

# BULLETIN



March 2001

NUMBER 412

## CONCRETE DRIVEWAYS



- ❑ Concrete driveways, poured in-situ, can be created in a variety of shapes and finishes. They are durable, cost effective and serviceable, but care should be taken in their design, set-out and installation to ensure lasting benefit is achieved.



# 1.0 SCOPE

1.0.1 This bulletin will help designers, builders and property owners in the selection of materials, installation and finishing options for residential concrete driveways and paths. The information is suitable for:

- driveways with a minimum thickness of 100 mm, intended for cars and trucks up to a maximum loaded weight of 2.5 tonnes
- paths with a minimum thickness of 75 mm, intended for pedestrian traffic only.

## 1.1 Advantages of Concrete Driveways

1.1.1 Concrete driveways are:

- extremely durable
- available in a variety of finishes and textures
- wear resistant
- oil and grease resistant
- relatively low cost.

# 2.0 PLANNING

2.0.1 Planning will include design and layout of the driveway and the selection of complementary materials, such as brick edgings or grass 'islands', which are to be incorporated in the design. Where access to underground services is required, incorporate removable paving areas into the layout.

2.0.2 Single and double driveways should not be less than 2.5 or 4 m wide respectively. Ease of vehicle manoeuvring must also be considered. Territorial Authorities may have regulations requiring

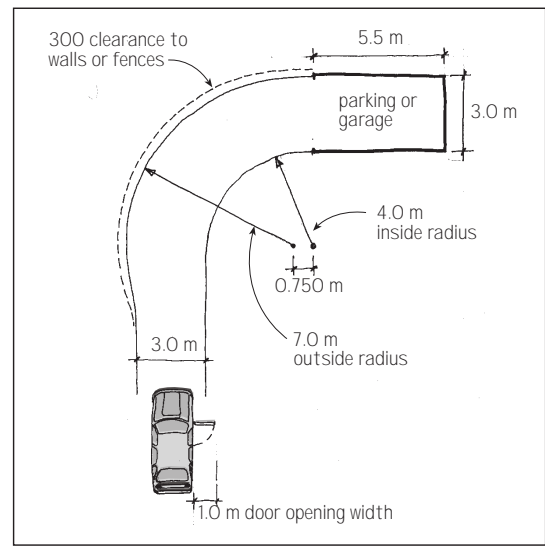


Figure 1. Turning dimensions for medium/large car.

driveways over certain lengths, or which access directly onto main roads, to have vehicle turn-around areas on the site.

2.0.3 Figure 1 shows the turning circle dimensions required by a medium/large car.

2.0.4 A decision also has to be made as to whether the concrete is:

- reinforced or unreinforced
- site mixed or ready mixed (supplied by a batching plant).

Table 1 offers comparisons between site and ready-mixed concrete. The need for reinforcement will depend largely on shrinkage control, as described in Section 6.0.

2.0.5 Site mixing concrete requires a well-organised working area that includes:

- electric-powered concrete mixer (minimum 25 litre) with an earth leakage protector on the power supply
- clean water supply giving trickle feed into a water drum
- container for lading water into the mixer
- dry area for storing cement bags or a cement box
- pre-mixed aggregate and sand (builders mix) adjacent to the mixer
- wheelbarrow, shovels
- clear area for barrow access.

Table 1. Comparison of ready-mixed concrete and site-mixed concrete.

Ready-Mixed Concrete	Site-Mixed Concrete
Bulk delivery enables quicker installation	Smaller mix batches and slower installation are suited to DIY
Uniformity of concrete quality	Variable quality
Requires access by large machinery (e.g. trucks, pumps)	Suitable for tighter work areas
Economic for larger job lots only	Suits smaller job lots
Stronger concrete achievable	Suits concrete strengths up to 20 MPa
Enables uniform curing and finishing work	Slower installation may require overlap of finishing and curing work
Site mixer not required, but may require more hand equipment (e.g. wheelbarrows) and labour	Site mixer required, but may require less labour and hand equipment

# 3.0 BUILDING REGULATIONS

3.0.1 Generally, building consents are not required for concrete driveways laid on ground. However, Territorial Authorities may require:

- resource consent for excavations beyond certain limits and driveways beyond certain gradients and lengths

- building consents for:
  - control of rainwater run-off
  - associated structural elements, such as retaining walls
  - slip resistance, where a driveway is also the main pedestrian access way.

