
VOLUME 7	PAVEMENT DESIGN AND MAINTENANCE
SECTION 2	PAVEMENT DESIGN AND CONSTRUCTION

PART 4

HD 27/04

PAVEMENT CONSTRUCTION METHODS

SUMMARY

Chapter 2 of this Part has been revised to reflect current pavement design issues. It offers broad guidance of the issues to be considered when widening existing roads. Chapter 3 that deals with rapid concrete construction has not been revised with this update of the Standard and although the advice continues to be valid, references may need to be checked.

INSTRUCTIONS FOR USE

1. Remove existing Contents pages for Volume 7.
2. Insert new Contents pages for Volume 7, dated February 2004.
3. Remove HD 27/94 [*Incorporating Amendment No. 1 dated March 1995 and Amendment No. 2 dated February 1999*] from Volume 7, Section 2, Part 4 and archive as necessary.
4. Insert HD 27/04 into Volume 7, Section 2, Part 4.
5. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.



THE HIGHWAYS AGENCY



SCOTTISH EXECUTIVE



Llywodraeth Cynulliad Cymru
Welsh Assembly Government

WELSH ASSEMBLY GOVERNMENT
LLYWODRAETH CYNULLIAD CYMRU



THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Pavement Construction Methods

Summary: Chapter 2 of this Part has been revised to reflect current pavement design issues. It offers broad guidance of the issues to be considered when widening existing roads. Chapter 3 that deals with rapid concrete construction has not been revised with this update of the Standard and although the advice continues to be valid, references may need to be checked.

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

**VOLUME 7 PAVEMENT DESIGN AND
MAINTENANCE**
**SECTION 2 PAVEMENT DESIGN AND
CONSTRUCTION**

PART 4

HD 27/04

**PAVEMENT CONSTRUCTION
METHODS**

Contents

Chapter

1. Introduction
2. Widening of Pavements
3. Rapid Construction and Repair of Concrete Pavements
4. References and Bibliography
5. Enquiries

1. INTRODUCTION

General

1.1 This Part contains details of various construction methods and techniques which are particularly relevant to Volume 7. General requirements for pavement construction methods can be found in the Specification (MCHW1) and in the Highway Construction Details (MCHW3). This Part includes details for the widening of existing pavements and covers the area of design, materials and construction. These techniques will be used more frequently as a high proportion of the trunk road network needs to be widened or improved to handle increased traffic capacity. Rapid construction and repair of concrete pavements is also covered and draws on experience gained from contracts both in the UK and in the United States.

Implementation

1.2 This Part shall be used forthwith on all schemes for the construction, improvement and maintenance of trunk roads including motorways, currently being prepared provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay. Design organisations should confirm its application to particular schemes with the Overseeing Organisation.

Mutual Recognition

1.3 The construction and maintenance of highway pavements will normally be carried out under contracts incorporating the Overseeing Organisation's Specification for Highway Works (MCHW1). In such cases, products conforming to equivalent standards and specifications of other member states of the European Community and tests undertaken in other member states will be acceptable in accordance with the terms of the 104 and 105 Series of Clauses of that Specification. Any contract not containing these Clauses must contain suitable clauses of mutual recognition, having the same effect regarding which advice should be sought.

2. WIDENING OF PAVEMENTS

General

2.1 With the projected increases in traffic, elements of the trunk road network, ranging from single carriageways to Dual 4-lane motorways, will continue to need to be widened and/or improved.

2.2 Each individual scheme will vary in scope since other improvements including changes in geometry, levels and superelevation and improvements to sight lines will often be included in addition to the provision of extra lanes. Widening may be symmetrical on-line, asymmetrical on-line (see Figure 2.1) or off-line on new ground, depending on the site and, in the case of widening from single to dual carriageway, will usually be a combination of all three in order to improve the line and gradients. Such changes will generally affect levels and crossfalls and, therefore, also impact on pavement design.

2.3 Widening, and associated improvement works, presents a valuable opportunity to upgrade the whole of the existing pavement, in line with current standards. All options for carrying out the works must be assessed on the basis of minimising whole life costs over a 40-year analysis period. Consideration should also be given to the principles of sustainable development, which will generally favour maximum use, or re-use, of the existing construction.

2.4 This chapter gives broad guidance on some of the pavement design and construction issues that should be considered where the widening of existing roads is proposed. It does not cover earthworks or general drainage issues associated with widening; advice on these is given in HA 43 (DMRB 4.1.7).

