordingly, there is a need for the sector to provide data in a BIM compliant form with complete resource efficiency and Environmental Product Declaration (EPD) data sets.

- **SG5.2 Customer expectations** – A significant amount of site waste stems from issues normally involving the client and the main contractor, regarding the aesthetics of completed blockwork and fair faced structural concrete elements. The issues can stem from poor workmanship or the client's unrealistic expectations of the materials being used and the tolerances of blockwork. Occasionally, this results in significant waste being generated because elements are taken down and the products disposed of in skips or used as 'low grade hard core' on site.

- **SG5.4 Responsible sourcing** – Within the precast concrete manufacturing sector, there has been a significant adoption of responsible sourcing policies through reporting and certification schemes such as BES 6001[13]. This, however, has only fed through into the Green Guide[14] and Code for Sustainable Homes[15] assessment schemes and is not widely acknowledged outside these schemes. So there is a potential benefit in an education programme for the client base as to the merits and benefits of using building materials that are responsibly sourced and certificated. Table 5 shows the resulting actions from the sub-group discussions.

Action **A5.1a** identifies the need to develop guidance for UK precast manufacturers so they can supply resource efficiency BIM compliant data sets for inclusion. This will allow designers and architects to use 'real' rather than 'generic' data for their BIM building designs and thus enable better management of the specification and procurement processes. It will also help to minimise inefficiencies in this part of the supply chain, typically over ordering or incorrect specification of products.

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[13] BES 6001 Responsible Sourcing of Construction Products
http://www.bsigroup.co.uk/en-GB/bes-6001-responsible-sourcing-of-construction-products/
[14] The Green Guide to Specification
http://www.bre.co.uk/greenguide/podpage.jsp?id=2126
[15] Code for Sustainable Homes
http://www.breeam.org/page.jsp?id=86

Table 5: Actions identified relating to the design for use and reuse of precast concrete products

Proposed action	Lead	Deliverable actions
SG5.1 Development of a standardised BIM compliant resource efficiency data set including how to incorporate the six key elements of Environmental Product Declaration data.	British Precast	**A5.1a** British Precast to promote the use of the standard formats for resource efficiency BIM data (and where appropriate EPD data sets) through guidance notes to its members. **By Mar 2014** (work to start).
SG 5.2 There is a need to manage client expectations better in respect of the aesthetics of products. CPD training to educate the client base through RIBA supported CPD content for designers and architects. British Precast to create a workmanship guide based on the contents of PAS 70, as a British Precast technical guidance note, for architects and the design community.	British Precast	**A5.2a** British Precast to develop CPD presentations and general practical guidance notes to promote good workmanship and manage customer expectations, including refinement to and redrafting of the existing PAS 70 as a British Precast technical guidance document. **By Dec 2014** (work to start).
SG 5.4 Promotion of responsible sourcing, aims and objectives, through engagement with the customer base via CPD activities, and guidance on how to maximise the benefits of applying BES 6001 to the supply chain and links with the UKCG and its register of BES 6001 certificated products and suppliers.	British Precast in association with the GCB, BDA, CPA and BRE	**A5.4a** Responsible sourcing guidance document to be developed by British Precast, with inclusion in CPD. The document is to incorporate guidance to manufacturers on how to maximise the benefits of having BES 6001 in respect to BREEAM and CSH. The document will also link with the UKCG and signpost links to BES 6001 certificates. A second document is to be developed in relation to the promotion of the benefits of responsible sourcing to the client base. **By Dec 2014** (work to be completed).

*Note SG5.3 was a design sub-group action only relevant to clay bricks and clay blocks, so it has been omitted.

Action **A5.2a** relates to the development of specific guidance in the form of 'guidance notes' and content of CPD presentations, promoting good workmanship on site, specifically when using precast concrete products. The aim is to minimise the generation of waste from poor site construction practice. There is a need to create a British Precast Technical Guidance Note, similar in content to PAS (Publically Available Specification) 70[16] for clay bricks, to make the approach applicable for precast concrete products and better manage client and customer expectations of the aesthetic qualities of the precast concrete products when installed. Often, close inspection of precast elements, whether fair faced structural panels, blockwork or roof tiles, results in aesthetic 'blemishes' being regarded as unacceptable. This can lead to sections of blockwork or other precast concrete elements needing taking down and rebuilding or to the client requesting extensive remedial works. The new British Precast Technical Guidance Note for the precast concrete sector will provide robust guidance on what is deemed acceptable and what is not on such aesthetic issues, and how they should be assessed on site.

Action **A5.4a** is based on the development of information and guidance in the promotion of responsible sourcing, and especially BES 6001 certification, to architects and designers. The precast concrete sector has been at the forefront of this development. However, based on feedback from the sub-group discussion, this is not widely understood by specifiers, main contractors or the client base.

[16] PAS 70 2003 HD clay bricks. Guide to appearance and site measured dimensions and tolerance. http://shop.bsigroup.com/en/ProductDetail/?pid=000000000030102669

This guidance and information will be provided via CPD content and through guidance documents for the wider construction community.

2.4 Construction

Sub-group SG6, led by the UK Contractors Group, focused on the construction process itself. Its primary interest concerned the actual construction process and thus entailed a significant amount of coordination of both materials and human resources. There have been several studies on site waste management, and the avoidance of waste generation[17] on construction sites, most of which came about from the introduction of the need to have operational Site Waste Management Plans brought in as a regulation in 2008[18].

Since 2008, site waste management has improved significantly. But, as a result of the development of this REAP, three outstanding issues relating to waste generation were identified as requiring more development:

- **SG6.1 Perceived value of the products** – There is a general perception within the construction sector that the actual value of construction products is not appreciated or understood by the construction workforce. As a result, the level of care and attention when it comes to protection in storage and the appropriate use of the materials on site contributes to site-based waste generation. So there is a need for better guidance for the site-based workforce, both main contractors and subcontractors, on the value of precast concrete products and the appropriate handling and storage on site.

- **SG6.2 Storage of void packs on site-based pallets** – Blocks are delivered to site in void packs – that is, packs which are not palletised but have 'fork' voids formed within the pack so they can be lifted using forklifts or cranes from the back of delivery vehicles. At the point of delivery, these packs are often lifted from the vehicles and blocks are stored on the ground, and they can be moved a number of times while on the construction site. This can result in mechanical damage to, and contamination of, the lower rows of blocks if stored in mud or on damp ground. SG6 identified that, by transferring the void packs on to suitable site-based pallets (slave pallets) on site at the point of off-loading, they could be handled and stored on site in a way that would reduce waste generation.

- **SG6.4 Site wastage rates** – WRAP has started collecting data relating to the wastage rates for specific construction materials from construction sites throughout the UK. There has been some uncertainty in respect of the values generated for precast concrete products, mainly concrete blocks, and thus no agreed figure is available. While there are studies available, such as a recent study by the Concrete Block Association (CBA), it was recognised that a robust survey was still needed and would be best delivered by WRAP.

Table 6 shows the actions developed by the sub-group in order to address these site-based issues.

Action **A6.1a and b** relate to the need to develop and present guidance and training packages to the site-based workforce on waste minimisation and avoidance in the handling, storage and use of precast concrete products on the construction site.

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[17] Understanding and Predicting Construction Waste' 2008 (WR0111) WRAP
http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=14677
[18] The Site Waste Management Plans Regulation 2008
http://www.legislation.gov.uk/uksi/2008/314/contents/made

The aim is to develop an awareness of the actual value of the products, both financially and in terms of the resource efficiency implications associated with the poor handling, contamination in storage and inappropriate use of precast concrete products.

Table 6: Actions identified relating to the construction process, storage and use of precast concrete products on construction sites

Proposed action	Lead	Deliverable actions
SG6.1 Development of better awareness of the actual value of the materials and how site management and best practice can be used to minimise wastage of materials on site. General support of existing actions in other sectors for the promotion of best practice in terms of site management and education of the workforce.	British Precast	**A6.1a** Identification of the training and guidance needed for different target audiences in relation to waste minimisation through on site actions. **By Dec 2013** (compilation of suitable resources completed). **A6.1b** Development of CPD and other training package content by British Precast to promote best practice on site, especially when bringing innovative products to market. Links to be established with other interested parties such as the RIBA, UKCG, RICS and Construction Skills. **By Dec 2014** (project team to be established and project started).
SG 6.2 Investigate the benefits of using site-based pallets for off-loading and site handling of void packs and storage.	Pallet manufacturers and main contractors	**A6.2a** Development of a case study to look at the potential benefits and reduction in site-sourced waste generation and losses of materials through storage and handling of void packs on site-based pallets. **By Dec 2014** (establish a project team and start study).
SG6.4 Agree the actual wastage rates and reasons why precast concrete products are wasted on construction sites so that appropriate targets for waste reduction can be set.	WRAP	**A6.4a.** To agree wastage rates of products listed in the WRAP wastage rates report to enable the publication and dissemination of the report and the use of the data set in tools and guidance. **By Mar 2014** (completed).

*Note SG6.3 was a sub-group action only relevant to clay bricks and clay blocks, so it has been omitted.

Action **A6.2a** identifies a need for a better understanding of the potential benefits of using site-based pallets (slave pallets) for the storage and handling of void packs, particularly block and paver packs. This would be best achieved by undertaking a number of case studies on different types of construction site to evaluate, on a like-for-like basis, whether the use of site-based pallets reduces the amount of damage or contamination of the products through handling and storage.

A6.4a concerns the need for representative site-based data for the current wastage rates of precast concrete, and for an understanding of the underlying reasons why this wastage occurs. WRAP has already collected data for a number of other construction materials and the inclusion of precast concrete would enable realistic waste reduction targets for sites to be set.

2.5 Demolition

SG7 focused on the demolition process and the current practice of recycling construction and demolition waste by using it as secondary aggregates recovery, rather than the reuse of precast concrete products, where the opportunities are more limited.

The sub-group was led by the National Federation of Demolition Contractors (NFDC), which represents the majority of the UK's demolition contractors. The suggested actions developed in order to address the resource efficiency aspects of the REAP were based on the recycling and crushing of precast concrete products, and the generation of secondary aggregates or general fill materials.

- **SG7.1 Recovery of blocks for reuse** – There is a possible market for the recovery and reuse of blocks (AAC, lightweight and dense) along with concrete roof tiles within the salvage sector, though widespread recovery and reuse is not yet a common process within the demolition sector. One of the main factors is the ability to remove mortar from the blocks to enable ease of recovery and reuse. The use of 'strong' mortars, i.e. those with a high cement content, increases the time and labour required in the dressing of the blocks in order to remove the mortar, thus increasing the cost of the recovered products.

