Concrete Roundabout Pavements

Technical Guide

Roads and Maritime Services | 26 August 2019

Document No. | RMS 19.1353 | Issue No. 4
About this release

<table>
<thead>
<tr>
<th>Issue</th>
<th>Date</th>
<th>Revision description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>August 2019</td>
<td>Major review. The sections that are already covered in the RMS Specifications or in the pavement standard drawings for SFCP have been deleted.</td>
</tr>
<tr>
<td>3.0</td>
<td>March 2004</td>
<td>Minor changes</td>
</tr>
<tr>
<td>2.0</td>
<td>March 1998</td>
<td>Minor changes</td>
</tr>
<tr>
<td>1.0</td>
<td>April 1996</td>
<td>Original publication</td>
</tr>
</tbody>
</table>

Title: Concrete Roundabout Pavements

Document Number: RMS.19.1353

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Authorised by: Director, Pavements and Geotechnical
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1 Introduction

1.1 Scope

Roundabouts are special forms of intersections designed to accommodate vehicles of all sizes, including emergency vehicles, buses, and truck and trailer combinations. By their nature, roundabouts create unique pavement design and construction challenges.

This Guide has been written to provide guidance on all aspects related to the joint layout design and construction of concrete roundabouts. The Guide only briefly discusses related issues such as geometric design and construction challenges with the view to providing guidance on how to overcome them. For aspects related to pavement thickness design, refer to sources listed in Section 3.

The Guide is intended to assist both designers and constructors and has been prepared to reflect current Roads and Maritime design and construction practices and requirements as developed in successfully completed projects. The principles outlined may also be applicable to non-roundabout intersections (including seagulls) of curvilinear layout.

1.2 Range of applications

Concrete roundabout pavements were first constructed in NSW in the early 1980s and have been adapted to a wide range of intersection sizes and layouts. They vary in size and capacity from relatively small intersections of local roads to very large intersections on highways. Their inner radius ranges from less than 5 m to greater than 50 m.

Examples of concrete roundabouts can be seen in urban locations such as Grafton, Ballina, Glen Innes, Woolgoolga, Coffs Harbour, Lismore, Taree, Warners Bay, Newcastle, Wyong, Gosford, Dubbo, Cooma, Albury and Corowa. Larger examples are located on the Goulburn Bypass, Ballina Bypass (see Figure 1 below) and on the Link Road from the M1 Motorway to Newcastle.

![Figure 1: Large grade separated roundabout at Ballina Bypass during construction](image-url)
1.3 Need for concrete roundabout pavements

Pavements within turning areas such as intersections are subject to abnormally high forces from heavy vehicles. Overturning moments impart loads onto the outer wheels as high as 60 to 80% of the total axle loading, as shown in Figure 2 below, thus imposing high compressive, flexural and shear forces within the pavement. These stresses increase with increasing speeds and reducing turning radii.

Concrete offers very competitive benefits as a pavement and wearing-surface material under such loading conditions.

1.4 Benefits of concrete pavement

The benefits that are typical for concrete pavements are:

- Economics: On the basis of whole-of-life cost, concrete roundabout pavements offer a very competitive option.
- Maintenance demand: Worldwide experience has shown that rigid pavements, when competently designed and constructed, provide a relatively low maintenance asset throughout their design life. Maintenance demand is likely to be an important consideration at intersections which are subject to high traffic.
- Construction expediency: A rigid pavement will normally be thinner than the flexible alternatives. The costs and risks associated with excavation, particularly in urban areas, are therefore reduced and this may provide significant benefits in areas of poor subgrade quality where compaction of granular materials is likely to be most difficult. Within commercial and residential areas, this may also lead to a reduction in vibration, noise and dust. It will also provide reduced impact on public utilities.
- Piecemeal Construction: Construction within urban areas is often necessarily piecemeal because of the constraints of public accesses. Such conditions are likely to restrict the use of large rollers in placing flexible pavements.
- Surface durability: A concrete pavement provides a durable, high-friction wearing surface.
- Local community benefits: In some country areas, raw materials for concrete will be more readily available than those for alternative pavement types, and construction will be more readily undertaken by local staff and contractors.
1.5 Performance

The majority of concrete roundabouts constructed to date in NSW have performed with very low maintenance demand. The rare cases of premature distress have invariably been related to poor joint design and/or construction quality.

Early designs commonly yielded slab dimensions up to 15 m which is far in excess of the current recommended limits. Some of these now exhibit significant permanent edge curling which appears to be related to the large dimensions; however, to date, the incidence of associated failure has been low.

1.6 Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>CRCP</td>
<td>Continuously reinforced concrete pavement</td>
</tr>
<tr>
<td>JRCP</td>
<td>Jointed reinforced concrete pavement (mesh reinforced, dowelled)</td>
</tr>
<tr>
<td>LCS</td>
<td>Lean-mix concrete subbase</td>
</tr>
<tr>
<td>PCP</td>
<td>Plain concrete pavement (untied, unreinforced)</td>
</tr>
<tr>
<td>PCP-R</td>
<td>Discrete reinforced slabs in otherwise plain concrete (PCP)</td>
</tr>
<tr>
<td>SFCP</td>
<td>Steel fibre reinforced concrete pavement</td>
</tr>
<tr>
<td>SFRC</td>
<td>Steel fibre reinforced concrete</td>
</tr>
<tr>
<td>SFCP-R</td>
<td>Discrete mesh-reinforced SFCP slab(s)</td>
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A more comprehensive list is provided in specification R83.

1.7 Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Trafficked slab</td>
<td>A slab is deemed to be trafficked if any part of that slab lies within the trafficked carriageway as defined by line marking.</td>
</tr>
<tr>
<td>Free edge</td>
<td>The term free edge is used in the context of limiting all restraint against the free movement of joints which are aligned normal to that edge/joint. A free edge is provided by an isolation joint or at an outer edge. (An isolation joint is provided to isolate the concrete pavement against other structures or material other than concrete). An isolation joint constitutes both a free edge and a relief edge.</td>
</tr>
<tr>
<td>Relief edge</td>
<td>The term relief edge is used in the context of the analysis of contraction stresses and tiebar design. A relief edge is defined as one which relieves contraction stresses in joints and/or edge ie an untied joint or an outer edge. By way of definition, a longitudinal untied butt joint constitutes a relief edge but does not constitute a free edge. It is a relief edge because it relieves transverse contraction stresses in the adjacent slab and in any parallel joints. Mismatching of transverse joints cannot be allowed.</td>
</tr>
</tbody>
</table>
across a butt joint because transverse joints in the first-placed face can induce cracking in the fresh (second-placed) slab.

It follows from the above discussion that an isolation joint should typically be continuous between free edges.

Shape factor Length to width ratio of a slab.