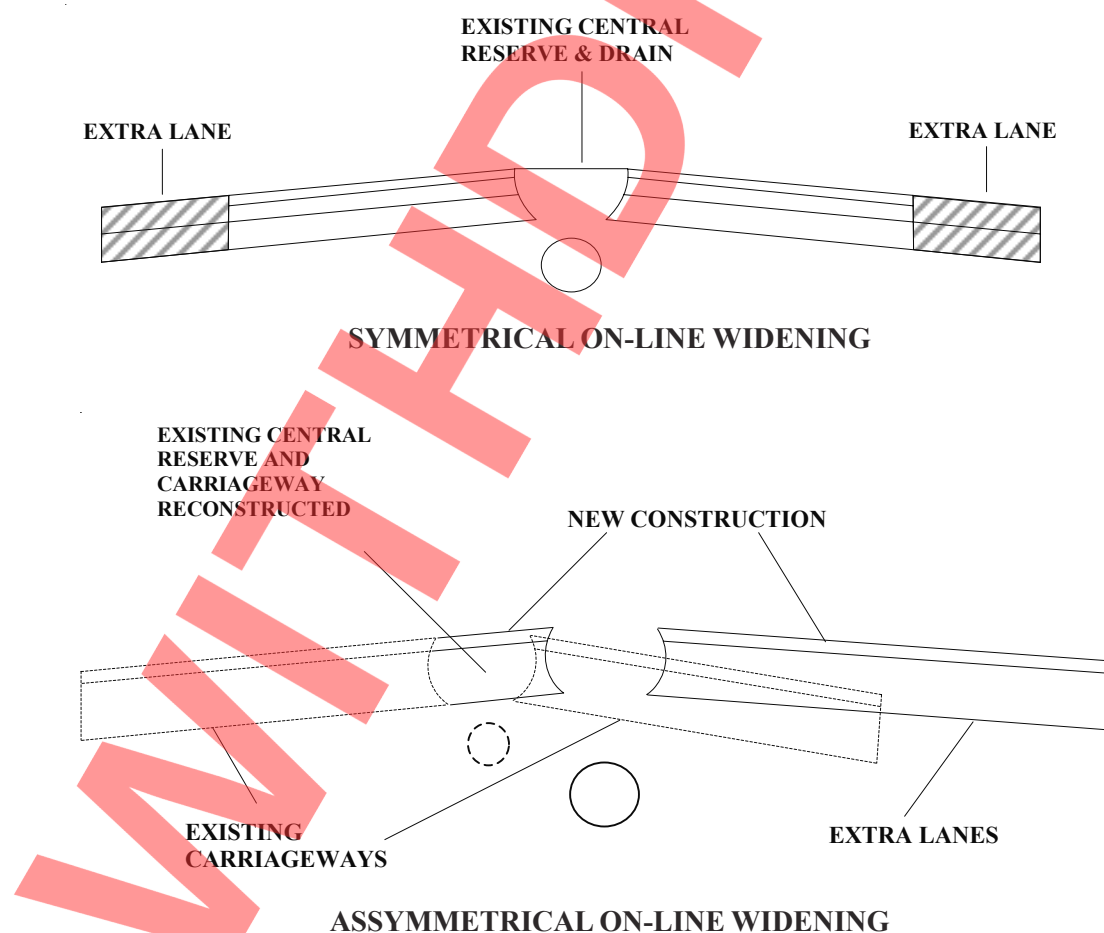


Figure 2.1 Basic Approaches to Road Widening

Evaluation of Existing Pavement

2.5 For on-line widening, where the new construction will abut the existing carriageway, a full assessment of the condition of the existing pavement should be obtained through surveys and detailed investigations on site in accordance with the advice given in HD 29 (DMRB 7.3.2) and HD 30 (DMRB 7.3.3). As-constructed records may also provide a useful source of information but it is important that the accuracy of such records, in particular the depths and extent of the pavement construction, is verified through exploratory excavation.

2.6 Guidance on the analysis of pavement surveys is given in HD 29 (DMRB 7.3.2) while advice on the interpretation of results and design of appropriate strengthening measures is given in HD 30 (DMRB 7.3.3).

2.7 In the case of flexible, and certain flexible composite, pavements the categorisation of the existing pavement as 'Long Life', 'Upgradeable to Long Life' or 'Determinate Life' should be determined, if not already known, in accordance with HD 29 (DMRB 7.3.2). Where the pavement is determined to be 'Upgradeable to Long Life' appropriate works to achieve the upgrade to the 'Long Life' classification should be considered, provided this is justified on the basis of the whole life cost assessment.

2.8 In conjunction with new construction and any maintenance or strengthening works to the existing pavement, consideration should be given to assessing the skidding resistance and riding quality of the existing pavement with a view to improvement where necessary. It is likely that the existing pavement will require a quiet surface course and to match the surface of the widened sections. Further information on the factors that affect skidding resistance and appropriate levels for varying site conditions is given HD 28 (DMRB 7.3.1) while advice on surfacing options is provided in HD 36, HD 37 and HD 38 (DMRB 7.5).

