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Transport Infrastructure Ireland

TII Publications



Notes for Guidance on the Specification for Road Works Series NG 2400 - Brickwork, Blockwork and Stonework

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NRA DMRB and MCDRW References

For all documents that existed within the NRA DMRB or the NRA MCDRW prior to the launch of TII Publications, the NRA document reference used previously is listed above under 'historical reference'. The TII Publication Number also shown above now supersedes this historical reference. All historical references within this document are deemed to be replaced by the TII Publication Number. For the equivalent TII Publication Number for all other historical references contained within this document, please refer to the TII Publications website.

BRICKWORK, BLOCKWORK AND STONWORK

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Brickwork, Blockwork and Stonework

NG 2401 **Cement**

- 1 The cement to be used in different locations should be shown in Appendix 24/1 with reference to the NRA Road Construction Details, as appropriate.
- 2 Sulphate-resisting Portland cement should be specified where there is a risk of sulphate attack; guidance is given in Table F1 of Annex F to I.S. EN 206-1.

NG 2404 **Mortar**

- 1 Table 24/1 in the Specification is confined to the more durable mortars which can withstand exposure to severe weather. Guidance on design and construction to achieve adequate durability of mortar joints is given in section 8 of EN 1996-1-1 and EN 1996-2.
- 2 An important consideration besides durability when selecting a mortar for a particular use is that increasing strength is accompanied by decreasing ability to accommodate movements such as drying shrinkage, expansion or settlement. Refer to Table NG 24/1.
- 3 Generally for brickwork, blockwork or stonework in bridgework, mortar designation (i) or (ii) will be appropriate except for manufactured stone, concrete and calcium silicate bricks and blocks, when mortar designation (iii) should be specified to allow for their relatively high shrinkage. Details of the mortar required for use in the Works should be shown in Appendix 24/1.
- 4 Extensive use of loadbearing brickwork, blockwork and masonry is not envisaged in new bridge construction but when these are required, reference should be made to I.S. EN 1996-1-1, and the Specification should contain an additional Clause which should include 28-day mean compressive strengths.
- 5 The approximate 28-day mean compressive strengths of the mixes in Table 24/1 are shown in Table NG 24/1.
- 6 Where a plasticiser is to be used the recommendations of the admixture manufacturer should be followed. Where previous evidence of the suitability of the mixer and time of mixing is not available trials should be conducted.

NG 2405 **Lime Mortar**

- 1 Lime mortars have good working qualities but develop strength very slowly. For this reason such mortars are rarely suited to present day needs and should only be used for masonry repointing and reconstruction of historic structures which were originally constructed using lime mortar. Further guidance is given in Clauses 2450 to 2465 of the specification.

NG 2406 Masonry Units (Bricks)

- 1** Consideration should be given to the quality of brick and mortar to enable water/sand blasting to be used to remove graffiti.

- 2** Full details of the units required for use in the Works should be shown in Appendix 24/1. The following terms of I.S. EN 771-1 should be used for the description of the units:
 - i) HD or LD units;
 - ii) Dimensions (length, width, height) and tolerance category;
 - iii) Compressive Strength;
 - iv) Net dry density;
 - v) Water absorption;
 - vi) Freeze/thaw resistance category;
 - vii) Active Soluble salts content category.

- 3** Masonry units with freeze/thaw resistance category F2 and active soluble salts content category S2 should be specified for facework. Bricks with a minimum strength of 7 N/mm², will normally be sufficient for non-structural facework fixed to concrete as described in Clause 2416. If a higher strength is required, e.g. where the facework is load bearing, this should be shown in Appendix 24/1.

NG 2407 Masonry Units (Blocks)

- 1** Full details of the units blocks required for use in the Works should be shown in Appendix 24/1. The following terms of I.S. EN 771-3 with regard to type and designation should be used for the description of the units:
 - i) HD or LD units;
 - ii) Dimensions (length, width, height) and tolerance category;
 - iii) Compressive Strength;
 - iv) Gross dry density;
 - v) Water absorption;
 - vi) Freeze/thaw resistance category;
 - vii) Block colour and texture (RCD/2400/3).

