Moltaí i dtaobh Oibreacha Forbartha
Láithreáin le haghaidh Limistéir Tithíochta

Recommendations for

site development works

for Housing Areas

Printed on recycled paper

AN ROINN COMHSHAOIL AGUS RIALTAIS ÁITIÚIL
DEPARTMENT OF THE ENVIRONMENT
AND LOCAL GOVERNMENT

Recommendations for Site Development Works for Housing Areas

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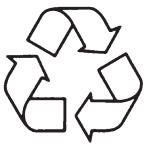

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Contents

FOREWORD

This document, which is an update of a similarly entitled An Foras Forbartha publication, (originally issued in 1974 and subsequently amended in 1984) is intended for the guidance of local authorities, public authorities, private developers and consultants, in the construction of site development works for housing areas.

The document sets out recommended standards and technical specifications for the various services, which should generally be acceptable to local authorities, in their administrative areas.

This publication does not contain all of the possible solutions to site development design problems and designers should be encouraged to propose imaginative alternatives, subject to approval as defined in the document.

It should be noted also, that some local authorities provide their own documented requirements in relation to site development works.

This document does not deal with issues of estate layout. Nevertheless, it is recognised that layouts which seek to ensure very low traffic speeds and greater priority for pedestrians and cyclists within housing areas should be encouraged. In particular circumstances, this consideration might well justify the adoption of standards other than those contained in this document.

Section 1: General

1.1 Definitions

For the purposes of this document, the following definitions apply:

1. **Local Authority:** The Local Authority which will assume responsibility for the development works on their completion.

2. **Developer:** The person, company or public body that undertakes the development works and from whom the Local Authority would take the development in charge.

3. **Approval:** "Approval" and "Approved" mean approval in writing by the Local Authority, of proposals submitted by the developer. This meaning does not extend to a planning application for "approval", unless it is specifically stated as such.

4. **Road:** A way for vehicles and other types of traffic.

5. **Roadway**: That portion of a road which is provided primarily for the use of vehicles.

6. **Footpath:** A road over which there is a public right of way for pedestrians only, not being a footway.

7. **Footway:** That portion of any road associated with a roadway, which is provided primarily for use by pedestrians.

8. **Drain:** Any underground pipework or conduit used for the conveyance of foul water or surface water, which is not intended to be taken over and maintained by the Local Authority.

9. **Sewer:** Any underground pipework or conduit used for the conveyance of foul water or surface water, which is intended to be taken over and maintained by the Local Authority.

10. **Foul Water:** Waste water, or trade effluent, or water containing excreted matter, whether human or animal.

11. **Surface Water:** The run-off of rainwater from roofs and paved ground surfaces.

12. **Watermain:** A pipe for the general distribution of water in a water supply system, not being a service pipe.

13. **Service Pipe:** A pipe for the conveyance of water from a watermain to an individual premises.

1.2 Scope

This document sets out recommended standards and technical specifications for the design and construction of roads and services associated with site development works for housing areas. It does not deal with workmanship criteria. The roads and services within the scope of this document are:

1. All roads within housing areas, with the exception of those intended:

   (a) as the principal means of access to more than 200 houses.
   (b) for use as bus routes.
   (c) to provide a through route for vehicular traffic.

2. Sewers and drains comprising pipes up to 300mm diameter

3. Watermains up to 225mm diameter and water service pipes.

4. Public Lighting within the housing area.

1.3 Technical Specifications

Within this document, technical specifications are either provided directly, or indirectly by reference to:

1. An Irish Standard Specification, identified by IS followed by a number and the year of publication.

2. A British Standard Specification, identified by BS followed by a number and the year of publication.

3. A harmonized European Standard Specification, identified by IS EN followed by a number and the year of publication.

4. Other published specifications, identified by their titles.

References to Irish, British and harmonized European Standard Specifications and any other published specifications, are to the latest edition current at the time of publication of this document. However, if this edition of the technical specification is subsequently revised or updated by the issuing body, the new version should be deemed to apply, unless approval is obtained to the contrary.

1.4 Materials

All works should be carried out with proper materials. Proper materials means materials which are fit for the use for which they are intended and for the conditions in which they are to be used, and includes materials which:

1. Bear a CE Marking in accordance with the provisions of the Construction Products Directive; or

2. Comply with an appropriate harmonized standard, European technical approval or national technical specification as defined in article 4(2) of the Construction Products Directive; or

3. Comply with an appropriate Irish Standard or Irish Agrément Board Certificate or with an alternative national technical specification of any State which is a contracting party to the Agreement on the European Economic Area, which provides in use an equivalent level of safety and suitability.

1.5 Consultation with Local Authority

Local Authority requirements vary on the nature and degree of consultation that is necessary, in relation to proposed housing developments in their individual administrative areas.

Prior to finalising the design of a proposal, the Developer is advised to ascertain the particular consultation process that obtains in the specific area, as well as the name(s) of the appropriate officer(s) for consultation purposes, on matters of Planning, Roads, Drainage, Watermains and Public Lighting. The Developer is furthermore advised to consult, at the earliest possible opportunity, with the appropriate officer(s) on matters such as:

1. **Planning:** Site suitability, layout design, housing density, open spaces, landscaping, etc.

2. **Roads:** Road reservations, road widening lines, culs-de-sac, junction sightlines and radii, gradients, alignments, roadway type, proposed construction traffic; inspection, testing and approval requirements, etc.

3. **Drainage:** The type of drainage system to be used, areas external to the development area whose drainage is required to be included (together with estimated discharge data), outfall points or connections to existing sewers, types of manhole and gully covers; inspection, testing and approval requirements, etc.

   Where the drainage layout is such as to require one or more connections to a public sewer, the Developer should ascertain whether or not the connections would be carried out by the Local Authority. Where these connections would be carried out by the Developer, the Local Authority requirements should be determined.

4. **Watermains:** Type and layout of watermain, connection points, types of surface boxes, locations of indicator plates and marker posts; inspection, testing and approval requirements, etc.

5. **Public Lighting:** Installation by ESB or private contractor, types of lighting column, lantern, lamp, ducting, cables, controls; inspection, testing and approval requirements, etc.

1.6 Information Required

The following information should be submitted by the Developer to the Local Authority. (This information may be included in the Developer's application for Planning Permission, or Approval, or may take the form of such documentation, together with supplementary data, all subject to approval).

1. A layout plan of the proposed development, showing the extent of the development site, site contours levels at 0.5m intervals, the location of boundaries and structures within the site and the location and levels of existing utilities, including those within the site as well as those external to the site, that would be affected by the development.

2. A plan showing the arrangement of the houses, with proposed ground floor levels, the layout of roads, footpaths, footways, sewers and drains, including sewer and drain sizes and positions of manholes and gullies.

3. A plan showing the layout of proposed watermains, including pipe sizes and positions of hydrants and valves.

4. Longitudinal sections and cross-sections of roads, indicating the proposed road construction, levels and gradients.

5. Longitudinal sections of proposed sewers and drains, showing levels, gradients, sizes, types and classes of pipe, types of joint and types of bedding, haunch and surround.

6. Longitudinal sections of proposed watermains, showing sizes, types and classes of pipe and positions of valves and hydrants.

7. A layout plan with sections of the proposed public lighting system, showing the location of lighting columns, auxiliary micro pillars and ducting and specifying the types of equipment to be provided. Details of the internal electrical arrangement for lighting columns and auxiliary micro pillars, as well as details of the overall earthing arrangements should also be included.

8. Drainage design calculations, demonstrating the capacity of the proposed pipe networks to discharge the design flows and run-off from the development.

9. Proposals for the treatment of existing surface and underground water-courses, boundaries and structures, within the development.

10. Proposals for the preservation of existing trees and other features.

Layout plans should be to a scale of not less than 1:500. Sections and elevations should be to a scale of not less than 1:100. All levels shown should be related to Ordnance Datum.

1.7 Other Services

With regard to services other than those being provided directly by the Developer e.g. electricity, telecommunications, gas, piped television etc., the Developer should comply with the requirements of statutory undertakers, or public utility companies responsible for such services. In relation to services on offer from private companies, the Developer should ascertain the Local Authority requirements in each specific instance.