1.8 Joint notation

At this point in time concrete roundabouts in NSW are invariably constructed in SFCP. All joints in this guide are marked as Type F, ie F1, F2, etc. Refer to the rigid pavement standards drawings for SFCP roundabouts for joint details.

2 Design Considerations

The design of concrete roundabout pavements presents several unique challenges. Some of these challenges are listed below:

a. For a typical roundabout geometry, it is impossible to avoid a high incidence of odd-shaped slabs with acute corner angles. Concrete is structurally most stable in slabs which are essentially square and with corner angles no more acute than 84°. Table 1 shows the relationship between corner angularity and stress level.

Table 1: Effect of corner angle on stress (Williams, 1986)

<table>
<thead>
<tr>
<th>Corner angle</th>
<th>Relative stress (%)</th>
</tr>
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<tbody>
<tr>
<td>90°</td>
<td>100</td>
</tr>
<tr>
<td>84° (a)</td>
<td>110 (c)</td>
</tr>
<tr>
<td>80° (b)</td>
<td>120</td>
</tr>
<tr>
<td>70°</td>
<td>140</td>
</tr>
<tr>
<td>60°</td>
<td>175</td>
</tr>
</tbody>
</table>

NOTES:
(a) Equal to a skew of 1 in 10
(b) Equal to a skew of 1 in 6
(c) Interpolation by Roads and Maritime

b. An odd-shaped plain concrete slab is defined by Roads and Maritime as one with a shape factor outside the range of 0.8 to 1.25. (The term ‘odd-shaped’ can also be used to describe slabs with acute corner angles. But, in the context of roundabouts, the two conditions are now separated because the treatment for each may be different, as explained below.)

Plain or mesh-reinforced slabs with higher shape factors are susceptible to mid-slab cracking (though the risk can be reduced by ensuring a high degree of load transfer at joints along the longer edge).
Such cracking is unlikely to be deleterious in mesh-reinforced slabs but is highly undesirable in plain slabs. SFCP will resist cracking at substantially higher shape factors, particularly if supported by long-edge load transfer.

c. Acute corner angles are susceptible to early corner cracking, a condition which is extremely difficult to contain or repair.

d. At steel ratios typically used in pavement slabs, mesh reinforcement is ineffective in preventing cracking of either type (odd-shaped or acute angled slabs). Mesh is effective in containing mid-slab cracks once they occur but is ineffective in containing corner cracking.

e. Within limits, steel fibre reinforcement has been proven very effective in preventing cracking of both types (odd shaped and acute angled slabs). It has also been proven effective in containing cracking once it has occurred (as a result, for example, of poor design detailing). This containment appears to begin at the early micro-cracking stage. SFCP therefore increases the design options of joint layout in roundabouts.

However, steel fibre reinforcement should be considered only as a flexural reinforcement for conventional slab configurations. In zones of unusually high stress (such as anchors), mesh or bar reinforcement is required, sometimes in lieu of, but possibly in addition to, the SFRC.

f. A further benefit of SFRC is the substantial reduction in base thickness due to increased flexural strength. This partly offsets the increased cost of SFRC.

Note that the high flexural strength of SFRC does not derive from the steel fibre reinforcement, but from the high cement content which is required for purposes such as fibre bond and workability.

Hence, the steel fibre reinforcement is incorporated not for the purpose of achieving flexural strength per se, but for its contribution to post-crack strength (toughness) and its apparent capacity to arrest micro-cracking such that full structural cracking does not develop.

PCP and JRCP pavements are feasible only in very large radius roundabouts where corner angles can be maintained above 84°. Angles down to 80° may be acceptable in PCP and JRCP pavements as long as they are kept remote from heavy vehicle wheel paths.

A composite format could be considered such that SFCP is provided within odd shaped areas and PCP or JRCP elsewhere. In practice, however, this is unlikely to be feasible because allowance for centripetal pavement stresses will invariably yield a high PCP/JRCP base thickness which, for practical and logistical reasons, would have to be retained in the SFCP. In the case of JRCP, extreme care would be required in the design and alignment of dowels.

CRCP roundabout pavements have been constructed in Belgium, but have not been tried in NSW. Trials of CRCP roundabouts have been carried out in Texas (See Figure 3).
Macro-synthetic fibres are successfully used overseas in place of steel fibres in concrete pavements. In the United States, macro-synthetic fibres are the most commonly used fibres in concrete paving applications. Figure 4 shows an example of a Macro-synthetic fibre reinforced concrete (MSFRC) roundabout pavement.

In summary, SFCP has provided solutions to several problems associated with the design of concrete roundabout pavements in NSW and until CRCP and MSFRC roundabout technologies are trialed in NSW, SFCP has proven to be the only viable option. This guide covers design options for only SFCP roundabouts.
3 Pavement Thickness Design

Pavement thickness design is conducted in accordance with the Austroads Guide to Pavement Technology Part 2 (Austroads, 2017) and Roads and Maritime Supplement to Austroads Guide (Roads and Maritime, 2018).

Pavement design is conducted using the software RPD developed by Roads and Maritime. In RPD the current design practice for SFRC roundabout pavements is based on flexural fatigue alone using a load safety factor of 1.6. Erosion analysis is not required.

A typical pavement structure with SFRC is shown in the Roads and Maritime Standard Drawings for Typical Pavement Profiles (Roads and Maritime, 2016).
4 Structural Design

The term 'structural design' encompasses aspects such as:

- Pavement thickness design
- Joint layout and detailing
- Reinforcement details (including tiebars)
- Terminal anchors
- Kerbs, islands and medians.

Structural design issues other than thickness design that are specifically related to concrete roundabout pavements are discussed below.

4.1 Geometric joint layout

Geometric joint layouts for roundabouts typically fall within two categories: square plan and radial plan.

4.1.1 Square layout

Design is the same as for a conventional (non-roundabout) intersection with essentially square geometric layout as shown in Figure 5 below:

![Figure 5: Square plan layout](image)

Paving would be undertaken in traditional straight runs with the intersecting roads constructed as 'add-ons'. This layout is best suited to smaller urban intersections where the radius of the central median is low (below about 4 m) and where the kerb radii at the junctions are less than about 10 m. Under the central median it may be structurally desirable to fully pave the base instead of leaving a block-out.

The design of this type of layout generally conforms to conventional design guidelines which are not covered in this Guide.
In larger roundabouts, this design is likely to yield excessive tied widths of pavement unless untied joints are provided.

### 4.1.2 Radial layout

An example of a radial layout is provided in Figure 6. This is the more common layout and is suited to large arterial and highway intersections.

Design of the radial layout is the main focus of this Guide.

![Figure 6: Radial plan layout](image)

For the purposes of this Guide, roundabouts are categorised according to plan size in accordance with Table 2. However, these are only vague classifications and some designs may not fall clearly within one category.

