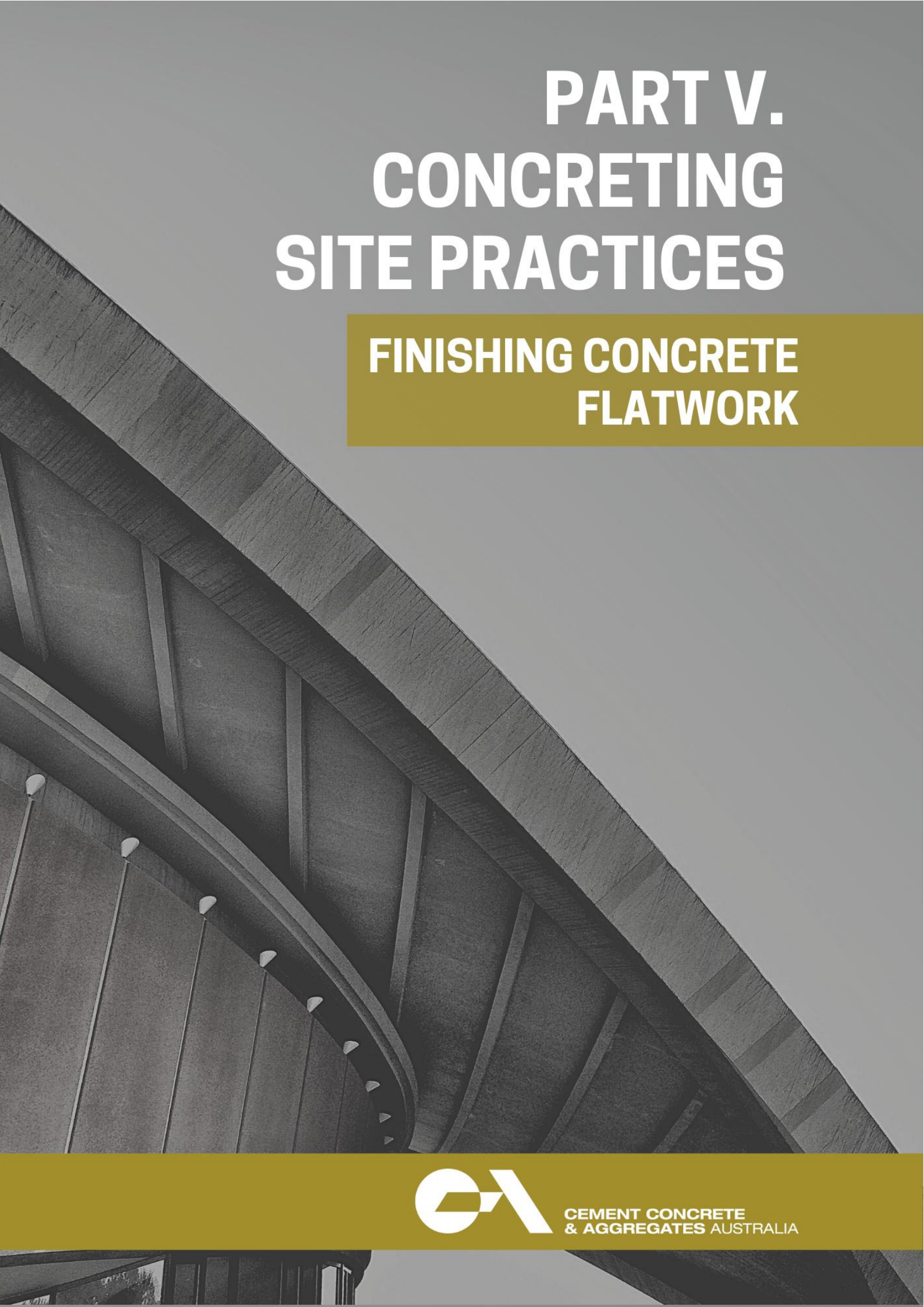
PART V. CONCRETING SITE PRACTICES

FINISHING CONCRETE FLATWORK



CEMENT CONCRETE & AGGREGATES AUSTRALIA

This section provides information on the finishing of freshly placed concrete. Generally, compaction (see Section 13 *'Compaction'*) and finishing are two separate operations; however, on flat horizontal surfaces (flatwork), they are often part of the same operation and can be considered together. Applied and off-form finishes for vertical and inclined surfaces are discussed in Section 27 *'Formwork'*.

