Cenin Cement Technology

Making High performance Low Carbon Cement Replacements from Calcareous Fly Ash
(Technical)

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ABSTRACT: Calcareous fly ash is a fine powder, having hydraulic and/or pozzolanic properties. It consists essentially of reactive calcium oxide (CaO), reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other compounds. The proportion of reactive calcium oxide shall not be less than 10,0% by mass. Calcareous fly ash containing between 10,0 and 15,0% by mass of reactive calcium oxide shall contain not less than 25,0% by mass of reactive silicon dioxide.

Cenin Limited has developed an advanced technology to process materials such as calcareous fly ash and turn them into high strength ultra low carbon cementitious binders. The products have been designed as a result of years of research carried out between the company and universities in the UK. The design and compliance of the products are ensured by using the latest analytical equipment that is available to the industry.

Keywords: Calcareous fly ash (CFA), Combined Heat and Power (CHP), X-ray fluorescence (XRF), X-ray diffraction (XRD), Semi-dry Product (SDP), Wet-cast Product (WCP), Particle size distribution (PSD), Chemical engineering, Ground Granulated Blast-furnace Slag (GGBS) and Pulverised Fuel Ash (PFA).

M Popham is the Managing Director of Cenin Limited and had until recently ran his own ready mix and quarrying operations in South Wales. He provides a wealth of knowledge from the ready mix industries.

G Hunt is the Technical Director of Cenin Limited. He has over 20 years experience in the pre-cast sector of the construction industry and has been researching alternative materials for the construction industry since 1992. From 2000 – 2006 he was a visiting honorary research fellow at Cardiff University. He is also a member of Guide Point Global formerly Vista Research (Association of World Leaders). Gary now heads the research centre for Cenin Limited.

Introduction

In Europe it is recognised that different cements have different properties and performance. European standard EN 197-1 defines and provides the specifications of 27 distinct common cement products. This paper is produced to highlight the benefits of the use of Calcareous Fly Ash (CFA) that is produced by Cenin at their Research and Development centre in S Wales, United Kingdom.

Calcareous ash is mostly produced by lignite combustion in dry-bottom boilers for heat and power generation. Lignite plays an important role in the energy mix in European countries especially in central and Eastern Europe. Calcareous ash is also produced at modern combined heat and power plants (CHP) in the UK and other parts of Europe (Much of which is still currently land filled at a cost to the environment).

The following extract is taken from European standard EN 197-1 and gives a defined statement on what is a Calcareous fly ash:

"Paragraph 5.2.4..3 Calcareous fly ash (W)"

"Calcareous fly ash is a fine powder, having hydraulic and/or pozzolanic properties. It consists essentially of reactive calcium oxide (CaO), reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other compounds. The proportion of reactive calcium oxide shall not be less than 10,0% by mass. Calcareous fly ash containing between 10,0 and 15,0% by mass of reactive calcium oxide shall contain not less than 25,0% by mass of reactive silicon dioxide."