- **SG7.2 Precast concrete sector support of the DRIDS** – The NFDC is in the final stages of developing practical guidance in the form of Demolition Refurbishment Information Data Sheets (DRIDS). The precast concrete sector has indicated a willingness to support and provide technical guidance, specifically in the assessment of the quality of recovered precast concrete products ready for reuse.

- **SG7.3 Review of European practice of reuse of precast concrete products** – Within continental Europe, there are a number of approaches to the promotion of recovery and reuse of construction materials from the demolition and deconstruction process. A comprehensive review of these practices could be used to inform the development of best practice in the UK for the recovery and reuse of precast concrete products.

Table 7 presents the actions resulting from the development of the action plan within the demolition sub-group.

Actions **A7.1a-c** relate to the practical aspects of recovering and processing concrete blocks from the demolition or rather the deconstruction process, in order that the blocks can be reused.

Action **A7.1a and b** refer to the types and specification of mortars for masonry construction as governed by European masonry mortar standards and UK and European building codes (building regulations). One potential solution to the ability to recover greater numbers of blocks from demolition processes would be to have mortars that have 'weaker' bonding to the blocks, and thus are easier to remove. The implications are wide-ranging and there is therefore a need to seek expert opinion from the mortar industry, via the Mortar Industry Association (MIA) and masonry structural engineers, to clarify what is possible and what the lower permissible boundaries are for lowering the bond strength of blockwork in practice.

Action **A7.2a** focuses on the precast concrete manufacturing sector supporting the aims of the NFDC in the development of the DRIDS. This comes in the form of the promotion of the DRIDS principles and the development of complementary guidance documents on the practical assessment methodology for the quality and physical properties of recovered precast concrete products ready for reuse, and thus for how the products could best be utilised in new build. In the past, British Precast or manufacturers have provided guidance but such guidance is not always heeded.

Table 7: Actions identified relating to the demolition of structures containing precast concrete products and the reuse of recovered products

Proposed action	Lead	Deliverable actions
SG7.1 Development of mortar specification and use guidance to allow for block recovery, while maintaining structural performance during service. Better understanding of the cost implications of block recovery from sites and the potential value of the end product.	British Precast NFDC (A7.1c)	**A7.1a** British Precast to develop CPD and general guidance and produce supporting material, following consultation with the Mortar Industry Association (MIA). **By Dec 2014** (work to be started). **A7.1b** Liaison with the NBS, structural engineers, the NHBC and MIA in order to develop support, if appropriate, for the redrafting of European Standards for Masonry Mortars in respect of mortar strengths for blockwork. **By Mar 2015** (work to be started). **A7.1c** Case study to develop a better understanding of the practicality, processes and cost implications of the recovery of precast concrete products for reuse from demolition sites. **By Aug 2014** (work to be started).
SG7.2 There is a need for the precast sector to work with the NFDC in the development and updating of the DRIDS. The DRIDS were launched in June 2013 but should be linked in with the REAP actions regarding updating and expanding scope of products. Links to the construction education package from the sub-group. General lack of understanding of what is fit for purpose and what is appropriate when selecting recyclable or reusable materials. Design for reuse to be included as well as link into the Green Construction Board objectives.	National Federation of Demolition Contractors with support from British Precast	**A7.2a** British Precast to provide practical support and technical information for the updating of the DRIDS. **By Dec 2013** (work to be started).
SG7.3 Development of appropriate best practice guidance based on the experiences of reuse and recycling of precast concrete products in Europe.	British Precast	**A7.3a** British Precast to liaise with European sector bodies to identify best practice across Europe and potentially adopt best ideas in the UK sectors. Initial survey and report to be completed. **By Mar 2014** (work started).

Action **A7.3a** relates to the development of best practice and the approach taken by different continental European countries in the recovery and reuse of precast concrete products from demolition. The ultimate aim is to inform and promote the recovery and reuse of any precast concrete products from the demolition process. This needs to be done in an appropriate way that is compatible with current building codes and regulations and maintains the embodied value of the products by extending the service life of the individual units. It is possible that the products themselves may re-enter the supply chain a number of times and thus the service life of the units may be in excess of that of the buildings themselves.

3 Next steps

To maintain a focus on the development and delivery of the actions identified within this report, the Joint CBB, PCC and RMC Management Team has agreed to meet formally twice yearly, in association with British Precast’s Sustainability and Environment Committee.

The underpinning objective of the development of this Resource Efficiency Action Plan for the precast concrete sector is based on the premise that, by delivering the actions identified, improvements and thus benefits will be achieved in supply chain segments and in the overall resource efficiency of the supply chain. For this to happen, there is a need to review and report progress periodically against the actions. It is the intention of the Joint Management Team to undertake this annually for all three REAPs, with an interim six-monthly review for each of the actions.

For the three REAPs, each action will have a ‘champion’ who will be the Joint Management Team’s representative with responsibility for the action and the reporting back of progress in achieving the targeted action, and for liaison with the lead delivery organisation.

Annually or as appropriate once the Joint Management Team has reviewed progress, it is the intention to publish updates on the actions identified in this REAP and make them available through British Precast, the BDA and Concrete Centre’s websites, as well as via links to the GCB’s ‘greening the industry’ portal.

Appendices

A1 Stakeholder group

This Resource Efficiency Action Plan (REAP) has been developed from the Precast Concrete REAP Stakeholder Group, which represents the segments of the supply chain ranging from raw material suppliers to demolition contractors and recyclers.

The development of this REAP has been managed by a Joint Project Management Team (Table A1) who have worked on both the Precast Concrete (PCC) REAP, the Clay Bricks and Clay Blocks (CBB) REAP and the Ready Mix Concrete (RMC) REAP. The rationale for this lies in the fact that, after manufacturing, the supply chain has a significant amount of commonality. So, to maximise the efficiency of data collection and feedback from the stakeholder group sub-groups, the project was managed jointly.

The Precast Concrete REAP is chaired by David Manley, Sustainability Manager, Hanson, with the administrative secretariat provided by Richard Sawyer of AMEC; the technical specialist and project lead is Dr Andrew Smith of Ceram. The production of this REAP was funded by WRAP.

Table A1: Joint Clay Bricks and Clay Blocks, Precast Concrete, and Ready Mix Concrete Project Management Team

Name		Company	Sector
Richard	Sawyer	AMEC	Administrative secretariat
Simon	Hay	Brick Development Association (BDA)	Trade association
Andrew	Smith	Ceram	Technical specialist
David	Manley	Hanson; PCC REAP Chair	Manufacturer
Emma	Hines	Lafarge Tarmac; RMC REAP Chair	Manufacturer
Guy	Thompson	Mineral Products Association (Concrete Centre)	Trade association
Mike	Leonard	Modern Masonry Alliance	Trade association
Hafiz	Elhag	British Precast	Trade association
John	Sandford	Wienerberger; CCB REAP Chair	Manufacturer
Gareth	Brown	WRAP	WRAP
Malcolm	Waddell	WRAP	WRAP

The Joint Project Management Team gratefully acknowledges the contribution made by members of the stakeholder group who have given freely of their valuable time to offer feedback and support to the sub-groups and in the development of this action plan. Members of the stakeholder group are listed in Table A2.

Table A2: Precast Concrete Stakeholder Group

Name		Affiliation
Gareth	Brown	WRAP
Howard	Button	National Federation of Demolition Contractors (NFDC)
Barry	Chambers	Taylor Wimpey
Luke	Chilcott	Roe Group
Graham	Clark	UK Contractors Group (UKCG); Lendlease
Chris	Clear	British Ready Mix Concrete Association (BRMCA)
Caroline	Cochrane	Aggregate Industries
Colin	Cook	H+H UK Limited
Steve	Cook	Willmott Dixon (& UKCG)
Stuart	Crisp	Concrete Pipeline Systems
Carl	Cuthbert	Hanson
Gary	Dawber	Reclaimed Bricks Ltd
Andy	Dix	PFF (Precast Flooring Federation)
Andrew	Dixon	Federation of Master Builders (FMB)
Eamonn	Duggan	Flahive Brickwork
Hafiz	Elhag	British Precast
Pam	Elliott	Brett Landscaping
Mark	Flavell	Concrete Pipeline Systems Assoc (CPSA)
Paul	Fletcher	Cemex
Nick	Gainsford	Concrete Pipeline Systems Assoc (CPSA); CPM Group
Shamir	Ghumra	Aggregate Industries
Annelli	Gilbert	Cemex
James	Goodall	Waterscan
Trevor	Grounds	T Grounds Associates
Samantha	Hanks	Scott ELM
Chris	Harrop	Interpave
Simon	Hay	Brick Development Association (BDA)
Ian	Heasman	Taylor Wimpey
Emma	Hines	Lafarge Readymix; RMC REAP Chair
Ian	Holton	Aggregate Industries

Name		Affiliation
Karen	Hunter	Scott ELM
James	Hurley	Built4Life (and NFDC)
Peter	Johnson	Kier Group
Charlie	Jones	Hanson
Mark	Kershaw	Crest Nicholson
David	Khana	BPI
Aaron	Lang	Aggregate Industries
Charlie	Law	BAM Construct (& UKCG)
John	Leader	Travis Perkins
Rod	Leigh	Jewson
Mike	Leonard	Modern Masonry Alliance
Andy	Littler	CBA (Concrete Block Association)
Greger	Lundesjo	Chartered Institute of Logistics and Transport (CILT)
David	Manley	Hanson; PCC REAP Chair
Peter	Matthews	Builders Merchants Federation (BMF)
Jerry	McLaughlin	MPA (Mineral Products Association)
John	Mercer	CTMA (Concrete Tile Manufacturers Association)
David	Morrell	Marshalls
James	Newton	Mott MacDonald
Michael	Noble	Scott ELM
Jonathon	O'Coy	FP McCann
Kieran	Owens	Creagh Concrete Products Ltd
Nicola	Owen	MPA (Mineral Products Association)
Barry	Proctor	Barry Proctor Services
Nick	Remfry	Costain
Norman	Richards	NR Richards Associates Ltd
David	Riley	Anglian Water
Geraint	Rowland	Costain
John	Sandford	Wienerberger; CCB REAP Chair
Richard	Sawyer	AMEC (REAP Secretariat)
Ben	Shaw	Costain

Name		Affiliation
Paul	Slater	MPA - Concrete Centre
Ian	Smart	Health & Safety Executive (HSE)
Andrew	Smith	Ceram (REAP technical lead and author)
James	Stanfield	Wincanton
Keith	Stark	Wastepack
Karl	Stevens	Forticrete
Andrew	Swain	Lafarge Tarmac
Guy	Thompson	The Concrete Centre (MPA)
Jane	Thornback	Construction Products Association (CPA)
Mike	Turner	Wincanton
James	Vance	Travis Perkins
Malcolm	Waddell	WRAP
Steve	Walker	Box Culvert Association
Graham	Winter	Environment Agency

A2 British Precast

British Precast is the trade association of precast concrete manufacturers. Its main aims are to promote precast concrete in the construction market and to disseminate information, through a range of industry representation and by shared knowledge, to add value to its member companies. As part of the Mineral Products Association (MPA), British Precast works closely with the rest of the concrete sector in the promotion of the sustainable production and use of concrete in the modern world.