CONTENTS

1. INTRODUCTION

In this section the techniques used to finish flat horizontal surfaces after the concrete has been compacted are described and discussed.

The compacting and finishing of concrete are generally two separate operations but, as noted above, sometimes (particularly with flat horizontal surfaces) they become part of the one operation. In such circumstances, it must always be remembered that a smooth surface finish is not necessarily evidence of good compaction underneath it. Care must always be taken to ensure that concrete is properly compacted.

2. GENERAL

'Flatwork' refers to a wide range of concrete floors or paving, and includes industrial floors, floors in commercial and domestic buildings (both on-ground and suspended), paths, patios, driveways and roads.

The finishing of flatwork involves a sequential combination of the following processes:

- Levelling;
- Floating;
- Trowelling;
- Other treatments.

These operations are carried out largely while the concrete is still plastic. The purpose of finishing is to achieve the desired:

- Level or profile;
- Flatness;
- Surface density and texture.

3. LEVELLING (SCREEDING)

3.1 GENERAL

Levelling or screeding is the initial operation carried out on a concrete slab after the plastic concrete has been placed in the forms and (if necessary) roughly levelled by shovel. Screeding is carried out by (a) working a beam backwards and forwards across the concrete to achieve a level surface or (b) by means of vibrating-beam screeds working off forms or guide rails. Levelling / screeding should be done before bleed water rises to the surface.

Usually, the final surface will be 'level', but the same screeding technique can be used on sloping surfaces, e.g. for driveways and ramps. In this case, the screeding should be commenced at the lower end and proceed up the slope.

3.2 HAND SCREEDING OFF FORMS OR SCREED RAILS

Screeding off edge-forms involves the use of a screed board to strike off the concrete to the height of the forms. Screed rails are temporary guides to support the screed board. These rails have to be removed after the surface is screeded, and the surface 'made good' while the concrete is plastic.

The striking surface of a screed board should always be straight and true. Proprietary screed boards such as hollow magnesium straightedges should be used for major commercial work and for house slabs. Lengths of dressed timber are satisfactory for minor work.

To enable it to be worked backwards and forwards without losing its level, the straightedge should be between 300 mm and 600 mm longer than the greatest distance between the edge-forms.

The surface is struck off by pulling the screed board forward along the slab, while moving it back and forth with a saw-like motion across the top of the edge forms. A small 'roll' of plastic concrete should always be kept ahead of the straightedge to ensure no hollows are left in the screeded surface and to maintain a plane surface. Excessive amounts of plastic concrete should be removed and placed ahead of the screed board.

3.3 HAND SCREEDING OFF 'WET SCREEDS'

'Wet-screeds' consist of pads or narrow strips of concrete (approximately 200 mm wide) placed to the correct level in advance of the main pour. The concrete finisher then uses these pads or strips as a height guide for levelling the slab.

This method allows large areas to be screeded without intermediate forms or guide rails being employed and without the necessity to accurately level the edge forms. However, this approach requires more skill and the availability of surveying equipment to accurately set the heights of the 'wet screeds'.

Generally, proprietary aluminium or magnesium screed boards with a handle are preferred for this type of work.

3.4 SCREEDING USING VIBRATING-BEAM SCREEDS

Vibrating-beam screeds provide significant compaction in addition to their screeding capability. Their use and operation are described in Section 13 *'Compaction'*.

The accuracy of the surface level achieved is dependent on the formwork on which the vibrating-beam 'rides'. This formwork must therefore be accurately levelled and firmly fixed so that it will not distort under the weight of the vibrating-beam. Special care should be taken to stabilise joints in formwork boards.

The screed itself should not 'sag' or distort under the weight of the vibration unit and, for this reason, a 4 m width is about the maximum limit for twin-beam, centrally mounted vibration unit screeds. However, trussed vibrating-beam screeds can span 20 m with minimal 'sag' and can be used to provide floors or pavement with very tight surface tolerances (**Figure 14.1**).

