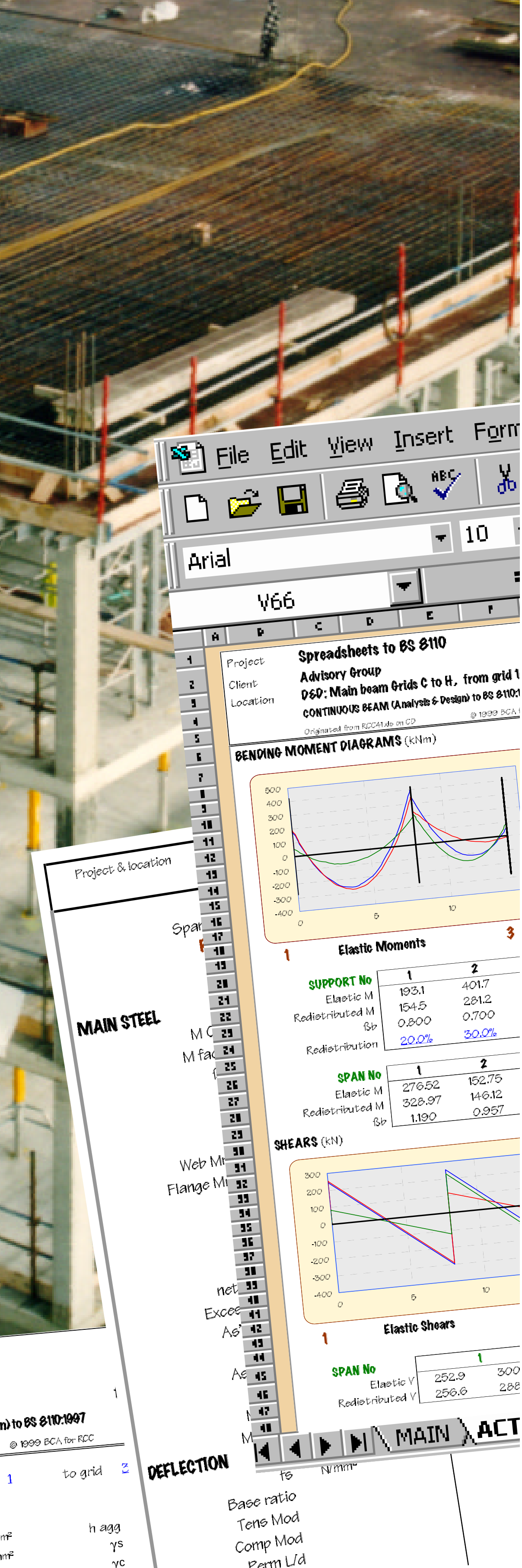

SPREADSHEETS FOR CONCRETE DESIGN to BS 8110 and EC2

User Guide to Excel spreadsheet files for contemporary reinforced concrete design with commentary and hard copy examples

C H Goodchild BSc, CEng, MCIOB, MIStructE

R M Webster CEng, FIStructE

REINFORCED CONCRETE COUNCIL

DETR ENVIRONMENT TRANSPORT REGIONS

FORWORD

This publication was produced by the Reinforced Concrete Council (RCC) as part of its project 'Spreadsheets for concrete design to BS 8110 and EC2'. This project was jointly funded by the RCC and the Department of the Environment, Transport and the Regions (DETR) under its Partners in Technology scheme and was made possible by members of industry with their contributions in kind.

The RCC was set up to promote better knowledge and understanding of reinforced concrete design and building technology. Its members are Allied Steel & Wire, representing the major supplier of reinforcing steel in the UK, and the British Cement Association, representing the major manufacturers of Portland cement in the UK.

Charles Goodchild is Senior Engineer for the Reinforced Concrete Council. He was responsible for the concept and management of this project and this publication.

Rod Webster of Concrete Innovation & Design is principal author of the spreadsheets. He has been writing RC spreadsheets since 1984 and is expert in the design of tall concrete buildings and in advanced analytical methods.

ACKNOWLEDGEMENTS

The ideas and illustrations come from many sources. The help and guidance received from many individuals are gratefully acknowledged.

Thanks are due to members of the project's Advisory Group for their time and effort in helping to make the project feasible and in bringing it to fruition. The members of the Advisory Group are listed inside the back cover.

The RCC extends its special appreciation to:
Richard Cheng, BSc, CEng, Eur Ing, FIStructE, author of the retaining wall and basement wall spreadsheets, Peter Noble for conversions and checking, and to Andy Pullen for initial studies into compatibility of spreadsheet software. Also to the late Sami Khan for help with post-tensioning spreadsheets. Thanks also to Alan Tovey (Tecnicom) and Gillian Bond (Words & Pages) for editing, design and production.

This User Guide, *Spreadsheets for concrete design to BS 8110: Part 1 and EC2* is available as:
- A publication plus CD-ROM available from BCA Publication Sales
- An Adobe Acrobat file UserGuid.pdf on the CD-ROM
- A Word document UserGuid.doc (text only) also available on the CD-ROM

Cover: Extracts from spreadsheets; photograph of the in-situ concrete frame building, ECBP, Cardington (©BRE)

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SPREADSHEETS FOR CONCRETE DESIGN TO BS 8110 and EC2

CONTENTS

Notes: In the text of this publication, spreadsheets are often referred to by their initial reference number rather than the full names given above. (A & D) = Analysis and Design.

INTRODUCTION

This publication has been produced under the Reinforced Concrete Council's project, 'Spreadsheets for concrete design to BS 8110 and EC2'. It provides.

- A User Guide for the spreadsheets produced under the above project
- Examples of current commercial reinforced concrete design
- A consensus of current commercial reinforced concrete design practice
- A consensus of opinion concerning reinforced concrete design to EC2.

The spreadsheets are intended to follow normal design practice and cater for the design of low- to medium-rise multi-storey concrete framed buildings.

Over a number of years, the Reinforced Concrete Council has developed spreadsheets to produce cost-optimised span/depth charts[1]. It was recognised that the spreadsheets could prove to be a very useful tool for all designers – equally useful to the single practitioner, larger organisations and educational establishments. Thus in 1996 a project was set up to commit reinforced concrete design to computer spreadsheet files. The project was jointly funded by the RCC and the Department of the Environment, Transport and the Regions (DETR) under its Partners in Technology scheme. It was made possible by the support and contributions of time given by individual members of industry. The project was managed by the Reinforced Concrete Council and guided by an 80-strong Advisory Group of interested parties, including consulting engineers and software houses.

The spreadsheets were to be issued with publications covering their use, complete with model designs and commentary. Two issues were originally envisaged: one to BS 8110: Part 1, 1997, *Structural use of concrete*[2], and one to *Eurocode 2, Design of concrete structures, Part 1*[3]. Owing to uncertainties with the final detailed content of EC2, the number of spreadsheets to the ENV has been curtailed. Nonetheless, it has been possible to maintain a comprehensive coverage and present the spreadsheets to EC2 with those to BS 8110 in this single-volume User Guide.

The design of concrete structures has been described as time consuming and costly. Computer programs are used extensively but designers are often reluctant to rely on 'black box' technology over which they have little knowledge or control. Computer spreadsheets, on the other hand, are user-friendly, completely transparent and very powerful, and are becoming increasingly popular in all aspects of engineering. They have powerful graphical presentation facilities and established links with other software, notably word processors. In structural engineering, they suit concrete design ideally, in that they can carry out a series of mathematical calculations and, as in design, can check whether certain conditions are met. They are an ideal medium to deal with the intricacies of concrete design.

And this is where it is hoped the publication and spreadsheets will help students and inexperienced engineers grasp an understanding of reinforced concrete design. For the experienced engineer, spreadsheets allow the rapid production of clear and accurate design calculations. It is hoped that the spreadsheets will allow younger users to understand concrete design and help them to gain experience by studying their own 'what if' scenarios. The individual user should be able to answer their own questions by chasing through the cells to understand the logic used. Cells within each spreadsheet can be interrogated, formulae checked and values traced.

In producing the spreadsheets several issues have had to be addressed. Firstly, which spreadsheet package should be used? Excel appeared to hold about 70% of the market amongst structural engineers and was thus adopted. More specifically, Excel '97 was adopted as being *de facto* the most widely available spreadsheet in the field. To avoid complications, it was decided not to produce corresponding versions using other spreadsheet packages.

In trying to emulate current practice, a consensus of opinion was sought and used on several design issues. For instance, with flat slabs, should deflection checks consider the whole bay width as opposed to checking column strips and middle strips? Should retaining walls conform to BS 8002[4], 8007[5] or CECP2[6]. It is anticipated that through use and continuing development more standardised design methods will emerge. Students and young engineers may follow the 'model' calculations presented in the spreadsheets to form an understanding of contemporary reinforced concrete design.

The introduction of Eurocode 2 is inevitable. Students and both inexperienced and experienced engineers will all need to grasp an understanding of design to this code. There are differences between EC2 and BS 8110. The spreadsheets should help with the transition. The introduction of Eurocode 2 will provide commercial opportunities for those who are prepared to use it.

It is believed that both novices and experienced users of spreadsheets will be convinced that spreadsheets have a great potential for teaching BS 8110 and Eurocode 2, improving concrete design and, above all, improving the concrete design and construction process.

Managing the spreadsheets

Use

Spreadsheets can be a very powerful tool. Their use will become increasingly common in the preparation of design calculations. They can save time, money and effort. They provide the facility to optimise designs and they can help instill experience. However, these benefits have to be weighed against the risks associated with any endeavour. These risks must be recognised and managed. In other words appropriate levels of supervision and checking, including self-checking, must, as always, be exercised when using these spreadsheets.

Advantages

For the experienced engineer, it is hoped that the spreadsheets will help in the rapid production of clear and accurate design calculations for reinforced concrete elements. The contents are intended to be sufficient to allow the design of low-rise multi-storey concrete framed buildings.

Spreadsheets allow users to gain experience by studying their own 'what if' scenarios. Should they have queries, individual users should be able to answer their own questions by chasing through the cells to understand the logic used. Cells within each spreadsheet can be interrogated, formulae checked and values traced. Macleod[7] suggested that, in understanding structural behaviour, **doing** calculations is probably not a great advantage; being close to the results probably is.

Engineers are often accused of having little idea of the costs of their designs. With spreadsheets, it is a very simple matter to multiply the quantities of reinforcement, concrete and formwork required by current rates to give an idea of material costs. By considering these costs along with time costs, different forms of concrete construction can be compared quickly and sizes or depths of elements can be sensibly optimised.

Other benefits include quicker and more accurate reinforcement estimates, and the possibilities for electronic data interchange (EDI). Already, bending schedules in the form of ASCII files derived from spreadsheets are the basis of some EDI and the control of bar-bending machines. Standardised, or at least rationalised, designs will make the checking process easier and quicker.

Appropriate use

In its deliberations[8] the Standing Committee on Structural Safety (SCOSS) noted the increasingly widespread availability of computer programs and circumstances in which their misuse could lead to unsafe structures. These circumstances include:

- People without adequate structural engineering knowledge or training may carry out the structural analysis.
- There may be communication gaps between the design initiator, the computer program developer and the user.
- A program may be used out of context.
- The checking process may not be sufficiently fundamental.
- The limitations of the program may not be sufficiently apparent to the user.
- For unusual structures, even experienced engineers may not have the ability to spot weaknesses in programs for analysis and detailing.

The committee's report continued: "Spreadsheets are, in principle, no different from other software…" With regard to these spreadsheets and this publication, the RCC hopes to have addressed more specific concerns by demonstrating "clear evidence of adequate verification" by documenting the principles, theory and algorithms used in the spreadsheets. The spreadsheets have also had the benefit of the Advisory Group's overview and inputs. Inevitably, some unconscious assumptions, inconsistancies etc[9]. will remain.

Liability

A fundamental condition of use is that the user accepts responsibility for the input and output of the computer and how it is used.

As with all software, users must be satisfied with the answers these spreadsheets give and be confident in their use. These spreadsheets can never be fully validated but have been through beta testing, both formally and informally, through members of the Advisory Group. However, users must satisfy themselves that the uses to which the spreadsheets are put are appropriate.

The initial spreadsheets were put through what was termed 'idiot-proofing' to try and guard against strange numbers being used. By its very nature, this exercise could not be all-encompassing. Future developments, such as adoption of European standards, might lead to use of concrete strengths of 37 N/mm^2 (f_{ck} = 30, f_{cu} = 37) and other material properties strange to UK eyes. Another example is reinforcement diameters of 14 mm that are used overseas.

Control

Users and managers should be aware that spreadsheets can be changed and must address change control and versions for use. The flexibility and ease of use of spreadsheets, which account for their widespread popularity, also facilitate ad-hoc and unstructured approaches to their subsequent development.

Quality Assurance procedures may dictate that spreadsheets are treated as controlled documents and subject to comparison and checks with previous methods prior to adoption. Users' Quality Assurance schemes should address the issue of changes. The possibilities of introducing a company's own password to the spreadsheets and/or extending the Revision history contained within the sheet entitled Notes! might be considered.

Managers might also consider making their own versions into template files, i.e. a spreadsheet saved with an .xlt extension instead of .xls. When the user opens one of these files, a copy is opened with a numerically incremented file name, i.e. Test.xlt will open as Test1.xlt. When the user saves, the Save as dialog box opens instead of directly saving.

Application

The spreadsheets have been developed with the goal of producing **calculations** to show compliance with codes. Whilst this is the primary goal, there is a school of thought[10] that designers are primarily paid for producing specifications and drawings which work on site and are approved by clients and/or checking authorities. Producing calculations happens to be a secondary exercise, regarded by many experienced engineers as a hurdle on the way to getting the project approved and completed. From a business process point of view, the emphasis of the spreadsheets might, in future, change to establishing compliance once members, loads and details are known. Certainly this may be the preferred method of use by experienced engineers.

The spreadsheets have been developed with the ability for users to input and use their own preferred material properties, bar sizes and spacings etc. However, user preferences should recognise moves for efficiency through standardisation. Another long-term objective is automation. To this end, spreadsheet contents might in future be arranged so that input and output can be copied and pasted easily by macros and/or linked by the end-user. There are counter-arguments about users needing to be closer to the calculations and results in order to ensure they are properly considered – see *Appropriate use* above.

We emphasise that it is up to the user how he/she uses the output. The spreadsheets have been produced to cater for both first-time users and the very experienced without putting the first-time user off. Nonetheless, their potential applications are innumerable.

Summary

With spreadsheets, long-term advantage and savings come from repeated use but there are risks that need to be managed. Spreadsheets demand an initial investment in time and effort – but the rewards are there for those who take advantage. Good design requires sound judgement based on competence derived from adequate training and experience – not just computer programs.

Familiarisation

Outline description

There are many different ways to present structural concrete calculations. 'Calcs' should demonstrate compliance with relevant design codes of practice, but different designers want to investigate different criteria and want to set out calculations in different ways. Spreadsheets cannot satisfy everyone. The spreadsheets presented here have been set out to cover the criteria that may be deemed 'usual'. It is incumbent on the user to judge whether these criteria are pertinent and sufficient for the actual case in hand. It is also incumbent on the user to ensure that the inputs are correct and that outputs are of the correct order of magnitude.

The spreadsheets are intended to follow normal design practice and cater for the design of low- to medium-rise multi-storey concrete framed buildings. Each type of element may be designed in several different ways, e.g. horizontal frame elements may be designed using:

- Element design: design of simple elements to BS 8110: Part 1[2]
- 'Tabular design': design of elements based on moment and shears derived from BS 8110: Part 1 Tables 3.12 and 3.5
- Analysis and design: design of elements based on moments and shears from analysis, e.g. sub-frame analysis, embodied within the spreadsheets.

Element design

The element design spreadsheets illustrate the basic principles of reinforced concrete design from input material properties, dimensions, moments, shears and axial loads, etc. They form the basis of element design used in succeeding spreadsheets. The moments, shears and axial loads used should be derived from separate analysis (e.g. hand calculations, sub-frame analysis spreadsheet or other analysis package). For further explanation the user is referred to BS 8110 or a number of standard reference works[11, 12, 13].

'Tabular design'

The tabular design spreadsheets use Tables 3.12 and 3.5 from BS 8110: Part 1 to automate the derivation of design moments and shears. The use of these tables is, however, restricted. For slabs, BS 8110: Part 1, Clause 3.5.2.4, restricts the use of Table 3.12 to where:

- In a one-way slab, the area of a bay (one span x full width) exceeds 30 m^2
- The ratio of characteristic imposed loads, q_k, to characteristic dead loads, g_k does not exceed 1.25
- The characteristic imposed load, q_k, does not exceed 5 KN/m^2, excluding partitions
- Additionally, for flat slabs, there are at least three rows of panels of approximately equal span in the direction being considered.

For beams, Clause 3.4.3, Table 3.5 is valid only where:

- Characteristic imposed loads, Q_k, do not exceed characteristic dead loads, G_k
- Loads are substantially uniformly distributed over three or more spans
- Variations in span length do not exceed 15% of the longest span

If design parameters stray outside these limits, the spreadsheets should be used with caution.

Analysis and design

To provide for more general application, these versions combine sub-frame analysis with design. Spreadsheets for one-way slabs, ribbed slabs, flat slabs and beams provide powerful design tools. Sub-frame analysis is used in the post-tensioned concrete design spreadsheet.

The flat slab spreadsheet is intended to be used one-direction at a time. The post-tensioned concrete design spreadsheet follows Concrete Society TR43[14] and involves sub-frame analysis at various limit states. The principles used are applicable to both beams and slabs with either bonded or unbonded tendons. The examples of the retaining wall and basement wall spreadsheets are based on common practice.

The sub-frame analysis spreadsheet, RCC21.xls, may of course be used alone (and the elements designed by other means such as RCC11.xls).

Column design

Column design is presented in, essentially, two different ways; either an amount of reinforcement is determined or the capacity of a section is checked – two valid design approaches.

Under RCC11 Element Design.xls (or RCC11.xls for short), the amount of reinforcement is calculated (by iterating to find the neutral axis depth in order to solve two simultaneous equations).

Under RCC52.xls for single axis bending and RCC53.xls for two axis bending, N-M interaction charts are derived from presumed reinforcement arrangements. Individual load cases are checked against the capacity of the column with the various reinforcement arrangements.

RCC51.xls is set out so that the user may undertake a traditional column load take down, assess design moments and critical axis before calculating the amount of reinforcement required.

RCC12.xls determines the capacity of an unsymmetrical reinforced column (or beam).

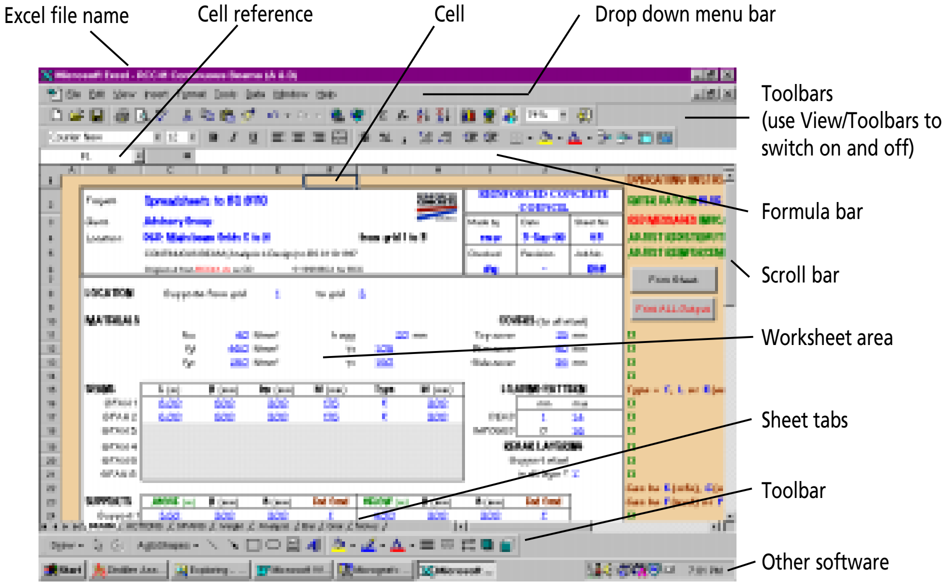
Others

Other spreadsheets provide for the design of pad foundations catering for one or two columns, punching shear, stairs (either as single flights and single landings or flights and landings as in a stair core), small retaining walls and basement walls. More detail and further references are given within the spreadsheets themselves.

Layout

As with all software, spreadsheets have their own jargon. The basic terminology for layout is shown on the following screen dump.

Typical spreadsheet layout



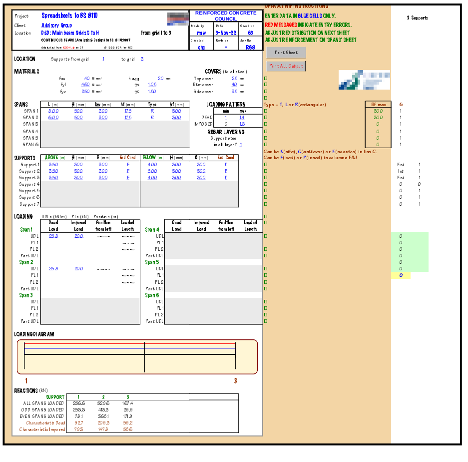
Sheet tabs (from RCC 41.xls)

Each spreadsheet may contain several linked sheets (i.e. layers or pages) that deal with different aspects of design. The sheet's name on the sheet tab as illustrated above gives an indication of the content. For the more involved spreadsheets, individual sheets are devoted to a full explanation of the design (with references for educational and validation purposes) or analysis, etc, and other sheets give an abridged version more in keeping with the requirements of experienced practising engineers. Further sheets may contain analysis calculations, data for graphs and calculation of reinforcement weight. All spreadsheets have a Notes! sheet where disclaimers, status and revision histories relating to each spreadsheet are incorporated (sheet names are differentiated by the use of an appended exclamation mark).

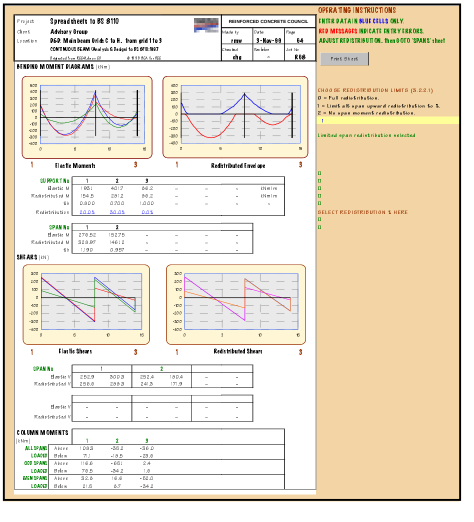
Those sheets with names in capitals are intended for printing out as design calculations: it is these sheets that are printed out as examples in this guide. Other sheets are available to view in the spreadsheets. These may need to be printed for checking purposes and parts of them, such as simple design routines, may be pasted into word-processed calculations (see *Printing*, page 14). Print-outs of [RCC41.xls]Weight!, Analysis!, Bar!, Graf!, and Notes!, and [RCC51.xls]Ltdcalcs! and Stiffs! shown at the end of their respective sections give typical illustrations of these types of 'workings' pages.

The spreadsheets are intended to be as consistent as possible. Generally, upper sheets consist of calculations, notes and workings as illustrated in the example below, which gives an indication of the contents of a typical spreadsheet. The first sheet consists of input, followed by results of analysis, design, weight of reinforcement, analysis, detailed design with references, graph data and finally a revision history.

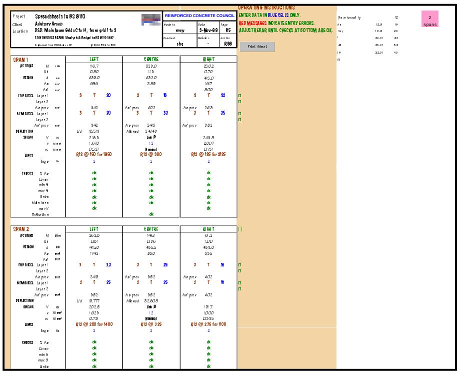
Typical spreadsheet (RCC41.xls)



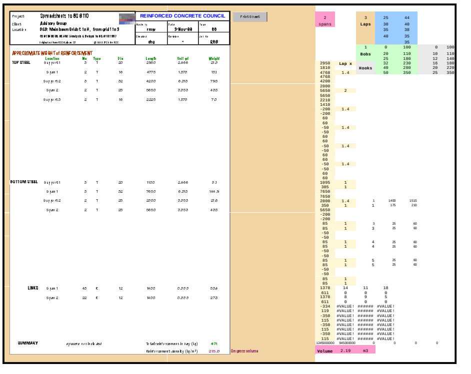
MAIN!
Main sheet



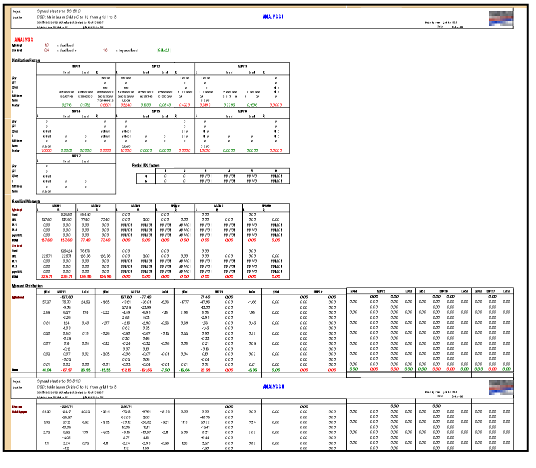
ACTIONS
Main graphical output of Bending Moment Diagrams, and shear force diagrams, but also input for redistribution



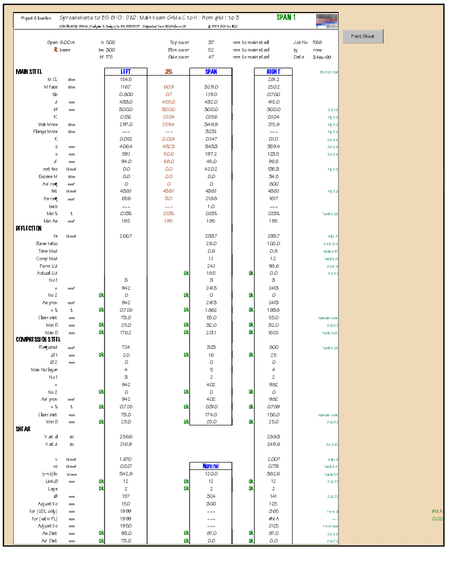
SPANS!
Design for sections of each span. Spans 3, 4, 5 and 6 follow on; extraneous spans blanked out. Input of bar size and link size required



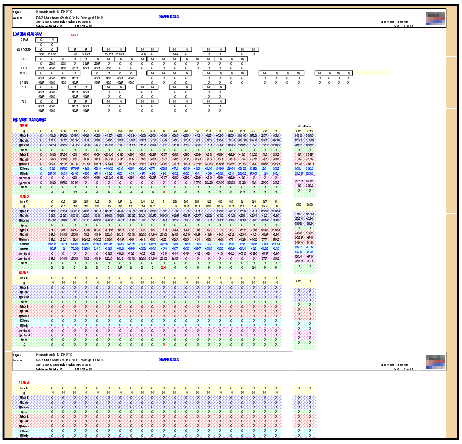
Weight!
Calculation of reinforcement



Analysis!
Workings of the sub-frame analysis carried out using moment distribnution



BAR!
Showing design of reinforcement with reference to code requirements. Spans 3, 4, 5 and 6 follow on from 1 and 2



Graf!
Data for graphs in charts

Notes!
Disclaimers, status and revision history of spreadsheet

Disclaimer

All advice or information from the British Cement Association and/or Reinforced Concrete Council is intended for those who will evaluate the significance and limitations of its contents and take responsibility for its use and application. No liability (including that for negligence) for any loss resulting from such advice or information is accepted by the BCA, RCC or their subcontractors, suppliers or advisors. Users should note that all BCA software and publications are subject to revision from time to time and should therefore ensure that they are in possession of the latest version.

This spreadsheet should be used in compliance with the accompanying publication '*Spreadsheets for concrete design to BS 8110 & EC2*' available from British Cement Association, Telford Avenue, Crowthorne, Berkshire RG45 6YS.

Status of spreadsheet

Public release version.

Revision history RCC41 Continuous Beams (A & D)

Date	Version	Action	Size (kB)
03-Aug-99	RCC41 v1.0	First public release. Includes β version comments	1029

Typical screen layouts

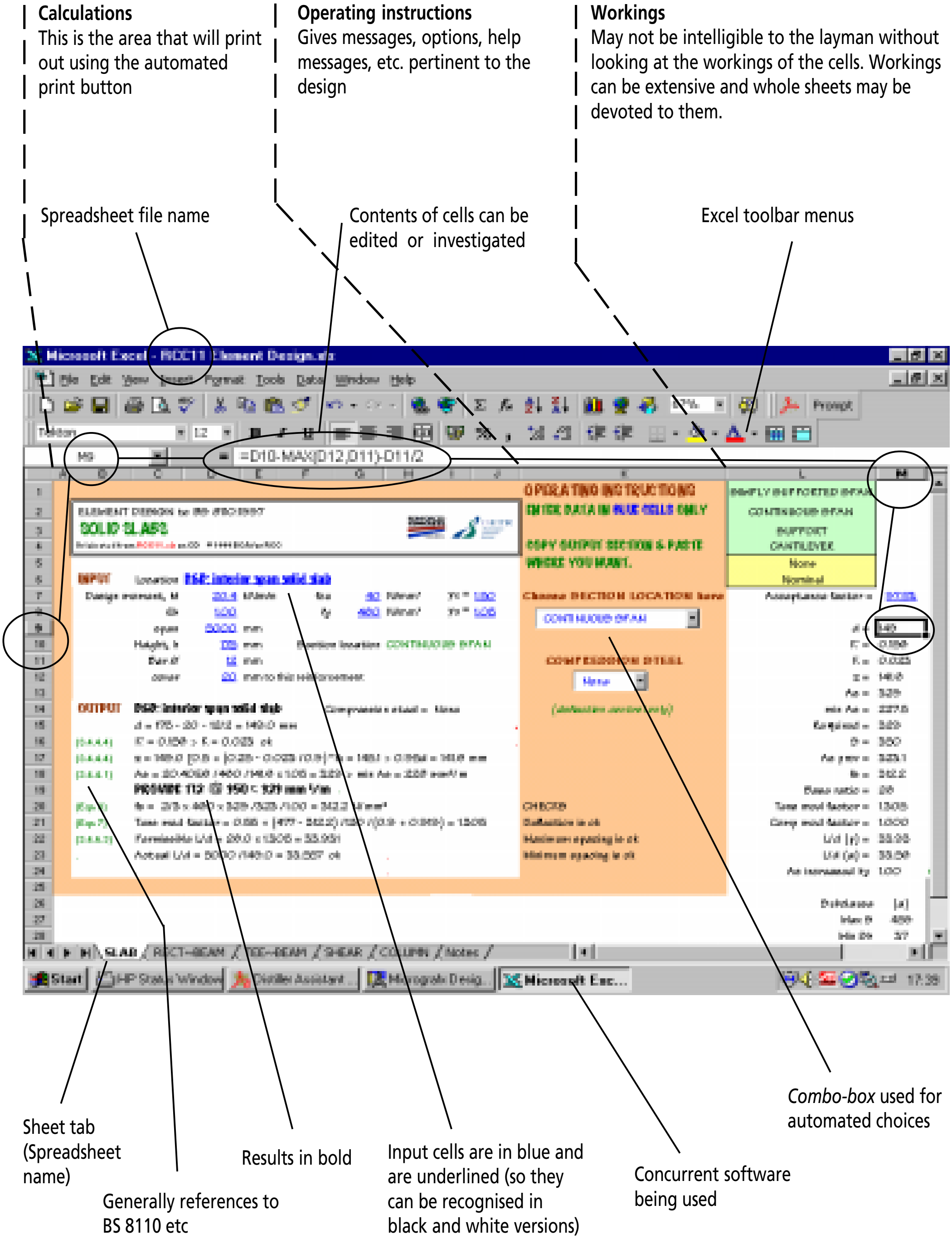
Upper sheets

The calculations are intended to mimic hand-written calculations as far as possible with a little more explanation by way of references to codes and derivation of numbers than would usually be the case in normal submissions. Sheets intended for printing out are divided into three sections, calculations, operating instructions and workings. The output is intended to be sufficient to allow detailing, although the designer should always consider and allow for rationalising reinforcement both within and between elements. The example below is from RCC11.xls. In this case, the sheet designs solid slabs from moments, shears, material data etc that are input by the user. Input cells are in blue and are <u>underlined</u> (so they can be recognised in black and white versions).

The cells under *Operating Instructions* contain help and error messages that are intended to help the user with the correct operation of the spreadsheet. They also contain variously checks, print boxes and combo-boxes. Box markers indicate where checks have been carried out and have proved satisfactory. Print buttons (buttons with macros assigned to them) automatically print out the calculation sheets provided that macros have not been switched off. Combo-boxes allow choices between specified options.

To the right hand side of many spreadsheets are intermediate calculations, data for graphs, etc. These 'workings' are not considered vital to understanding the calculation: they may nonetheless be viewed and investigated. 'Workings' may also be contained on supplementary sheets.

Typical screen layout



Other sheets

These sheets are not necessarily intended for printing out and may not be understandable without reference to the printed calculations. For instance, in the case shown imediately below (from [RCC52.xls]Calcs!) the N-M relationship for 32 mm diameter bars in this particular column is being calculated for increments of neutral axis depth. Many iterations are required in order to construct the N-M graph. There are therefore many calculations and these are set out in tables. The volume of calculations makes it difficult to produce legible print-outs on a limited number of sheets.

Notes!

The Notes! sheet illustrated at the bottom of the page shows the disclaimer, status and revision history of each spreadsheet. The disclaimer and status should be read and understood. The revision history provides a record of the spreadsheet being used and may provide a basis for users' QA procedures. The revision/version and name of the spreadsheet shoud appear on all print-outs. This example is taken from [RCC52.xls]Notes!