Design

2.9 The design of widened areas of pavement should be in accordance with HD 26 (DMRB 7.2.3). Proposals for on-standard designs must be submitted to the Overseeing Organisation for approval.

2.10 The ground conditions beneath an existing pavement, as determined during the investigation and

evaluation process, may be used as the basis for estimation of the long-term condition beneath an adjacent new pavement.

2.11 Where the carriageway is to be widened on-line it is essential that the greatest care is taken during design to ensure that the drainage paths under old and new pavements are maintained, particularly where falls and elevation are being altered. It is suggested that longitudinal and cross sections are produced at frequent intervals to check that the drainage is not hindered. Maintenance of drainage paths may result in a thicker bound construction than is required for the new pavement in accordance with HD 26 (DMRB 7.2.3), notably where an overlay is applied to strengthen or reprofile the existing pavement. Particular care must be taken in the use of bound sub-bases for widening to ensure that this layer does not effectively form an impermeable barrier, trapping water in the foundation of the existing construction.

2.12 Where the proposed new design thickness for a widening strip is thicker than the adjacent, structurally sound, existing flexible pavement, special provision may have to be made for sub-base drainage or the existing pavement may have to be overlaid to maintain drainage paths.

2.13 As some surface water does percolate through the pavement surface it is essential not to impede the flow of water in the underlying pavement layers. When matching new lanes against an existing carriageway the thickness of new bound layers will usually have to be the same or less. The interfaces of the underlayers should lead into each other or into positive drainage paths.

2.14 However, where the new and existing construction cannot be adequately matched, due, for example, to the use of different forms of construction or materials, the use of drainage layers may be required. Adjustment to the crossfall may also be required to ensure water is not trapped under the pavement.

2.15 Advice on crossfalls and other surface drainage considerations for wide carriageways is given in TA 80 (DMRB 4.2.2).

2.16 Where a new or modified drainage system is required for the widened pavement the detailing should take into account the need to keep the existing system operative until the new system can be brought into use.

2.17 The construction sequence may need to be planned to avoid the possibility of ponding during the works.

2.18 The overall design should take account of the need to keep disruption to a minimum. It is often beneficial that sections of new carriageway are made available to traffic as quickly as possible. Due consideration must also be given to the safety of the public and the Contractor's workforce.

2.19 Consideration should be given to providing a hardened central reserve in conjunction with widening works, in order to reduce routine maintenance. The surface finish of a hardened central reserve should contrast with that of the adjacent carriageway.

Pavement Materials

2.20 The only restriction on the type of material to be laid alongside the existing pavement, providing the materials conform to the requirements of the Specification (MCHW1), is that continuously reinforced concrete pavement construction should not be laid alongside an existing jointed rigid pavement. This is because it is not possible to tie the two constructions to provide satisfactory edge and corner support while accommodating relative movement due to thermal effects. The choice of which construction options to include in the tender documents is the responsibility of the Overseeing Organisation at the contract documentation stage and decisions should take account of future maintenance costs so that the whole life cost is kept to a minimum.

2.21 Consideration should be given to the use of high performance bond coats to enhance adhesion and seal between adjoining constructions (see MCHW1, Clause 901).

2.22 In the assessment of whole life costs, on the basis of a 40-year analysis period, consideration should be given to the future maintenance of both the existing and widened elements of the pavement. This is likely to favour options that ensure future maintenance can be timed to minimise interventions that cause disruption and delay. However, where site constraints and/or operational procedures indicate a preferred solution other than that which would give the lowest whole life cost, approval must be sought from the Overseeing Organisation, supported by evidence to demonstrate that the proposed solution will provide acceptable value for money.

2.23 Where it is required to provide increased load carrying capacity for the additional lanes yet maintain the same thickness as the existing pavement, the use of High Modulus Base (HMB) asphalt, flexible composite

construction or Continuously Reinforced Concrete Pavement (CRCP) should be considered.

2.24 Similarly, where overlay thickness is restricted, both HMB and CRCP should be considered as options for strengthening the existing carriageway.

Construction

2.25 In matching new pavements to existing, the level of the existing surface or any proposed overlay will have to be taken as datum for levels of the new surfacing irrespective of minor settlements. Any areas with major settlements affecting the riding quality should be identified for regulating or reconstruction prior to adding the new lanes. Alternatively, in the case of a rigid concrete pavement, local settlements may be rectified by slab jacking and vacuum grouting; see HD 32 (DMRB 7.4.2).