3.5 MACHINE-MOUNTED SCREEDS (LASER SCREEDS)

A more recent development in mechanising the screeding and compacting of concrete floors and pavements is the 'laser screed'. These four-wheel drive machines are positioned and then stabilised on hydraulically extended legs (**Figure 14.2**). The telescopic arm with the screed at the end is extended. The concrete is spread by auger and compacted by the screed as the arm is retracted towards the machine. Laser sensors mounted at the ends of the screed monitor the level and adjust the height automatically. The machines are able to produce floors to very stringent requirements in terms of flatness and accuracy of the level. There are machines of varying size, with screeds up to approximately 4 m wide and the telescoping arms able to extend out to approximately 6-8 m.

Figure 14.1 – Typical Trussed Vibrating Beam Screed

4. FLOATING

4.1 GENERAL

The purpose of 'floating' a concrete surface is to impart to it a relatively even but still open texture in preparation for other finishing operations, and particularly to:

- Embed large aggregate particles beneath the surface;
- Remove slight imperfections and produce a surface closer to the true plane;
- Compact the concrete and consolidate the mortar at the surface in preparation for other finishing operations;
- Close minor surface 'cracks' which might appear as the surface dries.

Two distinct 'floating' operations are carried out. The first of these is carried out after the recently placed concrete has been screeded and before bleed water appears on the surface. The second floating operation is carried out after bleeding has ceased and prior to final finishing.

The initial floating operation is carried out with a 'bullfloat' or 'darby'. The second floating operation is carried out by working the surface

of the concrete with hand floats, or by rotary finishing machines fitted with appropriate floats or shoes. The second operation should not begin until all bleed water has evaporated from the surface, or has been removed with a hessian drag, and the concrete has begun to harden to the point where, when the finisher walks on it, they leave only minor indentations in the surface. Such indentations should be removed by the floating operation.

Figure 14.2 – Typical Machine-mounted Beam Screed

4.2 BULLFLOATING

The bullfloat is a large float on a long handle which is worked back and forth on the concrete surface in a direction parallel to the ridges formed by screeding, i.e. transversely across the slab (**Figure 14.3**). The blade is typically aluminium or magnesium but may also be made of wood. The blade and handle are usually pivoted so that the angle of the blade can be changed depending on whether the stroke is forward or backward.

Figure 14.3 - Bullfloating

Bullfloating is particularly useful as an initial floating operation to smooth the concrete surface and embed any large aggregate pieces. It is typically carried out immediately after screeding and should be completed before bleed water appears on the surface.

To minimise the number of ridge marks left at the edge of the blade, bullfloat passes should not overlap by more than 50 mm.

A second use of the bullfloat may sometimes be required but care should be taken not to overwork the surface.

4.3 FLOATING BY HAND

Three types of hand float are in common use: wooden, magnesium and composite.

Wooden floats require skilled operators and timing is important. If used too early, they stick or dig in and can tear the surface. If used too late, they can roll the coarser particles of fine aggregate out of the surface.

Magnesium floats require less effort and will not roll coarse particles of fine aggregate out of the surface. They can be used after wood or power floating to give a more uniform swirl finish which creates a smoother texture than that produced by a wooden float.

Well-worn magnesium floats should be discarded. They develop an edge almost as sharp as that of a steel trowel, and use of them risks closing the surface too soon.

Composite floats have resin-impregnated canvas surfaces. They are smoother than wooden floats but slightly rougher than magnesium floats. They also can be used after wood or power floating.

The hand float is held flat on the surface and moved in a sweeping arc to embed the aggregate, compact the concrete, and remove minor imperfections and cracks. Sometimes, the surface may be floated a second time, after some hardening has taken place, to impart the final desired texture to the concrete (**Figure 14.4**).

4.4 FLOATING BY MACHINE

Machines for floating are usually trowelling machines with float shoes or, for use on low-slump concrete or toppings, disc-type machines (Kelly floats).

Float blades are wider than trowel blades and are turned up along the edges to prevent them digging into the surfaces whilst in the flat position. For this reason, floating with a trowelling machine equipped with normal trowel blades should not be attempted.

The power-float should be operated over the concrete in a regular pattern leaving a matt finish (**Figure 14.5**).

Concrete close to obstructions or in slab corners that cannot be reached with a power-float should be manually floated before power floating is begun.

The use of water sprays or other means of wetting the surface during finishing operations should not be permitted as such practices almost inevitably cause dusting of the slab when placed into service.

