CHAPTER TEN

Specification of Roads and Pavings

THIS chapter covers a wide range of constructional methods adopted in the provision of roads and footpaths. The modern practice is often to refer to roads as 'pavements', following American terminology.

In drafting specifications for roadworks it is probably advisable to subdivide the specification into the component parts or elements of the work. In some cases these sections need further subdivision into materials and construction or workmanship provisions. Alternatively all materials clauses can be grouped together at the beginning of the specification. This procedure has the great merit of avoiding duplication of items. One suitable approach in the drafting of roadwork specifications follows.

MATERIALS required for roads and footpaths.

ROAD BASES, including formation, hard shoulders and possibly soil stabilisation.

FLEXIBLE ROAD CONSTRUCTION: tarmacadam, bitumen macadam and asphalt.

RIGID ROAD CONSTRUCTION: concrete roads, including expansion and longitudinal joints.

ANCILLARY WORK: kerbs, channels, quadrants and edging.

SURFACE WATER DRAINAGE: road gullies, pipework and manholes.

FOOTPATH CONSTRUCTION: tarmacadam, bitumen macadam, asphalt, in situ concrete and paving slabs.

OTHER ITEMS

Grass verges

Street lighting: possibly covered by prime cost items and road crossings for cables.

Fencing: various types.

Readers are referred to Chapter V for more detailed clauses on concrete work and to Chapter XI for detailed clauses on sewers, drains and manholes. For bridgework, readers will find most of the information they require in the chapters covering excavation, concrete, brickwork, masonry, piling and iron and steelwork.

Typical specification clauses follow, covering a selection of the more commonly used materials and constructional methods. Some guidance on alternative methods, where appropriate, will be found in the explanatory notes.

TYPICAL SPECIFICATION CLAUSES	EXPLANATORY NOTES

ROAD-WORKS: MATERIALS

Hardcore for filling

Hardcore shall be natural broken stone, broken brick or other approved hard material, clean and free from any extraneous matter and graded from 225 mm (9 in.) to 75 mm (3 in.).	The actual material used will be largely determined by the materials available in the particular district.

Ashes

Ashes shall be clean, sharp foundry ashes containing not more than 20 per cent of dust and shall be free from foreign matter. Flue dust and destructor ashes will not be accepted.	Ashes are often used as a base for footpath surfacings and sometimes for concrete roads.

Aggregate for granular bases

Aggregate for granular bases shall be clean, hard crushed rock, limestone, slag or gravel of 50 mm (2 in.) or 40 mm (1½ in.) nominal size.

See Table 1 of B.S. 63: Single-sized Roadstone and Chippings.

Road tar for surface dressing

Road tar for surface dressing shall comply with B.S. 76, type A, and the equiviscous temperature of the tar shall be in accordance with Road Note No. 1: Recommendations for Tar Surface Dressings.

Note the use of Road Notes and other publications of the Road Research Laboratory as a guide to constructional methods.

Cut-back bitumen for surface dressing

Cut-back bitumen shall be obtained from an approved manufacturer and have a viscosity within the range prescribed by the Engineer.

Typical viscosities are 40–60 secs S.T.V. at 40°C in April, May and September, rising to 80–120 secs S.T.V. at 40°C in June to August.

Aggregate for surface dressing

Aggregate for surface dressing shall consist of hard, clean crushed rock or slag of 10 mm (⅜ in.) nominal size and shall comply with the grading requirements of B.S. 63.

Chippings used vary from 3 mm (⅛ in.) to 20 mm (¾ in.) in size and may be of granite, basalt, limestone, slag or gravel.

Bitumen road emulsion

Bitumen road emulsion for curing cement stabilised bases or sub-bases shall comply with B.S. 434.

B.S. 434 is entitled Bitumen Road Emulsion (Anionic).

Tarmacadam

Tarmacadam for carriageways shall consist of 40 mm (1½ in.) gauge material

Tarmacadam is normally laid in two courses, but single

for the base course and 10 mm (½ in.) gauge material for the wearing course. The grading of the 40 mm (1½ in). material shall be in accordance with B.S. 802, Table 1b. The grading of the 10 mm (½ in.) material shall also conform to B.S. 802 and shall be medium-textured material complying with Table 3 of the Standard. The aggregate shall be hard, durable and clean crushed limestone to the approval of the Engineer, and the binder shall be of tar.

Tarmacadam for footpaths shall consist of 25 mm (1 in.) gauge material for the base course and 10 mm (⅜ in.) gauge material for the wearing course. The grading of the materials, and the binder contents and viscosities shall comply with B.S. 1242.

course construction is sometimes used for surfacing and resurfacing work for light to medium traffic. Similar material of smaller gauge is specified for footpath work, but reference would be made to B.S. 1241 where gravel aggregate is required.

Testing requirements are also covered in the British Standard.

Bitumen macadam

Bitumen macadam for carriageways and footpaths shall be of similar material and gauge to that specified for tarmacadam. The grading of the 40 mm (1½ in.) material shall be in accordance with Table 2 and the 10 mm (½ in.) material shall comply with Table 5 of B.S. 1621.

The construction of bitumen macadam roads and paths is similar to those in tarmacadam. B.S. 1621 covers bitumen macadam with crushed rock or slag aggregate, while B.S. 2040 covers that with gravel aggregate.

Rolled asphalt

Rolled asphalt (hot process) base and wearing courses shall comply with B.S. 594 and shall have a natural rock aggregate.

Rolled asphalt is composed of asphaltic cement, fine aggregate, coarse aggregate and a filler.

Cold asphalt

Cold asphalt shall be manufactured in accordance with B.S. 1690 with a

Cold asphalt is used as an impervious wearing course,

crushed natural rock aggregate with a maximum size of 5 mm ($\frac{1}{4}$ in.).

as a carpet coat or for patching or sealing.

Waterproof underlay

The waterproof underlay shall consist of either waterproof paper complying with B.S. 1521, class B, or plastic sheeting to grade 250.

Cement and aggregates are covered in Chapter V.