NG 2408 Manufactured Stone

- 1** Manufactured stone is alternatively referred to as cast stone, or reconstituted stone.

- 2** Special requirements such as colour, special mixes, texture, and casting in stainless steel ties should be shown in Appendix 24/1.

NG 2409 Natural Stone

- 1 In some quarries the durability of stone is well known while in others the variations are such that each individual block has to be considered separately. The performance of the stone used in the area should be studied to gauge the effects of exposure. Samples of selected stones should be taken and these should represent the range of variations that are acceptable.

NG 2412 Brickwork and Blockwork

- 1 Different bricks and blocks, including reconstructed stone, possess different suction properties and any requirements regarding wetting before laying should be given on the Drawings in the Contract.
- 2 The bond and type of mortar required for jointing, and pointing where necessary, should be identified in Appendix 24/1 and for all visible work the coursing should be described, e.g. brickwork, 4 courses to 300mm.
- 3 The Drawings in the Contract should also include information regarding the use of purpose-made bricks or blocks, e.g. in quoins, copings or string courses, and of any sample panels of brickwork or blockwork which will be required to be built.
- 4 Reinforcement laps and cover should be detailed on the Drawings in the Contract. This is particularly important if the joints are raked out and left open.
- 5 The type of pointing required in exposed joints should be described in Appendix 24/1. Reference should be made to I.S. EN 1996-2.

NG 2413 Stonework

- 1 The selection of stone to be used for masonry will involve aesthetic as well as technical consideration.
- 2 Where required, directions should be shown in Appendix 24/1 regarding:
 - i) the amount and type of dressing the stones require on the face and sides;
 - ii) the minimum and maximum size of the stones;
 - iii) the treatment of the pointing;
 - iv) in the case of coursed work, the depth of the course;
 - v) stonework fixings including dowels, cramps, joggles, etc.;
 - vi) stones which must be laid damp;
 - vii) the limit of projection of any part of the exposed face of stones;
 - viii) the minimum and maximum thickness of joints.
- 3 Except in the case of the finest ashlar, joints should not normally be less than 6 mm thick in any part of the bed.
- 4 Reference should be made to BS 5628-3 for guidance on walling type, finishes and other relevant details.

- 5 When special stones are required for quoins, copings or other similar purposes, they should be detailed separately on the Drawings in the Contract. Special care should be taken in the choice of stone for parapets, cornices, string courses and places where more than one face of the stone is exposed. Such stones should have good weathering characteristics and be able to withstand frost.
- 6 The use of block-in-course stonework is limited to heavy engineering works and requires the use of power-driven plant to lift the heavy stones.

NG 2414 Cold Weather Working

- 1 The precautions to be adopted if bricks, blocks or stonework are to be laid in cold weather may include:
 - i) storing materials in a heated shed or covering them with waterproof sheets;
 - ii) warming fine aggregate and water but not the cement or lime;
 - iii) not wetting the bricks, blocks or stonework, but if necessary using a little more water for mixing the mortar;
 - iv) protecting the working areas and the site where mortar is mixed from frost, snow and rain;
 - v) ensuring compliance with Clause 2414 if special precautions are not taken.

NG 2415 Protection of New Work

- 1 Efflorescence in facework may be reduced by -
 - i) use of bricks with low soluble salt content (S₂ to I.S. EN 771-1);
 - ii) use of cements with low free-alkali content (less than 0.1%);
 - iii) use of well washed fine aggregate in mortars;
 - iv) avoidance of excessive amounts of plasticisers, used in accordance with the manufacturers recommendations;
 - v) protection of new work from rain.

NG 2416 Brick, Block and Stone Facework Fixed to Concrete

- 1 Brick, block and stone facework should normally be built after the concrete has hardened. Brickwork built by this method is less liable to discoloration from efflorescence than that used as formwork.
- 2 Full details of the method of construction and spacing of ties should be shown on the Drawings in the Contract. An adequate support should be provided so that the sole function of the ties is to hold the facework back to the concrete and not to carry its weight.
- 3 It is essential that there should be no voids between the facework and the backing so that damage will not be caused by water collecting behind the facework and subsequently freezing. The gap to be filled should be a minimum of 30mm.

