INFORMATION BULLETIN: IB 80

Residential Concrete Driveways and Paths

1.0 INTRODUCTION

The basic function of residential pavements such as driveways, paths and patios is to provide safe, easy access onto or around a property. Concrete is typically used to not only provide a durable paving surface sloped to provide surface water run-off, but one which can also incorporate a wide range of decorative finishes to complement the design and landscaping of the residence.

While providing a concrete pavement on the ground is relatively straightforward, there are many aspects of residential pavement design and construction that need to be considered in order to produce a finished product that will satisfy both the functional and aesthetic requirements demanded by home owners.

This Information Bulletin provides guidance on the planning, design, construction, maintenance and specification aspects that need to be considered to ensure a successful concrete paving project.

2.0 PLANNING

2.1 Footpath Area

Pavements between the kerb and property boundary will generally have to comply with the requirements of the Territorial Authority in respect of levels, grades and minimum details (thickness, reinforcement and concrete strength). These need to be established, as they may affect the grades (and possible need for transition zones) for the remainder of the driveway, especially on steep slopes with short distances from the boundary to the house.

2.2 Provision for Drainage

To allow adequate drainage of the surface, the recommended minimum grade or crossfall for a pavement is generally 1 in 50 (2%), or 20 mm per metre. The driveway should be at least 25 mm above the adjacent ground to allow for self drainage.

The maximum grade should not exceed 1 in 20 (5%) in the footpath area or 1 in 5 (20%) within the property boundary. Note that as the actual requirements may vary from these limits, especially in hilly areas, it is always advisable to check with the relevant Territorial Authority.

Where grades at or near the maximum are necessary for driveways, a transition zone at either end of the steep section may be required to prevent vehicles from 'bottoming' on the driveway (see **Figure 1**).

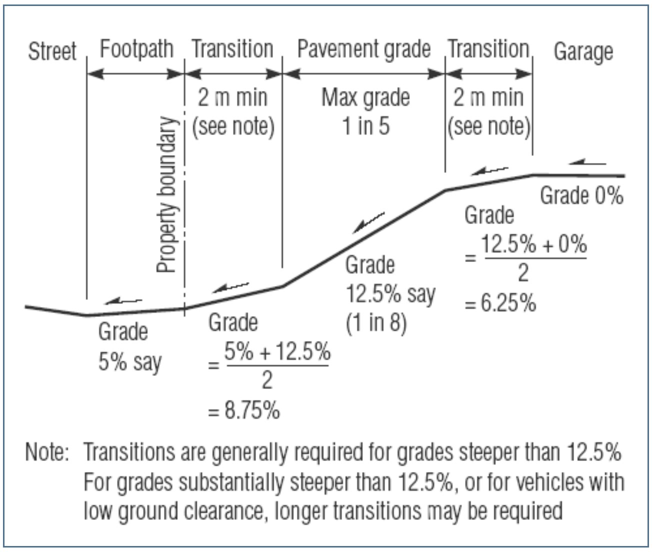

Figure 1: Transition zones for driveways

2.3 Trees

The presence of trees adjacent to the pavement may cause soil movements that change the ground levels and result in cracking of the pavement.

Particularly with expansive clays, the moisture drawn by tree roots can dry the soil, causing it to shrink and affect the pavement levels. Also tree roots may find their way under the pavement and cause damage by lifting sections of the slab.

2.4 Adjacent Structures

Where driveways and pavements are constructed adjacent to houses and other structures, New Zealand Building Code (NZBC) E2 requirements to prevent entry of surface water into the house need to be complied with.

- The vertical clearance from the pavement to the house ground floor slab shall be 150 mm for timber construction or 100 mm for masonry construction.

- The pavement shall be graded away from a building at a slope of 1 in 25 for at least 1 m.

- Where site conditions do not allow for a 1 m wide strip, a suitable drain is to be provided adjacent to the building to divert storm-water runoff as shown in **Figure 2**.