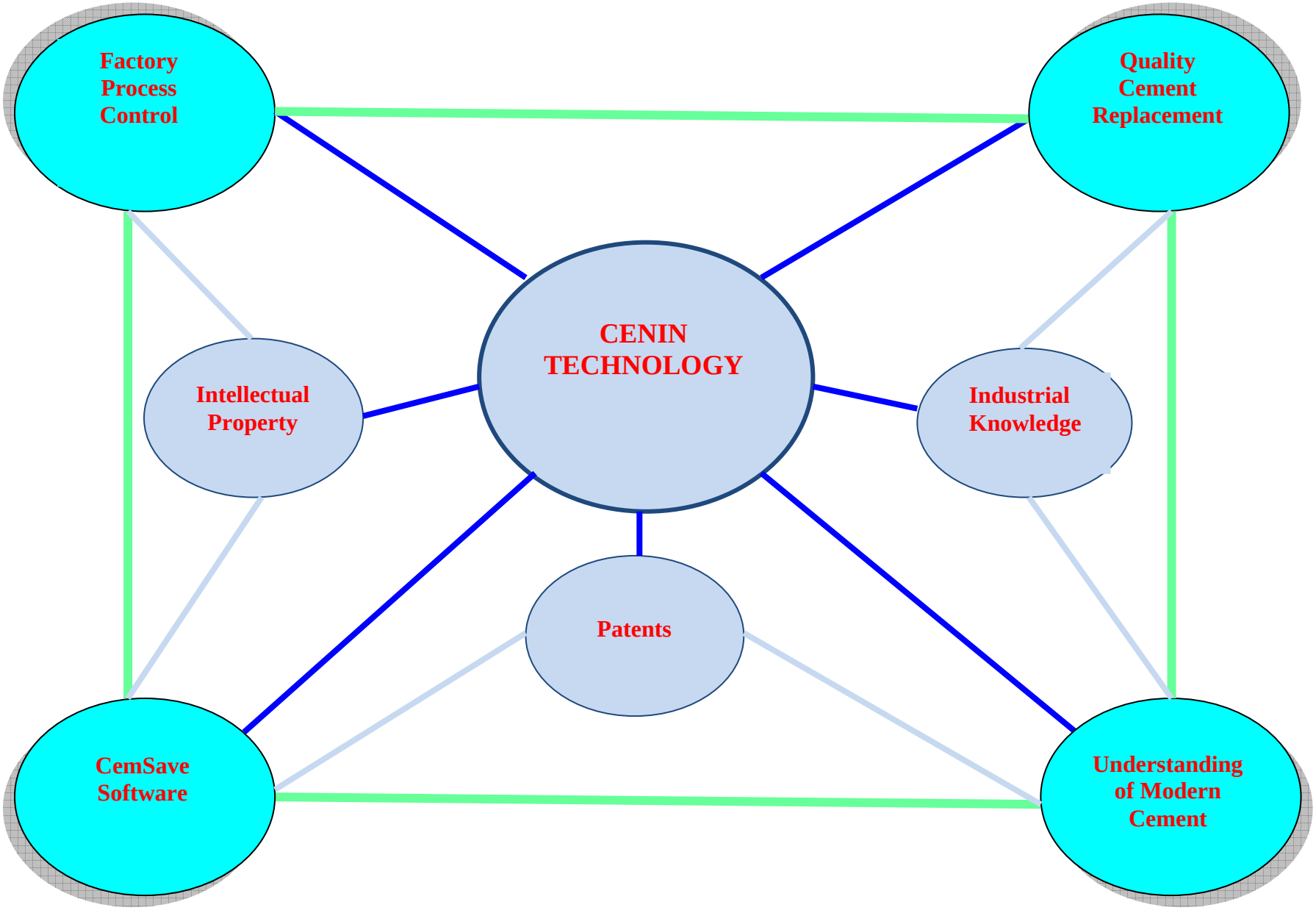
Cenin cement replacements falls into the category of a calcareous fly ash in accordance with BS EN 197-1:2000, Cement, Part1: Composition, specifications and conformity criteria for common cements. However it is stated in EN 450 that calcareous fly ash must come from coal fired power stations.

To the best of our knowledge there has been no calcareous fly ash produced from coal fired power stations in the UK for approximately 50 years. In contrast it is estimated that around 71 million tonnes of ash is produced in the rest of Europe with Greece and Germany being the top producers.

Cenin Limited have developed its technology to process materials such as calcareous fly ash by using a complex and rigorous analysis and modification technique developed by the companies technical director.

The Cenin product range is tested to the following European standards:
BS EN 196-1:2005, Methods of testing cement, Part 1: Determination of strength.
BS EN 196-2:2005, Methods of testing cement, Part 2: Chemical analysis of cement.
BS EN 196-3:2005, Methods of testing cement, Part 3: Determination of setting times and soundness.
BS EN 196-5:2005, Methods of testing cement, Part 5: Pozzolanicity test for pozzolanic cement.
BS EN 196-6:2005, Methods of testing cement, Part 6: Determination of fineness

Cenin Technology



Materials

All materials that are used by Cenin are well understood and have been used as construction materials for many years. Despite this fact much of this material that is produced is still destined for landfill.
Each raw material used by Cenin is processed individually and regular sampling and monitoring of the raw materials is taken to ensure that the materials are within the specification required for the end product.