2.26 Asymmetrical widening should be designed so that longitudinal joints between old and new are mid-lane or near lane divisions so avoiding wheel tracks. Short lengths crossing a lane diagonally, which may be dictated by realignment, may be acceptable.

2.27 Widening may result in existing drainage runs lying beneath the carriageway. It is normally unacceptable for manholes, gullies or other ironwork to be placed within vehicle running lanes. If this cannot be avoided then the use of higher specification chamber and gully tops should be considered. Advice on chamber and gully tops is given in HA 104 (DMRB 4.2.5), while guidance on general safety aspects of road edge drainage is given in HA 83 (DMRB 4.2.4). The use of combined drainage and kerb systems may also provide a viable option in some circumstances, and advice on these systems is given in HA 39 (DMRB 4.2.1).

2.28 Where widening asphalt pavements in similar construction, layers should be cut back and benched to key into the old construction (see Figure 2.2 for minimum widths). Joints into sub base or capping layer should be made where there is clean material. If necessary the 150 mm minimum should be increased until clean material is encountered. Special care is required during compaction of any granular layers to ensure a sound joint between the two materials.

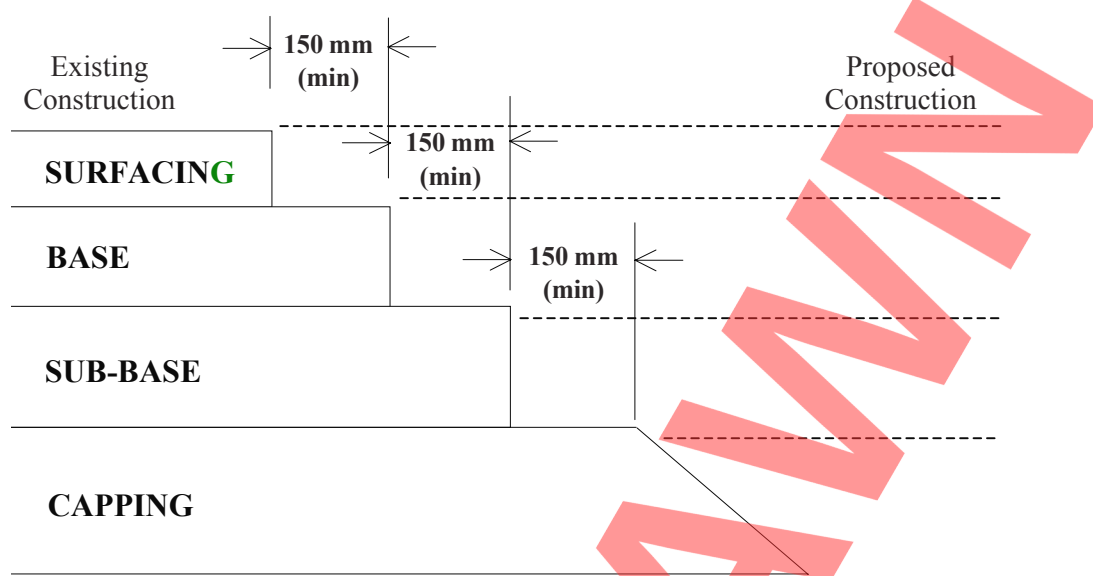


Figure 2.2 Benching at Joint between Sections of Bituminous Paving

2.29 Where the pavement construction is on the programme critical path rapid construction methods may need to be considered.

2.30 Where sufficient space is available asphalt materials can be laid quickly with pavers in echelon to avoid longitudinal joints which need cutting back when cold. In winter, successive layers can be placed in rapid succession, but both this and echelon work will depend on sufficient compaction plant being available to ensure adequate compaction can be achieved. Information on laying of asphalt surface course is given in HD 37 (DMRB 7.5.2).

2.31 When ambient temperatures are high, it may be necessary to delay the opening of the pavement to traffic to ensure that the surface course and lower layers are sufficiently stiff to resist deformation under vehicle loading.

2.32 Where asphalt material is to be laid against an existing pavement, drainage channels, kerbs, bridge parapets etc, suitable preformed sealing strips should be considered for application to the vertical surface of the existing pavement, after cutting back. This could avoid the need to overband the longitudinal joint or to cut a sealing groove and apply a poured sealant.

2.33 Details of rapid methods of concrete pavement construction are given in Chapter 3 of this Part. The road may be opened to normal traffic when the strength of the concrete has been demonstrated to have reached 25 N/mm².

2.34 Where an extra jointed concrete lane is added to an existing jointed concrete carriageway, the transverse joints should be aligned and of the same type and width. At the longitudinal joint between the existing and new concrete, a groove should be sawn to an appropriate depth and filled with an approved sealing compound.

