Abrasion – a key durability issue

Rudolph Kotzé, CCANZ's Technical Manager, tackles the common and not-so-common problems faced by concrete construction project teams on and off the site. Send your curly questions to us by fax on (04) 499 7760, email:lorraine@cca.org.nz, or by letter to CCANZ,P O Box 448, Wellington.

Abrasion – a key durability issue for industrial concrete floor slabs

The design and specification of industrial concrete floor slabs must take both strength and serviceability requirements into account. Especially where high performance floors are required, it is not sufficient to only specify concrete compressive strength as the main criteria.

A number of factors influence the durability or wearing resistance of concrete floor surfaces. For industrial floors,however, abrasion resistance is a key durability consideration. This depends on the environment the pavement will be operating under, corrosion of steel reinforcement, freeze-thaw and any possible chemical attack.

Strengthening resistance

Abrasion (wear) resistance is achieved by controlling a series of factors. The specified concrete strength must be complemented by proper construction practices. These include placing techniques, compaction, finishing and curing. Where very high abrasion resistance is required, special aggregates or dry-shake surface treatments may be needed. Toppings are available for specialist applications.

The relevant NZ Standard,NZS 3101:1995,uses strength as the primary parameter for specifying for abrasion. Reference is also made in the Standard to curing and finishing, in which case NZS 3109 and NZS 3114 should be consulted. The performance of a slab, as far as serviceability is concerned, is determined by the nature of the loading as well as products that could attack the concrete surface. Shrinkage of the concrete also needs to be carefully considered through the design and detailing of joints in the slab.

Purpose-built design

The designer needs to consider the total environment under which the slab will operate when specifying and designing the concrete. This includes:

Designing for strength

- Concrete compressive and tensile strength
- Reinforcing requirements
- Loads (both static and moving)

Designing for serviceability

- Loads (regular, including types of vehicles and wheels that will probably be operating on the slab)
- Shrinkage and temperature effects (such as movement joints)
- Abrasion (wearing) resistance.

CCANZ has recently published the Guide to Concrete Construction as well as Concrete Ground Floors & Pavements for Commercial and Industrial use, which address the design, construction and specification of concrete floor slabs in detail.

Key issues

Strength specification

It is important to recognise that Standards specify minimum requirements and that designers should consider that there may be a need to specify higher strengths than the minimum requirements of the Standards.

Minimum concrete strength for abrasion resistance

Member and type oftraffic	Minimum characteristic strength, fc(MPa)
Floors in commercial areas subject only to pedestrian and/or light trolley traffic	25
Floors subject only to light pneumatic-tyred traffic (vehicles < 3 t gross)	25
Floors in warehouse and factories subject to medium or heavy:	
• pneumatic-tyred traffic (vehicles > 3 t gross)	30
• non-pneumatic-tyred traffic	40
• steel-wheeled traffic	40 (to be assessed)

Finishing

Many of the problems associated with the performance of concrete pavements are caused by poor finishing procedures. During the compacting, levelling and power floating of a slab, a layer of cement-rich mortar is brought to the surface. This surface laitance can become too thick through excessive working of the over-wet concrete. Where this condition occurs the surface laitance will wear rapidly, possibly crazing (map cracking), and dust badly.

The use of fully compacted,low-slump concrete followed by the floating and trowelling operations at the correct times, will avoid the formation of the excessively thick laitance, and result in a durable pavement surface.

Floating and trowelling

Generally, floating and trowelling for large pavement areas,are carried out using power equipment. A power-trowelled pavement finish is obtained in two ways:

Recommended surface finishes

Typical Applications	Anticipated traffic	Exposure/service conditions	Finish
Office and administration areas,laboratories	Pedestrian or light trolleys	Pavements to receive carpet, tiles,parquetry, etc	Steel float
		Pavements with skid resistant requirements	Wooden float or Broomed/typed (light texture)
Light to medium industrial premises,light engineering workshops,stores warehouses or garages	Light to heavy forklift trucks or other industrial vehicles with pneumatic tyres	Smooth pavements	Steel trowel
		Dry pavements with skid resistant requirements	Steel trowel (carborundum dust or silicon carbide incorporated into concrete surface)
		Wet and external pavement areas	Broomed/typed hessian drag (light to medium texture)
Sloping pavements or ramps or high-speed-traffic areas			Broomed/typed (coarse texture) or grooved
Heavy industrial premises, heavy engineering works, repair work-shops,stores and warehouses	Heavy solid wheeled vehicles or steel-wheeled trolleys	Pavements subject to severe abrasion	Steel trowel/burnished finish (use of special aggregate monolithic toppings)

Stage 1:

Power-floating the stiffened concrete to even out any slight irregularities left by the vibrating beam.A power float is a machine with large horizontal steel rotating blades, used for the initial operations only. This operation does not (or should not) close or seal the concrete surface, so moisture is allowed to escape and not be trapped under the surface.

Stage 2:

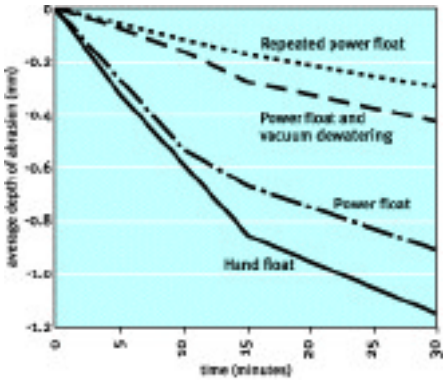
Power-trowelling is done to close the surface, making it smooth and dense. The power trowel is the same or a similar machine to a power float but fitted with small individual steel trowel blades that can be progressively tilted during trowelling operations. Depending on the use of the floor slab, two or even three passes of power trowelling may be needed or specified. This will ensure a very dense and smooth surface with high abrasion resistance. Designers need to be aware that this surface will invariably become very slippery if it is wet and requirements for slip-resistance and abrasion resistance will need to be balanced.

Recommended surface finishes

The table above provides designers with guidelines on types of finishes for typical applications.

Research on the affect of finishing on abrasion resistance is summarised in the figure below, taken from CCANZ Technical Report 08: 1994 "The Abrasion Resistance of Industrial Concrete Floor Slabs".

Affects of finishing on abrasion resistance



In short

In order to achieve durable concrete pavements, specifically high performance industrial floors, abrasion resistance is a major factor in ensuring a long service life. Specifying only concrete strength is not enough and designers must consider all factors that influence the overall long-term performance of these slabs.

For further technical information, or to purchase any of the publications mentioned, please contact the CCANZ or email library@cca.org.nz