Example of other sheet

32 Bar diameter

d' = 54 mm　　d = 246 mm　　Asc = 4825.5 mm²

N=0 quadratic　　a = 4221.000　　b = 594189.70　　c = -9.E+07

n max = 657.5　　Interval = 2.665　　*(24 intervals between N=0 and Nbal)*

N = 0　*(solve for zero N)*

n	Neutral axis	92.59	95.25	97.92	100.58	103.25	105.91	108.58	111.24	113.91
Fc	Conc comp force	390821	402069	413317	424565	435814	447062	458310	469558	480807
c strain	Steel comp strain	0.00146	0.00152	0.00157	0.00162	0.00167	0.00172	0.00176	0.00180	0.00184
tstrain	Steel tens strain	0.00580	0.00554	0.00529	0.00506	0.00484	0.00463	0.00443	0.00424	0.00406
fsc	Steel comp stress	276.11	287.53	298.33	308.56	318.26	327.47	336.23	344.57	352.52
fst	Steel tens stress	438.1	438.1	438.1	438.1	438.1	438.1	438.1	438.1	438.1
Fsc	Steel comp force	666191	693747	719804	744480	767882	790107	811240	831362	850541
Fst	Steel tens force	1057011	1057011	1057011	1057011	1057011	1057011	1057011	1057011	1057011
z	Conc lever arm	204.33	203.14	201.94	200.74	199.54	198.34	197.14	195.94	194.74
N	Fc + Fsc - Fst	0.00	38.80	76.11	112.03	146.68	180.16	212.54	243.91	274.34
M	M O R	207.77	211.15	214.36	217.41	220.31	223.08	225.71	228.21	230.60
Labels	for chart									
	N diff	38.80	37.30	35.92	34.65	33.47	32.38	31.37	30.43	29.55
	M diff	3.38	3.21	3.05	2.90	2.76	2.63	2.51	2.39	2.28

Notes! sheet

Disclaimer

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This spreadsheet should be used in compliance with the accompanying publication '*Spreadsheets for concrete design to BS 8110 and EC2*' available from British Cement Association, Telford Avenue, Crowthorne, Berkshire RG45 6YS.

Status of spreadsheet

Public release version.

Revision history RCC52 Column Chart generation

Date	Version	Action	Size (kB)
06-Aug-99	RCC52v1.0	First public release. Includes β version comments	2032

Using the spreadsheets

Using the spreadsheets for the first time / Frequently Asked Questions

Base versions

Initially, always start from the base versions on the CD-ROM. If in doubt, go back to the version on the CD-ROM. These safeguards are to avoid using corrupted or bespoke files. Eventually, familiarity with the spreadsheets and Quality Assurance procedures may overtake this basic precaution.

Please note that whilst all spreadsheet cells, apart from input cells, are covered by nominal protection, it is possible to change the contents of cells. Original versions by RCC can be sourced from the RCC's CD-ROM or website. Also, please note conditions of use and disclaimers associated with the use of the spreadsheets contained within the sheet titled Notes! and elsewhere in this User Guide.

Excel

The spreadsheets are normal Excel '97 files. Excel '97 (© Microsoft Corporation) is a standalone package or may be included as part of the Microsoft Office '98 package on PCs or Macs. The files are compatible with Excel 2000, part of Office 2000, and are likely to be compatible with future versions of Excel. Those not familiar with Excel are directed to the Help functions within Excel and relevant literature available at book and computer shops.

Please note that the spreadsheets will not necessarily work with previous versions of Excel (e.g. '95, 5.x etc) or other spreadsheet programs. This is due to incompatibility between software and backward incompatibility between versions. (To check which version of Excel you are running see sign-on screen, or Help/About Microsoft Excel or see Printreg.xls under Administrative files.). Those running Excel 2000 are advised to use the Save As/ .xls function to avoid inordinately large file sizes.

Long file names

The base versions of the spreadsheets are saved with long file names to aid familiarity with each spreadsheet's purpose. Some software and networks only recognise eight characters for a file name. In use, users may be requested by the system to allow abbreviated names, e.g. RCC11.xls .

As shorthand, the spreadsheets are generally referred to by their number rather than their name in full, i.e. RCC11.xls is used as shorthand for RCC11 Element Design.xls.

Loading a spreadsheet for the first time

Under Windows '95, '98 or NT insert the spreadsheet CD-ROM into the CD drive (drive D: assumed). A spreadsheet can be loaded using one of the following methods:

- From 'My Computer', double click on My Computer, double click on D (assumed CD drive), then double click on spreadsheet of your choice. Excel will boot up and most probably warn about macros before loading the spreadsheet fully. In order to proceed, enable macros (see below).
- Successively click Start/ Programs/ Microsoft Explorer. Double click on CD Drive (D). Double click on the spreadsheet of your choice, e.g. RCC11.xls. If not already loaded and available, Excel will boot up and load up with RCC11.xls
- Successively click Start/ Programs/ Microsoft Excel. Once Excel has booted up, click on File in top menu bar/ Open/ Look in and scroll through to the CD Drive.

No installation program *per se* is included. Under file managers such as Microsoft Explorer, the CD-ROM versions of the spreadsheets can be dragged and dropped into an appropriate folder specified by the user. Alternatively, from within Excel, the spreadsheets can be loaded directly from the CD-ROM – but should users wish to save the modified spreadsheet, it has to be saved to an alternative drive.

Macros

When loading the individual spreadsheets, Excel may warn you about the presence of macros. All the macros provided in the files are either to allow automated printing of the 'calculations' or to provide choices by way of combo-boxes. The printing macros have been assigned to buttons. Turning the macros off will not affect the actual function of the spreadsheets but will make printing of the sheets as configured more difficult and make the choice of options very much more difficult.

Fonts

Unless the appropriate fonts Tekton and Marker (supplied in the CD-ROM) have been installed by the user, the appearance on screen will be different from that in the publication and from that intended. These condensed fonts have been used to emulate a designer's handwriting and to allow adequate information to be shown across the page and in each cell.

If problems are experienced it is most likely that the fonts on your computer screen will have defaulted to the closest approximation of the fonts intended (e.g. the toolbar may say Tekton but a default font such as Arial will have been used). The spreadsheets will work but not as intended – ends of words may be missing, and numbers may not fit cells resulting in a series of hashes, #####. Column width and cell overlap problems occur only when the correct fonts are not loaded.

It is strongly suggested that the Tekton and Marker fonts are copied into your computer's font library. This may be done in the following manner, either:

- Start/ Settings/ Control Panel/ Fonts/ File/ Add Fonts and when asked "copy fonts to system directory" say yes.

or

- Through Microsoft Explorer and copying (or dragging) the font files into your font library, usually contained in Windows/ Set-up/ Fonts.

Default font size

Even with the correct fonts installed, the appearance of the sheets might be different from those in this publication. This may be due to the default font size on the user's computer being different from the font size 12 used in the development of the spreadsheets. For instance if the user's default font size is 10, pages will appear and print narrower than intended (as unformatted cells will revert to a narrower cell width than intended).

Please ensure that the default font size is set at 12. (Tools/ Options/ General/ Standard font and size). If standard font or size is changed it will become effective only after rebooting Excel. While the spreadsheets were developed using Tekton 12, many True Type font size 12 (e.g. Arial or preferably Times New Roman 12) may give adequate presentation.

If a series of hashes (#####) still appears, it may be necessary to resize the column width.

Screen view

The spreadsheets have been developed assuming that part, if not the whole, of the *Operating Instructions* column is in view. This column contains comments, instructions, checks, explanations etc. and is important to the correct operation of the spreadsheets.

Generally, a screen zoom of 75% has been used as a default size on the sheets. Occasionally, other zoom sizes have been used in order to aid comprehension.

Input

In the spreadsheets, input data is blue and <u>underlined.</u> New data may be input by overwriting default values or by entering values in 'greyed out' cells. Entering data in far-left greyed-out cells will also remove the grey conditional background to other cells, which will then require data entry. Some input cells refer back to data on previous sheets within a workbook. These are coloured magenta, but change back to blue if other data are entered.

Do not copy and paste input from one cell to another as this may cause formatting and other errors. Do not use Space, Enter (the space equals text). If similar input is required in other cells then use '= cell reference' with caution, e.g. '= B16' in the appropriate input cell.

All non-input cells should have nominal protection and the contents of these cells can be overwritten only if the user has taken positive steps to overcome protection in order to overwrite original contents.

In the page headers the 'Made by' and 'Checked' boxes should be completed or cleared by using a blank or hyphen; clearing the cell completely would produce '0' on subsequent sheets.

Values in red or red backgrounds

During operation, values in red or cells with red backgrounds flag either incorrect data to be changed or excess data to be cleared (manually). Even using Space as an entry might generate red backgrounds.

If you make a mess of it

Start again from the base version of the spreadsheet on the CD-ROM.

Printing

The sheets may be printed out in several ways:

- Through the automated print buttons in the spreadsheets (using these print macros will over-write print areas defined elsewhere)
- Using the Print icon on Excel's standard toolbar
- Using File/ Print within Excel
- Copying and pasting (special) parts of the spreadsheets to a word processor or other package. (Pasting (special) into a word processor file as a bitmap produces a wysiwyg image.
- Pasting as other formats will probably require some pre-copying formatting of the spreadsheet and/or post-formatting of receiving cells.)

Print areas may be defined by:

- Highlighting area then clicking File/ Print Area/ Set Print Area
- Clicking View/ Page Break Preview and adjusting boundaries to suit

Print previewing can be achieved using the Print Preview icon on the standard toolbar.

Print formatting

Different hardware and software are configured in many different ways. This situation leads to many variations on the actual print from individual printers. Best results are likely to be obtained from Windows printers but even these may not produce printing that is identical to that in this publication. Some manipulation for printing with your configuration may be inevitable. See also Printreg.xls under Admin files.

Auto complete

Excel's facility for AutoCompleting cells (e.g. entering 'T' might auto complete to 'Type') can be a mixed blessing. In most spreadsheets it should be turned off via Tools/ Options/ Edit and clearing the *Enable AutoComplete for cell values* box.

Help

Help is available from this User Guide, *Spreadsheets for concrete design to BS 8110: Part 1 and EC2*. This can be read as either:

- 2 colour printed copy available from BCA Publication Sales
- In full colour through the Adobe Acrobat file UserGuid.pdf on the CD-ROM. A copy of Adobe Acrobat Reader will be required to read this file. If not already installed on your computer, a copy is available for installation on the CD-ROM. This facility is provided courtesy of Adobe and is subject to their conditions of use
- As the Word document UserGuid.doc (text only) also available on the CD-ROM.

Help is also available at the following places:

- Within Excel under Help
- To the right hand side of the spreadsheets, cells under *Operating Instructions* contain help and error messages
- Queries should be e-mailed to rcc@bca.org.uk. Preference will be given to those who register and quote their password, but the RCC cannot guarantee to reply. See Shareware registration below. The RCC regrets that telephone enquiries cannot be dealt with.

Continued use

Shareware

These spreadsheets are offered as shareware. This can be considered a 'try before you buy' system where you are expected to pay the program authors a registration fee if you find the programs useful or if they are used for commercial design. In general you may pass on copies of shareware programs to colleagues within the UK, although commercial (for a fee) distribution requires special written permission from the publisher.

Shareware registration

Designers who use this software in the course of their work are requested to pay a registration fee of £50 + VAT per office where the spreadsheets are used. The registration will cover spreadsheets to both BS 8110 and EC2. In order to register please either use a print-out of Printreg.xls (see under *Supporting folders* page 152) or take a copy of this page, fill it in and return with payment to The Reinforced Concrete Council. Separate conditions apply for use outside the UK and for educational establishments - please apply in writing.

Registered User

Name:

Organisation:

Address 1:

Address 2:

Town:

County:

Postcode (& Country):

Phone:

Fax:

E-mail:

Nature of business:

No. of employees

Cheques payable to: 'The Reinforced Concrete Council'
Send to: Reinforced Concrete Council, Century House, Telford Avenue, Crowthorne, Berkshire RG45 6YS

Benefits of registration

Registrants will receive:

- A receipt
- A password
- By quoting their password, preferential treatment with regard to support
- By using their password, free access to download any new or updated spreadsheets that may be made available on the RCC's website at www.RCC-info.org.uk.

Registration will be valid for at least one year. Beyond that period the RCC reserves the right to charge for downloading updates in order to cover costs.

Support

E-mailed questions, comments, developments and suggestions are welcomed. Send them to rcc@bca.org.uk. The RCC regrets that it cannot guarantee to reply or to enter into correspondence. Preference will be given to those who register and quote their password. The RCC regrets that telephone enquiries cannot be dealt with.

Updates

It is intended that the RCC's website (www.RCC-info.org.uk) will include updated versions of the spreadsheets. These will be downloadable by registrants who can supply their valid password.

Conditions of use: disclaimers

A fundamental condition of use is that the user accepts responsibility for the input and output of the computer and how it is used.

Whilst the spreadsheets have been checked with all reasonable care and diligence, they cannot be guaranteed for use in every every eventuality.

Validation was held to be extremely important by the Advisory Group but these spreadsheets can never be fully validated. However, they but have been through beta testing, both formally and informally, through members of the Advisory Group and others. Users must satisfy themselves that the uses to which the spreadsheets are put are appropriate. Users must have read, understood and accepted the disclaimer contained on the inside front cover of this publication (and repeated in the sheet named Notes! in each spreadsheet).

Change control

Nominal protection

Users and managers should be aware that the preadsheets can be changed. Beyond nominal cell and sheet protection, the files are open and can be changed. There are several reasons for this:

- The files can be customised by users to their own preferred methods of presentation and design (e.g. deflections might be calculated to part 2 of BS 8110; individual firms or project logos might replace the RCC's logo)
- The protection should stop inadvertent changes and corruption of cells
- Developments and improvements can be made and fed back to the RCC. Such feedback is encouraged and allows a wider consensus to be gained
- Protection can always be overcome by determined users
- Fully protected files can hide cell contents
- Spreadsheet emulators are at present unsuitable for these particular applications
- Different designers want different facilities available to them and should not be restricted

The spreadsheets are all protected (but with no password). In other words users have to do something positive if they are to change any formulae, and must therefore take responsibility for any deliberate or accidental changes. The project's Advisory Group held this to be a sensible position.

Users and managers must address change control and versions for use. The RCC can only control the base versions issued on CD-ROM (and web page). The published examples can be used as record copies to help identify changes. Users' Quality Assurance procedures may dictate the use of more sophisticated protection measures.

Development

The protection may be over-ridden to allow customisation and individual development. Any development of the spreadsheets should be undertaken by experienced staff who have a good understanding of the problems and pitfalls of both design and spreadsheets. It may take an experienced engineer four or five times longer to prepare a spreadsheet than it would to produce the equivalent manual calculation: robust, commercially acceptable spreadsheets may take 50 times as long. They can take even longer to test, check and correct. Only repetition of use makes the investment of time worthwhile.

With relatively open files, designers are at liberty to alter the spreadsheets as they wish. However, they must satisfy themselves that any alterations are correct and do not interfere with any other aspect of the spreadsheet in question and conform to any QA procedures.

Notwithstanding the above, copyright of the spreadsheet contents remains with the BCA for the RCC. Altered or amended versions of the spreadsheets may not be sold or hired without the written permission of the RCC.

Please inform the RCC of any major discrepancies found or improvements made.

Saving files/file management

Many users save spreadsheets to a directory and/or folder of their choice. This is particularly true where spreadsheets pertaining to a particular project are saved to a folder given the project's name.

Assumptions made

During the course of development of these spreadsheets, a number of structural and computing assumptions have been made. These are discussed below

A_s enhancement

Several of the spreadsheets contain automatic routines that increase A_s in order to reduce service stress f_s and therefore increase modification factors in order to satisfy deflection checks. The 'A_s enhancement' values are the percentages by which A_s required for bending are increased in order to satisfy deflection criteria.

Reinforcement densities

Some spreadsheets give an indication of weight of reinforcement in the margin under *Operating Instructions*. These densities should be used with great caution. Many factors can affect actual reinforcement quantities on specific projects. These include different methods of analysis, non-rectangular layouts, large holes, actual covers used, detailing preferences (curtailment, laps and wastage), and the unforeseen complications that inevitably occur. As may be examined in the sheets entitled 'weight', the densities given relate to simple rectangular layouts and the RCC's interpretation of BS 8110. They make no specific allowance for wastage.

The densities assume that the areas or volumes of slabs are measured gross, e.g. slabs are measured through beams. Beam reinforcement densities relate to web width multiplied by overall depth

Rationalisation of reinforcement

Although it may appear that many of the spreadsheets give least-weight solutions (hence more bars, more work), the amounts of reinforcement derived are actually accurate (and not necessarily rationalised). It is intended, therefore, that the amounts of reinforcement derived from the spreadsheet should be considered as minima.

Redistribution

The spreadsheets with analysis allow redistribution in accordance with BS 8110: Part 1, Clause 3.2.2.1. The user may choose between three options. These options do not affect redistribution at supports but do determine how span moments are calculated, as shown in the following table.

The user should specify more rationalised reinforcement layouts to the detailer. Rationalisation should be done manually – there would seem to be too many variables and personal preferences to enable automatic rationalisation. A detailer can always close up spacing and/or reduce bar diameters if desired.

Most often the spreadsheets require bar size as input, rather than bar spacing. This can lead to unusual, but correct, spacings. Where bar diameter input is available, it may be worth investigating larger bars (at larger centres). For instance, in the design of a flat slab it would probably be preferable to use 4828 larger bars at greater centres rather than 6840 smaller bars at small centres (weight is marginally different, 82.5 kg/m³ c.f. 80.8 kg/m³). This results in 30% fewer bars compared with 2% extra steel. Rationalised arrangements with least number of bars without breaking

Redistribution of moments: options for calculating span moments

Spread-sheet option number	Design support moment	Design span moments	
		Support moment from which span moment is calculated	Comments
0	$\beta_b M$	$\beta_b M$	Design span moments will probably be less than elastic moment (minimum of 70% of elastic moment). This option may lead to a kinked bending moment diagram as the 70% kicks-in in the spans. In the case of thin sections such as slabs, consideration of span deflection and service stress often leads to reinstatement of any reinforcement theoretically saved.
1	$\beta_b M$	Minimum of $\beta_b M$ and M_{alt}/β_b	Design span moments might be less than elastic moment but less likely than with option 0. Increasing the minimum support moment for the calculation of span moment from M_{alt} to M_{alt}/β_b is seen as a sensible compromise between options 0 and 2.
2	$\beta_b M$	Minimum of $\beta_b M$ and M_{alt}	Design span moments cannot be less than than elastic moment. Most often used but if, typically, 20% redistribution is specified at supports, design span moments will increase by about 10% over elastic span moments. Again, in thin sections, consideration of deflection and service stress can limit additional amounts of reinforcement due to increased span moment.

Where
β_b = (moment after redistribution)/(moment before redistribution)
= 100% - % redistribution requested
M = elastic moment at support, all spans loaded
M_{alt} = maximum elastic Moment at support, alternate spans loaded

the spacing rules and least number of bar marks are always preferable. Eventually, it may be possible to automate this process, but for the time being it is between the program user (i.e. the designer) and the detailer to decide how to rationalise bar arrangements. Any estimates of reinforcement must take this process into account.

Other spreadsheets tend to size bars in such a way that minimum centres (or clear spacings) are not exceeded.

It is assumed that issues of detail will be considered by the engineer and detailer. Issues such as radius of bottom bars and beam bearings, space between bars in narrow beams, spliced bars at supports of beams, connection details, etc., need to be considered.

Imposed c.f. live loads

Loosely, *Imposed* load is taken to be the characteristic load input by the user. *Live* load is taken to be that part of the ultimate load that is not characteristic dead load (i.e. *Live* load = n - g_k).

#DIV/0! (Divide by zero) errors

In some spreadsheets, #DIV/0! results may arise and be displayed. In sheets intended for printing out, #DIV/0! indicates an error in or invalid input. In sheets of workings, they have no relevance to the validity of the sheet or the spreadsheet as a whole.

Please note that in many cases, but not all, a very small value has been used rather than zero in order to avoid #DIV/0! (divide by zero) problems in Excel, e.g. [RCC53.xls]Cases! 13:B18 where = IF(ERROR(G3),0.000001,G3) has been used.

Linking spreadsheets

To avoid complications, links between different spreadsheets have not been used. Nonetheless, for the experienced user, linking provides a powerful tool. The results of one spreadsheet can be linked through to become the input for another, or project data can be auto-loaded. This minimises the amount of input required and at the same time reduces the scope for error in data transfers. For example, the results of a beam analysis can be carried through to beam design. Any links created by the user are at his or her discretion.

Deflections

Deflection checks are based on span:depth criteria in the codes. Estimates of actual deflections are not yet available within the spreadsheets.

Analysis: cantilever deflections and support rotation

Support rotations are ignored. Support rotation cannot be determined except as part of a rigorous deflection analysis. Rotations cannot be easily derived from moment distribution, and in any case, gross section slopes are of little or no value. It is assumed that BS 8110's usual deemed-to-satisfy L/d checks ("rule of thumb") are adequate.

If support rotations are expected to be critical additional checks should be undertaken.

Sign convention

Sagging moments are considered to be positive moment and are plotted downwards. This convention was used so that Excel plots the bending moment diagram in the direction of the deflected form (the right way from the engineer' s point of view!).

Screen resolution

The spreadsheets have been developed in 1024 x 768 resolution, so that their appearance will be acceptable between SVGA (800 x 600) and 1280 x 1024. They will obviously work in VGA (600 x 480), but higher resolutions are recommended.

Y2K

The spreadsheets rely on Excel and the users' systems being year 2000 compliant.

RCC11 Element Design.xls

RCC11.xls includes sheets for designing

- Solid slabs,
- Rectangular beams,
- T beams (and ribbed slabs) for bending,
- Beam shear and
- Columns with axial load and bending about one axis.

RCC11.xls designs elements to BS 8110: Part 1, 1997. It is assumed that loads, moments, shears, etc. are available for input from hand calculations or analysis from elsewhere. A governing criterion can be deflection; span-to-depth ratios are used as per BS 8110: Part 1, Clause 3.4.6.

SLAB!

This sheet allows for the design of a section of solid slab in a single simply-supported span, in a continuous span, at supports or in a cantilever. These choices have a bearing on deflection limitations and the user should choose the appropriate location from the combo-box to the right hand side. The user may also choose to allow for no or nominal compression steel; this again affects deflection factors. To an extent the spreadsheet will automatically increase reinforcement in order to lower service stresses and enhance allowable span to depth ratios. The spreadsheet allows a certain amount of theoretical over-stress as defined by the user in cell M7. Engineering judgement is required to ensure that any over-stress is acceptable and that specified reinforcement is sensibly rationalised.

The example is taken from *Designed and detailed* [15]. The slight variance in reinforcement requirements is due to the spreadsheet allowing marginal over-stress and allowing centres in increments of 25 mm.

RECT~BEAM!

This sheet designs rectangular beams. The location of the beam may be either in a single simply-supported span, in a continuous span, at supports or in a cantilever. These choices have a bearing on deflection limitations and the user should choose the appropriate location from the combo-box to the right hand side.

When considering span reinforcement, the spreadsheet will, where necessary, automatically increase reinforcement in order to lower service stresses and enhance allowable span-to-depth ratios. In checking deflection, the sheet entitled RECT~BEAM! includes two bars of the specified reinforcement diameter to derive a modification factor for compression reinforcement. The facility to specify additional compression reinforcement to enhance span-to-depth ratios is contained within TEE~BEAM!

The example is taken from *Designed and detailed* [15]. The expression for area of tension steel required may be unfamiliar to some and is explained below:

$$\begin{aligned} As &= (39 \times 10^6/390.0 + 242.5 \times 10^6/381.1)/438.1 \\ &= ([M - M_u]/[d - d'] + M_u/z)/(f_y/\gamma_m) \\ &= As' + M_u(\gamma_m/zf_y) \\ &= 1684 \text{ mm}^2 \end{aligned}$$

TEE~BEAM!

TEE~BEAM designs T beams and L beams in single simply-supported span, end span, internal span or cantilever locations. Again, these choices have a bearing on deflection limitations and the user should choose the appropriate location from the combo-box to the right hand side. With respect to the effective width of the flange, the user may also choose that the section is considered as a tee- or an inverted L beam.

A default value for the width of the flange b_f is calculated and displayed as input. This cell may be overwritten if, for instance, say the user wishes to allow for openings etc. The default is calculated as being:

web width + 0.14 span for T beams, internal span

web width + 0.16 span for T beams, end span

web width + 0.07 span for L beams, internal span

web width + 0.08 span for L beams, end span

In the determination of compression steel, where the neutral axis lies below flange, the concrete in web, bw, below flange has been ignored. This is seen as a valid alternative to the approach in Clause 3.4.4.5 .

In order to calculate the appropriate deflection factor for compression reinforcement, there is a facility to specify compression reinforcement. When considering deflection, the spreadsheet will, where necessary, automatically increase span reinforcement in order to lower service stresses and enhance allowable span-to-depth ratios.

The example is taken from *Designed and detailed* [15]. The span could have been defined as an end span rather than interior span: the part of the span in hogging would have been greater than the 70% assumed and the width of the flange could have been taken as being wider (1580 mm), leading to some economy.

SHEAR!

This sheet checks beams or slabs for shear and calculates any shear reinforcement required. It is hoped that the input is self-explanatory.

Providing the applied load is fundamentally a UDL, or where the principal load is located further than 2d from the face of the support, BS 8110: Clause 3.4.5.10 allows shear to be checked at d from the face of support. Checks for maximum shear (either 5.0 N/mm² or $0.8f_{cu}^{0.5}$) are carried out automatically. A maximum link spacing of 600 mm is used; this is seen as a sensible maximum.

The example is taken from *Designed and detailed* [15]. The value of shear used is that at d from the face of support (i.e. 300.0 – (0.45 + 0.30/2) x 68.12 = 259 kN). The designed links would be necessary for a distance of 1500 mm from this position before reverting to nominal link arrangements. It may have been more appropriate to have used T10s and the full 300.0 kN shear at centre of support. This would have lead to T10 @125 for 1750 mm from the centre of support. (The difference in length of designed links is due to the different capacity of the nominal links.)

Apart from punching shear, shear in slabs is rarely critical. (See RCC13.xls.)

COLUMN!

This sheet designs symmetrical rectangular columns where both axial load, N, and maximum design moment, M_x are known (see BS 8110: Part 1, Clause 3.8.2, 3 and 4). It iterates x/h to determine where the neutral axis lies. The sheet includes stress and strain diagrams to aid comprehension of the final design.

For simplicity, where three or more bars are required in the top and bottom of the section, it is assumed that a (rotationally) symmetrical arrangement will be required for the side faces. This appears to be common practice, for small to medium sized columns.

For more detailed consideration see RCC52.xls. In particular, see RCC53.xls regarding the issue of side bars.

COLUMN! Assumes that the moment entered has already been adjusted, if necessary, for bi-axial bending. For many side and all corner columns, there is no other choice than to design for bi-axial bending, and the method given in Clause 3.8.4.5 must be adhered to, i.e., RCC53.xls or sheets 2 and 3 of RCC51.xls should be used.

Theoretical shortfalls in area of up to 2% are considered to be acceptable. In theory, negative amounts of reinforcement required can be obtained but these are superseded by requirements for minimum amounts of reinforcement in columns. No adjustment is made in the area of concrete occupied by reinforcement.

Maximum link centres are given. The routine in the area L61:U81 investigates shear when, in accordance with Clause 3.8.4.6, M/N > 0.6h. In such cases either a maximum allowable shear is shown where shear is critical, or input of shear and number of legs in links allows the links to be designed for the applied shear. Even in unbraced structures shear is rarely likely to be critical.

The example is taken from *Designed and detailed* [15].

ELEMENT DESIGN to BS 8110:1997

SOLID SLABS

Originated from RCC11.xls on CD

INPUT Location **D&D : interior span solid slab**

Design moment, M	20.4 kNm/m	fcu	40 N/mm²	γ_c =	1.50
ßb	1.00	fy	460 N/mm²	γ_s =	1.05
span	5000 mm				
Height, h	175 mm	Section location	CONTINUOUS SPAN		
Bar Ø	12 mm				
cover	20 mm to this reinforcement				

OUTPUT **D&D : interior span solid slab** Compression steel = None

d = 175 - 20 - 12/2 = 149.0 mm

(3.4.4.4) K' = 0.156 > K = 0.023 ok

(3.4.4.4) z = 149.0 [0.5 + (0.25 - 0.023 /0.9)^½ = 145.1 > 0.95d = 141.6 mm

(3.4.4.1) As = 20.40E6 /460 /141.6 x 1.05 = 329 > min As = 228 mm²/m

PROVIDE T12 @350 = 323 mm²/m

(Eqn 8) fs = 2/3 x 460 x 329 /323 /1.00 = 312.2 N/mm²

(Eqn 7) Tens mod factor = 0.55 + (477 - 312.2) /120 /(0.9 + 0.919) = 1.305

(3.4.6.3) Permissible L/d = 26.0 x 1.305 = 33.931

Actual L/d = 5000 /149.0 = 33.557 ok

ELEMENT DESIGN to BS 8110:1997

RECTANGULAR BEAMS

Originated from RCC11.xls on CD   © 1999 BCA for RCC

INPUT Location **D&D: Main beam 1st Floor @ internal support**

Design moment, M	282.0 kNm	fcu	40 N/mm²	γ_c = 1.50
ßb	0.70	fy	460 N/mm²	γ_s = 1.05
Span	8000 mm	Comp cover	40 mm to main reinforcement	
Height, h	500 mm	Tens cover	48 mm to main reinforcement	
Breadth, b	300 mm	Side cover	35 mm to main reinforcement	
Tens Ø	25 mm			
Comp Ø	12 mm	Section location	CONTINUOUS SPAN	

OUTPUT **D&D: Main beam 1st Floor @ internal support**

d = 500 - 48 - 25/2 = 439.5 mm

(3.4.4.4) K' = 0.104 < K = 0.122 *compression steel required*

(3.4.4.4) z = 439.5(0.5 + (0.25 - 0.104/0.9)^½) = 380.6 < 417.5 mm

(3.4.4.4) x = (439.5 - 380.6) /0.45 = 130.8 mm

d' = 40 + 12/2 = 46.0 mm

(Fig 3.3) **Gross fsc = 438.1 N/mm² from strain diagram**

(Fig 3.3) netfsc = 438.1 - 0.67 x 40 /1.5 = 420.2 > 0 N/mm²

Excess M = M - Mu = 282.0(0.122 - 0.104) /0.122 = 40.0 kNm

As' = 40.0E6 /420.2 /(439.5 - 46.0) = 242 mm²

PROVIDE 3T12 compression steel = 339 mm²

(Fig 3.3) fst = 438.1 N/mm²

As = (40.0E6 /393.5 + 242.0E6 /380.6) /438.1 = 1683 mm²

PROVIDE 4T25 tension steel = 1963 mm² *As enhanced by 7% for deflection*

(Eqn 8) fs = 2/3 x 460 x 1,683 /1,963 /0.70 = 375.6 N/mm²

(Table 3.11) Comp mod factor = 1 + 0.257 /(3 + 0.257) = 1.079 < 1.5

(Table 3.10) Tens mod factor = 0.55 + (477 - 375.6) /120 /(0.9 + 4.866) = 0.697 < 2

(3.4.6.3) Permissible L/d = 26.0 x 1.079 x 0.697 = 19.542

(3.4.6.1) Actual L/d = 8000 /439.5 = 18.203 ok

ELEMENT DESIGN to BS 8110:1997

SIMPLE TEE & L BEAMS

Originated from RCC11.xls on CD

REINFORCED CONCRETE COUNCIL DETR

INPUT Location **D&D : Main beam, 1st Floor 8m span**

M	328.0 kNm	fcu	40 N/mm²	γ_c = 1.50
ßb	1.00	fy	460 N/mm²	γ_s = 1.05
span	8000 mm	Comp cover	48 mm to main reinforcement	
h	500 mm	Tens cover	40 mm to main reinforcement	
bw	300 mm	Side cover	35 mm to main reinforcement	
bf	1420 mm			
hf	175 mm	Section location	INTERIOR SPAN	
Tens Ø	25 mm	Section type	T BEAM	
Top steel	2 no & Ø12			

OUTPUT **D&D : Main beam, 1st Floor 8m span**

d = 500 - 40 - 25/2 = 447.5 mm

K' = 0.156 > K = 0.029

(3.4.4.4) z = 447.5(0.5 + (0.25 - 0.029 /0.9)^½) = 432.7 > 425.1 mm

(3.4.4.4) x = (447.5 - 425.1) /0.45 = 49.7 mm

(3.4.4.4) As = 328.00E6 /425.1 /460 x 1.05 = 1761 mm²

PROVIDE 4T25 bottom = 1963 mm²

(Eqn 8) fs = 2/3 x 460 x 1,761 /1,963 = 275.1 N/mm²

(Table 3.11) Comp mod factor = 1 + 0.168 /(3 + 0.168) = 1.053 < 1.5

(Table 3.10) Tens mod factor = 0.55 + (477 - 275.1) /120 /(0.9 + 1.153) = 1.370 < 2

(3.4.6.3) Permissible L/d = 20.8 x 1.053 x 1.370 = 30.001

(3.4.6.1) Actual L/d = 8000 /447.5 = 17.877 ok **ok**

ELEMENT DESIGN to BS 8110:1997

BEAM SHEAR

Originated from RCC11.xls on CD ©1999 BCA for RCC

INPUT Location **D&D : Main beam, 1st Floor 8m span, RH end**

				d	b
fcu	40 N/mm²	γ_c =	1.50	450	300
fyl	250 N/mm²	γ_s =	1.05		

Main Steel		Link	Legs	Side cover	Shear V	UDL
2	25	12	2	35	259.0	68.1
no	mm Ø	mm Ø	No	mm	kN	kN/m

OUTPUT **D&D : Main beam, 1st Floor 8m span, RH end**

As = 982 N/mm² = 0.727%

(Eqn 3) v = 259.0 x 10³ /300 /450 = 1.919 N/mm²

(Table 3.8) vc = 0.665 N/mm², from table 3.8

(v - vc)bv = 376.1 N/mm

PROVIDE 2 legs R12 @125 = 430.8 N/mm

Provide for distance of 1500 mm

then nominal links = 2 legs R12 @ 325

ELEMENT DESIGN to BS 8110:1997

COLUMN DESIGN

SYMMETRICAL RECT-ANGULAR COLUMN DESIGN

REINFORCED CONCRETE COUNCIL

DETR Environment Transport Regions

Originated from RCC11.xls on CD

INPUT

Location **D&D: external column**

Axial load, N	1026 kN		fcu	40 N/mm²
Moment, M	117.0 kNm		fy	460 N/mm²
height, h	300 mm		fyv	460 N/mm²
breadth, b	300 mm		γm	1.05 steel
Max bar Ø	25 mm		γm	1.50 concrete
cover (to link)	30 mm		Link Ø	8 mm

CALCULATIONS

D&D: external column

from M As = {M - 0.67fcu.b.dc(h/2 - dc/2)}/[(h/2-d').(fsc+fst).gm] (3.4.4.1)

from N As = (N - 0.67fcu.b.dc/gm) / (fsc - fst) (Figs 2.1, 2.2 & 3.3)

where As = Ast = Asc: dc=min(h,0.9x)

.67fcu/gm =	17.9 N/mm²	d' =	50.5 mm
fy/gm =	438.1 N/mm²	d =	249.5 mm
from iteration, n.a. depth, x, =	182.1 mm	dc =	163.9 mm
0.67.fcu.b.dc/gm =	878.4 kN		
Steel comp strain =	0.00253		
Steel tens strain =	0.00130		
Steel stress in comp. face, fsc =	438 N/mm²	(Comp. stress in reinf.)	
Steel stress in tensile face, fst =	259 N/mm²	(Tensile stress in reinf.)	
from M, As =	825 mm²	from N, As =	825 mm²

OK

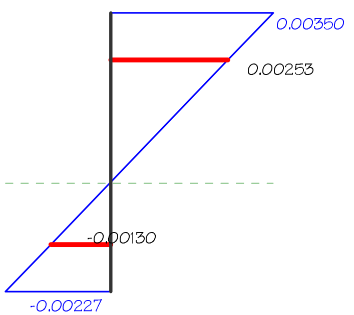
OUTPUT D&D: external column

As req'd = 825mm² T&B:- **PROVIDE 4T25**

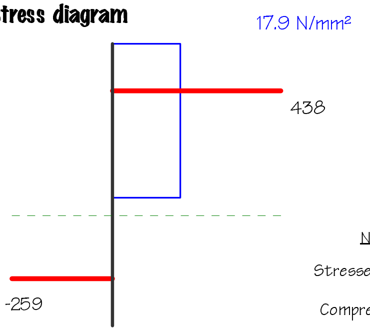
(ie 2T25T&B - 982mm² T&B - 2.2% o/a - @ 199cc.)