<table>
<thead>
<tr>
<th>Category (and example)</th>
<th>Inner Radius, $R_i$ (m)</th>
<th>Outer circulating radius, $R_o$ (m)</th>
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<tbody>
<tr>
<td>Small (Figure 14)</td>
<td>$\leq 10$</td>
<td>$\leq 20$</td>
</tr>
<tr>
<td>Medium (Figure 15)</td>
<td>$10 &lt; R_i \leq 20$</td>
<td>$20 &lt; R_o \leq 30$</td>
</tr>
<tr>
<td>Large (Figure 16)</td>
<td>$&gt; 20$</td>
<td>$&gt; 30$</td>
</tr>
</tbody>
</table>

The joint layout of small and medium roundabouts will generally be similar. The geometry will usually be such that the extent of odd shaped slabs will dictate the use of SFCP with slab lengths up to 6 m.
4.1.3 Roundabout zones

The layout of larger roundabouts (at least within the central zone, see Figure 7) will often resemble that of a conventional low-radius curve.

It is difficult to prepare 'model drawings' for roundabouts because each site varies significantly in terms of internal and external radii, and in the geometry of the approach legs. In the most difficult locations, the design may need to be a compromise between all considerations, but, with perseverance, it will generally be found that structural compromises can be planned in such a way that their likely impact is minimised.

![Figure 7: Roundabout zones](image)

As shown in Figure 7, the radial layout can be broken into three distinct zones for analysis purposes, namely:

- Central (circulating) zone
- Approach zone
- Transition (or merge) zone.

Central Zone

Within the central zone, the joint layout is designed to facilitate concrete placement in the conventional way by designing the 'longitudinal' axis as circular.

A series of concentric longitudinal joints is provided, the number of which depends essentially on the size of the roundabout. These concentric annuli are then intersected by radial transverse contraction joints. This forms a series of segments, the geometry of which is largely dictated by limits imposed on slab length and shape.

The circulating longitudinal joints are tied to contain radial (outward) migration of the slabs, and the radiating transverse joints are conventional contraction joints.
Approach zone

Within the approach zones, design and construction conform to conventional methods, i.e. the longitudinal joints are tied to prevent lateral spread and the transverse joints are conventional contraction joints. If the total tied width exceeds 22 m in accordance with the pavement standard drawings for SFCP (Roads and Maritime, 2019), an untied joint is introduced, normally along the crown and away from wheel paths.

In some cases, it may seem more convenient and/or economical to construct the approach zone in flexible pavements, but the following issues should be considered:

- Braking vehicles will impose high horizontal shear forces in approach legs that carry significant heavy vehicles.
- Given that the central zone is typically 10 m to 15 m wide, the magnitude of cyclic radial movement at the outer edge is likely to be about 5 mm. A flexible pavement constructed against this moving edge is likely to present a high maintenance demand.
- This problem can be countered by constructing two concrete slabs in the approach, with an anchor in the outer slab to reduce movement. On lightly trafficked legs, a single approach slab with anchor may be adequate.

Transition zone

The transition zone fills an area of irregular shape and will invariably present the greatest challenge in meeting the design guidelines. The transition zone is tied to the central zone (to prevent outward spread of the smaller slabs) and must therefore be structurally compatible.

An isolation joint is placed between the transition and approach zones to overcome the conflict of movement between the longitudinal direction in the approach roads and the radial direction in the central zone.

A sound joint layout caters for several factors, the dominant ones being:

- Construction aspects
- Structural integrity of the pavement.

Each of these is treated in detail below.

4.2 Construction aspects of design

The typical design shown in Figures 10, 11, 12 and 13 illustrates the principles outlined in this Section. Issues which warrant consideration at the design stage include:

- Concrete placement methods (slipformed vs fixed form)
- Practical paving widths and lengths
- Location of formwork to produce the design profiles
- Construction sequence
- Provision for traffic
- Availability of working and access space
- Location and type of kerbs, medians and traffic islands, and their construction sequence.
The efficient construction of roundabouts requires careful planning and scheduling of the concrete pours. The operating constraints vary significantly between projects, but common issues and practices are discussed below.

4.2.1 Placing method

Slipform placement is likely to be practicable only in larger radius roundabouts and on long approach legs. The use of a slipformer will impose some limitations; slipforming (with locally available machines) cannot be undertaken alongside existing kerbs. Conversely, construction of a kerb alongside an existing slab can be done by slipformer but not by an extruder. Hence, the choice of placement method may dictate the construction sequence.

4.2.2 Paving widths

It is logistically practical using modern, lightweight vibrating screeds to pave multiple-lane widths in a single pass. However, the designer should be aware of the inherent risks before allowing this practice (by specifying and/or permitting induced longitudinal joints). Major issues are:

- Risk of unsuccessful joint initiation. Refer to Section 4.6.1 for further information;
- Likelihood of reduced standards of workmanship in relatively wider area of paving without formed longitudinal joint. Refer to Sections 6.6 and 6.7 for further information.

4.2.3 Kerbs

It is often convenient to construct the outer kerb on the subbase concrete before the main paving slabs. The kerb can then be used as a screeding form and must therefore be constructed to close horizontal and vertical tolerances.

The same practice applies (at medians and islands) to type SE kerbs, but obviously not to type SF kerbs, a factor which may influence the choice of kerb type (Roads and Maritime, 2017). (Note also that the choice of kerb type may influence the jointing plan in the adjacent base, particularly at median noses.)

4.2.4 Medians and islands

Program the construction sequence of medians and islands to maximise flexibility in traffic management.

4.2.5 Traffic management

Advanced detailing of traffic movements and construction signposting, and advance notice of road closures or traffic changes are essential in view of the restricted working space and the concentration of traffic at intersections. Staging of construction should be considered in planning for traffic management.

The typical construction time for a roundabout is 9 -12 weeks, of which the concrete paving accounts for some 6 - 8 weeks. Included in these times is a delay of some 7 - 10 days after placing of base before it can be trafficked.

4.2.6 Sequence of construction

The central zone should be constructed by paving the outer runs first and then progressing towards the centre. This is likely to result in greater success in initiating transverse joints; this is explained in Section 4.6.5.
4.3 Structural Aspects of Design

Issues for consideration include:

- Joint location
- Total tied widths
- Slab shape factor
- Slab corner angles
- Traffic spectrum, and swept paths of heavy vehicles
- Surface profiles and superelevation
- Location and type of kerbs, medians, islands and pits.

Specific design issues are treated below.

4.3.1 Longitudinal joint location

Longitudinal joints should preferably be located close to, but within 0.1 m to 0.3 m offset from lane lines. The following factors are also to be considered:

- Visually they will be less obtrusive the closer they are to lane lines but raised pavement markers must not be placed over joints.
- For structural reasons, truck loadings are best kept away from joints. This applies less to tied corrugated joints than to untied joints. Furthermore, it should be accepted that within a roundabout there will necessarily be regular lane changing.
- The ride quality along a joint is likely to be inferior, and vehicles tend to track towards the centre of the roundabout. Joints would therefore be better located inside lane lines rather than outside them.
- Where it is impractical to locate them beside lane lines, joints should be placed centrally between lines rather than in the wheelpaths. In this context, 'centrally' can be taken to mean the central 0.4 m. The minimum preferred distance from a lane line is 1.5 m.