Fabric reinforcement

Steel fabric reinforcement shall comply with B.S. 1221, reference 125, weighing not less than 19·5 kg/m² (4·32 lb/ft²). The reinforcement shall be made up in mat form.

This type of fabric is made up of 5 s.w.g. wires at a pitch of 150 mm (6 in.) in each direction with electrically welded intersections.

Dowel bars

Dowel bars shall be formed of mild steel complying with B.S. 785, and shall be 20 mm ($\frac{3}{4}$ in.) in diameter, 600 mm (2 ft) in length, clean, straight and free from all deformations.

Dowel bars are often inserted across transverse joints in concrete road slabs to provide load transmission from one slab to the next.

Joint filler

The joint filler shall be pre-moulded and of a type and manufacture approved by the Engineer. It shall be not less than 10 mm ($\frac{1}{2}$ in.) thick. It shall be 25 mm (1 in.) less in depth than the thickness of the concrete slab, and accurately holed to receive the dowel bars.

Specimens shall be subjected to three applications of load at 20 hour intervals to obtain 50 per cent compression. The specimens shall recover at least 70 per cent of their thickness within 2 hours of the release of the last loading.

The joint filler is usually made of non-extruding fibre strips which are capable of adjusting themselves to the changing widths of expansion joints.

Joint sealer

The joint sealer shall be a rubber-bitumen compound of a proprietary brand, approved by the Engineer, and shall be poured in position in accordance with the manufacturer's instructions.

An alternative method of specifying joint sealers is given in the Ministry of Transport Specification for Road and Bridge Works, which refers to the U.S. Federal Specification and cone penetration, flow and bond test requirements.

Forms

Forms shall be of either steel or timber with a depth equal to the thickness of the slab.

Timber forms shall be free from warps and twists, of sufficient thickness to ensure adequate rigidity and with a tamping edge which is true to line and level.

Steel forms shall be of approved section and construction, and shall be perfectly straight or suitably curved, with a broad base and sufficient thickness to withstand, without displacement or distortion, the placing and compaction of the concrete. Steel forms shall be provided with an efficient locking device to ensure continuity of line and level through joints and with steel pins to hold them in position.

It is essential that all forms, whether of timber or steel, should be of adequate strength and properly fixed in the correct positions, to withstand the tamping or vibration of the concrete without movement.

Kerbs

Kerbs shall be of naturally coloured precast concrete and shall comply with B.S. 340. They shall contain a granite aggregate and be hydraulically pressed, with a 125 mm × 250 mm (5 in. × 10 in.)

The majority of road kerbs used today are of precast concrete, the strongest being of granite aggregate, and are hydraulically pressed with

half-battered section. Purpose-made radius kerbs shall be used for all radii of 12 m (40 ft) and less with the radius clearly marked on one of the unexposed faces.

patterned faces. There are nine different standard sections of concrete kerb.

Channels

Channels shall be of precast concrete with a granite aggregate complying with B.S. 340, and shall be 250 mm × 125 mm (10 in. × 5 in.) in section.

The same British Standard applies as for kerbs. Channels are now often omitted on grounds of expense.

Quadrants

Quadrants shall be of precast concrete with a granite aggregate complying with B.S. 340. They shall be of 300 mm (12 in.) radius, 250 mm (10 in.) deep with a half-battered curved face.

These are also covered by B.S. 340. They are often provided at each side of footpath crossings on the kerb line: 450 mm (18 in.) radius quadrants are also available.

Edgings

Edgings shall be of precast concrete with a gravel aggregate complying with B.S. 340. They shall be 50 mm × 150 mm (2 in. × 6 in.) in section with a half-rounded top.

These are used at the edges of tarmacadam, bitumen macadam and asphalt paths. Sections of 50 mm × 200 mm (2 in. × 8 in.) and 50 mm × 250 mm (2 in. × 10 in.) are also available.

Concrete flags

Concrete flags shall be naturally coloured precast concrete hydraulically pressed with a granite aggregate and shall comply with B.S. 368. The flags shall be 50 mm (2 in.) thick.

Precast concrete flags are made in four sizes: 900 mm × 600 mm (3 ft × 2 ft), 750 mm × 600 mm (2 ft 6 in. × 2 ft), 600 mm × 600 mm (2 ft × 2 ft), and 600 mm × 450 mm (2 ft × 1 ft 6 in.), and in two thicknesses: 50 mm and 65 mm (2 in. and 2½ in.).

Clayware gully pots

Clayware road gullies shall be 375 mm (15 in.) in diameter × 750 mm (30 in.) deep with a rodding eye in accordance with B.S. 439, Part 1.

Precast concrete gullies should be unreinforced and should comply with B.S. 556.

Gully gratings and frames

Gully gratings and frames shall comply with B.S. 497 and shall be curved bar gully gratings and frames, grade B, with a clear opening of 400 mm × 350 mm (16 in. × 14 in.), and weighing approximately 100 kg (2 cwt).

An alternative is to use kerb type gully covers and frames, grade C, with a clear opening of 475 mm × 375 mm (19 in. × 15 in.) and weight of 100 kg (2 cwt) for use in paths and verges. Grade A heavy duty gully gratings and frames, weighing up to 150 kg (3 cwt), are designed for use in main roads.

Grass seed

Grass seed for use on verges, central reserves and side slopes shall be a tested mix from an approved source, supported by certificates of purity and germination. The mixture shall consist of the following types of grass seed in the proportions given:

Perennial rye grass	60 per cent
Red fescue	20 per cent
Smooth stalked meadow grass	10 per cent
Crested dogstail	10 per cent

Different Engineers specify varying mixes largely resulting from past experience. A high proportion of hardy, quick-growing perennial rye grass is needed in these locations.

Fertiliser

The fertiliser for grass seeded areas shall consist of an approved compound containing:
10 per cent Nitrogen
15 per cent Phosphoric Acid
10 per cent Potash

It is good policy to state the three essential ingredients of the grassland fertiliser.

WORKMANSHIP: ROAD BASES

Surface soil

The Contractor shall strip all top soil from the area of carriageways, footways, verges, cuttings and embankments, and shall stack it where directed for future use.