Links : - **PROVIDE T8 @ 300**

Strain diagram



Stress diagram



Notes

Stresses in N/mm²

Compression +ve

- - - Neutral axis

RCC12 Bending and Axial Force.xls

This spreadsheet gives an interaction chart for moment against axial load for rectangular sections with asymmetrical reinforcement arrangements. Initially intended for beams with axial load it is also applicable to asymmetrically reinforced columns.

MAIN!

Moments are considered to be about the x-x axis. All applied loads and moments should be ultimate and positive, as positive moments induce tension in the bottom reinforcement.

With asymmetrical arrangements of reinforcement the diagram indicates that negative moments are theoretically possible. After much consideration, the diagram is considered to be correct but strictly is valid only for load cases where the member is operating above $0.1f_{cu}$ and with at least minimum eccentricity. These limits are shown on the graph. A reciprocal diagram is generated automatically when top and bottom steels are reversed in the input.

Calcs!

Calcs! Shows the derivation of the chart where moment capacity is calculated at intervals of neutral axis depth from n.a. depth for $N = 0$ to n.a. depth for $N = N_{bal}$, then in intervals from n.a. depth for $N = N_{bal}$ to n.a. depth for $N = N_{uz}$. This sheet shows workings and is not necessarily intended for printing out other than for checking purposes.

Project	**Spreadsheets to BS 8110**	**REINFORCED CONCRETE COUNCIL**	
Client	**Advisory Group**	Made by **RMW**	Date **30-Aug-99**	Page **25**
Location	**Beam C1-2, Level 3**	Checked **chg**	Revision **-**	Job No **R68**
	BENDING AND AXIAL FORCE to BS 8110:1997		
	Originated from RCC12.xls' on CD © 1999 BCA for RCC		

MATERIALS

fcu 35 N/mm² γ_s 1.05

fy 460 N/mm² γ_c 1.50

SECTION

h 450 mm

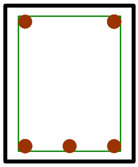
b 300 mm

COVERS (to main steel)

TOP 30 mm

BOTTOM 30 mm

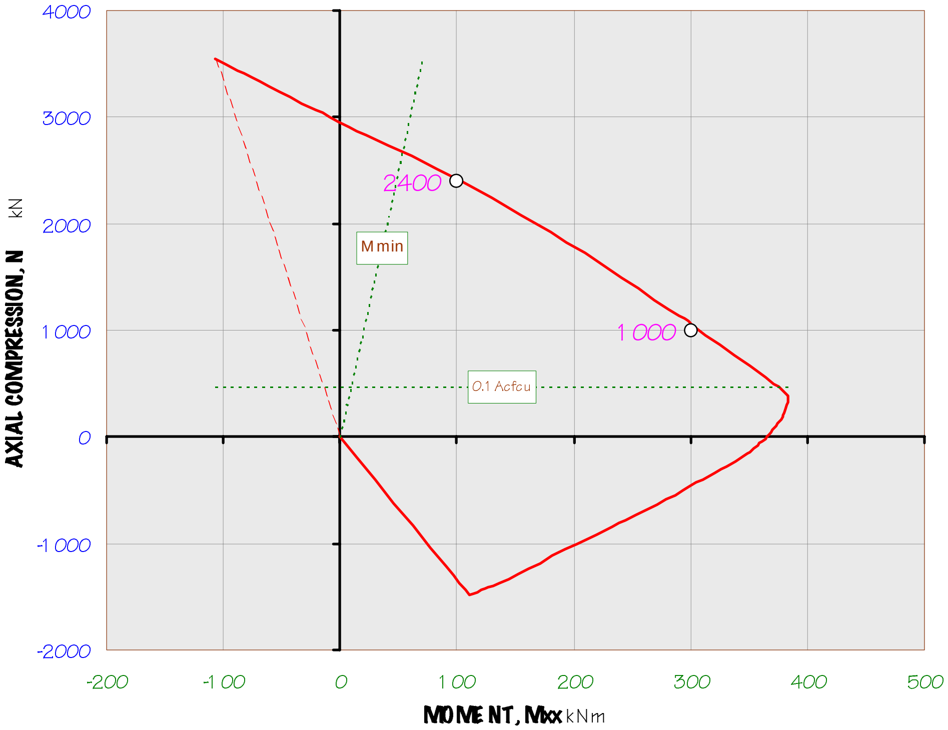
SIDES 30 mm



REINFORCEMENT

	Bar Ø	No	Area	%	Space
TOP	25	2	982	0.727	190.0
BOTTOM	32	3	2413	1.787	72.0

MN interaction chart for 450 x 300 section, C35 concrete.



LOADCASES (ULS)

CASE	N	Mxx
1	2400	100

CASE	N	Mxx
2	1000	300

RCC13 Punching Shear.xls

This spreadsheet designs punching shear links. Essentially it is intended to be used with simple rectangular flat slabs to BS 8110 i.e. with RCC33.xls. Equally it can be used in conjunction with RCC81.xls or to check wide beams in, say, troughed slabs.

The spreadsheet is presented as four pairs of sheets dealing with internal, edge, (external) corner and re-entrant corners.

It should be remembered that in slabs these traditional links are time-consuming to fix on site – proprietary systems are generally much quicker to fix on site and this far outweighs first cost.

INTERNAL! (Similarly EDGE!, CORNER and REENTRANT!)

These sheets constitute the input and main output. Input is fairly self-evident but, as ever, care must be exercised in ensuring correct values are used. The top diagram acts as a legend and the chart at the bottom of the sheet shows the column, any holes and link perimeters, and should act both as a check for input and help explain output. The x-x axis is across the page.

To the right is a combo-box that allows either:

- Input of both V_t (design shear transferred to column) and V_{eff} (design effective shear including allowance for moment transfer) is required. These figures should be available from sub-frame analysis e.g. output from RCC33.xls under *Reactions* (see p 50). A value of V_{eff}, computed from V_t and the factor according to location of the column (see BS 8110: Part 1, Clause 3.7.6) is suggested under *Operating Instructions*: in general this figure may be regarded as a maximum: calculating effective shear from moment transfer generally results in lower figures.

or

- Input of V_t alone. V_{eff} defaults to the values given in BS 8110: Part 1, Clause 3.7.6

The areas of steel in the two directions should be averages in each direction, i.e., ensure that it reflects the actual reinforcement in the sides of the perimeter, an average of column strips and middle strips as appropriate.

Except when checking column face shear, holes under half the slab depth or ¼ column side are ignored as in the second paragraph of BS 8110: Part 1, Clause 3.7.7.7. Multiple holes should be aggregated pro-rata as if they were one hole at one position.

The shear at 1.5 d and at the first perimeter requiring no reinforcement is shown under *Results*.

The examples emulate the example used for RCC33.xls, i.e. emanating from the in-situ building of the European Concrete Building Project (ECBP) at BRE Cardington. V_{eff} is given as an input. Reinforcement has been increased to T16 @ 150 (1340 mm^2/m) both ways to increase v_c to overcome problems with rules regarding $v > 2v_c$ (see Clause 3.7.7.5). As will be seen V_{eff} is less than $1.4V_t$. In the case of edge columns, a factor of 1.25 can be used if bending is about an axis parallel to edge and 1.4 if perpendicular (Clause 3.7.6.3). A worse case has therefore been taken.

Int Dets! (Similarly Edge Dets!, Corner Dets and Re-ent Dets!)

These sheets show design calculations, determination of critical perimeters, enclosed areas and link requirements complete with references to BS 8110. They are not necessarily intended for printing out other than for checking purposes. The area load is deducted from V_t, before V_t is enhanced.

These sheets use the relationship V_{eff}/V_t to calculate shear at successive perimeters. Deductions for holes in the calculation of shear perimeters are calculated by finding the angle defined by the extremities of the hole. The projection of this angle is deducted from the appropriate perimeter.

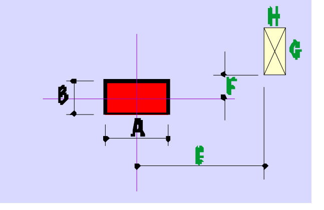
Project	**Spreadsheets to BS 8110**		**REINFORCED CONCRETE COUNCIL**
Client	**Advisory Group**		Made by **rmw** / Date **26-Nov-99** / Page **27**
Location	**ECBP Typical Floor Column B3**	**INTERNAL COLUMN**	Checked **chg** / Revision **-** / Job No **R68**
	PUNCHING SHEAR to BS8110:1997		
	Originated from RCC13.xls on CD © 1999 BCA for RCC		

MATERIALS

fcu	N/mm^2	40	
fyv	N/mm^2	460	
link Ø	mm	8	

STATUS
VALID DESIGN

Legend



DIMENSIONS

A	mm	400	E	mm	200
B	mm	400	F	mm	50
G	mm	150	H	mm	150

LOADING

Vt	kN	965.5	Veff =	kN	1060.7
ult UDL	kN/m^2	16.10			

SLAB

h	mm	250	dx	mm	215	Asx	mm^2/m	1340
			dy	mm	195	Asy	mm^2/m	1340
			ave d	mm	205	ave As	%	0.655

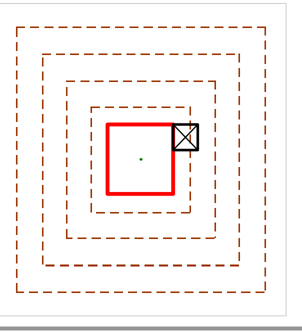
RESULTS

Veff =	1060.7	kN	vc =	0.7588	N/mm^2	(Table 3.8)
At col. face, v max =	3.559	N/mm^2	At 1.5d perimeter, v =	1.3650	N/mm^2	
			At 3.75d perimeter, v =	0.6820	N/mm^2	

PROVIDE LINKS (single leg)

Perimeter 1	**14 T8 @ 185**	102 from col face
Perimeter 2	**21 T8 @ 175**	256 from col face
Perimeter 3	**17 T8 @ 295**	410 from col face
Perimeter 4	**21 T8 @ 295**	564 from col face

Plan



Project	**Spreadsheets to BS 8110**		**REINFORCED CONCRETE COUNCIL**
Client	**Advisory Group**		Made by: **rmw** / Date: **26-Nov-99** / Page: **28**
Location	**Column B2**	**EDGE COLUMN**	Checked: **chg** / Revision: **-** / Job No: **R68**
	PUNCHING SHEAR to BS8110:1997		
	Originated from RCC13.xls on CD © 1999 BCA for RCC		

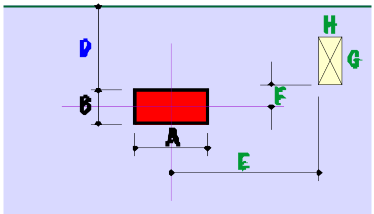
MATERIALS

fcu	N/mm^2	40
fyv	N/mm^2	460
link Ø	mm	8

STATUS

VALID DESIGN

Legend



DIMENSIONS

A	mm	400	E	mm	-75
B	mm	250	F	mm	-275
D	mm	0	G	mm	150
			H	mm	150

LOADING

Vt	kN	500.9	Veff =	kN	627.7
ult UDL	kN/m^2	16.10			

SLAB

h	mm	250	dx	mm	215	Asx	mm^2/m	2010
			dy	mm	195	Asy	mm^2/m	1340
			ave d	mm	205	ave As	%	0.811

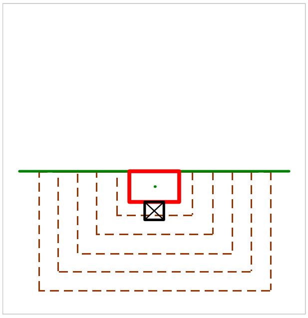
RESULTS

Veff =	627.7	kN	vc =	0.8147	N/mm^2 (Table 3.8)
At hole face, vmax =	4.013	N/mm^2	At 1.5d perimeter, v =	1.5976	N/mm^2
			At 4.5d perimeter, v =	0.6936	N/mm^2

PROVIDE LINKS (single leg)

Perimeter 1	**11 T8 @ 125**	102 from col face
Perimeter 2	**16 T8 @ 120**	256 from col face
Perimeter 3	**10 T8 @ 280**	410 from col face
Perimeter 4	**12 T8 @ 275**	564 from col face
Perimeter 5	**13 T8 @ 300**	717.5 from col face

Plan



Project	**Spreadsheets to BS 8110**	REINFORCED CONCRETE COUNCIL	
Client	**Advisory Group**	Made by: **rmw**	Date: **26-Nov-99** / Page: **29**
Location	**Columns A1, D1, A5 & D5** — CORNER COLUMN	Checked: **chg**	Revision: **-** / Job No: **R68**
	PUNCHING SHEAR to BS8110:1997		
	Originated from RCC13.xls on CD © 1999 BCA for RCC		

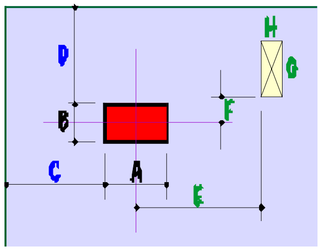
MATERIALS

fcu	N/mm^2	40
fyv	N/mm^2	460
link Ø	mm	8

STATUS

VALID DESIGN

Legend



DIMENSIONS

A	mm	400	E	mm	50
B	mm	250	F	mm	-275
C	mm	0	G	mm	150
D	mm	0	H	mm	150

LOADING

Vt	kN	272.0
ult UDL	kN/m^2	16.10

SLAB

h	mm	250	dx	mm	215	Asx	mm^2/m	2010
			dy	mm	195	Asy	mm^2/m	2010
			ave d	mm	205	ave As	%	0.983

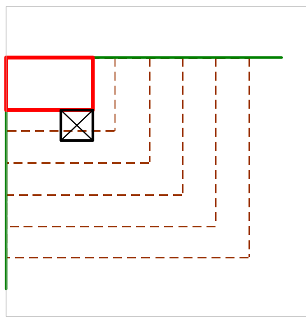
RESULTS

Veff =	340.0	kN	vc =	0.8686	N/mm^2 (Table 3.8)
At hole face, vmax =	3.408	N/mm^2	At 1.5d perimeter, v =	1.6818	N/mm^2
			At 4.5d perimeter, v =	0.8243	N/mm^2

PROVIDE LINKS (single leg)

Perimeter 1	**6 T8 @ 135**	102 from col face
Perimeter 2	**8 T8 @ 125**	256 from col face
Perimeter 3	**5 T8 @ 275**	410 from col face
Perimeter 4	**6 T8 @ 260**	564 from col face
Perimeter 5	**7 T8 @ 255**	717.5 from col face

Plan



Project	**Spreadsheets to BS 8110**	**REINFORCED CONCRETE COUNCIL**	
Client	**Advisory Group**	Made by: **rmw**	Date: **26-Nov-99** / Page: **30**
Location	**An example** — **RE-ENTRANT CORNER**	Checked: **chg**	Revision: **-** / Job No: **R68**
	PUNCHING SHEAR to BS8110:1997		

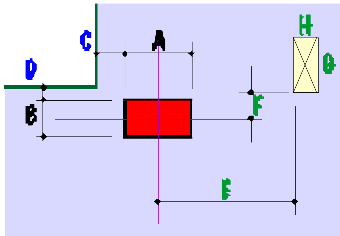
MATERIALS

fcu	N/mm^2	40	
fyv	N/mm^2	460	
link Ø	mm	8	

STATUS

VALID DESIGN

Legend



DIMENSIONS

A	mm	400	E	mm	200
B	mm	400	F	mm	-50
C	mm	-100	G	mm	100
D	mm	-100	H	mm	100

LOADING

Vt	kN	478.0	Veff =	kN	591.6
ult UDL	kN/m^2	16.10			

SLAB

h	mm	250	dx	mm	215	Asx	mm^2/m	1340
			dy	mm	195	Asy	mm^2/m	1340
			ave d	mm	205	ave As	%	0.655

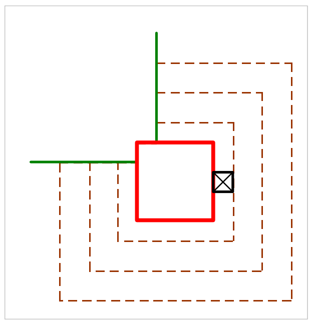
RESULTS

Veff =	591.6	kN	vc =	0.7588	N/mm^2 (Table 3.8)
At hole face, vmax =	2.213	N/mm^2	At 1.5d perimeter, v =	1.0039	N/mm^2
			At 3d perimeter, v =	0.6319	N/mm^2

PROVIDE LINKS (single leg)

Perimeter 1	**6 T8 @ 240**	102 from col face
Perimeter 2	**8 T8 @ 295**	256 from col face
Perimeter 3	**11 T8 @ 285**	410 from col face

Plan



Project	Spreadsheets to BS 8110		REINFORCED CONCRETE COUNCIL
Location	Column B2	EDGE COLUMN	
	PUNCHING SHEAR to BS8110:1997		Made by rmw Job No R68
	Originated from RCC13.xls on CD	© 1999 BCA for RCC	Date 19-Nov-99

DETAILED CALCULATIONS

Veff/Vt 1.2531 (enhancement factor) link leg area 50.3

Hole deduction ? YES

CRITICAL PERIMETERS

Per No	a	Internal	Choose μ	deduct	Final μ
1	307.5	3760	2130	248	1882
2	461.25	4990	2745	323	2422
3	615	6220	3360	399	2961
4	768.75	7450	3975	474	3501
5	922.5	8680	4590	549	4041
6	1076.25	9910	5205	624	4581
7	1230	11140	5820	699	5121
8	1383.75	12370	6435	775	5660
Hole face	0	1300	900	139	761
Col face	0		900	0	900

ENCLOSED AREAS

Per No	Edge D
1	0.566
2	0.941
3	1.410
4	1.974
5	2.632
6	3.385
7	4.233
8	5.175
Hole face	0.100
Col face	0.100

LINK REQUIREMENTS

Per No	v	Asv	Total No	Location	within Band?
1	1.5976	1337	26.59	1.50 d	1
2	1.2262	466	9.28	2.25 d	1
3	0.9871	554	11.03	3.00 d	1
4	0.8191	655	13.04	3.75 d	1
5	0.6936	756	0.00	4.50 d	0
6	0.5957	857	0.00	0.00 d	0
7	0.5166	958	0.00	0.00 d	0
8	0.4510	1059	0.00	0.00 d	0
Hole face	4.0128				
Col face	3.3912				

LINK PERIMETERS

147.9527

Per No	a	Internal	Choose μ	deduct	Final μ	No	Spacing
1	102.5	2120	1310	148	1162	11	125
2	256.25	3350	1925	223	1701.8	16	120
3	410	4580	2540	298	2241.6	10	280
4	563.75	5810	3155	374	2781.5	12	275
5	717.5	7040	3770	449	3321.3	13	300
6	871.25	8270	4385	524	3861.1	15	295
7	1025	9500	5000	599	4400.9	17	290
8	1178.75	10730	5615	674	4940.7	19	290
9	1332.5	11960	6230	750	5480.5	20	300

RCC14 Crack Width.xls

Crack Width!

In the design of reinforced concrete structures, it is assumed that the tensile capacity of concrete does not contribute to the strength of the structure, and steel reinforcement is provided to resist the internal tensile forces that develop. Because steel reinforcement can develop the resisting tensile force only by extension (i.e. steel needs to extend to develop stress), and hence causes cracks to form in the surrounding concrete, cracks in reinforced concrete structures cannot be avoided. In day-to-day practical design, crack widths are controlled by limiting the maximum spacings of the tension reinforcement. However there are times when the engineer will need to carry out more rigorous analysis and calculations, e.g. in the design of water-retaining structures, and design for severe exposure where estimation/prediction of crack width is important. This spreadsheet calculates crack widths in accordance with BS 8110 and BS 8007.

Crack width limits are set as:

- BS 8110: Part 1, Clause 3.12.11.2.1 0.3 mm – In 'normal' reinforced concrete structures
- BS 8007 0.2 mm – In water-retaining structures under severe or very severe exposure
- BS 8007 0.1 mm – In water-retaining structures with critical aesthetic appearance

In calculation of crack width, elastic theory with 'cracked section' is adopted. Both BS 8110: Part 2 and BS 8007 appendix B gives the crack width formula.

$$W = \frac{3 \times a_{cr} \times \varepsilon_m}{1 + 2\left(\frac{a_{cr} - c}{h - x}\right)}$$

In calculating crack width, w, the average strain, e_m, at the level where cracking is being considered allows a stiffening effect, e_2 of concrete between cracks

$$\varepsilon_m = \varepsilon_1 - \varepsilon_2$$

where e_1 is the theoretical strain at the level considered, calculated on the assumption of a cracked section using half the concrete modulus Ec to allow for creep effects

$$\varepsilon_2 = \frac{b \times (h - x)^2}{3 \times E_s \times A_s (d - x)}$$

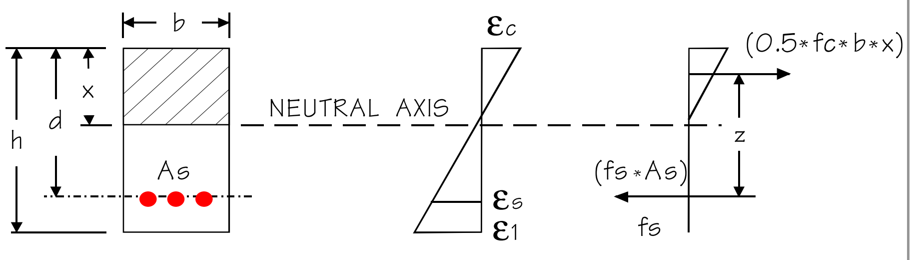
BS 8007 allows an additional enhancement factor of 1.5 in calculating e_2 for structures designed with a crack width limit of 0.1 mm. The spreadsheet provides an option to adopt this enhanced factor if design crack width is limit to 0.1 mm. To choose this option, select the blue 'check box' on the right hand margin.

a_{cr} is the distance from the point considered to the surface of the nearest longitudinal bar. The input value is defaulted to the distance at the point on the tension face midway between two bars. However other values can be entered to suit other locations, e.g. corner bars. The default value can be reset by pressing the blue button on the right hand margin.

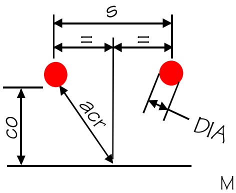
Project **Spreadsheets to BS 8110etc**		REINFORCED CONCRETE COUNCIL		
Client **Advisory Group**		Made by **RC**	Date **30-Aug-99**	Page **33**
Location **Grid line 1**				
Crack Width Calculations to BS8110: 1997/BS8007:1987		Checked **chg**	Revision **-**	Job No **R68**
Originated from RCC14.xls on CD	© 1999 BCA for RCC			

CRACK WIDTH CALCULATIONS - FLEXURE

-



INPUT



fcu =	35	N/mm^2
fy =	460	N/mm^2
Area of reinforcement " As " =	2093	mm^2
b =	1000	mm
h =	250	mm
d =	200	mm
Minimum cover to tension reinforcement " CO " =	40	mm
Maxmum bar spacing " S " =	150	mm
Bar dia " DIA " =	20	mm
" a_{cr} " =(((S/2)^2+(CO+DIA/2)^2)^(1/2)-DIA/2) as default or enter other value =	80.1	mm

"acr" is distance from the point considered to the surface of the nearest longitudinal bar

Applied service moment " Ms "=	69.0	KNm

CALCULATIONS

moduli of elasticity of concrete " Ec" = (1/2)*(20+0.2*fcu) =	13.5	KN/mm^2
moduli of elasticity of steel " Es " =	200.0	KN/mm^2
Modular ratio " α " = (Es/Ec) =	14.81	
" ρ " = As/bd =	0.010	
depth to neutral axis, "x" = $(-\alpha.\rho + ((\alpha.\rho)^2 + 2.\alpha.\rho)^{0.5}.d$ =	85	mm
" Z " = d-(x/3) =	172	
Reinforcement stress " fs " = Ms/(As*Z) =	192	N/mm^2
Concrete stress " fc " = (fs*As)/(0.5*b*x) =	9.50	N/mm^2
Strain at soffit of concrete beam/slab " ε_1 " = (fs/Es)*(h-x)/(d-x) =	0.001375	
Strain due to stiffening effect of concrete between cracks " ε_2 " =		
$\varepsilon_2 = b.(h-x)^2/(3.Es.As.(d-x))$ for crack widths of 0.2 mm	Used	
$\varepsilon_2 = 1.5.b.(h-x)^2/(3.Es.As.(d-x))$ for crack widths of 0.1 mm	n/a	
ε_2 =	0.000189	
Average strain for calculation of crack width " ε_m " = $\varepsilon_1 - \varepsilon_2$ =	0.001186	

Calculated crack width, " w " = $3.a_{cr}.\varepsilon m/(1+2.(a_{cr}-c)/(h-x))$

CALCULATED CRACK WIDTH, 'w' = 0.19 mm

RCC21 Subframe Analysis.xls

RCC21 SubframeAnalysis.xls analyses sub-frames in accordance with BS 8110 using moment distribution. Inputs are required on two sheets.

MAIN!

This single sheet consists of the main inputs, most of which should be self-explanatory. As in other spreadsheets, avoid pasting input from one cell to another as this may cause formatting and other errors.

The dimension of the flange width, b_f, is automated to be either b_w + 0.07 x span for L beams or b_w + 0.14 x span for T beams.

Unwanted data cells are 'greyed out'. The use of C, K, or E can alter the characteristics of a support from cantilever to knife-edge to encastre. Remote ends of supports may be F for fixed; otherwise they default to pinned. Extraneous data is highlighted in red or by messages in red. Under *Operating Instructions* a number of checks, mainly for missing entries, are carried out and any problems are highlighted. At the bottom of the sheet a simplistic but to-scale arrangement and loading diagram is shown. This is given to aid data checking. It may prove prudent to write down expected values for bending moments at each support down before progressing to ACTIONS!

Also, under *Operating instructions*, the user should input the type of redistribution required as explained more fully under *Redistribution* (see page 17).

- 0 means full redistribution
- 1 limits alternate span upward redistribution to the percentage specified
- 2 means no span moment redistribution

UDLs are input as line loads e.g. 4k N/m^2 for a 5.0 m wide bay would be input as 20 kN/m.

Ultimate and characteristic support reactions are given at the bottom of the sheet

ACTIONS!

This sheet includes charts showing the elastic bending moment diagram, redistributed moment envelope, elastic shear forces and envelope of redistributed shear forces. These diagrams are based on data from the analysis undertaken in Analysis! at 1/20 span points. Maximum span and support moments are given.

The user is required to input desired amounts of redistribution to the initial moments in line 26. Cell L14 allows three types of distribution according to the user's preference for calculating span moments (see Assumptions made: redistribution). Redistribution input is included close to the bending moment diagrams in order to give the user control rather than relying on blanket redistribution.
The sheet also tabulates elastic and redistributed ultimate shears and column moments according to the various load cases.

Analysis!

This sheet details the moment distribution analysis carried out but is not necessarily intended for printing out other than for checking purposes

Graf!

This sheet comprises data for graphs used on other sheets, particularly in ACTIONS! It is not necessarily intended for printing out other than for checking purposes

Project	**Spreadsheets to BS 8110**	**REINFORCED CONCRETE COUNCIL**	
Client	**Advisory Group**	Made by: **RMW**	Date: **29-Nov-99**
Location	**Level 2, Beam on line 6** from B to E	Checked: **chg**	Revision: **-**
	SUBFRAME ANALYSIS to BS8110:1997	Page: **39**	Job No: **R68**
	Originated from RCC21.xls on CD © 1999 BCA for RCC		

LOCATION Supports from grid B to grid E

SPANS

	L (m)	H (mm)	bw (mm)	hf (mm)	Type	bf (mm)
SPAN 1	7.000	600	375	150	T	1355
SPAN 2	12.000	600	375	150	T	2055
SPAN 3	12.000	600	375	150	T	2055
SPAN 4	6.000	600	375	150	T	1215
SPAN 5						
SPAN 6						

LOADING PATTERN

	min	max
DEAD	1	1.4
IMPOSED	0	1.6

SUPPORTS

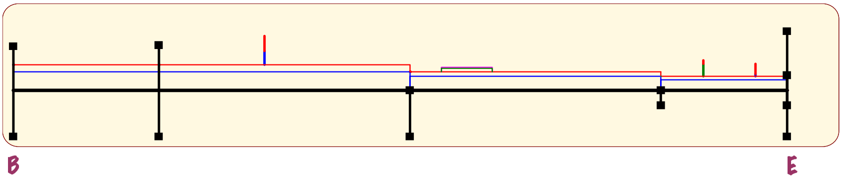
	ABOVE (m)	H (mm)	B (mm)	End Cond	BELOW (m)	H (mm)	B (mm)	End Cond
Support 1	2.95	400	300	F	3.10	400	300	P
Support 2	3.00	400	300	P	3.10	300	300	P
Support 3	0.00				3.10	400	300	P
Support 4	K					300		
Support 5	4.00	400	300	P	3.10	300	300	P
Support 6								
Support 7								

LOADING UDLs (kN/m) PLs (kN) Position (m)

	Dead Load	Imposed Load	Position from left	Loaded Length
Span 1				
UDL	32.20	12.50	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 2				
UDL	32.20	12.50	~~~~~	~~~~~
PL 1				~~~~~
PL 2	25	25	5.000	~~~~~
Part UDL				
Span 3				
UDL	24.42	8.65	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL	7.5	4.5	1.500	2.400

	Dead Load	Imposed Load	Position from left	Loaded Length
Span 4				
UDL	17.50	5.60	~~~~~	~~~~~
PL 1	24	6	2.000	~~~~~
PL 2	5	18	4.500	~~~~~
Part UDL				
Span 5				
UDL				
PL 1				
PL 2				
Part UDL				
Span 6				
UDL				
PL 1				
PL 2				
Part UDL				

LOADING DIAGRAM

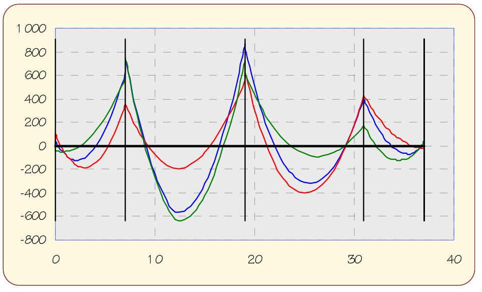


REACTIONS (kN)

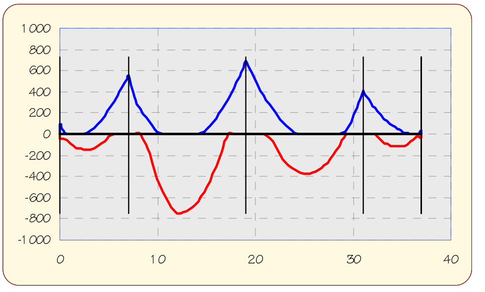
SUPPORT	1	2	3	4	5
ALL SPANS LOADED	153.5	724.8	778.3	478.4	75.0
ODD SPANS LOADED	177.7	465.9	568.4	415.9	-8.2
EVEN SPANS LOADED	27.2	621.0	636.4	271.0	116.7
Characteristic Dead	72.8	354.6	386.7	237.2	30.5
Characteristic Imposed	47.4	142.7	148.1	91.4	46.2

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
Location	Level 2, Beam on line 6, from B to E	RMW	30-Aug-99	36
	SUBFRAME ANALYSIS to BS8110:1997	Checked	Revision	Job No
	Originated from RCC21.xls on CD ©1999 BCA for RCC	chg	-	R68

BENDING MOMENT DIAGRAMS (kNm)



B Elastic Moments E



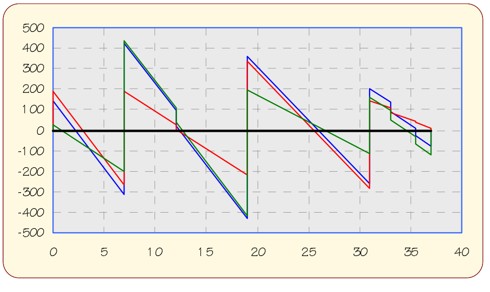
B Redistributed Envelope E

SUPPORT No	1	2	3	4	5		
Elastic M	95.3	743.3	868.6	427.6	34.3	~	kNm/m
Redistributed M	90.5	557.5	694.9	406.2	32.6	~	kNm/m
ßb	0.950	0.750	0.800	0.950	0.950	~	~
Redistribution	5.0%	25.0%	20.0%	5.0%	5.0%		

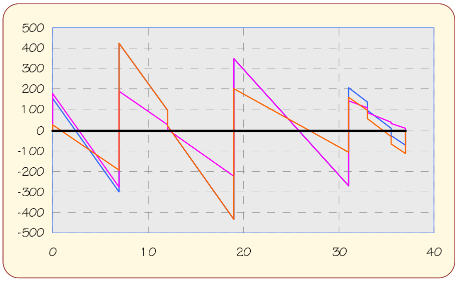
SPAN No	1	2	3	4		
Elastic M	185.0	633.1	400.1	121.4	~	~
Redistributed M	152.1	746.8	373.5	118.8	~	~
ßb	0.822	1.180	0.934	0.979	~	~

Based on support moments of min(ßbM, Malt/ßb)

SHEAR FORCE DIAGRAMS (kN)



B Elastic Shears E



B Redistributed Shears E

SPAN No	1		2		3	
Elastic V	191.0	312.6	435.6	432.2	356.9	282.0
Redistributed V	177.7	302.0	422.8	433.2	345.1	273.7

SPAN No	4					
Elastic V	203.4	118.4	~	~	~	~
Redistributed V	204.7	116.7	~	~	~	~

COLUMN MOMENTS (kNm)		1	2	3	4	5
ALL SPANS LOADED	Above	21.0	80.7			-4.1
	Below	15.0	32.9	-40.2		-2.2
ODD SPANS LOADED	Above	55.6	0.7			17.5
	Below	39.7	0.3	51.6		9.5
EVEN SPANS LOADED	Above	-22.7	116.5			-22.2
	Below	-16.2	47.6	-108.0		-12.1

RCC31 One-way Solid Slabs (A & D).xls

This spreadsheet analyses and designs (A & D: Analysis and design) up to six spans of one-way solid slabs to BS 8110 using continuous beam analysis. There is user input on each of the first four sheets and choice of reinforcement for each span is implicit.