- 4** The acceptable variation in depth from front to back of stones for masonry facework should be shown in Appendix 24/1.

Table NG 24/1: Mortar Compressive Strengths

| | Mortar designation | Compressive strength class | Cement: lime: sand | Masonry cement: sand | Cement: sand with plasticiser | Compressive strength at 28 days |
|---|--------------------|----------------------------|--------------------|----------------------|-------------------------------|---------------------------------|
| ↓ Increasing ability to accommodate movement, e.g. due to settlement, temperature and moisture changes | (i) | M12 | 1:0 to ¼:3 | - | - | 12 |
| | (ii) | M6 | 1: ½:4 to 4½ | 1:2½ to 3½ | 1:3 to 4 | 6 |
| | (iii) | M4 | 1:1:5 to 6 | 1:4½ | 1:5 to 6 | 4 |
| | (iv) | M2 | 1:2:8 to 9 | 1:5½ to 6½ | 1:7 to 8 | 2 |

NG 2450 Masonry Repointing of Historic Structures - Introduction

- 1** Clauses 2450 to 2465 shall be used for masonry repointing and reconstructing of historic structures where a lime mortar shall be used.

NG 2451 Masonry Repointing of Historic Structures - Mortar - Constituent Materials

Aggregates

- 1** Aggregates shall be selected in accordance with Table 24/3 of the Specification. Figure NG 24/1 provides a graphical representation of the tabulated ranges. All aggregates used should be well graded with a good distribution between the various sizes within the limits of the grading tolerances shown.

