Standard Method of Detailing Structural Concrete

A manual for best practice

Third edition

This document is intended to become a standard reference that can be used in conjunction with the normal design codes and manuals for work in structural design offices. The objective has been to provide 'good practice' guidance within a working document on structural concrete that can be used to interpret the designer's instructions in the form of drawings and schedules for communication to the site.

This edition considers the effects of Eurocode 2 on detailing principles and materials and attempts to provide guidance consistent with the Eurocodes. In addition, recent changes in practices and procurement of detailing services have been considered, such as the development of increased off-site fabrication and detailing being undertaken later in the construction sequence through initiatives such as contractor detailing.

The information and advice is based on Eurocodes and UK practice, which is associated with UK materials and labour costs. The principles and details are relevant for use in most parts of the world with only minor adjustment.

As with the original Standard method, the Steering Group was formed from members of both the Institution of Structural Engineers and the Concrete Society. Views have been taken from a wide consultation on the drafts prepared. All have been considered in finalising the document. Consequently the document reflects the current concerns and developments in the field of detailing.

The Steering Group is grateful for the funding provided by the Department of Trade & Industry in support of this project.

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FOREWORD

The *Standard method of detailing reinforced concrete* was published in 1970 and followed in 1973 by the Concrete Society's publication on *Standard reinforced concrete details*. This was updated in 1989 to incorporate a section on prestressed concrete and the title was amended to the *Standard method of detailing structural concrete*.

As with the original *Standard method*, the Steering Group was formed of members of both the Institution of Structural Engineers and the Concrete Society. We have taken the views from a wide consultation on the drafts prepared and are grateful for the variety of comments received, all of which have been considered in finalising the document. We are confident the document provides a reflection of the current concerns and developments in the field of detailing.

This document is intended to become a standard reference for work in structural design offices in conjunction with the normal design codes and manuals.

The previous documents were based on the design guidance in BS 8110. The new document considers the likely effects of Eurocode 2, as far as we can say at present, on detailing principles and materials and attempts to provide guidance that is consistent with Eurocode 2. Recent changes in practices and procurement of detailing services have also been considered such as the development of increased off-site fabrication and detailing being undertaken later in the construction sequence through initiatives such as contractor detailing. These can all blur the distinction between the work of the detailer and that of the designer. In practice, many decisions that are taken by the detailer may technically be the province of the designer. We have attempted to provide guidance of good practice in this document and to suggest the key items and information exchange that needs to be clarified to enable the various members of the design team to be clearly briefed to allow them to efficiently carry out their part of the works.

The Steering Group is grateful for the funding provided by the DTI to support this project. In developing and updating this guidance my particular thanks must go to John Clarke and Robin Whittle; the former for managing to succinctly record the many debates and finer points that had to be addressed and the latter for rising to the daunting task of drafting the document and preparing responses to the comments in a way that satisfied the wide variety of comments and viewpoints raised.

The original *Standard method* was widely distributed and accepted both in the UK and the rest of the world. Good designs invariably use the principles set out in the documents and we are confident that the new edition brings a timely update that properly reflects current developments and changes to this aspect of the construction industry.

J K Kenward
Chairman

1 INTRODUCTION AND SCOPE

The objective of this manual is to provide a working document on structural concrete that can be used to interpret the designer's instructions in the form of drawings and schedules for communication to the site.

The information given in the manual is essential for both the Designer and Detailer and both have a responsibility for ensuring that the correct information is provided. It should be noted that the Designer may be one of many different parties depending on the contractual arrangements.

The information and advice is based on Eurocodes and UK practice, which is associated with UK materials and labour costs. The principles and details are relevant for use in most parts of the world with only minor adjustment.

The purpose of this manual is to provide a standard reference that can be used on training courses and by detailers and design engineers alike. During the early stages of the development of the original document Arup made their detailing manual available to the Joint Committee and this proved a useful base document. As a consequence the concept of using Model Details to indicate the preferred method of detailing each type of structural element has been adopted. These Details can be found at the end of the appropriate section within Chapter 6.

A basic assumption in the preparation of this manual has been that it is the responsibility of the Designer to clearly specify design requirements to the Detailer and it is the responsibility of the Detailer to implement these requirements in a consistent way that will be clear, complete and unambiguous to the end user. In detailing structural concrete, the impact on all parties involved in the construction process should be borne in mind; details that lead to problems or extra costs on site cannot be termed good detailing.

