

The strengths and movements of concrete

by Vic Pannell FICConstM

A brief outline of the origins of mortars and concretes will give an insight into current materials and their correct use. Early concretes and mortars were made mainly from some form of limestone or a naturally occurring mixture of limestone and clay (lias limes).

Non-Hydraulic limes (Pure limes) were made from either quarried limestone or chalk from pits and include:-

Quicklime. (Lump lime) crushed limestone that has been kilned but still has the appearance of broken stone.

Putty Lime Lump lime to which water is added to produce a soft putty like substance after the excess water has drained off. This material has to be kept moist to remain useable.

Hydrated Lime Kilned limestone (lump lime) that has been 'slaked' by adding a precise amount of water to produce a fine powder that

can be bagged and distributed for site or factory use. This is a much more convenient and safer method of transporting and using lime than the putty process. Mortars made with pure limes will not harden in wet conditions and rely on drying out and re-absorbing from the atmosphere the carbon dioxide which was driven off during kilning. Used for repair and maintenance to internal plasterwork in historic buildings.

Hydraulic Limes Limes containing a proportion of clay added before the kilning process. The kilned material is ground to a powder for use on site. The combination of these two chemicals results in a product that

will harden when water is added to it. Hydraulic lime mortars require the presence of water until they are fully hardened and can be used for construction below ground level. Such limes varied in consistency and strength due to the variations in locally obtained raw materials and the lack of quality controls



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available today. This type of lime is still used for construction and repair of stone walling as it has the ability to 'give' somewhat under stress conditions and so reducing the risk of shear cracking. Hydraulic limes are generally graded by strength NHL2, NHL 3.5 and NHL 5.

Types of Cement

The most commonly used cement and the least expensive is Ordinary Portland Cement (OPC) with RHPC, ExRHPC and UHESPC being of similar raw materials but ground to a progressively finer powder resulting in a higher specific surface being presented to the mixing water. This in turn induces a faster chemical action (hardening) varying from 28 days to some 3 days.

Low heat cement hardens in some 3 months and is used for mass concrete works.

White cement has china clay as an ingredient and is used for decorative work in conjunction with selected aggregates but is otherwise considered as OPC.

Masonry Cement is a mixture of OPC and inert materials with a workability aid and is intended for mortar mixes for brickwork and blockwork but not for concrete mixes.

Hydrophobic Cement OPC with a quantity of calcium stearate added during manufacture. This has the effect of resisting moisture penetrating the cement particles during storage of bagged cement when good storage conditions are not available.

High Alumina Cement (HAC) This is not a Portland cement and is made by a different process. It must not be mixed with other cements, as this will cause 'flash setting' with eventual decomposition of the mass. It has a high heat of evolution and is best suited for comparatively slender units that are not intended for use in a warm humid position. HAC



has a comparatively slow setting time but hardens in 24 hours.

Note that some of these cements are not available off the shelf and may only be produced if a substantial production run was involved.

Movements in Concrete

Concrete is subject to various movements within its mass during and after the hardening period. The main movements are due to:-

- 1 Temperature change.
- 2 Changes in moisture content.
- 3 Stresses and strains imposed upon it, (Compression Tension and shear).

Thermal Movement

The temperature of freshly mixed concrete increases as the hardening process progresses and decreases towards its end (Heat of Hydration). The rate of temperature rise in Portland cements is dependent upon the size of the cement particles. The finer the cement powder the more rapid the heat gain and the shorter the hardening period.

Newly placed concrete hardens in a warm, or even hot state and on cooling is susceptible to internal fissuring with a resulting risk of weakness. The greater the mass of concrete the greater the risk of

internal fissuring. Therefore the more rapid the hardening of the cement the smaller the unit that can be cast at one time. When high alumina cement is used it may be necessary, on occasions, to use water cooling to prevent the heat of hydration from drying the concrete before it is fully hardened.

Mass concrete such as bulk foundations or river dams etc. present difficulty in dissipation of heat during hydration so the use of Low Heat cement would be expected, as would be a larger coarse aggregate with a maximum size of 100mm. On occasions large pieces of suitable rock up to 600mm may also be included during placing to reduce internal heat generation.

The Expansion Factor of concrete and steel is somewhat similar so there is little risk of rupture of bond between concrete and steel due to temperature change.