4.3.2 Total tied width

The total tied width in plain pavements is in most cases, typically limited to about 16 m. In SFCP, it would seem safe to increase this to about 22 m based on its increased tensile and flexural strength. This limit covers most design situations in typical roundabouts, except for the approach zones where this limit may be reached.

4.3.3 Isolation joints

An isolation joint is required to separate the transition and approach zones because of the conflict in the orientation of contraction joints.

All horizontally-moving joints (contraction and isolation) must be daylighted to a free edge to ensure that their movement remains unrestricted and that this movement does not induce cracking in the adjoining slab. The isolation joint provides a free edge for the radiating contraction joints where they would otherwise intersect the transverse face of the approach pavement.

Deflection angles are sometimes required in isolation joints, but they should be avoided if possible, because of the risk of a mismatch with the underlying subgrade beam.
4.3.4 Kerbs

Details of kerb interface with SFCP are provided in the pavement standard drawings for SFCP (Roads and Maritime, 2019).

Joint design adjacent to islands and medians warrants close attention to ensure that small portions of kerb will not be separated when the base joints are extended into the kerb. Median noses are the areas of greatest risk. The angle of intersection between the joint and the kerb should also be checked to minimise the risks of kerb spalling at acute angles. Joints which are located directly under, and parallel with, overlying kerbs (such as type SF) will induce cracking and spalling in the kerb within days of its placement.

At traffic islands, it will sometimes be better to construct the base under the full island area but, in other cases, the base can be omitted. Factors to be considered are:

- Possible future island changes can be simplified by full construction of the base.
- In some situations, joint layout design will be simplified by omission of the base but in others it will be simplified by provision of a continuous base (in terms of corner angle criteria, etc).

Where the base is discontinuous, two possible options are to construct a type SE kerb or widen the base by 0.5 m and provide a type SF kerb on the base widening. Refer to RMS standard drawing for kerb and channel details (Roads and Maritime, 2017).

4.3.5 Subgrade beams

At isolation joints and untied longitudinal joints, load-transfer efficiency can be enhanced to some degree by providing a subgrade beam under the subbase. However, it should be recognised that subgrade beams provide only limited structural contribution and hence it will invariably be better to locate untied joints outside commercial vehicle wheelpaths, in which case a subgrade beam is not warranted.

4.3.6 Terminal anchors

Anchors are provided at the interface between concrete and flexible pavements, at bridge structures and at steep grades. Refer to pavement standard drawings for SFCP (Roads and Maritime, 2019) for warrants.

Anchors fulfil two main functions:

- Restrain long-term growth of the concrete pavement and hence protect the adjoining flexible pavement or structure, and
- Prevent excessive opening of the transverse joints by restraining pavement growth, hence minimising sealant stresses.

The magnitude of cyclic horizontal movement at the concrete-to-flexible interface is proportional to its distance from the anchor, and hence this dimension should be limited to minimise stress on the flexible pavement. However, a lower limit of about 1.1 m is set, based on structural requirements of the anchors.

In a typical rural situation, a terminal / intermediate anchor may be required to restrain several hundred metres of pavement against outward thrust towards a major structure. Under these conditions, an anchor of 1.2 m depth (Type 12) is required. Under urban conditions where the terminal anchor is restraining less than, say, 25 m of pavement, an anchor of 0.6 m depth (Type 6) should suffice. In this context, at the interface of SFCP roundabout and flexible pavement a Type 6 anchor is sufficient.
4.3.7 Pits

Where pits are located within the pavement area, there is a high risk of unplanned cracking emanating from the corners. Joints adjacent to drainage pits should preferably be located such that they either align with one edge of the pit or are offset from the pit by not less than 1 m. If the structure cannot be aligned with the joints, it should be isolated completely from the pavement.

It is recommended that steel bars (trimmer bars) or mesh be provided to contain any cracking which occurs.

4.3.8 Tiebar spacing

Tiebars are provided to prevent the opening of the joint, so that aggregate interlock is maintained, and the ingress of incompressible material is minimised. They are typically 12 mm diameter bars, or occasionally, 16 mm.

Design guidelines within this Guide are based on the use of 12 mm diameter grade D500N tiebars, designated as ‘N12’ in accordance with AS/NZS 467114.

In transverse construction joints, the spacing is constant at 500 mm centres. For tiebar spacing in longitudinal joints refer to Table 7 in the pavement standard drawings for SFCP. The spacing in the longitudinal joints is reduced with increasing distance to the nearest relief edge.

In a typical roundabout layout, the inner-most Type F2 joint will have a constant tiebar spacing, because the median will typically constitute the nearest relief edge, and the joint will be at a constant distance from that median.

By contrast, the outer-most Type F2 joint will be located at a varying distance from its nearest relief edge. In some locations, the nearest relief edge will be an isolation joint and in other places it will be the back of the kerb.

Within the transition zone, therefore, tiebar spacing in the outer joint should theoretically be continually varied along the joint. This would be logically impractical (given that formwork has to be drilled to accommodate the ties) and prone to error, and so a compromise spacing needs to be chosen. It would be reasonable to nominate one (constant) spacing throughout each transition zone based on the longest relief edge distance.

Spacings are conveniently marked on plans using the following notations (Figure 8).

![Figure 8: Notation of constant spacing and change points](image)

When preparing construction drawings, the joint type and number of tie bars per slab should be labelled following the convention shown in Table 2 in the pavement standard drawings for SFCP (Roads and Maritime, 2019). It is tempting to provide just a table of design spacing in lieu of indicating the number of tiebars. This is strongly discouraged because it merely delegates the responsibility for design to the field staff. The interpretation and application of ‘relief-edge distance’ can be a challenging exercise for experienced designers. Therefore, this task should not be left to field staff who are invariably working to tight deadlines under exposed outdoor conditions.
4.4 Slab size and shape

Refer to Table 4 in the pavement standard drawings for SFCP (Roads and Maritime, 2019) for slab dimensional limits.

4.4.1 Slab width

In wide slabs curling stresses may develop which can induce cracking within the early days of construction. Hence, the maximum slab width is limited to about 4.3 m.

Minimum slab width can be reduced in SFCP compared to PCP due to the increased resistance to block cracking of SFCP. The minimum width in SFCP is limited to 1.0 m and 0.3 m for trafficked and un-trafficked areas respectively.

4.4.2 Slab length

In SFCP, European experience indicates that 6 m is the corresponding reasonable limit for integrity of both the slabs and the transverse contraction joints.