MAIN!

This single sheet consists of the main inputs, most of which should be self-explanatory.

The number of spans is altered by entering or deleting data under L (m). Unwanted data cells are 'greyed out'. The use of C, K or E can alter the characteristics of the end supports from cantilever to knife-edge to encastre. Extraneous data is highlighted in red or by messages in red. Under *Operating Instructions* a number of checks are carried out and problems are highlighted.

For the purposes of defining load, the section is assumed to be 1.00 m wide. At the bottom of the sheet a simplistic loading diagram is given to aid data checking. Great care should be taken to ensure this sheet is completed correctly for the case in hand. It may prove prudent to write down expected values of bending moments at each support down before progressing to ACTIONS!

Support reactions are given at the bottom of the sheet.

ACTIONS!

This sheet shows bending moment and shear force diagrams from the analysis undertaken in Analysis! The user is required to input the desired amount of redistribution to the initial moments in line 25. Cell J14 allows three types of distribution according to the user's preferences. Requesting redistribution at a cantilever produces a warning message in the remarks column.

SPANS!

In SPANS! the user is required to choose top, bottom and link reinforcement for each span. The amounts of bending and shear reinforcement required and checks are derived from detailed calculations in Bar! Unwanted cells are 'greyed' out.

Unless overwritten, reinforcement diameter specified for a support carries through both sides of the support, i.e. the diameter specified for the right hand support of a span carries over to the left hand support of the next span. It may be possible to obtain different numbers of bars each side of the support due to differences in depth or to comply with minimum 50% span steel; practicality should dictate that the maximum number of bars at each support should be used.

With regard to deflection, the area of steel required, A_s mm²/m, shown under heading *Design*, may have been automatically increased in order to reduce service stress, f_s, and increase modification factors to satisfy deflection criteria. The percentage increase, if any, is shown under *Deflection*. With respect to cantilevers, neither compression steel enhancement nor consideration of rotation at supports is included.

Hogging moments at ¼ span are checked and used in the determination of top steel in spans. Careful examination of the Bending Moment Diagram and Graf! should help to determine whether any curtailment of this reinforcement is warranted.

To avoid undue sensitivity, especially with regard to deflection, reinforcement may be over-stressed by up to 2.5%

Please note that this example has a high point load near to the first support. This load was chosen to illustrate that shear is checked and that shear links can be designed. In more usual circumstances, no shear links will be required and the shear link diameter input at G22 should be deleted.

Weight!

Weight! gives an estimate of the amount of reinforcement required in one direction of the slab per bay and per cubic metre. Bay and support widths are required as input.

Simplified curtailment rules, as defined in BS 8110 Clause 3.12, are used to determine lengths of bars. The figures should be treated as approximate estimates only as they cannot deal with the effects of designers' and detailers' preferences, rationalisation, etc, etc. They do not allow for reinforcement in supporting beams or for mesh.

Analysis!

This sheet details the moment distribution analysis carried out but is not necessarily intended for printing out other than for checking purposes.

Bar!

This sheet shows design calculations, complete with references to BS 8110. It is not necessarily intended for printing out other than for checking purposes. In many instance service stress, f_s, has been set to 1.0 or 0.0001 N/mm² to avoid problems with division by zero.

Graf!

This sheet comprises data for graphs used on other sheets, particularly in ACTIONS! It is not necessarily intended for printing out other than for checking purposes.

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
Location	8th Floor slab from A to G	mw	30-Aug-99	38
	ONE-WAY SOLID RC SLAB DESIGN to BS 8110:1997 c/w ANALYSIS	Checked	Revision	Job No
	Originated from RCC31.xls on CD © 1999 BCA for RCC	chg	-	R68

LOCATION supports from grid A to grid G

MATERIALS

fcu	35	N/mm²	h agg	20	mm
fy	460	N/mm²	γS	1.05	steel
fyv	460	N/mm²	γC	1.50	concrete

COVERS

Top cover	25	mm
Btm cover	25	mm

SPANS

	L (m)	H (mm)
SPAN 1	8.000	350
SPAN 2	7.200	250
SPAN 3	7.200	250
SPAN 4	7.200	250
SPAN 5		
SPAN 6		

SUPPORTS

Support No	Type
1	k
5	E

K(nife), C(antilever) or E(ncastre)

LOADING PATTERN

	min	max
DEAD	1	1.4
IMPOSED		1.6

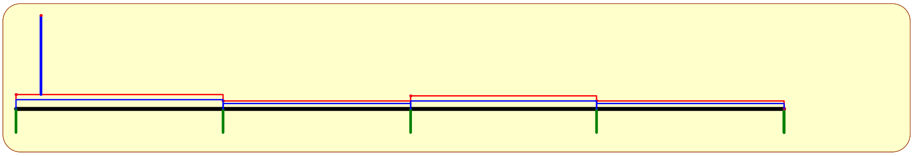
LOADING UDLs (kN/m²) PLs (kN/m) Position (m)

		Dead Load	Imposed Load	Position from left
Span 1	UDL	9.70	5.00	~~~~
	PL 1	75.00		1.000
	PL 2			
Span 2	UDL	6.00	1.50	~~~~
	PL 1			
	PL 2			
Span 3	UDL	8.50	5.00	
	PL 1			
	PL 2			

LOADING

		Dead Load	Imposed Load	Position from left
Span 4	UDL	6.00	1.50	~~~~
	PL 1			
	PL 2			
Span 5	UDL			
	PL 1			
	PL 2			
Span 6	UDL			
	PL 1			
	PL 2			

LOADING DIAGRAM



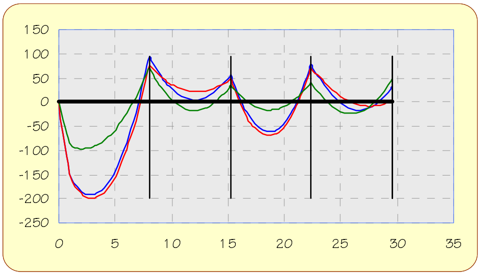
A G

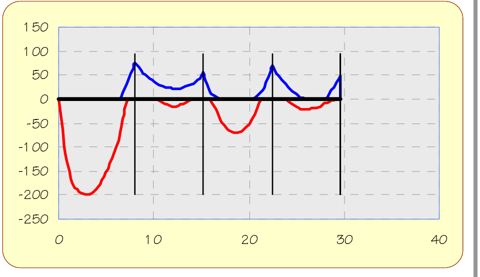
REACTIONS (kN/m)

SUPPORT	1	2	3	4	5
Characteristic Dead	97.97	79.89	47.15	55.54	19.65
Max Imposed	19.76	24.16	24.87	25.00	7.37
Min Imposed	-26.35	-6.12	-2.22	-4.53	-9.44
MAX ULTIMATE	168.77	150.51	105.80	117.75	39.30

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: mmw	Date: 30-Aug-99	Page: 39
Location	8th Floor slab, from A to G			
	ONE-WAY SOLID RC SLAB DESIGN to BS 8110:1997 c/w AN	Checked: chg	Revision: -	Job No: R68
	Originated from RCC31.xls on CD ©1999 BCA for RCC			

BENDING MOMENT DIAGRAMS (kNm/m)



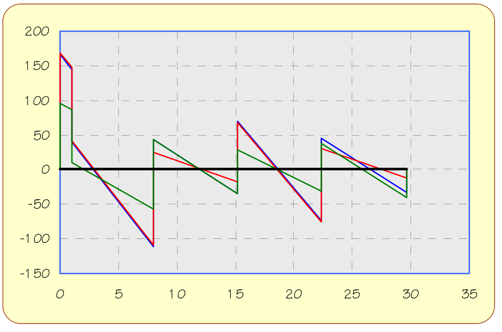


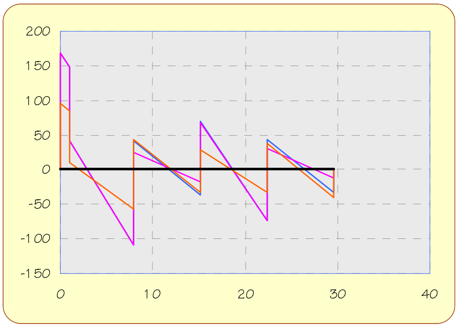
A Elastic Moments G A Redistributed Envelope G

SUPPORT No	1	2	3	4	5		
Elastic M		94.2	56.6	77.3	49.2	~	~
Redistributed M		75.4	55.5	69.6	48.7	~	~
ßb	1.000	0.800	0.980	0.900	0.990	~	~
Redistribution		20.0%	2.0%	10.0%	1.0%		

SPAN No	1	2	3	4		
Elastic M	199.2	18.6	70.0	24.7	~	~
Redistributed M	199.2	16.1	70.2	22.8	~	~
ßb	1.000	0.865	1.003	0.924	~	~

SHEAR FORCE DIAGRAMS (kN/m)





A Elastic Shears G A Redistributed Shears G

SPAN No	1		2		3	
Elastic V	168.8	111.2	44.1	33.9	68.8	74.9
Redistributed V	168.8	108.9	44.5	36.1	69.7	74.6

SPAN No	4					
Elastic V	45.3	39.9	~	~	~	~
Redistributed V	44.1	39.3	~	~	~	~

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL			
Client	Advisory Group	Made by	rmw	Date	29-Nov-99
Location	8th Floor slab, from A to G	Page	45		
	ONE-WAY SOLID RC SLAB DESIGN to BS 8110:1997 c/w ANALYSIS	Checked	chg	Revision	-
	Originated from RCC31.xls on CD © 1999 BCA for RCC	Job No	R68		

SPAN 1			LEFT	CENTRE	RIGHT
	Av	mm	1000		7000
ACTIONS	M	kNm/m	0.0	199.2	75.4
	ßb		1.00	1.00	0.80
	V	kN/m	168.77		108.87
DESIGN	d	mm	311.0	307.0	309.0
	As	mm²/m	455	1597	586
	As'	mm²/m	0	As' 0	As' 0
TOP STEEL			T 12 @ 225	10	T 16 @ 300
	As prov	mm²/m	503	0	As prov 670
BTM STEEL			T 12 @ 125	T 20 @ 125	T 16 @ 250
	As' prov	mm²/m	905	As prov 2513	As' prov 804
SHEAR	v	N/mm2	0.543		0.352
	vc	N/mm2	0.499	Shear links required	0.453
			Min 19 /m T 8		
DEFLECTION	L/d		26.059	Allowed 26.603 ok	(As increased by 49.8%)
& CHECKS	% As		ok	ok	ok
	d'/x		ok	ok	ok
	max S		ok	ok	ok

SPAN 2		LEFT	CENTRE	RIGHT
	Av	0		7200
ACTIONS	M	75.4	16.1	55.5
	ßb	0.80	0.87	0.98
	V	44.46		36.12
DESIGN	d	217.0	219.0	219.0
	As	838	325	609
	As'	0	As top 431	0
TOP STEEL		T 16 @ 225	T 10 @ 175	T 12 @ 175
	As prov	894	As' prov 449	As prov 646
BTM STEEL		T 16 @ 600	T 12 @ 300	T 12 @ 300
	As' prov	335	As prov 377	As' prov 377
SHEAR	v	0.205		0.165
	vc	0.613		0.547
			Links not required	
DEFLECTION	L/d	32.877	Allowed 55.325 ok	
& CHECKS	% As	ok	ok	ok
	d'/x	ok	ok	ok
	max S	ok	ok	ok

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL	
Client	Advisory Group	Made by: rmw	Date: Nov-99
Location	8th Floor slab, from A to G	Page: 41	
	ONE-WAY SOLID RC SLAB DESIGN to BS 8110:1997 c/w ANALYSIS	Checked: chg	Revision: -
	Originated from RCC31.xls on CD © 1999 BCA for RCC	Job No: R68	

SPAN 3

		LEFT				CENTRE				RIGHT			
	Av		0								7200		
ACTIONS	M		55.5				70.2				69.6		
	ßb		0.98				1.00				0.90		
	V		69.68								74.60		
DESIGN	d		219.0				219.0				219.0		
	As		609				770				764		
	As'		0			As top	325			As'	0		
TOP STEEL		T	12	@ 175		T	10	@ 225		T	12	@ 125	
	As prov		646			As' prov	349			As prov	905		
BTM STEEL		T	12	@ 250		T	12	@ 125		T	10	@ 225	
	As' prov		452			As prov	905			As' prov	349		
SHEAR	v		0.318								0.341		
	vc		0.547								0.612		
						Links not required							
DEFLECTION	L/d		32.877			Allowed	35.882	ok			(As increased by 5.2%)		
& CHECKS	% As		ok				ok				ok		
	d'/x		ok				ok				ok		
	max S		ok				ok				ok		

SPAN 4

		LEFT				CENTRE				RIGHT			
	Av		0								7200		
ACTIONS	M		69.6				22.8				48.7		
	ßb		0.90				0.92				0.99		
	V		44.15								39.30		
DESIGN	d		219.0				220.0				219.0		
	As		764				325				535		
	As'		0			As top	325			As'	0		
TOP STEEL		T	12	@ 125		T	12	@ 300		T	12	@ 200	
	As prov		905			As' prov	377			As prov	565		
BTM STEEL		T	10	@ 225		T	10	@ 225		T	12	@ 300	
	As' prov		349			As prov	349			As' prov	377		
SHEAR	v		0.202								0.179		
	vc		0.612								0.523		
						Links not required							
DEFLECTION	L/d		32.727			Allowed	54.810	ok					
& CHECKS	% As		ok				ok				ok		
	d'/x		ok				ok				ok		
	max S		ok				ok				ok		

RCC32 Ribbed Slabs (A & D).xls

Using continuous beam analysis, this spreadsheet analyses and designs up to six spans of ribbed slab to BS 8110. There is user input on each of the first three sheets and choice of reinforcement for each span is implicit.

MAIN!

This single sheet consists of the main inputs which should be self-explanatory.

The number of spans is altered by entering or deleting data under L (m). Unwanted data cells are 'greyed' out. The use of C, K or F can alter the characteristics of the end supports from cantilever to knife-edge to fixed. Extraneous data is highlighted in red or by messages in red. Under *Operating Instructions* a number of checks are carried out and any problems are highlighted.

For the purposes of defining load the section under consideration is assumed to be 1.00 m wide. It will be seen from Bar! that moments per metre are converted to moments per rib, and calculations of reinforcement areas required etc., are based on moments and shear per rib. Great care should be taken to ensure this sheet is completed correctly for the case in hand. It may prove prudent to write expected values of bending moments at each support down before progressing to ACTIONS!

Combo-boxes to the right under *Operating Instructions* define minimum bar sizes to be used (e.g. at supports between ribs) and whether the user wants to use links or not. If links are required these may be either designed or nominal links; the centres of nominal links can be changed.

Towards the bottom of the sheet a simplistic loading diagram is given to aid data checking. At the bottom of the sheet, support reactions are given.

ACTIONS!

This sheet shows bending moment and shear force diagrams from the analysis undertaken in Analysis! The user is required to input desired amount of redistribution to the initial moments in line 26. Cell L14 allows three types of distribution according to the user's preferences. See *Redistribution* under *Assumptions made* on page 17.

At some future stage might it be possible in the spreadsheet to summarise reinforcement and where and why failures have occurred.

SPANS!

In SPANS! the user is required to choose top, bottom and link reinforcement for each span. The amounts of bending and shear reinforcement required and checks are derived from detailed calculations in Bar! Unwanted cells are 'greyed' out.

The reinforcement diameter specified for a support carries through both sides of the support, i.e. the diameter specified for the right hand support of a span carries over to the left hand support of the next span. It should be noted that hogging moment is checked both at the centre of support (solid section) and the solid/rib intersection (ribbed section). As the moments at the solid/rib intersection each side of the support may differ, it may be possible to obtain a design giving different numbers of bars each side of the support. Practicality should dictate that the maximum number of bars at each support is used for detailing.

Hogging moments at ¼ span positions within a span are checked and are used in the determination of top steel in spans.

WEIGHT!

WEIGHT! Gives an estimate of the amount of reinforcement required in one direction of the slab per rib and per square metre. Simplified curtailment rules, as defined in BS 8110: Part 1, Clause 3.12, are used in the determination of lengths of bars. The figures should be treated as approximate estimates only as they cannot deal with the effects of designers' and detailers' preferences, rationalisation, etc, etc. They do not allow for reinforcement in supporting beams or for mesh.

Analysis!

This sheet details the moment distribution analysis carried out. It is not necessarily intended for printing out, other than for checking purposes.

Bar!

This sheet shows design calculations, complete with references to BS 8110. It is not necessarily intended for printing out other than for checking purposes. In spans, service stress, f_s, may be reduced to satisfy deflection criteria. In many instances, minima of 1.0 or 0.0001 have been used to avoid problems with division by zero.

Graf!

This sheet comprises data for graphs used on other sheets, particularly in ACTIONS! It is not necessarily intended for printing out other than for checking purposes.

Project	**Spreadsheets to BS 8110**		REINFORCED CONCRETE COUNCIL		
Client	**Advisory Group**		Made by	Date	Page
Location	**3rd Floor slab**	from 1 to 5a	mw	30-Aug-99	43
	RIBBED SLABS to BS 8110:1997 (Analysis & Design)		Checked	Revision	Job No
	Originated from RCC32.xls on CD	© 1999 BCA for RCC	chg	-	R68

LOCATION Supports from grid 1 to grid 5a

MATERIALS

fcu	35	N/mm²	h agg	20	mm
fy	460	N/mm²	γm	1.05	steel
fyv	460	N/mm²	γm	1.50	concrete
Density	23.6	kN/m³	(Normal weight concrete)		

COVERS (to links, or if no links, to reinf)

Top cover	20	mm
Btm cover	20	mm
Side cover	20	mm

RIBS

slab depth, hf	100	mm
Rib width	150	mm
Centres	900	mm
1 in	10	taper

SPANS

	L (m)	H (mm)	Solid (mm) Left	Solid (mm) Right
SPAN 1	6.500	275	450	1100
SPAN 2	7.000	275	1100	1100
SPAN 3	7.500	275	1100	450
SPAN 4				
SPAN 5				
SPAN 6				

SUPPORTS

Support No	Type
1	K
4	E

K(nife), C(antilever) or E(ncastre)

LOADING UDLs (kN/m²) PLs (kN/m) Position (m)

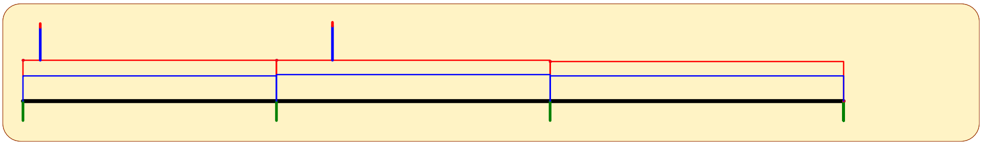
	Self Weight	Add Dead Load	Imposed Load	Position from left
Span 1				
UDL	3.93	2.50	4.00	~~~~
PL 1	~~~~	8.50	1.00	0.450
PL 2	~~~~			
Span 2	~	~	~	-
UDL	4.19	2.50	4.00	~~~~
PL 1	~~~~	8.50	1.00	1.450
PL 2	~~~~			
Span 3	~	~	~	-
UDL	3.82	2.50	4.00	~~~~
PL 1	~~~~			
PL 2	~~~~			

	Self Weight	Add Dead Load	Imposed Load	Position from left
Span 4				
UDL				
PL 1	~~~			
PL 2				
Span 5	~	~	~	-
UDL				
PL 1				
PL 2				
Span 6	~	~	~	-
UDL				
PL 1				
PL 2				

LOADING PATTERN

	min	max
DEAD	1	1.4
IMPOSED	0	1.6

LOADING DIAGRAM



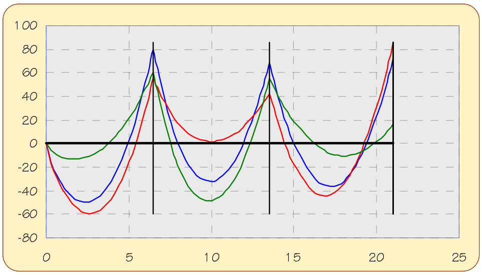
1 5a

REACTIONS (kN/m)

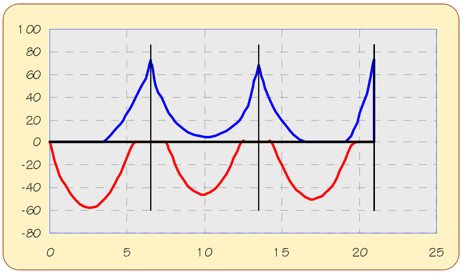
SUPPORT	1	2	3	4			
Characteristic Dead	23.4	57.9	48.0	23.8	~	~	~
Max Imposed	12.8	29.6	29.3	17.5	~	~	~
Min Imposed	-8.8	7.5	5.3	-9.0	~	~	~
MAX ULTIMATE	53.3	128.5	114.0	61.3	~	~	~

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: rmw	Date: Aug-99	Page: 44
Location	3rd Floor slab, from 1 to 5a	Checked: chg	Revision: -	Job No: R68
	RIBBED SLABS to BS 8110:1997 (Analysis & Design)			
	Originated from RCC32.xls on CD © 1999 BCA for RCC			

BENDING MOMENT DIAGRAMS (kNm/m)



1 **Elastic Moments** 5a

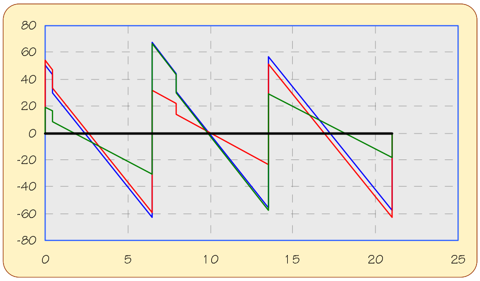


1 **Redistributed Envelope** 5a

SUPPORT No	1	2	3	4			
Elastic M	0.0	80.1	68.4	85.9	~	~	kNm/m
Redistributed M	0.0	72.1	68.4	73.0	~	~	kNm/m
ßb	1.000	0.900	1.000	0.850	~	~	~
Redistribution		10.0%	0.0%	15.0%			

SPAN No	1	2	3			
Elastic M	59.62	48.75	44.13	~	~	~
Redistributed M	57.40	45.65	50.02	~	~	~
ßb	0.963	0.936	1.133			

SHEAR FORCE DIAGRAMS (kN/m)



1 **Elastic Shears** 5a

1 **Redistributed Shears** 5a

SPAN No	1		2		3	
Elastic V	54.1	63.3	67.5	57.2	56.6	63.0
Redistributed V	53.3	62.1	67.4	57.4	56.6	61.3

SPAN No						
Elastic V	~	~	~	~	~	~
Redistributed V	~	~	~	~	~	~

Project	**Spreadsheets to BS 8110**	**REINFORCED CONCRETE COUNCIL**	
Client	**Advisory Group**	Made by **mw**	Date **30-Aug-99** / Page **45**
Location	**3rd Floor slab, from 1 to 5a**		
	RIBBED SLABS to BS 8110:1997 (Analysis & Desig	Checked **chg**	Revision **-** / Job No **R68**
	Originated from RCC32.xls on CD ©1999 BCA for RCC		

SPAN 1			**LEFT**	**CENTRE**	**RIGHT**
ACTIONS	M	kNm/m	0.0	57.4	72.1
	ßb		1.00	0.96	0.90
DESIGN	d	mm	243.0	239.0	239.0
	As	mm^2	0	519	653
	As'	mm^2	0	As T 218	As' 0
TOP STEEL			2 T 12 /rib	2 T 16 /rib	2 T 20 /rib
			+ 4 T8 between		+ 4 T8 between
	As prov	mm^2	427	As T prov 402	As prov 829
BTM STEEL			2 T 16 /rib	2 T 20 /rib	2 T 12 /rib
	As' prov	mm^2	402	As prov 628	As' prov 226
SHEAR	V	kN/m	53.26		V 62.09
	v	N/mm^2	0.725		v 1.013
	vc	N/mm^2	0.798	Link Ø 6	vc 0.935
LINKS			.	2T6 @1,200	2T6 @175 for 350
DEFLECTION			L/d 27.197	Allowed 38.637 ok	
& CHECKS	% As		ok	ok	ok
	Bar Ø & cover		ok	ok	ok
	Bar spacing		ok	ok	ok
	Dist to link		ok	ok	ok

SPAN 2			**LEFT**	**CENTRE**	**RIGHT**
ACTIONS	M	kNm/m	72.1	45.6	68.4
	ßb		0.90	0.94	1.00
DESIGN	d	mm	239.0	239.0	239.0
	As	mm^2	653	413	618
	As'	mm^2	0	As T 149	As' 0
TOP STEEL			2 T 20 /rib	2 T 12 /rib	2 T 20 /rib
			+ 4 T8 between		+ 4 T8 between
	As prov	mm^2	829	As T prov 226	As prov 829
BTM STEEL			2 T 12 /rib	2 T 20 /rib	2 T 12 /rib
	As' prov	mm^2	226	As prov 628	As' prov 226
SHEAR	V	kN/m	67.44		V 57.42
	v	N/mm^2	1.133		v 0.908
	vc	N/mm^2	0.935	Link Ø 6	vc 0.935
LINKS			2T6 @175 for 525	2T6 @1,200	.
DEFLECTION			L/d 29.289	Allowed 44.182 ok	
& CHECKS	% As		ok	ok	ok
	Bar Ø & cover		ok	ok	ok
	Bar spacing		ok	ok	ok
	Dist to link		ok	ok	ok

Project	**Spreadsheets to BS 8110**	**REINFORCED CONCRETE COUNCIL**	
Client	**Advisory Group**	Made by **rmw**	Date **Nov-99** / Page **46**
Location	**3rd Floor slab, from 1 to 5a**		
	RIBBED SLABS to BS 8110:1997 (Analysis & Design)	Checked **chg**	Revision **-** / Job No **R68**
	Originated from RCC32.xls on CD © 1999 BCA for RCC		

SPAN 3			**LEFT**		**CENTRE**		**RIGHT**	
ACTIONS	M	kNm/m	68.4	@col face		50.0		73.0
	ßb		1.00			1.13		0.85
DESIGN	d	mm	239.0			236.5		239.0
	As	mm²	618			457		661
	As'	mm²	0		As T	118	As'	4
TOP STEEL			**2 T 20 /rib**			**2 T 12 /rib**		**2 T 20 /rib**
			+ 4 T8 between					+ 4 T8 between
	As prov	mm²	829		As T prov	226	As prov	829
BTM STEEL			**2 T 12 /rib**			**1 T 25 /rib**		**1 T 16 /rib**
	As' prov	mm²	226		As prov	491	As' prov	201
SHEAR	V	kN/m	56.58				V	61.26
	v	N/mm²	0.889				v	1.221
	vc	N/mm²	0.935		link	6	vc	0.935
LINKS			.			**2T6 @ 1,200**		**2T6 @ 175 for 875**
DEFLECTION			L/d 31.712		Allowed	38.473 **ok**		
& CHECKS	% As		**ok**			**ok**		**ok**
	Bar Ø & cover		**ok**			**ok**		**ok**
	Bar spacing		**ok**			**ok**		**ok**
	Dist to link		**ok**			**ok**		**ok**

RCC33 Flat Slabs (A & D).xls

RCC33.xls analyses and designs bays of simple rectangular flat slabs to BS 8110: Part 1. The spreadsheet uses sub-frame analysis with pattern loading to calculate a bending moment envelope. This envelope may be subjected to redistribution.

For a complete rectangular flat slab the user is expected to use the spreadsheet at least four times (internal bay(s) x - x, internal bay(s) y - y, edge bay(s) x - x and edge bay(s) y - y). Punching shear should be checked using RCC13.xls.

The spreadsheet does **not** currently allow for holes or drops (maybe next time!). If holes are considered critical then the user is directed towards using RCC21.xls (sub-frame analysis) and allowing for holes in breadths used. See also Clause 3.7.5. The single load case of all spans loaded (Clause 3.5.2.3) is not used. Beyond panel aspect ratios of 1.5 consideration might be given to the appropriateness of using other forms of analysis (e.g. grillage or finite element).

The example emulates the design used on the in-situ building of the European Concrete Building Project (ECBP) at BRE Cardington, (albeit that on the ECBP f_{ck} = 30 N/mm^2 i.e. f_{cu} = 37 N/mm^2 and f_y = 500 N/mm^2 were used).

MAIN!

This sheet provides the main inputs to the spreadsheet (although other inputs occur in other sheets).

Most inputs are (we hope) self-explanatory. LEGEND! should help with definition of dimensions, e.g. edge distance C is actually from centreline of column to edge of slab. Cover is defined as being to the layer under design. The layering is set at T1 - B1 (& T2 - B2) although T1 - B2 might be deemed more appropriate (e.g. with prefabricated mats).

The number of spans is altered by entering data in the appropriate cells. Unwanted data cells are 'greyed' out. The use of C, K, F or P can alter the characteristics of a support from Cantilever to Knife-edge to Fixed to Pinned. Extraneous data is highlighted in red or by messages in red. Under *Operating Instructions* a number of checks are carried out and problems found are highlighted. At the bottom of the sheet a simplistic loading diagram is given to aid data checking. Great care should be taken to ensure that this sheet is completed correctly for the case in hand. It may prove prudent to estimate values for bay width bending moments at each support by hand before progressing to ACTIONS!

Cantilevers less than 1.00 m should be described as *end distances* (rather than cantilevers; otherwise certain logic regarding breadth of effective moment transfer strip, b_e (see BS 8110: Part 1, Figure 3.13), goes wrong). *End distances* equivalent to the half width of the column should be used to define slabs whose edge is flush with the outside of the column. On edge columns, b_e restricts $M_{t\,max}$ which in itself restricts the amount of moment transferred into columns above and below.

Load input should define the loads on the slab only. A combo-box is used to switch between the internal or edge bays. If EDGE is chosen, cells H14:I14 and E16:G16 become operative and information about the perimeter load along the edge and the distance of the edge from the centreline is required as input. Perimeter loading is assumed to be dead load.

Cell L51 gives an estimate of reinforcement requirements for the element considered in the direction considered (not both directions).

It will be noted that the example assumes the reinforcement is in the second layer; therefore warnings concerning cover greater than 40 mm should not be of too much concern.

The spreadsheet takes automatic measures to ensure deflection criteria are met. It may be argued that in this instance, with equal spans in the two directions, these measures are unwarranted in that deflection criteria will have been met in the orthogonal T1/B1 layer.

To the right under *Operating instructions* a number of checks are carried out. Box markers indicate where checks have been carried out and proved satisfactory.

ACTIONS!

This sheet shows bending moment and shear force diagrams from the analysis undertaken in Analysis! The user is required to input the desired amount of redistribution to the initial moments in line 26. Cell L14 allows three types of distribution according to the user's preference.

The sheet also provides output reactions and column moments. Using the value of V_{eff} for punching shear obviates the need to use the 1.15, 1.25 and 1.4 factors in Clause 3.7.6.2 to determine V_{eff} from V_t.

SPANS!

SPANS! details the amounts of reinforcement required derived from detailed calculations in Bar!

LEGEND!

LEGEND! gives an explanation of the dimensions used in MAIN! and for the analysis and design.

WEIGHT!

WEIGHT! gives an estimate of the amount of reinforcement required in one direction of the slab for the internal or end bays considered. Simplified curtailment rules, as defined in

Clause 3.12, are used to determine lengths of bars. The figures should be treated as approximate estimates only as they cannot deal with the effects of designers' and detailers' preferences, 'rationalisation', the effects of holes etc, etc. They do not allow for punching shear links or link carrier bars.

Analysis!

This sheet details the moment distribution analysis carried out but is not necessarily intended for printing out other than for checking purposes. It is derived from RCC21.xls.

Bar!

This sheet shows design calculations, complete with references to BS 8110. It is not necessarily intended for printing out other than for checking purposes.

Hogging moments at ¼ span positions within a span are checked and are used in the determination of top steel in spans.

Graf!