## 4.0 INSTALLATION CONTRACTS

4.0.1 While many concrete driveways and paths may be undertaken by the home owner, engaging a builder or specialist driveway installer should save time and provide a greater degree of expertise in material selection and finishes. For all contracted work:

- specify clearly the extent of the work and materials to be used
- agree a fixed contract price, programme and scope of work (including who is responsible for curing the concrete) prior to the work commencing.

## 5.0 MATERIAL SELECTION

5.0.1 Concrete is a mixture of aggregates, Portland cement and clean water. While the technology of concrete is a complex subject, the following principles will affect the general quality of concrete.

### 5.1 Water and Admixtures

5.1.1 The amount of water needed to obtain hydration (chemical hardening) of the cement is very small compared with what is added to make the mix workable.

5.1.2 For a given amount of cement in a mix, stronger concrete will be obtained if a stiff mix is used, but this is at the expense of workability. Ready-mixed concrete can be specified according to strength and slump. Typically, a slump of 80–120 mm is suitable for driveway concrete. Mixes at the stiffer end of this range (lower slumps) should be used where forming concrete to slopes.

5.1.3 Water should never be added to the ready-mixed concrete on site (to improve slump) without prior consultation with the batching plant, as this could affect the specified concrete strength, and therefore wearability, of the finished concrete surface.

5.1.4 Water-reducing and air-entraining admixtures, to promote workability without strength reduction, are routinely added to ready-mixed concrete above 17.5 MPa strength. Admixtures which affect curing times can be requested. Curing-enhancing admixtures are useful during winter when lower temperatures may

delay curing. Concrete should not be laid if temperatures are 5°C and falling.

### 5.2 Concrete Strength

5.2.1 The strength of concrete will determine its hardness and therefore its wearability, which is a most important requirement for driveways.

5.2.2 Mixing concrete on site will rarely result in a concrete strength above 20 MPa. Site-mixed concrete can also result in variable strength, colour and wearability, because of variations in water and cement content.

5.2.3 Strengths above 20 MPa are considered more suitable to achieve the necessary wear resistance and long-term serviceability for driveways. Where greater wearability and appearance is required, using ready-mixed concrete is recommended.

5.2.4 Concrete strength is also affected by the amount of compaction and curing that occurs. Vibrating the concrete will remove entrapped air, thus increasing density. Correct curing procedures will reduce plastic shrinkage cracking in the surface and improve wearability (see Section 8.3 Concrete Curing).

## 6.0 SHRINKAGE CONTROL

### 6.1 Crack Control

6.1.1 Concrete shrinks as it dries. Unless designed for, the shrinkage stresses can result in cracking in large expanses of concrete and in concrete formed to complex shapes (see Figure 2).

6.1.2 Cracking is controlled by a combination of strategically placed shrinkage control joints and/or reinforcement. Shrinkage control joints will concentrate shrinkage movement/cracking at a predetermined line rather than arbitrarily across a slab. Shrinkage control joints are placed at strategic points across a slab or at major changes of direction, depending on the reinforcing used, as shown in Figures 3 and 4.

6.1.3 Shrinkage control joints can be made by:

- separating strips cast into the slab
- saw cutting the slab after initial set has been achieved
- deep trowelling the wet concrete, just prior to initial set.

6.1.4 Cast-in strips can be either proprietary crack formers or other suitable thin dividers positioned in the slab. Saw

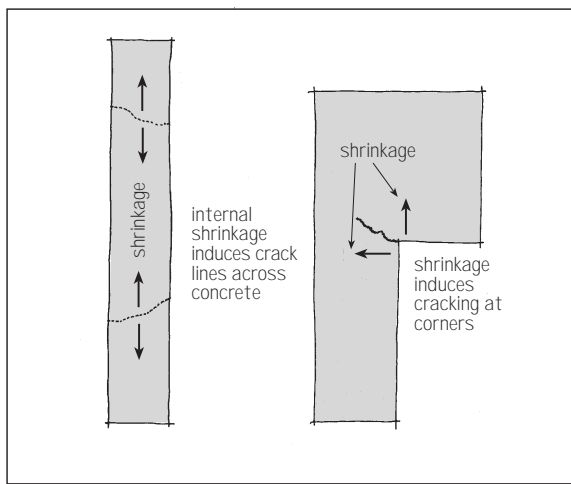


Figure 2. Uncontrolled cracking in concrete slabs (reinforced or unreinforced).