2.35 To reduce the time and cost of drilling for tie bars, consideration may be given to the use of bars which are deformed and so which may be shorter in length and/or larger in diameter than the requirements of the Specification (MCHW1).

2.36 Where existing concrete slabs have to be replaced the slabs could be sawn into small sections during one traffic closure and removed and replaced during the next.

2.37 A technique for strengthening a concrete road in conjunction with the widening of the carriageway has been developed in the USA. The strengthening consists of an overlay, of minimum depth 50mm, which is bonded to the surface of the existing paving. The widening can be placed separately from the bonded overlay or monolithically with the overlay in one pass (see Figure 2.3). Longitudinal joints are required in the new concrete at positions which are dependent on the dimensions of the existing carriageway and the widening strips. Tie bars are inserted into holes drilled in the sides of the existing slab.

2.38 Prefabricated slabs have been used for new concrete pavements in other countries. Construction is expensive but fast and can significantly reduce traffic delays. The slabs, which should be made to a high standard of dimensional accuracy, can have self-levelling devices and special dowel fixings to connect with neighbouring slabs. The voids between sub-base and slabs are filled by pressure grouting. The process needs special equipment.

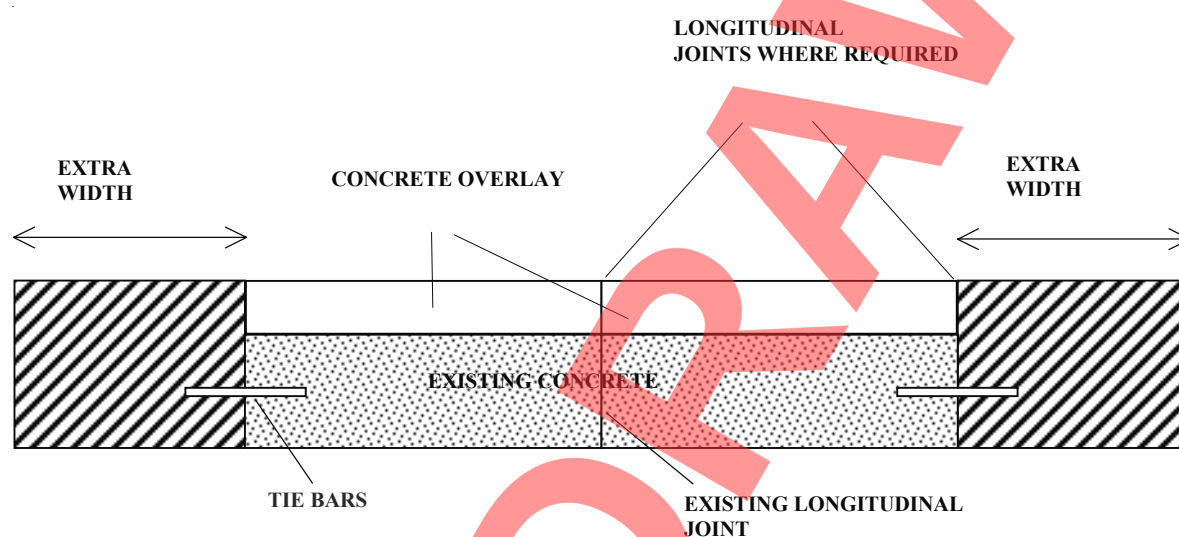


Figure 2.3 Strengthening of Concrete Road in Conjunction with Widening

3. RAPID CONSTRUCTION AND REPAIR OF CONCRETE PAVEMENTS

General

3.1 It has been traditional to wait long periods of 14 to 21 days for concrete to cure before use by traffic. The degree of maturity was based on the required strength at 28 days. This imposed restrictions on repairs and reconstruction in concrete when compared with bituminous surfaces. However, increases in traffic on major roads and the need to keep lane closures to a minimum has heightened the need for concrete to mature to sufficient strength in hours rather than days.

3.2 Extra rapid hardening cements were first used in the UK in 1970 for repairs to the M4 motorway which were opened to traffic in 6 hours. However, long possessions of carriageways for normal repairs or reconstruction gave no incentive for use of the more expensive rapid hardening cements. Other rapid construction methods have since been studied by British engineers and successful full scale trials have been carried out in the UK.

3.3 This Chapter gives the requirements for early opening of concrete pavements to traffic and includes advice on materials and methods for rapid construction. It will be of particular importance in reconstruction, widening schemes, minor improvements and repairs for benefits in traffic management.

Principles

3.4 Rapid construction in concrete depends on the rate at which the concrete can develop sufficient strength for opening the pavement to traffic.