The rationale in justifying an increase in slab length from 4.2 m in PCP to 6.0 m in SFCP is neither based on, nor supported by, mechanistic design theory but is related to the perceived higher capacity of SFRC to transfer shear stresses and to resist abrasion at the joint faces. However, consideration is also warranted of the fact that SFCP slabs tend to exhibit higher levels of permanent curling than do conventional slabs, though this has only rarely caused concern. The effect is thought to be related to the reduced creep relief in fibre reinforced concrete. On this basis, the Portland Cement Association (USA) suggests a rule-of-thumb guide that the length (in feet) be limited to 2.0 - 2.5 times the thickness (in inches). Hence, slabs of 180 mm would be limited to about 5.5 m and slabs of 200 mm to about 6.0 m.

On curves, the recommended maximum slab length applies at the outer edge.

In the pavement standard drawings for SFCP (Roads and Maritime, 2019) the lower length limit in SFCP is specified with the aim of minimising the uneven induction of joints. Slab lengths of 4 m to 6 m are preferred and the use of lower values should be limited to the inside of curves (where they are often unavoidable).

4.4.3 Shape factor

As mentioned in Section 2, in any roundabout there will invariably be a high incidence of odd-shaped and acute-cornered slabs. Mesh reinforcement in PCP (at typical steel ratios) is effective in slabs of poor shape factor but is largely ineffective in slabs with acute corners. SFCP is effective in both cases.

Experience to date indicates that SFCP can sustain much higher shape factors than conventional slabs but as of yet there is insufficient data available to derive specific recommendations. However, slab width limits detailed in the pavement standard drawings for the SFCP (Roads and Maritime, 2019) appear acceptable for slab lengths up to 6 m on the condition that one or both of the longer edges is afforded good load sharing with adjacent slabs via tied and corrugated faces.

By inference, a shape factor of maximum 6 (and about 20 in un-trafficked areas) is considered acceptable but this should be used with caution and with consideration of the specific loading conditions. Added insurance could be provided by incorporating mesh reinforcement (SL82) in these slabs.
4.5 Subbase joints

In lean-mix subbase, there is no limitation to the width between longitudinal joints, and hence multi-lane subbase paving is allowed without the need to induce intermediate joints. However, if longitudinal joints are provided, they must be located offset from, but close to, longitudinal joints in the base. A band width of 250 ± 150 mm offset from longitudinal base joints is typically specified.

For transverse joints, there are no restrictions. Subbase joints are untied butt (straight) joints. No treatment (such as scabbling or special debonding) is required apart from the initial curing spray. Corrugated faces are avoided because of the risk of early-age cracking at the concave arris.

4.6 Base joints

The joint types typically used in concrete roundabouts are:

- Type F1 longitudinal – tied and sawn
- Type F2 longitudinal – tied and formed
- Type F4 longitudinal – untied and formed
- Type F7 transverse construction – tied and formed
- Type F8 transverse contraction – untied and induced
- Type F14 isolation – with beam
- Type F15 isolation – without beam.

See Section 4.3.1 regarding preferred locations of longitudinal joints. Longitudinal joints must not terminate at induced joints.

Details of all joint types are provided in the pavement standard drawings for SFCP (Roads and Maritime, 2019). Some important aspects of some joints are provided below.

4.6.1 Longitudinal joints – tied and sawn (Type F1)

In roundabout design, caution is recommended in specifying or allowing the induction of longitudinal joints, and in most cases, it will be safer to specify that they be formed.

The success of induction depends on the stresses under the inducer being higher than those in adjacent sections of the slab. This is reasonably certain where the joint being induced lies centrally between two existing joints (or between a joint and a free edge). But it becomes less certain the further the inducing joint moves away from that central position, in which case a substantial risk exists that cracking will occur at the centre of the paved width rather than under the (offset) sawcut.

Where induced joints are permitted, sawcutting must be completed at the earliest possible time before unplanned cracking occurs. This will usually mean sawing on the night of placement and it will rarely be safe to delay cutting until the following morning. Where a delay is unavoidable (such as in very cold weather), overnight thermal protection may be required on the pavement.

4.6.2 Longitudinal joints – tied and formed (Type F2)

All formed longitudinal joints should be corrugated and tied as shown in the pavement standard drawings for SFCP (Roads and Maritime, 2019).
4.6.3 Longitudinal joints – untied and formed (Type F4)

Untied longitudinal joints should desirably be limited to areas not trafficked by commercial vehicles. It should be assumed that untied joints will open in excess of 2 mm and hence load transfer will be lost. Theoretically, therefore, the pavement thickness design would be based on a ‘without-shoulder’ condition but it will usually be possible to locate untied joints within painted/gore areas at least 0.5 m from commercial wheelpaths, in which case a ‘with shoulder’ design is valid.

Untied joints should be sealed to prevent ingress of incompressible and water. The design of joint sealants for untied joints (and the required reservoir) as shown in the pavement standard drawings for SFCP (Roads and Maritime, 2019) is indicative only and should be checked for specific projects according to the estimated joint movements.

4.6.4 Transverse construction joints – tied and formed (Type F7)

Transverse construction joints (see pavement standard drawings for SFCP (Roads and Maritime, 2019)) are required for planned interruptions such as the end of day’s operations, and for unplanned delays when the suspension of operations is likely to form a cold joint. They must be constructed in addition to contraction joints, and not in lieu of. In other words, a tied construction joint must not be placed in lieu of (and at the location of) a planned contraction joint. Construction joints need not be continuous across adjoining paving runs.

The joint is most conveniently placed normal to the longitudinal joints but in irregularly shaped areas they must be aligned such that corner angle criteria are satisfied.

Construction joints should desirably be located within the central third of a slab and they must also have an adequate separation distance from any adjacent joint (such as a transverse contraction joint or an isolation joint). This separation should be at least 1.2 m.

4.6.5 Transverse contraction joints – tied and induced (Type F8)

Contraction joints are located so that slab dimensional criteria are satisfied (see Section 4.4). Contraction joints must be continuous between free edges, i.e. daylighted.

Contraction joints are formed by sawcut or other inducer such as plastic strip inserts. However, only sawcutting will consistently provide the surface finish required for good ride quality, and hence other techniques should be limited to un-trafficked areas or zones where low traffic speeds impose a lower demand for surface finish.

Mismatching of an untied joint will result in reflection cracking into the adjacent slab and/or locking of the subject joint. Hence, untied joints (such as contraction joints) must never be allowed to form mismatched joints, except across isolation joints.

The typical 1:10 skew of rural contraction joints is usually deleted in urban situations because it introduces onerous construction complications and is probably unwarranted at low speeds.

On straights, therefore, joints are aligned square to the longitudinal joints and on curves they are aligned to meet intersecting joints and kerbs at the maximum angle possible within the recommended guidelines.

In SFRC, the depth of induction is increased compared to PCP and JRCP.