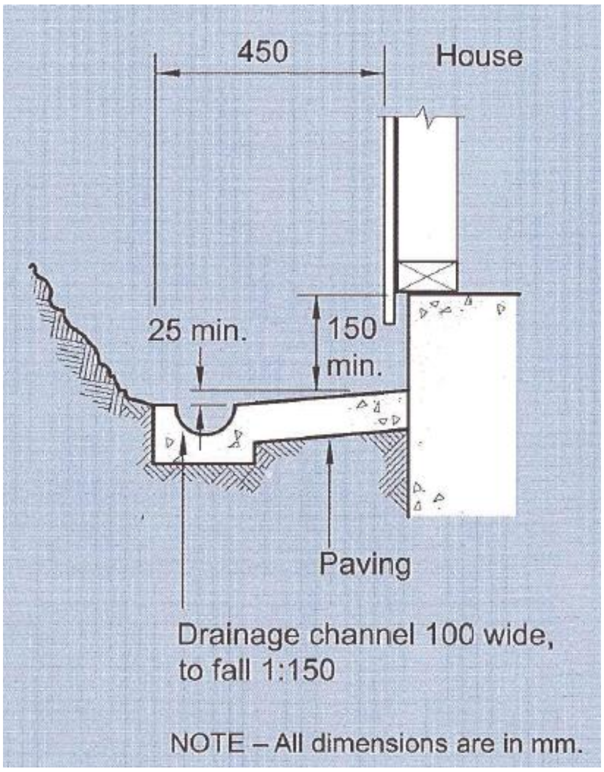

Figure 2: NZS 3604:2011, Figure 7.12

- **Flashings and damp-proofing courses.** Damp-proof course or flashings where required as a damp-proofing course shall be at least 100 mm above the finished surface level of the pavement adjacent to the wall.

- **Sub-floor ventilation openings.** If any existing sub-floor ventilation openings are covered by the paving, the NZBC requires new openings to be provided to reinstate the required ventilation area.

- **Ground movement.** In clay soils, the moisture content of the soil beneath areas of large paving may change over time, possibly causing movement of the soil and consequent changes to the paving and adjacent building levels.

  The possible effects of this movement on the drainage and adjacent walls should be considered, and the soil replaced if thought necessary.

2.5 Surface Finish

Whilst the range of surface finishes possible with concrete is too extensive to cover here, a surface finish appropriate for the application must be selected based on the following:

- **Slip Resistance**

  In NZBC Acceptable Solution D1/AS1 Table 2 gives acceptable finish types for wet and dry, level and sloping surfaces, for pavements with public access. All concrete and concrete paver surfaces listed are suitable for flat dry pavements. However smooth steel trowelled surfaces, exposed rounded aggregate surfaces or paint sealed surfaces are not suitable for flat wet pavements.

  Some surface texture is required to provide slip resistance, particularly in wet conditions. Suitable finishes for sloping wet pavements include wood float or coarse broomed finish, sand/grit impregnated coatings or crushed exposed aggregate. Tyned, dragged and stenciled finishes are another option. Pavers in wet sloping situations require friction testing. Note that if the pavement is subject to barefoot traffic (e.g. around a pool) the texture should not be too coarse. Suitable finishes for these applications include wood float, light broom or pebblecrete finish.

- **Cleaning**

  For pavements subject to spills, (e.g. barbeque, outdoor kitchen and eating areas), smooth finishes are the most appropriate since they are easy to clean and maintain. Use of a surface sealer can prevent spillage from penetrating the concrete, and facilitate cleaning.

3.0 DESIGN

3.1 Concrete

Strength

Concrete with a specified compressive strength of 20 MPa compliant with NZS 3104 is recommended for residential pavements. A higher strength may be required in certain situations, such as:

- **Heavier Loads.** If the pavement is being used by vehicles between 3 and 10 t gross mass, and infrequently by heavier vehicles that do not exceed the statutory limits for tyre, wheel and axle loads, a specified strength of 25 MPa or 30 MPa is recommended. Such pavements also need to be thicker (see **Table 1**).

- **Abrasion Resistance.** This is the ability of the concrete surface to resist wear; it is directly related to the strength of concrete and the quality of the surface finish. A 20 MPa concrete is satisfactory for most residential paving applications, including typical driveways. The higher strength recommended for heavier loads will also produce a higher abrasion resistance provided the surface finish and curing are carried out correctly.

- **Freezing and Thawing.** A 25 MPa concrete should be used if the pavement is subjected to occasional freezing, and a 30 MPa concrete where more than 50 freezing cycles occur each year. Also, an air entraining agent should be used in the concrete mix targeting a 5% air content.

Other Properties

If properties in addition to strength are required, 'Special Concrete' should be specified and the means by which compliance is established. For coloured and decorative pavement finishes, some of the properties (apart from the strength) that may be required include:

- **Colour pigments.** Supplier, colour and percentage by weight of cement to be used.

- **Aggregates.** For exposed aggregates, any information necessary to identify the stone required – size, type, texture, colour (e.g. nominal 10 mm aggregate consisting of 90% brown rounded river gravel and 10% crushed white quartz).

- **Cement colour.** Normal grey, off-white or white. Note that the availability of these should be checked prior to specifying. An alternative to achieve a lighter colour is the use of a titanium white colour pigment.