(a)

(b)

Figure 14.4 - Hand Floating (a) and Edging (b) are Important Finishing Tasks

Figure 14.5 – Power Floating in a Regular Pattern

5. TROWELLING

5.1 GENERAL

Trowelling is carried out some time after floating. The delay is to allow some stiffening to take place so that aggregate particles are not torn out of the surface when trowelling.

For a first trowelling, the trowel blade should be kept as flat against the surface as possible since tilting or pitching the trowel at too great an angle can create ripples in the concrete.

Additional trowelling may be used to increase the smoothness, density, and wear resistance of the surface. Successive trowelling passes should be made with smaller trowels pitched progressively higher. This increases the pressure at the bottom of the blade and helps compact the concrete surface.

The formation of blisters on the surface during trowelling indicates that the angle of the trowel is too great. As soon as blisters are seen they should be pushed down immediately and re-bonded to the base concrete using a magnesium float or a flat trowel – depending on the stiffness of the concrete. The angle of the trowel should then be reduced to prevent more blisters from forming.
***NOTE**: A blistered surface will not be durable. Blisters can be broken out by traffic movement and will reflect through any hard tile placed over them.*

5.2 TROWELLING BY HAND

A trowel for hand finishing has a flat, broad steel blade and is used in a sweeping arc motion with each pass overlapping the previous one.

The timing for trowelling to be most effective requires some experience and judgement, but as a guide, when the trowel is moved across the surface it should give a ringing sound.

5.3 TROWELLING BY MACHINE

The trowelling machine (power trowel or 'helicopter') is a common tool for all classes of work and consists of several (generally four) steel trowel blades rotated by a motor and guided by a handle. Larger machines are ride-on and are suitable for trowelling large areas such as factory floors (**Figure 14.6**).

Figure 14.6 – Multi-head power Trowel Machines are commonly used for Major Warehouse Projects

Trowelling by machine should be carried out systematically over the concrete in a regular pattern. Corner areas, areas close to obstructions and small irregularities should then be 'touched-up' with a hand trowel.

Successive trowelling passes, with a break to allow further hardening, will 'densify' the surface, providing increased wear resistance. Any successive trowelling passes should be at right angles to the previous pass for maximum effectiveness.

6. EDGING

Edging (**Figure 14.4**) provides a quarter-round *arris* along the edges of footpaths, patios, curbs and steps. It is achieved by running an edging trowel around the perimeter of the concrete. Edging trowels are steel (or brass) and incorporate a quarter-round forming edge. They are available in a variety of widths and with various diameter quadrants.

Edging improves the appearance of many types of paving and makes the edges less vulnerable to chipping. However, edging should not be used at joints in industrial or warehouse floors or in floors which will be tiled or carpeted.

Joints in industrial floors should have a crisp right- angled corner. On formed edges this is achieved principally by the form boards which should have sharp, right-angled edges. Hand

trowelling is generally used along such edges to ensure the sharpness of corners.

7. SURFACE TREATMENT

7.1 GENERAL

Surface treatments should be chosen to suit the anticipated service conditions or to give the concrete a particular appearance.

The choice of finish will be influenced by the following considerations:

- The type of traffic and its frequency;
- Whether the floor is subject to impact-loading;
- Whether chemicals will come into contact with the slab.

Consideration should also be given to the operations to be carried out on the floor, which may determine how smooth it should be, and the necessity for hygiene and the management of dust.

Surface treatments which can be used to provide different appearances include colouring, exposing the aggregate and texturing or imprinting.

7.2 'DRIERS' AND 'DRY-SHAKE TOPPINGS'

A difficult question relating to concrete floor finishing is whether to permit the use of 'dry-shake toppings', and if so, under what conditions. Their use to mask or patch up an unsatisfactory finish should not be permitted. However, when used by a skilled finisher, they can impart special finishes to flatwork (e.g. coloured and abrasion-resistant surfaces). In the hands of a skilled finisher, they may also be useful for correcting minor imperfections in a surface.

As a general rule it is necessary for there to be agreement between placer and customer, before finishing commences, as to whether dry shakes will be permitted and if so, under what circumstances.

When 'driers' (neat cement or mixtures of cement and sand) are used to soak up bleed water, the surface will almost certainly have a variable water/cement ratio resulting in poor wear resistance and they should not be used. If used the finished surface will almost certainly exhibit crazing and in extreme cases may delaminate.

