CEMENT ADMIXTURES ASSOCIATION

38a Tilehouse Green Lane, Knowle, West Midlands B93 9EY
Tel/Fax: 01564 776362
SECRETARY: JOHN DRANSFIELD

the Sign of Quality

Admixture Sheet – AES 8
Environmental Impact of Admixture Use

1 Introduction

Working through EFCA (The European Federation of Concrete Admixture Association), the British Cement Admixture Association CAA has been part of a project group developing Life Cycle information on the environmental impact of concrete in structures.

Other members of the project group include the European industries for cement (CEMBUREAU), aggregate (UEPG), steel (EISA), precast (BIBM) and the ready mix industry (ERMCO).

An independent consultant was employed to undertake a Life Cycle Inventory (LCI) on the products from each JPG member. The consultant also developed a computer based programme that was preloaded with the LCI information from the JPG members and could be used to obtain a Life Cycle Analysis (LCA) on 10 concrete elements (functional Units), typical of European concrete. All work was carried out in accordance with the appropriate parts of the ISO 14000 series of standards and the process was subject to an external critical review.

Based on this work, EFCA have now produced Environmental Declaration Sheets for most admixtures, providing practitioners with information to help undertake LCA of specific concrete structures. These Declaration Sheets are available from the CAA web site www.admixtures.org.uk.

EFCA members have been trained in the use of the LCA computer programme (EcoConcrete) and have used this LCA methodology to look at the environmental impact of admixtures in a number of typical concrete elements. As well as showing the potential environmental benefits of admixture use, the information can be used to show areas where future admixture development could be targeted to further improve the environmental profile and sustainability of concrete.

Admixtures are used at very low addition levels on concrete. 90% of all admixture use is at a dose of less than 0.1% of active chemical on concrete weight. Even at this level of addition, their beneficial effect on concrete properties is significant, providing a more cost-effective mix with improved placing characteristics and better durability. In spite of these benefits, the fact that admixtures are derivatives of the chemical industry means that they are regarded with suspicion by many regulators. This study was designed to investigate the environmental impact of admixture use on concrete in typical concrete elements (Functional Units) through their complete life cycle.

2 LCA Study and Methodology

The study undertaken by EFCA looked at the use of Plasticizing and Superplasticizing admixtures as these account for 80% of all admixture usage in Europe.
The admixture dosage was near the top of the typical dosage range to maximise any impact.
Concrete is typically specified on the basis of strength and consistence so this study compared concrete's with and without admixture at equal strength and consistence (based on water content and W/C).
Unit volumes of concrete were analysed for relative life cycle impact in the following functional units:

- An un-reinforced flat slab. (This included the effect of using 3 different classes of cement)
- A bridge abutment.
- A precast concrete wall.

In each case, where appropriate, the analysis considered:

- Raw materials, production and delivery of each concrete constituent
- Production and delivery of the concrete
- Formwork, reinforcing steel, placing and compaction of the concrete
- Maintenance during a defined lifetime
- Demolition and transport to landfill and or recycling.

The Life Cycle Analysis (LCA) methodology used in this study was CML–2 and used a computer tool, EcoConcrete, developed for the Joint Project Group by INTRON.
13 environmental impact categories were analysed as detailed in Fig 1.

CML-2 Impact	Units	Detail
Energy	**Mj**	**Total energy requirement**
Non Chemical Waste	**kg**	
Chemical Waste	**kg**	
Human toxicity	**kg 1,4DB**	**Toxic impact on human health**
Abiotic Depletion	**kg Sb**	**Natural resources, eg iron, oil etc**
Ecotox aquatic	**kg 1,4,DB**	**Toxic impact on aquatic ecosystems**
Ecotox sediment	**kg 1,4,DB**	**Toxic impact on sediment ecosystems**
Ecotox terrestial	**kg 1,4,DB**	**Toxic impact on land ecosystems**
Acidification	**kg SO2**	**Acidifying pollutants**
Eutrophication	**kg PO4-**	**Enhanced level of macronutrients**
Climate change	**kg CO2**	**Sun radiation absorption**
Photo-oxidant	**kg C2H4**	**Formation of reactive air pollutants**
Ozone depletion	**kg CFC 11**	**Thinning of the Ozone layer**

Figure 1, CML impact categories

3 Input data

General input data is shown below, deviations are noted on results graphs.