All necessary ducting for services under roads should be installed, at the approved locations and depths, prior to completion of the road surfacing.

1.8 Access

Access to the site should be made available to Local Authority staff, for such monitoring or inspection of work as may be required, during construction.

1.9 Completion

On completion of the project, the Developer should submit to the Local Authority, such as-constructed records as the Local Authority may require. This may entail the provision of some, or all of the drawings detailed in 1.6 above, but might also require the provision of closed circuit television sewer condition surveys, by approved contractors, with results presented on diskette, tape, compact disc, or other approved device.

1.10 Legal

Compliance with these recommendations does not confer immunity on the Developer from any legal requirements and does not remove the obligation on the Developer to comply with the requirements of the Planning Acts, relevant sections of the Building Regulations, the Safety Health and Welfare at Work Act 1989, etc.

Section 2: Roads and Footways

Design

2.1 Layout Design

Layouts should be designed so as to deter through traffic. Road alignments should be such as to limit vehicle speeds and facilitate pedestrian movement. However, narrower roadway widths should only be considered where realistic measures have been incorporated to eliminate on-street parking. Adequate access for wheelchairs and prams should be provided.

2.2 Roadway Width

The roadway width should be 6m except for culs-de-sac less than 60m long, where a width of 5.5m should be acceptable. A reduced roadway width may be approved for short spur culs-de-sac.

The amount of off-roadway parking to be provided per house, is subject to approval.

2.3 Junctions

An uncontrolled intersection is an intersection that does not rely on the positive controls of signs, or signals, for the allocation of priority amongst approach roads. Junctions should normally be designed as uncontrolled intersections, to the requirements of the National Roads Authority publication "Geometric Design Guidelines (Intersections at Grade) RT181".

All junctions internal to the development should be T-junctions. The stagger of these junctions and the layout of junctions with other roads, are subject to approval.

2.4 Junction Sightlines

The area of unobstructed sight distance required at a junction is termed the "clear sight-triangle" and is measured from a driver eye height of 1.05m to an object height of 1.15m. The clear sight triangle is illustrated in Figure 2.1.

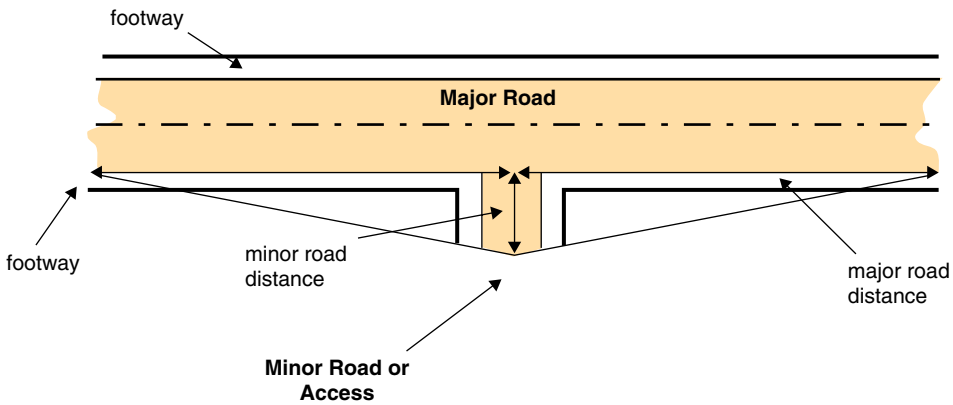


FIGURE 2.1: CLEAR SIGHT-TRIANGLE

The minimum dimensions of the clear sight-triangle for roads of various design speeds are given in Table 2.1, with the major road design speed determining the required dimensions.

TABLE 2.1 Junction sightline requirements

Design speed (km/h)	40	60	80	120
Major Road distance (m)	80	120	170	230
Minor Road distance (m)	4.5	4.5	4.5	4.5

2.5 Junction Radii

Junction radii should permit traffic to negotiate junctions safely and the following radii should normally be acceptable:.

1. Kerb radii at junctions of roads to which these recommendations refer, should be a minimum of 6m.

2. Kerb radii at a junction between an estate road and a road not covered by these recommendations, should be a minimum of 10.5m.

At particular junctions, in order to minimise crossing distance for pedestrians, lower radii than those stipulated in 1. and 2. above may be more appropriate, subject to approval.

2.6 Cul-de-sac Ends

Turning bays should be provided at the ends of culs-de-sac. The dimensions required for turning bays in residential culs-de-sac depend both on the maximum size of vehicle to be accommodated and on the frequency with which the turning bay would be used by that vehicle.

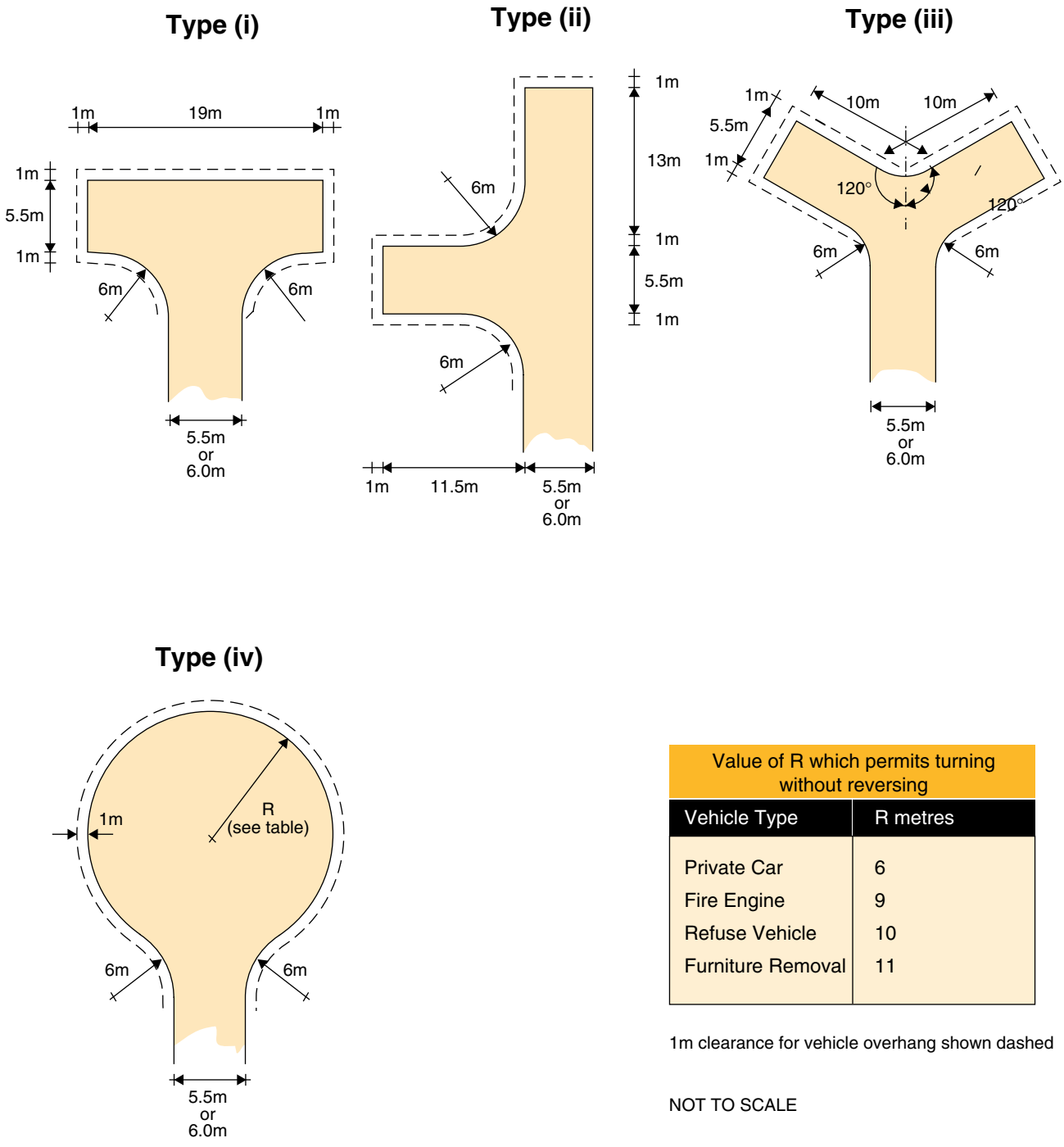
Figure 2.2 illustrates suitable turning bays for the end of culs-de-sac. The types (i), (ii) and (iii) shown on the figure, should enable most large refuse vehicles, or fire engines, to turn by means of a three point turn. Other types of turning bay may well be acceptable. Smaller dimensions would suffice for types (i), (ii) and (iii), where it is intended that only private cars should use the turning bay. Type (iv) permits turning, without reversing, for the indicated vehicle types.