It has not been the intention of the Joint Committee to decrease in any way the responsibility of the Designer, although it is recognised that certain details have design implications; therefore Designers should design with full knowledge of this manual. The term 'standard method' also needs clarification. It is not intended that any one detail should be copied slavishly for all situations, but all the principles should be followed, both in general and in detail. Details can be prepared with different objectives in mind, e.g. to reduce labour on site by detailing to allow off-site prefabrication of the reinforcement into cages, or to utilise the materials most readily available in a particular location or on site. It is believed that such different objectives can be satisfied by using the principles covered in this manual. The details have been prepared with the following priorities in mind:

- technical correctness and safety
- buildability and speed of construction
- labour and material costs.

This major revision of the manual introduces detailing rules that conform to BS EN 1992-1-1, *Eurocode 2: Design of concrete structures. Part 1.1: General rules and rules for buildings*[1] (EC2), BS EN 1992-1-2, *Structural fire design*[2] (EC2, Part 1.2), BS EN 1992-1-2, Eurocode 2: *Concrete bridges*[3] (EC2, Part 2) and BS EN 1992-3: *Liquid retaining and containing structures*[4] (EC2, Part 3). Where information incorporates National Determined Parameters from the UK National Annexes the values are given in '**bold**'.

In general, the conventional use of materials covered by Euronorms or British Standards is assumed. Where other authoritative documents exist, this manual refers to them rather than repeating them in full. It refers to generic rather than any particular proprietary system.

This revision also places more emphasis on the communication of information and the responsibility for detailing. The use of Contractor Detailing is recognised and the difference this makes to the process of detailing is considered.

Within the UK the use of mild steel reinforcement is no longer common practice and has now become more expensive than high yield reinforcement. Class C high yield reinforcement is considered to provide the required ductility for the specific situations where mild steel was considered necessary. Accordingly reference to mild steel has been removed. In deriving details and standards it is assumed that reinforcement will be supplied by a company holding a valid certificate of approval from a recognised third party product certification body, e.g. UK CARES (Certification Authority for Reinforcing Steels, www.ukcares.co.uk).

There is growing use of stainless steel for reinforcement for situations where greater durability is required. BS 6744: 2001[5] provides details on its use and testing.

The principles covered by BS 8666[6] have been adopted. BS 8666 defines a standard method of scheduling and a set of bar shapes that, in suitable combination, are normally sufficient for any detailing situation; it is considered to be an essential companion document to the manual.

The division between civil and structural engineering is somewhat arbitrary, and it follows that good practice is common to both structural engineering and civil engineering. There are, however, a number of factors that occur in large-scale works of which account be taken when detailing reinforcement. These include:

- provision of access for concrete to be safely placed in massive concrete sections such as raft foundations
- adjustments of reinforcement to take account of the effects in large pours of concrete. Attention is drawn to CIRIA report 135, *Concreting deep lifts and large volume pours*[7]
- suitable reinforcement arrangements to suit long-strip methods of laying ground slabs
- recognition of the likely positioning of construction joints and their effect on reinforcement arrangements (also important for building slabs)
- recognition of the effects of different concrete mixes and aggregates.

It should be noted that this manual does not cover

- the detailing of structures designed for seismic situations. For such situations reference should be made to BS EN 1998: *Design of structures for earthquake resistance*[8] and other relevant documents
- the detailing of joints and reinforcement for ground slabs. For such information reference should be made to the Concrete Society Technical Report 34, *Concrete industrial ground floors – A guide to their design and construction*[9]
- water resistance of wall and slab elements in contact with the ground. For such situations reference should be made to CIRIA Report 91[10] and CIRIA Report 139[11]
- the detailing of marine structures. For such structures reference should be made to BS 6349[12]
- the use of lightweight aggregate concrete. Reference for this should be made to EC2, Section 11.

