

Environmental Ranking of Cement

Lawrie Evans and Mark Mutter, JAMCEM Consulting Ltd, UK propose a new ranking system to encourage cement manufacturers to be more proactive with environmental measures – and customers to be more discerning in their buying choices.

Introduction

It is becoming increasingly evident that global warming is a generational challenge. There may still be head in the sand politicians attempting to ignore the warnings, but the mass of scientific data is now pointing to the conclusion that the challenge to reduce carbon dioxide emissions is critical to our future climate. The “Big Four” major sources of carbon dioxide now standing in the dock are transport, power generation, steel and cement. Transport is making substantial moves to electrification, but any attempt to increase fuel costs and reduce usage meets an immediate adverse reaction. Look no further than the “gilets jaunes” in France. Power generation is also rapidly pursuing a route to renewable sources, leaving steel and cement as the two major sources without a clear route for substantial reductions of carbon dioxide emissions.

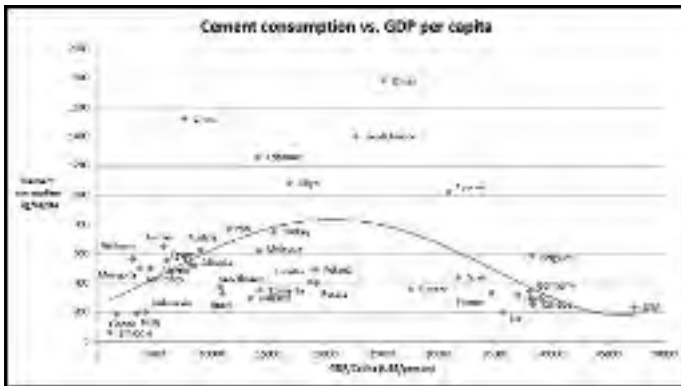


Figure 1: Cement Consumption kg/capita versus GDP/capita

Also, cement in its current form isn't going away in a hurry. Predictions are that the global peak of cement production is still in the future and likely to be 12% higher than current volumes. This is supported by the well-known curve shown in Figure 1, in which there are many countries - notably India and almost the entire continent of Africa - which lie on the growing left-hand side of the climb to peak cement consumption per capita.

The Portland cement recipe requires decarbonation of calcium carbonate and a large amount of heat for the process, both of which imply evolution of carbon dioxide. Many alternative cements to the Portland recipe with lower carbon dioxide footprints have been proposed but have yet to make a significant dent in the dominance of Portland cements in both pure and additions formats. With a global cement capacity approaching 6 billion tonnes and with a conservative asset valuation of \$150/annual tonne, total cement global assets are worth approximately \$900 billion and this will not be sacrificed or replaced easily.

What is the industry doing to improve its carbon footprint?

So what are the regulating authorities and the cement industry doing? The actions can be divided conveniently into developmental and major evolutionary steps.

The industry developmental steps include

- Reducing fuel and power consumption.
- Reducing clinker content of cement.
- Moves to alternative fuels, especially those with a significant biomass content.

For the authorities, the major action has been the introduction of carbon trading, most significantly in Europe but with other schemes emerging in many regions around the world.

Unfortunately, carbon trading has tended to become more significant as a financial tool rather than a driver of change and for every forward step in reducing specific emissions, such as in Europe, there have been other setbacks such as in Egypt, where the change from natural gas/oil to coal/petcoke has adversely impacted specific carbon dioxide emissions.

More evolutionary steps include

- Several routes to capture and dispose of carbon dioxide from modified kiln processes. But current costings indicate a trading cost of over \$100/t for carbon dioxide before breakeven is achieved.
- Using carbon dioxide in concrete (i.e. Solidia) with current developments directed at the pre-cast industry.
- The most advanced thinking with the current cement recipe is to source heat for the kiln process from diverse sources i.e. hydrogen, 100% biomass and electrification, but the issue of carbon dioxide from calcium carbonate remains.
- Other cement recipes remain in development but have yet to be produced in significant volumes.

How do we let end users know about this differentiation?

What is clear is that the impact of these initiatives is rarely clear to cement consumers and the general public and

most often references to “green” cements are made with little or no justification or quantification.