Developers should determine the local authority requirements with respect to turning capability, before finalising cul-de-sac layout.

2.7 Road Gradients

Longitudinal gradients should normally lie between 0.5% and 5%, but a higher minimum gradient of up to 1% may be required, depending on the type of surface and the method of application.

At junctions, the gradient of the side road should not be greater than 2%, for a distance of 7m from the junction.



Value of R which permits turning without reversing	
Vehicle Type	**R metres**
Private Car	6
Fire Engine	9
Refuse Vehicle	10
Furniture Removal	11

1m clearance for vehicle overhang shown dashed

NOT TO SCALE

FIGURE 2.2: RESIDENTIAL TURNING BAYS

2.8 Road Crossfall

A crossfall of 2.5% should be provided for a normal machine laid surface. This may be decreased to 2% for a high quality surface finish, or may be increased to 3% for hand laid surfaces.

2.9 Horizontal Alignment

Roads should normally be designed and located to intersect at angles of between 70 and 110 degrees and preferably at 90 degrees. Where one road crosses or meets another at an angle outside this range, suitable curves should be introduced in the alignment of the minor road, subject to approval, in order to improve the angle of intersection.

2.10 Driveways

Driveways should have a minimum width of 3m and a maximum gradient of 10%. A kerb upstand of 25mm should be provided at entrances.

2.11 Screen Walls

Screen walls should be constructed in accordance with the requirements of IS 325.

2.12 Services

Services should be laid underground, adjacent to the roadway. The laying of services in other locations is subject to approval.

The public area, including the footway (if any) beside the roadway, should be of sufficient width to accommodate the services required. Services should only be laid under the roadway where there is a requirement to cross the roadway. In such cases, services should be laid at right angles to the roadway.

2.13 Clearance

The normal minimum lateral clearance of fixed objects from the roadway edge should be one metre. This applies to items such as public lighting columns, posts, trees and piers at entrances to developments. Particular circumstances may require that this clearance be reduced. In no circumstance should this clearance be less than 450mm.

Construction

2.14 Specification

Road works should comply with the requirements of "Specification for Road Works" published by the Department of the Environment.

2.15 Roadway Construction

The roadway construction comprises the pavement layers and the pavement foundation. The pavement may be constructed using flexible materials, block paving, or in situ concrete. The pavement foundation comprises the sub-base and capping layer, laid over the natural subgrade soil.

The various construction options and the terminology for roadway construction are illustrated in Figure 2.3. In situ concrete, or flexible roadway, are the general forms of construction. Other forms, such as concrete paving blocks, or clay or calcium silicate pavers may also be appropriate, subject to approval.

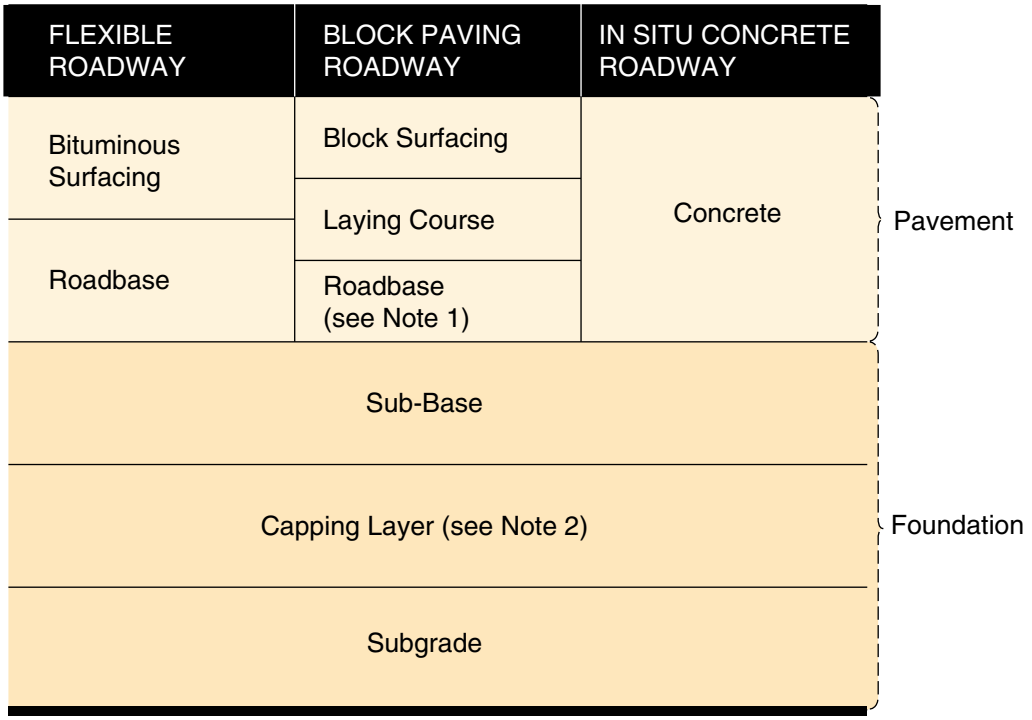


FIGURE 2.3: TERMINOLOGY FOR ROADWAY CONSTRUCTION

NOTE:
1. In lightly trafficked situations, a Roadbase would not be required under a Block Paving Roadway.
2. No capping layer is required with a subgrade CBR greater than 15%.

2.16 Subgrade Strength

Subgrade strength should be established by means of the California Bearing Ratio (CBR) Test, in accordance with BS 1377: Part 4: Section 7. Samples should be taken at the rate of one per 100m of road and where significant variations in soil type are anticipated. Extra samples may be required by the Local Authority where the difference in strength between two adjacent samples indicates a significant variation in soil type. In preparing the test specimen, the method of compaction should be the Static Compaction Method 2, as specified in paragraph 7.2.3.3 of BS 1377: Part 4.

The moisture content and density conditions used in the test should reproduce, as closely as possible, the conditions likely to apply under the road after construction. To estimate the appropriate density condition, a preliminary test may be carried out using the vibrating hammer method of compaction given in BS 1377: Part 4: Section 3, but with the soil at the expected average moisture content after construction. The CBR specimen should then be compacted to a density corresponding with 95% of the value obtained in the preliminary test.

In establishing subgrade strength, due account should be taken of the likely impact of the construction phase on the characteristics of the subgrade material. This may be critical, particularly on a site with a relatively high water table or poor drainage parameters. In such

cases, the in-service long term strength of the subgrade may be considerably less than that of the same soil in an undisturbed condition.

For subgrades with a CBR of less than 2%, a geotextile separator should be used and specialist advice should be sought regarding minimum thicknesses.

2.17 Depth of Sub-base & Capping Layer

The depth of the sub-base and capping layers will vary with the subgrade strength, as indicated by the CBR test results.

The thickness of the sub-base layer should be 150mm for all forms of roadway construction.

The thickness of the capping layer will vary with the CBR value, as indicated in Table 2.2. As can be seen from the table, if the CBR value of the subgrade exceeds 15%, no capping layer is required.

TABLE 2.2 Capping Layer - Minimum Construction Thicknesses

Lowest Subgrade CBR (%)	Minimum capping layer thickness (mm)
* Less than 2	(See footnote)
2-5	300
5-15	150
more than 15	no capping layer required

* For subgrades with a CBR of less than 2%, a geotextile separator should be used and specialist advice sought regarding minimum thicknesses.