3.5 Early strength development can be controlled by the type of cement, cement content, the water-cement ratio and by curing. Normal ingredients as for conventional pavement quality concrete should be used together with admixtures or additives depending on the degree of urgency. This may be under 6 hours or over 3 days according to the type of construction or repair being considered.

3.6 Rates of gain in strength can be enhanced by using rapid hardening types of cements, and increasing the cement content to reduce the period before use by traffic. Figure 3.1 illustrates this and the use of an early

strength cement in preference to larger quantities of Ordinary Portland Cement (OPC) will depend on the urgency and economics.

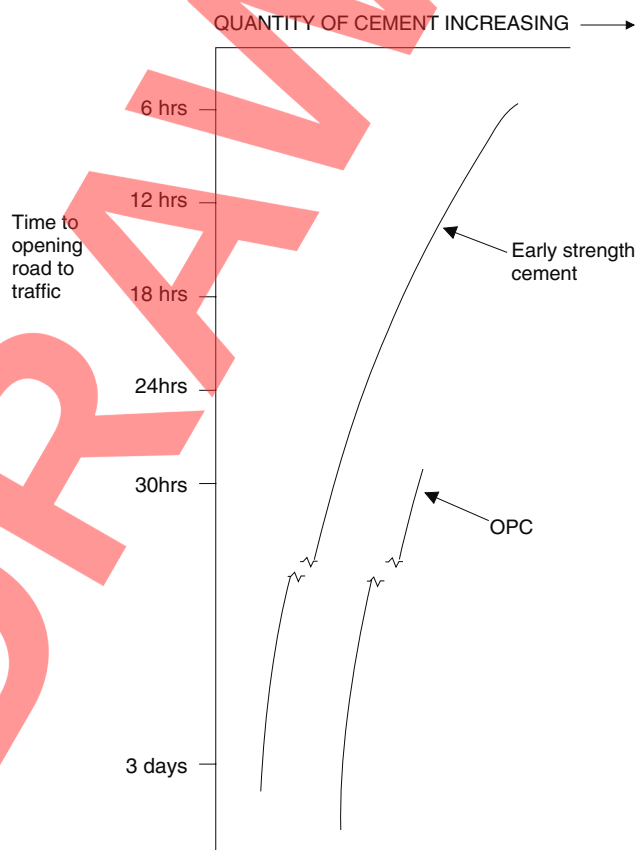


Figure 3.1 Increasing Cement Content to Reduce Time before Traffic

3.7 Further increase in strength can be achieved by accelerating curing methods.

Requirements

3.8 For designed mixes the concrete shall have to achieve the required 7 or 28 day strength for compliance with the Specification (MCHW1) 1000 Series.

3.9 Before use by any traffic, the following are the characteristic compressive strengths which each pavement layer shall be expected to reach, subject to the proviso given in paragraph 3.10.

Pavement quality concrete surface slabs	25N/mm ²
Pavement quality concrete roadbases	20N/mm ²

Roller compacted concrete, cement bound material or wet-lean concrete of the following grades:

CBM 4 or C20 concrete	15N/mm ²
CBM 3 or C15 concrete	10N/mm ²
CBM 2 or C10 concrete	7N/mm ²
CBM 1 or C 7 concrete	4.5N/mm ²

3.10 In the case of roller compacted concrete or CBM the next pavement layer may be laid within 4 hours of placing the cement bound layer. Once the next layer is laid the pavement shall not be trafficked until the cement bound layer is expected to reach the required strength given above.

3.11 Mortars for bedding iron work such as manhole cover frames during repairs may be trafficked when the strength is expected to be 20 N/mm². For rapid construction, this strength should be achieved within 2 hours.

MATERIALS

Cements

3.12 High early strength cements are now permitted in the Specification (MCHW1) 1000 Series and should be used for rapid construction and repairs. Concretes with standard rapid hardening Portland cements conforming to BS 12 (1991) have achieved 25 N/mm² strength in less than 18 hours, with cement contents of 400 kg/m³ or more.

3.13 Examples of special cements or concrete mixes which can give high early strength include:

- A calcium sulpho-aluminate based cement used extensively in the mining industry (40N/mm² in 3 hours).
- A high strength proprietary cement and fibre reinforced, non-shrink concrete (25N/mm² in 3 hours).
- A mixture of early strength Portland Cement, microsilica and superplasticiser.
- Proprietary polymer modified concrete mixes.

Pozzolanas

3.14 When Pulverized Fuel Ash (PFA) is added to the mix it improves the workability and allows a lower water-cement ratio, which in turn increases the concrete strength. It can be as additional fine material or as a partial Portland cement replacement. With the latter, early strength will be reduced as the pozzolanic reaction is secondary but leads to higher ultimate strength and denser concrete.

