Project Briefing

The project consists of 8 cylindrical digester tanks which were redundant. Foam concrete was used to infill the cone inside the tanks to a specific depth as required by the client. Once the cone was infilled the tanks were then demolished. Each tank base was filled in four lifts of 150 m³ equating to a placed volume of 600 m³, however 3 tanks required extra volume as they needed the floor to be higher than the rest the volume of these were around 1000 m³ each.

Since the lifts were of equal volume, each lift was thinner than the previous, as the cross sectional area of the cone increased. The maximum placing time for each 150 m³ pour was 4 hours. This had to be completed prior to the initial set taking place. Also the fresh foam concrete had to be kept to a depth as such that the hydrostatic pressure did not cause collapse of the cellular structure of the foam concrete at the bottom of the lift. It was apparent that during the placement the initial set was being accelerated by the residual heat of hydration from the layers below.

Accesses to inside the tanks were limited via 2 x 1 metre square holes for discharging the foam concrete. This was due to safety restrictions owing to the poor condition of the tank’s roof and the danger of falling debris. The discharge pipeline was lowered in to the tank and laid on the floor, pumping distance from the foam concrete pump varied from a few meters up to 200 linear meters.
The Site

Pictures below show access of the discharge pipelines, together with a picture of 4 of the 8 tanks that required infilling.

Figure 1 - Access to the Internals

Figure 2 - The Large Tanks
The Equipment Used
For this project FCL used 2 cement silos and our 10 meter long computerised batching plant. This was fed via cement tankers supplying a 70/30 mix of cement and pulverised fuel ash supplied in 30 ton deliveries supplying 4-5 loads daily at specific times throughout the day.

Access was very tight between the digester tanks for setting up the equipment.
Pictures of the Material inside the digester tank.

The above picture shows the first foam concrete pour into the cone of the digester tank.
Figure 5 - Foam Concrete mid-flow

Figure 6 - Settling Nicely, Self-levelling
Figure 7 - Temperature Probes were deployed during the pour.

Whilst completing this project we asked Thameside Test and Research Limited to monitor the temperature of the foam concrete within the cones.

We have attached the results of this test.

Foam Concrete Ltd

We have expertise and plenty of experience working in challenging environments, where our competitors would struggle to pump the volume, mix design or distances. Please contact Lynton Cox, who will be able to advise you on the best approach for your next project, references are available on request for this or any project that we have featured on our web site.
Introduction

As part of the refurbishment of Beckton Sewerage Treatment Works at Barking in Essex, Foam Concrete Ltd were commissioned by Temesis to install a low density foamed concrete fill in the bases of eight cylindrical concrete tanks to provide a suitable and stable working platform in each.

The base of each tank formed an inverted cone and was filled to a depth of approximately three metres with a low density foamed concrete of 700 kg/m³ containing 315 kg/m³ cement and 135 kg/m³ (30%) pulverised fuel ash (PFA) to give a minimum compressive strength of 1.5 MPa at 28 days. Each tank base was filled in four lifts of 150 cubic metres, placed over consecutive days. Since the lifts were of equal volume, each lift was thinner than the previous, as the cross sectional area of the cone increased.

It was important to limit the volume of each placement of foamed concrete since:

- each placement had to be completed before initial set occurred.
- the overburden of fresh concrete had to be kept to a depth such that the hydrostatic pressure did not cause collapse of the cellular structure of the foamed concrete at the bottom of the lift.

It became apparent during placement that the initial set was being accelerated by the residual heat of hydration from the layer below.

Thameside Test & Research Limited was commissioned to install temperature monitoring sensors in each lift to quantify the generation of heat after placement and while subsequent lifts were placed.

Figure 1 - Schematic of foamed concrete placement in a typical tank
Temperature monitoring

Access to the interior of the tanks was limited to two holes each approximately one metre square, one of which was utilised to pump the foamed concrete into the tank leaving the other through which the temperature sensors could be placed. Due safety restrictions owing to the poor condition of the tank’s roof and the danger of falling debris, the thermocouples had to be placed by launching them through the hole from outside the tank; this together with the fallen steelwork inside the tank, made accurate placement impossible. However placement of one thermocouple near the centre of each of Lifts 2, 3 and 4 and one thermocouple near the edge of each of Lifts 3 and 4 was achieved.

Each thermocouple was monitored continuously and readings recorded at 30 minute intervals on a data logging device installed outside the tank. Temperature monitoring was carried out from 19th to 22nd April 2013.