Where local weak areas of subgrade strength exist, increased construction thicknesses, as approved, should be provided.

Where the Contractor proposes to use the sub-base for construction plant and traffic, it may be necessary to strengthen the sub-base (and capping layer, if any), in order to accommodate the method of construction and the type of plant and traffic proposed. It might well be, that the loading conditions during the construction phase could be more onerous than those experienced when the pavement is in full service. The thickness of sub-base (or capping layer and sub-base) required in such cases, would be dependent on the CBR of the subgrade and the construction traffic, as measured in Standard Axles. The Contractor's proposals in this regard are subject to approval. Any permanent thickening required should be across the entire width of the foundation, unless otherwise approved. Temporary thickening should not impede drainage of the sub-base or subgrade.

Damage caused by construction traffic should be remedied, as approved, before construction of the pavement layers.

2.18 Capping Layer Material

Capping layer material should comprise either crushed rock, natural gravel, crushed gravel, or crushed concrete. The material should have a maximum size of 100mm and the maximum allowable passing the 75 micron sieve should be 10%. The material should be well graded throughout all sizes.

Selected demolition materials which meet the above requirements may also be used, subject to approval.

2.19 Sub-base Material

Sub-base material should comprise Type B granular material, in accordance with Clause 804 of the Specification for Roadworks. The material should lie within the grading limits set out in Table 2.3.

TABLE 2.3 Sub-base Material - Range of Grading

Sieve size IS 24	Percentage by mass passing
75 mm	100
37.5mm	85-100
10 mm	40-70
5 mm	25-45
600 μm	8-22
75 μm	0-10

Particle size distribution should be determined by the washing and sieving method of BS 812: Part 103. All material used should be frost resistant

Material passing the 425μm sieve, when tested in accordance with BS 1377, should be non-plastic.

The material should have a ten percent fines value of 100kN, or more, when tested in accordance with BS 812.

The sub-base should be laid and compacted to the requirements of Clause 802 of the Specification for Roadworks, without drying out, or segregation.

Other materials may be used, subject to approval.

2.20 Roadbase Material

Roadway roadbase material should normally comprise lean mix concrete, wet mix macadam, dry bound macadam, or dense bitumen macadam.

1. Lean mix concrete: Aggregates for lean mix concrete may consist of either coarse and fine aggregate batched separately, or an all-in aggregate, having a maximum nominal size not exceeding 40mm nor less than 20mm and should lie within the grading limits set out in Table 2.4

TABLE 2.4 Lean mix concrete - Range of Grading

Sieve size IS 24	Percentage by mass passing	
	Nominal maximum size	
	40mm	20mm
75 mm	100	
37.5 mm	95-100	100
20 mm	45-80	80-100
5 mm	30-40	35-45
600 μm	8-30	10-35
150 μm	0-6	0-6

Particle size distribution should be determined by the washing and sieving method of BS 812: Part 103. The ratio, by mass of cement to aggregate, should be such as to produce 28 day cube strengths of not less than 10N/mm^2 and not more than 20N/mm^2.

2. Wet Mix Macadam: Wet mix macadam should consist of crushed rock, lying within the grading limits set out in Table 2.5.

TABLE 2.5 Wet Mix Macadam - Range of Grading

Sieve size IS24	Percentage by mass passing
50 mm	100
37.5 mm	95-100
20 mm	60-80
10 mm	40-60
5 mm	25-40
2.36 mm	15-30
600 μm	8-22
75 μm	0-8

Particle size distribution should be determined by the washing and sieving method of BS 812: Part 103. The moisture content of the wet mix macadam should be the optimum $\pm$0.5%, as determined by the vibrating hammer method test, in accordance with BS 1377.

3. Dry-bound Macadam: Dry-bound macadam should consist of coarse and fine aggregate. The coarse aggregate should consist of crushed rock complying with the 50mm, or the 40mm nominal sizes of BS 63 and the fine aggregate should all pass the 5mm IS sieve size. The coarse aggregate should be compacted in 100mm layers and fine aggregate, as required, vibrated into the voids of the coarse aggregate.

4. Dense Bitumen Macadam: Dense bitumen macadam should be 40mm nominal size dense roadbase, in accordance with BS 4987: Part 1.

Roadbase materials should be compacted in accordance with Clause 705, 802, or 809 of the Specification for Roadworks, as appropriate.

2.21 Concrete Roadways

1. Construction: Concrete roadways may be reinforced or unreinforced and should be constructed generally as shown on Figure 2.3.

The minimum thicknesses of reinforced and unreinforced concrete slabs should be 150mm and 180mm respectively.

Paving quality concrete should be 37.5N/mm^2 air entrained concrete made from natural aggregates, cement, water and air entraining agent. Aggregates should be natural materials complying with IS 5. Cement should be normal Portland cement, complying with IS 1. The air entraining agent should comply with BS 5075. Other admixtures may be used, subject to approval. The constituents should be proportioned as set out in Table 2.6

TABLE 2.6 Constituents for Paving Quality Concrete

Minimum cement content	325kg/m^3
Maximum free water/cement ratio	0.55
Maximum aggregate size	20mm
Minimum fine aggregate content	30%
Air content	3.5-6.5%
Slump	50mm

A separation membrane should be placed between the concrete and the sub-base. The membrane should be impermeable plastic sheeting, 125 microns thick laid without creases. The most commonly used separation membrane is polythene sheeting. Where an overlap is necessary, this should be at least 300mm.

2. Joints: Joints should be provided in a concrete pavement, in order to accommodate the horizontal movement due to changes in temperature and moisture content. There are four types of joint viz.

Transverse contraction joints
Transverse expansion joints
Longitudinal joints
Formed contraction joints

Details for each of these joints are shown in Figures 2.4, 2.5, 2.6 and 2.7 respectively. Maximum transverse joint spacing should be as shown in Table 2.7

TABLE 2.7 Maximum transverse joint spacing

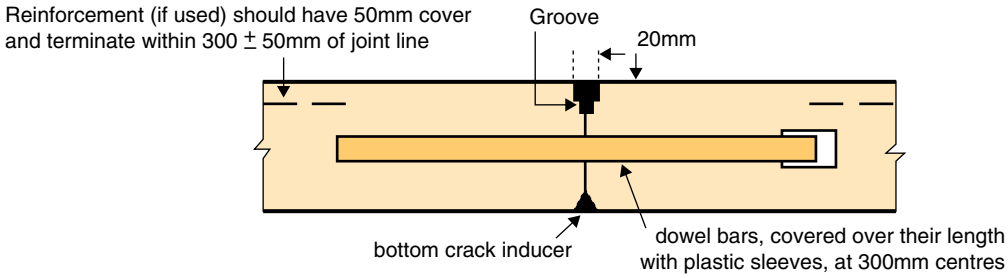
	Slab thickness (mm)	Maximum spacing (m)
Unreinforced Concrete	180 - 200	4.5
	201 - 250	5.0
	Reinforcement, long mesh to BS: 4483	Maximum spacing (m), any slab thickness
Reinforced Concrete	C283	15
	C385	20
	C503	25

The spacings in Table 2.7 refer to contraction joints. Transverse expansion joints would not generally be required for roads constructed under summer conditions. However, for a road constructed during the winter months, expansion joints are recommended. In order to avoid uncertainty, it is considered good practice to provide expansion joints, irrespective of the time of year laid. Transverse expansion joints should be provided at intervals of 60-75m, where they would replace a transverse contraction joint.

Expansion joints should also be provided, to form small slabs around all manhole covers, gullies and surface boxes occuring on the roadway. The slabs should be at least as large as the external dimensions of the relevant chambers.

Transverse construction joints are required at the end of a day's work, or in the event of a plant breakdown. All such joints should take the form of either a contraction or expansion joint. In no instance should a construction joint be located closer than 2m from an existing joint position. A formed contraction joint is detailed in Figure 2.7.

Roadways wider than 4m should have a central longitudinal joint.