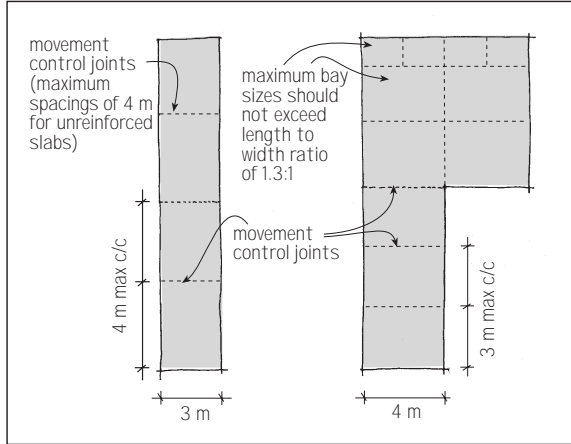


Figure 3. Movement control joint set-out for unreinforced slabs.

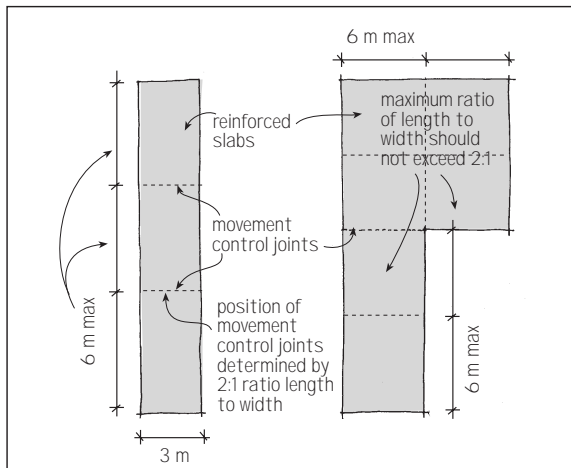


Figure 4. Movement control joint set-out for reinforced concrete slabs.

cutting, deep trowelling or cast-in formers must be to  $\frac{1}{3}$  slab depth in reinforced slabs and  $\frac{1}{2}$  slab depth in unreinforced slabs (see Figure 5).

6.1.5 Where reinforcement is used, crack control joints can be placed further apart because the reinforcement will partly resist the shrinkage forces in the concrete. Concrete driveways can therefore be grouped as either 'unreinforced' or 'reinforced'.

## 6.2 Unreinforced Driveways

6.2.1 Shrinkage in unreinforced concrete is controlled by the size and shape of the concrete area, as shown in Figure 3. Ideally, shrinkage control joints for unreinforced slabs should be at a maximum of 3 m centres. Where square shapes are impractical, rectangular shapes should not exceed a ratio of 1.3:1 length to width or 4 m x 3 m maximum.

## 6.3 Reinforced Driveways

6.3.1 Reinforcement is used in thin slabs (100 mm or less) to reduce shrinkage movement. Its usefulness in preventing cracking caused by loading or by differential settlement of the ground beneath the slab is more doubtful because of the relative thinness of the driveway slab.

6.3.2 Shrinkage control joints for reinforced slabs are positioned at 6 m maximum centres. Again, square shapes are preferable, but rectangular shapes should not exceed a ratio of 2:1, or 6 m x 3 m (see Figure 4).

## 6.4 Steel Reinforcement

6.4.1 Minimum reinforcement is 668 mild steel mesh, lapped 150 mm at joints, or D10 mild steel bars at 300 mm centres in both directions, with all bars tied at intersections. The steel should be at least 50 mm inside the outer edges of the slab and at least 30 mm below the top surface. The steel must be in the top half of the slab to resist shrinkage cracking.

