Early concrete strength to cut capital congestion

By Dr Chris A Clear, technical director of the British Ready-Mixed Concrete Association (BRMCA)

The Mayor of London and Transport for London (TfL) have introduced a targeted lane rental scheme that allows TfL to charge companies a daily fee for undertaking roadworks on London's busiest roads at the busiest times. This scheme should encourage more efficient working and reduce disruption from roadworks.

One way to help minimise the amount of time that works disrupt traffic is to clarify the early age strength requirement of concretes, and other cement bound materials, used for the reinstatement of openings in highways. This was an aim of a project funded by the Department for Transport (DfT) and Transport for London (TfL) entitled 'Reducing Congestion from Highway Works'.

It is up to highway owners and their designers to specify the compressive strength class of concrete or other cement bound material required for reinstatement. Using HD 27/04[1] it is possible to determine the minimum cube strength required from the reinstatement material to open the highway to traffic, as shown in Table 1.

Table 1: Minimum strength of reinstatement materials required for opening the highway to traffic

Reinstatement material	Compressive strength class* 7 day	28 day	Minimum cube strength for opening traffic**, N/mm sq	Target laboratory cube strength at opening, N/mm sq
Concrete	-	C32/40	25	32
	-	C20/25	20	25
Concrete or Cement Bound Granular Material (CBGM) B	-	C16/20	15	19
	-	C12/15	10	13
Foamed concrete	-	C8/10	7	9
	-	C5/6	4	6
	C3/4	-	2.8	3.6
	C1.5/2	-	1.4	1.8

* Strength class minimum characteristic cylinder/cube strength
** Based on values given in HD 27/04

Reducing the curing period

One of the most frequently used materials for highway reinstatement is a C16/20 concrete or CBGM B concrete as a base layer in a composite road. This material is usually subject to a 'deemed to satisfy' curing period of seven days before trafficking, and this is where there is scope to reduce the time the highway is closed for reinstatement.

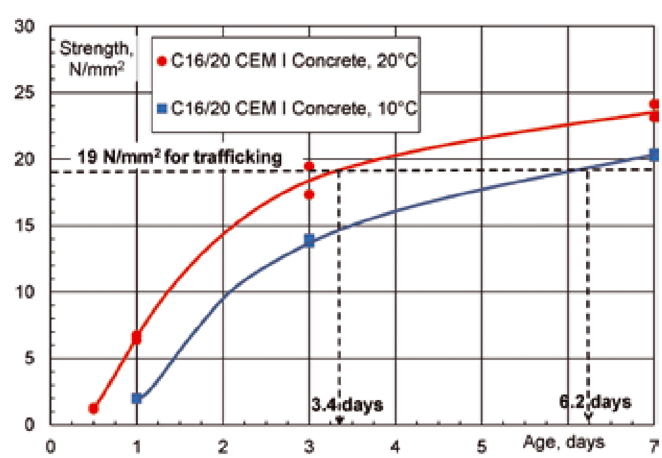
From Table 1 the minimum cube strength required for a C16/20 before trafficking is 15 N/mm sq, deemed equivalent to a 19 N/mm sq measured on laboratory cured cubes. Figure 1 shows the relationship between compressive cube strength of laboratory cured specimens of a C16/20 CEM I concrete or CBGM B with age, at both 20 deg C and 10 deg C. The 28-day target mean strength for a C16/20 is around 30 N/mm sq, where with CEM I as the binder the 7-day strength is expected to be 24 N/mm sq. That is around 80 per cent of the 28-day strength. Where a cement is used that includes 30 per cent fly ash or 50 per cent ggbs only around 70 per cent of the 28-day strength is normally achieved. Using the 20 deg C line from Figure 1 it is evident that a C16/20 only requires up to 3.5 days to reach the required strength, and only where the curing temperature is reduced to 10 deg C does the time required increase to just over six days.

At a depth of around 1.2 m the ground temperature is typically from a minimum 4 deg C in March to a maximum of 17 deg C in September[2]. Therefore, 10 deg C is a reasonable estimate for unfavourable conditions, accepting that as cement bound materials generate heat on hydration they will be warmer than the surrounding ground temperature. It may be argued that a seven-day curing period for reinstatement material is safe and is useful guidance for where there is no urgency. Where it is important to re-open the highway, to reduce congestion and save cost, then there is potential to reduce the curing period to that required to achieve the necessary in-situ strength. As shown in the Figure 1 example the curing time could be reduced to less than four days for CEM I C16/20 under favourable conditions.

A practical solution is for the reinstatement contractor to adopt in-situ testing to demonstrate that the required strength has been achieved, rather than just accept overly conservative deemed to satisfy rules for curing time.