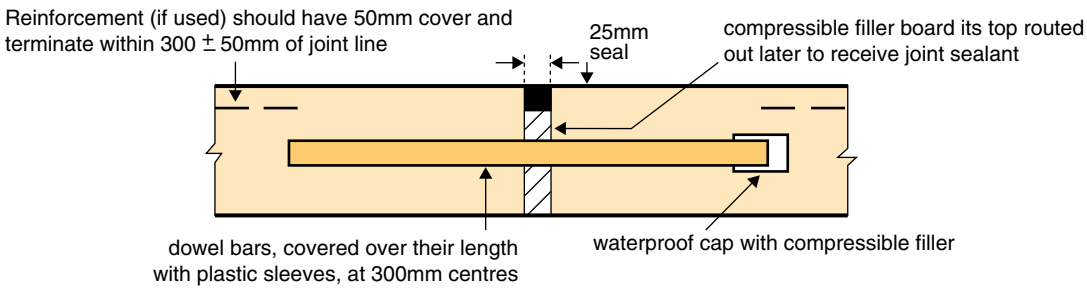


Note (i) Groove formed by vibrating a narrow strip into the plastic concrete. This strip is then removed and replaced by a temporary filler. Alternatively a preformed sealing strip can be inserted into the plastic concrete acting as both the top crack inducer and temporary joint. The top of the groove is later widened by sawing to 20mm and then sealed.

Note (ii) The combined depth of the top groove and bottom crack inducer should be between a quarter and a third of the slab depth. Alternatively a deep surface groove can be sawn to a depth between a quarter and a third of the slab depth and the bottom crack inducer omitted. This is the preferred option.

Note (iii) For concrete slabs up to 230mm deep the dowel bars should be 20mm diameter and 500mm long. Above this depth the bars should be 25mm diameter and 600mm long.

FIGURE 2.4: TRANSVERSE CONTRACTION JOINT



Note (i) For concrete slabs up to 230mm deep the dowel bars should be 20mm diameter and 500mm long. Above this depth the bars should be 25mm diameter and 600mm long.

FIGURE 2.5: TRANSVERSE EXPANSION JOINT

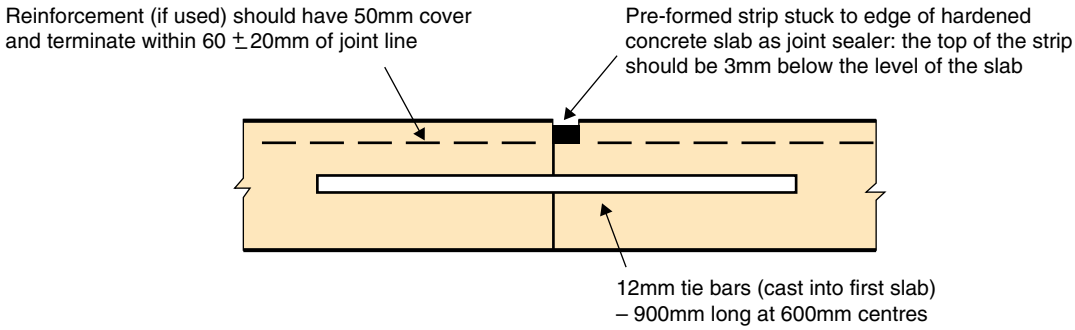
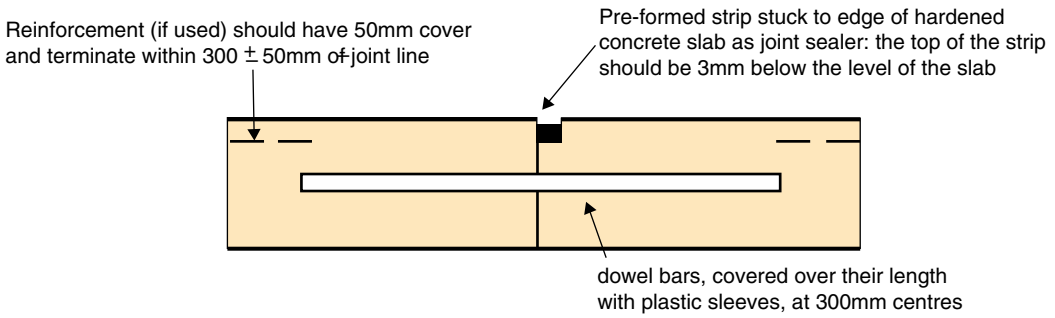


FIGURE 2.6: LONGITUDINAL JOINT



Note (i) For concrete slabs up to 230mm deep the dowel bars should be 20mm diameter and 500mm long. Above this depth the bars should be 25mm diameter and 600mm long.

FIGURE 2.7: FORMED CONTRACTION JOINT

Sawing of joint grooves should be undertaken as soon as possible after the concrete has hardened sufficiently to enable a sharp edged groove to be produced, without disrupting the concrete and before random cracks develop in the slab. This would usually be within 6 to 24 hours after the concrete is poured. The grooves should be between 1/4 and 1/3 the depth of the slab and of any convenient width not less than 3mm. The groove can be widened by sawing at this stage, or later, to accommodate the joint sealant.

Expansion joint filler should be compressible board 25mm thick, for the full depth of the concrete. The top of the filler board should be routed out later, to a depth of 25mm, in order to receive the joint sealant.

Dowel bars and tie bars should be Grade 250 steel, complying with BS 4449 and should be free from oil, dirt, loose scale and rust. Dowel bars should be straight, free of burrs and other

irregularities, with the sliding end sawn. Dowel bars should be debonded over their length with a tough, durable plastic sheath of average thickness not greater than 1.25mm. For expansion joints, the expansion space available in the waterproof cap should be 10mm greater than the thickness of the joint filler board.

Joint grooves should be sealed with a hot applied joint-sealing compound complying with BS 2499 Type A2 and the finished surface of the seal should be 3mm below the surface level of the concrete.

Other expansion joint filling or sealing materials, or other debonding agents may be used, subject to approval.

3. Reinforcement: Where reinforced concrete is used, the reinforcement should be long mesh steel fabric, complying with BS 4483 and should be free from loose mill scale, rust, dirt, oil, paint or grease. The minimum weight of reinforcement should be 2.61 kg/m^2. The reinforcement should have 50mm minimum cover from the surface and should terminate between 250 and 350mm from any transverse joint and between 40 and 80mm from a longitudinal joint. The reinforcement should terminate between 100 and 150mm from the edges of the slab. Reinforcing mats should overlap such that the transverse wire of one mat would lie within the last complete mesh of the previous mat and the overlap should be at least 450mm.

2.22 Block Paving Roadways

Block paving roadways should be constructed generally as shown on Figure 2.3. The layout and structural design of the pavement is subject to approval.

The structural design of pavements constructed with clay or concrete block pavers, should comply with the requirements of BS 7533.

Clay and calcium silicate pavers should comply with BS 6677: Part 1, type PB with chamfers. 200 x 100 x 65mm pavers are generally the preferred size.

Concrete block pavers should comply with BS 6717: Part 1, type R. 200 x 100 x 80mm pavers are generally the preferred size.

Horizontal interlock should be given to the paving, either by the use of shaped blocks, or by laying rectangular blocks in a herringbone pattern. At the edge of the pavement, restraint should be provided, in order to prevent the pavers and the laying course from migrating outwards and losing interlock.

Clay and calcium silicate pavers should be laid in accordance with BS 6677: Parts 2 & 3.

Concrete block pavers should be laid in accordance with BS 6717: Part 3.

Laying course sand and jointing sand should comply with gradings C and F in Table 5 of IS 5 respectively.

2.23 Flexible Roadways

Flexible roadways should be constructed generally as shown on Figure 2.3.

The minimum roadbase thickness should be 150mm, except for dense bitumen macadam roadbase, which should have a minimum thickness at any point, of 80mm.

The Contractor may use either the sub-base, or the roadbase appropriately strengthened, for construction plant and traffic.

The requirements for so using the sub-base, are set out in clause 2.17 above. Any damage caused by construction traffic should be remedied, as approved, before laying of the roadbase.