Driveway Width

The typical driveway width is 3 m, however 2.7 m is acceptable where room is tight. However, accommodating larger vehicles may be difficult. A 3.6 m driveway allows a comfortable amount of room for passengers exiting a car. Double car driveways need to be between 6 m and 7.3 m wide.

3.2 Thickness

Table 1 shows recommended thickness along with concrete compressive strength. The load the slab can carry is also dependant on the adequacy of the subgrade to support the loaded slab. See Section 4.0 Construction.

Table 1: Pavement Thickness and Specified Concrete Compressive Strength

Pavement Use	Pavement Thickness	Pavement Concrete Specified Strength
Paths & Patios (Foot traffic only)	75 mm	20 MPa
Typical Driveway -Vehicle use < 3 t gross	100 mm	20 MPa
Pavement with vehicles 3 t to 10 t	150 mm	25 or 30 MPa

3.3 Reinforcement

The use of steel reinforcement or mesh does not increase the load capacity of the pavement, or affect its thickness. Its function is mainly to hold tightly closed any shrinkage cracks that may form. In general, the amount of reinforcement required to provide the appropriate degree of crack control will depend on the thickness of the slab, the joint spacing, and the resistance to the slab shrinkage between joints.

For a 75 mm footpath which typically would have closely spaced joints (up to 3 m), and hence little risk of cracking, either no reinforcement or an 668 mesh is generally appropriate. For 100 mm thick pavements having joints spaced further apart (up to 5 m), 665 mesh would typically be used, and for 150 mm thick pavements, 663 mesh.

The construction of driveway pavements without reinforcing mesh is not recommended.

Mesh is typically based on a 150 mm square grid but mesh based on a 300 x 300 mm grid is available allowing the placers to walk between the mesh rods rather than on the mesh itself. Note that slab construction requiring building consent requires SE 62 (147 mm^2/m) Grade 500E (ductile) reinforcing mesh.

In some cases increasing the minimum reinforcement would be recommended. For example, where decorative finishes are required, increasing the mesh size by one or even two sizes, will provide better control of cracking that may occur, so that it does not significantly affect the appearance.

3.4 Crack Control

All standard concretes shrink during their drying out phase. Basically this shrinkage starts at the end of the curing period and will continue until the moisture content stabilises with the ambient conditions, which may take many months. While the key elements that determine the potential amount of shrinkage are the type and quantities of materials used in the concrete mix, particularly water content, cement content and aggregate type/content, it is not possible to design a concrete mix that will avoid slab shrinkage altogether.

Cracks observed within one to two days are not caused by the long-term drying of hardened concrete. They are caused by premature drying of plastic concrete or by 'early age' thermal movements. These are primarily issues that need control during the construction phase.

When shrinkage strain causes stresses to exceed the tensile strength of the concrete slab, then the slab will crack. In practice there is likely to be a combination of linear shrinkage between free joints and curling effects.

Curling is caused by the differential shrinkage within the depth of the slab, i.e. the top dries out faster than the bottom of slab. With the top shortening more than the bottom, the slab will try to curl upwards at any edges or joints. At free joints concrete on each side of the joint can move relative to one another.

The classic design for shrinkage in a concrete ground slab relates to allowing the shrinkage movements to take place and controlling the positions of where the movement is allowed to occur. This process is influenced by the following:

(a) **Ground friction.** If the interface between the concrete slab was frictionless, then the phenomenon of the concrete shrinkage would not cause any stress build up. Friction can be reduced by placing polyethylene sheeting or a 20mm thick layer of sand under the slab.

(b) **Construction features that cause a constraint to movement.** For example, slabs tied to foundations internal or external, changes in direction of the slab. Such construction features need to be isolated to allow the slab to move independently of them.

Joints typically form a weakened plane at which the concrete cracks. Without them, drying shrinkage will result in random cracking. Joints should be provided at maximum 5 m centres, depending in the reinforcement, and at any changes in shape (e.g. a narrow path attached to a driveway), at any changes in direction (e.g. around corners, especially where a re-entrant corner may be formed), and at any rigid structures (e.g. access holes, pits, columns) that may prevent movement and increase the risk of cracking.

Free movement joints should be placed at maximum 15 m centres to allow the pavement on each side to move independently of each other.

Double car driveways require a longitudinal joint splitting the driveway.

Wherever possible, the location of joints should be planned. A typical layout of joints in the paving to a residence is shown in **Figure 4** (page 5). Note that one aim should be to make the concrete panels defined by joints roughly square in shape. The ratio of length to width should not exceed 1.7:1. For decorative work, joints should if possible be located to suit the proposed decorative pattern or finish.

With all joint types, the angles formed at edges and intersections of joints should not be too acute, as this increases the risk of cracking and/or breaking off the tapered section of concrete. A good detail in these situations is to keep at least 500 mm of the joint at more than 75° (and preferably at right angles) to the slab edge (see **Figure 3**).