Members of British Precast manufacture a wide range of construction products, and as such are divided into the following product 'sub-groups' based on the nature of the products and manufacturing processes being used. There are seven main sub-sector groups:

- Dense and lightweight aggregate blocks
- Autoclaved aerated concrete (AAC) blocks
- Paving blocks and flags
- Concrete roof tiles
- Structural precast concrete products (e.g. precast panels and facades)
- Concrete pipes (including culverts and manholes)
- Concrete flooring (including beams and slabs).

In addition, there is a wide range of suppliers of materials used in precast concrete products that are associate members of British Precast. In total, more than 100 companies are represented by British Precast.

British Precast sub-groups represent the following trade associations within the precast concrete products sector.

Members:

- Aircrete Products Association (APA)
- Architectural Cladding Association (ACA)
- Box Culvert Association (BoxCA)
- Concrete Block Association (CBA)
- Construction Packed Products Association (CPPA)
- Concrete Pipeline Systems Association (CPSA)
- Concrete Sleeper Manufacturers' Association (CSMA)
- Interpave
- Precast Flooring Federation (PFF)
- Structural Precast Association (SPA)
- Concrete Tile Manufacturers Association (CTMA).

Associates:

- Interlay
- Modern Masonry Alliance (MMA).

Further information about British Precast can be obtained from its website: www.britishprecast.org

A3 About precast concrete

Precast concrete products in the main represent factory produced construction materials from a concrete (cement + aggregate + water ± admixture) based body mix. Depending on the specific product being manufactured, this mix design may be similar in composition to ready mix concrete, but some specific products, such as autoclaved aerated concrete (AAC) blocks, have a very different mix composition and are much finer grained.

The raw materials used in the precast concrete manufacturing process include all or some of the following constituents:

- Cement including alternative cement replacements e.g. pulverised fuel ash (PFA) and ground granulated blast furnace slag (GGBFS)
- Aggregates, including recycled aggregates
- Admixtures, including polymers, air entrainment and plasticisers/water reducing agents
- Pigments and colourants
- Water
- Reinforcement, typically steel rods and wires or occasionally 'plastic' fibres depending upon the product and/or application.

The quantities (body mix) and types of materials used depend on the type of product being manufactured and the actual manufacturing process. The cement content and reinforcement provide the structural strength of the mix while the aggregates typically provide the bulk, though many do contribute to the overall performance of the concrete.

Production or manufacturing sites are generally not restricted in geographical location because the majority of the components used are not limited to specific parts of the country and are readily available throughout the UK.

In the UK, precast concrete has been one of the main construction product sectors, with an annual turnover which exceeded £2 billion in 2008, and has more than 10,000 people in full-time employment working in well over 500 production sites. It is estimated that around 20 million tonnes of precast was manufactured in 2011, using millions of tonnes of aggregates and other natural resources, emitting 2.8 million tonnes of CO_2 and generating around 665,800 tonnes of process/factory waste. Resource efficiency is therefore a major issue for precast concrete manufacturers.

British Precast has been running a sustainability strategy scheme since 2008, which looks at a wide range of sustainability principles and measures the industry performance against a number of KPIs, with a set of targets to be achieved by 2012 and proposed targets and objectives to 2020 and beyond. The scheme allows the industry to collect information on resource efficiency and waste generation but no detailed information beyond the factory gate, or detailed analysis on the drivers and implications of product use, wastage or end of life, has ever been conducted.

One of the beneficial outcomes of this REAP is therefore in addressing this shortfall in the data collection and evaluation process. Through the 'actions' presented, the aim is to develop a way of setting objectives and reporting progress against 2020 targets annually.

Precast Concrete REAP datasheet:

Dense and lightweight aggregate concrete blocks

Introduction

All concrete blocks, either dense or lightweight, comprise a concrete mix of coarse aggregate, sand (fine aggregate), cement and water. The variations in density, and thus some of the physical properties, come from the type of aggregate used.

Ultra Lightweight concrete blocks are typically formed from lightweight aggregates, usually naturally occurring or man-made lightweight aggregates, such as expanded clay granules, producing a block with a density ranging from 850kg/m^3 to 950kg/m^3 and a strength of 3.6-7.3N/mm^2.

Lightweight blocks are manufactured using a combination of lightweight aggregates, such as expanded clay granules along with furnace bottom ash, a recycled by-product from combustion processes, producing a block with a density of between 1,350kg/m^3 and 1,450kg/m^3 and strength of 3.6-7.3N/mm^2.

Dense concrete blocks are manufactured from standard mineral aggregates or recycled secondary aggregates and produce blocks with a density of between 1,900kg/m^3 and 2,100kg/m^3 and a compressive strength of 7.3-10.4N/mm^2.

Sector profile and market size

The concrete block sector in the UK in 2011 produced approximately 55 million m^2 of dense, lightweight and aerated (AAC) blocks[19]. Dense and lightweight concrete blocks account for about 22.9 million m^2 and 15.1 million m^2 respectively for production and 22.1 million m^2 and 14.8 million m^2 for deliveries.

Manufacturing process

The majority of lightweight and dense aggregate concrete blocks are manufactured by batch moulding, where the dry components are thoroughly mixed before a measured amount of water is added and mixing continues. This semi-dry (moist) mix is fed into a mould chain and mechanically pressed to form the block shape (Figure 2).

Once demoulded, the blocks are cured either in a warm and humid chamber or are left to cure in a covered storage area. The primary difference between these two curing processes is the cement content of the mix. Higher cement contents are generally needed for ambient condition curing whereas, for forced curing, less cement is needed because curing is complete within about 24 hours.

Resource efficiency implications

Recycled aggregate is commonly used in all types of block manufacturing, though the properties of the recycled aggregate dictate which product and how much can be added in order to maintain the properties of the blocks. The content of recycled aggregate varies but can be up to 95% for lightweight and generally up to 30% for dense block products, although some manufacturers produce 'eco friendly' type products with a higher recycled content.

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[19] Dept of Business Innovation & Skills. Monthly statistics of building materials and components No 345. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/137604/13-p125c-construction-building-materials-commentary-february-2013.pdf

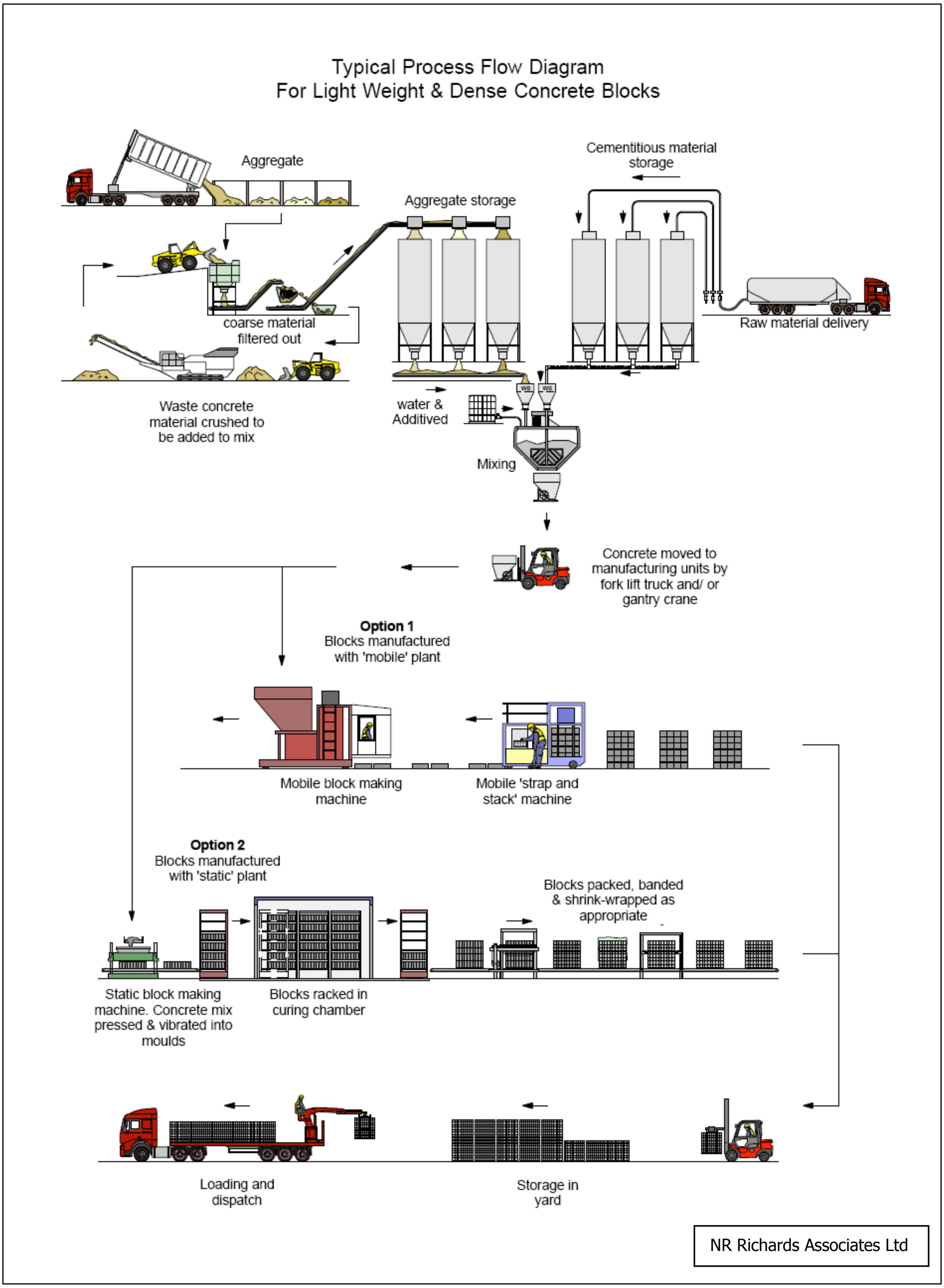

Figure A1: Process flow diagram for precast lightweight and dense concrete block production

Cement usage has a significant inherent resource efficiency impact (materials and carbon (energy and emissions)). Therefore, rather than using pure Portland Cement (CEM I), many of the block manufacturers use either CEM II or CEM III cement blends, containing up to 40% alternative binders, commonly recycled materials such as PFA and GGBS.