Recommended depths of induction are:

- In PCP and JRCP: D/4 (+10,–0) mm
In SFCP, the depth of induction is increased because the fibre imparts a high tensile capacity and hence induction is substantially more difficult to achieve. Although a crack may form under the inducing sawcut, the steel fibres bridging the crack will hold it closed; as a result each third to fifth joint will open while the others remain tightly closed. This is most likely to occur in shorter slabs, and hence it is desirable to construct the central zone by starting with the outer runs so that the cracking therein helps to induce cracking in the inner runs.

As for all base types, the timing of sawcutting is a critical factor for success and it will very rarely be possible to postpone cutting until the following day (see Section 6.10).

All joints must be sealed (possibly at several stages) to prevent the ingress of incompressibles.

### 4.6.6 Isolation joints with beam (Type F14) and without beam (Type F15)

An isolation joint is geometrically similar to an expansion joint, but the latter includes dowels. The dowels are omitted in isolation joints because their presence is likely to conflict with differential horizontal shear movements or their accurate placement would unnecessarily complicate construction.

In the absence of dowels, a subgrade beam can be provided to enhance load-transfer efficiency, but it should be recognised that a beam will be no more than a lesser compromise, particularly whilst the slabs are in the concave (edges up) condition. Dowels act to reduce differential vertical deflections across the joint and this load-sharing action reduces both base flexural stresses and imposed subbase stresses.

A subgrade beam will be passive during concave curling but is likely to reduce concentrated subbase stresses during convex and flat slab conditions. A subgrade beam is warranted only at joints with significant commercial-vehicle loadings and would not seem to be warranted in lightly-trafficked areas. They are placed under the subbase for both structural and constructability purposes.

The presence of an isolation joint allows a freedom in the joint design in that intersecting joints may 'mismatch' across it. In contrast, an untied butt joint will not allow mismatching because of the high risk of reflection cracking into the second-placed slab.

Isolation joints without beams (Type F15) are also required to isolate structures such as manholes and pits from the pavement, again to prevent reflection cracking.

The design of joint sealants for isolation joints (and the required reservoir as shown in the pavement standard drawings for SFCP (Roads and Maritime, 2019)) is indicative only and should be checked for specific projects according to the estimated joint movements.

### 4.6.7 Mismatched joints

Tied joints may be mismatched as experience to date indicates that effectively tied joints which undergo only hinging (but not contraction/expansion) are unlikely to reflect into adjoining slabs.

Mismatching of an untied joint will result in reflection cracking in the adjacent slab and/or locking of the subject joint. All untied joints must therefore be continuous between free edges, ie daylighted, except across isolation joints. In this context, an isolation joint constitutes a free edge, but an untied butt joint does not.

There is one situation where 'bending' of this rule appears to be tolerable. Where a longitudinal untied or isolation joint is needed (because of excessive tied width) it is convenient to change from the untied to a tied condition simply by introducing tiebars at the crossing of a transverse contraction joint. Strictly speaking, the untied joint is not daylighted to a free edge, but the consequences are unlikely to be
deleterious. The untied section will not cause reflection cracking because a joint already exists and any locking of the untied joint will probably be limited to a short length. It is possible that the first few tiebars will eventually yield but this is of little consequence.

### 4.7 The design draft

Drafting the geometric joint layout will necessarily be a trial-and-error operation. It is ideally suited for CAD as manual drafting is laborious and time consuming. In the past, inexperienced designers developed their skills by preparing a manual draft. This was done with pencil and eraser, and at a scale of about 1:200 for the required accuracy.

The base drawing is to be at a suitable scale for the required accuracy so that it fits in one sheet (preferably A3 size) and should show items such as:

- Kerbs - including location, type and chainages
- Medians and islands
- Painted gores
- Drainage pits
- Crown lines.

The designer should also be conversant with local requirements for the provision for traffic.

Discrete paving runs are best displayed using stipple (as shown in Figure 9) or coloured shading.

A checklist covering the full design exercise is provided in Section 4.10.
4.8 Survey

There are two common methods of setting out roundabout pavements in the field and the choice will have a bearing on the details required to be shown on the drawings.

The first is by use of traditional survey methods working from set-out marks. For this method, the designer will have to provide thorough dimension details on the drawings which will be sufficient to locate each joint node in the field. Offsets from fixtures such as traffic islands should also be nominated (with a tolerance) to facilitate checking of the layout.

The second method is using Electronic Total Station, in which case all joint nodes need to be co-ordinated for location and level.
4.9 Typical designs

Typical designs are provided in Annexure A and Annexure B. The designs in these figures are applicable to SFCP only, because of the adopted slab dimensions and corner angles.

4.9.1 Typical design sequence

The following information is provided to assist the preparation of joint layouts. Figure 10, Figure 11, Figure 12 and Figure 13 in Annexure A show a typical design sequence, in 16 steps (illustrated by a medium-radius roundabout but applicable in principle to all sizes).

4.9.2 Small-radius roundabout

Figure 14 in Annexure B shows an example of a complying joint layout option for a small radius roundabout.

4.9.3 Medium radius roundabout

Figure 15 in Annexure B shows a joint layout option for a medium radius roundabout including notes for designers.

4.9.4 Large-radius roundabout

Figure 16 in Annexure B shows three alternative jointing arrangements within transition zones. Some layouts will be easier to construct than others because of factors such as magnitude of paving width, width variations within a paving run and even the frequency of change. The choice of screed-board length will be dictated by the maximum width within a run, but a second (shorter) screed may have to be retained for narrower sections within a run.

4.10 Designer’s checklist

The following information is provided as a summary checklist for a typical design procedure.

Choice of pavement format, ie PCP, JRCP or SFCP?

- Format selection is required prior to thickness design.
- Prepare a rough draft of the joint layout in one section of the roundabout, following the procedure outlined in Figures 10, 11, 12 and 13. For this draft, select a transition zone with the most acute approach leg and the lowest radii curves.
- SFCP will usually be the most suitable format which satisfies all criteria.

Pavement thickness design

- Complete the thickness design in accordance with the Austroads Design Guide (Austroads, 2017) and RMS Supplement (Roads and Maritime, 2018).
- In calculating the design traffic, has adequate account been taken of the combined traffic loading from all approach legs?
- Does the traffic growth factor account for commercial growth rates, in contrast to total growth rates?
• Is an improved subgrade warranted?
• Are pavement edge drains warranted? Are the effects of landscaping schemes catered for?

**Joint layout design**

• Follow the procedure as detailed in Figures 10, 11, 12 and 13.
• Has allowance been made for planned future changes to approach roads and/or traffic movements?