2 COMMUNICATION OF INFORMATION

2.1 General

Accurate detailing has an important role in the procurement and durability of reinforced concrete structures. The actual process of detailing normally comes relatively late in the procurement process. Concepts and working details can be decided during the early design phases but the preparation of final reinforcement drawings and schedules is generally squeezed into a period between completion of final design and the start of construction on site. Thus, very often it becomes a critical process in the construction programme. In the UK, pressure on construction timescales and moves towards non-traditional forms of construction has tended to make detailing an even more critical and pressured activity.

2.2 The reinforcement process

Detailing can only really begin in earnest once the final design is available. The design requirements are normally given to the detailer in the form of design calculations, marked up GA drawings, beam schedules or completed pro forma or similar.

It is important that detailing is carried out with responsibilities and adequate timescales clearly defined. Issues such as site constraints, relevant standards, laps, covers, concrete grades, holes, detailing preferences, etc must all be covered. These requirements should be formalised into a detailing specification (see Construct's *Guide to contractor detailing*[13]) whether detailing is carried out in-house or outsourced. Ideally the contractor's preferred methods and sequence of construction should be made known and accommodated.

The requirements for the whole structure should be handed over and explained to the detailer at a single point in time. Packages of information that need to be provided to match the construction sequence or phasing must be defined. For instance sufficient information for the detailing of foundations and (wall and column) starter bars may be the first package required to be delivered.

Drawings and schedules can then be prepared by the detailer.

Once drawings and schedules have been completed, they are usually checked by the detailers themselves, checked by the designer for design intent and compliance with standards, and where appropriate, checked by contractors for buildability and completeness, all in according with the relevant contracts, specifications and Quality Assurance procedures.

As far as possible, design changes once detailing has started should be avoided. Any changes significantly affect and interrupt work flows, increase workloads and greatly increase the risk of errors. However, there are often situations where final design information is not available and design developments and checks cause alterations or requirements to change. While not ideal, changes are almost inevitable and their control needs to be addressed. An agreed system of design freezes is most beneficial.

Once the reinforcement drawings and schedules gain the status of construction drawings they are distributed to the relevant parties. In traditional contracts, the reinforcement drawings and schedules will be issued to the Contract Administrator and to the main contractor, client's Quantity Surveyor, etc. The main contractor normally distributes the information to site staff, quantity surveyors, buyers etc and to specialist subcontractors. The schedules will be sent to the reinforcement fabricator/supplier.

The reinforcement is usually 'called off' from site. As the work proceeds and reinforcement is required, the site will ask for reinforcement from certain schedules to be delivered. Again depending on circumstances, these may be bulk deliveries, individual pages of schedules or schedules recast by site into work packages. On site, deliveries of reinforcement call for inspection, craneage, sorting, storage, and document processing. Unless just-in-time deliveries are feasible or suitable storage areas are available adjacent to the work area, the reinforcement may need to be sorted and moved again just prior to fixing. Prefabrication, e.g. prefabricated pile, column and beam cages, may be carried out on or off site.

The reinforcement supplier or fabricator has to predict 'call offs' so that sufficient stock and manpower is available to answer their many customers' requirements. The cutting and bending process is well documented but of most concern are addressing issues such as price changes, clarity of information, off-cuts, non-standard shapes, full deliveries and most especially delivery timescales. Deliveries that are required within 48 hours of the receipt of a call off usually attract a premium.

The reinforcement is placed and fixed by steel fixers then checked in-situ. Responsibility for checking reinforcement should be covered in the specification. Formal pre-concreting checks should include checks of the reinforcement, covers, inserts and specialist items etc. The reinforcement should be checked again during concreting for position and afterwards dowels and starter bars should be treated and/or protected. The specification may also require a cover meter survey of after concreting.

Through all these processes correct and current reinforcement drawings and schedules play a vital role in getting it right on site. The schedules also play another vital role as they form the basis for payments to suppliers and contractors.

The communication of reinforcement detailing information from the design office to the site must be as efficient as possible. Traditionally the Designer has also been responsible for preparing the reinforcement detail drawings and schedules, i.e. 'Designer Detailing'. The emergence of specialist concrete contractors has provided an alternative means of producing the information through 'Contractor Detailing'. Both systems handle the same technical information but differ in the timing and the emphasis of the way it is produced. Some of the advantages and disadvantages are listed in Table 2.1.