Surface soil or turf should be stripped from the site of the roadworks. Most of it will be required later for soiling verges and other grassed areas.

Excavation

The Contractor shall excavate in any material down to formation level or to such lower level as is required by the Engineer to reach a sound foundation. The spoil shall be used as filling, if approved by the Engineer, or removed from the site.

There is usually an obligation on the Contractor to provide a tip for the disposal of surplus excavated material.

Preparation of formation

The whole area of carriageways whether on fill or in excavation shall be thoroughly consolidated to the satisfaction of the Engineer. In general a 2500 kg ($2\frac{1}{2}$ ton) smooth wheeled roller will be adequate for this purpose. Any soft places shall be cut out and replaced with suitable hard, dry filling material and again consolidated.

The finished surface of the formation shall be reasonably smooth and free from loose material and shall be approved by the Engineer. The formation shall have gradients and crossfalls parallel to those of the finished road surface and provision shall be made for the removal of surface water that will collect near the edges of the formation. The surface water shall be directed to

It is essential that the formation or subgrade should be carefully formed and consolidated to the correct levels. The type and weight of roller required will vary with the characteristics of the subgrade. Any soft spots within the carriageway limits must be cut out and replaced with suitable consolidated material and arrangements made for disposing of surface water which would otherwise accumulate on the surface of the formation.

It is good practice to seal the formation with a surface dressing of hot tar or bitumen

surface-water gully pots or to temporary ditches with suitable outlets formed clear of the formation, through grips at 3 m (10 ft) intervals. The Contractor shall take care to prevent damage to gully pots or blocking of pots with earth or other debris.

Within 24 hours of the final preparation of the formation, or as soon as practicable thereafter, the Contractor shall surface dress the formation with hot tar, as previously specified, at a temperature within the range 93°–127°C (200°–260°F), evenly applied at a rate of 1·2–1·5 l/m² (3–4 yd²/gal) with a distributor complying with B.S. 1707: Hot Binder Distributors for Road Surface Dressing. Immediately after spraying, the binder shall be covered with 5 mm (¼ in.) gravel chippings at the rate of 160 m²/1000 kg (200 yd²/ton), and be adequately rolled with a 2500 kg (2½ ton) roller.

and chippings of gravel, crushed rock or slag. Some Engineers permit the hand application of binder and chippings.

Filling

No filling material shall be laid until the surface soil has been removed. Filling shall consist of approved material from the excavations or hardcore as specified and shall be placed and consolidated in layers not exceeding 225 mm (9 in.) in thickness of loose material. Consolidation shall be effected by the use of a suitable roller or approved heavy plant and during the process of consolidation the Contractor shall ensure that the material used for filling shall have the correct water content to secure maximum compaction.

The final surface of filling shall be carefully levelled and graded, finishing

The filling material will be determined by a number of factors, including depth of fill, class of road and nature of surplus excavated material. The type of plant required for consolidation purposes will likewise be influenced by the depth and type of fill.

parallel to the profile of the road surface.

Sub-base

The carriageway sub-base shall consist of ashes, as specified, laid and rolled to a consolidated thickness of 100 mm (4 in.). The roller shall be the heaviest which will compact the sub-base without unduly disturbing the underlying formation.

The sub-base lies between the formation and the road base in flexible construction. With rigid pavements this layer will constitute the base lying between the formation and the road slab. Thicknesses may range from 100 mm (4 in.) to 250 mm (10 in.), depending on the CBR value and frost susceptibility figure for the subgrade.

Water-bound granular base

The base course shall consist of hard, durable igneous rock with a maximum size of 50 mm (2 in.), laid in two layers each with a consolidated thickness of 100 mm (4 in.).

The aggregate shall be mixed with 2–5 per cent of water depending on the type of aggregate in an approved mixer. Compaction shall be effected with an 8000–10,000 kg (8–10 ton) smooth-wheeled roller with a minimum of 10 passes.

It is generally considered undesirable to lay water-bound granular bases in layers more than 150 mm (6 in.) thick. Alternative forms of construction include dry-bound granular base, low-binder macadam and tar or bitumen-bound granular base.

Lean concrete base

The coarse aggregate shall be washed gravel complying with B.S. 882, Table 3, in an all-in aggregate, with a maximum size of 20 mm ($\frac{3}{4}$ in.). The mix shall be 1 part of Portland cement to 20 parts of all-in aggregate with a water content of

This is weak concrete with a low water content, consolidated by rollers. This gives a strong but rather expensive form of base, but is used extensively for rigid roads to

5–6 per cent by weight, mixed in an approved batch-type mixer.

The lean concrete base shall be 200 mm (8 in.) thick and shall be compacted within 1½ hours of laying with a 400 kg (8 cwt) vibratory roller, followed by an 8000–10,000 kg (8–10 ton) deadweight roller. Within 1 hour of compaction the surface shall be sprayed with 55 per cent bitumen emulsion at the rate of 0·75 l/m² (6 yd²/gal). The lean concrete base shall attain a minimum strength of 10 MN/m² (1400 lbf/in.²).

carry heavy traffic flows. Readers requiring more information on the grading of aggregates are referred to the Ministry of Transport Specification for Road and Bridge Works, 1963 (H.M.S.O.).

Soil cement

The basic material shall consist of crushed rock graded in accordance with the Ministry of Transport specification, mixed with 10 per cent by weight of Portland cement in an approved paddle type mixer. The moisture content shall be determined using the methods outlined in B.S. 1377.

The soil cement shall be laid 150 mm (6 in.) thick and shall be compacted within 2 hours of mixing, starting with a 2000–3000 kg (2–3 ton) smooth-wheeled roller and following with an 8000–10,000 kg (8–10 ton) smooth-wheeled roller.

The soil cement shall be cured by spraying the stabilizing layer with 55 per cent bitumen emulsion at the rate of 0·75 l/m² (6 yd²/gal) as soon as compaction is complete.

A variety of materials can be used for soil cement or cement stabilization, including naturally occurring soil, washed or processed granular material, crushed rock or slag, and pulverised fuel ash or burnt colliery shale. Where suitable soil exists on the site, mix-in-place construction can be adopted, whereby cement is spread ahead of the mixer after the soil has been pulverised. Methods of testing are detailed in B.S. 1924.