The thermal movement of hardened concrete is dependent upon the temperature to which it is subjected. Natural, as well as man made heat can cause variations in the temperature within a hardened concrete and this will cause the concrete to expand and contract in relation to these temperature changes,

Unless consideration is given to suitable joints to allow these

movements to take place, rupture will occur.

There is a particular problem when concrete road, or similar, slabs are constructed as in these instances the surface is subjected to considerable temperature changes whilst the underside is less so.

Moisture movement

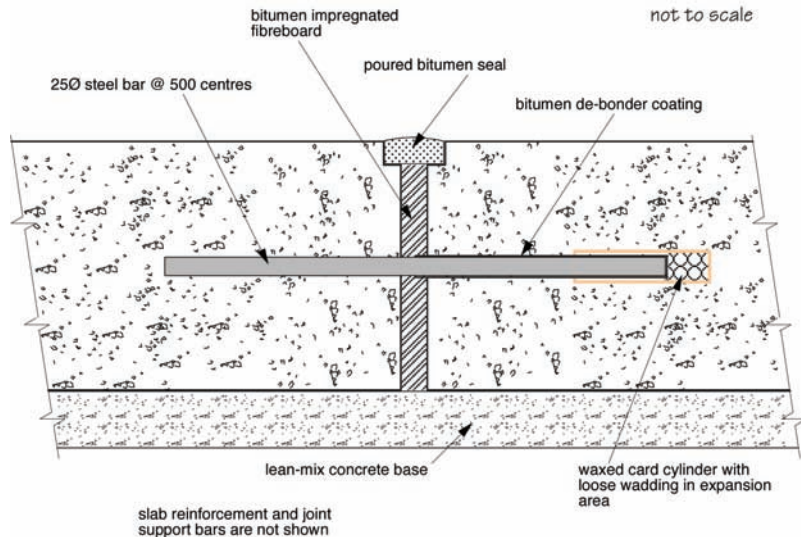
Moisture is usually the most important cause of movement within concrete and the two main points to consider are:-

- 1 The movement caused by the concrete drying out (drying shrinkage.)
- 2 That which takes place at future wetting and drying periods.

Whilst water is necessary to mix and harden the concrete, an excess will cause a rapid loss of ultimate strength.

The minimum amount of water required to allow complete hydration (hardening) of the cement is 35 litres to every 100kg OPC cement. **A water cement ratio of 0.35.** A mix using this amount would be almost impossible to fully compact, leaving air voids and therefore weakness. Many factors are used to determine the amount of water to be added to a mix but an example of Mix Design is too lengthy to explain here. However, the following gives an indication of the points that have to be considered.

- 1 The grading of fine, medium and coarse aggregates.
- 2 The proportions of fine, medium and coarse aggregates.
- 3 The amount of water already in the aggregates.
- 4 The amount of water required to allow full compaction of the concrete, (consider the method of compaction).
- 5 The specified strength of the concrete.
- 6 The use of any admixtures.
- 7 Calculate the amount of cement and water to be added to the mix.



Concrete compacted by the best means possible will still contain some 3-5% air voids. This could result in a loss of some 30% compressive strength.

- 8 Calculate the quantities for the batch size for the mixer used.

If the mix design has been carried out correctly the true balance between air voids and strength will be reached. For pre-stressed and structural concrete, water/cement ratios of some 0.45 and 0.55 respectively maybe expected.

One of the tasks most susceptible to moisture loss is that of road or other large slab construction where a relatively large surface area is presented to the drying effects of the sun and wind.

The top surface dries quickly and in doing so, shrinks to some extent. whilst the lower depths dry more slowly and tension is set up within the slab. Cracking will occur on the top surface because the concrete is still too weak to resist it. These cracks occur in a squared pattern and are known as 'dicing'; they will penetrate into the depth of the slab, reducing its 'effective depth' and allowing salt laden surface water to attack the reinforcing steel.

Two methods are used to reduce, if not irradiate, this 'initial shrinkage.

- 1 Spray the surface with wax or plastic emulsion to prevent moisture loss to the atmosphere. No traffic or movement should be allowed on the surface until it is cured.
- 2 Lay light reinforcement mesh some 30mm below surface during construction.

Where two road slabs meet expansion and contraction joints are used to accommodate both initial and subsequent wetting and drying cycles, the thermal movement and the transfer of traffic loading from one slab to another. These joints must be watertight.