6.4.2 For small offsets in slabs, shrinkage control may be attempted with the use of supplementary steel in place of crack control joints. Steel for crack resistance is placed diagonally across the corners, as shown in Figure 6. While this method of crack control can be applied to both reinforced and unreinforced concrete, it is not as reliable as shrinkage control joints and is therefore recommended for minor offsets only. Where crack control is to be relied on, use properly formed crack control joints.

## 6.5 Fibre Reinforcement: Polypropylene

6.5.1 Adding cut strands of polypropylene to the concrete mix will add strength and increase wear resistance. This cut strand admixture also enables an increase in the maximum spacings of crack control joints from 3 m to 4 m in unreinforced slabs.

6.5.2 Use fibrillated polypropylene cut strands (approximately 25 mm long), at the rate of 0.9 kg/m<sup>3</sup> of concrete. The fibres are added as the last ingredient during the mixing process.

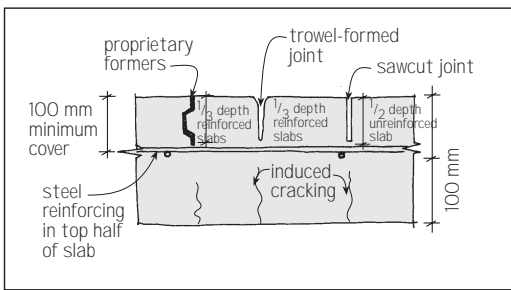


Figure 5. Alternative crack control joints.

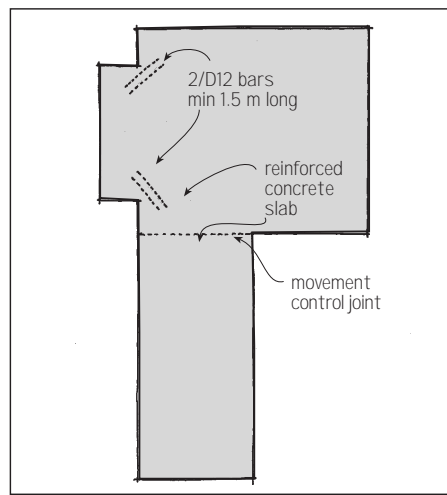


Figure 6. Diagonal steel crack restraint for small offsets.

## 7.0 PREPARATION

7.0.1 Clear away topsoil and dig out any loose or soft patches to expose a base of original firm ground. (A simple test for adequate firmness is when a 12 mm diameter steel rod cannot be pressed into the ground). Loose materials such as firm sand and gravels will provide a suitable base, but they need to be 'contained', i.e. prevented from eroding or moving out from under the slab.

7.0.2 Excavate the ground to the levels required and follow any necessary gradients, so that prepared ground is approximately 100 mm below finished slab levels. Pathways for pedestrian traffic can be 75 mm thick, but maximum bay sizes (as described in 6.2.1) should be reduced to 2.5 m maximum.

7.0.3 Clear away loose material. Hollows can be filled with a compacted basecourse material or weak concrete. It is best to pre-fill these so that the slab has a uniform thickness, which will reduce the tendency for random cracking.

7.0.4 Build up perimeter edges as screeds for finishing slab levels, either by using temporary formwork or with permanent

edgings. Temporary screeds, to reduce screeding spans to about 3 m, can be placed through the centre of larger slab areas to aid levelling. Long screed spans will risk sagging of the screed board, creating hollow areas in the centre of the slab where rainwater could later pond.

7.0.5 Minimum falls of 1:100 are required to achieve water run-off and reduce the risk of ponding.

7.0.6 Slab edge thickening is generally not required, although reinforced edge thickening can provide better resistance for wheel loads at vehicle crossings and along edges of vehicle slabs. Also use edge thickenings to reduce the risk of undermining of the slab over sand and gravels.

7.0.7 Dampen the ground and the edge formwork immediately prior to placing the concrete, to prevent accelerated drying and reduction of concrete strength.

Table 2. Slip resistance guide for surface finishes to driveways and paths.