**Assess constructability**

• Are the designed paving widths practical given the available construction expertise and equipment?
• Assess the likely locations of transverse construction joints and shade the resulting construction pours/sequence.
• Does the design facilitate reasonable and economical paving output rates?
• Review the layout as follows:
  a. Show the linemarking and traffic islands in the jointing layout.
  b. Generate coordinates for each corner of all slabs to assist in survey set out.
5 Materials and their function

Material requirements for SFRC are covered in Roads and Maritime Specification R83. For guidance on the application and interpretation of these requirements, refer to Specification Guide NR83.

Note that material and concrete mix requirements for terminal anchors are also covered in R83.

Likewise, material and concrete requirements for subbase concrete and subgrade beams are covered in Roads and Maritime Specification R82. For guidance on the application and interpretation of the requirements specified in R82, refer to Specification Guide NR82.
6 Construction

6.1 General

Construction requirements are specified in Roads and Maritime Specification R83. For guidance on the application and interpretation of these requirements, refer to Specification Guide NR83.

Neglect of the fundamentals of good concrete practice has been the cause of much of the premature distress in pavements and structures throughout the world. The following is a brief discussion of selected issues that specifically apply to SFRC that otherwise are discussed in NR83.

6.2 Formwork

Forms are generally timber, steel or a composite of both. For high quality work, forms should be set to tolerances at least equal to those specified for the finished surface because the screeding process will dictate the surface profile and finishing operations can do little to correct poorly controlled screeding. Formwork should be checked by both level and straightedge.

Construction of the outer kerb and gutter prior to the base allows the use of the gutter as a screeding form. In this case, accuracy of the gutter placement will obviously be very important.

Slabs in the transition zone frequently have a width which exceeds the length of typical vibrating screeds. In such cases, temporary screed rails can be used to divide the slab into two approximately equal widths. As soon as possible after placing the concrete on each side, the temporary rail is removed, and the remaining space is filled with concrete. However, thorough compaction at the joint is essential to reactivate the first-placed mix and to prevent the formation of a cold joint.

6.3 Reinforcement

An important consideration for tiebars is the bond strength (or pull-out strength) because it can have major implications for the level of stresses in the pavement and hence on the pavement life. Load sharing is dependent on shear capacity at the joint. Shear capacity is provided by aggregate interlock (or corrugations) and this will be effective only whilst the faces are kept in close contact. Tiebars are provided purely to act in tension to hold the faces together and they have no effective shear capacity.

If the joint opens excessively, the pavement will be acting in a 'no shoulder' condition and hence will have substantially reduced flexural life. Further, the alkaline environment required to protect the tiebars against corrosion will be destroyed if the joint width (at the bar level) exceeds about 0.5 mm.

The highest failure rate for tiebar 'pull-out' occurs where bars have been pushed into the edge of a formed slab or kerb, particularly in low-slump slipform mixes.

6.4 Consistency

There is an increased temptation to retemper because of its apparent low workability of SFRC. Prior to commencement of construction, this issue should be fully discussed with batchers and agitator drivers to ensure that they do not over-wet the mix based on their experience with plain concrete.
6.5 Mix Uniformity

With SFRC, the sequence and method of charging the mixer is critical. Even under favourable conditions, fibre 'balling' is likely to periodically occur, and site staff must therefore add this to their surveillance list. Every effort should be made to remove the balls before their incorporation.

ACI experience suggests that balling typically results from inadequate initial dispersion and rarely develops during mixing (ACI, 2008). Thorough dispersion has proven to be a demanding task and would seem to warrant the design of specialised equipment.

6.6 Placement and Compaction

There should be no doubting that compaction is just as important in SFRC as it is in plain concrete. In addition to the usual benefits of good compaction, SFRC requires full and consistent compaction to achieve good fibre bond strength.

In multilane paving there is likelihood of reduced standards of workmanship in relatively wider area of paving without formed longitudinal joint. Limiting the paving widths to 4.3 m will facilitate placement using conventional vibrating screeds. Operations such as finishing and curing are also simplified. As such, it will reduce the risk of poor construction quality.

6.7 Finishing

Finishing and curing techniques must be of the highest standard to achieve the specified surface tolerances with a surface texture which is durable under the highly abrasive action of turning traffic. The difficulty of achieving these standards will increase substantially with increased paving widths beyond 4.3 m.

6.8 Surface Texture

The texture in roundabouts needs to cater for high centripetal and shear forces resulting from rapid changes in traffic direction and from breaking movements.

The following process is required to achieve adequate surface texture:

(i) Light brooming to enhance the microtexture, followed by;

(ii) Tining to provide adequate macrotexture.

Hessian dragging is not suitable on SFRC because it plucks the surface fibres. Tining on roundabouts can be either longitudinal or transverse, but the paving methods will usually favour transverse.

For both brooming and tining, it is desirable to use reasonably flexible bristles/tines to achieve a low angle of attack which doesn't pluck the fibres.

Smooth finishes, such as those from power trowelling (helicopters) will give a low-friction surface (even when followed by light tining) and are therefore not permitted. (In addition to that, curing compounds should be applied long before the concrete is old enough to support power trowelling.)
Durability of the surface texture will be largely dependent on the quality of the finished concrete and hence effective curing is an important consideration.

6.9 Curing

Pavements are typically constructed under severe exposure conditions and therefore Roads and Maritime specifications require the use of high quality curing compounds and a high standard of application.

The timing of application can also be critical, particularly under conditions conducive to plastic shrinkage cracking. Good construction practice dictates that curing should commence soon after the bleed water sheen leaves the surface. Curing must be in place before significant drying occurs and must thereafter be maintained long enough to achieve the required strength and durability, and to minimise shrinkage. The importance of timely and effective curing cannot be overstated.

In very cold weather, action must be taken to prevent freezing of the surface. Polythene sheeting alone (preferably black) can maintain the concrete temperature up to 7°C above the outside air temperature if it is fully weighted along all edges. In colder situations, hessian may have to be placed under the polythene sheeting.

6.10 Jointing

In the sawn joints the difficulty in sawcutting is determining its optimum timing. This can vary significantly depending on the temperature, humidity, aggregate type and other factors which affect the hardening and shrinkage rates. It will rarely be possible to postpone sawing until the morning after placement. This applies equally to transverse and longitudinal sawing. In summer, cutting may be required as soon as 4 hours after placement but in winter this could rise to 18 hours or more. Premature sawing will result in excessive spalling at arrises, whilst late sawing will result in unplanned random cracking. A compromise is therefore required, it is generally accepted that a small amount of ravelling is expected. The production of perfectly sharp and square edges indicates that sawing was probably a little late, with the attendant risks of random cracking.

SFRC will probably ravel slightly more than plain concrete because of the plucking of fibres.

Typically, a single sawblade width is cut initially, and this is later widened just prior to sealing. The widening cut will generally remove most of the ravelling caused by the first sawcut.

In roundabout design, it will be safer to specify the longitudinal joints to be formed (Refer to Section 4.6.1).

At all formed joints, the first-placed face must be positively treated to ensure debonding from subsequent pours.