Figure 3: Joint perpendicular to slab edge

3.5 Surface Tolerances

Pavements generally have to meet two independent tolerance criteria: the 'flatness' of the surface and 'levelness' or variation from the designed elevation. Both of these should be specified.

The flatness tolerance gives the permitted variation from a 3 m straightedge placed on the surface. For hand-placed pavements, a reasonable flatness tolerance is a maximum deviation or gap of 5 mm under a 3 m straightedge placed anywhere on the pavement, including on slopes. The maximum abrupt deviation anywhere on the surface shall be 5 mm.

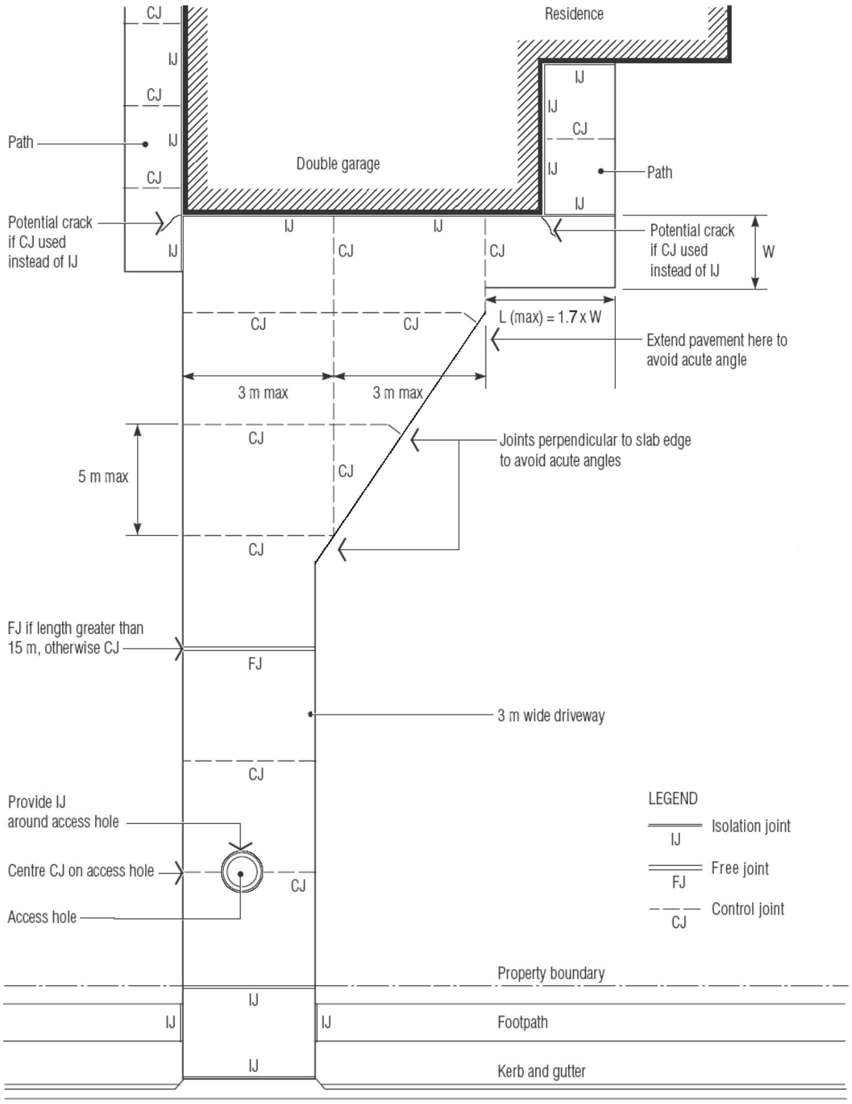

Figure 4: Typical joint layout for a 100 mm thick driveway with 665 mesh

The levelness tolerance gives the permitted variation of the slab surface from a fixed external reference point or datum. A reasonable tolerance for the surface of a newly-constructed pavement would be ±10 mm from the designed level or elevation. Note that the nominal slab thickness should not be compromised by tolerance variations.

3.6 Permeable Pavements

Permeable (or pervious) pavements are being specified in areas where runoff from existing hard surfaces due to extreme rainfall events causes overloading of the stormwater systems. Permeable concrete is similar to no fines concrete and has continuous voids which allow water to infiltrate through the pavement. Alternatively, permeable pavers can be used.

The water is held in storage under the pavement which effectively reduces the peak runoff entering the sub-grade or the stormwater system.

Information on permeable pavements is found in reference 2.