Although water forms an integral part of the process and is the primary activator of the cement binding process that holds the aggregates together, concrete block plants have a relatively low resultant water usage, both as a raw material and in its use for washing down moulds.

In addition, there is a carbon (fuel) impact relating to the transportation of the raw materials to the manufacturing site.

There are resource efficiency impacts during the manufacturing process, namely the type of curing process used. Where forced, warm and humid curing chambers are used, water and heat are required to create the curing conditions within the chamber whereas, for the ambient curing process, more cement is required.

Figure A2 shows how the resource efficiency indicators for aggregate block manufacturers compare with all British Precast members' KPIs. Lightweight and dense aggregate concrete blocks accounted for 3.6mt of production in 2011, around 31.9% of the tonnage reported for British Precast membership as a whole. The bar chart reveals that carbon emissions (because of low energy consumption) are less than half the precast average. Thanks to efficient recycling and waste reuse systems inside factories, the amount of aggregate block waste going to landfill is considerably lower (110 grams per tonne). The same applies to cement content (as a factor of concrete's embodied carbon) and water use.

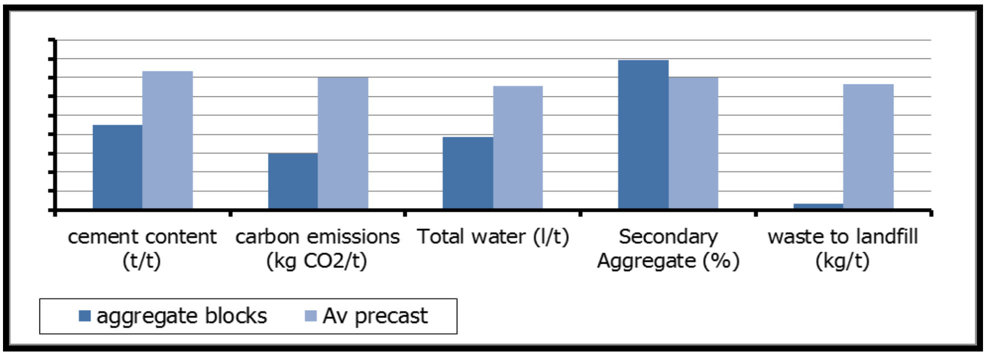

Figure A2: British Precast resource efficiency indicators for lightweight and dense concrete blocks (2011)

Precast Concrete REAP datasheet:

Autoclaved aerated concrete blocks

Introduction

Aerated concrete blocks, commonly referred to as Aircrete or AAC (Autoclaved Aerated Concrete), are lightweight thermal insulation blocks normally used as internal masonry blocks.

As a result of the raw materials and manufacturing process, the cellular (bubbly) texture of the blocks creates a typical density of between 450kg/m^3 and 750kg/m^3, while achieving compressive strengths in the range of 3-9N/mm^2. The closed cellular structure and the low density are the key elements in the functionality of the product.

Sector profile and market size

Production in the UK during 2011 equated to approximately 16.5 million m^2 of production and 16 million m^2 of deliveries.

Manufacturing process

Within the UK, there are two main raw material combinations used to manufacture AAC blocks:

- Portland Cement – lime – pulverised fuel ash (PFA)
- Portland Cement – lime – fine silica sand.

Unlike most other concrete products, the AAC block manufacturing process uses a combination of natural hydration reactions, reactions that take place at ambient temperature and pressures when water is added to Portland Cement, and accelerated curing processes resulting from high temperature and high pressure autoclaving of the products.

The concrete mix is essentially a very fine grained mixture of the cement, the lime, PFA and sand with water. To this, finely powdered aluminium is added. The reaction between the aluminium powder and the alkalis liberated from the cement hydration process results in the production of hydrogen gas, which gives the AAC blocks their characteristic aerated texture.

The aeration (rise) process takes place in moulds and, once an initial set has occurred, the AAC blocks are loaded into large autoclaves where they are steam cured, typically at a pressure of between 800kPa and 1,100kPa and at a temperature of around 180°C. Once autoclaved, nearly all the cement hydration process has taken place and the products are ready for immediate use.

Resource efficiency implications

The main raw material impacts on resources efficiency are the manufacturing of the Portland Cement and lime, and fine grinding of the silica sand.

UK AAC block manufacturing uses up to 80% recycled materials[20]. This is predominantly the recycled PFA recovered from coal-fired power stations.

[20] Aircrete Products Association
http://www.aircrete.co.uk/benefits/sustainable-credentials.html

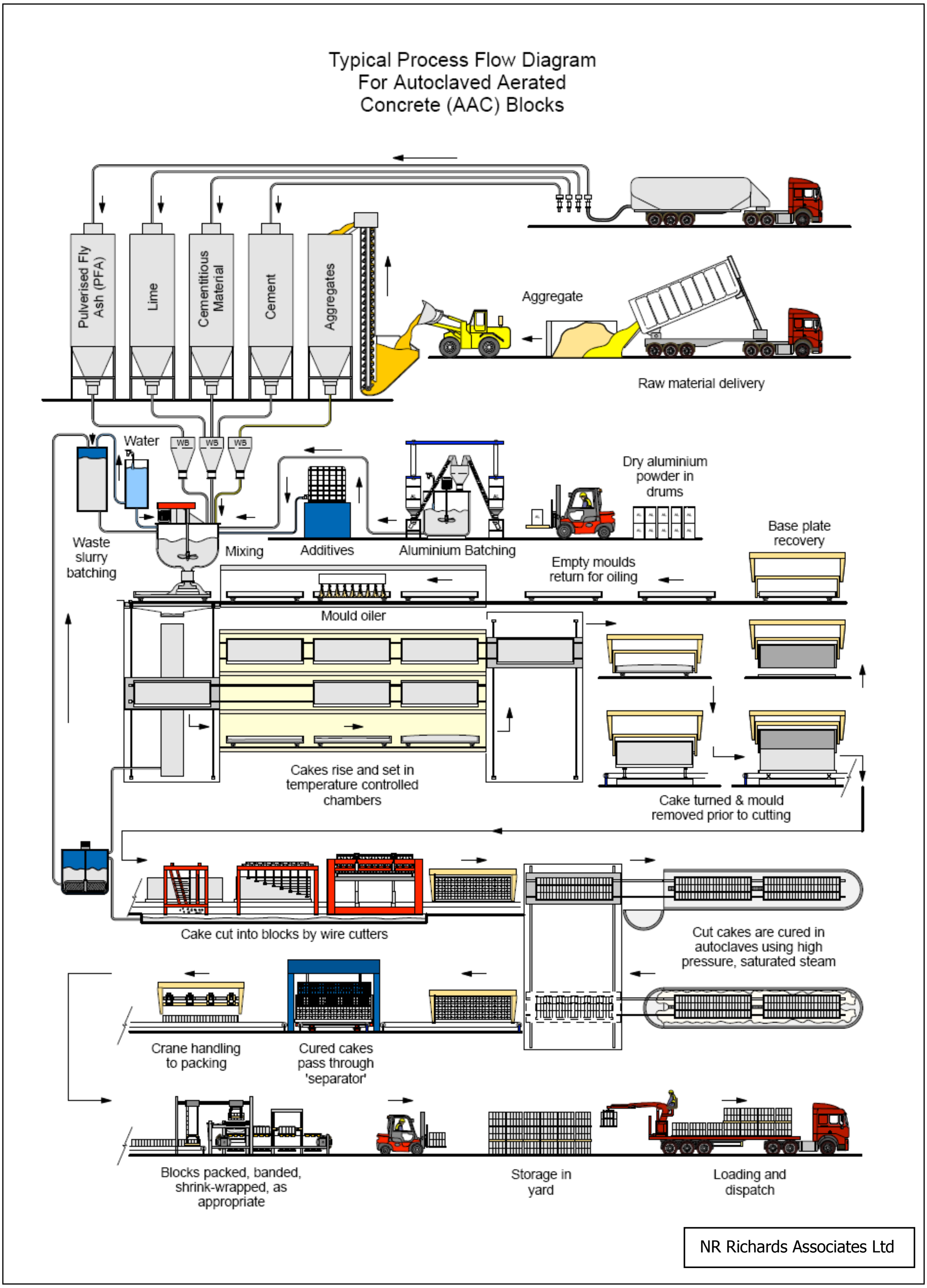

Figure A3: Process flow diagram for autoclaved aerated concrete block production

Because of the autoclaving process, AAC has a high energy impact resulting from the steam generation process and the heating needed to cure the products.

In addition, there is a carbon (fuel) impact relating to the transportation of the raw materials to the manufacturing site.

Water, a requirement of the curing or hydration process and therefore a critical raw material, is also considered to have resource efficiency impacts.

The primary negative resource efficiency impacts in the manufacturing process are the energy requirement to produce steam, the pressurisation and temperature generation within the autoclaves, and the water usage per tonne of product, as shown in Figure A4. In both cases, these are the highest of all the precast concrete product sub-groups but reflect the specific process employed to manufacture the products. Against this is the recycled aggregate content (not shown in the bar chart below), which is the highest of all the sub-groups, with on average 98% of the aggregate usage, typically pulverised fuel ash (PFA), being recycled. In addition, the unit weight of an AAC block is considerably lower than an equivalent aggregate concrete block, so transportation load and fuel usage per functional unit (m^2) are lower from a logistics perspective.