One potential idea that could drive cement producers to focus more on reducing CO₂ is that of giving cements a clear environmental ranking, such that consumers and the general public can understand the CO₂ generated in the manufacture of cement. This will influence customer behaviour and therefore the revenue streams of the cement producers. The measures of Kg of CO₂ per tonne of clinker or cement are certainly useful, but what is not clear is how much of any improvement in this measure is due to the production of lower strength cements. As the vast majority of cement is used for the strength it can produce in concrete and mortar applications, the parameter proposed for ranking has to take both CO₂ emissions and resultant strength of the produced mortar / concrete into account. The CO₂ factor would be that attached to the original clinker source and the percentage content in a given cement. Where cement from grinding plants use outsourced clinker, it is proposed that the clinker(s) used are ranked for kg CO₂ / tonne clinker in order to correctly assign a ranking to the cement produced by that grinding plant.

The compressive strength parameter would be defined as that achieved at 28 days, the parameter generally used for the majority of concrete designs. Thus kg CO₂ / tonne cement / MPa of 28 day mortar strength using EN standard testing methods would become the standard environmental performance for cements. EN standards for compressive strengths have been selected as the standard in most widespread use. There are also well-known conversion factors which can allow strengths obtained from other standards to be converted to EN standards. It is further proposed that the kg CO₂ / tonne cement / MPa parameter should be classified in a similar manner to those of domestic appliances such as washing machines, televisions etc. and be ranked in bands A+++ to F. This will allow more clarity in labelling. As well as CO₂ from the kiln process any emissions from slag and fly ash driers and

from artificial pozzolan calciners etc. should be included in the CO₂ measure for the ranking.

There are several counter arguments to this type of environmental ranking i.e.

- a) 28-day strength is not the only consideration i.e. for precast customers.
- b) Mortar strength performance is not always replicated in concrete applications.
- c) CO₂ emissions from the production of slag and fly ash are not included.
- d) The CO₂ emitted from power generation and used on the plant or from any captive power generation installed at a plant is not included.
- e) The ranking takes no account of the minimum cement requirement in many concrete specifications.

No ranking method can entirely eliminate discussion as to the exact measures to be used but the relatively simple ranking which has been adopted for domestic appliances using methods largely initiated by the European Union has led to a virtuous circle of development such that even A+++ ranking is not sufficiently good to include current best practice. Today it is difficult to imagine a customer buying an E ranked washing machine and given equal price who would buy a B ranked machine over an A++ ranked?

What would the environmental ranking of cement look like?

As an example of cement environmental ranking a typical CEM I 52.5N in Europe has a kg CO₂/tonne cement of 828 for a 28-day compressive strength of 63MPa. By dividing the 828 by 63 a ranking of 13.2 is produced. By comparison an average CEM II/A-L 42.5N, with a lower clinker content than the CEM I, has a kg CO₂/tonne cement of 747 for a 28-day compressive

CEMENT TYPE	kg CO ₂ / t cement / MPa strength 28d	kg CO ₂ / t cement
CEM I 52.5N	12.9	794
CEM II/A-LL 42.5R	13.4	700
CEM II/A-LL 32.5R	13.4	649
CEM II/B-LL 32.5R	15.7	573
CEM IV/A-V 32.5R	12.2	571

Table 1: Cement Types and kg CO₂ / t cement / MPa compressive strength at 28 days for a typical European cement plant. Conventional kg CO₂ / t cement data also included for comparison.

