

FARM BUILDINGS



PAUL MOONEY

Novel cement shown to have a

LIVESTOCK farmers who have seen at first hand the costly wear on silage slabs caused by effluent will be interested in the results of research published recently by two scientists in Trinity College, Dublin.

They studied the extra durability under exposure to silage effluent of concrete made with the inclusion of an alternative — though commercially available — cement.

The material in question is ground granulated blast furnace slag (GGBS) cement. The bulk of cement used for manufacturing concrete here is Portland cement, essentially made by burning limestone. As its full name suggests, GGBS cement is a byproduct of steel manufacturing.

Limestone is used as a flux in the smelting of iron ore in blast furnaces, and can be extracted afterwards as granulated slag. Ground to a powder, the slag can be used

as a cement. In concrete manufacturing, it is used to replace Portland cement in the mix on a one-to-one weight basis, with typical replacement rates of 30% to 50%.

Some 20 million tonnes of GGBS is produced in Europe each year, and much of this is used for manufacturing concrete.

Because of the cost, GGBS was traditionally more widely used in areas where iron smelting was carried out.

GGBS cement — and the concrete made with it — has different chemical make-up to Portland cement, and this has benefits for particular building applications, including an ability to wear better in certain types of aggressive environment.

It has been suggested that GGBS concrete would be more durable in silage pits than the Portland variety, and some studies have been carried out. To my knowledge, GGBS concrete has not

been used in any silage pit in Ireland.

Over the past few years, it has become apparent exactly how corrosive silage effluent can be.

The Department of Agriculture responded by specifying a higher cement content in concrete for grant-aided structures, which resulted in slower wear and a longer working life for silage pits and channels, etc.

The Trinity researchers, Sara Pavia and Eoin Condren, are both attached to the College's Department of Civil, Structural and Environmental Engineering.

They compared the durability of concrete made with GGBS with concrete made with Portland cement when exposed to silage effluent. Among their conclusions were:

- A more durable concrete mix for use in silos can be specified by incorporating GGBS as a partial substitute for Portland cement.
 - The addition of GGBS will increase the lifespan and decrease the amount of maintenance needed for Portland cement concrete silos.
 - Attack by silage effluent is not as superficial as previously reported — silage effluent corrodes deeply into Portland cement concrete.
- The researchers made up



Silage effluent corrodes deeply into Portland cement concrete.

100mm cubes of concrete in three different proportions and immersed them in a synthetic silage effluent in three cycles of 28 days each. The proportions used were: 100% Portland cement; a 50/50 ratio of each cement; and a mix of 70% GGBS and 30% Portland cement. The cubes were made using standard procedures, including a 28-day curing period.

By immersing the cubes in the effluent for 28 day cycles, the researchers hoped to mimic farming conditions under which effluent will flow from harvested grass for a similar period.

The pH of the solution was maintained at 4.0 by the addition of acetic and lactic acids. The acids reacted with the concrete and were neutralised with salts formed as a by-product of the reaction.

TEST RESULTS

Visual degradation was obvious on the concrete made

from 100% Portland cement after immersion in silage effluent, as noted in the research report, "with corners and edges invariably disintegrating when pressurised".

The cubes containing the GGBS cement visually fared better and were "largely unaltered".

"The visual results indicate that the higher the percentage of GGBS incorporated into the mix, the better the durability on exposure to silage effluent," according to the report. All concrete mixes showed an

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Where to find GGBS cement

MANY concrete manufacturers will supply concrete with GGBS cement included if asked, usually without any change to price. There are a number of importers and distributors including Eoocem, Irish Cement, Cemex and Northern Ireland based Civil and Marine.

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greater resistance to silage acid

Table 1: Percentage loss of mass for each mix

Sample	Average loss in mass (%)
100% Portland cement	5.9
30% GGBS	4.0
50% GGBS	1.9

increase in permeability after immersion in silage effluent when compared to reference cubes, which were not immersed.

The permeability increase rate was higher for the 100% Portland cement concrete. Less permeable concrete doesn't allow corrosive substances to penetrate.

Likewise, all samples showed a progressive increase in water absorption. This indicated that the concrete had become more porous due to corrosion. The results suggested that the use of GGBS reduced absorp-

tion, more so at the higher inclusion rate. Cubes were also tested for capillary action, as the more fluid sucked into concrete by capillary action, the more susceptible it will be to attack by effluent.

Suction was higher for all samples after immersion in the acids. Yet again, GGBS came out on top; the higher the GGBS content in the concrete, the lower the suction.

LOSS OF MASS

The researchers also measured loss of mass, on the basis that this would be a clear illustration of the

Table 2: Average percent loss of compressive strength as a result of exposure to silage effluent

Sample	% loss in compressive strength
100% Portland cement	46.74
30% GGBS	32.74
50% GGBS	21.82

amount of degradation that had occurred.

There was a relatively steady decline in mass over the three cycles of immersion. This, along with the increase in water absorption, led the researchers to conclude that the corrosion by silage acids goes deeper than has been suggested by previous researchers.

The Portland cement concrete lost mass at a faster rate than those containing GGBS, and the concrete with higher inclusion of GGBS lost least mass. Table 1 shows the percentage loss of mass for

each mix. The researchers tested compressive strength on the basis that it is a good indicator of long-term durability, which is generally accepted as giving a longer working life.

Even prior to immersion, the two concrete mixes made with GGBS had greater strength.

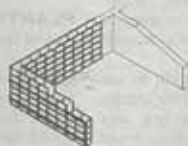
The measured compressive strengths were 13.83, 19.76 and 24.79 N/mm² for the Portland cement, 30% GGBS and 50% GGBS mixes, respectively. The loss of strength was reduced by inclusion of GGBS, as shown in Table 2.



LEFT: Concrete made with 100% Portland Cement
RIGHT: Concrete made with 50% GGBS cement and 50% Portland cement.

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