Irrespective of the method of detailing chosen, it is essential that all the design information, that is required for detailing, is provided. Furthermore a standard way of providing the information reduces the scope for mistakes and speeds up the process. Currently for any particular type or size of project, the calculations, and consequently the detailing instructions, produced by different Designers vary considerably both in format and content. These variations affect the efficiency of the industry, particularly in that:

- The variations make the checking of calculations and instructions by Designers time-consuming and laborious. In addition the communication of design information to external checking authorities can be unnecessarily confused and protracted.
- It takes longer for the Detailer to absorb the reinforcement information given and increases the possible need for clarification. It can also lead to a degree of abortive work and misunderstanding between Designer and Detailer.

Table 2.1 Advantages/disadvantages of Designer and Contractor Detailing

Advantages of Designer Detailing/ Disadvantages of Contractor Detailing	**Advantages of Contractor Detailing/ Disadvantages of Designer Detailing**
Details from Designer Detailing are produced as an integral part of the design and can be more easily tailored to the demands of the Designer.	Contractor Detailing can more readily take into account the Contractor's preferred method of working.
Production of reinforcement details by Designer Detailing can take place while the design is still being finalised, thus saving elapsed time. A typical example where it might be more efficient for the designer to produce details is for foundations.	Reinforcement details by Contractor Detailing can be prepared taking account of the Contractor's preferred methods of construction and final material selection.
Preparing clear design information for Contractor Detailing takes longer and is likely to be later than for Designer Detailing with less time for checking or changes.	Preparing reinforcement details by Contractor Detailing benefits from following the actual construction programme.
The approval process for Contractor Detailing can take longer because of the rechecking required.	Designer detailed work may require re-working to take account of the Contractor's method of working.

Although it is clearly more efficient for the construction process to invoke a time freeze on the provision of new or altered information (e.g. mechanical and electrical information) this may not always be in the interests of the Client who is looking for the optimum solution.

The following includes the typical information required for detailing (see 2.6 for examples):

- General Arrangement (GA) drawings: they must be fully dimensioned, with sufficient sections and details, and should show or reference all necessary service holes, provisions for ducts and cast fittings.
- Project specification: Unless noted otherwise, the requirements of EC2 and this manual will be deemed suitable and applicable. Special requirements should be stated (e.g. seismic).
- Design requirements in one of the following forms:
  - the structural design calculations
  - marked-up GAs: This is common practice for small uncomplicated projects
  - element schedules: Sketches of the required reinforcement by element
  - pre-printed drawings (completed proformas)
  - sketches and tables incorporated with Computer Aided Design (CAD).

The efficient communication of information from Designer to Detailer is important. However, it is not suggested that a rigorous format for calculations be adopted throughout the industry. It is preferred that the Designer should recognise and tailor the guidelines given in this manual to suit the different situations that arise. The following points should be considered when the Designer is preparing instructions to the Detailer:

- Instructions should be indexed. An edited calculation index is normally sufficient.
- Basic design information relating to concrete and reinforcement grades, fire resistance, durability and associated concrete covers should be given by a Detailing Notice Sheet preceding the detailing instructions.

  Where information is available concerning the construction process (e.g. construction method, pour sequence etc.) this should be provided to the Detailer.

  Any special requirements should be noted on individual calculation/instruction pages.
- Detailing instructions should comprise only the calculation sheets describing the geometric and reinforcement requirements of a particular structural element. Information concerning general analysis of the structure, e.g. stability analysis, computer listings, is not required.

  The instructions should include clear diagrams of the reinforcement layering directions, TI, T2 etc. and the layering at cross-over of elements, consistent with the design calculations.

  Reference should be made to the Model Details in this manual where appropriate or alternative sketches supplied.
- Detailing information should be normally given in the right hand margin of the calculation sheet. Where the calculations for an element or series of elements are lengthy or complex the relevant reinforcement information should be extracted and presented in a summary sheet.
- The use of marked-up outline drawings as a summary should be accompanied by calculations for congested areas or where the section is small.
- Sketch details. All instructions should explicitly address the curtailment of reinforcement including the angle of strut assumed in shear design (see 6.3.2). Where conditions permit the use of standard arrangements these should be adopted. The instructions should also note where the standard curtailments may still be used where the elements fall outside the conditions for their use.

