Abrasion Resistance

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 New Zealand Standard, NZS 3101, 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.

Strength Specification

Traditionally when additional abrasion resistance is required, it has been normal to specify an increased concrete compressive strength. Refer ***Figure 1***.

Research has shown that with decreasing water cement ratios (increasing compressive strength) the abrasion resistance of the concrete surface increases.

An advantage of using compressive strength as a tool for getting improved abrasion resistance is that generally there is a high degree of confidence that you get what you have asked for. There is a good degree of quality control and testing to ensure that the compressive strength specified is that delivered.

Figure 1

Minimum concrete strength for abrasion resistance

Member and type of traffic	Minimum characteristic Strength, f'c (MPa)
Floors in commercial areas subject only to pedestrian and/or light trolley traffic	25
Floors subject only to light pneumatic-tyred traffic (vehicles < 3t gross)	25
Floors in warehouses and factories subject to medium or heavy:	
• pneumatic-tyred traffic (> 3t 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 and dust badly.

The use of fully compacted low-slump concrete, followed at the correct times by the floating and trowelling operations, 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.

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 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

Since abrasion is a surface-related phenomenon, how the surface is prepared and cared for during construction can have a significant impact on its abrasion resistance performance.

Figure 2

Finishing method's effect on abrasion resistance – w/c ratio of 0.65 and polythene sheet curing

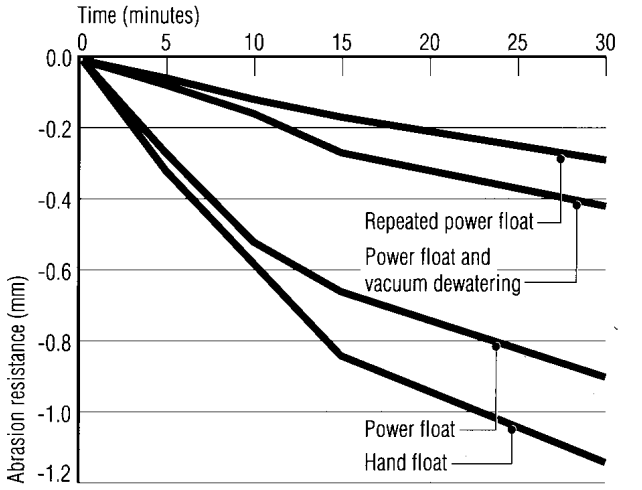
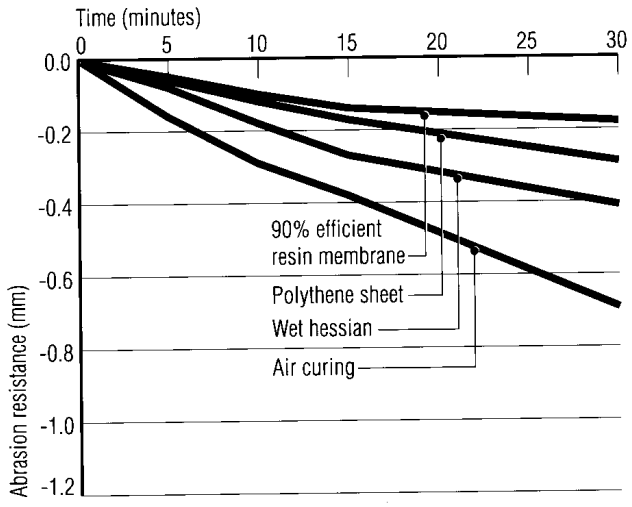


Figure 2 and ***Figure 3*** illustrate the importance of the finishing process and curing. These graphs show that if a hard abrasion resistance surface is

Figure 3

Finishing method's effect on abrasion resistance – w/c ratio of 0.65 and polythene sheet curing



required, specify that repeated power trowelling is required and ensure curing is effective and occurs as early as possible. Be aware that hard steel trowelling will probably result in a crazed surface; this is usually a visual effect with no serviceability problems.

We also recommend that the required surface finish is the subject of a pre-pour meeting involving the concrete supplier, contractor, engineer and placer. ***Table 1*** provides designers with guidelines on types of finishes for typical applications.

Joint Protection

Common sights in many warehouses are racking systems served by reach trucks. These vehicles have small, almost solid wheels that put severe loads on joints. Free movement joints will open up after drying shrinkage has occurred, and the stresses that develop at the joint corners when the truck passes over them can cause fretting of the edges.

The solution is to reinforce the joint edges, usually with steel. To prevent problems with vertical alignment mismatch, it is also preferable that these joints are dowelled.

Table 1

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 workshops, 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).

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