Cement:	CEM I 52.5,	Flat slab and Precast wall unit
	CEM II A-L 32.5R,	Flat slab and Bridge pylon
	CEM IIIA 42.5	Flat slab

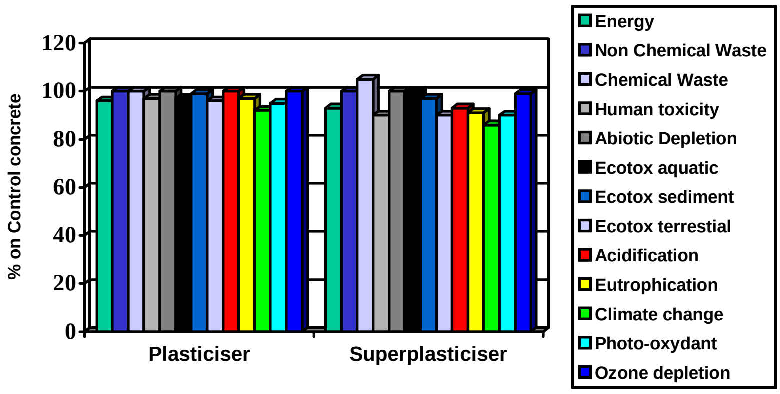
Aggregate: All mixes were uncrushed fines at 40% and crushed coarse at 60%.
Admixtures: Plasticizer at 0.5% by weight on cement. Superplasticizer at 1.5% or 1.1%.
Water reduction: Assumed as 10% for plasticizers, 20% for superplasticizers at these dosages.

Reinforcement:	Flat slab,	none
	Bridge Pylon	122 kg/m3
	Precast Wall	45 kg/m3

Delivery: Information on truck size and delivery distance constant for all comparisons.
Maintenance: Bridge Pylon only, repainted every 10 years.
Life Cycle: Flat slab and wall unit, 50 years, Bridge pylon 100 years.
Demolition: Landfill/recycling: 80/20 % for concrete, 5/95 % for steel.

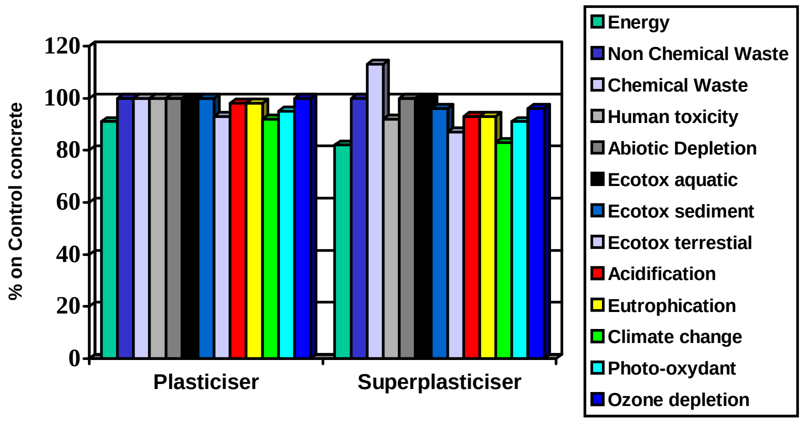
4 Effect of admixture use

The percentage change in total value of each impact category, resulting from the addition of plasticizing and superplasticizing admixture, is compared with the non-admixture control in Figures 2 and 3. The two functional units shown represent the typical and worst cases from the set.



Cement CEM IIA-L 32.5R, **Functional Unit:- Flat Slab**,

Figure 2



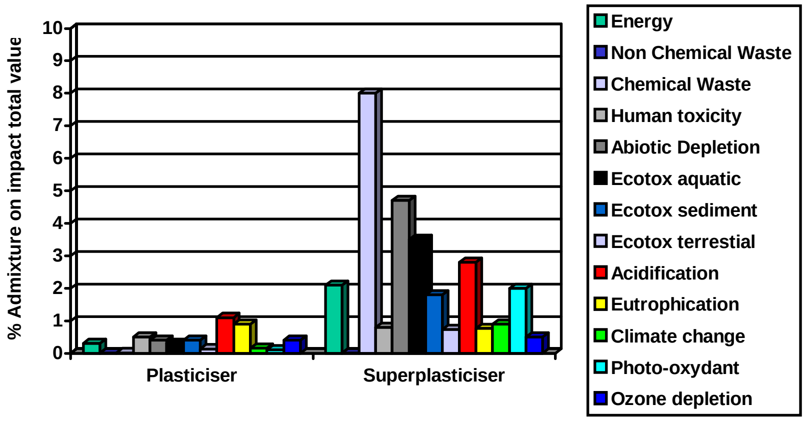
Cement CEM I 52.5, **Functional Unit:- precast wall unit,**

Figure 3

It can be seen that the effect of the admixture is always small but generally beneficial in reducing the total value of most impact categories. The exception is for chemical waste from the superplasticizer, however, it should be remembered that the values have been normalised to 100% for the control. In the case of the superplasticiser in the precast wall, this equates to an increase of just 10 g of non-hazardous chemical waste per cubic meter of concrete while the reduction in energy is several hundred Mj per cubic meter of concrete.

