The practical aspects of pumping structural lightweight concrete

P M Follett, Pozzolanic Lytag Ltd, summarises
the main aspects when pumping lightweight concrete (LWC) for structural use. Also included are a number of practical tips which should be of particular use to contractors, pump operators and ready mix companies. The items of good practice are also relevant to normal concrete

There is clearly a trend towards the increased use of concrete pumps and as most LWC is placed above ground level it is not surprising that pump mixes are used more often than standard or 'skip' mixes. A pumpable LWC was first developed in 1975 and since that date at least 300 000cu m have been placed in the UK; in fact rarely will a project start where no one on site has had previous experience of the mix.

General

If a concrete mix is to be pumped it must have sufficient workability to pass through the line without requiring excessive pressure, and the applied pressure must be sufficient to overcome pipe friction, inertia and any vertical head. A lightweight aggregate will reduce the pressure required to overcome inertia and any vertical head; also if the aggregate is rounded in shape then pipe friction is kept to a minimum. There is, however, one important difference about lightweight aggregate: it will absorb additional moisture when under pressure in the concrete pump. For information, a typical pressure exerted onto the concrete within the pump will be 30bar. Now if this pump pressure produces an appreciable loss of workability, then increased pipe friction will occur and a blockage is likely.

Taking an international view, there are perhaps three methods of successfully pumping LWC:

- add some sort of admixture
- use a low pressure pumping unit, eg, the SEM type air placer
- vacuum soak the aggregate.

The low pressure method has been used in this country, but it is relatively slow and is thus only suitable for certain applications. Vacuum soaking of the aggregate would at first glance be very attractive, since fully saturated aggregate cannot absorb any more moisture, but the equipment is not available in the UK and more importantly the aggregates are then frost susceptible and drying out times for the concrete are extended. It is not surprising that the use of a pumping admixture is the most practical solution, and work began in this area in around 1970.

Mix design

Firstly, it should be stated that, at the present time, only LWC mixes containing natural sand fines are capable of being pumped successfully. Some concrete has been pumped using lightweight fine aggregate but its use should be restricted to non-structural applications.

After many trials to find a suitable pump mix which possessed a tolerance to increased pressure Fosroc developed the first commercially available admixture in 1975, Conplast 242. The admixture is a blend of thickening and plasticising agents which produce a workable yet cohesive concrete. A typical mix design for a cubic metre of pumpable LWC using Lytag aggregate would be:

520kg (0.65m^3)	Lytag pump grade (dry)
730kg	suitable natural sand (dry)
410kg	ordinary Portland cement
1kg	admixture
210kg	water
0.51	water/cement ratio.

Cormix have also developed their own admixture, which is known as Cormix PA, and more recently Fosroc launched Conplast 13. All these admixtures have proved successful and are supplied in powder form and should be 'ribbon fed' into the mixer at the plant.

It is useful to note that although the thickening effect will take some minutes to appear, the plasticiser enables the admixture to disperse surprisingly quickly through the mix. An accurate assessment of flow should be taken after 10 minutes have elapsed.

The lightweight 'pump grade' aggregate provides a more continuous grading between the sand and coarse aggregate. With all pumped concrete the grading of the sand is of vital importance; it should be of proven performance and as a rule of thumb about 20 per cent passing the 300micron sieve is satisfactory. A figure as low as 10 per cent is unlikely to provide sufficient resistance to the passage of the cement matrix. A final note on fine aggregates: crushed rock fines may not have a suitably even grading and should thus be assessed carefully.

Mix adjustment

Moisture content of the sand and lightweight aggregate should be assessed to obtain the true batch weights. Then, with the moisture content of the lightweight aggregate defined, an allowance should be made for the additional absorption of the particles. Thus:

Total water = Effective water content
− moisture in the sand
+ water for the additional absorption of the lightweight aggregate.

For an aggregate such as Lytag a typical water absorption by dry weight after mixing would be 15 per cent for a pumpable mix. When dry batching into ready mix trucks, it is advisable to place at least 50 per cent of the water into the drum prior to the addition of the aggregates and cement.