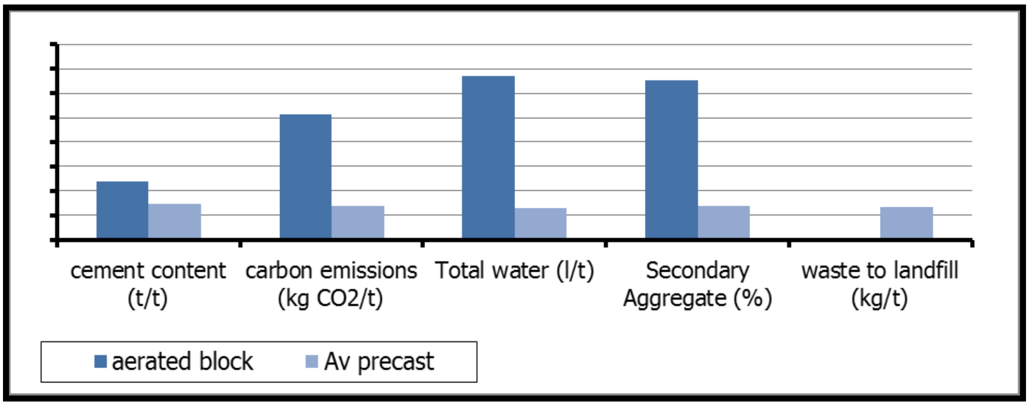

Figure A4: British Precast resource efficiency indicators for aerated concrete blocks (2011)

Precast Concrete REAP datasheet:

Paving blocks and flags

Introduction

Paving blocks and flags represent the external paving products produced by precast concrete manufacturers. The concrete paving sector is represented by their trade association, Interpave. Manufacturers produce products for both the domestic and commercial markets, and distribute either directly to site or via builders' merchants, DIY chains or specialist paving contractors.

In both cases, the principal body of the concrete is a standard cement and aggregate water mix, with or without admixtures and pigments.

Manufacturing process

There are two main manufacturing processes for the paving block, paving flag and allied products (kerbs), dependent upon the strength requirements and capital investment in the production facility.

Paving flags (slabs) can be produced by either wet casting into flexible silicon rubber or similar moulds or hydraulically pressed into a mould box. The main difference in the mix is the water content at the time of production. Wet casting requires the concrete mix to be fluid and thus able to flow and fill the mould, often with the aid of a vibrating table to aid de-airing. Typically, after 48-72 hours, the silicone rubber moulds are removed and the flags allowed to cure for an extended period.

Paving blocks and other pressed products tend to be much dryer mixes, similar to dense aggregate concrete blocks, and are predominantly produced from a blended dry mix to which a controlled amount of water is added. This batch is used to charge the moulds, which are then hydraulically pressed and demoulded almost immediately before being loaded into a curing chamber for accelerated curing.

Resource efficiency implications

In terms of resource efficiency implications, more water is needed in the mix for wet cast products, whereas both water (steam) and heat are needed for the curing of the pressed products.

As with all moulded concrete products, there is also need to wash out the used moulds between recharge, resulting in additional water usage above and beyond what is required for the hydration of the cement binders (embodied).

In addition, there is a carbon (fuel) impact relating to the transportation of the raw materials to the manufacturing site.

Many of the Interpave members[21] use recycled or reclaimed materials within their production facilities, with some manufacturers achieving >80% recycled or reclaimed materials in some products.

[21] Interpave (website): http://www.paving.org.uk/commercial/sustainability.php

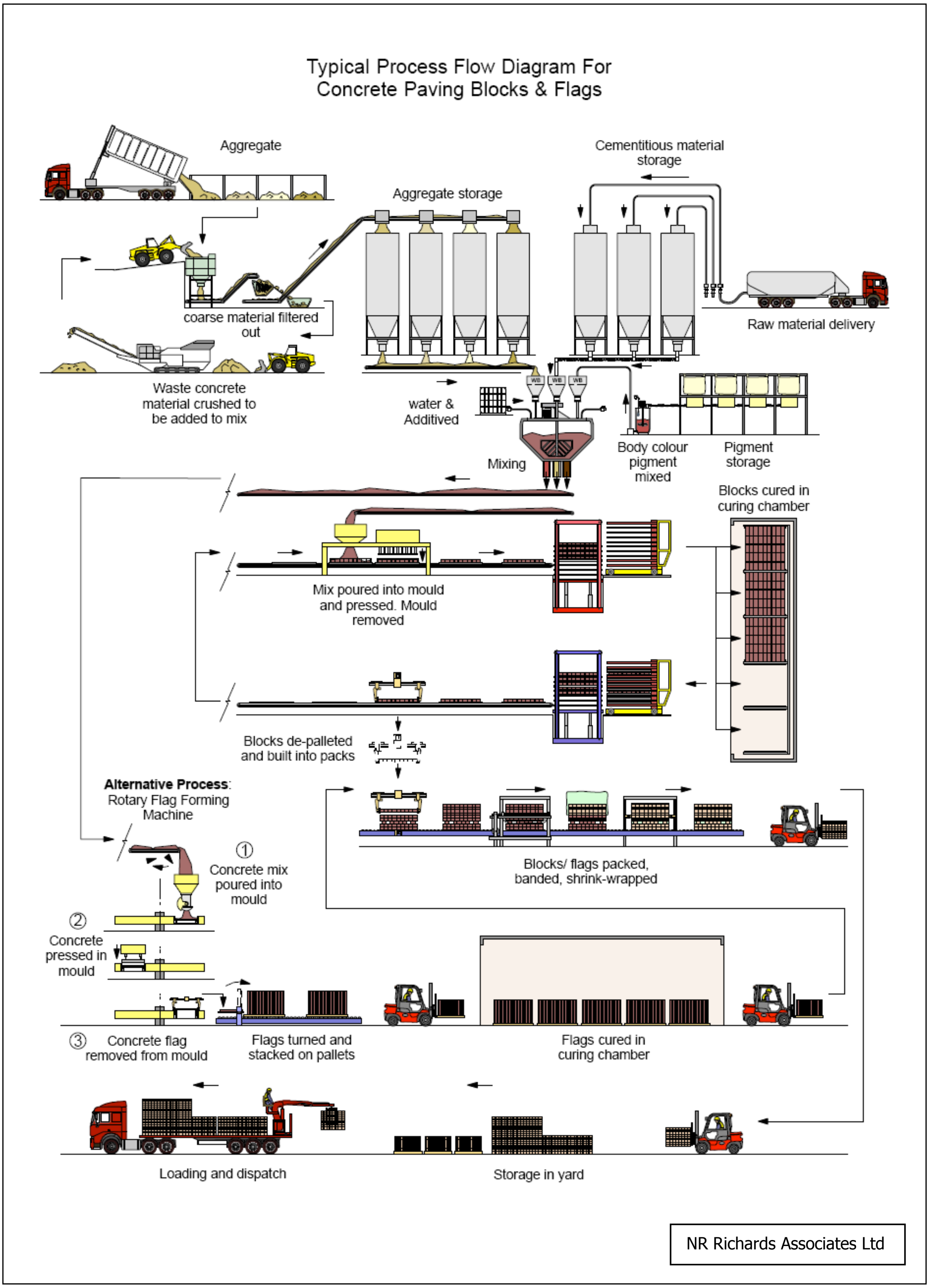

Figure A5: Process flow diagram for concrete paving blocks and flags production

Figure A6 shows the resource efficiency data for British Precast's manufacturing members within this sector. In general, the resource efficiency indicators show that the concrete paver and flag production sector are equal to or just below the precast sector average for most of the indicators. One exception not demonstrated below is the average distance for delivery, which was about 60km greater than the precast sector's average in 2011.

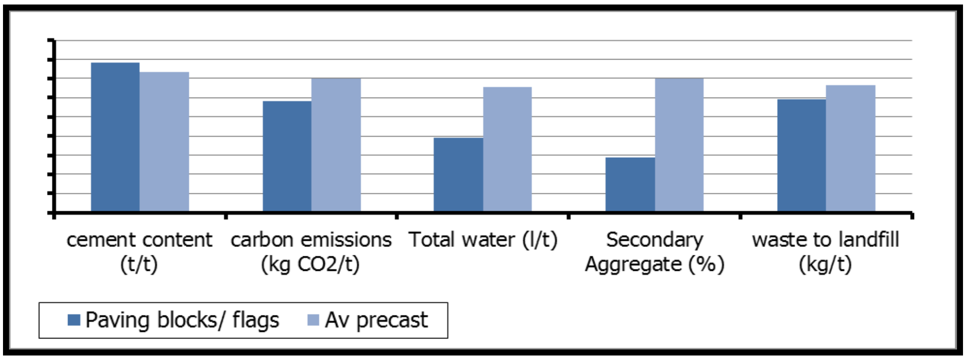

Figure A6: British Precast resource efficiency indicators for concrete paving blocks and flags (2011)

Precast Concrete REAP datasheet:

Concrete roof tiles

Introduction

Concrete roof tiles are manufactured from a standard fine concrete mix of cement, aggregate, pigments and water. As with other precast concrete products, the raw materials lend themselves to being substituted for recycled or alternative materials, and both alternative cement and recycled aggregate materials are commonly used in the manufacturing process for resource efficiency and sustainability impact reduction.

Sector profile and market size

Concrete roofing tile production in 2011 was reported to be approximately 17.7 million m^2 and resulted in 17.1 million m^2 of deliveries.

Manufacturing process

Most concrete roofing tiles are produced by an extrusion process, based on the blending of the raw materials with the addition of water to achieve an extrudable 'stiff' body. Following extrusion, the tiles are cured in curing chambers before being packed, ready for distribution.

Resource efficiency implications

Cement usage has a significant inherent resource efficiency impact (materials and carbon (energy and emissions)). Therefore, rather than using pure Portland Cement (CEM I), many of the roof tile manufacturers use either CEM II or CEM III cement blends, containing up to 40% alternative binders, commonly recycled materials such as PFA and GGBFS.

As water forms an integral part of the process and is the primary activator of the cement binding process that holds the aggregates together, concrete roof tile plants have a relatively high resultant water usage, both as a raw material and in washing down moulds and extruders.

There are additional resource efficiency impacts during the manufacturing process, namely the type of curing process used. Where curing chambers are used, water and heat are required to create the curing conditions within the chamber. In addition, there is a carbon (fuel) impact relating to the transportation of the raw materials to the manufacturing site.