3.15 Microsilica can also be used to increase early strength and density, but it reduces the workability, so plasticisers or superplasticisers are necessary to keep a low water-cement ratio.

3.16 These materials tend to make cohesive mixes which require vibration for compaction and finishing.

Admixtures

3.17 As many of the high early strength cements have quick setting properties, the workability needs to be maintained during transit to site. Plasticisers and superplasticisers should be used for this as well as reducing the water-cement ratio. Air entraining agents should be used for slab replacement wherever possible but need not be used for small batches of high strength concrete for thin bonded patches.

Aggregates

3.18 For high early strength concrete, angular aggregates from crushed rock or crushed gravel are preferable. The addition of more fines in the form of PFA and microsilica will produce a denser concrete with few voids.

3.19 As some cements may have high alkali contents, the requirements for prevention of Alkali Silica Reaction (ASR) will still apply, so non-reactive aggregates may be needed.

MAIN CONSTRUCTION

3.20 Normal paving operations as specified in the Specification (MCHW1) 1000 Series will apply. Concrete mixes should usually be designed mixes and tested for compliance with the Specification at the appropriate age, unless the use of prescribed mixes is approved by the Engineer.

3.21 Slip form pavers with their higher outputs have an advantage over fixed form plant for rapid construction, and setting out guide wire posts is quicker than laying forms more common with the necessary bedding.

3.22 Auger pavers or truss type vibrating finishing beams provide a good finish and are more versatile for small areas and are recommended for use with internal vibration using poker vibrators for compaction of thick slabs, as in the Specification (MCHW1) 1000 Series.

3.23 Where there is restricted access, eg. in single lane widening, conveyors can help to spread the concrete quickly.

3.24 Transverse joints other than in single bay replacement, should be sawn but may be wet-formed in winter. Cork seals can be used as formers and so avoid the need for a separate sealing operation, for individual slabs or short lengths.

3.25 Higher slab temperatures may result from the heat of hydration of higher cement contents and cause more thermal stress on cool nights. It may be advantageous to saw some joints early within 2 hours of placing the concrete, using a light saw which cuts a groove through a bearing plate which holds the concrete in place and prevents coarse aggregate being plucked out, instead of waiting about 4 hours or more before being able to use a conventional saw. This may relieve early stress and avoid random cracking before the joints can be properly sawn. Any such joint grooves should be deepened and widened for sealing using a conventional saw as required in the Specification (MCHW1) 1000 Series if the joint is not already cracked.

3.26 Dowels can be inserted satisfactorily with slip form pavers, without creating surface irregularities and poor riding quality, if the insertion mechanism does not stop the paver nor have a vertical reaction on any conforming plate. Alternatively, dowels may be placed on cages. When dowels are inserted from the surface or if joints are to be wet-formed, additional compaction and regulation is necessary, by a longitudinal oscillating and vibrating finisher.

Curing

3.27 The concrete should be cured, as required in the Specification (MCHW1) 1000 Series using resin compound or bituminous spray for the relevant pavement layer.

3.28 In addition thermal insulation blankets as specified in Specification (MCHW1) 700 Series should be used to accelerate the strength development to meet the specified strength in the required time. Insulation blankets will be necessary if the road is to be trafficked in any period between 5 hours and 3 days after the concrete is placed. They may also help the strength development of the special cements which can be trafficked in under 5 hours.

3.29 The purposes of the insulation blankets are to:

- Assist in the prevention of loss of moisture from the concrete so increasing the rate of hydration and reducing shrinkage.
- Promote a uniform temperature gradient through the slab so reducing the risk of thermal cracking.
- Induce a higher temperature within the slab by retention of the heat of hydration and accelerate the chemical reaction, leading to strength development.

CONCRETE PAVEMENT REPAIRS

3.30 Concrete for repairs may be designed mixes or prescribed mixes. Before prescribed mixes can be used, evidence of the strength development of such a mix should be obtained. Proprietary prepacked mixes come within the term of prescribed mixes. All such mixes should be able to develop 40N/mm² at 28 days and 25N/mm² at the time required for use by traffic.

3.31 Once a prescribed mix has been approved, the proportions and ingredients should not be changed. Quality will depend on correct proportioning.

3.32 Non-shrink concretes are preferred for thin bonded patch repairs. Some high strength concretes used for patching can be affected by high temperatures soon after placing. The patches can be subjected to warping and tend to de-bond around the perimeter. Under traffic these can then crack.