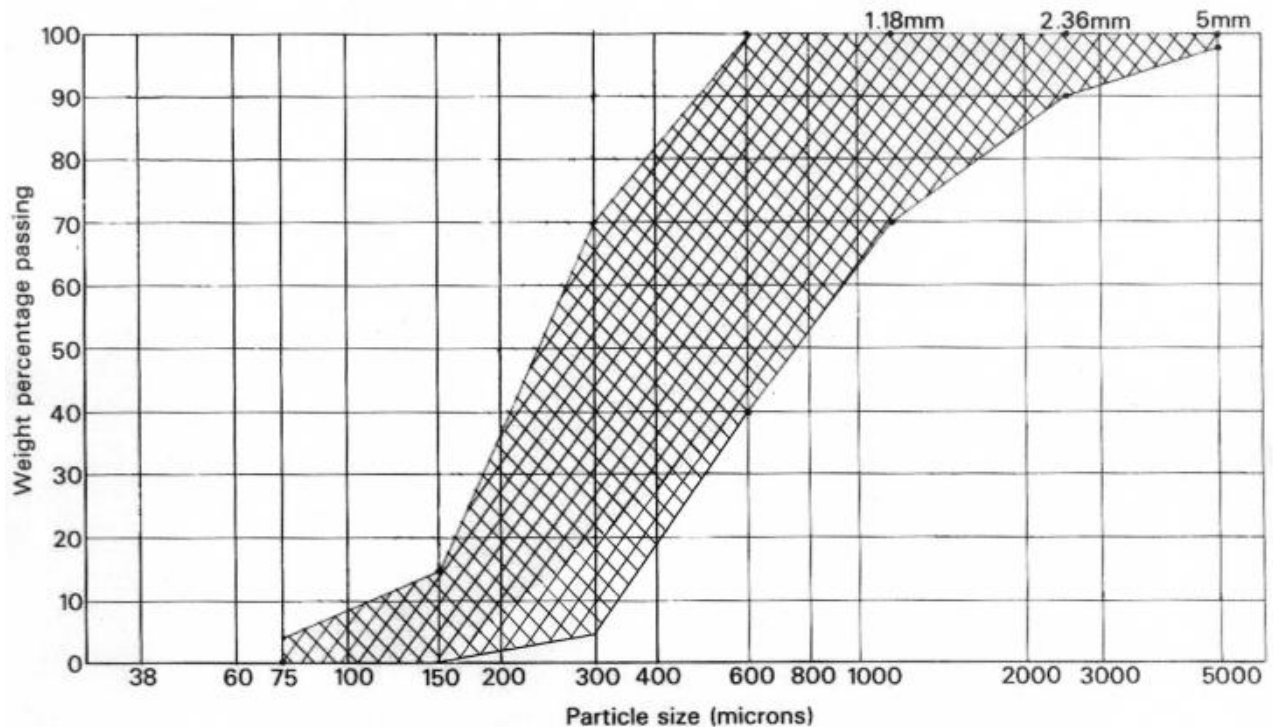


Figure NG 24/1: Aggregate Grading Requirements

Pozzolans

- 2 Where overhead joints are to be filled, use of a calcined refined china clay pozzolan or other approved pozzolan, may be required to aid the set of the mortar being applied and to minimise slumping. The ratio of pozzolan is described as a percentage addition to the lime/aggregate mix (e.g. 2:5 + 3%).
- 3 The Employer's Representative approval shall be sought prior to use of any Pozzolanic additives.

NG 2452 Masonry Repointing of Historic Structures - Mortar

- 1 Lime mortars from different manufacturers have differing relative bulk densities (RBD). This necessitates a variation in the proportion of lime to aggregate dependent on the RBD of the lime being used. The variation in the volume of lime required could be more than 50% depending on the choice of lime manufacturer. The RBD of the NHL5 used in producing Table 24/4 in the Specification is $0.636\text{kg}/\text{dm}^3$. The RBD of the NHL3.5 used in producing Table 24/4 in the Specification is $0.612\text{kg}/\text{dm}^3$.
- 2 The mix design shall take into account the RBD of the manufacturer's lime product being used.

- 4 Mortar shall be selected on the basis of the guidance provided in Table 24/4.
- 5 Alternatively, a suitable pre-bagged mortar selected on the basis of the guidance provided in Table 24/4 may be used subject to the approval of the Employer's Representative.
- 6 Generally for the repair of masonry arch bridges, a selection of mortar reference (a) or (b) from Table 24/4 will be appropriate except for areas below water level where the stonework cannot be temporarily banded. Details of the mortar required for use in the Works should be shown in Appendix 24/3.
- 7 In some circumstances it may not be appropriate to use a sprayed reference (a) mortar (e.g. where deep joints exist over a small area where it would be uneconomical to mobilise spraying plant or where propping or tying of pinning stones is impractical). In such instances, use of a reference (c) gauged mix may be appropriate.
- 8 A gauged mix is far more cohesive than the other mortars described and is often able to support pinning stones of considerable size if held in place for a few minutes to allow an initial set.

Mixing Hydraulic Lime and Sand to Make Mortars on Site

- 9 Mixing mortars by volumes is a risky and inaccurate process unless it is carried out using full bags of lime and known quantities of sand accurately measured in full buckets. Moisture content can significantly affect sand volume.
- 10 At the very least, when full bag mixers are not available, the sand supplied shall be neither too wet nor too dry and that properly reserved gauging boxes or strong buckets of equal volume are used to determine the quantities of material being used.
- 11 When measuring lime by volume adequate care must be taken to 'tamp' the measuring vessel in order to reduce as far as possible the air content of the powder thus ensuring the correct volume of lime is employed.
- 12 Mixes using damp or wet aggregate shall be mixed using paddle or pan mixers. Rotating tilting drum mixers shall not be used as experimentation has proven them to be ineffective leading to 'balling or clumping'.