3.7 Segmental Pavements

Concrete segmental pavers ranging from small brick-sized units to the larger flag pavers are available in a variety of colours, finishes and textures. Information on segmental pavers including permeable pavers is available from the New Zealand Concrete Masonry Association website (www.nzcma.org.nz).

4.0 CONSTRUCTION

4.1 Subgrade Preparation

The preparation of the subgrade (supporting ground) for residential pavements is a relatively simple process as typically the loads are light. All topsoil (which may settle) should be removed and the area levelled to provide a uniform platform for the pavement. For heavy loads, the ability of the subgrade to adequately support the loads without excessive deflection and cracking of the pavement needs to be considered.

A reasonably uniform foundation is essential to the long-term performance of a concrete pavement. An assumption that a concrete pavement will bridge over a poor subgrade could lead to a false sense of security. Thus, any poor, saturated, highly compressible or otherwise weak areas should be removed and replaced with suitable subgrade or roadbase material, adequately compacted with a plate compactor or small roller, to avoid subsequent settlement. The same applies to the backfilling of service trenches.

A level area also minimises the friction between the pavement and ground. This reduces the restraint of the pavement, and in turn, the risk of unplanned cracking.

4.2 Subbase

The function of the subbase of granular material is to provide a more-uniform slab support by equalising minor subgrade defects (see **Figure 5**) and to prevent water wicking up through the concrete. The granular fill should have a good particle size distribution – aggregate meeting the Transit New Zealand grading requirements for AP20 and AP40 are suitable. 100 mm is a typical subbase thickness, for clay subgrades the thickness should be increased.

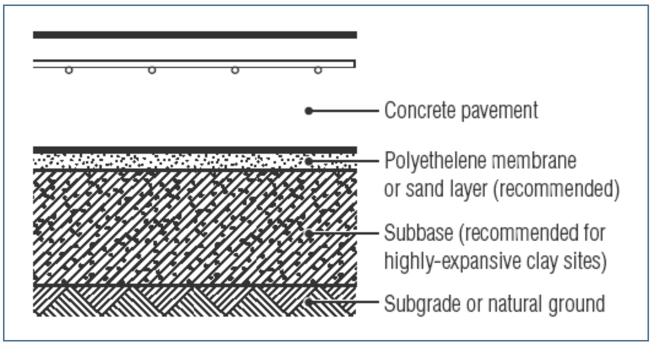

Figure 5: Typical pavement cross-section

4.3 Reducing Friction Under the Slab

Providing polyethylene sheeting, 0.25 mm thick, is optional as an effective way of reducing the friction between the slab and subgrade/subbase. The sheet edges should be taped. Compared to placing the concrete directly on the subbase, the frictional force and hence restraint of the slab can be more than halved. This allows the concrete slab to move more freely due to drying shrinkage and thermal volume changes, thereby reducing the risk of cracking.

4.4 Reinforcement Fixing

The reinforcement (usually mesh) should be located within the top third of the pavement, and have 30 mm of concrete cover to the top of the slab. It should be fixed in position using purpose made supports or mesh chairs, spaced at maximum 800 mm centres to prevent sagging of the reinforcement during concrete placement.

Note that for light meshes, the spacing may need to be reduced to prevent sagging.

Mesh should not be walked into position or lifted to height using a hook during concrete placement. Nor should the concrete truck be driven over it to gain access for concrete discharge. Where sheets of mesh are joined, they should have a minimum overlap of two cross wires (i.e. the two outermost cross wires of each sheet are overlapped).

4.5 Formwork

Formwork should be secured accurately in position to maintain lines and/or shape during concrete placement, and set to the correct levels so as to provide a guide for the finished surface levels and tolerances. Formwork should pegged so that it is ridged enough to take the load of the concrete during placing and finishing without distortion, at say 1 m centres.

4.6 Concrete Ordering

When concrete is ordered, the following information shall be supplied:

(a) The specified compressive strength.

(b) The nominal maximum aggregate size.

(c) The slump.

(d) The method of placement.

(e) Any additional requirements associated with Special concrete (if applicable).

Typically for driveways, the specified strength should be 20 MPa, the nominal maximum aggregate size 20 mm and the recommended slump should be 100 mm if using hand held mechanical screed vibrators. For hand screeding without mechanical vibration, the slump should be higher at 120-130 mm, whilst for vibrating beam screeds the slump should be lower at 80 mm.

4.7 Placing of Concrete

Water should not be added to the ready-mix truck on site without a good reason. When water is added to concrete over and above that specified by the concrete plant, this will reduce the strength and surface wear resistance arising from traffic, and increase concrete shrinkage. However, where the slump in the truck on site is too low, for instance water may have evaporated from the truck in hot weather, NZS 3104 allows water to be added in a controlled manner to increase the slump back up to the specified value, but in no circumstances shall the added water exceed 10 litres per cubic metre of concrete. This is preferable to placing concrete for which the slump is too low resulting in lack of compaction of the pavement.