ROAD SURFACINGS

Tarmacadam

The carriageway surfacing shall consist of two coats of tarmacadam, machine-laid to a consolidated minimum thickness of 80 mm (3¼ in.), with limestone aggregate and a tar binder. The base course shall consist of 40 mm (1½ in.) nominal size material as specified, rolled to the required profile with a 10,000 kg (10 ton) roller, with a width of roll of not less than 450 mm (18 in.), to a consolidated thickness of 65 mm (2½ in.), in the manner described in B.S. 802.

The wearing course shall be of medium-textured material as specified to a nominal size of 15 mm (½ in.). The wearing course shall be rolled to the required profile with a 10,000 kg (10 ton) roller to a consolidated thickness of 20 mm (¾ in.). The finished surface of the tarmacadam shall be blinded immediately after consolidation with approved grit of a grading not exceeding 3 mm (⅛ in.) to dust. The grit shall have been coated with 2–3 per cent of tar of e.v.t. not exceeding 30°C (86°F).

Where construction joints occur in the surfacing, the edge of the previous work shall be cut back to a vertical face which shall be coated with hot tar before any new work is laid against it. The adjoining edges of manhole covers and similar fittings shall be cleaned and painted with hot tar. The surface across joints shall be tested for truth of level and any irregularities exceeding 5 mm (3/16 in.) with a 3 m (10 ft) straight edge shall be rectified immediately.

Tarmacadam surfacing can take various forms, from single-course to two-course work and from open- to close-textured material. The type of aggregate and binder can also be varied.

The courses must be laid to the correct profiles and adequately consolidated, usually with a 10,000 kg (10 ton) roller.

B.S. 802 gives details of the grading of the aggregate and the binder content.

Bitumen macadam

The carriageway surfacing shall consist of two coats of open-textured bitumen macadam machine laid to a consolidated minimum thickness of 85 mm (3½ in.), with limestone aggregate and cut-back asphaltic bitumen binder. The base course shall consist of 40 mm (1½ in.) nominal size material as specified rolled to the required profile with a 10,000 kg (10 ton) roller, with a width of roll of not less than 450 mm (18 in.), to a consolidated thickness of 65 mm (2½ in.), in the manner described in B.S. 1621.

The wearing course shall be of 15 mm (½ in.) nominal size material complying with Table 5 of B.S. 1621. The wearing course shall be rolled to the required profile with a 10,000 kg (10 ton) roller to a consolidated thickness of 25 mm (1 in.). The surface of the newly compacted bitumen macadam shall be blinded with bitumen-coated limestone grit not exceeding 3 mm (⅛ in.) nominal size.

Where construction joints occur in the surfacing, the edge of the previous work shall be cut back to a vertical face which shall be coated with hot bitumen before any new work is laid against it. The adjoining edges of manhole covers and similar fittings shall be cleaned and painted with bitumen.

The accuracy of the finish in the longitudinal direction shall be checked with a 3 m (10 ft) straight edge and the maximum permissible gap between the underside of the straight edge and the bitumen macadam shall be 10 mm (½ in.)

Various constructional methods are available, using single-course or two-course construction, and the bitumen macadam can be open- or close-textured.

A wide range of aggregates can be used, as indicated in B.S. 1621, and the binder can be either cut-back or straight-run bitumen. An alternative material for blinding is fine cold asphalt to B.S. 1690. The total thickness of two-course construction varies from 75 mm (3 in.) to 115 mm (4½ in.) for normal work.

Note the alternative and more comprehensive method of specifying maximum permissible surface irregularities to that adopted for tar macadam.

for base course and 5 mm ($\frac{1}{4}$ in.) for wearing course.

Rolled asphalt (hot process)

Rolled asphalt surfacing to carriageways shall consist of two coats of hot rolled asphalt machine-laid to a consolidated minimum thickness of 100 mm (4 in.), all in accordance with the general requirements of B.S. 594. The base course shall have a consolidated thickness of 65 mm ($2\frac{1}{2}$ in.) and shall consist of 70 per cent of an approved crushed rock coarse aggregate and an asphaltic cement of bitumen of 40/60 penetration.

The wearing course shall have a consolidated thickness of 40 mm ($1\frac{1}{2}$ in.) and shall consist of 30 per cent of an approved crushed rock coarse aggregate and an asphaltic cement of equal proportions by weight of bitumen of appropriate penetration and refined Lake asphalt.

The wearing course shall, except under exceptional conditions, be laid within 3 days of the laying of the base course. The base course shall have a clean surface and no traffic, except that required in connection with the wearing course, shall be permitted on it. The surface of the newly laid wearing course shall be blinded with 20 mm ($\frac{3}{4}$ in.) coated chippings rolled into the surface at a uniform rate of between 70 and 90 m^2/1000 kg (90 and 110 yd^2/ton), with a roller weighing not less than 5000 kg (5 tons).

The accuracy of the finish in the longitudinal direction shall be checked with a 3 m (10 ft) straight edge and the maximum permissible gap between the

Most of the essential requirements relating to the manufacture and laying of hot rolled asphalt are detailed in B.S. 594. Some amplification is, however, necessary as outlined in the accompanying specification clauses.

Hot rolled asphalt can be laid as a single course or in two courses and it is advisable to produce a roughened surface by applying pre-coated chippings.

underside of the straight edge and the asphalt wearing course shall be 5 mm ($\frac{3}{16}$ in.).

Cold asphalt

Cold asphalt shall be manufactured and laid in general accordance with B.S. 1690, with a limestone aggregate. Cold fine asphalt shall be machine-laid in a single wearing course with a consolidated thickness of 20 mm ($\frac{3}{4}$ in.) to the required profiles.

Pre-coated bitumen stone chippings (10 mm ($\frac{1}{2}$ in.) single size) shall be evenly distributed over the newly laid asphalt at the rate of 80–130 m²/1000 kg (100–160 yd²/ton). The asphalt and chippings shall then be compacted with a roller weighing not less that 5000 kg (5 tons). Road channels, 250 mm (10 in.) wide, shall be left clear of chippings.