- 13 Mixes using dry aggregate, being combined prior to being deposited into the hopper of dry-process mix spraying equipment, can be mixed satisfactorily using a rotating tilting drum mixer.
- 14 In all instances, as the powders are fine and easily dispersed in the air, the mixing procedure should be carried out with care and in phases of sand, then lime, then more sand, then more lime with the ingredients being mixed at each stage to a uniform colour and consistency.
- 15 Where stricter controls over the compressive and flexural strength of the mortar are appropriate, trial mixes should be produced, cured and tested in accordance with the compliance criteria described in the Specification.
- 16 Cementitious mortars are generally not appropriate for use on masonry arch bridges as their high compressive strength and lack of flexibility can lead to stonework damage.

Mixing Lime Putty Mortars for Gauging

- 17 Gauged mortars are inherently more difficult to use than other mixes both in respect of the ratios of component parts and the combination of the various ingredients.
- 18 Combining or mixing lime putty, NHL and sand on site requires considerable effort, kneading, chopping and beating the lime putty and sand together vigorously until a uniform colour is achieved. It is difficult to mix these materials to the correct consistency using normal modern site practice.
- 19 Mechanical mixing using a Roller Pan Mixer produces the best results. This type of mixer combines the materials with little or no additional water. Other mixing equipment will generally not provide a suitable mix without the addition of significant amounts of water: this can lead to high early shrinkage and poor bond characteristics and significantly increases the risk of freeze thaw failure.
- 20 A 1:1:6 mix being 1 part NHL5, 1 part lime putty and 6 parts sand would be made up by mixing the lime putty (1 part) with sand (6 parts) as described above to create 'course stuff' and set aside for gauging immediately before use. When required, 6 parts of the 'course stuff' is mixed with 1 part NHL 5 as described.
- 21 The NHL should always be mixed with clean water to make a very stiff paste before mixing as lime putty mortars are very stiff, cohesive materials and do not accept powder combination readily.
- 22 The paste and the course stuff should be mixed thoroughly until a uniform colour and consistency has been achieved.
- 23 Gauging should be specified by weight. For a 1:1:6 gauged mix using NHL5 with a RBD of 0.636kg/dm^3 , measuring by weight would give a mix of 6.36kg NHL5 to 10 litres of putty to 60 litres of aggregate. NHL's with different RBD's should be varied accordingly.

NG 2454 Masonry Repointing of Historic Structures - Preparation

- 1 In structures subject to very heavy vegetative growth, vegetation should be treated with a systemic herbicide and fully removed well in advance of the works in order to ensure that the vegetation has been totally killed to prevent re-growth.

- 2 In instances where roots are particularly large and invasive some localised demolition and reconstruction might be required as directed by the Employer's Representative in order to remove root or stem growth prior to killing with an approved systemic herbicide.
- 3 Application of mortar to areas subject to significant water ingress is ineffective due to wash-out. Prior to commencement of any repointing works, flowing water shall be inhibited. Measures to inhibit water ingress might include removal of soft verges over bridges by installation of rubbing strips, installation of drainage to the rear of the abutments etc.

NG 2455 Masonry Repointing of Historic Structures - Application Methods

- 1 As a guide, a 20mm wide joint can generally be pointed full depth at 40-50mm with a good sharp sand mortar. If the joint is deeper a spray application is more appropriate to ensure that the mortar effectively reaches the back of the joint.
- 2 Where pinning stones are used it is not generally necessary to match the pinning stones to the existing arch stones unless so directed by the Employer's Representative. This might be the case where a structure is particularly aesthetically pleasing or in a location where aesthetic considerations are paramount.
- 3 Old pantiles are useful as pinnings as the relative ease with which they can be shaped and their bold colour permits identification for ongoing monitoring of repairs.
- 4 Limestone and stones with similar properties are generally too hard for use as pinnings unless specifically required for aesthetic reasons.
- 3 A suitable quantity of stones for pinning should be provided. A large selection from which the mason can choose significantly reduces the amount of cutting and shaping required.

NG 2459 Masonry Repointing of Historic Structures - Cold Weather Working

- 1 Special precautions may be required to prevent new mortar work from being affected by frost for up to 10 days after placing. This may necessitate provision of heating. Generally this should be avoided by programming work in periods of frost-free conditions (i.e. spring and summer months).