Products

Cenin produce two main types of products as alternatives to GGBS and PFA, they are Semi-dry Product (SDP) and Wet-cast Product (WCP) and for these products we have several grades as follows:

- SDP (N)
- SDP (HR30)
- WCP
- WCP (HR 30)
- WCP (HR 50)
- Composite Portland cement blended with any of above combinations

Product Design

The products have been designed as a result of years of research carried out between the company and universities in the UK. The design and compliance of the products are guaranteed by using the very latest analytical equipment that is available to the industry.

Figure 1 XRF. **Figure 2 XRD.**

1. X-Ray Fluorescence (XRF) – Elemental Analysis, Process and Quality Control.
2. X-Ray Diffraction (XRD) is a high-tech, non-destructive technique for analyzing a wide range of materials.

The quality control of the raw materials and final product is carried by a combination of particle size analysis and chemical analysis carried out by XRF, then further supported by XRD analysis.

The design of the product is carried out by studying the crystal formation of Portland cement during hydration and then using its patented process software reproducing these structures without using a kiln. Recent advances now allow Cenin to produce quality cementitous binders without any cement or clinker present. Studies on the hydration process have been carried out over long periods of time; the main crystalline structures formed with Portland cement can be replicated without the use of clinker to achieve 28 day strength of 30 Mpa.

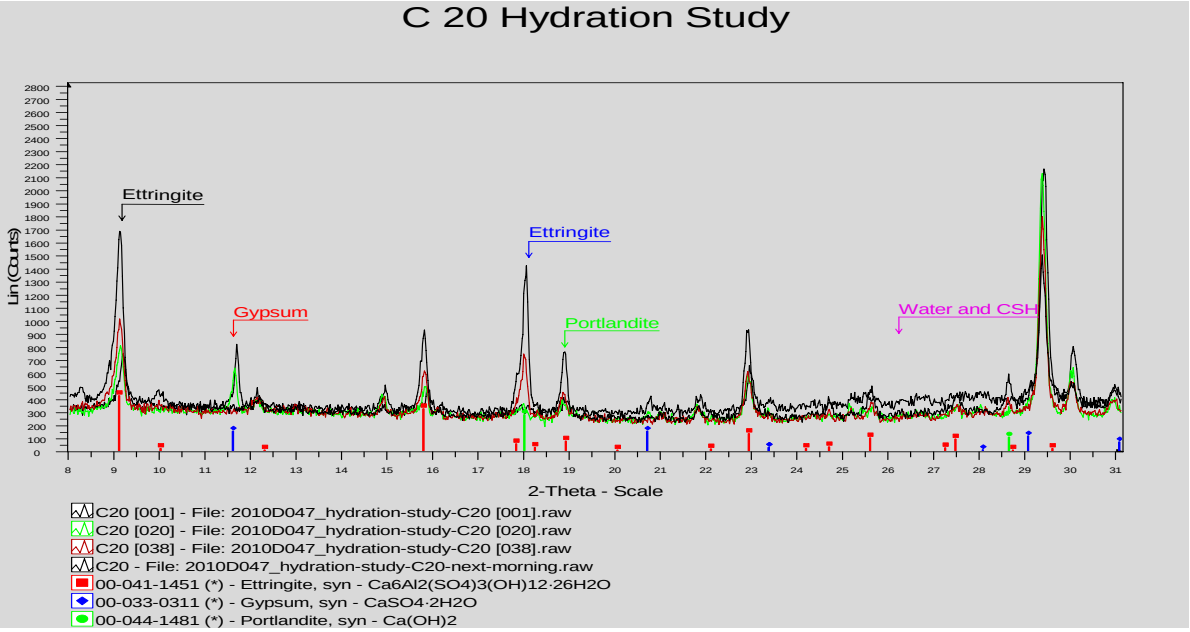


Figure 3 Continuous XRD scanning during the first twenty four hours of hydration.

The crystal structures of Portland cement are well understood and have been for many years, Cenin has developed the ability to build and manage these structures to the point where its cement replacements will perform equal to that of Portland cement in an identical environment.