When laying cold asphalt against existing work, the old material shall be cut back to provide a dense vertical face which shall be painted with hot bitumen.

Fine cold asphalt is used for a variety of purposes, but particularly as carpet coats and for blinding, sealing and patching. Its great advantage is its ease of application and it is now used extensively in the repair and maintenance of roads and paths. It has a life of up to 10 years.

Surface dressing

Hot tar shall be evenly applied to the carriageway surface by means of a distributor complying with B.S. 1707: Binder Distributors for Road Surface Dressing, at the rate of 0·75–1 l/m² ($4\frac{1}{2}$–6 yd²/gal.). The temperature of the tar at the time of application to the road surface shall be appropriate to the equiviscous temperature of the tar being used, but in no case shall it fall below 82°C (180°F).

Immediately after spraying, the tar

The rate of application of binder and chippings varies with the condition of the surface which is being dressed and the type and size of chippings. For initial surface dressing of an open-textured coated macadam wearing course, 5 mm ($\frac{1}{4}$ in.) slag chippings applied at the rate of 110–140 m²/1000 kg (140–170 yd²/ton) and tar at the

TYPICAL SPECIFICATION CLAUSES	EXPLANATORY NOTES
shall be covered with an even layer of 10 mm ($\frac{1}{2}$ in.) clean slag chippings applied at the rate of 70–80 m²/1000 kg (90–100 yd²/ton). The chippings shall be rolled with a roller weighing 6000–8000 kg (6–8 tons), rolling being continued until a uniform compact surface has been obtained. When required the Contractor shall mix an approved adhesion agent with the binder prior to spraying.	rate of 0·6–0·7 l/m² ($6\frac{1}{2}$–8 yd²/gal.) would be suitable. Where a hot cut-back bitumen is used as binder, the temperature of application would be 121–177°C and the rate of spread of the binder would be 0·6–0·9 l/m² (5–8 yd²/gal.) depending upon conditions. (See Ministry of Transport: Specification for Road and Bridge Works.)

NOTE: Other suitable applications for periodic surface dressing would be:

Type of aggregate	*Rates of application*	
	Tar	*Aggregate*
20 mm ($\frac{3}{4}$ in.) slag or crushed rock	1–1·3 l/m² ($3\frac{1}{2}$–4 yd²/gal.)	60–70 m²/1000 kg (70–80 yd²/ton)
15 mm ($\frac{1}{2}$ in.) gravel	0·9–1 l/m² ($3\frac{1}{2}$–5 yd²/gal.)	70–80 m²/1000 kg (90–100 yd²/ton)
20 mm ($\frac{3}{4}$ in.) gravel	1·2–1·5 l/m² (3–4 yd²/gal.)	60–70 m²/1000 kg (70–80 yd²/ton)

CONCRETE CARRIAGEWAY CONSTRUCTION

Waterproof underlay

A waterproof underlay, as previously specified, shall be laid over the base to the concrete carriageway. Laps at joints shall be not less than 150 mm (6 in.) and the underlay shall be free from tears or any other damage when the concrete is deposited upon it.

A waterproof underlay is necessary to prevent loss of water and cement from the concrete slab into the porous base. It must be properly lapped at joints.

Road base levels

Immediately before the underlay is laid the top surface of the road base shall be checked by working a scratch template off the side forms. All irregularities shall be corrected immediately and the surface protected from disturbance in any form.

A final check on road base levels is essential to ensure a constant minimum thickness of concrete road slab.

Forms

Forms shall comply with the requirements previously specified. They shall be set true to line and level on a foundation of sufficient strength to ensure that they will not be disturbed by the placing and compacting of the concrete.

Bent or damaged forms shall not be used. The forms shall be tested for level with a 3 m (10 ft) straight-edge before any concrete is laid and where a variation of more than 3 mm ($\frac{1}{8}$ in.) is found the form shall be taken up and reset. The Contractor shall make good at his own expense any irregularities in the concrete surface resulting from the movement of forms.

Forms shall be set for at least 60 m (200 ft) in advance of the point where concrete is being placed and they shall remain in position for at least 24 hours after concrete has been deposited against them. The Contractor shall set forms to the required radius where the curve has a radius of less than 45 m (150 ft).

A suitable foundation for forms would be a strip of concrete or mortar, 25 mm (1 in.) to 50 mm (2 in.) thick. Forms are kept true to line by the insertion of not less than three pins to each 3 m (10 ft) length of form and by the use of locking joints.

Another way of ensuring that an adequate length of form is fixed in position before concrete is placed is to specify that forms shall be set in position at least 30 hours before concrete is placed against them.

Concrete mix

The concrete used in the road slab shall be class B. When instructed by the Engineer two 150 mm (6 in.) cubes shall

It is normally required that the concrete mix shall be such as to provide concrete of a

be made from a representative sample of concrete being delivered at the point of deposit. The average crushing strength of the two cubes shall be not less than 28 MN/m² (4000 lbf/in.²). The cubes shall be made in accordance with the procedure given in Section 6 of CP 144.

If the strength of the cubes is below the specified value, three cores shall be cut from the appropriate section of road slab and tested for crushing strength at an age of approximately three months. If the average strength of the three cores when calculated as equivalent cube strength falls below 31 MN/m² (4500 lbf/in²) the Engineer may order the removal of the concrete at the Contractor's expense.

The water/cement ratio of the concrete shall not exceed 0·55 by weight. The concrete shall be of suitable workability for full compaction and the compacting factor shall be determined in accordance with B.S. 1881: Methods of Testing Concrete.

certain compressive strength at 28 days. Provision must therefore be made for the making and testing of sufficient test cubes of concrete to ensure that the required strength is attained.

Rigid control of the water content of the concrete is also needed to prevent loss of strength.

Specification clauses covering the batching and mixing of concrete are not included here as they have already been given in Chapter V. Class B concrete would probably be a 1:2:4 mix.

Crushing strengths could also be expressed in N/mm².