FACTOR OF EXPANSION.

Thermal 0.000005 Per degree F
Equivalent to 5mm per kilometre per degree F.

Assume the temperature of a concrete road slab ranging from -10 to +70 °F, the expansion would be $80 \times 5 = 400\text{mm}$ per km or 25 inches per mile.

FACTOR OF EXPANSION.

Moisture 0.0003 Equivalent to 0.3mm per metre = 300mm per km or 19 inches per mile, including initial shrinkage. Moisture i.e. rain, causes expansion of a dry slab but may also have a cooling effect; so it can be seen that there is often a balancing effect.

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Site organisation

- Machine to lay 36ft (6.8m) width and 0.3m thick progresses 1m per minute.
- Concrete required ≈ approximately 2m³ per minute
- A 6m³ flatbet steel lorry must unload and clear in 3 minutes.

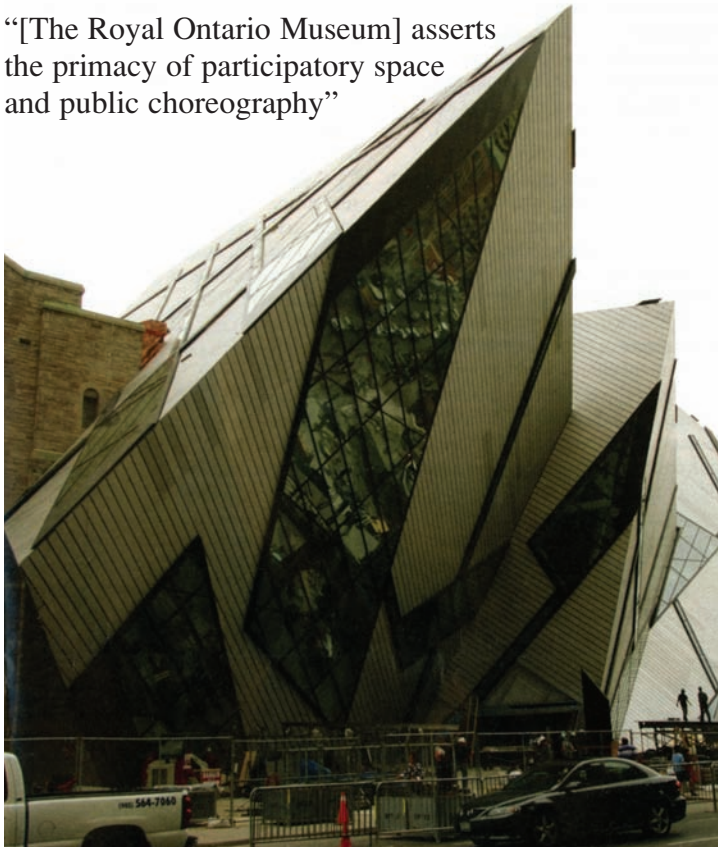
Consider:

1. Site access to deliver and store aggregates.
2. Number and position of cement silos and water storage supply
3. Concrete delivery lorries access to road laying machine that may be a few miles from mixing plant.

Constant regular delivery to the laying is essential. A supply breakdown could result in removing placed concrete back to a previous joint. The whole production system would be halted and financial problems due to wasted labour time and materials would occur.

CAN I QUOTE YOU ON THAT?

“[The Royal Ontario Museum] asserts the primacy of participatory space and public choreography”



The Royal Ontario Museum opened its doors over three years ago but still echoing round the corridors is the architect’s explanation of the shape to a stunned local population.

*Design by Daniel Libeskind,
Co-design Bregman & Homann*

Ed.