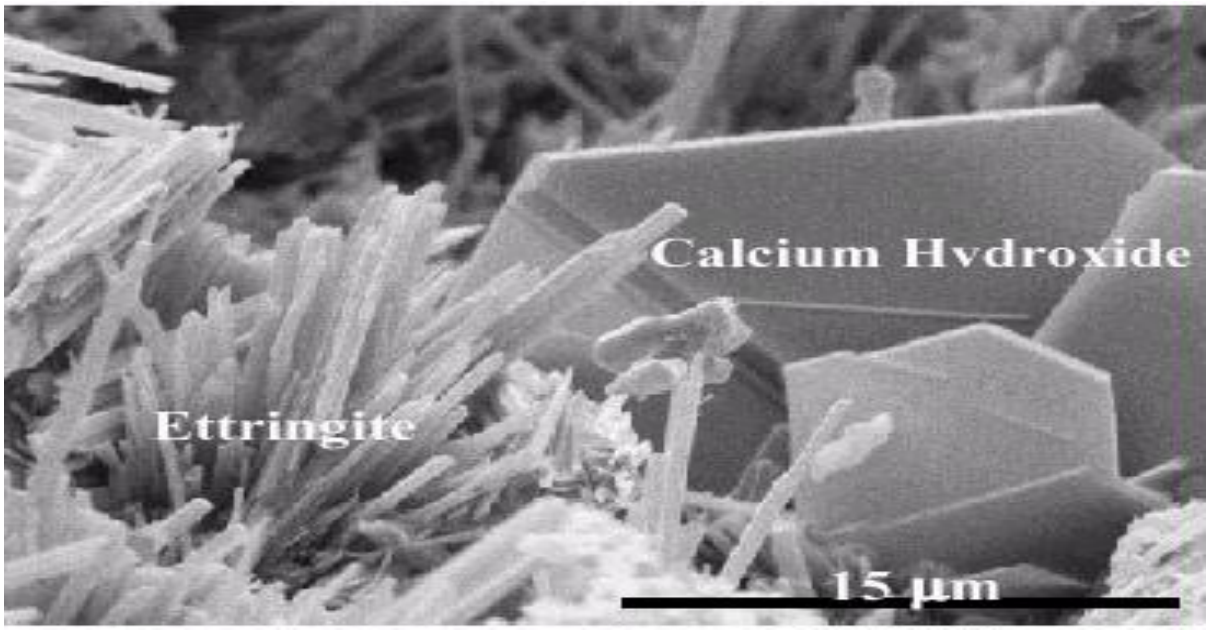


Figure 4 Cement crystals forming with time

The crystals form within the first six hours and then grow with time as the cement paste fully hydrates.