Placing concrete and reinforcement

The mixed concrete shall be deposited in its final position within 20 minutes of leaving the mixer. It shall be spread uniformly over the road base to a depth of 100 mm (4 in.), with great care being taken to ensure that it is of uniform composition and that no segregation takes place. The concrete shall then be compacted to the 100 mm (4 in.) depth by a vibrated hand tamper.

The steel fabric reinforcement shall be accurately assembled and fitted to-

Concrete road slab thicknesses are affected by the properties of the soil, inclusion or omission of base or steel reinforcement and the intensity of the traffic to be carried.

Concrete road slabs are usually reinforced with a single layer of steel fabric reinforcement positioned about 50 mm (2 in.) down

gether to form a mat on the compacted concrete. The use of small pieces of fabric will not be permitted. All laps shall be one complete mesh and the reinforcement shall terminate 50 mm (2 in.) from the edges and from all joints in the concrete, unless otherwise directed by the Engineer.

After the reinforcement has been placed in position the top 50 mm (2 in.) of concrete shall be spread and tamped to give a total slab thickness of 150 mm (6 in.). Care must be taken to prevent disturbance of the reinforcement and the top layer of concrete shall be spread and tamped within 30 minutes of placing the bottom layer. Spreading and compacting of concrete shall be continuous between joints.

from the top surface of the slab.

Many concrete road slabs are laid with vibrated hand tampers, but with important projects to carry heavy traffic flows concrete spreaders and compacting and finishing machines, of the type described in the Ministry of Transport Specification for Road and Bridge Works, may be used.

Compacting concrete

Concrete shall be compacted with a tamper weighing not less than 10 kg/m (7 lb/lin. ft), having a 75 mm (3 in.) tamping edge shod with a steel strip and fitted with an approved type of vibrator. Tampers shall be worked off the side forms and that for the base course shall be recessed at the ends to permit the base concrete to be tamped to a level 50 mm (2 in.) below the finished level of the road.

Tamping shall continue until a uniform closely knit surface is obtained. The surface shall be left slightly serrated except for smooth channels, 250 mm (10 in.) wide, and smooth strips, 65 mm ($2\frac{1}{2}$ in.) wide, adjoining the arrises at joints. Tamping towards a joint shall cease 600 mm (2 ft) from the joint and

It is important that concrete in a road slab should be properly compacted to produce a slightly corrugated road surface to the correct profile.

Strips in the channels need to be finished smooth to offer the least possible resistance to the free flow of water towards gullies, etc.

Tampers need to be of a certain minimum weight per unit length to ensure adequate compaction, and most engineers insist on the use of vibrators.

On large-scale projects the concrete is usually spread by

the remainder shall be tamped working away from the joint.

On completion of tamping, the surface shall be checked with a 3 m (10 ft) straight-edge and any irregularities exceeding 3 mm ($\frac{1}{8}$ in.) shall be corrected immediately.

The channels shall be floated to a smooth finish for a width of 250 mm (10 in.) with a steel float and shall be checked with a straight-edge and spirit level to ensure that there is a true fall to gullies at all points. Any faults disclosed by these checks shall be made good immediately. The concrete around a gully shall be slightly dished towards it and care shall be taken to ensure that there is no obstruction to the free flow of water into the gully. All cast iron frames of manholes, gullies, etc., shall be separated from the concrete by a strip of jointing material not less than 5 mm ($\frac{1}{4}$ in.) thick.

a hopper type of concrete spreader, and a compacting and finishing machine strikes off the concrete to the correct level, compacts the concrete by vibration and/or mechanical tamping, and finishes the concrete by a transverse oscillating screed.

Transverse expansion joints

Each transverse joint shall be an expansion joint located at intervals not exceeding 18 m (60 ft) and at the positions shown on the drawings or where directed by the Engineer. The joints shall be 15 mm ($\frac{1}{2}$ in.) wide, straight and vertical, and extend the full depth of the slab at right angles to the axis of the carriageway. Expansion joints shall be filled with an approved pre-moulded filler of a resilient non-extruding type as specified. This filler shall extend from the underside of the slab to within 25 mm (1 in.) of the top of the slab. The arrises to the adjoining concrete slabs shall be rounded to a radius of 5 mm

The provision of transverse expansion joints is essential to allow the concrete to expand with subsequent rises in temperature.

The width of expansion joints is usually 15 mm ($\frac{1}{2}$ in.) or 20 mm ($\frac{3}{4}$ in.) and the joint filler, of non-extruding material, normally finishes about 15–25 mm ($\frac{1}{2}$–1 in.) from the top of the slab. The joints are subsequently sealed with a rubber/bitumen or other suitable sealing compound.

Dowel bars are often in-

(¼ in.), by careful use of a suitable edging tool, and there must be absolute truth of level across the joints at all points.

As soon as possible after completion all expansion joints shall be brushed clean, dried and sealed with the specified joint sealer. The sealing compound shall fill the joints flush with the surface of the road, protecting and covering both arrises.

The joints shall be provided with dowel bars, 600 mm (2 ft) in length and of 20 mm (¾ in.) diameter, spaced at mid-depth of the slab parallel to the road surface and to the centre line of the road. The dowel bars shall be spaced at 375 mm (15 in.) centres with both end bars positioned 150 mm (6 in.) from the edges of the slab. The dowel bars shall be bonded to the concrete for one-half of their length and the other half be coated with bitumen. The free ends shall be fitted with a closely fitting closed cap 100 mm (4 in.) long, of non-collapsible metal or waterproof cardboard. A disc of felt or other compressible material, 20 mm (¾ in.) thick, shall be inserted between the end of the dowel bar and the end of the cap to permit horizontal movement of the bar in the sleeve. The bars shall be so fixed that they cannot be displaced during concreting and the joint filler shall have holes drilled in it to accommodate the dowel bars.

corporated to provide load transmission from one slab to the next. Provision must be made for movement of the slabs by securing the dowel bars in one slab but leaving them free to move in the adjoining slab. The size of bars used varies from 20–30 mm (¾–1¼ in.) in diameter.