NG 2461 Masonry Repointing of Historic Structures - Protection of the Environment

- 1 Repointing of masonry arch bridges often takes place above or within watercourses. Due regard shall be paid to the protection of marine life and adequate advice shall be sought from the relevant Fisheries Boards or other Statutory Authorities as necessary prior to commencement of the works.
- 2 Suitable precautions shall be taken such to ensure that spillages and/or waste materials do not enter the watercourse or pollute ground or ground water.
- 3 Choice of materials for use below the waterline should be made taking environmental considerations into account.
- 4 Bat surveys (and surveys of other wildlife if considered necessary) shall be undertaken prior to commencement of any work in respect of repointing arch barrels.

NG 2464 Masonry Repointing of Historic Structures - Materials - Compliance

General

- 1** In general when there is limited experience in the use of lime mortar it is advisable to undertake trial mixes prior to commencement of the Works.

- 2** Undertaking closely supervised trial mixes in advance of the Works will assist in demonstrating the importance of adequate site controls, which will highlight the repercussions should the later site mixes fall short of the required specification

NG Sample Appendices

NG SAMPLE APPENDIX 24/1: BRICKWORK, BLOCKWORK AND STONWORK

[Note to compiler: This should include:]

- 1 Locations where sulphate-resisting Portland cement is to be used [2401.1].
- 2 Mortar designations and colour for brickwork, blockwork and stonework [2404.1, 2404.3, 2412.5, RCD/2400/2].
- 3 Additional performance requirements for admixtures [2404.3].
- 4 Particular requirements for clay masonry units (bricks) to I.S. EN 771-1 [2406.1].
- 5 Particular requirements for aggregate concrete masonry units (blocks) to I.S. EN 771-3 [2407.1, RCD/2400/2].
- 6 Particular requirements such as colour, special mixes, texture and casting-in stainless steel ties for manufactured stone [2408.1].
- 7 Details of the type and quality of natural building stone [2409.1, RCD/2400/3 and RCD/2400/4].
- 8 Type of bonding for brickwork and blockwork [2412.1].
- 9 Locations where overhand work is permitted [2412.3].
- 10 Locations where pointing is required and the type of pointing [2412.5, RCD/2400/3, RCD/2400/3 and RCD/2400/4].
- 11 Locations where jointing is required and the type of finish to be used [2412.6].
- 12 Requirements for dimensions of stones if different from the requirements of sub-Clause 2413.1.
- 13 Requirements for tooling stonework [2413.6, 2413.7].
- 14 Requirements for dimensions of bond stones if different from the requirements of sub-Clause 2413.9.
- 15 Details of the requirements for levelling squared random rubble coursed and uncoursed stonework [2413.9].
- 16 The variation in depth, front to back for masonry facework [2416.4].
- 17 Whether stonework is coursed or uncoursed, and course heights [RCD/2400/3, RCD/2400/4].
- 18 Type of coping to stonework walls [RCD/2400/3, RCD/2400/4].
- 19 Type of rendered finish to blockwork walls [RCD/2400/1].

NG SAMPLE APPENDIX 24/2: BRICKWORK, BLOCKWORK AND STONEMWORK : NRA ROAD CONSTRUCTION DETAILS

[Note to compiler: List the relevant Series 2400 RCDs (2412.1 & 2413.1)]

| Clause No. | Road Construction Detail Drg No. |
|-------------------|---|
| 2412.1 | RCD/2400/1, 2, 3, 4, 5, 6 |
| 2413.1 | RCD/2400/3, 4, 5 RCD/2400/7 |

NG SAMPLE APPENDIX 24/3: REQUIREMENTS FOR MASONRY REPOINTING AND RECONSTRUCTION OF HISTORIC STRUCTURES

[Note to compiler: This should include:]

- 1 Additives [2451.10, 2451.11 & 2451.12]
- 2 Special Requirements for Special Structures [2458.3]
- 3 Types of Mortar Required, Sampling and Testing Requirements for Mortar [2464.2, NG2452.6]
- 4 Trial Mixes [2464.10]



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