  Where only bending moment and shear force diagrams are provided these should be accompanied with clear instructions concerning curtailment. This method can be inefficient for detailing unless the Designer has given thought to the rationalisation of the layout (e.g. beam cages).

  Where reinforcement is congested or there are particularly complex connections e.g. corbels, nibs, deep beams to thin cross-section walls or columns, details should be sketched at a large size, even full-size, to confirm buildability. The sequence of installation must be considered to ensure beams can be lifted and placed.
- Each particular structural element requires specific design and geometric information. The list of information required is given in 'Detailing Information' sub-section of Chapter 6 for each element.
- Always provide the Detailer with the latest revision of relevant GAs and sections to avoid abortive work and the possible issue of incorrect details.
- The Designer should seek to maintain regular direct contact with the Detailer during the detailing process.

It is recommended that in the absence of an instruction from the Designer for a particular detail, or for nominal reinforcement, the Detailer should assume that the standards described by this manual are to be applied.

Where the Model Details given in this manual are not applicable to the geometric configuration, the Detailer should provide suitable alternatives based on similar principles.

2.3 Designer detailing

In order that the detailing is carried out in the most efficient manner, wherever possible, the Designer should seek to discover the Contractor's preferred methods and agree a sensible programme and sequence of work eliminating any unrealistic demands. Where the construction sequence is dependent on the design the Designer should provide a description of the design philosophy and constraints in addition to the information listed in 2.1.

Provide a description of the design intent and the form of construction assumed in design.

All sketches and rebar correspondence should be given a unique identification sketch or instruction number.

'Nominal' reinforcement should be assumed to be in accordance with the relevant element in Section 6 unless clearly stated by the designer.

2.4 Contractor detailing (see also *A guide to contractor detailing of reinforcement in concrete*[13])

Where detailing is commissioned through the Contractor under Works Contract for a project the following managerial points should be noted:

- The sub-contract should clearly state and define the responsibilities of each party.
- Legal advice should be sought, where necessary, to remove any doubts over contractual liabilities.
- The Specialist Concrete Contractor should be satisfied with the obligations and duties imposed by the contract and any warranties.
- The Specialist Concrete Contractor should have adequate insurance cover commensurate with the exposure to the relevant risks and liabilities.

2.5 Electronic data interchange (EDI)

The key to successful data exchange is to ensure that the specification of the data to be transferred from one party to another is clearly and rigorously defined.

Electronic transfer of data allows contractors to manage schedules and their revisions more quickly and are less prone to error than the old fax or postal methods which required re-keying of data. The widespread adoption of electronic data interchange (EDI) by the industry brings with it the need for careful and consistent schedule formats complying with BS 8666[6]. This allows the data to be transferred across the entire supply chain.

Minimum requirements

The following is a list of the minimum requirements for setting up accurate electronic data which can be universally accepted:

- Use of consistent nomenclature for drawing and revision numbers or letters, i.e.:
  - Revisions 1 and 2 should never be succeeded by revisions C and D.
  - The number 0 should never be interchanged with the letter O.
  - A revision at bar mark level should be consistent with the Drawing level, e.g. if a bar mark revision is marked 2 the drawing and schedule revision should be marked 2, although lower revisions can be displayed against the appropriate bar mark, if they were not changed in the new revision.
- Every bar mark must have a Member Name against it.
- Member Names must remain consistent through a schedule. The name itself is not important but a member called, for example 'garage-1' in one part of a schedule and later abbreviated to 'grge-1' in another part will be recognised by software as 2 different members.
- The same bar mark must never repeat within the same member name.
- When a library of Shape Code 99s is created (e.g. 99-01, 99-02 etc.) the shapes should be defined graphically and remain consistent for the duration of the contract.

