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# Lightweight aggregates

## The search for strength without weight



Sinter strand for the production of Lytag with ignition hood in the background

Over the years, the list of reasons for using lightweight aggregates in concrete has increased. Historically, the main reason would often have been the need for the structure as a whole or a single component of it to be lightweight. Today, the list includes a whole range of motives, not least being the ecological pressures from the dwindling supplies of the more traditional naturally occurring materials.

Among the more obvious reasons are the following:

- Many lightweight aggregates are manufactured partly from waste materials
- The reduced dead loads allow longer unpropped spans
- Economies may be made in foundations
- Transport costs are lower
- Cranage demands are reduced
- Lightweight concrete can be used in refurbishment work without increasing foundation requirements

In the UK, the proportional usage of lightweight aggregate concrete (LWAC) still lags behind countries such as the USA

and most of Europe. The picture is changing, however, and – as Geoff Mays showed in CONCRETE May/June 1991 – the use has been steadily increasing over the past few decades.

Last year saw the publication by Blackie of *Structural lightweight aggregate concrete*, edited by John L Clarke, then chief structural engineer with the British Cement Association. The following extracts from the book describe the various lightweight aggregates now available.

### Lightweight aggregates in the UK

Currently available lightweight aggregates are listed in Table 1.

#### Foamed slag

Foamed slag is produced by pouring molten blastfurnace slag (at more than 1350°C) onto a foaming bed consisting of a large number of water jets in a concrete base. The water converts to steam on contact with the slag and penetrates into it. The rapid expansion that then takes

place foams the slag into a cellular structure. Alternatively, water may be sprayed onto the molten slag as it leaves the furnace. After cooling, the slag is stockpiled and later crushed and graded. The aggregate is very angular with an open vesicular texture.

#### Leca and Fibo

Leca (produced in the UK) and Fibo (produced in Scandinavia) are expanded clay aggregates. They are made by feeding pelletized clay into a long rotary kiln inclined at about 5°. As the pellets pass down the sloping kiln, they are progressively dried and pre-heated, fired and finally cooled.

During the firing process, which takes place at about 1200°C, the pellets expand by up to six times their original volume.

#### Lytag

Lytag is produced in the UK from pulverized-fuel ash, pfa, large quantities of which are generated as a by-product at power stations. Suitable pfa, usually less than 8% loss-on-ignition, is first homogenized and then conditioned through a continuous mixer with around 12-15% water and, if necessary, additional fine coal to enable the pellets to be fired.

After pelletizing, the material is conveyed to a sinter strand – a continuously moving grate – which passes beneath an ignition hood. Control of the firing process and coagulation within the pellets is achieved by varying the speed of the sinter strand and the amount of air drawn through the bed.

The finished product is formed into a block of hard brick-like spherical nodules, lightly bonded by fusion where they touch. As the sinter strand reaches the end

Table 1: Lightweight aggregates available in the UK (1993)

Aggregate proprietary name	Type	Manufacturing process	Shape/texture	Typical dry loose bulk density (kg/m <sup>3</sup> )	Typical concrete strength (N/mm <sup>2</sup> )
Foamed slag	Foamed slag	Foaming bed	Angular/vesicular	750	<40
Leca/Fibo	Expanded clay	Rotary kiln	Rounded/smooth	425	<30
Lytag	Sintered pfa	Sinter strand	Rounded/fine	825	>40
Pellite	Blastfurnace slag	Pelletization	Irregular/smooth	900	>40
Granulex	Expanded slate	Rotary kiln	Irregular/rough	700	>40
Liapor	Expanded shale	Rotary kiln	Rounded/smooth:fine	650	>40

of its travel to return to the feeding station, much of the bed is discharged into a breaker that parts the lightly bonded pellets before the final grading.

The surface and internal structure of the finished pellet, although closed, is sufficiently open-textured to have encapsulated interstices between the coagulated pfa particles. These interstices are minute but are permeable to water and allow moisture to evaporate even when incorporated into concrete.

### Pellite

Pellite is a pelletized expanded blastfurnace slag produced in the UK. The process was developed in the early 1970s to overcome environmental problems associated with the production of foamed blastfurnace slag on open foaming beds or pits. Not only does the slag pelletization process overcome these problems but it also produces an aggregate with a closed surface.

To manufacture the aggregate, liquid blastfurnace slag at about 1400°C passes through a refractory orifice 'block' to control the flow. It is then allowed to flow onto a sloping vibratory plate covered with running water. The vibration breaks up the slag flow and the trapped water immediately vaporizes and expands the slag.

At the lower end of the vibrating slab, water is sprayed onto the slag, creating further expansion while chilling the surface. When they reach the bottom, the expanded globules – still semi-molten – discharge onto a horizontally rotating drum with fins which project the slag globules through a water mist. Here the globules become more rounded and cool further, producing pellets with a smooth



*Lytag particles and cross-section. This sintered pfa product has an open interior with a glassy outer skin*

surface encasing a glassy matrix and non-absorbent cellular structure.

### Granulex and Liapor

Like Fibro, Granulex and Liapor are not made in the UK. Both, however, are suitable for high-strength or prestressed concrete and both are made by bloating argillaceous materials in a rotary kiln.

Granulex is produced from slate in north-western France, just north of Le Mans. After reducing to 12-15 mm, the slate is fed into a three-stage kiln with a firing, or bloating, temperature of about 1150°C. The resultant aggregate particles are roughly cubic with a density of between 650 and 1,250 kg/m<sup>3</sup> and a coarse surface texture with very low water absorption. The finished product is crushed and graded up to 25 mm maximum size.

Liapor is produced from shale in Bavarian Germany between Nuremberg and Munich. The shale – a soft rock with low moisture – is crushed, dried and milled into a fine powder, generally less than 250 µm. Next, the powder is pelletized as with Lytag (except that no fuel is added) and then coated with powdered limestone before being fired in a kiln.

During the firing, particle density can be controlled by varying the temperature and speed of rotation of the kiln. Of all the aggregates currently available, Liapor is claimed to offer the greatest versatility to the designer for selecting an appropriate concrete density to suit the application. While the particle shape and surface texture of Liapor remain essentially the same, the internal porosity can be varied during manufacture.

### The future

In John Clarke's book, it states that "research on structural concrete has established that appropriate lightweight aggregates do not have the deficiencies in performance compared to concrete made with natural aggregates." As the need increases for alternative aggregate sources, there are opportunities for capitalizing on the resources that exist. For example, it is estimated that there are around 150 million tonnes of 'stockpiled' pfa in the UK. Although Lytag has provided a basis for exploitation of this pfa, the finished aggregate has a single density and so has been limited in its application to structural concrete. The chapter concludes that, although the technology is available for successful lightweight aggregate manufacture in the UK, there has to be considerable investment in process control of the feed material before any new generation becomes available.

*Leca is an expanded clay aggregate. The particles are superficially similar to Lytag but are about one-half the density*