Recorded temperatures

The thermocouple installed in Lift 2 recorded a 45ºC rise in temperature over 16 hours after placement, peaking at 65ºC. The most rapid rate of gain in temperature, 5ºC per hour, being recorded between 6 and 10 hours after placement, after which the heating levelled off and the temperature began to fall after 20 hours. This coincided with the placement of Lift 3.

Sensors installed in Lift 3 recorded a rapid rate of gain in temperature, recorded at 10ºC per hour during the first 5 hours after placement. Lift 3 eventually experienced an 80ºC rise in temperature after placement, peaking at 91ºC at 16 hours, and the material began to lose heat after 18 hours.

Sensors installed in Lift 4 recorded similar rates of gain in temperature and peak values as those recorded for Lift 3.

Temperature monitoring was stopped seventy hours from the time of placement of Lift 2 due to the site having to be cleared of plant by this time. Results of the temperature monitoring against time are presented graphically at Figure 4.


**Observations**

It can be observed from the temperature plots that there is a levelling off of gain in temperature or a small drop in temperature at about two hours after placement which would be coincident with the initial set of the concrete, thereafter the temperature increase steadily to the maximum.

It was noted that coincident with the beginning of the drop in temperature of the foamed concrete in Lift 3, the sensor in lift 2 recorded a small, 3°C, gain as the heat from the overlying material permeated to the lower layer. The temperature differential between the two lifts being 35°C at that time. A similar gain in temperature was recorded by the sensors in Lift 3 after placement of Lift 4.
The higher rates of gain in temperature and higher peak temperature values recorded in Lifts 3 and 4 can be attributed to these lifts being supported over almost their entire area by previously placed foamed concrete, therefore each gained heat from, and were insulated by, the underlying material.

The temperature of Lift 4 dropped below that of the underlying lift at approximately 20 hours after placement since this material could continue to shed heat from its top surface, while the lower layers were heated and insulated by the subsequently placed materials.

A timeline of events is presented at Table 1.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Timeline sequence of events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (hours)</td>
<td>Event</td>
</tr>
<tr>
<td>$T_0$</td>
<td>Lift 2 placed, monitoring commenced</td>
</tr>
<tr>
<td>$T_{16}$</td>
<td>Maximum temperature recorded in Lift 2</td>
</tr>
<tr>
<td>$T_{20}$</td>
<td>Lift 2 begins to loose heat</td>
</tr>
<tr>
<td>$T_{22}$</td>
<td>Lift 3 placed</td>
</tr>
<tr>
<td>$T_{38}$</td>
<td>Maximum temperature recorded in Lift 3</td>
</tr>
<tr>
<td>$T_{40}$</td>
<td>Lift 3 begins to lose heat</td>
</tr>
<tr>
<td>$T_{41}$</td>
<td>Lift 2 shows heat gain from overlying material</td>
</tr>
<tr>
<td>$T_{42}$</td>
<td>Lift 4 placed</td>
</tr>
<tr>
<td>$T_{55}$</td>
<td>Maximum temperature recorded in Lift 4</td>
</tr>
<tr>
<td>$T_{55}$</td>
<td>Lift 3 shows heat gain from overlying material</td>
</tr>
<tr>
<td>$T_{56}$</td>
<td>Lift 4 begins to lose heat</td>
</tr>
<tr>
<td>$T_{62}$</td>
<td>Temperature in Lift 4 falls below that of Lift 3</td>
</tr>
<tr>
<td>$T_{70}$</td>
<td>Monitoring stopped</td>
</tr>
</tbody>
</table>

**Discussion**

High temperature curing of conventional dense concretes can result in high early strengths at the expense of later age strength due to the formation of sub-optimal structures in the hydrated products. Cellular concrete products, either chemically aerated or foamed, are often steam cured at 70°C or autoclaved at 120°C during production and do not suffer from this early / long term strength crossover.
During steam curing of cellular concrete products, the temperature is raised to 70°C between two and four hours after placement, maintained for a further four hours and dropped to ambient over a further two hours. The rate of gain in temperature within the body of the foamed concrete placed on site was somewhat slower, at approximately 70°C over ten hours. The thermal stresses in the foamed concrete would therefore be of lesser magnitude both during the heating and cooling phases and should be easily accommodated in this low modulus material.

The high temperature curing would also benefit the hydration of the pulverised fuel ash (PFA) addition in the mixture since this requires a high energy input to initialise the pozzolanic reaction. The hydration of the PFA would result in some further gain in early / mid term strength.

The effect of the gain in early strength due both to the high temperature curing and the initialisation of the hydration of the PFA would not be reflected in compressive strengths attained by test cubes taken at the time of placement and cured at 20°C.