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Diary dates

*Note: All but two of the events listed are for Southern Region. If you want your events included please send written details to the editor.
Note: all Southern Region lectures are CPD accredited and certificates will be issued. Food is made available following each lecture. The lectures are held at The Mountbatten Centre Alexandra Park Portsmouth 7.45pm for 8.00pm. Contact Eric Richards 02392 618049*

January 2011

- 12 Securistyle 2 – Ventilation and Sustainability
- 31 **South West Region** AGM – 7.30pm Stephens Dance Centre

February 2011

- 5 51st Annual Dinner and Dance
The Royal Beach Hotel, Southsea
- 9 SIG Roofing – Working at Height

March 2011

- 9 Annual General Meeting
- 14 **South West Region** CPD Seminar – Improving energy efficiency with spray foam. 7.30pm Stephens Dance Centre. Free buffet

April 2011

- 13 Forticrete – Designing Architectural Masonry (Prov.)
- 22 Skittles Evening – HMS Dryad Golf Club, Southwick

May 2010

- 11 Joint Meeting ICM/CIOB

VIEWPOINT is the newsletter of the Institute of Construction Management (ICM) and is for circulation to the members of the Institute. Articles or comments for inclusion are very welcome and in any form.

The editor is Clive Feather who can be contacted at:
email: cfd@barnhousestudio.co.uk

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Viewpoint

the someday supplement

On yer bike you pirates



BSA will probably have a number of our members thinking of motorbikes, although it is to be remembered that the initials come originally from the firm - Birmingham Small Arms: suppliers of the Lewis Gun for the first world war. BSA nowadays still has the capacity to evoke fear in certain quarters, as they are the initials of the Business Software Alliance. The BSA has recently been involved in an exercise to detect pirate copies and illegal use of computer software programmes, which they allege is costing the software developers nearly £150 million each year. Research has shown that one in five software packages in use is illegal and successful prosecutions have been brought and out of court settlement made. If you are using unlicensed/copied software you should take steps to rectify the situation: you should bear in mind that other operators may have installed pirated software on your computer/s without your knowledge, so a regular software audit is recommended: remember that if anyone shoots off an email containing illegal software from

your computer, you are immediately at risk. In a recent out of court settlement, the London based architectural firm Architype parted with £10,000 to avoid legal action – this alone should make you think twice.

Ed.



Southern Region 51st Annual Dinner & Dance

Royal Beach
Hotel, Southsea
Saturday 5th
February 2011

The 2011 Caravan and B&B Rally



Will be at Dartmouth South Devon Camping and Caravanning site near Dartmouth.

Those that have contacted me are now booked in.

A river trip for Saturday and barbecue and Sunday Brunch and walk along Slapton sands, and Dartmouth.

Those staying at B&B plenty of places near by, but you may need to book soon, as the Summer weather is hot and sunny, so everyone will want to holiday.

Mike & Dorothy Bishop – 01962 713000

Trip to the track



ICM members took to the road driving in September for an afternoon visit to the new Formula One Pits & Paddock complex at Silverstone.

An informative time was spent, initially with a briefing on the project in the site offices always more enjoyable with a splendid buffet lunch provided by Buckingham Group Contracting Ltd., followed by a tour of this high profile scheme.

Earlier this year Buckingham Group had been involved in providing major track improvements and extensive construction of a new hardened run-off area specifically for the British Moto GP: all in a 12-week period.

Last winter work also commenced on the provision of a new pit lane and paddock complex, sited between Club Corner and Abbey.

At ground floor level the paddock area has provision for 41 team garages along its 360m steel framed structure. On the upper floor we saw the formation of hospitality suites with external balconies able to host 4,000 people, a media centre and a race control box sited under a super gull-wing shaped roof.

The roof is monolithic with a

seamless liquid roofing application. The open plan power-floated mezzanine floors offer the client, Silverstone Holdings, opportunities and flexibility in being able to convert areas of various functions, exhibitions, displays and VIPs: The quality of floor finish was excellent.

At the time of the visit the 1,200 tonne steel frame had recently been completed with curtain walling in progress.

Clive Bailie, Buckingham Project Manager, explained the

restriction imposed of a 2-week close down prior to the British Grand Prix in July when a contractor's presence was not desirable. He also outlined the co-operation, planning and communication undertaken with the client on day-to-day deliveries and logistics of carrying out the work within the circuit and having to cross the track which, surprisingly, is in use full time throughout the year.

Work is on target for its Spring 2011 completion when the starting grid and finishing line will be moved in front of the new structure from their current position on the other side of the track in preparation for the British Grand Prix next year.

Members who attended offer their thanks to Adrian Stammers, Health & Safety Manager of Buckingham Group who organised the trip on our behalf and to Clive Bailie, Project Manager who through their enthusiasm and commitment gave us a very interesting day on a well run, organised, tidy and safe project.

Gary Francis, FICConstM

