

# Recycling eggshells



## Summary:

Bumble Hole Foods Ltd is probably the most respected egg processing company in the UK. The company produces products based on liquid egg (whole egg, egg white, egg yolk and egg blends), egg mayonnaise and boiled eggs. The processes result in significant amounts of eggs waste to be disposed of. Currently, eggshell waste is spread on farm land as a fertiliser. However, as this is a seasonal activity, the company requested the University to engage with them in finding additional innovations and markets.

## The objectives:

To find suitable applications for recycling eggshell waste.

## Eggshell description:

Chicken eggshell is one of the agricultural wastes which is currently receiving attention from researchers and has the potential for being used in medical and dental therapy. Eggshell has as an important constituent, pure  $\text{CaCO}_3$ , and low porosity. Its composition has been chemically determined (by weight) as: calcium carbonate (94%), magnesium carbonate (1%), calcium phosphate (1%) and organic matter.

## Natural materials with similar characteristics:

**Limestone** is a sedimentary rock, formed by the deposition and subsequent cementation at the earth's surface and within bodies of water. Skeletal remains of aquatic creatures contain minerals like calcite and aragonite. These are different crystal forms of the salt calcium carbonate ( $\text{CaCO}_3$ ), which is the primary composition of limestone.

**Calcium oxide** is a white crystalline solid with a melting point of 2572C. It is manufactured by heating limestone, coral, sea shells, or chalk, which are mainly  $\text{CaCO}_3$ , to drive off carbon dioxide.

**Portland cement** consists essentially of compounds of lime (calcium oxide (62.8%)) mixed with silica (silicon dioxide, (22.3%)) and alumina (aluminium oxide, (4.5%)).

**Lime** is obtained from a calcareous (lime-containing) raw material, and the other oxides are derived from an argillaceous material. Additional raw materials such as silica sand, (iron oxide (3.4%)), and bauxite-containing hydrated aluminium, may be used to get the desired composition.

## Academic team:

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## Experimental investigation:

**In construction application:** Investigations were conducted using different percentages of eggshell as cement replacement in concrete. Unconfined compressive strength tests were used to compare the properties of concrete with the eggshell replacement. The control and concretes with 5, 10, 15 and 20% dry cement replacement were tested for 1, 7 and 21 days, with a water /cement ratio of 0.6%.

The tests indicated that compressive strengths were higher than the control concrete for a 5% eggshell replacement at 7 and 21 days. The tests suggest that up to 5% of eggshells could be used to replace cement, giving cost savings as well as providing an alternative use for the eggshells.

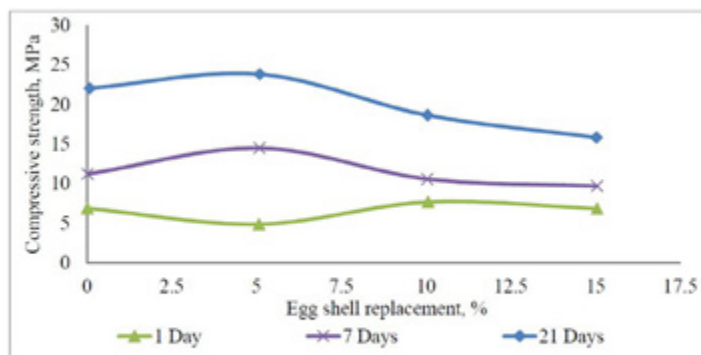


Figure 1 Change in compressive strength with different eggshell proportion replacement.

## Conclusion:

- Compressive strength was higher than control concrete for 5 % eggshell replacement at 7 and 21 days of curing ages. Eggshell replacements greater than 10 and 15 % had lower strength than control concrete.
- Replacement of lime with eggshell showed an improvement in stability at 4% of eggshell, compared with the untreated soil.
- The density of stabilised soil did not change much but the stabilised soil need higher water content.
- Eggshell can replace sand for making hollow building blocks.

**In geotechnical application:** Soil stabilisation may be broadly defined as the alteration or preservation of one or more soil properties to improve the engineering characteristics and performance. When the mechanical stability of soil cannot be obtained by combining natural materials, it is stabilised by adding lime, cement, bituminous materials, or special additives. Eggshells could be used as an alternative soil stabiliser to lime since they have the same chemical composition.

Soil mixed with eggshell powder and/or lime at optimum water content. The maximum dry density is decreased by adding the stabilisers while the water content increases.

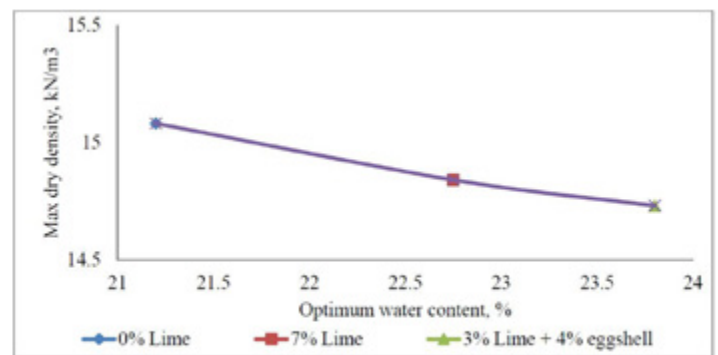


Figure 2 Maximum dry density and optimum water content.

## Recommendations:

This report concentrates on geotechnical and construction applications. It concludes that eggshell can be used into the following applications:

- Replace lime in stabilised soils.
- Use the eggshell as cement replacement to make concrete.
- Replace sand in hollow blocks.
- Use eggshell powder as fine filler material.