Surface Water

Any water ponding on the ground should be removed prior to placing the concrete to avoid problems with water mixing with the concrete and, segregation and washing out of cement paste from the aggregate. These can affect the strength and durability of the concrete.

Concrete placement should commence from one corner of the pavement and proceed continuously out from that point, with new concrete always being deposited onto the face of the concrete already placed to ensure interblending and avoid segregation, i.e. the separation of the aggregate from the cement paste within a concrete mix which may lead to honeycombing in the hardened concrete. When placing concrete the following should be considered:

- **Transport.** Often concrete is moved from the concrete truck to its final location by a concrete pump. If a wheelbarrow is used, a typical placing rate of about 1 to 1.5 m^3/h can be achieved, the travel distance is limited to about 50 m for continuous work, and a relatively level, smooth access is required to avoid jolting and possible segregation of the concrete.

  For driveways on a slope, concrete placement should commence at the lowest point.

- **Segregation**. Segregation should be avoided by placing concrete as near as possible to its final location. Concrete should not be made to flow into its final position through the use of vibrators, or be dropped from heights of more than 2 m.

4.8 Compaction of Concrete

Adequate compaction of the concrete significantly reduces its porosity, increases its strength, enhances the abrasion resistance and general durability, and minimises the risk of cracking. While any deeper sections of the pavement such as edge thickenings and downturns should be compacted using an immersion vibrator, for slabs on ground that are 100 mm or less in thickness, adequate compaction can usually be achieved through the placing, screeding and finishing processes. Sometimes, surface vibration will be used in the form of a small hand-held vibrating screed.

Immersion vibrators are not recommended for 100 mm thick slab-on-ground construction as the slab depth does not allow proper immersion of the vibrator head, and the plastic sheeting under the slab (if present) may be damaged.

4.9 Floating the Concrete

After the concrete is placed and compacted, leave the surface until the bleed water has stopped coming to the surface, i.e. the surface appears dry. At this stage work the surface smooth with a ball float or magnesium float. Some finish types, e.g. course broom, can be applied directly after this compaction and leveling stage.

Generally power floating and power trowelling are not used on pavements.

In hot or windy weather care needs to be taken to prevent premature drying of the surface (see 4.11).

4.10 Surface Finishes

Slip and skid resistant concrete surfaces can be achieved by the appropriate texturing during the finishing operations. The term 'slip' refers to pedestrian traffic while 'skid' is the term used for vehicular traffic. Suitable slip finishes are listed in NZBC Acceptable Solution D1/AS1 Table 2 and are covered here in section 2.5.

Broomed finishes can produce a greater degree of skid resistance, suitable for vehicular traffic. For greater skid resistance on ramps, a steel tyned comb can be used to groove the concrete surface. Compacting the surface of the concrete by trowelling will improve the strength and abrasion resistance, thereby assisting to maintain the slip resistant properties of the surface. It is important therefore that, where possible, the surface be trowelled either prior to the finish being applied (i.e. broom finish) or during the process of applying the finish (i.e. colour surface toppings).

Given the range of decorative products, finishes and finishing techniques available, the suitability of the finish for the intended purpose should be confirmed with either the manufacturer or applicator.

Where a surface sealer that may affect the texture is applied, care should be taken to ensure the finished surface provides the necessary slip and skid resistance. Incorporating silica dust or carborundum dust in an applied sealer is another technique to either maintain or improve the slip/skid resistance. Two types of decorative finish which are frequently used for driveways are an exposed aggregate finish or a stamped finish. These finishes require specialist skill in achieving a decorative finish which will enhance the driveway appearance and retain its décor into the future. These special finishes should not be attempted by the home handyman and before choosing a specialist contractor ask to see three examples of finished driveways using the finish you are contemplating. More detail on these types of finishes can be found in Reference 3.

4.11 Curing of Concrete

Residential pavements for foot and light vehicular traffic should be cured for a minimum period of 3 days. This should be increased to 7 days if located near the coast (within 1 km) and/or subject to heavier traffic. Curing allows the concrete to achieve its potential strength and durability. When concrete is not cured (i.e. is allowed to dry out too quickly), a significant reduction in its strength results. The reduction of concrete strength has a significant effect on abrasion resistance of the surface of the pavement when used by vehicular traffic. One of the main contributors to surface wear and dusting problems is the reduction in strength due to inadequate compaction and curing.