3.33 Effective curing will reduce the risk of temperature stress and warping. The traditional method of curing patches is to spray with resin curing compound and cover the patches with damp hessian and an impermeable sheet to retain moisture in the patch. Large variations of temperature in the patch can be avoided by using insulation blankets.

Sealing Joints

3.34 Most hot and cold poured sealants need to be placed into dry mature concrete. They need to be placed into grooves which have been grit blasted to ensure a good bond. Grit blasting may be carried out as soon as the concrete is expected to reach 15N/mm^2 and the joints can be sealed as soon as possible after that instead of waiting 14 days as required in the British Standard. Otherwise the joints should be sealed in accordance with the Specification (MCHW1) 1000 Series.

3.35 As most joints will have to be sawn, the sealing groove would be suitable for compression seals or pre-compressed neoprene impregnated expanding foam seal, or cork strips, which can be placed as soon as the groove has been cut which would be earlier than sealing with applied sealants. Pre-compressed neoprene impregnated expanding foam sealant strips should comply with The British Board of Agrément certificate 88/2123C.

STRENGTH ASSESSMENT

3.36 Assessment of strength for trafficking will depend on whether the mix is a designed mix or a prescribed mix. For designed mixes, cubes should be taken and tested at early ages commensurate with the time required for opening to traffic, which should be allowed as soon as the concrete reaches 25N/mm^2 .

3.37 Cubes made, stored and tested in accordance with BS 1881 (1983) will not necessarily reflect the real strength in the pavement. Without accelerated curing, the strength in the pavement will vary with temperature and climatic conditions and is usually 5% less than the strength of the cubes stored under laboratory conditions. Temperature matched curing (TMC) of specimens for testing would give more realistic results if time allows.

3.38 In the absence of TMC, approximate values of the pavement strength can be obtained from cubes made and stored alongside the pavement, insulated in such a way as to simulate the conditions in the pavement.

3.39 Strength development curves for a particular mix can be obtained by testing cubes at different ages on trial mixes before work starts. If such curves are used to assess the time for opening to traffic or for gauging when to test cubes on site, ambient temperatures at time of placing should be compared with the temperature at which the strength development curve was obtained. For any significant drop in temperature (more than 5°C) additional time should be allowed, as strength development slows in cooler weather. Insulation blankets will help to maintain an even temperature.

4. REFERENCES AND BIBLIOGRAPHY

References

1983

BS 1881; Part 108; “Making Cubes”, BSI.
BS 1881; Part 111; “Storing Cubes”, BSI.
BS 1881; Part 116; “Testing Cubes”, BSI.
Note: BS 1881 now replaced by BS EN 12390

1991

BS 12; “Specification for Portland Cements”, BSI.
Now replaced with BS EN 197-1.

Design Manual for Roads and Bridges

HD26 (DMRB 7.2.3) Pavement Design.
HD28 (DMRB 7.3.1) Skidding Resistance.
HD29 (DMRB 7.3.2) Structural Assessment Methods.
HD30 (DMRB 7.3.3) Structural Assessment Procedure.
HD32 (DMRB 7.4.2) Maintenance of Concrete Roads.
HD36 (DMRB 7.5.1) Surfacing materials for new and maintenance construction.
HD37 (DMRB 7.5.2) Bituminous surfacing materials and techniques.
HD38 (DMRB 7.5.3) Concrete surfacing and materials.
HA39 (DMRB 4.2.1) Edge of pavement details.
HA43 (DMRB 4.1.7) Geotechnical considerations and techniques for widening highway earthworks.
HA83 (DMRB 4.2.4) Safety aspects of road edge drainage features.
HA104 (DMRB 4.2.5) Chamber tops and gully tops for road drainage and services: Installation and maintenance.

Manual of Contract Documents for Highway Works

Specification for Highway Works (MCHW1).

Notes for Guidance on the Specification for Highway Works (MCHW2).

5. ENQUIRIES

All technical enquiries or comments on this Standard should be sent in writing as appropriate to:

Chief Highway Engineer
The Highways Agency
123 Buckingham Palace Road
London
SW1W 9HA

G CLARKE
Chief Highway Engineer

Chief Road Engineer
Scottish Executive
Victoria Quay
Edinburgh
EH6 6QQ

J HOWISON
Chief Road Engineer

Chief Highway Engineer
Transport Directorate
Welsh Assembly Government
Llywodraeth Cynulliad Cymru
Crown Buildings
Cardiff
CF10 3NQ

J R REES
Chief Highway Engineer
Transport Directorate

Director of Engineering
The Department for Regional Development
Roads Service
Clarence Court
10-18 Adelaide Street
Belfast BT2 8GB

G W ALLISTER
Director of Engineering