Concrete finishes	Level surface		Sloping surface	
	Resistance when dry	Resistance when wet	Resistance when dry	Resistance when wet
Smooth trowelled	yes	no	yes	no
Wood float	yes	yes	yes	yes
Broomed	yes	yes	yes	yes
Exposed rounded aggregate	yes	Test results required	yes	Test results required
Exposed crushed aggregate	yes	yes	yes	yes
Patterned	yes	yes	yes	yes
Painted	yes	no	no	no

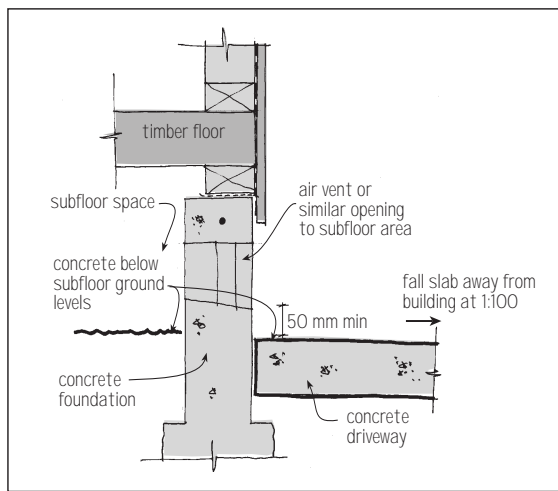


Figure 7. Driveway below subfloor openings.

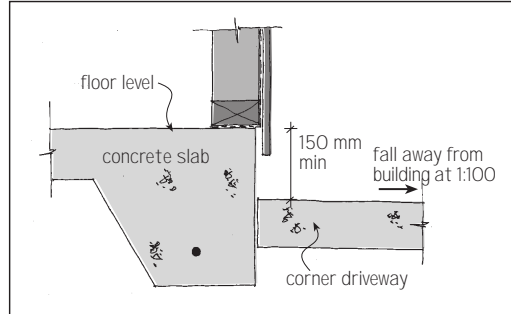


Figure 8. Driveway below concrete floor level.

## 8.0 CONCRETE PLACEMENT AND CURING

8.0.1 A guide for concrete placement and curing is contained in the BRANZ publication *Good Concrete Floors and Basements Practice*. This book is concerned with floor slabs, which generally require a higher level of finish than driveway slabs, and the reader should adapt the information to suit.

### 8.1 Concrete Placing

8.1.1 Key requirements for concrete placing include:

- avoid delays that will allow the concrete to stiffen before placement and finishing
- avoid segregation of the mix, which will occur if the concrete is dropped more than 1.5 m
- place the concrete evenly, spreading it a little higher than finished levels, and keep a moist edge against which to place the next load
- compact the concrete (preferably with a 20-30 mm head mechanical vibrator) to remove air entrapped during the handling process, and settle the concrete against edge screeds.

### 8.2 Concrete Levelling

8.2.1 Key requirements for concrete levelling include:

- strike off the concrete to finished levels using a screed board, or straight edge, passed across the formwork edges (mechanical screeders are not generally required for driveways)
- trowel the driveway surface to a consistent smoothness ready for surface finishes (see Section 9.0).

### 8.3 Concrete Curing

8.3.1 The key requirement for concrete curing is prevention of rapid drying of the surface of the slab by:

- protecting it from direct sunlight
- sheltering it from drying winds
- maintaining a moist surface using a fine mist spray for the first three days. (Heavy sprays or water flooding will risk spoiling surface textures).

## 9.0 SURFACE FINISHES

9.0.1 Surface finishes for driveways usually require a greater degree of slip resistance than internal floor slabs. Surfaces for pedestrian accessways must meet slip resistance requirements described in Clause D1 *Access routes* of the New Zealand Building Code. BRANZ Bulletin 370 *Slip Resistant Floors* describes methods of achieving slip resistance. See Table 2 for slip resistance for concrete driveways and paths.

### 9.1 Wood Floating

9.1.1 Finishing the concrete with a wood float will maintain a coarser finish than that produced by a steel float. Steel floating draws water and cement to the surface, producing a harder, smoother finish. However, under prolonged weather exposure and use, this smoothness can be worn away, leaving a patchy appearance. Wood floating will give a coarser finish of more uniform appearance.