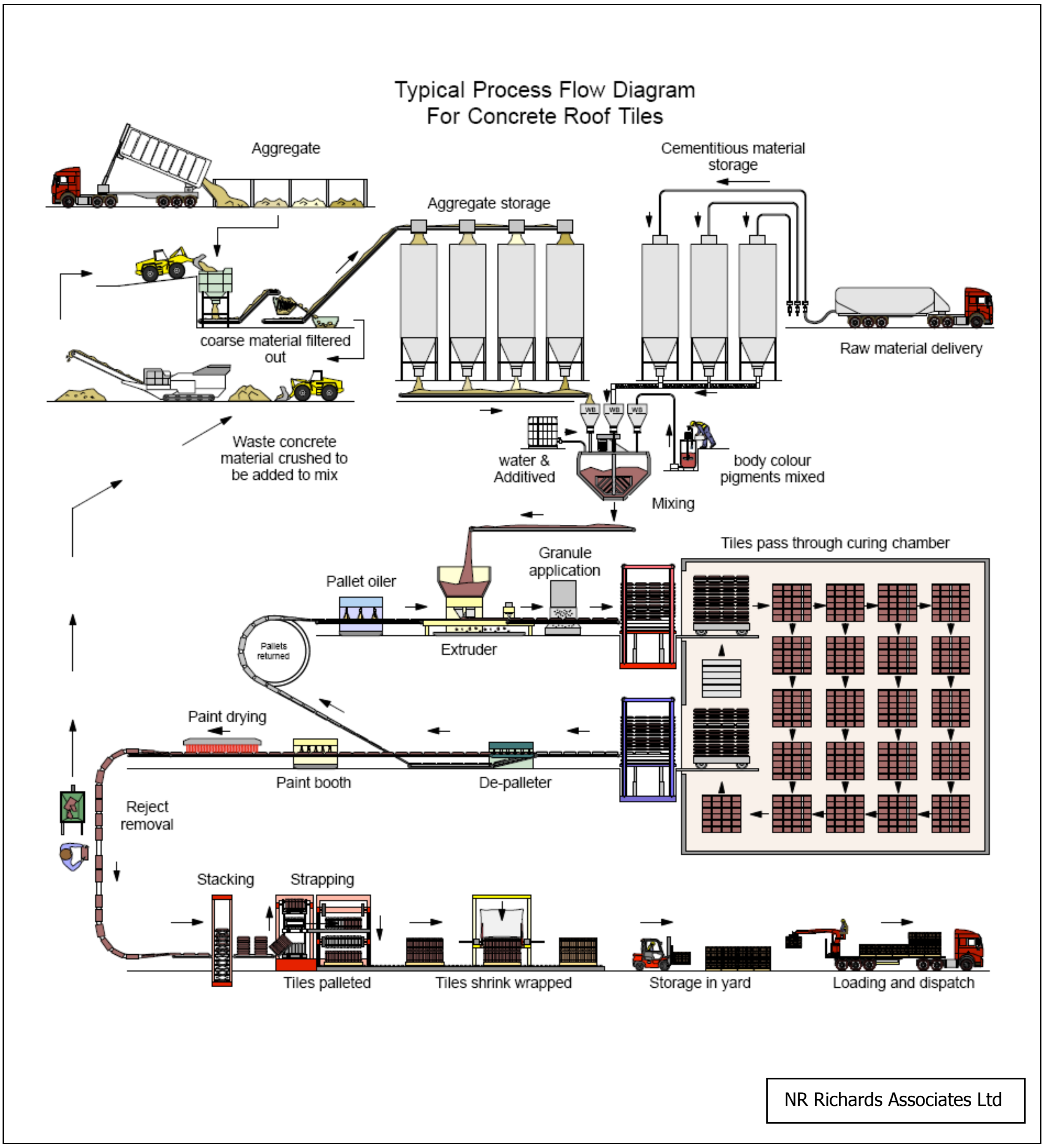

Figure A7: Process flow diagram for concrete roof tile production

Figure A8 shows the main resource efficiency indicators for British Precast's roof tile manufacturing members. The figures show that concrete roof tile production has a higher carbon emission (because of higher energy consumption) and a higher cement content per tonne of product than the precast sector average.

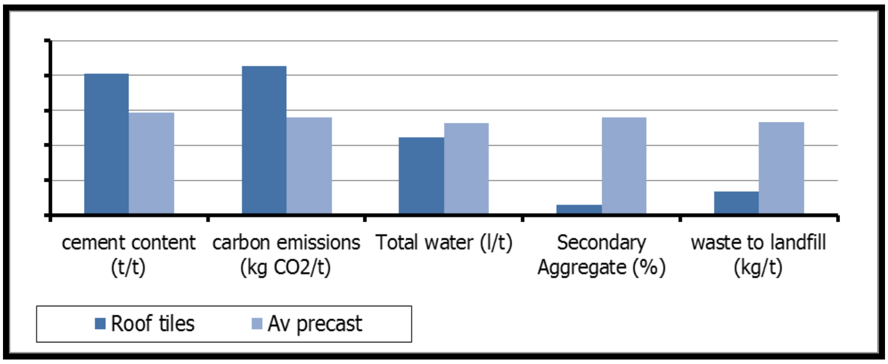

Figure A8: British Precast resource efficiency indicators for concrete roof tiles (2011)

Precast Concrete REAP datasheet:

Structural precast concrete

Introduction

Ranging from cladding panels to staircases and grandstands, the structural precast concrete sector provides off site preformed construction elements that are reinforced with a steel framework, with the units cast in large moulds.

Depending upon the type of surface finish required, the mix design for structural precast concrete elements is similar to ready mix concrete, a mixture of coarse and fine aggregates with cement and water. Where fair finished surfaces are required, the moulds are typically pre-lined with the desired face mix before the bulk body of concrete is poured.

The majority of structural precast elements have steel reinforcement bars that provide additional strength and rigidity to the elements.

Manufacturing process

Manufacturing is predominantly through casting into preformed moulds. Moulds are usually either steel moulds for standard products or timber for bespoke items.

Resource efficiency implications

Cement usage has a significant inherent resource efficiency impact (materials and carbon (energy and emissions)). So, rather than using pure Portland Cement (CEM I), many of the structural concrete manufacturers use either CEM II or CEM III cement blends, containing up to 40% alternative binders, commonly recycled materials such as PFA and GGBFS.

Steel reinforcement bars and mesh are used in products and, although significant amounts of steel are recycled back into the steel production process, the reinforcement is not reused but supplied as new following reprocessing.

There are additional resource efficiency impacts during the manufacturing process, namely the type of curing process used. Where curing chambers are used, water and heat are required to create the curing conditions within the chamber.

In addition, there is a carbon (fuel) impact relating to the transportation of the raw materials to the manufacturing site.

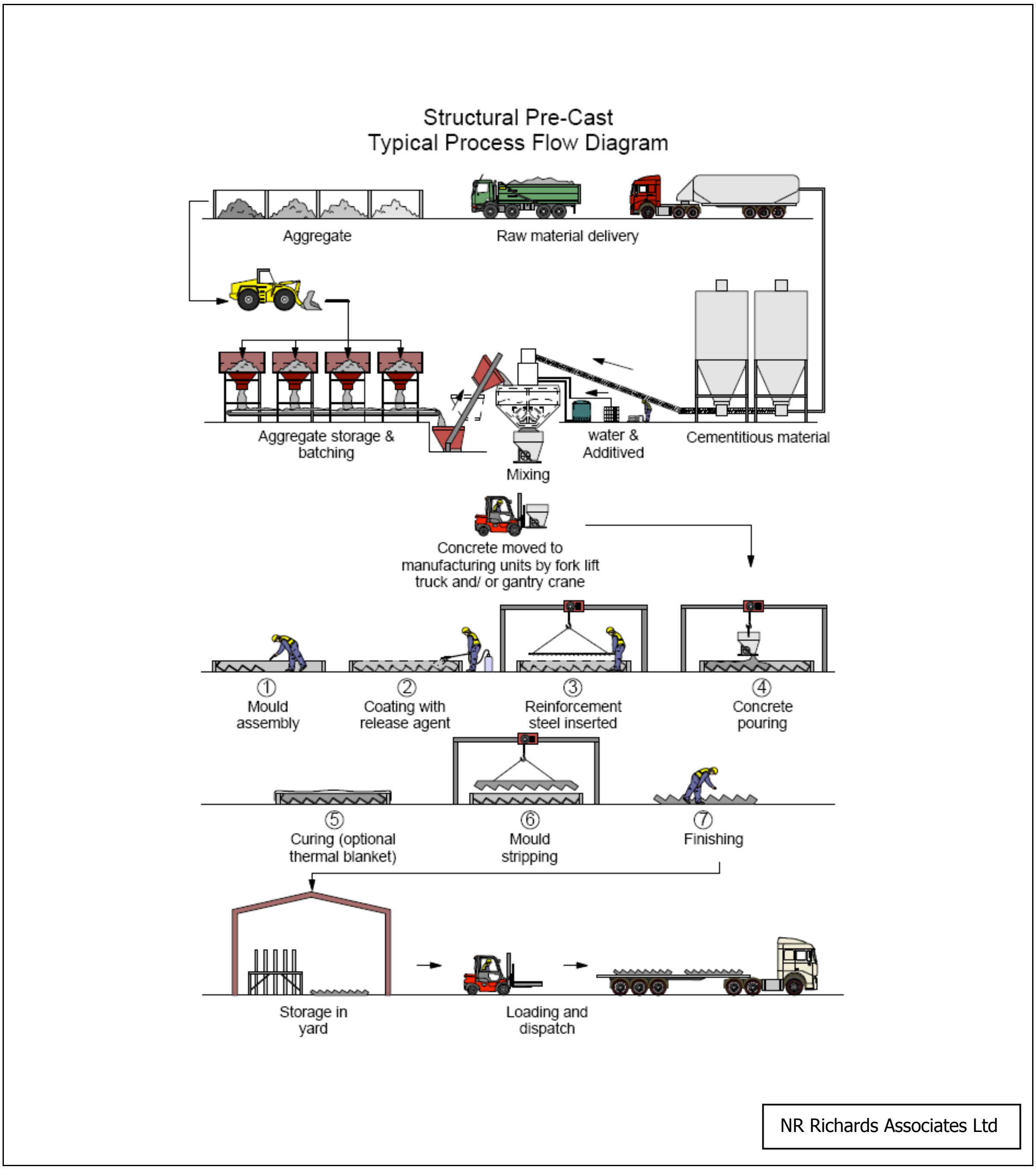

Figure A9: Process flow diagram for structural precast concrete production

Figure A10 shows the resource efficiency data from British Precast's manufacturing members of structural concrete elements. The figures for 2011 indicate that the resource efficiency impacts are generally lower than the average for the whole precast sector, with the exception of waste to landfill and cement content. It was not possible to identify why factory waste is not recycled (on site or off site). Of the water consumed in manufacturing, nearly all is from the mains supply.