This sheet comprises data for graphs used on other sheets, particularly in ACTIONS!

Project	**Spreadsheets to BS 8110**		
Client	**Advisory Group**		
Location	**ECBP Typical Floor**	from grids **A** to **D**	
	FLAT SLAB ANALYSIS & DESIGN to BS 8110:1997		
	Originated from RCC33.xls on CD	© 1999 BCA for RCC	

REINFORCED CONCRETE COUNCIL

Made by	Date	Page
mmw	13-Oct-99	49
Checked	**Revision**	**Job No**
chg	-	R68

MATERIALS

fcu	40	N/mm²	h agg	20	mm
fyl	460	N/mm²	γs	1.05	steel
fyv	460	N/mm²	γc	1.50	concrete

COVERS

	mm	TO LAYER
Top cover	25	1
Btm cover	25	1

SPANS

	L (m)
SPAN 1	7.500
SPAN 2	7.500
SPAN 3	7.500
SPAN 4	
SPAN 5	
SPAN 6	

GEOMETRY

Bay type	INTERNAL	
Slab depth, h	250	mm
Panel width, b	7500	mm
End distance	125	from supt 1
End distance	125	from supt 4

PERIMETER LOADS *characteristic*

8.85 *kN/m outside supports 1 & 4*

LOADING PATTERN

	min	max
DEAD	1.0	1.4
IMPOSED		1.6

SUPPORTS

	ABOVE (m)	H (mm)	B (mm)	End Cond	BELOW (m)	H (mm)	B (mm)	End Cond
Support 1	3.750	250	400	F	3.750	250	400	F
Support 2	3.750	400	400	F	3.750	400	400	F
Support 3	3.750	400	400	F	3.750	400	400	F
Support 4	3.750	250	400	F	3.750	250	400	F
Support 5								
Support 6								
Support 7								

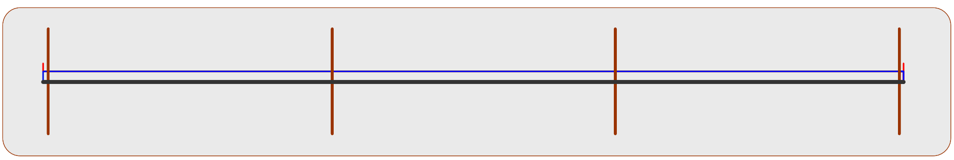
LOADING

UDLs (kN/m²) PLs (kN/m) Position (m)

Span 1	Dead Load	Imposed Load	Position from left	Loaded Length
UDL	7.50	3.50	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 2				
UDL	7.50	3.50	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 3				
UDL	7.50	3.50	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				

Span 4	Dead Load	Imposed Load	Position from left	Loaded Length
UDL			~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 5				
UDL			~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 6				
UDL			~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				

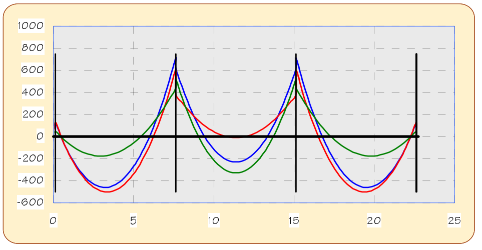
LOADING DIAGRAM



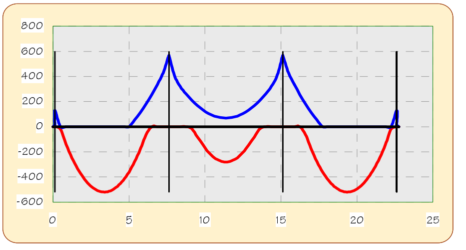
A D

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by rmw	Date 13-Oct-99	Page 50
Location	ECBP Typical Floor, from grids A to D			
	FLAT SLAB ANALYSIS & DESIGN to BS 8110:1997	Checked chg	Revision -	Job No R68
	Originated from RCC33.xls on CD © 1999 BCA for RCC			

BENDING MOMENT DIAGRAMS (kNm)



Elastic Moments

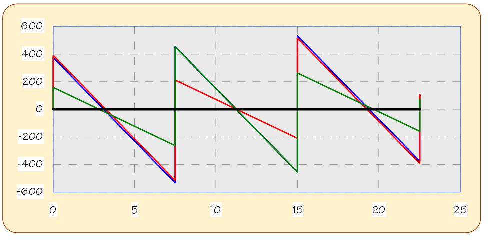


Redistributed Envelope

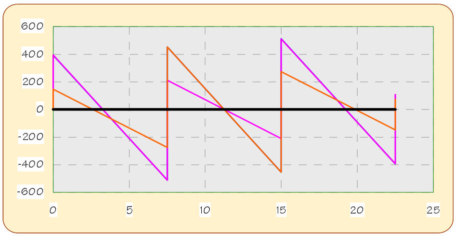
SUPPORT No	1	2	3	4			
Elastic M	128.2	710.4	710.4	128.2	~	~	~
Redistributed M	128.2	568.4	568.4	128.2	~	~	~
ßb	1.000	0.800	0.800	1.000	~	~	~
Redistribution		20.0%	20.0%				
End support reinf. Ø mm	16			16			
	*			*			

SPAN No	1	2	3			
Elastic M	501.02	328.88	501.02	~	~	~
Redistributed M	520.17	280.67	520.17	~	~	~
ßb	1.038	0.853	1.038	~	~	~

SHEARS FORCE DIAGRAMS (kN)



Elastic Shears



Redistributed Shears

SPAN No	1		2		3	
Elastic V	389.8	531.7	452.8	452.8	531.7	389.8
Redistributed V	394.1	512.7	452.8	452.8	512.7	394.1

SPAN No						
Elastic V	~	~	~	~	~	~
Redistributed V	~	~	~	~	~	~

REACTIONS (kN)

SUPPORT	1	2	3	4
ALL SPANS LOADED	500.9	965.5	965.5	500.9
ODD SPANS LOADED	502.1	722.4	722.4	502.1
EVEN SPANS LOADED	220.4	727.7	727.7	220.4
Veff for punching	627.7	1059.3	1059.3	627.7
Characteristic Dead	248.0	458.2	458.2	248.0
Characteristic Imposed	96.8	202.5	202.5	96.8

COLUMN MOMENTS (kNm)

		1	2	3	4
ALL SPANS LOADED	Above	53.3	-45.9	45.9	-53.3
	Below	53.3	-45.9	45.9	-53.3
ODD SPANS LOADED	Above	59.7	-107.1	107.1	-59.7
	Below	59.7	-107.1	107.1	-59.7
EVEN SPANS LOADED	Above	18.0	40.1	-40.1	-18.0
	Below	18.0	40.1	-40.1	-18.0

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
Location	ECBP Typical Floor, from grids A to D	mw	Aug-99	51
	FLAT SLAB ANALYSIS & DESIGN to BS 8110:1997	Checked	Revision	Job No
	Originated from RCC33.xls on CD © 1999 BCA for RCC	chg	-	R68

SPAN 1			LEFT	CENTRE	RIGHT
ACTIONS	ßb		1.000	1.038	0.800
	Be		650		3750
	Total M	kNm	79.9	520.2	480.2
	Mtmax	kNm	183.6		1059.5
MIDDLE STRIP	Width	mm	6850	3750	3750
	M	kNm	2.3	234.1	120.1
	d	mm	219.0	215.0	217.0
	As	mm²/m	4	698	354
	As deflection	mm²/m		851	354
			Provide T12 @325 T1	Provide T20 @350 B1	Provide T16 @550 T1
	As prov	mm²/m	348	898	366
	Top steel			Provide T12 @325 T1	
	Deflection		L/d = 7,500 /215.0 = 34.884 < 26.0 x 1.466 x 1.050 x 0.9 = 36.038		OK
			(As increased by 21.9 % for deflection)		
COLUMN STRIP	Width	mm	650	3750	3750
	M	kNm	79.9	286.1	360.2
	d	mm	217.0	215.0	217.0
	As	mm²/m	1403	853	1075
	As deflection	mm²/m		1194	1075
			Provide T16 @125 T1	Provide T20 @250 B1	Provide T16 @125:250 T1
	As prov	mm²/m	1608	1257	1206
	Top steel			Provide T12 @325 T1	
	Deflection		L/d = 7,500 /215.0 = 34.884 < 26.0 x 1.454 x 1.050 x 0.9 = 35.729		OK
			(As increased by 40.0 % for deflection)		
CHECKS	% As		ok	ok	ok
	Singly reinforced		ok	ok	ok
	max S		ok	ok	ok

SPAN 2			LEFT	CENTRE	RIGHT
ACTIONS	ßb		0.800	0.853	0.800
	Be		3750		3750
	Total M	kNm	480.2	280.7	480.2
	Mtmax	kNm	1059.5		1059.5
MIDDLE STRIP	Width	mm	3750	3750	3750
	M	kNm	120.1	126.3	120.1
	d	mm	217.0	217.0	217.0
	As	mm²/m	354	373	354
	As deflection	mm²/m	354	431	
			Provide T16 @550 T1	Provide T16 @450 B1	Provide T16 @550 T1
	As prov	mm²/m	366	447	366
	Top steel			Provide T12 @325 T1	
	Deflection		L/d = 7,500 /217.0 = 34.562 < 26.0 x 1.464 x 1.050 x 0.9 = 35.970		OK
			(As increased by 15.5 % for deflection)		
COLUMN STRIP	Width	mm	3750	3750	3750
	M	kNm	360.2	154.4	360.2
	d	mm	217.0	215.0	217.0
	As	mm²/m	1075	460	1075
	As deflection	mm²/m	1075	570	
			Provide T16 @125:250 T1	Provide T20 @550 B1	Provide T16 @125:250 T1
	As prov	mm²/m	1206	571	1206
	Top steel			Provide T12 @325 T1	
	Deflection		L/d = 7,500 /215.0 = 34.884 < 26.0 x 1.423 x 1.050 x 0.9 = 34.974		OK
			(As increased by 23.8 % for deflection)		
CHECKS	% As		ok	ok	ok
	Singly reinforced		ok	ok	ok
	max S		ok	ok	ok

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL	
Client	Advisory Group	Made by: mmw	Date: Aug-99 · Page: 52
Location	ECBP Typical Floor, from grids A to D	Checked: chg	Revision: - · Job No: R68
	FLAT SLAB ANALYSIS & DESIGN to BS 8110:1997		
	Originated from RCC33.xls on CD · © 1999 BCA for RCC		

SPAN 3			LEFT	CENTRE	RIGHT
ACTIONS	ßb		0.800	1.038	1.000
	Be		3750		650
	Total M	kNm	480.2	520.2	79.9
	Mtmax	kNm	1059.5		183.6
MIDDLE STRIP	Width	mm	3750	3750	6850
	M	kNm	120.1	234.1	2.3
	d	mm	217.0	215.0	219.0
	As	mm²/m	354	698	4
	As deflection	mm²/m	354	851	
			Provide T16 @550 T1	Provide T20 @350 B1	Provide T12 @325 T1
	As prov	mm²/m	366	898	348
	Top steel			Provide T12 @325 T1	
	Deflection		L/d = 7,500 /215.0 = 34.884 < 26.0 x 1.466 x 1.050 x 0.9 = 36.038		OK
			(As increased by 21.9 % for deflection)		
COLUMN STRIP	Width	mm	3750	3750	650
	M	kNm	360.2	286.1	79.9
	d	mm	217.0	215.0	217.0
	As	mm²/m	1075	853	1403
	As deflection	mm²/m	1075	1194	
			Provide T16 @125:250 T1	Provide T20 @250 B1	Provide T16 @125 T1
	As prov	mm²/m	1206	1257	1608
	Top steel			Provide T12 @325 T1	
	Deflection		L/d = 7,500 /215.0 = 34.884 < 26.0 x 1.454 x 1.050 x 0.9 = 35.729		OK
			(As increased by 40.0 % for deflection)		
CHECKS	% As		ok	ok	ok
	Singly reinforced		ok	ok	ok
	max S		ok	ok	ok

RCC41 Continuous Beams (A & D).xls

The spreadsheet designs multiple-span rectangular or flanged beams using sub-frame analysis to derive moments and shears. The intention is to provide the design and analysis of up to six spans of continuous beams with or without columns above and below. Spans may incorporate cantilevers, fixed ends or knife-edge supports. There are three main sheets: MAIN!, ACTIONS! and SPANS!

MAIN!

This sheet contains user input of materials, frame geometry and load data.

Input data is blue and underlined. New data may be input by overwriting default values or by entering values in 'greyed out' cells. Entering a value of 5.0 in cell C18 will clear a line of data in both the span and support data ready for input. Guidance on input for the type of section and type of end condition of the support is given under *Operating Instructions*.

The sheet has been set up with as many 'carry throughs' as possible, i.e. input cells are made equal to preceding input cells to make the inputting of regular beams easier. Inputting C18 as "= C17" will insert *6.00* in the remaining spans: it will also remove the grey conditional background to the remaining spans, supports and loads and allow data entry. Deleting C18, indeed C19, will blank out remaining spans, etc. Generally, values in red or red backgrounds indicate either incorrect or excess data. For instance, if knife-edge supports are required, enter 'K' in cells C24, C25 etc. This will elicit red data to the right, which needs to be cleared manually.

Do not copy and paste input values as this can corrupt formatting (copy and "paste values only" is OK).

'Rebar layering' refers to whether there are beams in the other direction. Answering yes drops by one bar diameter the steel at the supports. For instance when using splice bars at the support, bars in the other direction have to be avoided - and allowed for in the design.

With respect to cantilevers, design for bending caters for moments at the face of support; design for deflection considers the cantilever from the centre line of support. In beam-to-beam situations the width of support can be input as being very small to avoid under-design in bending.

The example is taken from *Designed and detailed* [15]. In order to reflect this publication, the spreadsheet has been set up with the beams being considered as rectangular in both the analysis *and* design. The analysis in the spreadsheet mimics *Designed and detailed*, but as the spreadsheet considers the rectangular section for design, more reinforcement is required particularly in the span. Some economy would have been gained by considering the beams as T sections rather than rectangular (192 kg/m^3 c.f. 222 kg/m^3). The spreadsheet notes that cover to the top exceeds 40 mm. In this case, the crack width should normally be checked.

ACTIONS!

ACTIONS! Includes bending moment and shear force diagrams, summaries of moments and shears and user input for amounts of redistribution. users should ensure that the amounts of redistribution are always considered as there are no default values.

SPANS!

This sheet designs reinforcement for bending in spans and supports, and for shear in the spans.

User input is required for the diameters of bending and shear reinforcement and for the number of legs of links in each span. Some intuition may be required to obtain sensible and rational arrangements of reinforcement. In order to discourage the use of second layers of reinforcement, the input cells for diameters of reinforcement in second layers are nominally protected.

Support moments (including cantilever moments) are considered at the face of the support. This may lead to unequal amounts of reinforcement being designed for each side of the support (see Bar!). Usually, the detailer would be expected to detail the larger amount of reinforcement: however where different section occur either side of a support, the detailer should be briefed as to the designer's detailed requirements.

Non-existent spans are blanked out.

Besides the limit of maximum modification factor for deflection = 2.0, an additional limit of maximum allowable area of steel to comply with deflection criteria, A_{sdef}, = 2 x A_{sreqd}, has been imposed.

Weight!

This sheet estimates the weight of reinforcement in the beam when designed according to normal curtailment rules as defined in BS 8110. Workings are shown on the right hand side of the sheet. The estimate may be printed out using File/print or the print button on the normal toolbar. It should be recognised that different engineers' and detailers' interpretations of these clauses, and different project circumstances and requirements will all have a bearing on actual quantities used.

Analysis!

This sheet shows the moment distributions used in the analysis of the beam: it is not intended for formal printing.

It will be seen that the loads are considered initially as $1.0g_k$ over all spans then as $(g_{fg} - 1.0)g_k + g_{fq}q_k$ over alternate spans.

Bar!

Intended mainly for first time users and young engineers, this sheet gives further details of the calculations summarised in SPAN! Support moments are considered at faces of supports; checks at ¼ span relate to hogging and any top steel required is provided in the span.

Graf!

This sheet provides data for the charts in MAIN! and ACTIONS!: it is not intended for formal printing.

Project	Spreadsheets to BS 8110		REINFORCED CONCRETE COUNCIL
Client	Advisory Group		Made by: rmw · Date: 13-Oct-99 · Sheet No: 55
Location	D&D: Main beam Grids C to H	from grid 1 to 3	Checked: chg · Revision: - · Job No: R68
	CONTINUOUS BEAM (Analysis & Design) to BS 8110:1997		
	Originated from RCC41.xls on CD	© 1999 BCA for RCC	

LOCATION Supports from grid 1 to grid 3

MATERIALS

fcu	40 N/mm²	h agg	20 mm	Top cover	25 mm
fyl	460 N/mm²	γ_s	1.05	Btm cover	40 mm
fyv	250 N/mm²	γ_c	1.50	Side cover	35 mm

COVERS (to all steel)

SPANS

	L (m)	H (mm)	bw (mm)	hf (mm)	Type	bf (mm)
SPAN 1	8.00	500	300	175	R	300
SPAN 2	6.00	500	300	175	R	300
SPAN 3						
SPAN 4						
SPAN 5						
SPAN 6						

LOADING PATTERN

	min	max
DEAD	1	1.4
IMPOSED	0	1.6

REBAR LAYERING

Support steel in alt layer ? Y

SUPPORTS

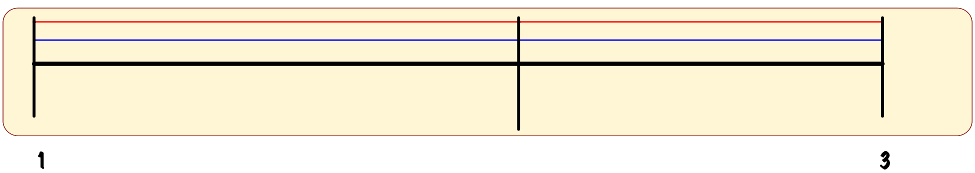
	ABOVE (m)	H (mm)	B (mm)	End Cond	BELOW (m)	H (mm)	B (mm)	End Cond
Support 1	3.50	300	300	F	4.00	300	300	P
Support 2	3.50	300	300	F	5.00	300	300	P
Support 3	3.50	300	300	F	4.00	300	300	P
Support 4								
Support 5								
Support 6								
Support 7								

LOADING UDLs (kN/m) PLs (kN) Position (m)

	Dead Load	Imposed Load	Position from left	Loaded Length
Span 1				
UDL	25.8	20.0	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 2				
UDL	25.8	20.0	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 3				
UDL			~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				

	Dead Load	Imposed Load	Position from left	Loaded Length
Span 4				
UDL			~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 5				
UDL			~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 6				
UDL			~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				

LOADING DIAGRAM

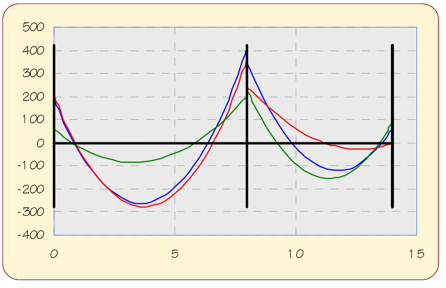


REACTIONS (kN)

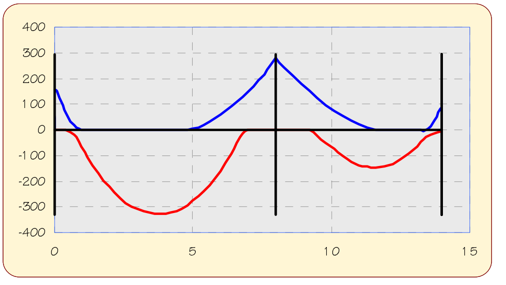
SUPPORT	1	2	3
ALL SPANS LOADED	256.6	529.6	167.4
ODD SPANS LOADED	256.6	413.3	29.9
EVEN SPANS LOADED	78.1	365.1	171.9
Characteristic Dead	92.7	209.3	59.2
Characteristic Imposed	79.3	147.8	55.6

Project	**Spreadsheets to BS 8110**	REINFORCED CONCRETE COUNCIL		
Client	**Advisory Group**	Made by **mw**	Date **30-Aug-99**	Page **56**
Location	**D&D : Main beam Grids C to H, from grid 1 to 3**	Checked **chg**	Revision **-**	Job No **R68**
	CONTINUOUS BEAM (Analysis & Design) to BS 8110:1997			
	Originated from RCC41.xls on CD ©1999 BCA for RCC			

BENDING MOMENT DIAGRAMS (kNm)



1 **Elastic Moments** 3

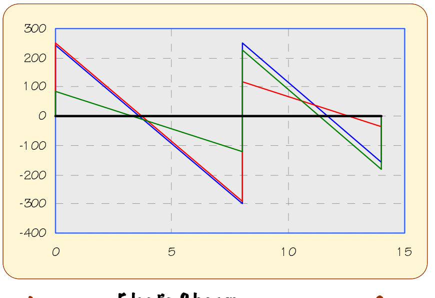


1 **Redistributed Envelope** 3

SUPPORT No	1	2	3				
Elastic M	193.1	401.7	86.2	~	~	~	kNm/m
Redistributed M	154.5	281.2	86.2	~	~	~	kNm/m
βb	0.800	0.700	1.000	~	~	~	~
Redistribution	20.0%	30.0%	0.0%				

SPAN No	1	2				
Elastic M	276.52	152.75	~	~	~	~
Redistributed M	328.97	146.12	~	~	~	~
βb	1.190	0.957	~	~	~	~

SHEARS (kN)



1 **Elastic Shears** 3

1 **Redistributed Shears** 3

SPAN No	1		2			
Elastic V	252.9	300.3	252.4	180.4	~	~
Redistributed V	256.6	288.3	241.3	171.9	~	~

Elastic V	~	~	~	~	~	~
Redistributed V	~	~	~	~	~	~

COLUMN MOMENTS		1	2	3
ALL SPANS LOADED	Above	108.3	-35.2	-36.0
	Below	71.1	-18.5	-23.6
ODD SPANS LOADED	Above	116.6	-65.1	2.4
	Below	76.5	-34.2	1.6
EVEN SPANS LOADED	Above	32.8	16.6	-52.0
	Below	21.5	8.7	-34.2

Project	**Spreadsheets to BS 8110**	**REINFORCED CONCRETE COUNCIL**	
Client	**Advisory Group**	Made by **rmw**	Date **13-Oct-99** / Page **57**
Location	**D&D: Main beam Grids C to H, from grid 1 to 3**	Checked **chg**	Revision **-** / Job No **R68**
	CONTINUOUS BEAM (Analysis & Design) to BS 8110:1997		
	Originated from RCC41.xls on CD © 1999 BCA for RCC		

SPAN 1			**LEFT**	**CENTRE**	**RIGHT**
ACTIONS	M	kNm	116.7	329.0	250.2
	ßb		0.80	1.19	0.70
DESIGN	d	mm	433.0	432.0	415.0
	As	mm²	656	2188	1617
	As'	mm²			800
TOP STEEL	Layer 1		**3 T 20**	**2 T 16**	**3 T 32**
	Layer 2				
	As prov	mm²	942	As' prov 402	As prov 2413
BTM STEEL	Layer 1		**3 T 20**	**3 T 32**	**2 T 25**
	Layer 2				
	As' prov	mm²	942	As prov 2413	As' prov 982
DEFLECTION			L/d 18.519	Allowed 24.149	
SHEAR	V	kN	216.9	**Link Ø**	249.8
	v	N/mm²	1.670	12	2.007
	vc	N/mm²	0.527	**Nominal**	0.731
LINKS			**R12 @ 150 for 1950**	**R12 @ 300**	**R12 @ 125 for 2125**
	legs	No	2	2	2
CHECKS	% As		**ok**	**ok**	**ok**
	Cover		**ok**	**ok**	**ok**
	min S		**ok**	**ok**	**ok**
	max S		**ok**	**ok**	**ok**
	Links		**ok**	**ok**	**ok**
	Main bars		**ok**	**ok**	**ok**
	max V		**ok**		**ok**
	Deflection			**ok**	

SPAN 2			**LEFT**	**CENTRE**	**RIGHT**
ACTIONS	M	kNm	262.8	146.1	61.2
	ßb		0.81	0.96	1.00
DESIGN	d	mm	415.0	435.5	439.0
	As	mm²	1742	830	335
	As'	mm²			
TOP STEEL	Layer 1		**3 T 32**	**2 T 25**	**2 T 16**
	Layer 2				
	As prov	mm²	2413	As' prov 982	As prov 402
BTM STEEL	Layer 1		**2 T 25**	**2 T 25**	**2 T 16**
	Layer 2				
	As' prov	mm²	982	As prov 982	As' prov 402
DEFLECTION			L/d 13.777	Allowed 32.608	
SHEAR	V	kN	202.8	**Link Ø**	131.7
	v	N/mm²	1.629	12	1.000
	vc	N/mm²	0.731	**Nominal**	0.395
LINKS			**R12 @ 200 for 1400**	**R12 @ 325**	**R12 @ 275 for 1100**
	legs	No	2	2	2
CHECKS	% As		**ok**	**ok**	**ok**
	Cover		**ok**	**ok**	**ok**
	min S		**ok**	**ok**	**ok**
	max S		**ok**	**ok**	**ok**
	Links		**ok**	**ok**	**ok**
	Main bars		**ok**	**ok**	**ok**
	max V		**ok**		**ok**
	Deflection			**ok**	

Project	**Spreadsheets to BS 8110**		**REINFORCED CONCRETE COUNCIL**
Client	**Advisory Group**	Made by **rmw**	Date **26-Nov-99**	Page **58**
Location	**D&D: Main beam Grids C to H, from grid 1 to 3**	Checked **chg**	Revision **-**	Job No **R68**
	CONTINUOUS BEAM (Analysis & Design) to BS 8110:1997		
	Originated from RCC41.xls on CD © 1999 BCA for RCC		

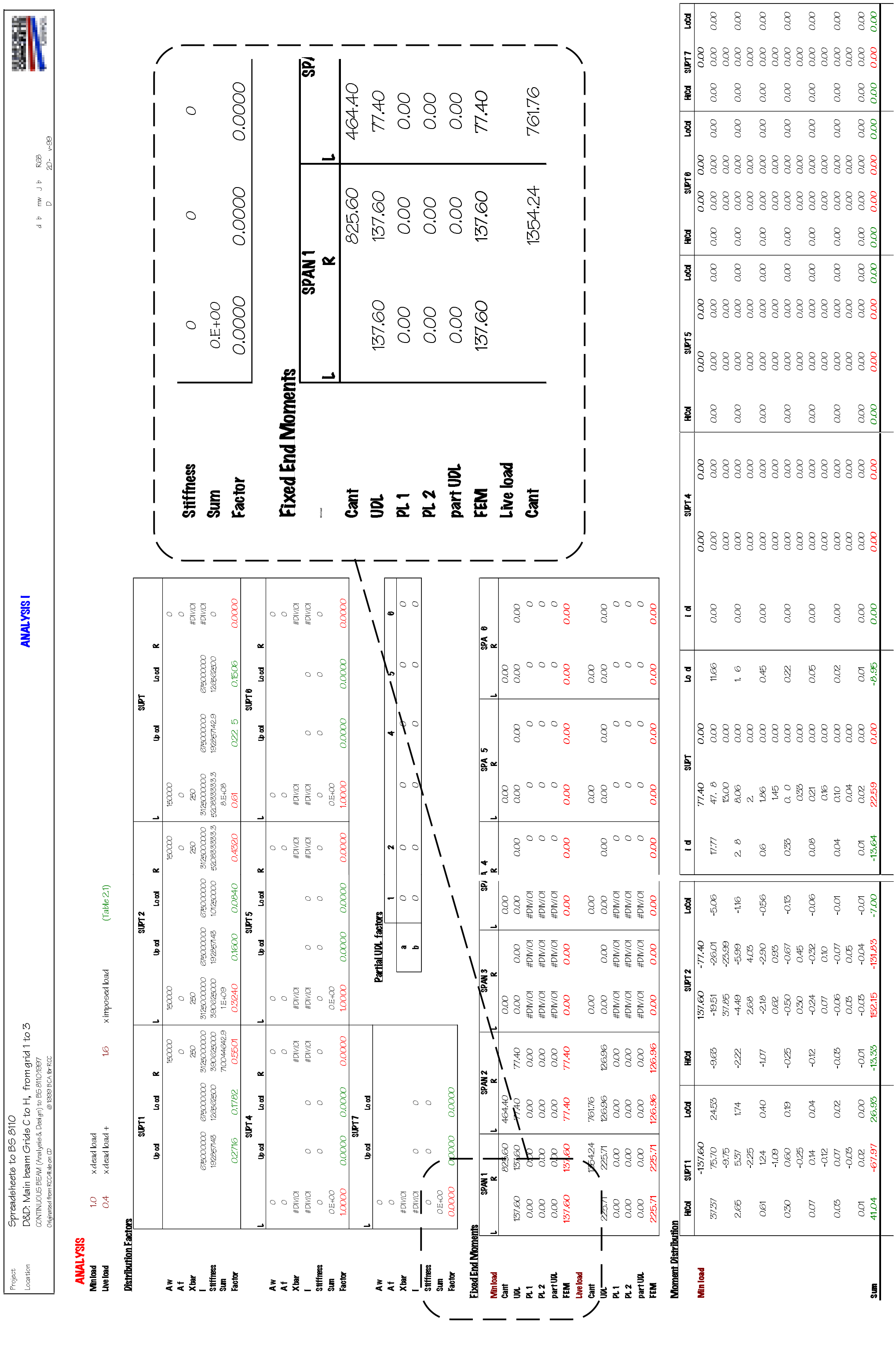
APPROXIMATE WEIGHT of REINFORCEMENT

	Location	No	Type	Dia	Length	Unit wt	Weight
TOP STEEL	Support 1	3	T	20	2950	2.466	21.8
	Span 1	2	T	16	4775	1.578	15.1
	Support 2	3	T	32	4200	6.313	79.5
	Span 2	2	T	25	5650	3.853	43.5
	Support 3	2	T	16	2225	1.578	7.0
BOTTOM STEEL	Support 1	3	T	20	1100	2.466	8.1
	Span 1	3	T	32	7650	6.313	144.9
	Support 2	2	T	25	2800	3.853	21.6
	Span 2	2	T	25	5650	3.853	43.5
	Support 3	2	T	16	1525	1.578	4.8
LINKS	Span 1	43	R	12	1400	0.888	53.4
	Span 2	22	R	12	1400	0.888	27.3

SUMMARY *spacers not included*

Total reinforcement in bay (kg) 471

Reinforcement density (kg/m³) 215.0


ANALYSIS
Distribution Factors
Fixed End Moments
Moment Distribution
Partial UDL factors
Stiffness
Sum
Factor
Cant
UDL
PL 1
PL 2
part UDL
FEM
Live load
SPAN 1
L
R
137.60
825.60
464.40
0.00
77.40
1354.24
761.76
0.E+00
0.0000

Project & location | Spreadsheets to BS 8110 : D&D: Main beam Grids C to H : from grid 1 to 3 | **SPAN 1**

CONTINUOUS BEAM (Analysis & Design) to BS 8110:1997 Originated from RCC41.xls on CD © 1999 BCA for RCC

Span 8.00 m	h 500	Top cover	37	mm to main steel	Job No	R68
R beam	bw 300	Btm cover	52	mm to main steel	by	rmw
	hf 175	Side cover	47	mm to main steel	Date	13-Oct-99

MAIN STEEL			**LEFT**	**.25L**		**SPAN**		**RIGHT**	BS8110 Ref
M CL	kNm		154.5					281.2	
M face	kNm		116.7	60.9		329.0		250.2	
ßb			0.800	0.7		1.190		0.700	
d	mm		433.0	455.0		432.0		415.0	
bf	mm		300.0	300.0		300.0		300.0	3.4.1.5
K'			0.132	0.104		0.156		0.104	Fig 3.3
Web Mres	kNm		297.0	259.4		348.9		215.8	Fig 3.3
Flange Mres	kNm		~~~	~~~		323.1		~~~	Fig 3.3
K			0.052	0.024		0.147		0.121	3.4.4.4
z	mm		406.4	432.3		343.3		359.4	3.4.4.4
x	mm		59.1	50.6		197.2		123.5	3.4.4.4
d'	mm		94.0	68.0		45.0		96.5	
net fsc	N/mm²		0.0	0.0		420.2		135.3	Fig 3.3
Excess M	kNm		0.0	0.0		0.0		34.5	
As' req	mm²		0	0		0		800	
fst	N/mm²		438.1	438.1		438.1		438.1	Fig 3.3
As req	mm²		656	321		2188		1617	
bw/b			~~~	~~~		1.0		~~~	
Min %	%		0.13%	0.13%		0.13%		0.13%	Table 3.25
Min As	mm²		195	195		195		195	
DEFLECTION									
fs	N/mm²		266.7			233.7		293.7	Eqn 8
Base ratio						26.0		100.0	3.4.6.3/4
Tens Mod						0.8		0.8	Table 3.10
Comp Mod						1.1		1.2	Table 3.11
Perm L/d						24.1		98.6	3.4.6.3
Actual L/d					ok	18.5	ok	0.0	3.4.5.1
TENSION STEEL									
As	mm²		656			2188		1617	
Ø 1	mm	ok	20		ok	32	ok	32	
Ø 2	mm		0			0		0	
Max No/layer			4			3		3	
No 1			3			3		3	
=	mm²		942			2413		2413	
No 2		ok	0		ok	0	ok	0	
As prov	mm²		942			2413		2413	
= %	%	ok	0.726		ok	1.862	ok	1.938	
Clear dist	mm		73.0			55.0		55.0	between bars
Min S	mm	ok	25.0		ok	32.0	ok	32.0	3.12.11.1
Max S	mm	ok	176.2		ok	201.1	ok	160.1	Table 3.28
COMPRESSION STEEL									
Required	mm²		724			323		800	Table 3.25
Ø 1	mm	ok	20		ok	16	ok	25	
Ø 2	mm		0			0		0	
Max No/layer			4			5		4	
No 1			3			2		2	
=			942			402		982	
No 2		ok	0		ok	0	ok	0	
As' prov	mm²		942			402		982	
= %	%	ok	0.726		ok	0.310	ok	0.789	
Clear dist	mm		73.0			174.0		156.0	between bars
Min S	mm	ok	25.0		ok	25.0	ok	25.0	3.12.11.1
SHEAR									
V at cl	kN		256.6					288.3	
V at d	kN		216.9					249.8	3.4.5.10
v	N/mm²		1.670					2.007	Eqn 3
vc	N/mm²		0.527			**Nominal**		0.731	Table 3.8
(v-vc)bv	N/mm		342.8			120.0		382.6	Table 3.7
Link Ø	mm	ok	12		ok	12	ok	12	3.12.7.1
Legs		ok	2		ok	2	ok	2	
@	mm		157			324		141	3.12.7.1
Adjust to	mm		150			300		125	
for (UDL only)	mm		1999			~~~		2165	from cl
for (with PL)	mm		1999			~~~		#N/A	- = -
Adjust to	mm		1950			~~~		2125	from face
As Dist	mm	ok	93.0		ok	87.0	ok	87.0	3.4.5.5
As' Dist	mm	ok	73.0		ok	0.0	ok	0.0	3.12.7.2