6.11 Trafficking the pavement

Early trafficking of the base concrete must be limited to construction operations such as sawcutting and joint sealing. Premature heavy trafficking can cause structural cracking, particularly at times when the base is in a curled condition.

All other vehicular access must be restricted until the achievement of an in situ comprehensive strength of 25 MPa, and until all joints have been permanently sealed.
7 Pavement standard drawings for SFCP roundabouts


Note however that they only apply to steel fibre reinforced concrete pavements (SFCP) and must not be used for other rigid pavement formats.

These details may need to be tailored to suit project-specific conditions.

8 Project examples

Project examples of small, medium and large roundabouts are included in Annexure C.
9 References


2. Australian/ New Zealand Standard AS/NZS 4671 - Steel reinforcing materials


Annexure A – Typical Design Sequence

Step 1: Begin with a plan showing kerbs, medians, islands, etc. Features such as crown lines and drainage pits should also be shown because they will dictate the location of longitudinal joints. Choose a suitable scale that fits in one sheet.

Step 2: Mark the inside edge of base 0.5 m inside the (roundabout) kerb.

Step 3: Measure the resulting total base width (12.0 m in this case).

Step 4: Mark the circulating joints with consideration of lane lines and the likely tracking path of heavy vehicles. Limit the width of the outermost paving run to limit slab sizes in the transition zones. Slab widths should preferably be limited to 4.3 m except for the transition zones where this might be impractical.

Step 5: Mark tentative locations of isolation joints with consideration of:
- Equalisation (and maximisation) of intersection angles at the kerbs.
- Total lined widths (18.8 m and 17.5 m in this case).
- Slab widths within the transition zone (6.0 m in this case).

Issues to consider:
- Corner angles.
- Slab lengths when radiating joints are projected to the outer slabs within structural limits. (Note that limits can be exceeded in untrafficked or lightly trafficked areas)
- Interaction with medians and kerbs, etc.

Two options are shown: kerbs should either be offset or should intersect the median in such a way that resulting kerb segments are manageable in size. This criterion may influence the length of adjoining slabs.

To facilitate future rescaling of joints and for accuracy of kerb placement a reasonable lower limit of offset would be about 0.1 m.

Figure 10: Preliminary steps in joint layout design

Figure 11: Tentative position of transverse contraction joints
Joint Types

Type F2: Longitudinal, tied and formed.
Type F7: Transverse construction, tied and formed.
Type F8: Transverse contraction, untied and sawn.
Type F14: Isolation, with beam.

# = Relief edge distance (Cl 4.3.8)

Step 7: Terminate outer circulating joints at a Type 7 joint.
Step 8: Realign outer circulating joint as necessary to achieve minimum desirable slab widths.
Step 9: Reposition Type 14 joints to limit slab widths and corner angles in the transition zones.
Step 10: Check alignment of radiating joints within transition zones to compromise slab lengths, widths and corner angles.

Step 11: Design the approach layout. Note that base concrete can be omitted under larger medians/islands but should be continuous under smaller ones. Type 14 joints effectively constitute a 'free edge' and hence mismatching of intersecting joints is acceptable.
Step 12: Check total lied widths. If excessive, replace one of the central Type 2 joint with a Type 4 Joint (desirably in an area offset by minimum 1.0 m from major commercial vehicle paths).
Step 13: Specify the location of all joints. Give sufficient dimensions to facilitate field audit of set out accuracy, particularly at locations such as the termination of Type 2 joints where they are at a variable offset from the adjacent Type 2 joint.
Step 14: Specify the type and location of terminal anchors.
Step 15: Add dimensions as necessary according to survey needs and joint identification where warranted.
Step 16: Specify tiebar spacing in all Type 2 joints.

Figure 12: Geometric adjustments to conform with slab dimensional limits

Figure 13: Labelling joint types and tiebar design
Annexure B – Typical Designs of small, medium and large radius roundabouts

Figure 14: Small Radius Roundabouts – typical design
Type F14 joints effectively constitute a 'free edge' and hence mismatching of intersecting joints is permitted. Longitudinal joints are preferably located close to (but offset from) lane lines, and located on crown lines or can also be placed mid-way between lane lines. (Section 4.3.1)

See warrant for untied joints (Section 4.6.6)

Total tied width limited to 22.0 m (Section 4.3.2)

Limits on corner angles (Section 4.4.3)

Slab lengths limited to 6.0 m (Section 4.4.2). This is generally measured between (and square to) Type F8 joints at the worst location within the trafficked area. Ignore Type F7 joints in this exercise.

Terminal Anchor type 6 refer to RMS SFCP Standard Drawings

Joints in kerbs, medians are to duplicate those in the adjoining base (Section 4.3.4)

Minimum slab widths (Section 4.4.1)

Limits on corner angles (Section 4.4.3)

Tiebar spacing (Section 4.3.8)

Slab widths limited to 4.3 m (Cl 4.4.1)

Terminal Anchor type 6 refer to RMS SFCP Standard Drawings

Joint Type F2 must terminate at a formed joint (ie not an induced joint such as Type F8) for logistic reasons (Section 4.2)

Type F7 joint locations are indicative only and their use, location and frequency will be dictated by construction logistics. Where used, they should be located not less than 1.2 m from a Type F8 joint (Section 4.6.5)

Figure 15: Medium Radius Roundabout – typical design
Slab lengths limited to 6.0 m (Section 4.4.2). This is generally measured between (and square to) Type F8 joints at the worst location within the trafficked area. Ignore Type F7 joints in this exercise. Note the compromise between slab lengths and corner angles.

# = Relief edge distance (Section 4.8.3)

Slab lengths within approach leg can be varied within the range of 5.0 ± 1.0 m

Type F14 joints effectively constitute a 'free edge' and hence mismatching of intersecting joints is acceptable

Minimum slab widths (Section 4.4.1)

Chainages along kerb lines to facilitate setting out of joints in the field (Section 4.9)

Terminal Anchor type 6 refer to RMS SFCP Standard Drawings

Figure 16: Large Radius Roundabout – typical design
Annexure C – Project examples of small, medium, and large roundabouts
Road control line
Flexible pavement
Joint type
Transverse joint F8
Pavement anchor
Longitudinal joint F2
Tiebar spacing (mm)
SFCP reinforced (SFCP-R)
NOTE
Isolation joint F14
Construction joint F7

Legend
Road control line
Joint type
SFCP
SFCP reinforced (SFCP-R)
Flexible pavement
Tiebar spacing (mm)
Longitudinal joint F2
Isolation joint F14
Transverse joint F8
Pavement anchor
Construction joint F7

NOTE
Project specific details are not shown

Figure 17: Project example of Small Radius Roundabout
Figure 18: Project example of Medium Radius Roundabouts

NOTE
Project specific details are not shown in this drawing
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Project specific details are not shown