Alternatively, the roadbase may be used by construction traffic, provided it is increased in thickness by 50mm and surface dressed in accordance with clause 2.24 below. Damage caused by construction traffic should be remedied, as approved, before laying of the surface course. Contaminated materials should be made good by cleaning; if this proves impractical the layer should be removed and replaced.

Roadway surfacing should consist of one of the following:

1. Two courses, consisting of a basecourse, 40mm minimum thickness at any point, of 20mm nominal size dense basecourse bitumen macadam and a wearing course, 25mm minimum thickness at any point, of 10mm nominal size close graded wearing course bitumen macadam, both of which should comply with BS 4987.

2. A combined wearing course and basecourse, 80mm thickness at any point, consisting of 40mm nominal size single course bitumen macadam, complying with BS 4987.

2.24 Surface Dressing

Surface dressing should be carried out in accordance with the manual "Surface Dressing" published by the Department of the Environment. The binder should be cutback bitumen or cationic bitumen emulsion, complying with the specifications issued by the Department of the Environment. Other binders may be used, subject to approval.

Cutback bitumen should be of the appropriate grade recommended in the manual. Cationic bitumen emulsion should have a nominal bitumen content of 70%. The binder should be spread at the appropriate rate recommended in the manual. Chippings should be of a single size (as approved by the local authority), cubical in shape and should comply with the requirements of Table 4 of the manual.

2.25 Footways

Footways should have a sub-base, of minimum thickness 100mm, complying with clause 2.19 above and should normally be of in-situ concrete construction, 100mm in depth generally, but increasing to 150mm where there is vehicular access. Other forms of footway construction are subject to approval.

The minimum footway width should normally be 2m. Where isolated obstructions occur on footways, the minimum clear width at the obstruction should be 1.2m. Footways should have a cross slope of 2.5% and where adjacent to roadways, this slope should be towards the roadway. Joints should be formed in a straight line, at right angles to the footway, at a maximum spacing of 3m and each joint should include a double layer of roofing felt, complying with IS 36, for the full depth of the joint.

A separation membrane, as specified in clause 2.21 above, should be placed between the concrete and the sub-base.

Concrete should be air entrained paving quality, as specified in Table 2.6 of clause 2.21 above.

2.26 Kerbs

At roadway edges, kerbs should show between 100mm and 150mm above the channel, except at vehicular accesses, where they should be reduced to 25mm over the channel and at wheelchair and pram accesses where an upstand of 10mm should be provided. The footway slope at such dished kerbs should not normally exceed 7%.

Cast-in-situ concrete kerbs should be 300mm deep by 225mm wide, laid on a 100mm sub-base which should be haunched. Concrete should be air entrained, as specified in Table 2.6 of clause 2.21 above.

Precast kerbs should be 250mm by 125mm, complying with IS 146 and should be laid on a 100mm thick by 300mm wide concrete bed and haunch.

Alternative kerb types at roadway edges are subject to approval.

2.27 Cement

Cement should comply with IS 1.

2.28 Concrete Aggregates

Coarse and fine aggregates from natural sources, for concrete, should comply with IS 5.

Section 3: Sewers and Drains

3.1 Compliance

Drainage works should comply generally with the requirements of BS 8005: Part 1, BS 8301 and the Specification for Roadworks.

3.2 Separate Systems

Some public sewers carry foul water and surface water (combined systems) in the same pipe. All new drainage systems should be designed and constructed on the basis of a separate system, even where draining into a combined system.

3.3 Pipe Types

The following pipes and fittings may be used for foul and surface water sewers and drains:

1. Unplasticized polyvinylchloride (PVC-U) pipes and fittings, in accordance with the requirements of IS 424.

2. Spigot and socket concrete pipes, in accordance with the requirements of IS 6.

3. Clayware pipes and fittings, in accordance with the requirements of IS EN 295.

4. Glass reinforced plastics (GRP) pipes and fittings, in accordance with the requirements of BS 5480.

5. Glass composite concrete (GCC) pipes and fittings, in accordance with the requirements of BS 5911: Part 101.

Joint types and materials are subject to approval.

Rebated concrete pipes and fittings, in accordance with the requirements of BS 5911: Part 100, may be used for surface water sewers and drains only. Joints should incorporate an elastomeric ring in compliance with Type D of BS 2494.

Other pipes and fittings may be used, subject to approval.

3.4 Pipe Sizes & Gradients - Surface Water

Performance criteria for protection against surcharge and flooding should be determined by the local authority.

The area to be taken into account, should be the total area of the roofs, together with the total area of paving contributing to the pipe system. Paving from which the run-off flows onto permeable surfaces should not be included. Where there is a possibility that the run-off from unpaved areas might cause ponding, or contribute significantly to the pipe flows, proposals for the drainage of such areas are subject to approval.

Surface run-off (l/s) should be calculated by means of the Modified Rational Method (Wallingford Procedure).

$$Q = A_p \times i \times C_r \times C_v \times 2.78$$

where

Q = Rate of run-off (l/s)
A_p = Impermeable area (ha)
i = Intensity of rainfall (mm/h)
C_r = Routing coefficient
C_v = Volumetric run-off coefficient

For areas which require a main surface water drain of up to 200m in length, rainfall intensities (i) of 75mm per hour for roof surfaces and 50 mm per hour for paved surfaces may be used. For larger areas, the rainfall intensity/duration/frequency relationship requires to be established, having regard to such local rainfall records as are available.

Recommended storm return periods for the design of drainage pipework, within the context of this publication, are set out in Table 3.1.

TABLE 3.1 Recommended Storm Return Periods for the Design of Drainage Pipework

Type of Site	Return Period Years
Sites with average surface gradient greater than 1%	1
Sites with average surface gradient of 1% or less	2
Sites where consequences of flooding are severe	5

It may be assumed that the maximum discharge of storm water from an area occurs when the duration of the storm is equal to the time of concentration (t) of the area. The time of concentration is the longest time taken for the rain falling on the area to reach the drain, plus the time taken to reach the point of concentration.

$$t = \text{time of entry} + \frac{\text{length of drain}}{\text{full bore velocity of flow}}$$

The time of entry may be regarded as representing the delay and attenuation of flow over the ground surface. Time of entry generally lies in the range of 4 to 8 minutes, with the larger figure applicable to a relatively flat subcatchment and the smaller value to relatively steep subcatchments. (Subcatchment refers to the area contributing to each individual pipe length).

Particular conditions may warrant a time of entry outside this range.

The value of the Routing coefficient (C_r), varies with the shapes of the time-area diagram and the rainfall profile. A value of 1.3 is commonly used.

The value of the Volumetric run-off coefficient (C_v), represents the proportion of rainfall on the paved areas that appears as surface run-off in the storm drainage system. The coefficient ranges from about 0.6 on catchments with rapidly draining soils, to about 0.9 on catchments with heavy soils.

Other methods of calculation of the Rate of run-off are subject to approval.

The minimum size of pipe should be 100mm. Pipes should be laid at gradients that would produce velocities in the range of 0.8m/sec to 3m/sec, when flowing half full.

Subject to the limitations imposed by the foregoing, pipe sizes and gradients should be selected from approved tables for the hydraulic design of pipework.

3.5 Pipe Sizes & Gradients - Foul Water

Pipes carrying foul water should be designed to accommodate six times average foul water flow. Average flow should be taken as 1,000 litres per dwelling per day. Gradients should be selected so as to maintain self-cleansing velocity under normal discharge conditions. Twice the average daily flow can be used as the criterion for the self-cleansing velocity. Subject to Table 3.2, all pipework should be laid at gradients that would produce velocities lying in the range of 0.75m/sec to 3m/sec, when flowing half full.

TABLE 3.2 Pipe sizes & Gradients - Foul Water

No. of Dwellings Contributing	Minimum Pipe Diameter (mm)	Minimum Gradient
1	100	1 in 60
2	100	1 in 100
3 or more	150	1 in 150

No single foul drain should serve more than eight dwellings.