Typical methods of curing concrete pavements include: covering the concrete with an impermeable membrane (e.g. plastic sheeting weighted in contact with the surface or a chemical curing compound complying with AS 3799 or ASTM C309); or by keeping any exposed surfaces continuously wet (e.g. ponding or spraying with water). Wetting at intervals (e.g. in the morning and afternoon) does not keep the concrete continuously moist, particularly in hot weather conditions and is therefore not regarded as an adequate method. Black plastic should not be used for curing of external surfaces, as this may increase heat gain and cause problems with slab curling.

Decorative concrete pavements should not be cured with plastic sheeting, damp sand or wet hessian, as these materials may promote uneven colour or staining.

Chemical curing compounds compatible with the sealer, or the sealer itself if complying with the requirements of a chemical curing compound, should be used for these types of decorative pavements.

4.12 Hot and Cold Weather Conditions

Concrete should not be placed at ambient temperatures higher than 30°C or lower than 5°C with the temperature descending or below 2°C with the temperature ascending. In hot weather, early loss of moisture from the slab causing plastic cracking of the surface can occur as the rate of evaporative drying exceeds the rate of bleeding, resulting in the surface drying out prematurely.

A combination of hot weather, low humidity and windy conditions increase the risk of plastic cracking. The use of an evaporative retarder such as aliphatic alcohol (antivap) will slow down the rate of evaporation. The use of wind breaks, shade covers will help but may not be practical in extreme weather.

In cold weather, delayed setting and finishing times, slower strength gain and even freezing of the surface are of concern. Concrete should be protected from freezing for at least 24 hours after finishing by covering the surface with insulative blankets.

Where there is a high temperature swing, in excess of 13°C from daytime to nighttime following the pour, the concrete may crack and should be covered with an insulating blanket.

4.13 Joints

Isolation joints

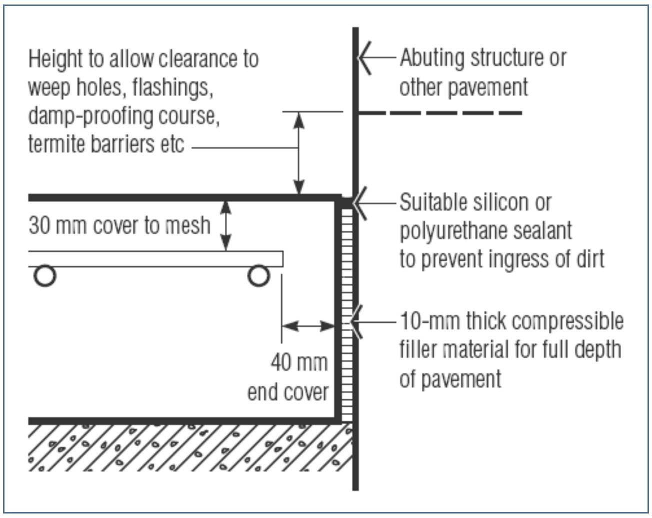

Figure 6: Typical isolation joint

Figure 6, as would be used against the foundations of an adjoining structure for instance, should not impede any relative movement. This may be horizontal, vertical or both and may include rotation. While movement from concrete drying shrinkage will normally cause the joint to open with time, temperature changes may give rise to joint closing movements.

Control Joints

The control joint in **Figure 7** can be made by:

- Saw-cutting a groove with a conventional concrete cutting saw 12-18 hours after finishing.
- Green-cutting a groove with a soff-cut saw following finishing, when the concrete has hardened sufficiently to prevent unraveling.

or alternatively:

- Inserting a pre-moulded strip into the concrete as it is being placed.
- Use of a grooving tool immediately after the concrete has been placed.

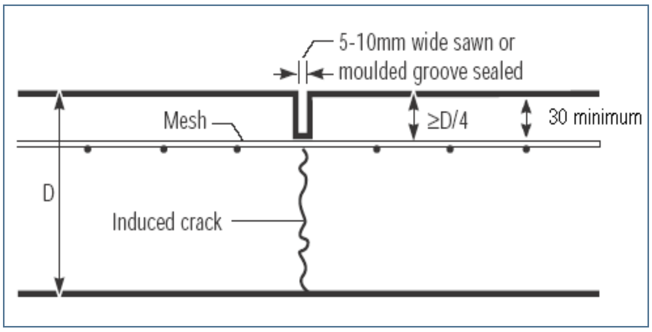

Figure 7: Typical sawcut control joint

Note that if joints are saw cut, these should be installed prior to shrinkage cracking occurring.

As a guide, saw cuts should be made not more than 12 hours after finishing of the slab if temperatures exceed 25°C, and not more than 16 to 18 hours after finishing of the slab for lower temperatures.