'Dry-shake toppings' have been used to 'mask' concrete which is not of the correct quality and/or which has been poorly placed and compacted. Although the surface might appear 'hard' in the first instance the base concrete will be inadequate for the purpose for which it was intended.

7.3 ABRASION-RESISTANT TOPPINGS

The appropriate wear (abrasion) resistance, impact resistance and chemical resistance of flatwork is generally achieved by specifying the appropriate strength of concrete and properly compacting, finishing and curing it.

Since the wear resistance of concrete is directly related to its compressive strength, AS 3600 stipulates minimum requirements for resistance to abrasion as shown in **Table 14.1**.

Where very high levels of wear resistance are required, metallic dry shakes can be used to good effect. They consist of cement mixed with either specially treated malleable graded iron filings, or a mixture of carborundum (silicon carbide) and emery particles. Similarly, the incorporation of steel fibres in the concrete mix can increase wear resistance.

The application of metallic dry shakes and subsequent finishing of the concrete is a skilled operation, usually performed by specialist operators. The metallic dry shake is distributed over a floated concrete surface. The surface is then floated again and may then be trowelled. If steel fibres are used in the mix, they can affect concrete workability and finishing.

Table 14.1 – Strength Requirements for Abrasion (from Table 4.6 in AS 3600)

Member and/or traffic	Minimum characteristic compressive strength, f'_c (MPa)
Footpaths and residential driveways	20
Commercial and industrial floors not subject to vehicular traffic	25
Pavements or floors subject to:	
(a) Pneumatic-tyred traffic	32
(b) Non-pneumatic-tyred traffic	40
(c) Steel-wheeled traffic	To be assessed, but not less than 40.

The use of surface hardeners – such as products based on sodium silicate or silico-fluoride compounds – may provide some additional wear resistance but should not be used to justify lower grades of concrete than those specified in AS 3600. Whilst having some effect during the early life of a floor, re-application of these compounds will be necessary as the floor wears.

7.4 SLIP AND SKID RESISTANCE

Slip and skid-resistant concrete surfaces can be created by texturing the plastic concrete. The term 'slip' relates to pedestrian surfaces, while 'skid' is the term used for vehicular pavements. Finishing the concrete with a wooden or sponge float will give the surface a degree of slip resistance. Such surfaces will be suitable for foot traffic on level or near-level paving.

AS/NZS 4586 sets out required slip resistance for various areas in domestic and pedestrian areas. Bowman [1] provides a detailed discussion of the topic of slip resistance and an explanation of how to use the Standard.

A stiff-bristled broom or dampened hessian sheet, drawn across the trowelled surface, can produce a greater degree of skid-resistance suitable for vehicular traffic.

For greatest skid-resistance, on ramps or high-speed roadways, freshly trowelled concrete can be grooved with steel *tynes* (see also under *Texturing* below).

7.5 CHEMICAL RESISTANCE

Good quality concrete can withstand attack from many chemicals. Provision of a high grade of concrete properly placed, compacted, finished and cured is generally the best way to provide maximum chemical resistance. In some cases, chemical resistance may be further increased by the use of surface hardeners such as sodium silicate, silico-fluoride compounds or other protective coatings. Where the surface is subjected to attack from very aggressive chemicals (e.g. agents containing inorganic or organic acids) the use of a suitable protective coating is required. Such coatings should be applied after the concrete has been properly cured but before it is exposed to the chemical attack. (For further guidance on this topic see Section 25 *'Properties of Concrete'*.)

7.6 COLOURED CONCRETE

Concrete can be coloured by incorporating a pigment into the concrete mix. As pigments are expensive it has been common to apply a dry-shake topping containing a pigment onto normal 'uncoloured' concrete surfaces.

The dry shake consists of a mix of cement, oxide pigment and clean, sharp sand. Typical proportions are 1-part cement / 0.06 to 0.1-part oxide / 2-parts clean, sharp sand. The exact proportion of oxide depends on the shade required. If too little oxide is used a washed-out colour will be obtained in the final finish. Using oxide at levels >10% of cement content adds no extra colour as at this addition level, colour saturation has been reached.

All components of the dry-shake mix should be thoroughly blended before use. The pigment and cement are initially mixed together, and then the sand is added.