For further information see www.trl.co.uk/reducingcongestionfromhighwayworks/

Figure 1: Relationship between strength of C16/20 CEM I concrete and



References

1 THE HIGHWAYS AGENCY. Design manual for roads and bridges. Volume 7 Pavement design and maintenance. Section 2 Pavement design and construction. Part 4. HD27/04 Pavement construction methods. February 2004.

2 METEOROLOGICAL OFFICE. Averages of earth temperature at depths of 30 cm and 122 cm for the United Kingdom 1931-1960. Report MO 794. London, The Stationery Office, 1968.

Post-Tensioned Concrete

Material efficiency and structural performance

Ben Ume, Chairman of the Post-Tensioning Association (PTA)

The practice of post-tensioning (PT) allows the full utilisation of the high compressive strength of concrete. A prestress force is applied to a concrete member using high strength steel strand and specialised anchorage assemblies. The strand is profiled through the concrete slab and counteracts a portion of the applied loads to give an extremely efficient structure.

Post-tensioning involves stressing the tendons after the concrete has been placed and cured. The tendons are cast into ducts or sleeves to allow the strand to slide through the hardened concrete and corrosion protection is normally provided by injecting cement grout or grease. Post-tensioning is used in bridges, floor slabs, silos and many other forms of construction. It can bring significant benefits in terms of economy, construction programme, structural performance and reduction in material usage.

Material efficiency: achieving thinner floor slabs

Post-tensioning has the minimum structural thickness of any floor system. The reduced slab thickness reduces the amounts of concrete and reinforcement required, generating important cost and material savings.

Achieving thinner slabs maximises floor to ceiling height and can even create additional floors within the same building height. Additional savings can be made on the costs of cladding and services.

Minimising the structural thickness of the floor slabs also lowers the self weight of the building, which in turn reduces foundation loadings and yields smaller foundations, further lowering material costs.

Flexibility and adaption: achieving longer spans

Post-tensioned concrete can span further than reinforced concrete and competes economically with steel structures. The longer spans that can be achieved by post-tensioning reduce the number of columns required and give greater layout flexibility and more expansive interiors.

Post-tensioned concrete during construction, Whitmore School, Harrow

Bournville College, part of the redevelopment of the former MG Rover site at Longbridge

As well as affording greater flexibility of internal layout, post-tensioned slabs are able to follow irregular column grids and curves and cope with the complex geometry incorporated within many ambitious structures today.

Flexibility also extends to the ability to carry out future modifications to the slabs. Whether for change of use or to accommodate unforeseen requirements, the creation of penetrations within PT slabs can be carried out easily and safely provided that changes which may affect the existing structure are designed by a competent engineer and carried out by a qualified post-tensioning specialist[1].

Speed of construction

Post-tensioning has a short lead-in time and can be constructed rapidly. Once complete the slabs provide a safe working platform for other trades allowing follow-on trades to commence earlier in the programme.

The reduction in the amount of material required and the subsequent reduced reinforcement congestion, allow the fixing of the systems and the placing of the concrete to be achieved more quickly and easily. Post-tensioning also allows early stripping of formwork, accelerating floor construction.

Significant benefits in the speed of construction make post-tensioning ideally suited to accelerated construction schedules.

Thermal mass and exposed soffits

The reduced cracking of PT slabs makes them ideal for internal fair faced soffits. Surfaces are aesthetically pleasing and offer a durable, low maintenance finish.

The thermal mass properties of concrete, which allow the transfer of heat between the surface of the material and its interior at a rate that matches the daily heating and cooling cycle of the building, are proven and well documented[2]. The exposed soffits of post-tensioned slabs allow full exploitation of the thermal mass properties to help reduce temperature fluctuations, and contribute to savings on heating and costly air-conditioning systems.

Summary

Post-tensioning already leads the way in the US and Australia and the benefits of this solution are now growing in recognition in the UK. With the benefit of material efficiency and consequent cost and carbon savings it is increasingly attractive and with the growth in the number of installers, PT can continue to go from strength to strength bringing benefits to clients, designers and contractors.

[1] PTA Guidance Note GN01: Post-Formed Holes Through Post-Tensioned Slabs, PTA, 2010.

[2] Utilisation of Thermal Mass in Non Residential Buildings, The Concrete Centre, 2007.

Members of the Post-Tensioning Association are directly engaged in the design, manufacturing and/or installing of post-tensioning materials. Visit our website www.post-tensioning.co.uk for a list of members, technical guidance notes and case studies, including the recent winner of the PTA awards.