To avoid delays, green-cutting (i.e. the same day) is possible using a soff-cut saw. The surface should be thoroughly cleaned after cutting.

If joints are wet-formed by scoring the plastic concrete with an edging tool (tooled joint), ensure that the groove does not fill with cement slurry and render the joint less effective.

Free Movement Joints

For free movement joints the mesh should be terminated each side of the joint. To allow some tolerance in the location of the saw cut, crack inducer or tooled joint, cut the ends of the mesh wires at least 50 mm clear of the proposed joint location (**Figure 8**).

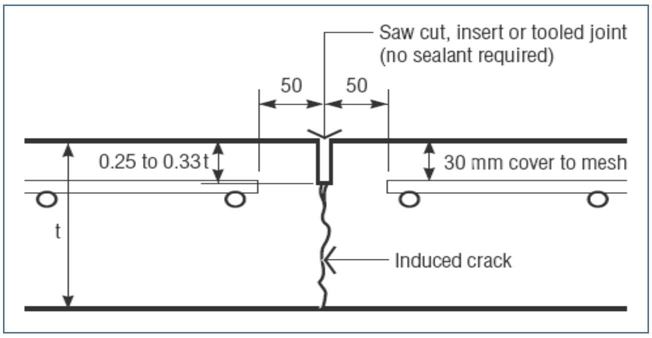

Figure 8: Free movement joint

Construction Joints

A construction joint **Figure 9** is used to accommodate an unplanned break in concrete placement. The joint should be formed to allow adequate compaction and finishing of the concrete along the edge. Once the concrete has hardened, the formwork is removed, the edge roughened to provide aggregate interlock across the joint and the new concrete placed against the existing edge.

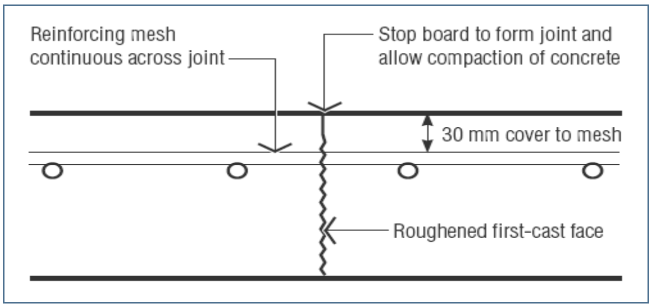

Figure 9: Typical construction joint

4.14 Joint Sealants

Many types of joint sealants are available. For pavements, high-performance sealants such as polyurethane or silicone should be used. They are supplied in cartridges for easy use with a caulking gun, come in a range of colours to suit various decorative finishes and are UV light resistant. While the life of the sealant depends on a number of factors, the following basic rules concerning their use should be observed to achieve adequate performance:

- **Joint preparation.** The surfaces should be clean, dry and primed if necessary. Applying sealants to 'green' concrete can result in bubbling and loss of adhesion. The surface temperature should be above 5°C.

- **Joint geometry.** For typical joints, the cross-sectional depth of the seal should be at least half the width, and never greater than the width.

- **Backing systems.** To perform adequately when the pavement moves, sealants should adhere only to the sides of the joint. While the joint filler will normally ensure this, a backing rod may sometimes be necessary to achieve the required joint geometry.

- **Setting time.** The setting time of the sealant determines when it can be brought into service, or when the pavement can be used. Polyurethane sealants will cure at a rate of about 2-3 mm of depth per day in temperatures over 5°C. Fast-curing and two-part products will be marginally faster. Silicones skin quickly but have a slower cure-through-depth time.

4.15 Surface Sealers

Sealers are used to prevent staining and to facilitate cleaning of the concrete surface. They should be applied after the curing period and when the concrete has dried out sufficiently to allow the sealer to penetrate into the concrete surface.

Note that some sealers may also function as a chemical curing compound and should be applied after finishing. Some sealers may also be tinted and thus provide both a seal and a coloured finish.

As the penetration of sealers into the concrete surface varies, their suitability for a particular application should be discussed with the manufacturer.

Steep driveways warrant special consideration; non-penetrating sealers that form a film on the surface can reduce slip and skid resistance, and are thus generally not suitable for this application unless the surface texture applied to the concrete is coarse enough to still provide adequate slip and skid resistance. Penetrating sealers or those with slip-resistant properties are recommended for steeper grades.

REFERENCES

1. NZS 3104:2003 Specification for Concrete Production

2. Pervious Concrete Payments. Download from www.concretenetwork.com/pervious

3. Cement Concrete & Aggregates Australia (2007). *Exposed-aggregate finishes for flatwork:* Bulletin 02. Download from http://www.concrete.net.au/publications

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