Timing is crucial when coloured dry shakes are applied. All bleeding should have ceased and the water sheen on the concrete should no longer be visible. The dry-shake mix is then broadcast over the surface sufficiently thickly to produce a topping 3-4 mm thick. It is then floated and trowelled onto the concrete without the surface being overworked. The most consistent colour outcome is obtained when about two-thirds of the dry-shake material is applied in one direction and then the remainder applied at 90° to the first pass.

7.7 TEXTURING

Useful textures can be obtained using brooms of varying degrees of stiffness, as well as hessian or sponges. These can produce finishes which are both functional and attractive.

Brooms may be used to provide a variety of textures. The timing of brooming and the angle at which the broom is held will affect the appearance. An extension handle is usually fitted so that the broom can be pulled right across the surface in one motion and, after each traverse of the concrete, the broom head should be tapped or cleaned to prevent an accumulation of mortar in the bristles.

Where a broomed texture is used and traffic is heavier than domestic or light commercial traffic, the texture should be deeper. Lightly broomed textures look attractive when first done but wear quickly in industrial situations, whereas a medium or coarse broom texture should provide a good, skid-resistant surface over the design life of the floor or pavement (**Figure 14.7**).

Tyning is used in applying a skid-resistant surface on concrete road paving. Immediately after the paving machine has completed its function, a separate tyning machine places a skid-resistant finish by drawing a ‘rake’ system across the surface of the paved concrete – usually in an orientation transverse to the direction of the paving.

Exposed aggregate finishes are achieved by washing away the top layer of cement mortar from the surface of the concrete once initial setting has taken place. Timing is crucial to achieving a good exposed aggregate finish.

The surface of cement paste is generally removed with a fine water spray, supplemented by light brooming with a soft brush.

Figure 14.7 – Broom Finishing helps to provide Skid Resistance

Concrete mixes may be 'modified' for exposed aggregate finishes (e.g. by increasing the proportion of the size of aggregate which it is desired to feature).

Where a 'special' aggregate is to be exposed, this can be spread evenly (broadcast) over the levelled concrete and tamped into the surface which is then floated. After a delay to allow some hardening to take place the cement paste on the surface is washed away to expose the aggregate. To ensure a durable surface, less than one third of the diameter of the stones should be exposed.

7.8 IMPRINTING

Imprinting or 'pattern paving' provides a wide range of texturing possibilities – including slate

and brick look-alikes. The usual technique is for the concrete to be placed, compacted, bullfloated and a coloured dry-shake topping applied. The surface is then covered with plastic sheeting or a release agent and the patterning moulds are systematically stamped into the surface. On completion of stamping the moulds (and plastic) are removed and the surface is lightly broomed and subsequently cured. Any de-bonding agent used is washed off before applying a 'sealer' which helps provide a uniform colour and often gives a wet or polished look to the surface.

It should be noted, however, that skill and experience are generally necessary to achieve satisfactory results with this type of finish.

8. TOLERANCES

The tolerances specified for the surfaces of slabs or other flatwork should be appropriate to their final use. Achieving tight tolerances increases costs. It may be necessary, for example, to have tight tolerances in warehouses with high-racking bays but it would be unnecessarily expensive to have very tight tolerances for loading dock areas where the delivery trucks are received.

AS 3600 specifies floor tolerances to ensure that structural behaviour is not impaired. It does not specify tolerances for the serviceability or usefulness of the floor.

Floors generally have to meet two independent tolerance criteria. One deals with the desired elevation and the other with the 'flatness' of the floor.

The 'elevation tolerance' gives the permitted variation of the slab surface from a fixed external reference point or datum.

For pavements requiring very high tolerances (e.g. warehouses in which loosely stacked items are moved on forklift pallets) reference should be made to the CCAA Technical Note (T48) *'Guide to Industrial Floors and Pavements'* [2].

9. REFERENCES

1) Bowman, R. *'An Introductory Guide to the Slip Resistance of Pedestrian Surface Materials'* (HB 197) CSIRO and Standards Australia (1999)
2) *'Guide to Industrial Floors and Pavements – Design, Construction and Specification',* Cement Concrete and Aggregates Australia, Technical Note T48 (2009)
3) CCAA, *'Guide to Concrete Flatwork Finishes'*, CCAA T59 (2008)

10. RELEVANT AUSTRALIAN STANDARDS

1) AS 1379 – *Specification and supply of concrete*
2) AS 3600 – *Concrete structures*
3) AS/NZS 4586 – *Slip resistance classification of new pedestrian surface materials*

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