Control of workability

As a result of the mix design and the aggregate shape of a material such as Lytag, a semi-flowing concrete is produced. It is generally accepted that the slump test is not a reliable measure of workability for slumps over 100mm, so the use of a flow table as defined in BS 1881: Part 105:1984 is recommended. Figures 1–4 show the equipment before, during and after the test. The flow is defined as the mean of two diameters on completion of the test procedure. Flows in the range 50–60cm are satisfactory for pumping, but where higher pump pressures are being experienced flows up to 65cm are permissible, providing the site cube records indicate a sufficient margin of strength.

Arrival on site

With a lightweight concrete it is inevitable that some loads will have stiffened during

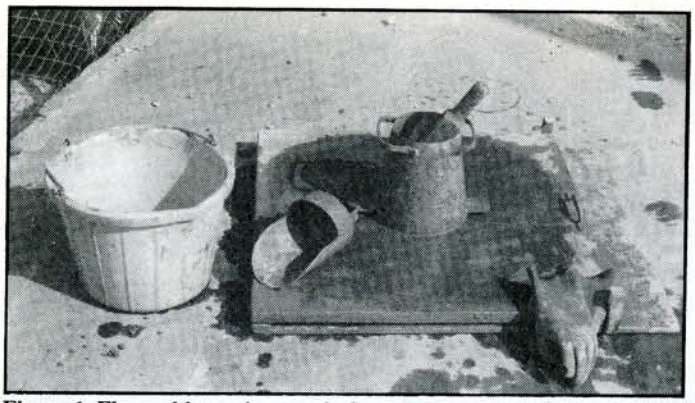


Figure 1: Flow table equipment before test

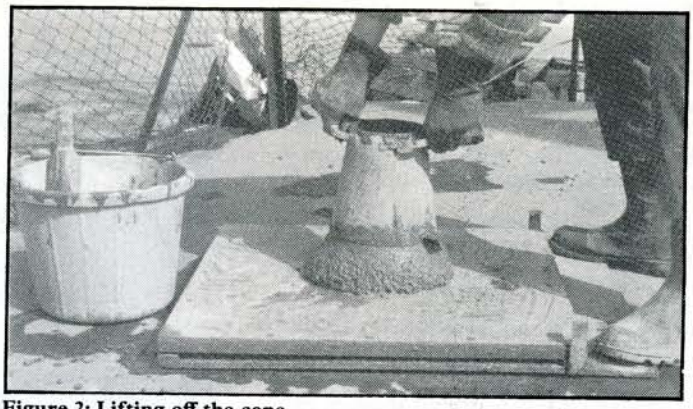


Figure 2: Lifting off the cone

Figure 3: Flow table during operation, 15 No lifts and drops are required

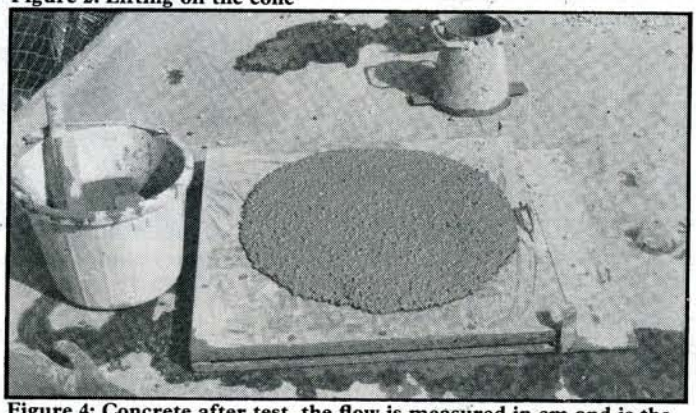


Figure 4: Concrete after test, the flow is measured in cm and is the mean of two diameters

transit, this is a result of time dependent absorption. An interesting point is that it is unlikely that a load of lightweight concrete will arrive on site with excess workability!