Subject to the limitations imposed by the foregoing, pipe sizes and gradients should be selected from approved tables for the hydraulic design of pipework.

3.6 Bedding & Cover - Rigid Pipes

Rigid pipes do not deform appreciably under their design load. Rigid pipe materials exhibit a linear, brittle stress-strain behaviour.

The load carrying capacity of a rigid pipe is dependant on three main factors - the minimum crushing strength of the pipe, the class of bedding used and the uniformity of the support provided by the foundation along the pipeline.

Bedding and cover requirements for rigid drainage pipes are set out in Figure 3.1 and Table 3.3. It should be noted that Class D bedding should not be used, unless accurate trimming can ensure full bearing of the pipe on the trench floor. Class F bedding is generally suitable in all soil conditions, but measures may be required to prevent ground water flow in the trenches, during construction.

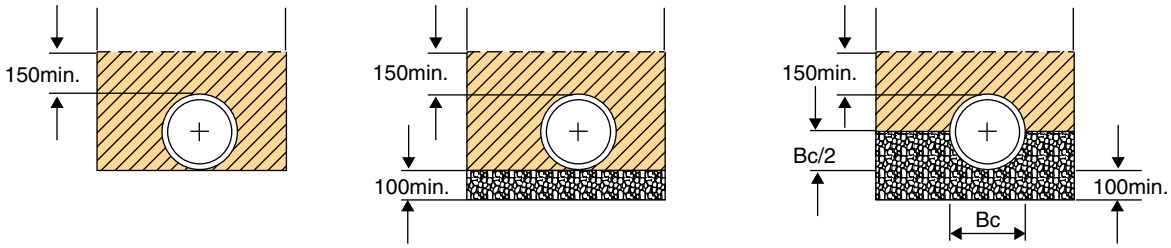


FIGURE 3.1: BEDDING AND SURROUND FOR RIGID DRAINAGE PIPES

Selected fill should be free from stones larger than 37.5mm, lumps of clay over 75mm, timber, frozen material and vegetable matter.

Granular material should be either 14mm to 5mm graded aggregate, or 10mm single sized aggregate, complying with the requirements of IS 5: Part 1: 1990, Table 7 and should have a Compaction Factor value not greater than 0.2 when measured in accordance with BS 8301: 1985, Appendix D.

TABLE 3.3 Limits of cover in metres for standard rigid pipes in any width of trench

		Gardens		Light traffic Roads	
Pipe Diameter	Bedding Class	Min	Max	Min	Max
100mm	D	0.6	4.2	1.2	4.1
100mm	F	0.6	5.8	1.2	5.8
100mm	B	0.6	7.4	1.2	7.4
150mm	D	0.6	2.7	1.2	2.5
150mm	F	0.6	3.9	1.2	3.8
150mm	B	0.6	5.0	1.2	5.0
225mm	D	-	-	-	-
225mm	F	0.6	2.5	1.2	2.1
225mm	B	0.6	3.3	1.2	3.2
300mm	D	-	-	-	-
300mm	F	0.6	2.2	-	-
300mm	B	0.6	2.6	1.2	2.4

Pipes laid in open spaces should have a minimum cover of 0.9m.

Where it is not possible to achieve the minimum cover stipulated in Table 3.3, pipes should be bedded and surrounded in concrete, 150mm thick, Class E, in accordance with Clause 1502 of the Specification for Roadworks.

For depths of cover greater than the maxima stipulated in Table 3.3, pipes with a higher crushing strength and/or bedding with a higher bedding factor are required, subject to approval.

3.7 Bedding & Cover - Flexible Pipes

Flexible pipes deform under load and the extent of this deformation depends upon the stiffness of the pipe and the compaction of the immediately surrounding fill. The materials for these pipes exhibit ductile stress-strain characteristics.

A flexible pipe derives its load bearing capacity from the pipe stiffness and the passive resistance developed in the surrounding materials. Bedding and surround requirements for flexible pipes are shown in Figure 3.2.

In the case of Vee Trench excavation, a sub-trench should be dug as shown in Figure 3.2. Otherwise, the form of construction is the same as that of the Typical Trench case.

Flexible pipes should be laid with a minimum cover of 1.2m in roads and driveways, 0.9m in open spaces and footpaths not adjacent to roadways and 0.6m in gardens. Where it is not

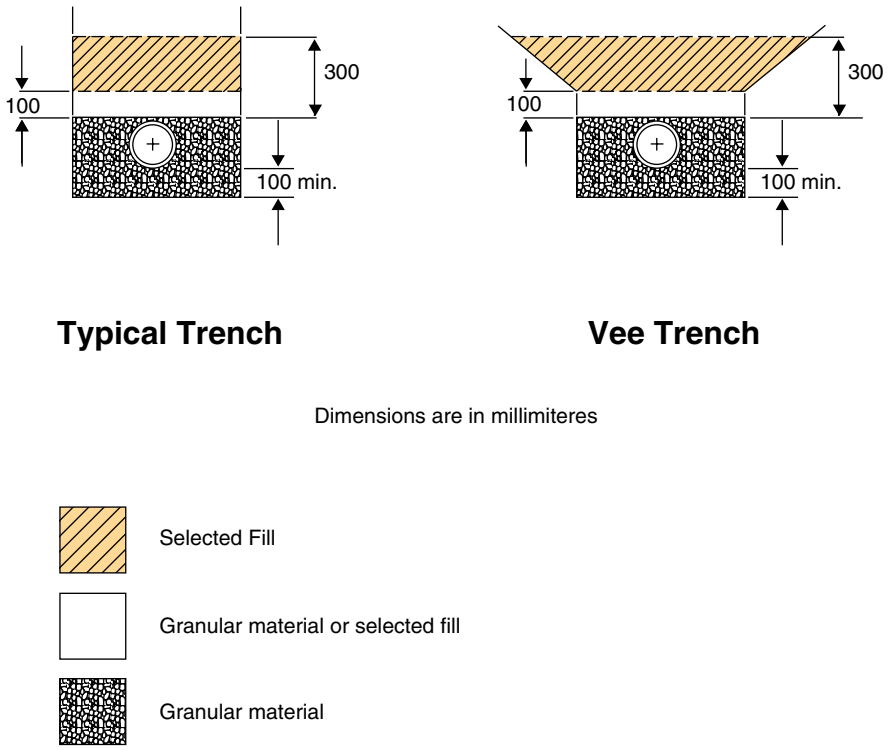


FIGURE 3.2: BEDDING AND SURROUND FOR FLEXIBLE DRAINAGE PIPES

possible to achieve these minimum covers, additional measures should be taken in order to protect the pipework. These measures might take the form of a layer of concrete paving slabs, with at least a 75mm layer of granular material between pipes and slabs, for gardens and open spaces. In the case of a road, a reinforced concrete surround, or reinforced concrete bridging slabs may be required. All such measures are subject to approval.

Flexible pipes may be laid at depths of up to 10m, without further specific design.

3.8 Trench Width

The limits of cover specified in Clauses 3.6 and 3.7 are irrespective of trench width.

Trench width at the level of the top of the pipe should generally be as narrow as safe working conditions would allow, with a minimum width of 300mm plus the external diameter of the pipe barrel.

When the trench width exceeds four times the outside diameter of the pipe barrel in the case of rigid pipes, or six times the outside diameter of the pipe barrel in the case of flexible pipes, the granular material may be sloped down from that width to the trench formation.

3.9 Trench Compaction

Sidefill of either granular material or selected fill, should be placed uniformly on either side of the pipe, in layers not exceeding 100mm, each layer being compacted by hand tamping until the pipe has a minimum of 150mm compacted cover. Care should be taken that the process of compaction does not displace the pipe from its correct line and level.

Backfill should be placed in layers not exceeding 300mm, each layer then being well compacted. Mechanical compaction equipment should not be used, until there is a minimum of 450mm of compacted material above the crown of the pipe.

3.10 Accessibility

Sewers should be accessible for maintenance and repair and should be constructed on public property.