Project	Spreadsheets to BS 8110	GRAPH DATA I	
Location	D&D: Main beam Grids C to H, from grid 1 to 3		Made by rmw Job No R68
	CONTINUOUS BEAM (Analysis & Design) to BS 8110:1997		Date 30-Nov-99
	Originated from RCC41.xls on CD © 1999 BCA for RCC		

LOADING DIAGRAM

14.39

BEAM	0	14																								
	0	0																								
SUPPORTS	0	0		8	8		14	14		14	14		14	14		14	14		14	14						
	-57.6	50.38		-72	50.38		-57.58	50.38		-14.4	0		-14.4	0		0	0		0	0						
D UDL	0	0	8	8	8	14	14	14	14	14	14	14	14	14	14	14	14	14	14							
	0	25.8	25.8	0	25.8	25.8	0	0	0	0	0	0	0	0	0	0	0	0	0							
L UDL	25.8	45.8	45.8	25.8	45.8	45.8	25.8	0	0	0	0	0	0	0	0	0	0	0	0							
D PUDL	0	0	0	0	8	8	8	8	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14		
	45.8	45.8	45.8	45.8	45.8	45.8	45.8	45.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
L PUDL	45.8	45.8	45.8	45.8	45.8	45.8	45.8	45.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
PL 1	0	0		8	8		14	14		14	14		14	14		14	14									
	45.8	45.8		45.8	45.8		0	0		0	0		0	0		0	0									
	45.8	45.8		45.8	45.8		0	0		0	0		0	0		0	0									
PL 2	0	0		8	8		14	14		14	14		14	14		14	14									
	45.8	45.8		45.8	45.8		0	0		0	0		0	0		0	0									
	45.8	45.8		45.8	45.8		0	0		0	0		0	0		0	0									

MOMENT DIAGRAMS

SPAN 1

																						at col face	
X	0	0	0.4	0.8	1.2	1.6	2	2.4	2.8	3.2	3.6	4	4.4	4.8	5.2	5.6	6.4	6.8	7.2	7.6	8	0.15	7.85
M(e) all	0	179.5	87.03	5.497	-65.1	-125	-173.7	-212	-239	-255	-260	-254	-238	-210	-172	-123	8.501	90.46	183.3	287.1	401.7	143.5	357.5
M(e) odd	0	193.1	97.35	12.53	-61.4	-124	-176.6	-218	-248	-268	-276	-274	-260	-236	-201	-155	-30.6	48.04	137.6	238.1	349.4	155.9	306.4
M(e) even	0	54.34	22.63	-4.95	-28.4	-47.7	-62.92	-74	-80.9	-83.8	-82.4	-77	-67.4	-53.7	-35.9	-13.9	42.35	76.69	115.2	157.7	204.5	41.97	186.5
Beam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M(r) all	0	154.5	57.26	-29	-104	-169	-222.6	-265	-297	-318	-328	-327	-315	-293	-259	-215	-92.9	-15.7	72.35	171.3	281.2	116.7	238.7
M(r) odd	0	154.5	57.26	-29	-104	-169	-222.6	-265	-297	-318	-328	-327	-315	-293	-259	-215	-92.9	-15.7	72.35	171.3	281.2	116.7	238.7
M(r) even	0	65.21	36.03	10.97	-9.96	-26.8	-39.44	-48	-52.4	-52.7	-48.9	-40.9	-28.8	-12.6	7.776	32.25	93.59	130.5	171.4	216.6	265.8	53.78	246.9
70% max	0	135.2	68.15	8.768	-19.9	-33.4	-44.05	-51.8	-56.7	-58.6	-57.7	-53.9	-47.2	-37.6	-25.1	-9.76	29.64	63.32	128.3	201	281.2	109.1	250.2
70% min	0	38.04	15.84	-3.46	-45.6	-87.4	-123.6	-152	-174	-187	-193	-192	-182	-165	-141	-109	-21.4	33.62	80.61	110.4	143.1	29.38	130.5
Lower bound	0	0	0	-29	-104	-169	-222.6	-265	-297	-318	-328	-327	-315	-293	-259	-215	-92.9	-15.7	0	0	0	29.38	130.5
Upper bound	0	154.5	68.15	10.97	0	0	0	0	0	0	0	0	0	0	7.776	32.25	93.59	130.5	171.4	216.6	281.2	116.7	250.2
Beam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LO		4	4	0.8	4	4	4	4	4	4	4	6	8	8	8	8	8	6.8	8	8	8		

SPAN 2

Local X		0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3	3.3	3.6	3.9	4.2	4.8	5.1	5.4	5.7	6	0.15	5.85
X		8	8.3	8.6	8.9	9.2	9.5	9.8	10.1	10.4	10.7	11	11.3	11.6	11.9	12.2	12.8	13.1	13.4	13.7	14		
M(e) all		348.1	275.4	208.9	148.5	94.19	46.05	4.04	-31.8	-61.6	-85.2	-103	-114	-119	-118	-111	-78.9	-53.4	-21.9	15.82	59.64	311	36.96
M(e) odd		250.1	215.3	182.9	152.8	125	99.51	76.35	55.52	37.01	20.83	6.964	-4.58	-13.8	-20.7	-25.3	-27.5	-25.1	-20.4	-13.3	-3.97	232.4	-8.94
M(e) even		229.8	164.4	105.1	51.91	4.882	-36.02	-70.8	-99.4	-122	-138	-149	-153	-151	-142	-128	-81.3	-48.6	-9.8	35.14	86.2	196.3	59.9
Beam		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M(r) all		281.2	211.9	148.7	91.64	40.71	-4.086	-42.8	-75.3	-102	-122	-136	-144	-146	-142	-131	-92.2	-63.5	-28.6	12.48	59.64	245.8	35.29
M(r) odd		281.2	244.9	210.9	179.2	149.9	122.8	98.13	75.75	55.68	37.94	22.52	9.421	-1.36	-9.81	-15.9	-21.2	-20.4	-17.3	-11.8	-3.97	262.8	-8.16
M(r) even		281.2	213.2	151.4	95.62	46.02	2.554	-34.8	-66	-91.1	-110	-123	-130	-130	-124	-113	-71	-40.9	-4.65	37.71	86.2	246.4	61.19
70% max		243.6	192.8	146.2	106.9	87.49	69.66	53.45	38.87	25.91	14.58	4.874	-3.21	-9.66	-14.5	-17.7	-19.2	-17.6	-6.86	24.6	60.34	217.7	41.93
70% min		160.8	115.1	73.55	36.34	3.417	-25.21	-49.5	-69.6	-85.3	-96.8	-104	-107	-105	-99.7	-89.8	-56.9	-37.4	-15.3	-9.33	-2.78	137.4	-6.26
Lower bound		0	0	0	0	0	-25.21	-49.5	-75.3	-102	-122	-136	-144	-146	-142	-131	-92.2	-63.5	-28.6	-11.8	-3.97	137.4	-8.16
Upper bound		281.2	244.9	210.9	179.2	149.9	122.8	98.13	75.75	55.68	37.94	22.52	9.421	0	0	0	0	0	0	37.71	86.2	262.8	61.19
Beam		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LO		3	3	3	3	3	3	1.8	3	3	3	3.6	6	6	6	6	6	6	5.4	6	6		

SPAN 3

Local X		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0
X		14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14		
M(e) all		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M(e) odd		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M(e) even		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beam		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M(r) all		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M(r) odd		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M(r) even		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70% max		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70% min		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower bound		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper bound		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beam		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LO		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

PL 2	0	0	
	45.8	45.8	
	45.8	45.8	

MOMENT DIAGRAMS

SPAN 1

X	0	0	0.4
M(e) all	0	179.5	87.03
M(e) odd	0	193.1	97.35
M(e) even	0	54.34	22.63
Beam	0	0	0
M(r) all	0	154.5	57.26
M(r) odd	0	154.5	57.26
M(r) even	0	65.21	36.03
70% max	0	135.2	68.15
70% min	0	38.04	15.84
Lower bound	0	0	0
Upper bound	0	154.5	68.15
Beam	0	0	0
LO		4	4

SPAN 2

Local X		0	0.3
X		8	8.3
M(e) all		348.1	275.4

RCC42 Post-tensioned Slabs & Beams (A & D).xls

This spreadsheet designs post-tensioned slab and beam elements in accordance with BS 8110: Part 1, 1997. In essence the spreadsheet checks a number of parameters: stresses at transfer, stresses in service, moments of resistance at ULS, shear, vibration, deflection, neutral axis depth, and reinforcement service stress. These checks are shown in SUMMARY!

The spreadsheet is set out in several layers.

- **MATDATA!** Defines load cases, various options and material properties.
- **SUMMARY!** Summarises the design, analysis, checks and outputs from the rest of the spreadsheet.
- **DETAILS!** Shows the workings for the moment distribution for the various load cases, profiles, prestress losses and checks in some detail.
- **DEFLECT!** Shows workings for deflection at $^1/20$ points along each span.
- **Graf!** Provides the data for the graphs, and values generated are used for checking.

Users are referred to *Post-tensioned concrete floors – Design Handbook*(14), and *Post-tensioned concrete floors*(16) for further details of methods and values used.

A maximum of three spans may be considered. Cantilevers are not available. Shortening is calculated in the losses section, but is not used to modify column moments. The effects of restraint to both columns and prestress in the member must be considered. The spreadsheet considers one direction at a time only.

MATDATA!

The first sheet includes all the general and material input data used in the subsequent sheets. Load combinations and load factors are defined. The input under *Options* should be self-explanatory. The choices have implications on the design as shown below.

- Stressing ends determines where prestressing losses occur
- Prestressing system – Specifying unbonded or bonded changes prestress loss calculations. Prestress losses tend to be higher with bonded tendons as wobble factors and coefficients of friction are higher but using several strands in a single duct can lead to overall economy, especially in more heavily loaded beams.
- Commonly 70% to 75% is taken for initial estimates for jacking force/final force. This quantity is calculated at Details!N68:N69 and has to be re-specified in Details! line 68 to be within 5 % of that calculated.
- With respect to allowable flexural tensile stresses in prestressed beams (and slabs), BS 8110: Part 1, defines three classes (see Clause 4.3.4.3). These classes determine the limits of tensile stress. For example see BS 8110: Part 1, Clause 4.1.3, which also allows 5.0N/mm² tensile strength for C40 concrete. For Class 3, which is generally used for internal environments, cracking is allowed either up to 0.1 mm or, more usually, to 0.2 mm.
- *Slab or Beam* varies shear requirements and determines whether nominal top bonded reinforcement is included in the spans or not. Nominal top steel is included in mid-span of beams. If slabs are specified, the user may choose to use nominal top steel to overcome hogging moments in the spans. Invoking the nominal bonded reinforcement in mid-span should overcome most problems with hogging in, say, dissimilar spans of slabs. *Slabs* requires a second input; type of slab alters parameters used in checking vibration.
- Normal curtailment rules for bonded reinforcement are not necessarily satisfactory for post-tensioned slabs and beams. Nonetheless the spreadsheet assumes that curtailment occurs at 0.3 x span.

With regard to concrete, the usual minimum strength used in prestressing is 40 N/mm². The minimum allowable strength at transfer (i.e. when the tendons are initially stressed), f_{ci}, is 25 N/mm². Ambient temperatures during curing may be taken as 15°C for a UK summer, but otherwise may be dependent upon curing/insulation regimes. Typically, long-term Relative Humidity may be taken as 45% indoors, or 85% outdoors for the UK. Other data used in the determination of various concrete factors, e.g. determination of creep factors, is shown on the right hand side of the sheet. These factors are case specific and have been derived from the best available data for the various parameters shown. The formulae for calculating creep factors and free shrinkage strain are from C&CA paper TDH 2391(17), and use the following factors.

- K_b is a factor depending on the composition of the concrete,
- K_c is an environmental factor,
- K_d is a maturity factor,
- K_e is an effective member thickness factor, and
- K_t covers the development of the deferred deformation with time.

Factors used in the derivation of material data are shown on the next page as screen dump from the right hand side of this sheet.

Details of strand used in the UK are given at the bottom of the sheet. Users should ensure that their chosen strand is readily available. *Post-tensioned concrete floors*(16) gives typical values for m (coefficient of friction), K (wobble factors), Rel% (relaxation) and draw-in (mm) in Tables 2.6 and 7.1.

It is usually assumed that working loads are applied at a concrete age of 60 days (user input). The quasi-permanent imposed load should be assessed from the y_2 factor in EC2, which is usually 20% of imposed load for dwellings, 30% for offices and stores, and 60% for parking. (*One never takes 100%, as y_2 adjusts for the very different f (creep) values. Hence 30% is appropriate for more or less permanently loaded structures: the high value for parking is to compensate for long-term dynamic effects.*)

Factors used in the derivation of material data

BS 8110 Table 4.2			
30	3.8	0	3.2048
40	5	5	0
50	5.8	0	0

		1.271	1.267	1.258	1.249	1.245	1.235	1.225	1.210	1.195	1.185	1.170	1.160	1.145	1.110	1.075
Maturity Curve		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	0	0.8	1	1.5	2	2.5	3	4	5	6	7	8	9	10	13	16
	0.8	0.2	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1	3	3	4
30	0	2.6	4.5	7.9	10.3	12.2	13.7	16.2	18	19.5	20.6	21.7	22.6	23.2	25.2	26.5
40	0	5.2	7.8	12.2	15.5	18.1	20.1	23.2	25.5	27.3	29	30.4	31.3	32.2	34.5	36.1
50	0	11.4	12.7	18.1	22.2	25.1	27.3	31.1	33.7	35.8	37.8	39.2	40.3	41.3	43.9	45.5
60	0	13.7	15.2	21.7	26.6	30.1	32.8	37.3	40.4	43	45.4	47	48.4	49.6	52.7	54.6
40	0	5.2	7.8	12.2	15.5	18.1	20.1	23.2	25.5	27.3	29	30.4	31.3	32.2	34.5	36.1
50	0	11.4	12.7	18.1	22.2	25.1	27.3	31.1	33.7	35.8	37.8	39.2	40.3	41.3	43.9	45.5
40	0	5.2	7.8	12.2	15.5	18.1	20.1	23.2	25.5	27.3	29	30.4	31.3	32.2	34.5	36.1

Longterm	fcu inf	Et inf
	40	28.00

EARLY STRENGTH				
1	4	0.8	5.8	
40	23.2	25.5	2.3	25.04

LATE STRENGTH				
40	60	0	100	
40	38.9	40	1.1	38.90

Kc = Relative Humidity factor														
30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
3.2	3.13	3.05	2.95	2.85	2.77	2.65	2.5	2.3	2.13	1.9	1.7	1.5	1.25	1
50	55	2.85	2.77	0.08	0	2.850								

Kd = Ambient factor							
30	90	210	420	840	2700	5400	10800
60	120	210	420	1860	2700	5400	
1.8	1.6	1.4	1.2	1	0.75	0.65	0.5
120	120	1.6	1.4	0.2	30	1.550	
1500	1860	1	0.75	0.25	660	0.911	1.000

Kb = Cement Content & W/C Ratio factor							
	0.4	0.5	0.6	0.7	0.8		
200		0.5	0.8	1.02	1.28		
300	0.7	0.9	1.17	1.48	1.82		
400	0.83	1.17	1.63	2.1	2.55		
500	0.97	1.45	2	2.55	3.1	0.5	
300	0.7	0.9	1.17	1.48	1.82	0.981	
400	0.83	1.17	1.63	2.1	2.55	1.308	
	0.739	0.981	1.308	1.666	2.039	0.327	1.145

Ke = Effective Thickness factor			406.5	406.5	#DIV/0!					
0	50	100	150	200	250	300	350	400	450	500
10	1.2	1	0.94	0.85	0.795	0.75	0.733	0.72	0.709	0.7
Span 1	400	450	0.72	0.709	0.011	6.5	0.719			
Span 2	400	450	0.72	0.709	0.011	6.5	0.719			
Span 3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!			

εc = Free Shrinkage Strain												
40	45	50	55	60	65	70	75	80	85	90	95	100
420	405	380	360	330	305	275	243	205	162	115	58.5	0
50	55	380	360	20	0	380						

Ke factor for Shrinkage										
0	50	100	150	200	250	300	350	400	450	500
10	1.3	1.05	0.907	0.8	0.71	0.65	0.587	0.55	0.513	0.5
Span 1	400	450	0.55	0.513	0.037	6.5	0.548			
Span 2	400	450	0.55	0.513	0.037	6.5	0.548			
Span 3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!			

Ultimate Shrinkage Strain - Bending												Kt
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	0.93143
%	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	
Kp	0.9418	0.9418	0.9418	0.9418	0.9418	0.9418	0.9418	0.9418	0.9418	0.9418	0.9418	
εcs	208.9	208.9	208.9	208.9	208.9	208.9	208.9	208.9	208.9	208.9	208.9	microstrain
	m 23.3039			Ec 28 28			Ø 2.3462		Ec 8.3677		Ks = 23.75	

Ultimate Shrinkage Strain - Prestress			
	Span 1	Span 2	Span 3
%	0.3	0.3	0.3
Kp	0.9335	0.9335	0.9335
εcs	207.1	207.1	#DIV/0!

SUMMARY!

The first page (top part of the sheet entitled SUMMARY!) shows input for the sub-frame analysis, i.e. dimensions and loads.

Input should be fairly self explanatory. It should be noted that H is in the plane of the screen and b, b_w etc. at right angles to the plane of the screen. Several warnings are given under *Operating Instructions;* conditional formatting of cells flags incorrect data.

Supports can be made to be knife-edge by inputting K in column D: remote ends of columns can be either F for fixed, or P for pinned. The line can be left blank. A support width (h below) can be used in conjunction with a 'K' support so that design moments are used at the support face.

Data under 'Normal Direction' is used for the vibration checks. The number of bays affects possible modes of vibration, which is checked in accordance with CS TR43 [14]. The vibration response factors calculated are accordance with Steel Construction Institute[18] and Concrete Society guidelines.

Vibration should not be a problem in post-tensioned slabs and beams. Normally, vibration response factors of 12 are used for very busy offices, 8 for normal offices, or 4 for high specification offices or laboratories where vibration is critical.

Loads are characteristic and are for the whole bay width (not expressed as kN/m² – unless a 1 m bay width is being analysed). The self-weight is a user input. The construction load is intended to be that required to be applied during transfer (usually 1.5 kN/m²). However, designers should consider the load history of the slab to ensure worst cases are checked, e.g. temporary loads while casting floors above. Bay widths in the normal direction do not affect the loading unless, of course, the user chooses to introduce a suitable relationship (in the loads input).

The current configuration is shown in a chart. This gives a scale representation of the spans, supports, loads and an idealised cross section of each member. Charts also show representations of the tendon profiles and equivalent loads used in the analysis. For the tendons, a reversed parabolic profile is used but minimum lengths of straight tendon are used at the supports as recommended by Khan [16]. Service equivalent loads are shown: those at transfer may be viewed at DETAILS!B361:N372.

The next page (SUMMARY ii) as shown below is the nub of the spreadsheet: it has a number of key inputs and outputs. These include inputs of P_i / P_j (initial force/ jacking force), P_f / P_j (final force/ jacking force), number and height of tendons, and amounts of bonded reinforcement (some of the inputs are necessary to avoid circular arguments).

As it is the nub of this spreadsheet the source of any failures or missing information (e.g. no tendons or no tendon height specified) will become apparent in SUMMARY ii. It is suggested that users may wish to create a second window of this part of the spreadsheet (Window/ New Window/ Arrange).

Extract from SUMMARY ii

SUMMARY ii: Tendons & bonded reinforcement

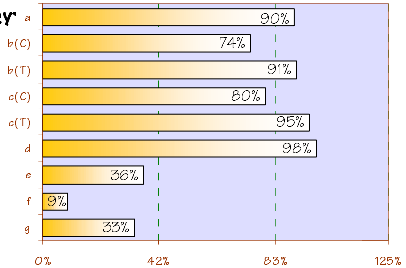
(a) **TENDONS** Pj = 130 kN Pf/Pi = 90.0% Pf/Pj = 80.0% kN

No of STRANDS	Supt 1	Span 1	Supt 2		Span 2	Supt 3		Span 3	Supt 4
Recommended	23	23	23	25	25	25	0	0	0
Use	24	24	24	24	24	24	0	0	0
Recommend'd height	295	40	485		40	295		0	
Height mm	300	40	480	480	40	300	300	0	
Length Straight mm	150		150	150		0	0		0
x to max Sag mm		5311			7006			0	
Pi kN	2765	2759	2757	2757	2759	2765	0	0	0
Balance Load kN	278.0		371.3	354.2		261.2	0.0		0.0
Pf kN	2501	2496	2493	2493	2496	2501	0	0	0
Balance Load kN	251.5		335.8	320.4		236.2	0.0		0.0

CHECKS

Tendons (a) OK
Stresses at transfer (b) OK
Stresses in service (c) OK
ULS MOR (d) OK
Shear (e) OK
Vibration (f) OK
Deflection (g) OK
Neutral axis depth OK
Rebar stress OK

'EFFICIENCY'



GLOBAL STATUS **VALID DESIGN**

With regard to *Tendons* the spreadsheet automatically calculates the number of tendons for each span using an algorithm. The algorithm uses either the maximum of the median stress levels, or the maximum permitted. The spreadsheet calculates the minimum number of strands required so that permissible concrete tensions are not exceeded at either the initial or final stage. Thus the numbers of tendons are then shown as recommended values, and the user can override them if required. Once the number of tendons for each span has been fixed, the program attempts to find an optimum single level of initial prestress for all strands (this often appears to be the maximum permissible). If the minimum force required generates excessive compressive stresses, the section is deemed to have failed.

Tendons are assumed to be level through supports and follow a parabolic profile between. The points of inflection are taken to be at $^{1}/10$ of the clear span points.

Besides number of tendons, the main user control is to adjust the value of P_f / P_i. This adjusts the number of tendons. One would rarely need to adjust tendon heights.

The checks carried out are listed below.

- Tendons (a)
- Stresses at transfer (b)
- Stresses in service (c)
- ULS MOR (d)
- Shear (e)
- Vibration (f)
- Deflection (g)
- Neutral axis depth
- Rebar stress

In the spreadsheet, those that are unsatisfactory are highlighted and directions are given for further information.

There are also two charts. The 'efficiency' chart gives the user an idea of how hard the section is working or how far it is out. The second chart, ultimate limit state moment envelope and moments of resistance (capacity), should be used in conjunction with choosing amounts of bonded reinforcement.

The third page (SUMMARY iii) shows stresses at transfer and in service in both tabular and chart form. It should be noted that, in keeping with current practice, moments are considered at the face of columns. Thus peak moments are not necessarily at column centrelines and moments might be different each side of an internal column. Definition of tendon height is theoretically for the whole of the profile at supports. The convention used in the stress charts is:

- Red squares – tension, blue circles – compression
- Solid markers – bottom, hollow markers – top
- Dotted lines – permissible stresses

The fourth page (SUMMARY iv) gives details of shear envelopes, vibration and deflection together with support reactions and column moments.

DETAILS!

Over nine pages, DETAILS! shows detailed calculations regarding section properties, distribution factors, moment distribution used for the sub-frame analysis, profiling constants, pre-stressing losses, balanced loads, ULS moment and shear checks, and finally vibration.

DEFLECT!

The deflection sheet gives details of calculations dealing with defections. The sheet entitled Graf! shows graph data extracted from each sheet.

TYPICALC!

This sheet is intended to illustrate typical calculations for a particular point in a span in order to show how all the criteria are satisfied. The sheet illustrates the transfer and service stress checks and the calculation of Moment of Resistance carried out in tabular form in Graf! The point chosen is at ¼ span and is highlighted in Graf!

Graf!

Graf! provides the data for the charts of the configuration and loads, tendon profile, equivalent loads, ULS moments and capacities, shear envelopes, deflections, stresses at transfer and stresses in service within SUMMARY! Each chart is plotted at $^{1}/20$ points along each span. Many values within Graf! are used and checked for being minima or maxima for the various criteria. For instance it may be here that problems with hogging moments are found.

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POST-TENSIONED ANALYSIS & DESIGN to BS 8110:1997 - GENERAL DATA

LOAD COMBINATIONS

INITIAL	SLS 1	Initial prestress + OW + construction load on all spans
	SLS 2	Initial prestress + OW + construction load on odd spans
	SLS 3	Initial prestress + OW + construction load on even spans
FINAL	SLS 4	Final prestress + dead + imposed load on all spans
	SLS 5	Final prestress + dead + imposed load on odd spans
	SLS 6	Final prestress + dead + imposed load on even spans
ULTIMATE	ULS 1	Final prestress + factored dead and imposed load on all spans
	ULS 2	Final prestress + factored dead + factored imposed load on odd spans
	ULS 3	Final prestress + factored dead + factored imposed load on even spans
DEFLECTION	SLS 7	Final prestress + dead + 30% imposed load on odd spans

NOTES

INPUT IS UNDERLINED.
FRAMES ARE
ASSUMED TO BE

LOAD FACTORS

	min	max
DEAD	1	1.4
IMPOSED	0	1.6

VIBRATION

Limiting reponse factor = 8

OPTIONS

Stressing Ends	B	(L, R, B)	Prestress system	U	(U, B)
Jacking F/strength	0.7		BS 8110 Class	3	(Clause 4.1.3)
Slab or beam	B	(B or S)	Limiting crack width	0.2	mm

Assume 20% max redistribution

Damping, ζ (2% to 8%) 5%

MATERIALS

CONCRETE

fcu = 40	Ec28 = 28	σc = 13.20	σt = 5.00	unmodified
At days 4.80 fci = 25.04	Eci = 21.72	σic = 10.02	σit = 3.20	unmodified
Cement content 330	W/C ratio 0.55	OPC or RHPC ? OPC		
Ave ambient during curing = 15°C	Long term R/H % 50	γm = 1.50		

STRAND

fpu = 1860	Ap, mm² = 100	μ = 0.140	K = 0.0010
Ep = 195	Rel % = 2	Draw in = 6	Depth to strand centre = 40

REBAR

fy = 460
γm = 1.05

COVERS

	Top	Bottom	Sides
to links	25	25	25

LOADING SEQUENCE

Permanent loads for Ø assessm 30% of Imposed is permanent

	Load	@Age	fcut	Et	Ø	Ec
	kN/m²	days	N/mm²	kN/mm²	Creep	kN/mm²
Own weight	13.81	4.80	25.04	21.72	3.64	4.68
Applied dead	42.00	60	38.90	27.54	2.14	8.78
Quasi-Permanent Imposed	9.60	- = -				
COMBINED	65.41	-	-	25.59	2.45	7.41

NOTES on MATERIALS

BRITISH LOW RELAXATION STRAND

Type	Dia	Area	Breaking	Weight
Standard	15.2	139	1670	1.090
	12.5	93	1770	0.730
Super	15.7	150	1770	1.180
	12.9	100	1860	0.785
Compact	15.2	165	1820	1.295
	12.7	112	1860	0.890

RELAXATION at 0.7fpu

Ambient°C	20	40	60	80	100
Relaxation	1.8	3.5	5.1	7.5	10.7

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POST-TENSIONED ANALYSIS & DESIGN to BS 8110:1997

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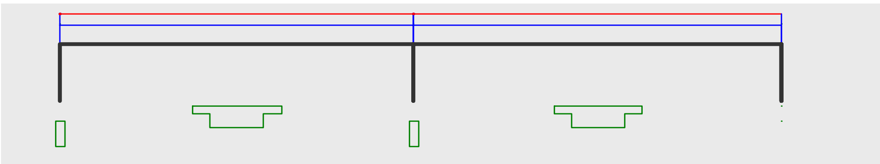
SUMMARY I : Dimensions and Loads

SPANS	L m	H mm	bw mm	hf mm	Section	bf mm	No Bays	BAY WIDTH m
SPAN 1	12.000	525	1800	200	T	3000	5	6.000
SPAN 2	12.500	525	1800	200	T	3000	5	6.000
SPAN 3								

NORMAL DIRECTION

SUPPORTS	ABOVE m	H mm	B mm	End Cond	BELOW m	H mm	B mm	End Cond
SUPPORT 1					4.000	300	600	F
SUPPORT 2					4.000	300	600	F
SUPPORT 3	K							
SUPPORT 4								

CONFIGURATION BEAM supporting Solid Slab to BS8110 Class 3 (0.2 mm crack width), fcu = 40, Stressed from Both Ends



LOADING UDLs~kN/m (char), PLs~kN (char), Position~m

SPAN 1	OW	Applied Dead	Imposed Load	Position from left	Loaded Length
UDL	13.81	42.00	32.00	~~~~~	~~~~~
PL 1					~~~~~
PL 2					~~~~~
PartUDL					
Construction	~~~~~	~~~~~	18.00	~~~~~	~~~~~

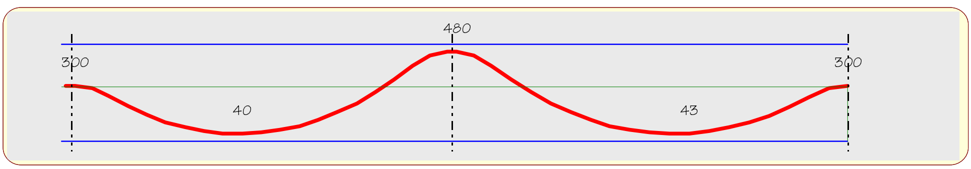
SPAN 2	OW	Applied Dead	Imposed Load	Position from left	Loaded Length
UDL	13.81	42.00	32.00	~~~~~	~~~~~
PL 1					~~~~~
PL 2					~~~~~
PartUDL					
Construction	~~~~~	~~~~~	18.00	~~~~~	~~~~~

SPAN 3	OW	Applied Dead	Imposed Load	Position from left	Loaded Length
UDL				~~~~~	~~~~~
PL 1					~~~~~
PL 2					~~~~~
PartUDL					
C'struction	~~~~	~~~~		~~~~~	~~~~~

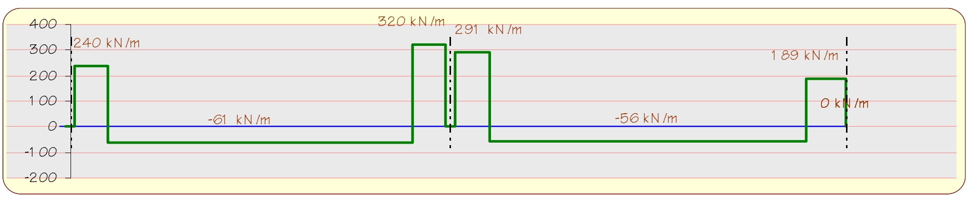
GLOBAL STATUS

VALID DESIGN

TENDON PROFILE (heights to strand centre: see heights specified under TENDONS below)



EQUIVALENT LOADS in service



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SUMMARY ii: Tendons & bonded reinforcement

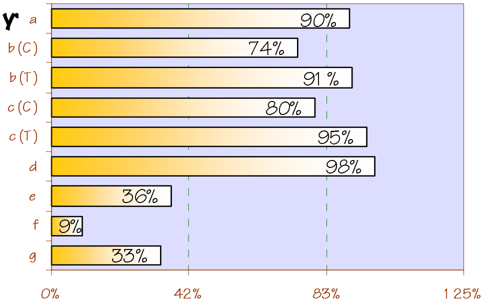
(a) **TENDONS** Pj = 130 kN Pf/Pi = 90.0% Pf/Pj = 80.0% kN

No of STRANDS	Supt 1	Span 1	Supt 2		Span 2	Supt 3		Span 3	Supt 4
Recommended	23	23	23	25	25	25	0	0	0
Use	**24**	**24**	**24**	**24**	**24**	**24**	**0**	**0**	**0**
Recommend'd heigh	295	40	485		40	295		0	
Height mm	300	40	480	480	40	300	300	0	
Length Straight mm	150		150	150		0	0		0
x to max Sag mm		5311			7006			0	
Pi kN	2765	2759	2757	2757	2759	2765	0	0	0
Balance Load kN	278.0		371.3	354.2		261.2	0.0		0.0
Pf kN	2501	2496	2493	2493	2496	2501	0	0	0
Balance Load kN	251.5		335.8	320.4		236.2	0.0		0.0

CHECKS

Tendons (a)	**OK**
Stresses at transfer (b)	**OK**
Stresses in service (c)	**OK**
ULS MOR (d)	**OK**
Shear (e)	**OK**
Vibration (f)	**OK**
Deflection (g)	**OK**
Neutral axis depth	**OK**
Rebar stress	**OK**

'EFFICIENCY'



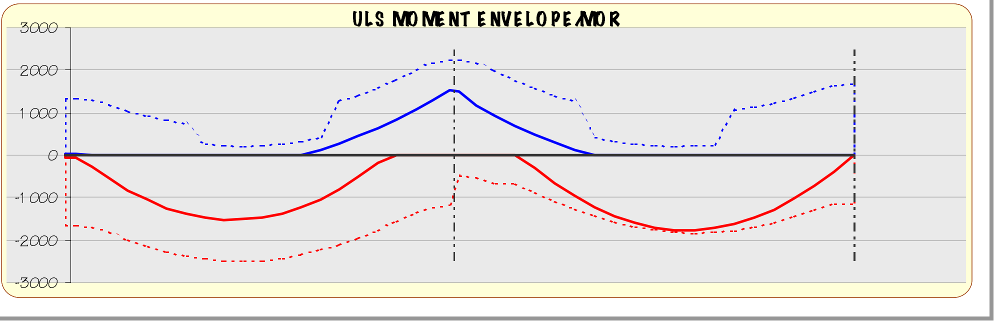
GLOBAL STATUS **VALID DESIGN**

REINFORCEMENT Input bonded rebar arrangement *(Support bars curtailed at 0.3L)*

	Supt 1	Span 1	Supt 2		Span 2	Supt 3		Span 3	Supt 4
Main bar Ø	16	20	20		12	20		20	16
No	20	20	20		20	20		20	20
%	0.426%	0.665%	0.665%		0.239%	0.665%		0.000%	0.000%
Link Ø =	10								
No of legs	8	8	8	8	8	8	8	8	8

