ANALYTICAL AND MECHANICAL INVESTIGATION OF LIGHTWEIGHT EXPANDED CLAY AGGREGATES FOR UTILIZATION IN CONCRETE

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By

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بسم الله الرحمن الرحيم

وقل رب زدني علما

صدق الله العظيم

بسم الله الرحمن الرحيم

ANALYTICAL AND MECHANICAL INVESTIGATIONS OF LIGHTWEIGHT EXPANDED CLAY AGGREGATES FOR UTILIZATION IN CONCRETE

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C O N T E N T S

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CHAPTER I

INTRODUCTION

AND OBJECT OF INVESTIGATION

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I.A- INTRODUCTION :

1- Expanded Clay and Expanded Shale Aggregates :

When certain clays and shales are heated to semi-plastic stage, often termed "the point of incipient fusion", they expand or "bloat" to as much as seven times their original volume, owing to the formation of gases within the mass of material at the fusion temperature. The cellular structure so formed is retained on cooling and the product may be used as a lightweight aggregate. For the production of such aggregate, the clay should soften at a temperature which can be reached and maintained economically and at the same time it should contain constituents which will produce gases at such temperature. If such constituents are not present naturally in the clay, they may be incorporated during manufacture. The relation between chemical composition and the ability to bloat has been studied by many workers ever since Jackson[1] put forward his theories in 1903. A very comprehensive account of an investigation was given by Riley[2] in 1950. There can be no doubt that a thorough understanding of the factors which contribute to bloating is very desirable, but of practical purposes, the empirical assessment of clays in regard to their "bloating" is made speeder and more directly informative their expensive mineral analysis. A first indication of the bloating characteristics of clay and shale can be obtained by heating individual pellets of the materials at various temperatures over the range at which such bloating is likely to take place. It is essential that the clay should raised to the operative temperature very rapidly, and it is very convenient of the required range of temperature can be obtained in a single furnace. Such furnace has been designed at the Building Research Station. In this, there are 12 temperature zones between 120 and 1350°C. A separate sample for each temperature level (consisting of two pellets) is fired for 5 min. and then quickly removed from the furnace. When cool, the pellets are measured and the expansion computed. Thus the optimum temperature for the bloating can be assessed. Expanded clay and shales have been used in the USA and Continental Europe for many years. In the USA, expanded shales were used as aggregates for concrete ships in the first world war[3]. The well known product "Haydite" was produced in the early 1920's and is still being produced from clay or shale in rotary kilns fired by oil, gas or pulverised fuel.

Expanded shales and clays are also produced on sintering hearths, and have been so made for many years, the first being manufactured in 1931 under the name of Lytag (not to be confused with a present-day product of the same name made in England, which is a sintered pulverised-fuel ash aggregate). A more recent aggregate produced in the USA from clay expanded on a sintered hearth is Aglite.

In north America to-day there are probably about 60 different brands of expanded clay and shale aggregates and perhaps 100 or more separate plants. The best known of the expanded shales in the USA are, Basalite, Crestlite, Rocklite, Materialite, Lite-rock, Galite and Nytralite, and the expanded clays, Aglite and Gravelite. The brand names Haydite and Solite are used for both shales and clays. In Canada, the expanded shales are Herculite, Saturnalite, and Aggrite, and the expanded clays are Solite, Literock and Echolite. In Europe, the Danish-produced "LECA" has been made for more than 35 years is now produced under licence in many other countries. This is a light; rounded, smooth skinned clay product made in rotary kiln. Expanded shale aggregate is manufactured in Holland, Germany, Poland, USSR, and elsewhere in Europe.

No doubt because of the large supplies of furnace clinker and foamed slag which have for so long been available in the UK, there was formely limited interest in expanded clay, although there was some production for ship-building during the second world war. In the early 1950's however, production of expanded clay was started under licence from "LECA" of Denmark. This is still an important aggregate in England. For nearly 30 years, Aglite has been produced in Britain as well as in the USA, by the sintering hearth method. In the UK, this aggregate is being made from clay mixed with ground coke, but is also being manufactured from shale-bearing waste from coal-washing plants.

As with other lightweight aggregates, concrete produced from expanded clay or shale depends for its strength not only upon the inherent strength of the aggregate, but also upon the degree of compaction, which in turn is influenced by the shape and grading of the aggregates it is sometimes said that fragmental aggregate is capable of giving the greater strength, but that the round material gives better workability and so may often lead indirectly to stronger concrete if only by permitting a lower water/cement ratio. Practical experience, however, seems to show that it is the shape of the fine fraction and the grading of this which influences the workability of the mix and the fines derived from a so called rounded aggregate may be as harsh and irregular as that from a fragmental aggregates. The workability of harsh aggregate can usually be improved by the use of air-entraining agents in the mixing water. With careful grading and good compaction, the lighter types of expanded clay aggregates can produce remarkable strong concrete at modest density. Indeed the strength to be expected from a mix depends very much on the grading, the water/cement ratio and the degree of compaction.

2- Tests for Determining Expansion Capacities :

Laboratory have a choice of various processes for assessing the expandability of ceramic raw materials serving for the production of lightweight aggregates. A simple process which yields good guideline values may be carried out in a muffle furnace. Raw-formed particles or, also shale fragements, are subjected to an expansion process in two stages. The particles are pre-dried at 110°C where upon they are exposed to heat radiation directly in the furnace at various temperatures in the range of 1000-1250°C. It is to be noted, however, that the obtained effects will not be directly reproducible in large-scale production processes. This is due to the fact that in a laboratory of this type the thermal engineering conditions are almost ideal whereas such conditions can not usually be obtained in rotary kilns. The large-scale ZS-process is probably closest to such thermal engineering conditions.

The heat microscope is an important implement for studying the sintering, softening and expansion behaviour of such raw materials. One advantage of this method is to be seen in the fact that the test samples can be observed in each heating phase and recorded on a film. The analysis of the film provides information on the thermal behaviour of the raw material with the temperature rising linearly, i.e. about the softening point, the temperature of maximum expansion capacity and about the start of smelting. The tests show that the expandability of expandable raw materials increases with rising heat velocities. Another laboratory process comprises the opportunity of analyzing ceramic raw materials by means of the inclined tube furnace, this type of furnace presumably being the nearest to actual industrial practice. An electrical heated tube furnace is used, the heat being such that the optimum expansion temperature is obtained at the furnace centre. A proven method to determine optimally by way of laboratory technology the raw material specific