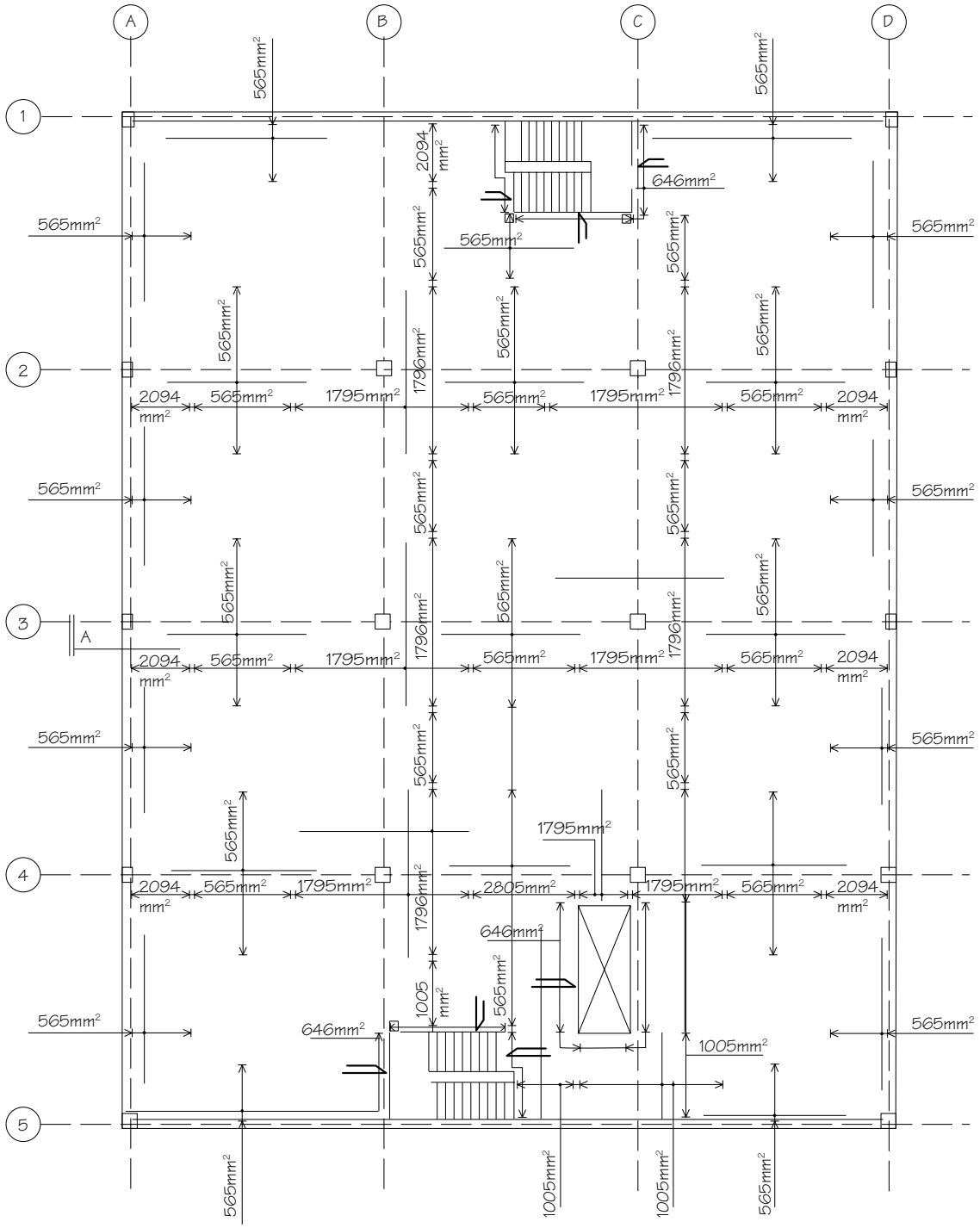
Recommended procedures

- When a revision is issued, each schedule page should display this revision, regardless of whether any bar marks have changed on that page.
- Revised bar marks should be individually labelled with the revision number or letter. A bar mark should retain the revision number or letter at which it was last revised for accurate revision history.
- When schedules are produced we recommend a naming convention of drawing number_revision, e.g. 213_02.

2.6 Examples of typical methods of providing the required information for detailing

Example 1

Flat slab Example of a marked up general arrangement drawing for a flat slab. Notes on drawing should include concrete grade and cover, or reference to these. The general arrangement drawings should also be provided.



Where contour plots from proprietary systems are provided the level of rationalisation to be applied should be agreed between the Designer and Detailer. Alternatively where crack control is important a schematic layout of Bars should be given.

The method of showing where holes and the associated reinforcement trimming details required for M&E purposes must be clearly stated (see also 6.2.2).