Should the workability be low prior to discharge it is important to add water to achieve the specified workability, providing that this is not due to rapid setting of the cement, eg, in very hot weather. It is usual practice to put forward an acceptance procedure for the controlled addition of water including re-mixing and re-testing. It should be noted that the addition of water to achieve the specified workability is allowed in BS 5328:1981.

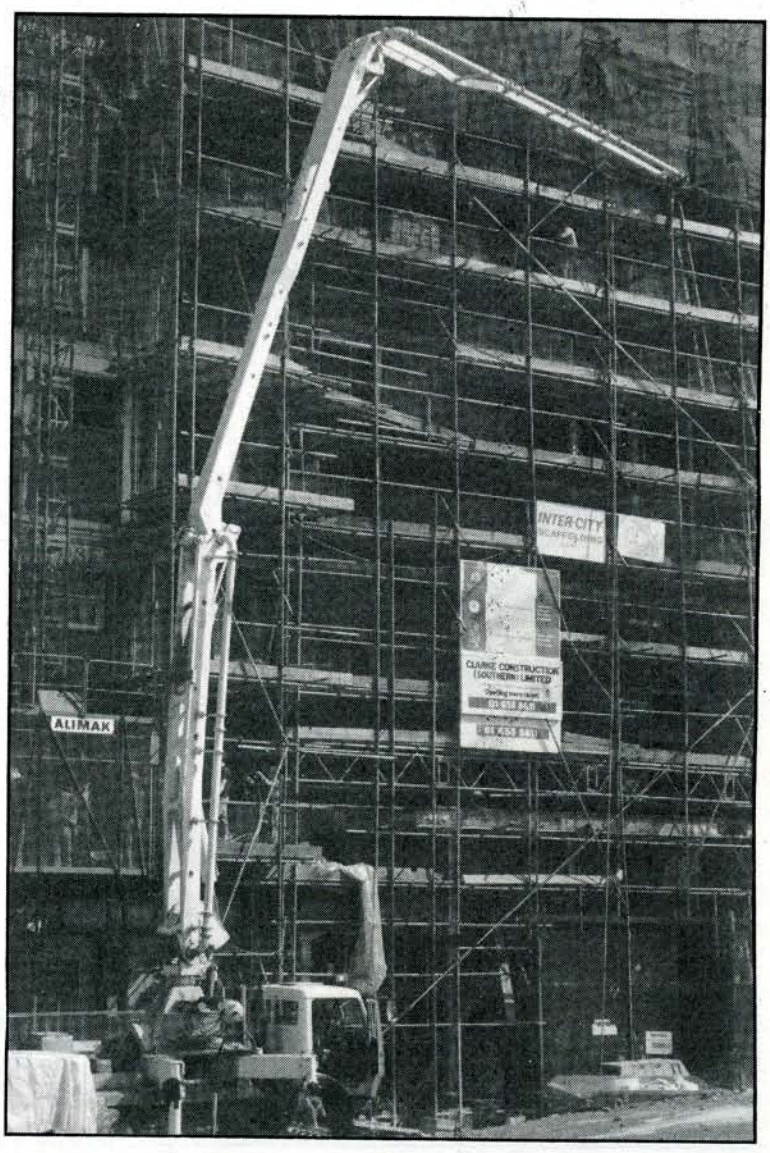
Pumping

Modern concrete pumps are sophisticated and very efficient when compared with earlier models. Almost all the current pump types consist of hydraulic double action mechanisms and these are well suited for pumping LWC. Another type of mechanism is the peristaltic or 'squeeze' pump and these are also effective for LWC.

At every instance when pumping is being contemplated, the following guidelines are useful **for heights up to 40m and total line length of, say, 150m (see Figure 5):**

- One 50kg bag of cement should be mixed to form a grout for each 30m of line and 3m should be allowed for every right angle bend in the pipeline. NB: Use 25ltr of water per bag to get a 0.5 water/cement ratio
- A minimum line diameter of 100mm is recommended
- Pipework should be clean and free from any build-up of hardened concrete
- Use pipework with a flush internal surface
- Reduce the number of bends to a minimum
- At greater heights and distances, do not use a short 125mm by 100mm reducer a long way from the pump

Figure 5: Lightweight concrete being pumped into a building to form structural floors



- Avoid excessive lengths of rubber pipeline.