(d) **ULS MOMENTS** With bonded reinforcement

	Supt 1	Span 1	Supt 2		Span 2	Supt 3		Span 3	Supt 4
Mu	42.7	1522.1	1531.7	1502.2	1765.2	11.5	0.0	0.0	0.0
MOR	1362.9	2495.4	2252.7	2252.7	1815.1	1681.3	0.0	0.0	0.0



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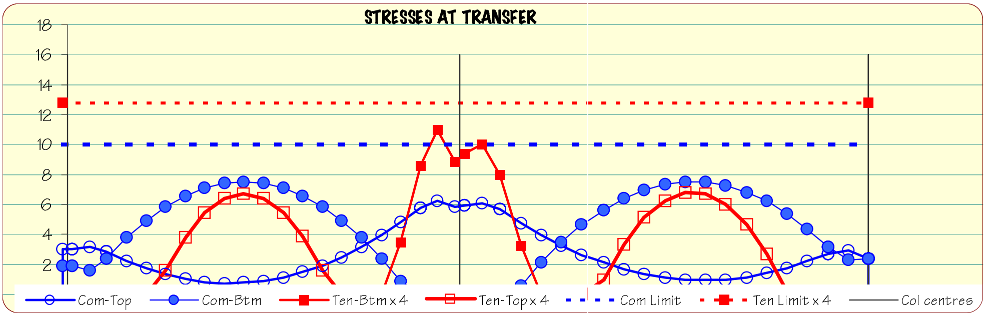
SUMMARY iii STRESSES

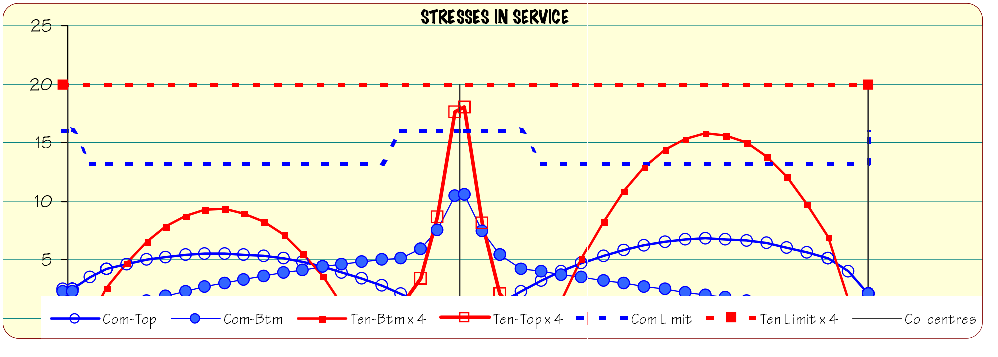
(b) **STRESSES at TRANSFER**

	Supt 1	Span 1	Supt 2		Span 2	Supt 3		Span 3	Supt 4
Tendon height	286.8	41.8	462.3	462.4	41.9	285.2	0.0	0.0	0.0
Pi	2764.9	2759.1	2756.6	2756.6	2759.2	2764.9	0.0	0.0	0.0
Max Compression	3.13	7.49	6.27	6.08	7.51	2.92	0.00	0.00	0.00
Max Tension	0.00	-1.69	-2.75	-2.50	-1.70	0.00	0.00	0.00	0.00



(c) **STRESSES in SERVICE**

	Supt 1	Span 1	Supt 2		Span 2	Supt 3		Span 3	Supt 4
Tendon height	286.8	40.5	462.3	462.4	40.7	285.2	0.0	0.0	0.0
Pf	2501.1	2495.9	2493.3	2493.3	2496.1	2501.1	0.0	0.0	0.0
Max Compression	3.53	5.56	10.49	10.61	6.81	4.06	0.00	0.00	0.00
Max Tension	0.00	-2.33	-4.41	-4.51	-3.95	-0.40	0.00	0.00	0.00



Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
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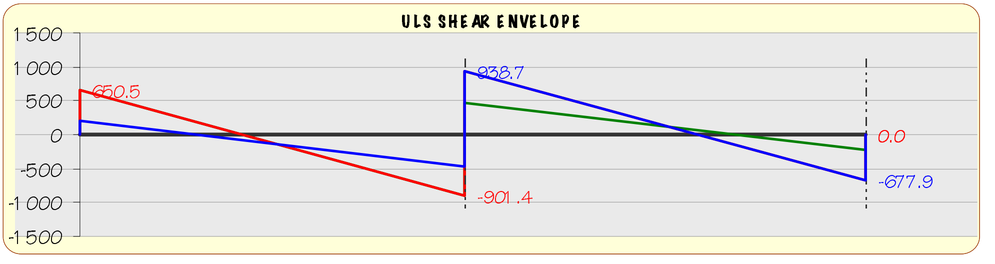
SUMMARY iv

(e) **SHEAR** Link Ø = 10

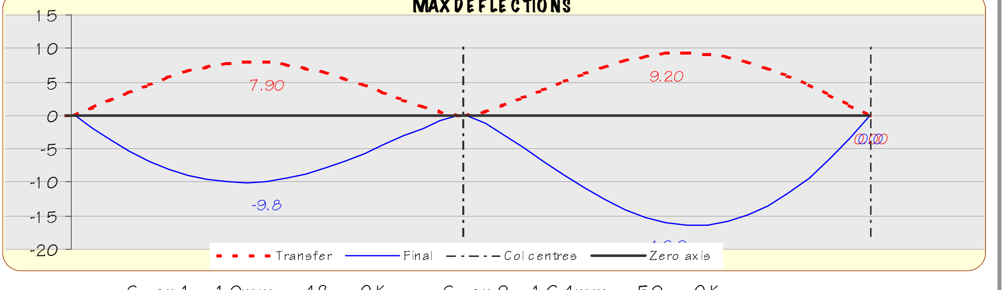
	Span 1 Left	Span 1 Right	Span 2 Left	Span 2 Right	Span 3 Left	Span 3 Right
V	636.0	882.1	919.3	677.9	0.0	0.0
cracked?	N	Y	Y	N	N	N
Vc	1396.8	736.8	757.3	1396.8	0.0	0.0
No of legs	8	8	8	8	8	8
Link spacing	375	375	375	375		



(f) **VIBRATION**

	Span 1	Span 2	Span 3
Response factor	0.62	0.73	0.00
	OK	OK	OK

(g) **DEFLECTION**



Span 1 = 10mm < 48 OK Span 2 = 16.4mm < 50 OK

SUPPORT REACTIONS	Supt 1	Supt 2	Supt 3	Supt 4	
ULS 4	650.5	1840.2	677.9	0.0	kN
ULS 5	655.4	1362.1	232.0	0.0	kN
ULS 6	199.1	1409.3	677.9	0.0	kN
DEAD	274.4	803.8	289.0	0.0	kN
IMPOSED	147.0	484.4	152.6	0.0	kN

COLUMN MOMENTS		Supt 1	Supt 2	Supt 3	Supt 4	
ULS 4	Above	0.00	0.00	0.00	0.00	kNm
	Below	0.00	0.00	0.00	0.00	kNm
ULS 5	Above	0.00	0.00	0.00	0.00	kNm
	Below	0.00	0.00	0.00	0.00	kNm
ULS 6	Above	0.00	0.00	0.00	0.00	kNm
	Below	0.00	0.00	0.00	0.00	kNm

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TYPICAL CALCULATION

BS 8110 Reference

for Span 1 at 3.60 m from C/L of LH support

Class 3 Tee section, h = 525 mm, bw = 1800 mm hf = 200 mm, bf =3000 mm.

Ac = 1185000mm2, Z top = 120.0E6 mm³, and Z bottom = 93.3E6 mm³

Tendons are unbonded, Ap = 100mm2, fpu = 1,860 N/mm2 and 75.9 mm from soffite

There are 24 tendons, jacked to 1,302 N/mm² or 70.0% fpu

Prestress losses at this section are -2,500.7 kN at transfer and -2,237.1 kN longterm

(b) Stresses at transfer 4.3.5

M = 394.4 kNm hogging, and prestressing force = 2,761.1 kN

Max compression (bottom) = M/Z + P/A = 394.4E3 / 93.3 + 2,761.1 / 1185 = 6.56 N/mm²

< 10.02 N/mm² allowed

Max tension (bottom) = M/Z - P/A = -158.3E3 / 93.3 - 2,761.1 / 1185 = 0.96 N/mm²

< 3.00 N/mm² allowed

(c) Stresses in service 4.3.4

M = 400.5 kNm sagging, and prestressing force = 2,497.5 kN

Max compression (top) = 400.46E6 / 120.0E6 + 2,497.5E3 / 1185E3 = 5.44 N/mm²

< 13.33 N/mm² allowed

Max tension (bottom) = 400.46 / 93.3 - 2,497.5 / 1185 = 2.18 N/mm²

< 4.73 N/mm² allowed

(d) MOR at ultimate limit state 4.3.7

M = 1,382.7 kNm sagging, and prestressing force = 2,497.5 kN

fpe = 1000 x 2,497.5 / 24 / 100 = 1,040.6 N/mm²

Reinforcement d = 480 mm

Rp = 1860 x 100 x 24 / 40 / 3000 / (525 - 75.86) = 0.083

fpe/fpu = 1,040.6 / 1860 x 1.05 = 0.587

Lte = 12,250 mm

fpb (unbonded)

= 1,040.6 + 7000 x (525 - 75.86) / 12,250 (1 - 1.7 x 0.083) = 1,261.1 N/mm² Eq 52

Tendon force = 1,261.1 x 24 x 100 / 1000 = 3,026.7 kN

Rebar force = 460 / 1.05 x 6,283 / 1000 = 2,752.6 kN

Total tensile force = 3,026.7 + 2,752.6 = 5,779.4 kN

Compression block depth, dn = 1000 / 5,779.4 / 0.45 / 40 / 3000 = 107.03 mm

MOR = (3,026.7 (525 - 75.9 - 107.03 / 2) + 2,752.6 x (480 - 107.03 / 2)) / 1000 Eq 51

= 2,371.4 kNm > 1,382.7 ok

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DETAILED CALCULATIONS

SECTION PROPERTIES

	Supt 1	Span 1	Supt 2		Span 2	Supt 3		0	0
Flange area, Af		240000			240000			0	
Web area, Aw		945000			945000			0	
Total area, Ac		1185000			1185000			0	
Flange Yf		100			100			0	
Web Yw		262.5			262.5			0	
Σ = Ac.Yt		2.7E+08			2.7E+08			0	
Yt		229.59			229.59			0.00	
Yb		295.41			295.41			0.00	
If		4.8E+09			4.8E+09			0	
Iw		2.3E+10			2.3E+10			0	
Σ = Ixx		2.8E+10			2.8E+10			0	
Zt		1.2E+08			1.2E+08			0	
Zb		9.3E+07			9.3E+07			0	
em	4.59	255.41	184.59	184.59	255.41	4.59	300.00	0.00	#######
St	1.045	-1.521	2.822	2.822	-1.521	1.045	0.000	0.000	0.000
Sb	0.942	4.244	-1.345	-1.345	4.244	0.942	0.000	0.000	0.000

DISTRIBUTION FACTORS

	SUPT 1			SUPT 2				SUPT 3				SUPT 4		
	Up col	Lo col	R	L	Up col	Lo col	R	L	Up col	Lo col	R	L	Up col	Lo col
I	0	1.35E+09	2.76E+10	2.76E+10	0	1.35E+09	2.76E+10	2.76E+10	0	0	0	0	0	0
Stiffness	0	3.38E+08	2.3E+09	2.3E+09	0	3.38E+08	2.2E+09	2.2E+09	0	0	0	0	0	0
Sum			2.63E+09	4.84E+09				2.2E+09				0		
Factor	0.0000	0.1281	0.8719	0.4746	0.0000	0.0697	0.4556	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000

Partial UDL factors

	1	2	3
a	0	0	0
b	0	0	0

FIXED END MOMENTS

OWN WEIGHT	SPAN 1		SPAN 2		SPAN 3	
	L	R	L	R	L	R
Cant		994.0	1078.6		0.0	
UDL	165.7	165.7	179.8	179.8	0.0	0.0
PL 1	0.0	0.0	0.0	0.0	#DIV/0!	#DIV/0!
PL 2	0.0	0.0	0.0	0.0	#DIV/0!	#DIV/0!
partUDL	0.0	0.0	0.0	0.0	0.0	0.0
FEM	165.7	165.7	179.8	179.8	0.0	0.0
IMPOSED						
Cant		2304.0	2500.0		0.0	
UDL	384.0	384.0	416.7	416.7	0.0	0.0
PL 1	0.0	0.0	0.0	0.0	#DIV/0!	#DIV/0!
PL 2	0.0	0.0	0.0	0.0	#DIV/0!	#DIV/0!
partUDL	0.0	0.0	0.0	0.0	0.0	0.0
FEM	384.0	384.0	416.7	416.7	0.0	0.0

APPLIED DEAD	SPAN 1		SPAN 2		SPAN 3	
	L	R	L	R	L	R
Cant		3024.0	3281.3		0.0	
UDL	504.0	504.0	546.9	546.9	0.0	0.0
PL 1	0.0	0.0	0.0	0.0	#DIV/0!	#DIV/0!
PL 2	0.0	0.0	0.0	0.0	#DIV/0!	#DIV/0!
partUDL	0.0	0.0	0.0	0.0	0.0	0.0
FEM	504.0	504.0	546.9	546.9	0.0	0.0
CONSTRUCTION						
Cant		1296.0	1406.3		0.0	
UDL	216.0	216.0	234.4	234.4	0.0	0.0
FEM	216.0	216.0	234.4	234.4	0.0	0.0

MOMENT DISTRIBUTION

	HiCol	SUPT 1	LoCol	HiCol	SUPT 2		LoCol	HiCol	SUPT 3		LoCol	HiCol	SUPT 4	LoCol
		-165.7			165.7					0.0			0.0	
OWN WEIGHT	0.0	144.4	21.2	0.0	-78.6	-75.5	-11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		-39.3			72.2	0.0			-37.7	0.0			0.0	
ODD SPANS	0.0	34.3	5.0	0.0	-34.3	-32.9	-5.0	0.0	37.7	0.0	0.0	0.0	0.0	0.0
		-17.1			17.1	18.9			-16.5	0.0			0.0	
	0.0	14.9	2.2	0.0	-17.1	-16.4	-2.5	0.0	16.5	0.0	0.0	0.0	0.0	0.0
		-8.5			7.5	8.2			-8.2	0.0			0.0	
	0.0	7.5	1.1	0.0	-7.5	-7.2	-1.1	0.0	8.2	0.0	0.0	0.0	0.0	0.0
		-3.7			3.7	4.1			-3.6	0.0			0.0	
	0.0	3.2	0.5	0.0	-3.7	-3.6	-0.5	0.0	3.6	0.0	0.0	0.0	0.0	0.0
		-1.9			1.6	1.8			-1.8	0.0			0.0	
	0.0	1.6	0.2	0.0	-1.6	-1.6	-0.2	0.0	1.8	0.0	0.0	0.0	0.0	0.0
		-0.8			0.8	0.9			-0.8	0.0			0.0	
	0.0	0.7	0.1	0.0	-0.8	-0.8	-0.1	0.0	0.8	0.0	0.0	0.0	0.0	0.0
Σ	0.0	-30.4	30.4	0.0	125.1	-104.0	-21.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Project **Spreadsheets to BS 8110**		REINFORCED CONCRETE COUNCIL			
Client **Advisory Group**		Made by	Date	Page	
Location **Level 2 - Beam on Grid 7**		RMW	01-Sep-99	73	
POST-TENSIONED ANALYSIS & DESIGN to BS8110:1997		Checked	Revision	Job No	
Originated from RCC42.xls on CD	© 1999 RCC	chg	-	R68	

DETAILED CALCULATIONS ii

	HiCol	SUPT 1	LoCol	HiCol	SUPT 2		LoCol	HiCol	SUPT 3		LoCol	HiCol	SUPT 4	LoCol
OWN						-179.8			179.8					
WEIGHT	0.0	0.0	0.0	0.0	85.3	81.9	12.5	0.0	-179.8	0.0	0.0	0.0	0.0	0.0
EVEN		42.7			0.0	-89.9			41.0	0.0			0.0	
SPANS	0.0	-37.2	-5.5	0.0	42.7	41.0	6.3	0.0	-41.0	0.0	0.0	0.0	0.0	0.0
		21.3			-18.6	-20.5			20.5	0.0			0.0	
	0.0	-18.6	-2.7	0.0	18.5	17.8	2.7	0.0	-20.5	0.0	0.0	0.0	0.0	0.0
		9.3			-9.3	-10.2			8.9	0.0			0.0	
	0.0	-8.1	-1.2	0.0	9.3	8.9	1.4	0.0	-8.9	0.0	0.0	0.0	0.0	0.0
		4.6			-4.0	-4.5			4.5	0.0			0.0	
	0.0	-4.0	-0.6	0.0	4.0	3.9	0.6	0.0	-4.5	0.0	0.0	0.0	0.0	0.0
		2.0			-2.0	-2.2			1.9	0.0			0.0	
	0.0	-1.8	-0.3	0.0	2.0	1.9	0.3	0.0	-1.9	0.0	0.0	0.0	0.0	0.0
		1.0			-0.9	-1.0			1.0	0.0			0.0	
	0.0	-0.9	-0.1	0.0	0.9	0.8	0.1	0.0	-1.0	0.0	0.0	0.0	0.0	0.0
Σ	**0.0**	**10.4**	**-10.4**	**0.0**	**127.9**	**-151.8**	**23.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
IMPOSED		-384.0			384.0					0.0			0.0	
ODD	0.0	334.8	49.2	0.0	-182.3	-175.0	-26.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SPANS		-91.1			167.4	0.0			-87.5	0.0			0.0	
	0.0	79.5	11.7	0.0	-79.5	-76.3	-11.7	0.0	87.5	0.0	0.0	0.0	0.0	0.0
		-39.7			39.7	43.7			-38.1	0.0			0.0	
	0.0	34.6	5.1	0.0	-39.6	-38.0	-5.8	0.0	38.1	0.0	0.0	0.0	0.0	0.0
		-19.8			17.3	19.1			-19.0	0.0			0.0	
	0.0	17.3	2.5	0.0	-17.3	-16.6	-2.5	0.0	19.0	0.0	0.0	0.0	0.0	0.0
		-8.6			8.6	9.5			-8.3	0.0			0.0	
	0.0	7.5	1.1	0.0	-8.6	-8.3	-1.3	0.0	8.3	0.0	0.0	0.0	0.0	0.0
		-4.3			3.8	4.1			-4.1	0.0			0.0	
	0.0	3.8	0.6	0.0	-3.8	-3.6	-0.6	0.0	4.1	0.0	0.0	0.0	0.0	0.0
		-1.9			1.9	2.1			-1.8	0.0			0.0	
	0.0	1.6	0.2	0.0	-1.9	-1.8	-0.3	0.0	1.8	0.0	0.0	0.0	0.0	0.0
Σ	**0.0**	**-70.4**	**70.4**	**0.0**	**289.9**	**-241.0**	**-48.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
IMPOSED						-416.7			416.7				0.0	
EVEN	0.0	0.0	0.0	0.0	197.8	189.8	29.1	0.0	-416.7	0.0	0.0	0.0	0.0	0.0
SPANS		98.9			0.0	-208.3			94.9	0.0			0.0	
	0.0	-86.2	-12.7	0.0	98.9	94.9	14.5	0.0	-94.9	0.0	0.0	0.0	0.0	0.0
		49.4			-43.1	-47.5			47.5	0.0			0.0	
	0.0	-43.1	-6.3	0.0	43.0	41.3	6.3	0.0	-47.5	0.0	0.0	0.0	0.0	0.0
		21.5			-21.6	-23.7			20.6	0.0			0.0	
	0.0	-18.7	-2.8	0.0	21.5	20.6	3.2	0.0	-20.6	0.0	0.0	0.0	0.0	0.0
		10.7			-9.4	-10.3			10.3	0.0			0.0	
	0.0	-9.4	-1.4	0.0	9.3	9.0	1.4	0.0	-10.3	0.0	0.0	0.0	0.0	0.0
		4.7			-4.7	-5.2			4.5	0.0			0.0	
	0.0	-4.1	-0.6	0.0	4.7	4.5	0.7	0.0	-4.5	0.0	0.0	0.0	0.0	0.0
		2.3			-2.0	-2.2			2.2	0.0			0.0	
	0.0	-2.0	-0.3	0.0	2.0	1.9	0.3	0.0	-2.2	0.0	0.0	0.0	0.0	0.0
Σ	**0.0**	**240**	**-240**	**0.0**	**296.4**	**-351.8**	**55.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
APPLID		-504.0			504.0					0.0			0.0	
DEAD	0.0	439.4	64.6	0.0	-239.2	-229.6	-35.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ODD		-119.6			219.7	0.0			-114.8	0.0			0.0	
SPANS	0.0	104.3	15.3	0.0	-104.3	-100.1	-15.3	0.0	114.8	0.0	0.0	0.0	0.0	0.0
		-52.1			52.1	57.4			-50.1	0.0			0.0	
	0.0	45.5	6.7	0.0	-52.0	-49.9	-7.6	0.0	50.1	0.0	0.0	0.0	0.0	0.0
		-26.0			22.7	25.0			-25.0	0.0			0.0	
	0.0	22.7	3.3	0.0	-22.7	-21.8	-3.3	0.0	25.0	0.0	0.0	0.0	0.0	0.0
		-11.3			11.3	12.5			-10.9	0.0			0.0	
	0.0	9.9	1.5	0.0	-11.3	-10.8	-1.7	0.0	10.9	0.0	0.0	0.0	0.0	0.0
		-5.7			4.9	5.4			-5.4	0.0			0.0	
	0.0	4.9	0.7	0.0	-4.9	-4.7	-0.7	0.0	5.4	0.0	0.0	0.0	0.0	0.0
		-2.5			2.5	2.7			-2.4	0.0			0.0	
	0.0	2.1	0.3	0.0	-2.5	-2.4	-0.4	0.0	2.4	0.0	0.0	0.0	0.0	0.0
Σ	**0.0**	**-92.4**	**92.4**	**0.0**	**380.5**	**-316.3**	**-64.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Project **Spreadsheets to BS 8110**	REINFORCED CONCRETE COUNCIL		
Client **Advisory Group**	Made by **RMW**	Date **01-Sep-99**	Page **74**
Location **Level 2 - Beam on Grid 7**			
POST-TENSIONED ANALYSIS & DESIGN to BS 8110:1997	Checked **chg**	Revision **-**	Job No **R68**
Originated from RCC42.xls on CD © 1999 RCC			

DETAILED CALCULATIONS iii

	HiCol	SUPT 1	LoCol	HiCol	SUPT 2		LoCol	HiCol	SUPT 3		LoCol	HiCol	SUPT 4	LoCol
APPLID						-546.9			546.9				0.0	
DEAD	0.0	0.0	0.0	0.0	259.6	249.2	38.1	0.0	-546.9	0.0	0.0	0.0	0.0	0.0
EVEN		129.8			0.0	-273.4			124.6	0.0			0.0	
SPANS	0.0	-113.2	-16.6	0.0	129.8	124.6	19.1	0.0	-124.6	0.0	0.0	0.0	0.0	0.0
		64.9			-56.6	-62.3			62.3	0.0			0.0	
	0.0	-56.6	-8.3	0.0	56.4	54.2	8.3	0.0	-62.3	0.0	0.0	0.0	0.0	0.0
		28.2			-28.3	-31.1			27.1	0.0			0.0	
	0.0	-24.6	-3.6	0.0	28.2	27.1	4.1	0.0	-27.1	0.0	0.0	0.0	0.0	0.0
		14.1			-12.3	-13.5			13.5	0.0			0.0	
	0.0	-12.3	-1.8	0.0	12.3	11.8	1.8	0.0	-13.5	0.0	0.0	0.0	0.0	0.0
		6.1			-6.1	-6.8			5.9	0.0			0.0	
	0.0	-5.3	-0.8	0.0	6.1	5.9	0.9	0.0	-5.9	0.0	0.0	0.0	0.0	0.0
		3.1			-2.7	-2.9			2.9	0.0			0.0	
	0.0	-2.7	-0.4	0.0	2.7	2.6	0.4	0.0	-2.9	0.0	0.0	0.0	0.0	0.0
Σ	**0.0**	**31.5**	**-31.5**	**0.0**	**389.0**	**-461.8**	**72.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
CONSTRUCTION ODD SPANS		-216.0			216.0					0.0			0.0	
	0.0	188.3	27.7	0.0	-102.5	-98.4	-15.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		-51.3			94.2	0.0			-49.2	0.0			0.0	
	0.0	44.7	6.6	0.0	-44.7	-42.9	-6.6	0.0	49.2	0.0	0.0	0.0	0.0	0.0
		-22.3			22.3	24.6			-21.5	0.0			0.0	
	0.0	19.5	2.9	0.0	-22.3	-21.4	-3.3	0.0	21.5	0.0	0.0	0.0	0.0	0.0
		-11.1			9.7	10.7			-10.7	0.0			0.0	
	0.0	9.7	1.4	0.0	-9.7	-9.3	-1.4	0.0	10.7	0.0	0.0	0.0	0.0	0.0
		-4.9			4.9	5.3			-4.7	0.0			0.0	
	0.0	4.2	0.6	0.0	-4.8	-4.6	-0.7	0.0	4.7	0.0	0.0	0.0	0.0	0.0
		-2.4			2.1	2.3			-2.3	0.0			0.0	
	0.0	2.1	0.3	0.0	-2.1	-2.0	-0.3	0.0	2.3	0.0	0.0	0.0	0.0	0.0
		-1.1			1.1	1.2			-1.0	0.0			0.0	
	0.0	0.9	0.1	0.0	-1.1	-1.0	-0.2	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Σ	**0.0**	**-39.6**	**39.6**	**0.0**	**163.1**	**-135.6**	**-27.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
CONSTRUCTION: EVEN SPANS						-234.4			234.4					
	0.0	0.0	0.0	0.0	111.2	106.8	16.3	0.0	-234.4	0.0	0.0	0.0	0.0	0.0
		55.6			0.0	-117.2			53.4	0.0			0.0	
	0.0	-48.5	-7.1	0.0	55.6	53.4	8.2	0.0	-53.4	0.0	0.0	0.0	0.0	0.0
		27.8			-24.2	-26.7			26.7	0.0			0.0	
	0.0	-24.2	-3.6	0.0	24.2	23.2	3.6	0.0	-26.7	0.0	0.0	0.0	0.0	0.0
		12.1			-12.1	-13.3			11.6	0.0			0.0	
	0.0	-10.5	-1.5	0.0	12.1	11.6	1.8	0.0	-11.6	0.0	0.0	0.0	0.0	0.0
		6.0			-5.3	-5.8			5.8	0.0			0.0	
	0.0	-5.3	-0.8	0.0	5.3	5.0	0.8	0.0	-5.8	0.0	0.0	0.0	0.0	0.0
		2.6			-2.6	-2.9			2.5	0.0			0.0	
	0.0	-2.3	-0.3	0.0	2.6	2.5	0.4	0.0	-2.5	0.0	0.0	0.0	0.0	0.0
		1.3			-1.1	-1.3			1.3	0.0			0.0	
	0.0	-1.1	-0.2	0.0	1.1	1.1	0.2	0.0	-1.3	0.0	0.0	0.0	0.0	0.0
Σ	**0.0**	**13.5**	**-13.5**	**0.0**	**166.7**	**-197.9**	**31.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

ELASTIC SUPPORT MON BEFORE EQUIVALENT LOADING (3.2.1.2.2)

	SUPT 1	SUPT 2		SUPT 3		SUPT 4
		LEFT	RIGHT	LEFT	RIGHT	
SLS 1	46.1	582.8	589.2	0.0	0.0	0.0
SLS 2	59.6	416.0	391.3	0.0	0.0	0.0
SLS 3	6.5	419.7	453.7	0.0	0.0	0.0
SLS 4	127.2	1608.8	1626.7	0.0	0.0	0.0
SLS 5	151.3	1312.4	1274.8	0.0	0.0	0.0
SLS 6	56.8	1318.9	1385.7	0.0	0.0	0.0
SLS 7	102.0	1109.4	1139.4	0.0	0.0	0.0
ULS 1	187.4	2369.6	2395.9	0.0	0.0	0.0
ULS 2	242.6	1688.5	1587.5	0.0	0.0	0.0
ULS 3	25.7	1703.5	1842.2	0.0	0.0	0.0

101.99 1109.4

Min load 1.0 x dead

Max load 0.4 x dead + 1.6 x imposeTable 2.1)

REDISTRIBUTION 20% (3.2.2.1)

	ßb - 80%	ßb + 110%				
Max M	194.1	1916.7		0.0		0.0
ULS 1	194.1	1916.7	1916.7	0.0	0.0	0.0
ULS 2	194.1	1857.4	1746.3	0.0	0.0	0.0
ULS 3	28.2	1873.9	1916.7	0.0	0.0	0.0

Project **Spreadsheets to BS 8110**		REINFORCED CONCRETE COUNCIL			
Client **Advisory Group**		Made by **RMW**	Date **01-Sep-99**	Page **75**	
Location **Level 2 - Beam on Grid 7**					
POST-TENSIONED ANALYSIS & DESIGN to BS 8110:1997		Checked **chg**	Revision **-**	Job No **R68**	
Originated from RCC42.xls on CD	© 1999 RCC				

DETAILED CALCULATIONS iv

TOTAL LOADS

	Span 1				Span 2				0			
	UDL	PL1	PL2	part UD	UDL	PL1	PL2	part UD	UDL	PL1	PL2	part UD
SLS 1	381.7	0.0	0.0	0.0	397.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SLS 2	381.7	0.0	0.0	0.0	172.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SLS 3	165.7	0.0	0.0	0.0	397.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SLS 4	1053.7	0.0	0.0	0.0	1097.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SLS 5	1053.7	0.0	0.0	0.0	697.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SLS 6	669.7	0.0	0.0	0.0	1097.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SLS 7	784.9	0.0	0.0	0.0	817.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ULS 1	1551.9	0.0	0.0	0.0	1616.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ULS 2	1551.9	0.0	0.0	0.0	697.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ULS 3	669.7	0.0	0.0	0.0	1616.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SUPPORT SHEARS BEFORE EQUIVALENT LOADING

	Span 1		Span 2		Span 3	
SLS 1	146.1	235.6	245.9	151.6	0.0	0.0
SLS 2	161.1	220.5	117.6	55.0	0.0	0.0
SLS 3	48.4	117.3	235.1	162.5	0.0	0.0
SLS 4	403.4	650.3	678.9	418.7	0.0	0.0
SLS 5	430.1	623.6	450.8	246.8	0.0	0.0
SLS 6	229.7	440.0	659.6	437.9	0.0	0.0
SLS 7	308.5	476.4	499.9	317.6	0.0	0.0
ULS 1	632.4	919.5	961.6	655.0	0.0	0.0
ULS 2	637.4	914.6	488.5	209.1	0.0	0.0
ULS 3	181.0	488.6	961.6	655.0	0.0	0.0

SLS SPAN MOM BEFORE EQUIVALENT LOADING

		Left	< >	PL1	< >	PL2	< >	Right	Loadings		0	0
SPAN 1												
Elastic V	SLS 3	48.4	0	48.4	0	48.4	100	117.3	13.81	0.00	0.00	0.00
	SLS 5	430.1	0	430.1	0	430.1	100	623.6	87.81	0.00	0.00	0.00
X bar	SLS 3		0.000	0.000	0.000	0.000	3.506		12			
	SLS 5		0.000	0.000	0.000	0.000	4.898		MAX			
Span M	SLS 3	6.5	-6.5	-6.5	-6.5	-6.5	78.4	419.7	78.4			
	SLS 5	151.3	-151.3	-151.3	-151.3	-151.3	902.0	1312.4	902.0	at	4.898	
SPAN 2											0	0
Elastic V	SLS 2	117.6	0	117.6	0	117.6	100	55.0	13.81	0.00	0.00	0.00
	SLS 6	659.6	0	659.6	0	659.6	100	437.9	87.81	0.00	0.00	0.00
X bar	SLS 2		0.000	0	0.000	0	8.518		12.5			
	SLS 6		0.000	0	0.000	0	7.512		MAX			
Span M	SLS 2	391.3	-391.3	-391.3	-391.3	-391.3	109.5	0.0	109.5			
	SLS 6	1385.7	-1385.7	-1385.7	-1385.7	-1385.7	1092.1	0.0	1092.1	at	7.512	
SPAN 3											0	0
Elastic V	SLS 3	0.0	100	0.0	100	0.0	100	0.0	0.00	0.00	0.00	0.00
	SLS 5	0.0	100	0.0	100	0.0	100	0.0	0.00	0.00	0.00	0.00
X bar	SLS 3		0.000	0	0.000	0	0.000		0			
	SLS 5		0.000	0	0.000	0	0.000		MAX			
Span M	SLS 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
	SLS 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	at	0.000	

TENDONS (a) Breaking load = 186.0 Assume 104.2 kN max per strand

	Supt 1	Span 1	Supt 2		Span 2	Supt 3		0	0			
Pf min	0	1390.7	2295.2	2532.7	1959.6	-5314.0	0.0	0.0	0	2532.7	min	0
Pf max	######	2727.9	5106.2	5016.9	2811.7	######	0.0	0.0	0.0	2727.9	max	
MIN		2295.2			2532.7			0.0				
MAX		2727.9	OK		2811.7	OK		0.0	OK	104.2	Pf per strand	
Recomm'ed Number		23			25			1				0.225
Actual Number		24			24			0	Max(MIN):Min(MAX) = 0.9008			
Recomm'ed height		40			40			0		Margin (Min:Max)< 10%		