3.11 Access to Sewers

Access to sewers and drains should be provided at maximum intervals of 90m and in the following positions:

1. At all changes of direction.
2. At all changes of gradient.
3. At the head of all sewer and drain lengths.
4. At all sewer junctions and all changes in pipe diameter.
5. At the point of connection of a branch drain with a main drain or sewer, or on the branch drain within 12m of such connection.

Access should generally be provided by means of a manhole but, subject to approval, a proprietary access junction may be used in lieu of a manhole, on a drain where the depth to invert is less than 600mm. An untrapped gully at the head of a drain would suffice as access. Where there is a trapped gulley at the head of a drain, it should be provided with a rodding eye, or an alternative means of access, within one metre of the gully.

3.12 Drain to Sewer Connections

Subject to the requirements of Clause 3.11, the connections of drains to sewers should be made in such a manner as to minimise any interruption of the flow, by one of the following methods:

1. Where there is an adjacent manhole, the connection should be made at the manhole.
2. Where there is not an adjacent manhole, it may be necessary to construct a new manhole.
3. When connecting directly to a sewer or a drain, an oblique or curved square junction pipe inserted in the main may be used.
4. As an alternative to method 3., an oblique type saddle may be used. Saddles should not be used on pipes of 100mm diameter, nor to connect pipes of the same diameter.

In the case of methods 3. and 4., an approved slow bend may be used in the drain, immediately upstream of the connection.

Intercepting traps between drains and sewers should not be used, except where the Local Authority requires them at connections with existing sewers.

3.13 Joints

All pipes should have flexible joints formed by a method recommended by the pipe manufacturer. Elastomeric sealing rings, complying with the requirements of BS 2494, type D, should be used.

3.14 Manhole Construction

Manholes should be durable, resistant to water penetration, resistant to leakage and should be designed and constructed so as to minimise the risk of blockage.

Manholes may be constructed of:

1. Solid concrete blockwork, complying with the requirements of IS 20.
2. In situ concrete, 30N/mm^2, 20mm maximum aggregate size.
3. Precast concrete units, complying with the requirements of BS 5911: Part 200.
4. Other materials, as approved.

Manhole bases should be constructed of concrete, 30N/mm^2, 20mm maximum aggregate size, minimum thickness 150mm for depths up to 3.3m and 225mm for depths in excess of 3.3m. Alternatively, approved precast concrete bases may be used.

The minimum wall thickness for concrete blockwork, or in situ concrete, should be 200mm for depths up to 3.3m and 300mm for depths on excess of 3.3m.

Blockwork mortar should be Class 1 in accordance with Clause 1721 of the Specification for Roadworks. All mortar joints should be completely filled and flush pointed as the work proceeds. Blockwork walls should be scudded and rendered in two coats externally, to a minimum thickness of 20mm. The rendering materials should have a 1:3 cement sand dry volume ratio and should incorporate an approved waterproofing agent. The sand should comply with the requirements of BS 1199.

Where precast concrete units are used for the manhole chamber, special attention should be paid to jointing. Where manholes are constructed wholly above the watertable, rebated joints sealed with cement mortar may be satisfactory. In waterlogged ground, or where the water table is above the manhole base, joints should be made watertight, preferably using a non-rigid jointing material such as a mastic sealant, or an elastomeric ring.

Where precast units are installed in unstable ground, or are likely to be subjected to exceptional or eccentric loads, a 150mm concrete surround, 30N/mm^2, 20mm maximum aggregate size should be provided. Care should be taken to compact the concrete under incoming and outgoing pipes. Any joints in the concrete surround should be staggered with those of the precast units.

Roofs should consist of a reinforced concrete slab, minimum thickness 150mm, designed to carry all live and dead loads. Alternatively, approved precast concrete roofs may be used.

3.15 Manhole Dimensions

Manhole dimensions depend on the size of the main drain or sewer and on the number, size and position of branch pipes entering. The design size should permit entry, without unduly restricting operating space.

Minimum internal dimensions of manholes should be as in Table 3.4. Subject to the minimum sizes given, adequate dimensions may be calculated for straight inverts on the following basis:

1. Length: Considering the side with the greater number of branches, provide the sum of the branch diameters plus 200mm per branch for branches up to 150mm diameter (or, 300mm per branch for branches greater than 150mm diameter), plus 300mm.

2. Width: Provide 300mm for each benching with branches, or 150mm for a benching with no branches, plus the diameter of the pipe.

Manholes with curved channels, or with a difference in level of over 300mm between incoming and outgoing pipes, require special consideration and the dimensions should be subject to approval.

TABLE 3.4 Minimum Internal Dimensions of Manholes
Pipe Diameter ≤ 300mm)

	Depth to Invert (m)	Rectangular		Circular Diameter (m)
		Length (m)	Width (m)	
	≤ 1.5	1.2	0.75	1.0
	1.5 to 2.7	1.2	0.75	1.2
*	> 2.7	1.2	0.84	1.2

* For depth to invert of more than 2.7m, a working chamber and access shaft may be provided in lieu of a full-sized manhole for the full depth. The chamber height should be not less than 2m above the top of the benching and its dimensions should be as for the manhole. The minimum internal dimensions of the shaft should be 0.9 x 0.84m (rectangular), or 0.9m diameter (circular).

3.16 Channels & Benching

An open channel of half-round section, bedded and jointed in 1:3 cement sand mortar, should extend the whole length of the manhole. Where there is change in pipe size between the main pipe entering and that leaving the manhole, the connecting channel should consist of an approved proprietary taper. Where a suitable taper is not available, the channel should be formed from in situ concrete, 30N/mm^2, 20mm maximum aggregate size, finished with a 1:3 cement sand mortar.

A vertical in situ benching should be formed from the top edge of the channel, to a height not less than the soffit of the outlet. It should be rounded off to a radius of about 25mm and then sloped upwards at a gradient of about 1:12 to meet the wall of the manhole. The benching should be floated to a hard smooth surface, with a coat of 1:3 cement sand mortar laid monolithically.

In the case of branch channels, the benching should be so shaped as to guide the flow in the desired direction.

Alternatively, precast base units, incorporating channels and benching may be used, subject to approval.

3.17 Manhole Covers & Frames

Manhole covers and frames are subject to approval, but should comply generally with the requirements of IS EN 124. The minimum opening dimensions should be 600mm x 600mm (rectangular), or 600mm diameter (circular). The appropriate class of cover and frame that should be used in various locations is given in Table 3.5.

TABLE 3.5 Manhole Covers and Frames

* Class	Location
Class D 400	Roadways, hard shoulders, vehicular accesses
Class B 125	Footways, grass verges
Class A 15	Areas inaccessible to motor vehicles

* Ref: IS EN 124

3.18 Manhole Steps & Ladders

Steps should be provided in manholes of between one metre and 4.5m in depth. Ladders should be used, instead of steps, for manholes deeper than 4.5m.

Manhole steps should comply with the requirements of BS 1247: Part 1. Blockwork, in situ concrete and precast concrete manholes should be provided with steps, in two vertical runs, 300mm apart centre to centre. The steps should be at 300mm intervals in each run and the two runs should be staggered vertically, by 150mm. The top step should be a maximum distance of 450mm from the ground surface and the bottom step should be a maximum distance of 300mm above the top of the benching. Precast concrete units should have built-in steps, as provided for in Clause 3.6.5 of BS 5911: Part 200.

Access ladders should be fabricated from steel complying with the requirements of IS EN 10113. Stringers should be not less than 65mm x 12mm in section, 300mm apart and drilled with holes 20mm diameter for shouldered 22mm diameter rungs at 300mm centres. At the top, the stringers should be bent at right angles, to a radius of 150mm and an allowance made for a horizontal run of 225mm before ending in a face plate, for fixing to the manhole wall. Horizontal stays, not less than 65mm x 12mm in section should be provided at intervals not exceeding 2.4m. The ladder and stays should be hot-dipped galvanized, after fabrication in accordance with the requirements of BS 729. The method of fixing the ladder to the manhole wall is subject to approval. The top rung should be a maximum distance of 450mm from the ground surface and the bottom rung should be a maximum distance of 300mm above the top of the benching. Alternative ladder designs may be used, subject to approval.