For heights up to 60m and total line length of, say, 200m:

- Increase minimum pipe diameter to 125mm
- Do not use the boom of the concrete pump, thus eliminating at least 10 No short radius bends
- Use a higher pressure pump with an adequately powered engine and positive sealing to the changeover valve, eg, elephant, rock valve, S valves
- Use a long radius bend at the bottom and top of any vertical risers, (see Figure 6)
- Increase the allowable workability, subject to sufficient site cube results showing an adequate strength margin
- If necessary, consider an increase in admixture dosage or the use of pfa as a further pump aid.

To date, LWC has not been pumped for heights over 60m. **The following items should be considered if pumping to a greater height is necessary:**

- Use line diameter over 125mm and a system of airtight jointing between each pipe
- Use a powerful pump with smaller main pistons; output may be reduced but higher pressures can be tolerated without excessive friction caused by reducers soon after the valve mechanism
- Use a supplementary gate valve between the pump and vertical riser to eliminate back pressure when not pumping
- Consider the use of pumps in tandem for heights well over 60m.

With one ready mix vehicle discharging into the pump at any time a typical rate of placing would be 20–25m³/hour, but faster rates can be achieved if more than one vehicle can be positioned at the pump hopper.

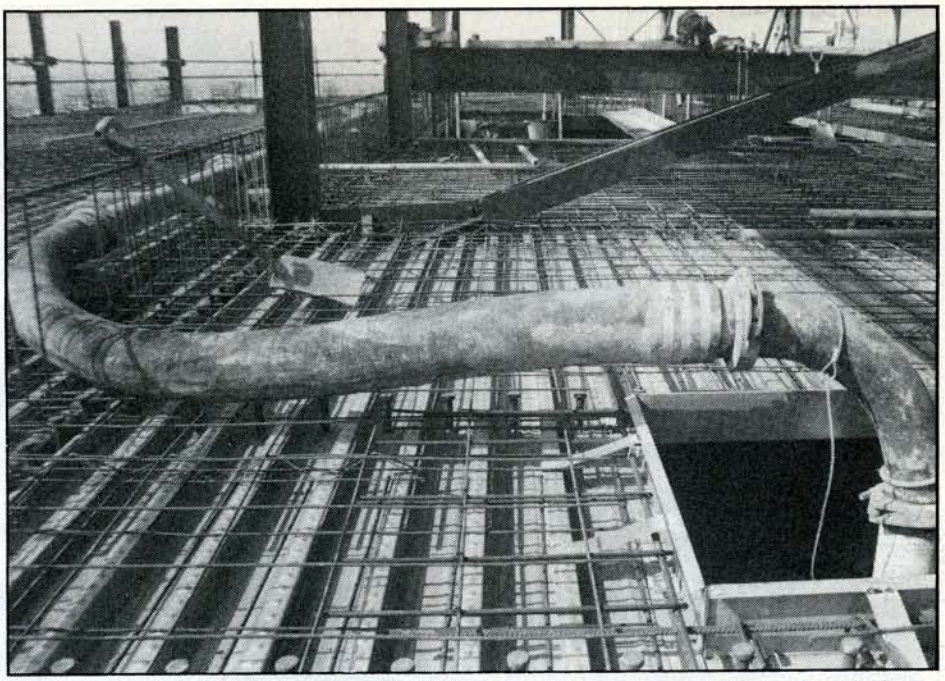


Figure 6: A long radius bend, as shown, should be used at the top and bottom of vertical risers

Compacting and finishing

The concrete should be vibrated as for normal concrete, and if a smooth finish is required a second pass will be necessary a little time after placing. Power floating and vacuum dewatering can be carried out using normal methods. Although the self curing properties of LWC may be advantageous, curing should be employed as for normal concrete. □