Longitudinal joints

When road slabs are constructed of two-lane or greater width, the carriageway shall be constructed in longitudinal strips each 3·3 m (11 ft) wide. The longi-

With roads exceeding 5 m (16 ft) in width it is usual to construct the roads in a number of longitudinal strips

tudinal joints shall be tongued and grooved joints of the type shown on the drawings, formed by means of a suitably shaped timber or metal strip attached to the forms.

with suitable joints between them.

Curing concrete

As soon as the concrete surface is complete, it shall be cured by the mechanical application of an approved resinous curing compound at the rate of 0·2–0·3 l/m² (20–25 yd²/gal.). The compound shall be uniformly distributed over the road surface in the form of a fine spray.

The concrete surface shall then be protected against the effects of sun and rain during the setting period by the erection of tents of light movable frames covered with suitable opaque waterproof material, arranged to discharge any water clear of the newly-laid concrete.

The concrete must not be allowed to dry out quickly or it will lose part of its strength and surface cracks will develop, particularly in hot weather or with drying winds. The curing treatment specified is that recommended by the Ministry of Transport.

Traffic on finished surface

No vehicular traffic shall be allowed on the finished concrete surface within 20 days of completion where ordinary Portland cement is used or 10 days with rapid-hardening cement, provided that the joints have been permanently sealed in both cases. The Contractor shall take all necessary action to ensure compliance with this clause.

The concrete must be given adequate time to attain sufficient strength before any vehicles are allowed to pass over it. The time period can be reduced by the use of special cements.

ANCILLARY WORK

Kerbs, channels, quadrants and edgings

Precast concrete kerbs, channels and quadrants shall be bedded and jointed in cement mortar on concrete foundations (class C) of the dimensions shown on the Drawings. Immediately after being laid, the kerbs and quadrants shall be haunched on the back face to half their height in concrete, class C, to the dimensions shown on the Drawings. Precast concrete edging shall be supported at the joints by a spadeful of concrete, class D.

The exposed face of kerbs and quadrants shall be not less than 100 mm (4 in.) nor more than 105 mm (4¼ in.) above the channel of the road, except where it is necessary to provide an artificial fall in the channel. The exposed surfaces of kerbs, channels, quadrants and edgings shall conform to the required gradients and curves in the vertical plane and to the required lines and curves in the horizontal plane.

Kerbs, etc. are sometimes laid on a semi-dry concrete foundation, thus dispensing with the need for a mortar bed. With concrete roads it is common practice to lay half-section kerbs on a mortar bed, 15–25 mm (½–1 in.) thick, laid directly on the concrete road slab. To give ample support to the kerbs, it is advisable to provide two 10–15 mm (⅜–½ in.) diameter steel dowel bars, 125–150 mm (5–6 in.) long, to each length of kerb, driven into the concrete while it is still green. The kerbs are then backed up with concrete. Concrete class C would probably be a 1:3:6 mix, and D – 1:12.

Road gullies

Road gullies shall be provided in the positions shown on the Drawings or as directed by the Engineer. Gully pots shall be set truly level on a bed of concrete, class C, 150 mm (6 in.) thick and be surrounded with a minimum of 100 mm (4 in.) of similar concrete. Any backfill around the concrete casing shall be thoroughly consolidated.

The frames to gully gratings shall be set in cement mortar, finishing 5–10 mm

Specification requirements as to the concrete casing of gully pots vary from job to job. Some Engineers specify a 100 mm (4 in.) concrete surround while others require 150 mm (6 in.). In some cases it is specified that the concrete surround is to fill the excavated hole entirely.

The introduction of two or

($\frac{1}{4}$–$\frac{1}{2}$ in.) below the adjoining road surface, on two or three courses of 225 mm (9 in.) brickwork in engineering bricks laid in English bond. Once gullies have been connected to the sewer, the gratings or a temporary cover must be fixed to prevent earth or other material gaining access to the gully or sewer. The Contractor shall clear at his own expense all gullies and/or sewers which become silted or blocked due to non-compliance with this requirement.

three courses of brickwork between the gully pot and the grating gives a measure of flexibility in determining the level at which the gully pot is to be placed.

Electric cable ducts

Excavate for and lay 75 mm (3 in.) diameter asbestos cement cable ducts in the positions shown on the plan or where directed by the Engineer, to a depth of 600 mm (2 ft) below the finished road level. The ducts shall be jointed with detachable sockets and two rubber rings to each joint.

The ends of the ducts shall extend 600 mm (2 ft) beyond the face of the kerb on either side of the carriageway and be sealed with tile or slate stoppers set lightly in cement mortar. The ends of ducts shall be marked with 50 mm × 50 mm (2 in. × 2 in.) timber pegs, 750 mm (2 ft 6 in.) long, surrounded in concrete and extending 150 mm (6 in.) above ground, and shall be inscribed with the letter E and painted a distinctive colour.

It is particularly important to lay service ducts under concrete roads to accommodate future services and so eliminate the need to break up the road slab at a later date. An alternative material is second quality clayware pipes. The ends of the ducts should be clearly marked to avoid much abortive labour in excavation at a later date to expose the ducts.

FOOTPATHS

Tarmacadam footpaths

Tarmacadam footpaths shall be laid on a bed of hardcore with a minimum

The tarmacadam consists of crushed rock or slag with a

consolidated thickness of 75 mm (3 in.), blinded with ashes.

The footpath surfacing shall consist of two coats of tarmacadam laid to a minimum consolidated thickness of 50 mm (2 in.) to the required gradients and a crossfall of 1 in 48 towards the kerb. The tarmacadam surfacing shall be laid in accordance with the requirements of B.S. 1242: Tarmacadam 'Tarpaving' for Footpaths, Playgrounds and Similar Works.

The base course shall have a minimum consolidated thickness of 30 mm (1¼ in.) and the wearing course shall be 20 mm (¾ in.) thick, each with grading and binder content requirements complying with Tables 3 and 4 of B.S. 1242 respectively and each rolled with a 4000 kg (4 ton) roller.