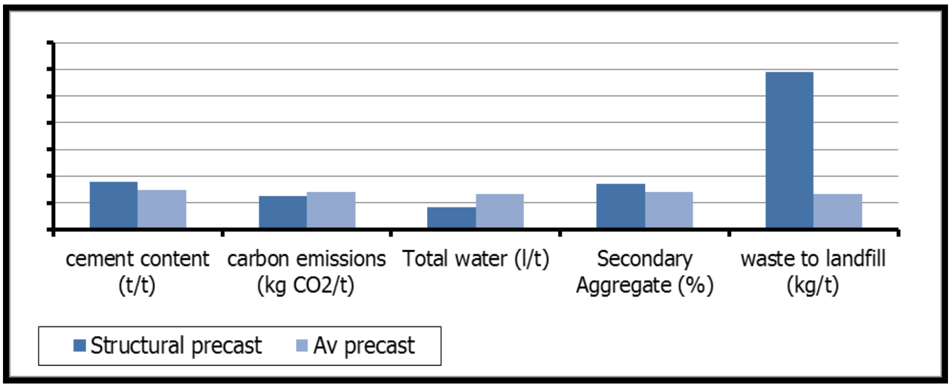

Figure A10: British Precast resource efficiency indicators for structural precast concrete (2011)

Precast Concrete REAP datasheet:

Concrete pipes

Introduction

Concrete pipes and box culverts are typically used for the channelising of water courses underground, but some box culverts are used as access tunnels for pipework and cabling. The units themselves come in a wide variety of shapes and sizes but essentially form a segmented pipe or tunnel when slotted together and sealed with suitable compression joints.

As with most precast concrete, the raw materials used are very similar to ready mix concrete, coarse and fine aggregates added to cement and water. Steel reinforcement is commonly used to provide extra strength and rigidity.

Manufacturing process

The manufacturing process is a cast moulding process in a specialist factory vibration system setting. Moulds are normally fabricated from steel plates, with fixings such that the mould casings can be easily removed after the concrete has set. Figure A11 shows a stylised production process flow diagram for concrete pipe production.

Resource efficiency implications

Cement usage has a significant inherent resource efficiency impact (materials and carbon (energy and emissions)). So, rather than using pure Portland Cement (CEM I), many of the concrete pipe manufacturers use either CEM II or CEM III cement blends, containing up to 40% alternative binders, commonly recycled materials such as PFA and GGBFS.

Steel reinforcement bars and mesh are used in products and, although significant amounts of steel are recycled back into the steel production process, the reinforcement is not reused but supplied as new following reprocessing.

The moulds, specifically the wooden bespoke moulds, have a resource efficiency impact. Although occasionally they can be reused for a short period of time, by virtue of being bespoke they are often of limited use and typically the wood is either cut down for new moulds or is discarded after use.

There are additional resource efficiency impacts during the manufacturing process, namely the type of curing process used. Where curing chambers are used, water and heat are required to create the curing conditions within the chamber.

In addition, there is a carbon (fuel) impact relating to the transportation of the raw materials to the manufacturing site.

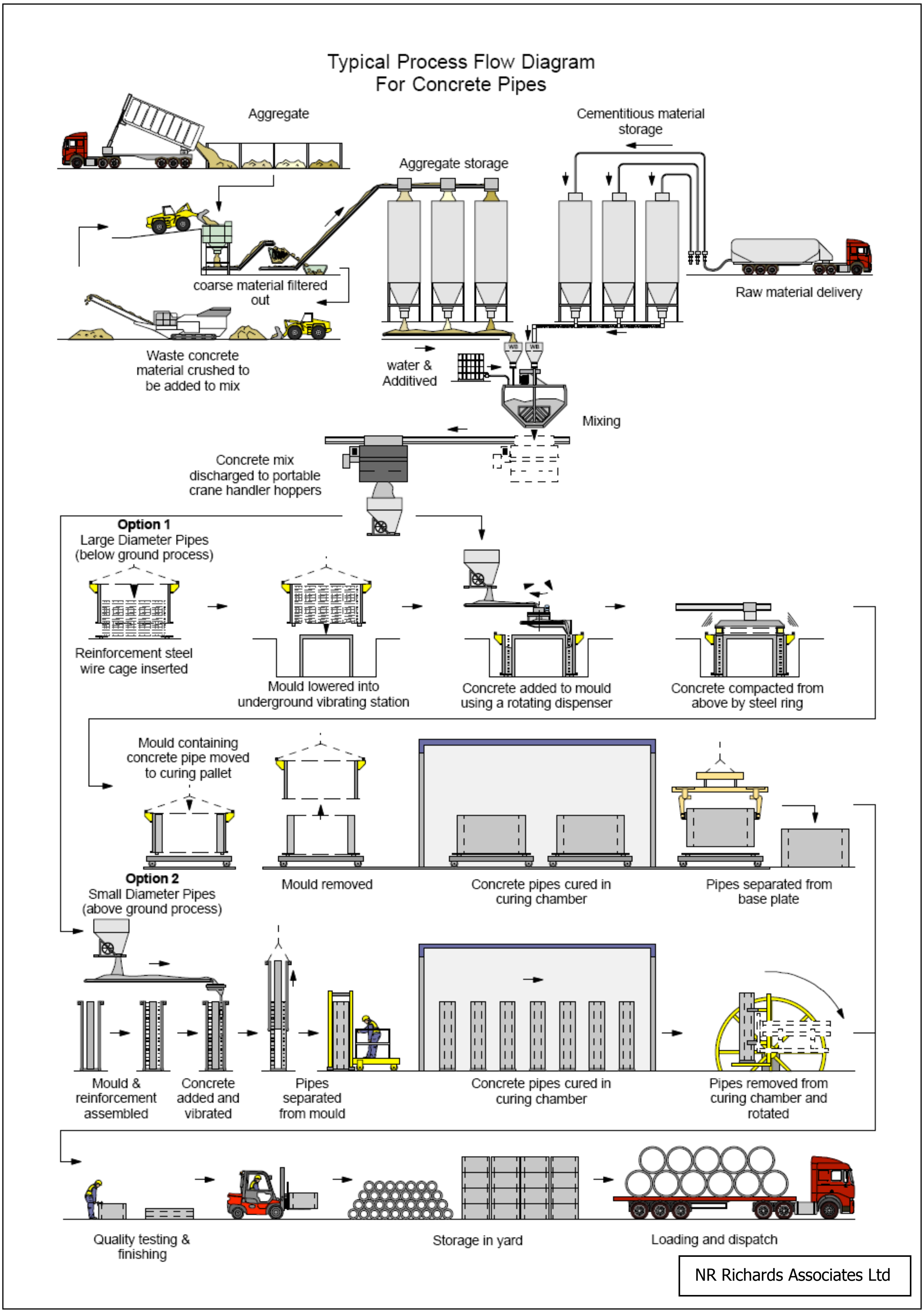

Figure A11: Process flow diagram for concrete pipe production

Figure A12 shows the resource efficiency data for 2011 for the concrete pipe manufacturing sector. Cement content per tonne of product is slightly above the average for the precast sector as a whole, but other indicators are generally at or below the average.

One exception, however, is the waste generation per tonne of product, which is almost double the precast sector average. By virtue of the intended end use, damage and cracks to pipes and culverts render the products not fit for purpose, so the products will tend to be crushed and recycled back into the process or sent off site for recycling into secondary aggregates. However, as shown by Figure A12, most of that waste is recycled and a very small amount (compared with average precast values) goes to landfill.

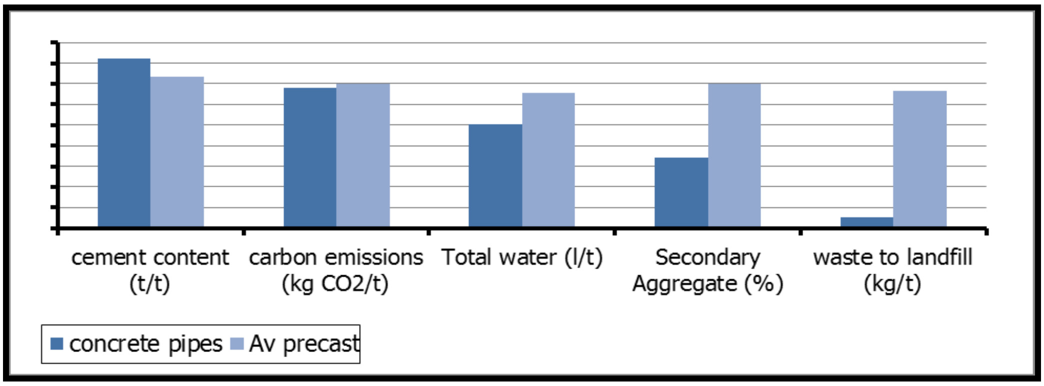

Figure A12: British Precast resource efficiency indicators for concrete pipes and culverts (2011)

Precast Concrete REAP datasheet:

Concrete flooring

Introduction

Precast concrete flooring elements are used in both domestic and commercial applications, and comprise three main types of flooring system - hollowcore, beam and block, and beam and pot.

The raw materials used for the production of flooring products are essentially the same as any of the cast concrete products, aggregates, cement and water. In the hollowcore and beams systems, steel wires are used to provide the pre-stressing element to the products.

Manufacturing process

The manufacturing process is based on an extrusion or slip form casting process into long casting beds. For the hollowcore and beams systems, pre-stressed high tensile strength steel wires are placed within the beds before the concrete is extruded. Once set, the floors and beams are demoulded and cut to length.

Resource efficiency implications

Cement usage has a significant inherent resource efficiency impact (materials and carbon (energy and emissions)). So, rather than using pure Portland Cement (CEM I), many of the concrete flooring manufacturers use either CEM II or CEM III cement blends, containing up to 40% alternative binders, commonly recycled materials such as PFA and GGBFS.

Steel reinforcement bars and mesh are used in the products and, although significant amounts of steel are recycled back into the steel production process, the reinforcement is not reused but supplied as new following reprocessing.

There are additional resource efficiency impacts during the manufacturing process, namely the type of curing process used. Where curing chambers are used, water and heat are required to create the curing conditions within the chamber.

In addition, there is a carbon (fuel) impact relating to the transportation of the raw materials to the manufacturing site.