### 9.2 Broom Finish

9.2.1 After bringing the concrete to a float finish, and before initial set of the concrete, brush the surface in continuous even strokes using a broom or rake to lightly texture the surface. The brush strokes should be of even pressure, parallel and continuous from edge to edge of the slab. It is usual to make the strokes in the short direction (across the slab) at right angles to the traffic flow.

9.2.2 An added finishing detail is to trowel the slab edges after brooming, to leave a smooth perimeter strip.



### 9.3 Exposed Aggregate

9.3.1 After levelling and trowelling the slab, a suitable retardant can be sprayed or coated onto the exposed surface to delay hydration (setting) of the top surface. After the slab has achieved an initial set, the surface can then be pressure hosed to remove fines and laitence, exposing the aggregate. Uniform retardant application and water pressure are important in achieving an evenly textured finish. Prepare a test area first to determine the degree of texturing required.

### 9.4 Patterning

9.4.1 Pattern stamping of the concrete surface can be undertaken to produce a geometric 'paving', 'cobblestone' or similar finish to the top surface. Steel stamping frames are used, but these are usually only available from contractors who will undertake the complete work of slab installation. Pattern stamping is often undertaken in conjunction with coloured concrete.

### 9.5 Coloured Concrete

9.5.1 Concrete can be coloured using liquid or powder pigment. More uniform results are achieved with pre-mixed concrete where a whole batch or job lot can be mixed to the same colour. On-site colouring, where pigment is applied to each mix, is more prone to colour variation. Colour pigments can usually be purchased at a local hardware store and application rates will depend on the density of colouring required. Follow the manufacturer's recommended doses. It is recommended that sample batches be prepared to determine mix and pigment quantities for the required colour effect.

9.5.2 Discuss the use of pigments with read-mixed concrete suppliers, as some accelerating admixtures used in conjunction with pigments will result in a blotchy appearance.

9.5.3 An alternative colouring procedure is 'dry shaking', where dry powder is applied over the concrete surface while it is still wet. This gives a distinctly mottled effect.

## 10.0 CONTROL OF WATER RUN-OFF

10.0.1 Concrete driveways are impervious surfaces which, over large areas, can accumulate significant rainwater run-off. If uncontrolled, this run-off can:

- erode ground from the edge of the slab

- cause ponding on the slab surface
- overflow into adjacent internal buildings
- overflow onto roadways, in possible contravention of Territorial Authority requirements.

10.0.2 To avoid edge ground erosion:

- form an edge channel and drain to a collection point
- shallow dish the concrete and provide a yard sump and piped drainage to a soak pit or stormwater system (check first with Territorial Authority).

10.0.3 To avoid ponding, form finished surfaces to a definite fall, form collection points and drain to stormwater drains.

10.0.4 To avoid overflows into adjacent internal buildings:

- ensure driveway surfaces fall away from buildings
- provide overflow points at least 150 mm lower than internal concrete floor levels
- finish driveway levels at least 50 mm below subfloor air vents on sills of basement doorways, and ensure subfloor ground level is higher than the driveway surface (see Figures 7 and 8).

10.0.5 To avoid overflows onto roadways, form collection points and drain to stormwater drains.

## 11.0 FURTHER READING

### BRANZ Bulletins

- 351 Preventing Corrosion of Reinforcing Steel in Concrete
- 370 Slip Resistant Floors
- 382 Curing Concrete
- 363 Repairing Cracks in Concrete
- 372 Durability and Crack Control in Domestic Concrete Floor Construction
- 395 Timber Framed Garages
- 285 Designing for Thermal and Moisture Movement.

### BRANZ Publications

Good Concrete Floors and Basements Practice.

## 12.0 CREDITS

BRANZ acknowledges the input to this bulletin, in the form of critical comment, from:

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Alan Martin, The Open Polytechnic of New Zealand  
Greg Burn, Fletcher Residential Ltd.  
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<b>CBI 92-23</b>
CI/SfB   (90.4)   Eq4
Date: March 2001

ISSN 1170-8395

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