Environment

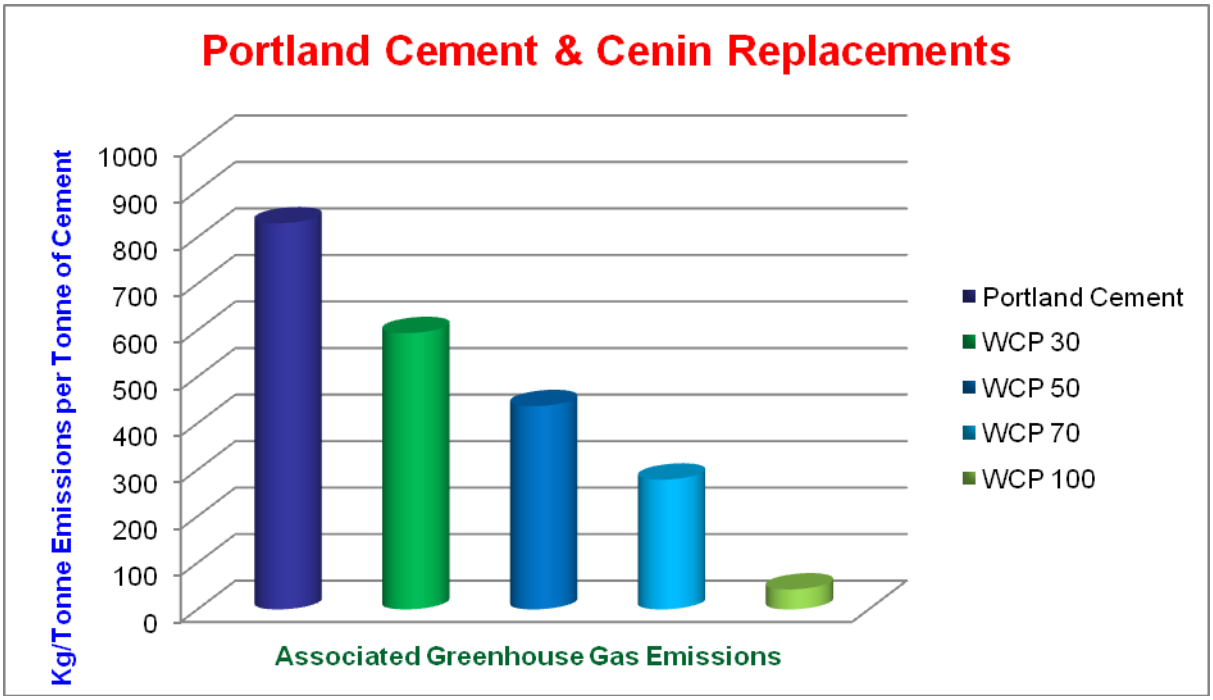


Figure 5 Associated Greenhouse Gas Emissions for Cenin Replacements.

The greater the level of replacement using the Cenin replacements results in the greater carbon reduction. Concretes have been produced using one hundred percent Cenin replacements to achieve concrete strengths of 30Mpa at twenty eight days.

Summary of emissions

ECCM estimates that, under current operational infrastructure and practices, the GHG emissions associated with Cenin cement replacement product cradle to gate are equivalent to **43kg of CO_2 per tonne of product**.

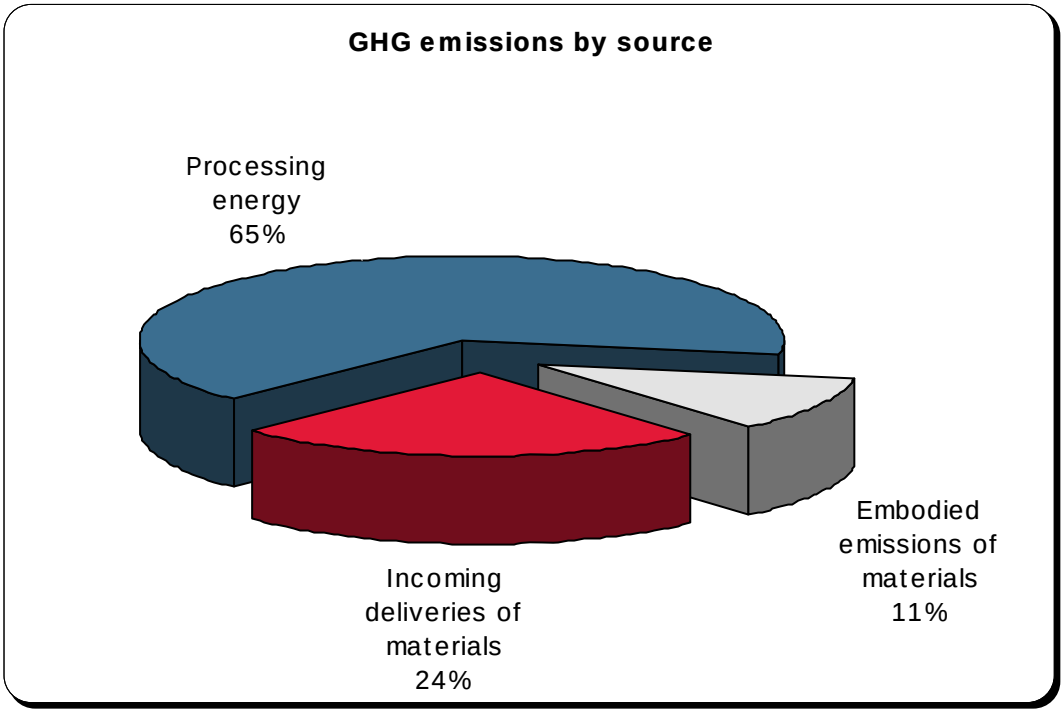


Figure 6 Breakdown of Emissions by source.