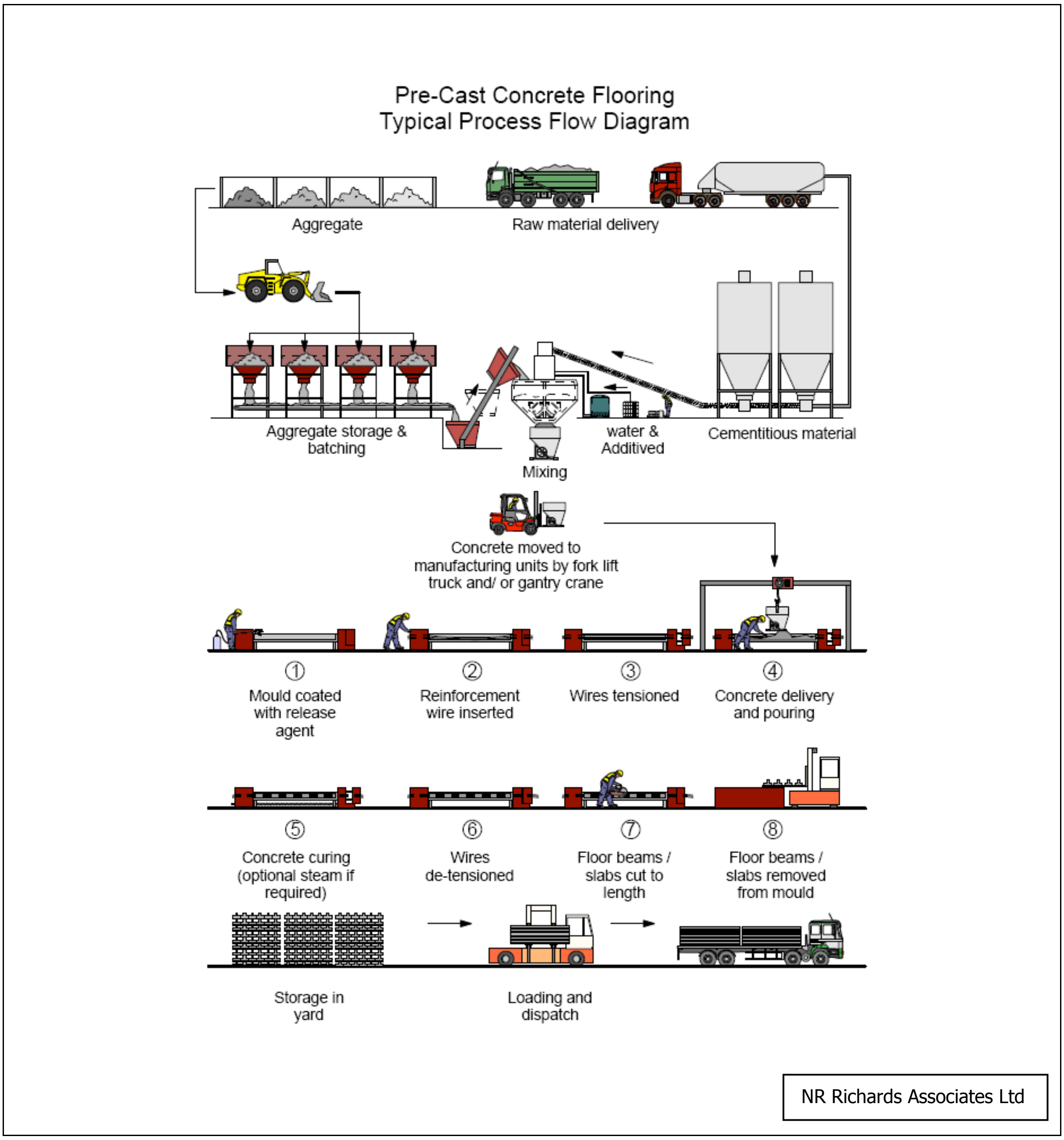

Figure A13: Process flow diagram for precast concrete flooring production

Figure A14 shows the resource efficiency data relating to British Precast's manufacturing members for 2011. Apart from waste to landfill, all flooring resource efficiency impact indicators measured as part of British Precast's Sustainability Charter show that the impacts are generally slightly lower than the precast sector as a whole.

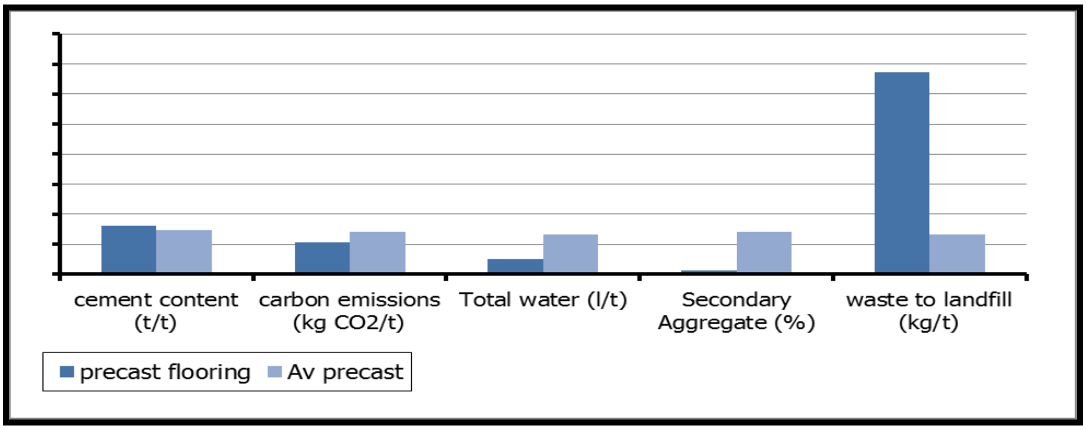

Figure A14: British Precast resource efficiency indicators for concrete flooring (2011)

Of note are the delivery distances and average load, which indicate that delivery distances were on average nearly double that for other precast concrete products in 2011 and that the average load is approximately three-quarters of the precast sector as a whole. This may be a consequence of the destination of the flooring systems, in relation to the production facilities, during 2011. However, this anomaly does offer the potential to investigate further and, where appropriate, to address it in the REAP review process.

A4 Post-manufacturing resource efficiency

Logistics and packaging

Much of the available data for logistics and packaging waste is generic to the construction sector, but there is specific information from British Precast in respect of average delivery distance. This will have a bearing on the resulting energy (carbon footprint).

The precast concrete sector average delivery distance is 107km (2011 data) with an average load of a little over 22t. As previously highlighted, precast concrete flooring in 2011 had significantly higher delivery distances, with an average of 196km, and an average lighter load at 16t.

Concrete roof tiles, on the other hand, have on average shorter delivery distances: 97km and heavier loads at 25.5t. Again, this is likely to reflect the location of manufacturing facilities in respect of main markets, and the ability to load delivery vehicles more efficiently than with other precast products.

Design, construction and demolition

For the remaining segments of the supply chain, the available current resource efficiency indicators are generic in the main and reflect the construction and demolition process as a whole, rather than with any focus on the individual impacts of any specific construction material.

WRAP's unpublished report[22], 'Upper and Lower Wastage Ranges for Construction Products', indicates that waste arising from lightweight blocks is in the region of 10%, and for dense concrete blocks between 2% and 7%, depending upon the site practice and whether or not specialist block layers were employed. It appears that the main factors influencing the wastage rate on the construction site are:

- Methods of work (workmanship)
- The need to cut blocks
- Design of structure being too complex
- Damage during transportation to site and handling on site
- Over ordering
- Use of blocks for unplanned variations and for applications other than their unintended purpose (demarcation of routes and roads inside construction sites).

Over ordering appears to be one of the greatest issues with site-based construction. For block work, typically ordered by the square metre, three projects reported by WRAP showed that between 10% and 23% of blocks were ordered in excess of what was needed.

Although these are averages based on a number of projects, the highest wastage rate was recorded on a specific public building project, which amounted to 609m^2 of waste block.

DEFRA's report[23], 'Understanding and Predicting Construction Waste' (WR0111) published in 2008, identified that, for all concrete wastage, rates vary depending upon the type of building being constructed. The survey ranges from wastage rates (volume wastage in m^3 per 100m^2 floor space) of 6.95m^3/100m^2 for public building projects down to 0.52m^3/100m^2 for leisure facilities.

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[22] Upper and Lower Wastage Ranges for Construction Products 2011 (WAS908-001) (unpublished)
[23] Understanding and Predicting Construction Waste' (WR0111) http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=14677

WRAP's study[24] into the production of hollowcore flooring units identified that Bison Concrete Products Ltd generate only 2% concrete waste during the process, all of which is recovered and recycled back into production. The only waste leaving site destined for landfill was about 1% of production weight in the form of timber shuttering.

The demolition and recycling part of the supply chain deals with buildings and structures that have reached the end of their useful life and the space they occupy is required for a new use. This offers many potential resource efficiency opportunities in respect of the blocks and precast concrete elements that have been used. Firstly, if a building can be reused in part or in entirety, it provides the most resource efficient approach. However, if the building requires removal, deconstruction allows for the potential to maximise recovery of the construction products, ready for reuse. Currently, many buildings are demolished resulting in the generation of Construction and Demolition Waste, which is predominantly reprocessed and used as recycled aggregate.

WRAP's report on Construction, Demolition and Excavation Waste (CDEW) arisings for England[25] for 2008 shows the recording of approximately 9.21mt of recycled aggregate, predominantly crushed concrete and precast concrete products.

General CDEW reporting shows that the majority of 'hard inert' materials are recovered and processed, typically into recycled aggregate. Although this is a lowering of the value in the waste hierarchy compared with reuse of the precast products themselves, materials are being diverted away from landfill, predominantly through crushing the concrete and producing secondary aggregates, much of which is generally used on site as piling mats.

Some cast studies[26] indicate that the potential for high levels of recovery of demolition arisings, in excess of 95%, includes significant levels of concrete recovery. However, the majority was recovered by downgrading the value of the concrete materials to secondary aggregates. In such projects, little if any processed (crushed) concrete leaves site and goes to landfill. Excess from a site's redevelopment is normally utilised on other sites, though typically as low grade fill type materials.

[24] WAS 003-003: Offsite Construction Case Study. Waste Reduction Potential of Precast concrete Manufactured Offsite
http://www.wrap.org.uk/sites/files/wrap/Pre-cast%20concrete%20-%20Full%20case%20study1.pdf

[25] Construction, demolition and excavation waste arisings, use and disposal for England 2008
http://www2.wrap.org.uk/downloads/CDEW_arisings_use_and_disposal_for_England_2008.838476e2.9526.pdf

[26] ICE Demolition Protocol Case Study Brent W01 Development
http://www2.wrap.org.uk/downloads/WRAP_Case_Study_WO1_formatted_050307.512ccaf8.4654.pdf