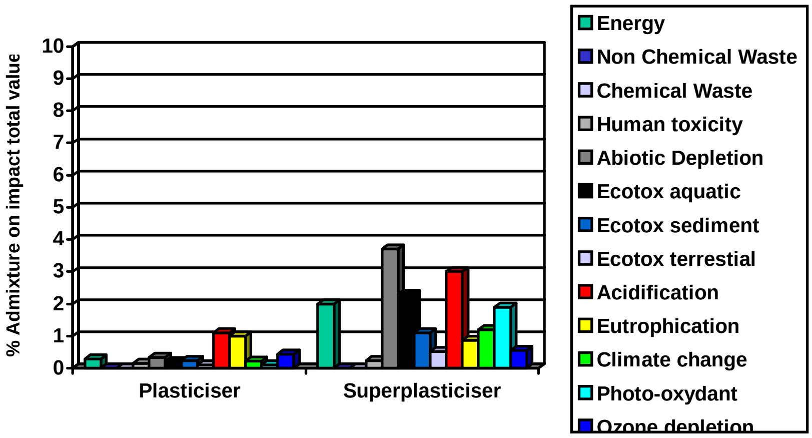
5 Contribution of admixture to total value

The percentage contribution to total value of each impact category, resulting from the addition of plasticizing and superplasticizing admixture, is shown in Figures 4 and 5. The two functional units shown represent the typical and best cases from the set.



<u>**Cement CEM I 52.5**</u> **Functional Unit:- Flat Slab,**

Figure 4



<u>**Cement CEM IIIA 42.5,**</u> **Functional Unit:- Bridge Pylon,**
Plasticiser consistence S2 Super P consistence S3

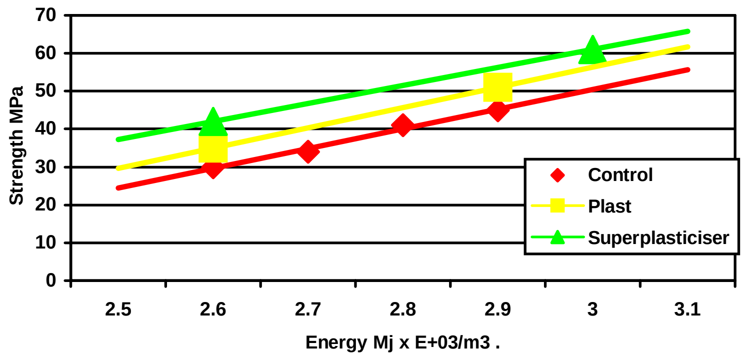
Figure 5

For most impact categories, the contribution from the admixture is less than one percent. The typical and largest exception is the chemical waste from superplasticizer production at about eight percent. However, as previously noted, the actual value of this waste is very small, as the whole concrete production process produces little chemical waste.

It is interesting to note that the superplasticiser contribution to chemical waste has fallen to less than one percent in the bridge pylon. This is because of the large amount of waste resulting from the regular painting of the structure and accounting for over 99% of the total chemical waste in this LCA. Surface protection is required for most construction materials including steel and wood but is often unnecessary with good quality concrete. It can be seen that if the need for protection is eliminated or reduced, this will have a significant beneficial environmental impact on this category.

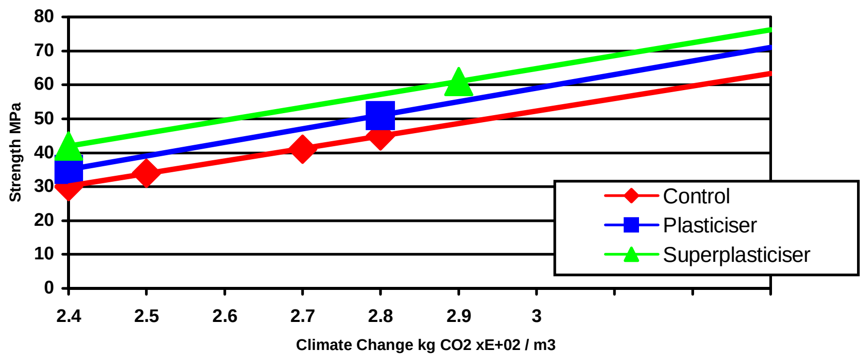
6 Effect admixture addition on the strength / impact profile

Concrete is normally specified by strength and admixtures can be used to optimise strength at a given consistence class. The study looked at the strength profile of concrete with and without admixture over a range of cement and water/cement ratios against the effect on environmental impact category. The study looked at 3 cements but the relative profiles were similar for all three so only the CEM IIIA 42.5 is shown here. Two impact categories, Energy and Climate Change are used to show the effect. See figures 6 and 7.



Cement CEM IIIA 42.5 **Functional Unit:- Flat Slab**

Figure 6



Cement CEM IIIA 42.5 **Functional Unit:- Flat Slab**

Figure 7

It can be seen that both superplasticizers and plasticizers are environmentally effective in reducing energy consumption and CO_2 release, compared to a control mix of the same strength.

7 Conclusions

This investigation confirms the potential environmental benefits of admixture use in concrete, especially in reducing energy consumption and carbon dioxide release.

When compared with admixture free concrete of equal strength and consistence, the admixture always gives a small improvement in the overall impact values.

Admixtures have a very small effect on the total environmental impact of concrete. For most of the impact categories studied, the admixture contribution accounts for less than 1% of the total value.

The information obtained from this type of study can be used to show areas where future admixture development could be targeted to further improve the environmental profile and sustainability of concrete.