Immediately after consolidation the surface of the tarpaving shall be lightly dusted with limestone grit graded 3 mm (⅛ in.) to dust at a rate of not less than 290 m²/1000 kg (350 yd²/ton). After dusting the surface shall be lightly rolled.

binder of tar or a tar-bitumen mixture.

Tarpaving can be laid in one or two courses, and in the case of a single course the thickness may range from 10 mm (½ in.) to 30 mm (1¼ in.). In two-course work total compacted thicknesses vary from 45 mm (1¾ in.) to 75 mm (3 in.).

The dusting grit may be dry or coated with 2–3 per cent of suitable tar or bitumen, or alternatively fine cold asphalt may be used.

Asphalt footpaths

Asphalt footpaths shall be laid on a 75 mm (3 in.) soil cement base as previously specified. The surface of the soil cement shall be covered with a tack coat of bitumen emulsion applied at the rate of 0·35–0·55 l/m² (10–16 yd²/gal.).

Fine cold asphalt complying with B.S. 1690 shall then be laid with a minimum consolidated thickness of 20 mm (¾ in.), rolled with a 2000 kg (2 ton) roller. After initial consolidation, 15 mm (½ in.) pre-coated limestone chippings shall be

Suitable bases for fine asphalt surfaced footpaths include hardcore, concrete and soil cement. The thickness of the asphalt may vary from 10 mm (⅜ in.) to 25 mm (1 in.). The tack coat may be omitted when the surfacing is being laid on a recently laid base course. The final application of chippings is optional.

rolled into the surface of the asphalt, at the rate of 80–130 m²/1000 kg (100–160 yd²/ton).

Flagged footpaths

Paving flags shall be laid on a 75 mm (3 in.) consolidated base of ashes, rolled with a 2500 kg (2½ ton) roller, and a 20 mm (¾ in.) bed of lime mortar.

Precast concrete flags 50 mm (2 in.) thick, as specified, shall be laid to a 150 mm (6 in.) bond with closely butting joints to a crossfall of 1 in 48 towards the kerb, neatly cut to all splays and around all boxes, etc. Standard size flags only shall be used with any 600 mm ×450 mm (2 ft × 1 ft 6 in.) flags used at the back of the path. Where paths are circular in plan the flags are to be laid with cross joints radiating to the point from which the arc is struck. After laying, flags are to be grouted in lime slurry.

Flags can be of precast concrete, stone or reconstructed stone. A good even mortar bed is to be preferred to the five-pat system of bedding. A much sounder job is obtained by grouting the flags on completion.

In situ concrete footpaths

In situ concrete paths are to be laid on a 50 mm (2 in.) consolidated bed of ashes or hoggin. The concrete shall be a 1:2:4 mix with a 20 mm (¾ in.) graded aggregate, finishing 3 in. thick with a lightly tamped surface. Expansion joints shall be provided at 9 m (30 ft) intervals and dummy joints at 2 m (6 ft) intervals. All arrises shall be rounded to a radius of 5 mm (¼ in.).

This is a relatively cheap form of footpath construction. It should be not less than 60 mm (2½ in.) in thickness and should have ample expansion and dummy joints. Various surface finishes are available.

OTHER ITEMS

Grass verges

A layer of suitable vegetable soil not less than 150 mm (6 in.) thick shall be spread and levelled over the areas to be grassed to the correct gradients and crossfalls. The vegetable soil shall be free from all rubbish, large stones and other harmful material, shall comply with B.S. 3882 and shall be finished to a fine seed tilth, not less than 50 mm (2 in.) thick.

At an approved time a fertiliser, as specified, shall be distributed at the rate of 0·05 kg/m² (1½ oz/yd²), followed by the specified mixture of grass seed at the rate of 0·06 kg/m² (2 oz/yd²), which shall be lightly raked in and lightly rolled if the surface is dry.

To secure good results at least 150 mm (6 in.) of good vegetable soil raked to a fine tilth is necessary. It is undesirable to lay verges to gradients in excees of 1 in 4 or less than 1·5 m (4 ft 6 in.) wide. Where heavy soil is encountered it is advisable to provide a 100 mm (4 in.) layer of clinker or gravel under the verges.

B.S. 3882 details the texture, soil reaction, stone content and method of testing topsoil. Turf should comply with B.S. 3969.

Chain-link fencing

Chain-link fencing shall be erected to the correct lines with the level of the top of the fencing following roughly the mean level of the ground. The line wires shall be pulled drum tight with proper straining fittings at the straining posts. Each straining post shall be properly strutted in the direction of each line of fence. All straining posts and struts shall be set in concrete, class C, 100 mm (4 in.) thick on all sides for half the depth of the post in the ground.

The chain-link fencing shall comply with B.S. 1722, Part 1 and shall be green plastic coated 1·5 m (5 ft) high × 50 mm (2 in.) mesh × 10½ gauge, tied to four line wires of 9½ gauge with 14 gauge

Chain-link fencing is very popular as it provides a good durable form of boundary. It is made in a variety of heights from 750 mm (2 ft 6 in.) to 2 m (6 ft), with meshes ranging from 30 mm (1¼) to 75 mm (3 in.). Posts can be of steel, concrete or timber.

Cleft chestnut pale fencing to B.S. 1722, Part 4, is suitable for temporary fencing for highway jobs and similar purposes.

Other more permanent types of fencing include close-

binding wire ties at 450 mm (18 in.) centres. The posts shall be mild steel angle at 3 m (10 ft) centres of the following dimensions:

Intermediate posts: 45 mm × 45 mm × 5 mm ($1\frac{3}{4}$ in. × $1\frac{3}{4}$ in. × $\frac{3}{16}$ in.)

Straining posts. 65 mm × 65 mm × 6 mm ($2\frac{1}{2}$ in. × $2\frac{1}{2}$ in. × $\frac{1}{4}$ in.)

Struts: 45 mm × 45 mm × 5 mm ($1\frac{3}{4}$ in. × $1\frac{3}{4}$ in. × $\frac{3}{16}$ in.)

All shall be 2·5 m (7 ft 6 in.) long.

boarded fences and wooden post and rail fencing, both of which are covered in B.S. 1722.