Cenin's first manufacturing plant is co located on a large site that will shortly have several different sources of renewable energy supplying sustainable heat and power. ECCM estimates that, once the renewable sources are available, the GHG emissions associated with bulk Cenin cement replacement product cradle to gate will be reduced to approximately **16kg of CO_2e per tonne of product**.

The emissions associated with the manufacture of conventional Portland cement are equivalent to 830 kg of CO_2 per tonne of cement (University of Bath 2008). The results of this assessment indicate that Cenin's technology provides significant GHG reductions. These reductions are mainly achieved as a result of:

- Using existing industrial waste or by-products, negating the need for quarrying the raw materials.
- Low energy requirements. Cenin's technology requires approximately 36kWh per tonne of product manufactured, while typical energy requirements for Portland cement production are approximately 1,270kWh per tonne of cement (University of Bath 2008).
- No process-related emissions other than those from energy usage.

Cenin Product Performance

The performance of the Cenin replacements are designed to customer's requirements, at low rates of replacement, higher strength performance than Portland cement can be achieved at high rates of replacement similar strengths to Portland cement are achieved , as seen in figure 7 below.

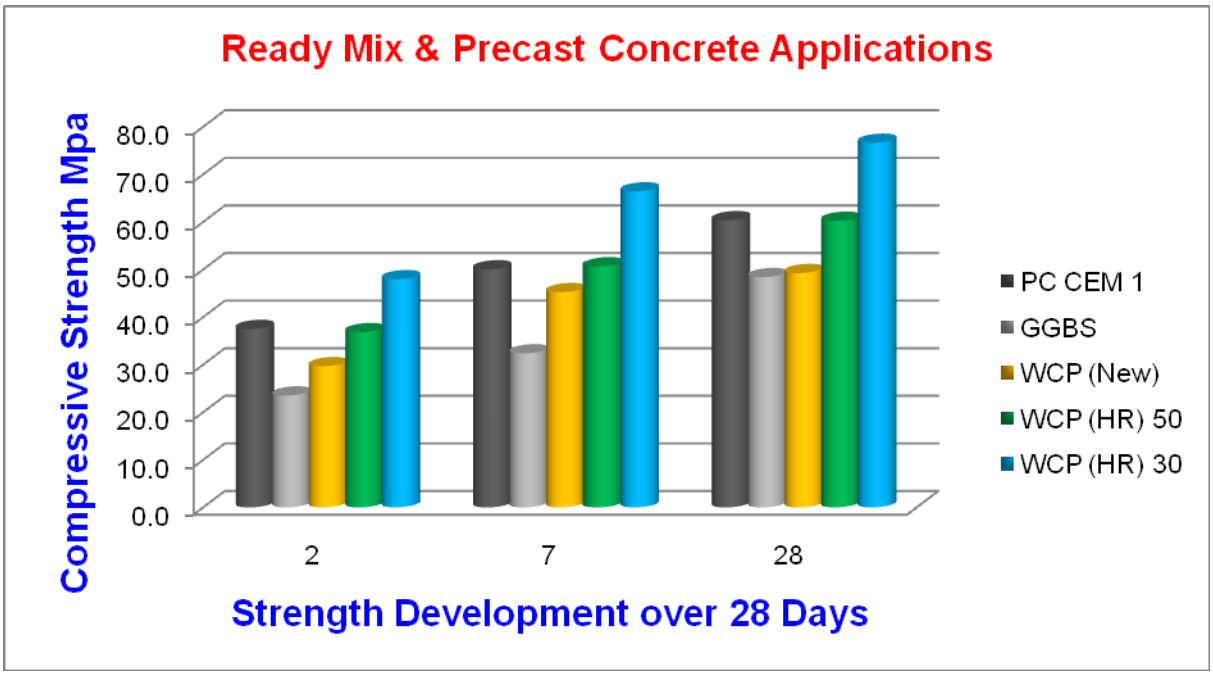


Figure 7 Strength Development of Portland cement, GGBS and Cenin products.

Cenin Technology Key Benefits

- Produces high quality cement replacements cost effectively
- The products are Ultra Low Carbon.
- It utilises mineral wastes not currently used
- Eliminates quarrying and landfill
- It is a proven technology delivering product every day to concrete plants.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