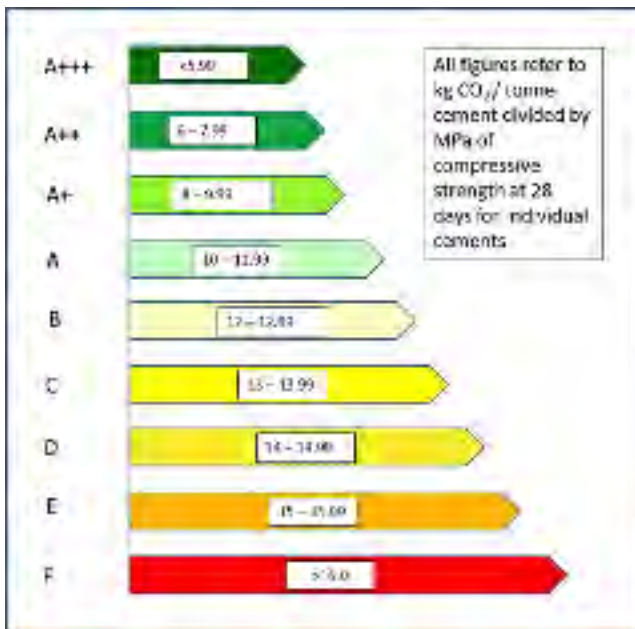


Figure 2: Proposed environmental rankings for cements

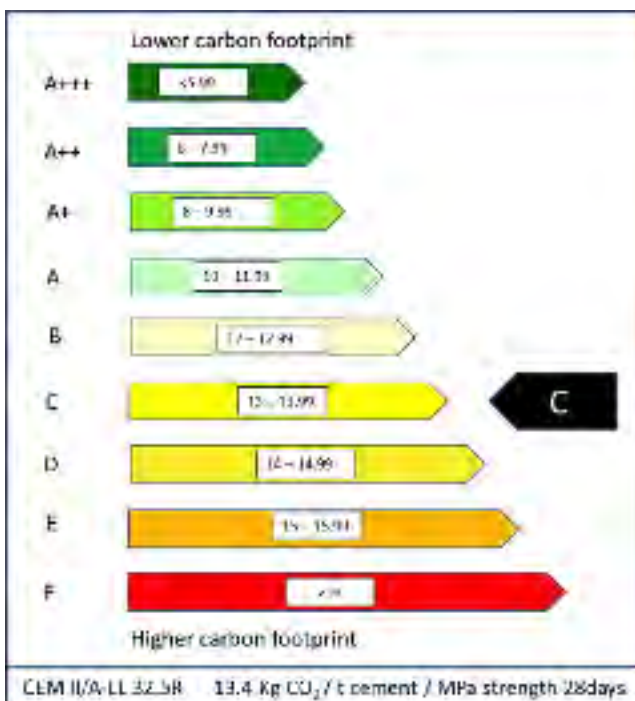


Figure 3: Example of environmental labelling for cements

strength of 53MPa. This produces a ranking of 14.1, apparently inferior in ranking to the CEM I. Why is this the case? The major part of the explanation is usually to be found in the cement grinding system, where the softer limestone in the CEM II is preferentially ground over the clinker. With poor separators this leaves a higher proportion of clinker insufficiently ground to contribute to strength development in mortar and concrete. By comparison, cements with fly ash, slag and pozzolanic additions give significantly better results as the additions are active in developing strength, especially at ages of 28 days and beyond. However, even in this case it is important that preferential grinding and poor separators do not rob the cement of any potential strength development.

As an illustration of this point, figures for the range of products from a typical European plant are shown in Table 1

It can be seen that there is a significant range of kg CO₂ / t cement / MPa compressive strength at 28 days data and not necessarily in the expected direction as shown by the more conventional kg CO₂ / t cement data. However, the fly ash cement (CEM IV/A-V 32.5R) is clearly the best performer on both counts.

Overall, the suggested ranges for the overall environmental ranking of cements are shown in Figure 2. These

ranges cover most cements produced.

The overall result for a given cement is the classification shown in Figure 3. In this case it is for the CEM II/A-LL 32.5R in the plant example given in Table 1.

The result is clearly labelled as a “C” classified cement and customers can also evaluate competing cements for their environmental ranking and make decisions based on the rankings.

Environmental ranking could influence buyer behaviour

As previously stated, the issue of minimum cement content in concrete has to be addressed in parallel with any attempt to rank cements. Worldwide standards for minimum cement content in concrete vary widely and there are many expert opinions suggesting that a critical review of these standards is urgently required. This review could significantly reduce the amount of cement used in many concretes.

Moving the cement industry to a more carbon dioxide friendly future will follow many routes, but by ranking cements in the manner proposed, the efforts of manufacturers to progress in fuel consumption reduction, biomass utilisation, improved grinding and better use of active additions can be seen clearly by customers, government bodies, environmentalists and the wider public.

Note

A version of this article was previously published in World Cement's January 2019 issue.