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
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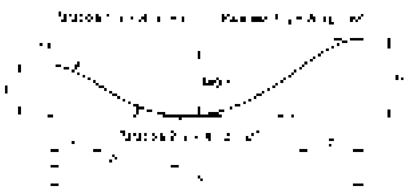
DETAILED CALCULATIONS v

PROFILING

	Span 1	Span 2	0
a	1050	1100	0
X	-0.692	0.4091	0
Y	-1.758	-1.846	0
Z	0.9103	0.8988	0
b	5161	6856	0
c	1050	1250	0
netL	11700	12350	0
y1	260	440	0
y3	440	260	0
A1	-5E-05	-6E-05	0
A2	1E-05	1E-05	0
A3	-6E-05	-4E-05	0
y a	207.1	369.4	0.0
y c	369.4	200.8	0.0



STRESSING LENGTHS

Stressed from BOTH ends

SPAN	No	Length	AVGE
	24	24650	
1	0	24650	24650
	0	12300	
	24	24650	
2	0	12650	24650
	0	12650	
	0	24650	
3	0	12650	0
	0	0	

PRESTRESS LOSSES Pj = 130 kN Ap = 100 Ltmax = 24650

	Supt 1	Span 1	Supt 2		Span 2	Supt 3		0	0
FRICTION & WOBBLE									
Angle θ	0.101		0.135	0.128		0.095	0.000		0.000
x left	0	5161	11700	11700	18556	24050	24050	24050	24050
				0	6856	12350	12350	12350	12350
							0	0	0
x right	24050	18889	12350	12350	5494	0	0	0	0
	24050	18889	12350	12350	5494	0			
	11700	6539	0						
um θ left	0	0.202	0.471	0.471	0.727	0.917	0.917	0.917	0.917
				0.000	0.257	0.446	0.446	0.446	0.446
							0.000	0.000	0.000
m θ right	0.917	0.715	0.446	0.446	0.189	0.000	0.000	0.000	0
	0.917	0.715	0.446	0.446	0.189	0			
	0.471	0.269	0						
from left	0.0	102.6	233.3	233.3	354.4	441.7	441.7	441.7	441.7
	0.0	0.0	0.0	0.0	0.0	0.0			
				0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	0.0	102.6	233.3	233.3	354.4	441.7	441.7	441.7	441.7
from right	441.7	350.6	225.2	225.2	98.4	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0			
				0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	441.7	350.6	225.2	225.2	98.4	0.0	0.0	0.0	0.0
Loss	220.8	226.6	229.2	229.2	226.4	220.8	0.0	0.0	0.0
DRAW-IN									
x left	300	5461	12000	12300	19156	24650	24650	24650	24650
				300	7156	12650	12650	12650	12650
							0	0	0
x right	24350	19189	12650	12350	5494	0	0	0	0
	24350	19189	12650	12350	5494	0			
	12000	6839	300						
Px left(B)	2671.1	2768.0	2890.9	2665.5	2665.5	2665.5	2665.5	2665.5	2665.5
Px right(B)	2676.3	2676.3	2676.3	2897.5	2774.7	2676.3	0.0	0.0	0.0
Loss	113.9	113.9	113.9	113.9	113.9	113.9	0.0	0.0	0.0
ELASTIC LOSS									
Loss	25.1	25.1	25.1	25.1	25.1	25.1	0.0	0.0	0.0
Σ losses	359.9	365.6	368.2	368.2	365.4	359.9	0.0	0.0	0.0
Initial Force	**2765**	**2759**	**2757**	**2757**	**2759**	**2765**	**0**	**0**	**0**
RELAXATION									
Loss	55.3	55.2	55.1	55.1	55.2	55.3	0.0	0.0	0.0
SHRINKAGE									
Loss	96.9	96.9	96.9	96.9	96.9	96.9	0.0	0.0	0.0
CREEP									
Loss	111.6	111.4	111.3	111.3	111.4	111.6	0.0	0.0	0.0
Σ losses	263.8	263.5	263.3	263.3	263.5	263.8	0.0	0.0	0.0
Final Force	**2501**	**2496**	**2493**	**2493**	**2496**	**2501**	**0**	**0**	**0**

Deanna Troi's Table
for Bonded Tendons

ß	Z	Pi	
0.0008	12227	111.1	1 Left
0.0000	0	0.0	2 Left
0.0000	0	0.0	3 Left
0.0000	0	0.0	1 Right
0.0007	12522	111.5	2 Right
0.0000	0	0.0	3 Right

Project **Spreadsheets to BS 8110**	REINFORCED CONCRETE COUNCIL		
Client **Advisory Group**	Made by **RMW**	Date **01-Sep-99**	Page **77**
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POST-TENSIONED ANALYSIS & DESIGN to BS 8110:1997			
Originated from RCC42.xls on CD ©1999 RCC			

DETAILED CALCULATIONS vi

BALANCE LOADS

	Supt 1	Span 1 Left	Span 1 Right	Supt 2 Left	Supt 2 Right	Span 2 Left	Span 2 Right	Supt 3 Left	Supt 3 Right	0 Left	0 Right	0
y1	260	260	440	440	440	440	260	260	0	0	0	0
a	1050	1050	1050	1050	1100	1100	1250	1250	0	0	0	0
b	5161	5161	6539	6539	6856	6856	5494	5494	0	0	0	0
INITIAL PRESTRESS												
V1 = -We	278.03		371.30		354.19		261.16		0.00		0.00	
UDL	264.8	-67.6	-67.6	353.6	322.0	-61.5	61.5	208.9	0.0	0.0	0.0	0.0
FINAL PRESTRESS												
V1 = -We	251.48		335.84		320.36		236.23		0.00		0.00	
UDL	239.5	-61.2	-61.2	319.9	291.2	-55.7	55.7	189.0	0.0	0.0	0.0	0.0

BALANCE LOAD

		Span 1 Left	Span 1 Right	Span 2 Left	Span 2 Right	0 Left	0 Right
CENTR	a/L	0.343		0.460		0.000	
E LEFT	b/L	0.271		0.330		0.100	
	factor	0.132	0.055	0.130	0.073	0.081	0.009
	FEM i	-441.9	-185.0	-576.9	-324.1	0.0	0.0
	FEM f	-399.7	-167.3	-521.8	-293.2	0.0	0.0
E	a/L		0.457		0.340		0.800
RIGHT	b/L		0.671		0.730		0.500
	factor	0.073	0.130	0.055	0.132	0.098	0.098
	FEM i	-324.3	-581.2	-179.5	-432.3	0.0	0.0
	FEM f	-293.3	-525.7	-162.3	-391.0	0.0	0.0
LEFT	a/L	0.088		0.088		#DIV/0!	
END	b/L	0.056		0.056		#DIV/0!	
	factor	0.049	0.004	0.049	0.003	#DIV/0!	#DIV/0!
	FEM i	163.3	11.7	215.7	15.5	0.0	0.0
	FEM f	147.7	10.6	195.1	14.0	0.0	0.0
RIGHT	a/L		0.088		0.100		#DIV/0!
END	b/L		0.944		0.950		#DIV/0!
	factor	0.004	0.049	0.003	0.044	#DIV/0!	#DIV/0!
	FEM i	15.7	218.0	10.1	142.3	0.0	0.0
	FEM f	14.2	197.2	9.1	128.7	0.0	0.0
TOTALS	**FEMi**	**-587.3**	**-536.5**	**-530.6**	**-598.6**	**0.0**	**0.0**
	FEMf	**-531.2**	**-485.2**	**-479.9**	**-541.4**	**0.0**	**0.0**

BALANCE LOAD MOMENT DISTRIBUTION

	HiCol	SUPT 1	LoCol	HiCol	SUPT 2	SUPT 2	LoCol	HiCol	SUPT 3	SUPT 3	LoCol	HiCol	SUPT 4	LoCol
INITIAL		587.3			-536.5	530.6			-598.6	0.0			0.0	
	0.0	-512.0	-75.2	0.0	2.8	2.7	0.4	0.0	598.6	0.0	0.0	0.0	0.0	0.0
		1.4			-256.0	299.3			1.3	0.0			0.0	
	0.0	-1.2	-0.2	0.0	-20.5	-19.7	-3.0	0.0	-1.3	0.0	0.0	0.0	0.0	0.0
		-10.3			-0.6	-0.7			-9.9	0.0			0.0	
	0.0	9.0	1.3	0.0	0.6	0.6	0.1	0.0	9.9	0.0	0.0	0.0	0.0	0.0
		0.3			4.5	4.9			0.3	0.0			0.0	
	0.0	-0.3	0.0	0.0	-4.5	-4.3	-0.7	0.0	-0.3	0.0	0.0	0.0	0.0	0.0
		-2.2			-0.1	-0.1			-2.1	0.0			0.0	
	0.0	1.9	0.3	0.0	0.1	0.1	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0
		0.1			1.0	1.1			0.1	0.0			0.0	
	0.0	-0.1	0.0	0.0	-1.0	-0.9	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.0
		-0.5			0.0	0.0			-0.5	0.0			0.0	
	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Σ	**0.0**	**73.8**	**-73.8**	**0.0**	**-810.2**	**813.5**	**-3.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
2nd'y M	0.0	61.1	-61.1	0.0	-300.9	304.2	0.0	0.0	12.7	0.0	0.0	0.0	######	0.0
FINAL		531.2			-485.2	479.9			-541.4	0.0			0.0	
	0.0	-463.1	-68.1	0.0	2.5	2.4	0.4	0.0	541.4	0.0	0.0	0.0	0.0	0.0
		1.3			-231.6	270.7			1.2	0.0			0.0	
	0.0	-1.1	-0.2	0.0	-18.6	-17.8	-2.7	0.0	-1.2	0.0	0.0	0.0	0.0	0.0
		-9.3			-0.5	-0.6			-8.9	0.0			0.0	
	0.0	8.1	1.2	0.0	0.5	0.5	0.1	0.0	8.9	0.0	0.0	0.0	0.0	0.0
		0.3			4.1	4.5			0.3	0.0			0.0	
	0.0	-0.2	0.0	0.0	-4.0	-3.9	-0.6	0.0	-0.3	0.0	0.0	0.0	0.0	0.0
		-2.0			-0.1	-0.1			-1.9	0.0			0.0	
	0.0	1.8	0.3	0.0	0.1	0.1	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0
		0.1			0.9	1.0			0.1	0.0			0.0	
	0.0	-0.1	0.0	0.0	-0.9	-0.8	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.0
		-0.4			0.0	0.0			-0.4	0.0			0.0	
	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Σ	**0.0**	**66.8**	**-66.8**	**0.0**	**-732.9**	**735.8**	**-3.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
2nd'ry M	0.0	55.3	-55.3	0.0	-272.2	275.1	0.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0

Project **Spreadsheets to BS 8110**			**REINFORCED CONCRETE COUNCIL**
Client **Advisory Group**	Made by **RMW**	Date **01-Sep-99**	Page **78**
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POST-TENSIONED ANALYSIS & DESIGN to BS 8110:1997			
Originated from RCC42.xls on CD © 1999 RCC			

DETAILED CALCULATIONS vii

SUPPORT MOME WITH EQUIVALENT LOADING

	SUPT 1	SUPT 2 LEFT	SUPT 2 RIGHT	SUPT 3 LEFT	SUPT 3 RIGHT	SUPT 4
SLS 1	-27.7	-227.5	-224.3	0.0	0.0	0.0
SLS 2	-14.2	-394.2	-422.2	0.0	0.0	0.0
SLS 3	-67.3	-390.5	-359.9	0.0	0.0	0.0
SLS 4	60.5	875.9	890.8	0.0	0.0	0.0
SLS 5	84.5	579.5	539.0	0.0	0.0	0.0
SLS 6	-9.9	586.0	649.8	0.0	0.0	0.0
SLS 7	35.2	376.6	403.6	0.0	0.0	0.0
ULS 1	127.3	1183.9	1180.9	0.0	0.0	0.0
ULS 2	127.3	1124.5	1010.4	0.0	0.0	0.0
ULS 3	-38.5	1141.0	1180.9	0.0	0.0	0.0
DEAD	25.6	750.3	758.7	11.5	0.0	0.0
IMPOSED	46.4	586.3	592.8	0.0	0.0	0.0

SUPPORT SHEA WITH EQUIVALENT LOADING

	Span 1			Span 2			0.0		
SLS 1	166.1	-20.0	215.6	220.6	25.3	177.0	0.0	0.0	0.0
SLS 2	181.1	-20.0	200.6	92.2	25.3	80.3	0.0	0.0	0.0
SLS 3	68.4	-20.0	97.3	209.7	25.3	187.8	0.0	0.0	0.0
SLS 4	421.4	-18.1	632.2	656.0	22.9	441.6	0.0	0.0	0.0
SLS 5	448.1	-18.1	605.5	427.8	22.9	269.7	0.0	0.0	0.0
SLS 6	247.7	-18.1	421.9	636.7	22.9	460.9	0.0	0.0	0.0
SLS 7	326.6	-18.1	458.3	477.0	22.9	340.6	0.0	0.0	0.0
ULS 1	650.5	-18.1	901.4	938.7	22.9	677.9	0.0	0.0	0.0
ULS 2	655.4	-18.1	896.5	465.6	22.9	232.0	0.0	0.0	0.0
ULS 3	199.1	-18.1	470.6	938.7	22.9	677.9	0.0	0.0	0.0
DEAD	274.4		395.2	408.6		289.0	0.0		0.0
IMPOSED	147.0		237.0	247.4		152.6	0.0		0.0
ELASTIC									
ULS 1	612.2	-18.1	939.7	977.0	22.9	639.6	0.0	0.0	0.0
ULS 2	673.6	-18.1	878.4	452.9	22.9	244.7	0.0	0.0	0.0
ULS 3	213.1	-18.1	456.6	932.8	22.9	683.9	0.0	0.0	0.0

ADJUSTED SPAN MOMENTS

									Loadings		0	0	
Span 1		Left	< >	PL1	< >	PL2	< >	Right	UDL	PL1	PL2	pUDL	12
V	SLS 1	166.1	0	166.1	0	166.1	100	215.6	31.8	0.0	0.0	0.0	
	SLS 2	181.1	0	181.1	0	181.1	100	200.6	31.8	0.0	0.0	0.0	
	SLS 3	68.4	0	68.4	0	68.4	100	97.3	13.8	0.0	0.0	0.0	
	SLS 4	421.4	0	421.4	0	421.4	100	632.2	87.8	0.0	0.0	0.0	
	SLS 5	448.1	0	448.1	0	448.1	100	605.5	87.8	0.0	0.0	0.0	
	SLS 6	247.7	0	247.7	0	247.7	100	421.9	55.8	0.0	0.0	0.0	
	SLS 7								65.4	0.0	0.0	0.0	
	ULS 1	650.5	0	650.5	0	650.5	100	901.4	129.3	0.0	0.0	0.0	
	ULS 2	655.4	0	655.4	0	655.4	100	896.5	129.3	0.0	0.0	0.0	
	ULS 3	199.1	0	199.1	0	199.1	100	470.6	55.8	0.0	0.0	0.0	
Xbar	SLS 1		0.000	0.000	0.000	0.000	5.222						
	SLS 2		0.000	0.000	0.000	0.000	5.694						
	SLS 3		0.000	0.000	0.000	0.000	4.953						
	SLS 4		0.000	0.000	0.000	0.000	4.800						
	SLS 5		0.000	0.000	0.000	0.000	5.104						
	SLS 6		0.000	0.000	0.000	0.000	4.439						
	ULS 1		0.000	0.000	0.000	0.000	5.030						
	ULS 2		0.000	0.000	0.000	0.000	5.068						
	ULS 3		0.000	0.000	0.000	0.000	3.568						
M	SLS 1	-15.1	15.1	15.1	15.1	15.1	448.7	281.8	M		X bar	T height	
	SLS 2	-1.5	1.5	1.5	1.5	1.5	517.2	115.1	517.2	max	@5.694	41.8	
	SLS 3	-54.7	54.7	54.7	54.7	54.7	224.0	118.8	224.0	min	@4.953	41.6	
	SLS 4	71.9	-71.9	-71.9	-71.9	-71.9	939.5	1336.6					
	SLS 5	96.0	-96.0	-96.0	-96.0	-96.0	1047.7	1040.2	1047.7	max	@5.104	40.5	
	SLS 6	1.5	-1.5	-1.5	-1.5	-1.5	548.4	1046.7	548.4	min	@4.439	49.3	
	ULS 1	138.8	-138.8	-138.8	-138.8	-138.8	1497.1	1644.5					
	ULS 2	138.8	-138.8	-138.8	-138.8	-138.8	1522.1	1585.2	1522.1	max	@5.068	40.7	
	ULS 3	-27.09	27.09	27.09	27.09	27.09	382.27	######	382.3	min	@3.568	77.2	

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
Location	Level 2 - Beam on Grid 7	RMW	01-Sep-99	79
	POST-TENSIONED ANALYSIS & DESIGN to BS 8110:1997	Checked	Revision	Job No
	Originated from RCC42.xls on CD © 1999 RCC	chg	-	R68

DETAILED CALCULATIONS viii

									Loadings		0	0	
Span 2		**Left**	< >	**PL1**	< >	**PL2**	< >	**Right**	**UDL**	**PL1**	**PL2**	**pUDL**	12.5
V	SLS 1	220.6	0	220.6	0	220.6	100	177.0	31.8	0.0	0.0	0.0	
	SLS 2	92.2	0	92.2	0	92.2	100	80.3	13.8	0.0	0.0	0.0	
	SLS 3	209.7	0	209.7	0	209.7	100	187.8	31.8	0.0	0.0	0.0	
	SLS 4	656.0	0	656.0	0	656.0	100	441.6	87.8	0.0	0.0	0.0	
	SLS 5	427.8	0	427.8	0	427.8	100	269.7	55.8	0.0	0.0	0.0	
	SLS 6	636.7	0	636.7	0	636.7	100	460.9	87.8	0.0	0.0	0.0	
	SLS 7								65.4	0.0	0.0	0.0	
	ULS 1	938.7	0	938.7	0	938.7	100	677.9	129.3	0.0	0.0	0.0	
	ULS 2	465.6	0	465.6	0	465.6	100	232.0	55.8	0.0	0.0	0.0	
	ULS 3	938.7	0	938.7	0	938.7	100	677.9	129.3	0.0	0.0	0.0	
Xbar	SLS 1		0.000	0.000	0.000	0.000	6.935						
	SLS 2		0.000	0.000	0.000	0.000	6.682						
	SLS 3		0.000	0.000	0.000	0.000	6.594						
	SLS 4		0.000	0.000	0.000	0.000	7.471						
	SLS 5		0.000	0.000	0.000	0.000	7.667						
	SLS 6		0.000	0.000	0.000	0.000	7.251						
	ULS 1		0.000	0.000	0.000	0.000	7.258						
	ULS 2		0.000	0.000	0.000	0.000	8.343						
	ULS 3		0.000	0.000	0.000	0.000	7.258						
M	SLS 1	285	-285	-285	-285	-285	480	13	**M**		**X bar**	**T height**	
	SLS 2	87	-87	-87	-87	-87	221	13	542.0	max	(6.594	41.9	
	SLS 3	149	-149	-149	-149	-149	542	13	221.0	min	(6.682	41.2	
	SLS 4	1352	-1352	-1352	-1352	-1352	1099	11					
	SLS 5	1000	-1000	-1000	-1000	-1000	640	11	1198.0	max	(7.251	40.7	
	SLS 6	1111	-1111	-1111	-1111	-1111	1198	11	640.4	min	(7.667	44.9	
	ULS 1	1642	-1642	-1642	-1642	-1642	1765	11					
	ULS 2	1471	-1471	-1471	-1471	-1471	471	11	1765.2	max	(7.258	40.7	
	ULS 3	1642	-1642	-1642	-1642	-1642	1765	11	470.8	min	(8.343	59.9	

									Loadings		0	0	
0		**Left**	< >	**PL1**	< >	**PL2**	< >	**Right**	**UDL**	**PL1**	**PL2**	**pUDL**	0
V	SLS 1	0.0	100	0.0	100	0.0	100	0.0	0.0	0.0	0.0	0.0	
	SLS 2	0.0	100	0.0	100	0.0	100	0.0	0.0	0.0	0.0	0.0	
	SLS 3	0.0	100	0.0	100	0.0	100	0.0	0.0	0.0	0.0	0.0	
	SLS 4	0.0	100	0.0	100	0.0	100	0.0	0.0	0.0	0.0	0.0	
	SLS 5	0.0	100	0.0	100	0.0	100	0.0	0.0	0.0	0.0	0.0	
	SLS 6	0.0	100	0.0	100	0.0	100	0.0	0.0	0.0	0.0	0.0	
	SLS 7								0.0	0.0	0.0	0.0	
	ULS 1	0.0	100	0.0	100	0.0	100	0.0	0.0	0.0	0.0	0.0	
	ULS 2	0.0	100	0.0	100	0.0	100	0.0	0.0	0.0	0.0	0.0	
	ULS 3	0.0	100	0.0	100	0.0	100	0.0	0.0	0.0	0.0	0.0	
Xbar	SLS 1		0.000	0.000	0.000	0.000	0.000						
	SLS 2		0.000	0.000	0.000	0.000	0.000						
	SLS 3		0.000	0.000	0.000	0.000	0.000						
	SLS 4		0.000	0.000	0.000	0.000	0.000						
	SLS 5		0.000	0.000	0.000	0.000	0.000						
	SLS 6		0.000	0.000	0.000	0.000	0.000						
	ULS 1		0.000	0.000	0.000	0.000	0.000						
	ULS 2		0.000	0.000	0.000	0.000	0.000						
	ULS 3		0.000	0.000	0.000	0.000	0.000						
M	SLS 1	0	0	0	0	0	0	######	**M**		**X bar**	**T height**	
	SLS 2	0	0	0	0	0	0	######	0.0	max	(0.000	0.0	
	SLS 3	0	0	0	0	0	0	######	0.0	min	(0.000	0.0	
	SLS 4	0	0	0	0	0	0	0					
	SLS 5	0	0	0	0	0	0	0	0.0	max	(0.000	0.0	
	SLS 6	0	0	0	0	0	0	0	0.0	min	(0.000	0.0	
	ULS 1	0	0	0	0	0	0	0					
	ULS 2	0	0	0	0	0	0	0	0.0	max	(0.000	0.0	
	ULS 3	0	0	0	0	0	0	0	0.0	min	(0.000	0.0	

Project **Spreadsheets to BS 8110**		**REINFORCED CONCRETE COUNCIL**	
Client **Advisory Group**	Made by **RMW**	Date **01-Sep-99**	Page **80**
Location **Level 2 - Beam on Grid 7**	Checked **chg**	Revision **Date**	Job No **R68**
POST-TENSIONED ANALYSIS & DESIGN TO BS8110			

Originated from RCC42.xls on CD

DETAILED CALCULATIONS ix

(d) **ULS MOMEN**

	Supt1 Right	Span 1	Supt 2 Left	Supt 2 Right	Span 2	Supt3 Left	Supt3 Right	0	0 Left
DESIGN MOMENT	42.7	1522.1	1531.7	1502.2	1765.2	11.5	0.0	0.0	0.0
TENDON HEIGHT	300.0	40.7	480.0	480.0	40.7	300.0	0.0	0.0	0.0
fpe	1042	1040	1039	1039	1040	1042	0	0	0
Hinges		2			2			0	
Lt		24.50			24.50			0.00	
Lte		12250			12250			0	
dt	300.0	484.3	480.0	480.0	484.3	300.0	0.0	0.0	0.0
dr	482.0	480.0	480.0	480.0	484.0	480.0	0.0	0.0	0.0
Rp	0.207	0.077	0.129	0.129	0.077	0.207	0.000	0.000	0.000
fpe/fpu	0.588	0.587	0.586	0.586	0.587	0.588	0.000	0.000	0.000
TABLE 4.4 1a	0.90	1.00	1.00	1.00	1.00	0.90	0.00	0.00	0.00
1b	0.92	1.00	1	1	1.00	0.92	0	0.00	0
2a	0.86	1.00	0.97	0.97	1.00	0.86	0	0.00	0
2b	0.88	1.00	0.99	0.99	1.00	0.88	0	0.00	0
fpb bonded	1616	1771	1758	1758	1771	1616	0	0	0
fpb unbonded	1153	1281	1253	1253	1281	1153	0	0	0
TENDON FORCE	2768	3073	3007	3007	3074	2768	0	0	0
As	4021	6283	6283		2262	6283		0	0
REBAR FORCE	1761.7	2752.6	2752.6	2752.6	990.9	2752.6	2752.6	0.0	0.0
TOTAL TENSION	4530	5826	5760	5760	4065	5521	2753	0	0
dn	139.8	107.9	177.8	177.8	75.3	170.4	0.0	0.0	0.0
Steel stress	438	438	438	438	438	438	0	0	0
Zt	230.1	430.3	391.1	391.1	446.7	214.8	0.0	0.0	0.0
Zr	412.1	426.1	391.1	391.1	446.4	394.8	0.0	0.0	0.0
MOR	1362.9	2495.4	2252.7	2252.7	1815.1	1681.3	0.0	0.0	0.0

(e) **SHEAR**

ft= 1.518

		Span 1 Left	Span 1 Right	Span 2 Left	Span 2 Right	0 Left	0 Right	
V		636.0	882.1	919.3	677.9	0.0	0.0	
Mu		42.7	1531.7	1502.2	11.5	0.0	0.0	
Mo		211.9	570.2	570.2	211.9	0.0	0.0	
Cracked ?		N	Y	Y	N	N	N	
UNCRACKED	fcp	2.111	2.104	2.104	2.111	0.000	0.000	
	Vco	1396.8	1395.7	1395.7	1396.8	0.0	0.0	
CRACKED	Aps	2300	2300	2500	2500	0	0	
	As	6321	8583	8783	8783	0	0	
	d	415.8	480.0	480.0	209.0	0.0	0.0	
	As%	0.845	0.993	1.017	2.335	0.000	0.000	
	fpe/fpu	0.411	0.350	0.362	0.363	0.000	0.000	
	vc	0.555	0.585	0.590	0.915	0.000	0.000	
	Vcr	3479.3	736.8	757.3	######	0.0	0.0	
Vc		1396.8	736.8	757.3	1396.8	0.0	0.0	Links required
Asv/Sv		1.643	1.643	1.643	1.643	0.000	0.000	
Sv		375	375	375	375	0	0	

(f) **VIBRATION** nx = 2

	Span 1		Span 2		0		
ny : ly	5	6.000	5	6.000	0	0.000	Khan/Williams Ref
lx : ly	3E+10	2E+09	3E+10	2E+09	0	0	(Concrete Society Method)
λx : λy	1.934	5.170	2.015	4.963	0.000	0.000	(9.8)
kx : ky	1.267	1.037	1.246	1.041	0.000	0.000	(9.9, 9.10)
ω	65.41	54.51	65.41	54.51	0.00	0.00	
δx : δy	10.04	16.47	16.41	16.47	0.00	0.00	
fx : fy	5.57	5.84	5.47	4.58	0.00	0.00	(9.11)
fbx : fby	5.57	5.84	5.47	4.58	0.00	0.00	(9.12, 9.13)
fx : fy	5.57	5.84	5.47	4.58	0.00	0.00	(9.14)
Nx : Ny	1.388	2.036	1.404	1.995	1.000	1.000	(9.17, 9.18)
Cx : Cy	255.2	250.9	256.6	381.6	0.0	0.0	(9.19)
Rx : Ry	0.37	0.26	0.36	0.37	0.00	0.00	(9.20)
R	0.62		0.73		0.00		(9.21)

Project	**Spreadsheets to BS 8110**		**REINFORCED CONCRETE COUNCIL**
Client	**Advisory Group**	Made by: **RMW**	Date: **01-Sep-99**	Page: **81**
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POST-TENSIONED ANALYSIS & DESIGN to BS 8110:1997

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DEFLECTION CALCULATIONS

SPAN 1 As(b) = 6283 d = 480 h = 525 bw = 1800 bf = 3000 hf = 200 $bd^3/12$ = 2E+10

Distance	0	525	1050	1650	2250	2850	3450	4050	4650	5250	5850	6450	7050	7650	8250	8850	9450	10050	10650	11175	11700
Element b	263	525	563	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	563	525	263
d'	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	45	45	45	45	45	45
As(t)	4021	4021	4021	4021	4021	4021	4021.2	4021.2	4021.2	4021.2	4021.2	4021.2	4021.2	4021.2	4021.2	6283	6283	6283	6283	6283	6283
TRANFORMED SECTION PROPERTIES at TRANSFER					E = 21.72		m = 9.21		m - 1 = 8.21												
A	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06
A.Yt	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08
Yt	234.91	234.91	234.91	234.91	234.91	234.91	234.91	234.91	234.91	234.91	234.91	234.91	234.91	234.91	234.91	232.22	232.22	232.22	232.22	232.22	232.22
Yb	290.09	290.09	290.09	290.09	290.09	290.09	290.09	290.09	290.09	290.09	290.09	290.09	290.09	290.09	290.09	292.78	292.78	292.78	292.78	292.78	292.78
Ixx	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10
TRANFORMED SECTION PROPERTIES - LONG TERM					E = 7.41		m = 26.99		m - 1 = 25.99												
A	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06
A.Yt	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08	4E+08
Yt	244.31	244.31	244.31	244.31	244.31	244.31	244.31	244.31	244.31	244.31	244.31	244.31	244.31	244.31	244.31	236.7	236.7	236.7	236.7	236.7	236.7
Yb	280.69	280.69	280.69	280.69	280.69	280.69	280.69	280.69	280.69	280.69	280.69	280.69	280.69	280.69	280.69	288.3	288.3	288.3	288.3	288.3	288.3
Ixx	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10
TRANFORMED SECTION PROPERTIES - IMPOSED					E = 27.54		m = 7.26		m - 1 = 6.26												
A	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06
A.Yt	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08
Yt	233.71	233.71	233.71	233.71	233.71	233.71	233.71	233.71	233.71	233.71	233.71	233.71	233.71	233.71	233.71	231.64	231.64	231.64	231.64	231.64	231.64
Yb	291.29	291.29	291.29	291.29	291.29	291.29	291.29	291.29	291.29	291.29	291.29	291.29	291.29	291.29	291.29	293.36	293.36	293.36	293.36	293.36	293.36
Ixx	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10
DEFLECTIONS at TRANSFER																					
M (SLS 3)	77.4	73.8	-6.5	-132.6	-239.2	-326.5	-394.4	-442.9	-472.1	-481.8	-472.2	-443.2	-394.8	-327.1	-239.9	-133.4	-7.5	137.8	302.4	404.3	405.0
1/R	1E-07	1E-07	-9E-09	-2E-07	-3E-07	-5E-07	-6E-07	-6E-07	-7E-07	-7E-07	-7E-07	-6E-07	-6E-07	-5E-07	-3E-07	-2E-07	-1E-08	2E-07	4E-07	6E-07	6E-07
Load	3E-05	6E-05	-5E-06	-1E-04	-2E-04	-3E-04	-3E-04	-4E-04	-4E-04	-4E-04	-4E-04	-4E-04	-3E-04	-3E-04	-2E-04	-1E-04	-6E-06	0.0001	0.0002	0.0003	0.0002
Load x dist	0.0038	0.0294	-0.006	-0.189	-0.466	-0.806	-1.178	-1.553	-1.901	-2.19	-2.392	-2.475	-2.41	-2.167	-1.714	-1.002	-0.06	1.1754	2.5635	3.3566	1.7007
End slope	-0.002																				-1E-03
Span	0	-1.07	-2.17	-3.43	-4.61	-5.68	-6.57	-7.26	-7.72	-7.93	-7.90	-7.61	-7.10	-6.38	-5.50	-4.48	-3.40	-2.32	-1.30	-0.54	0
Cant	0	-12.23	-12.80	-13.46	-14.05	-14.51	-14.81	-14.90	-14.76	-14.37	-13.74	-12.85	-11.74	-10.43	-8.94	-7.33	-5.65	-3.97	-2.35	-1.07	0
	0	**-1.07**	**-2.17**	**-3.43**	**-4.61**	**-5.68**	**-6.57**	**-7.26**	**-7.72**	**-7.93**	**-7.90**	**-7.61**	**-7.10**	**-6.38**	**-5.50**	**-4.48**	**-3.40**	**-2.32**	**-1.30**	**-0.54**	**0**
DEFLECTIONS - LONG TERM																					
M (SLS 7)	13.0	137.3	177.5	174.7	170.4	164.5	157.1	148.3	137.8	125.9	112.4	97.5	81.0	62.9	43.4	22.3	-0.3	-24.4	-50.0	-126.2	-308.6
1/R	4E-08	5E-07	6E-07	6E-07	6E-07	5E-07	5E-07	5E-07	5E-07	4E-07	4E-07	3E-07	3E-07	2E-07	1E-07	7E-08	-9E-10	-8E-08	-2E-07	-4E-07	-1E-06
Load	1E-05	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0001	9E-05	4E-05	-5E-07	-5E-05	-9E-05	-2E-04	-3E-04
Load x dist	0.0015	0.1242	0.3441	0.5676	0.7549	0.9233	1.0676	1.1823	1.2621	1.3015	1.2952	1.2378	1.1238	0.9479	0.7047	0.3694	-0.005	-0.458	-0.934	-2.309	-2.855
End slope	0.0024																				0.0006
Span	0	1.24	2.35	3.42	4.28	4.95	5.42	5.70	5.81	5.76	5.56	5.22	4.77	4.22	3.60	2.93	2.24	1.54	0.87	0.33	0
Cant	0	7.58	8.40	9.13	9.65	9.98	10.11	10.05	9.82	9.42	8.88	8.20	7.41	6.53	5.56	4.55	3.51	2.48	1.47	0.63	0
	0	**1.24**	**2.35**	**3.42**	**4.28**	**4.95**	**5.42**	**5.70**	**5.81**	**5.76**	**5.56**	**5.22**	**4.77**	**4.22**	**3.60**	**2.93**	**2.24**	**1.54**	**0.87**	**0.33**	**0**
DEFLECTIONS - IMPOSED																					
M(SLS 5-7)	-31.29	27.69	80.51	133.30	178.04	214.71	243.31	263.85	276.33	280.75	277.10	265.38	245.60	217.76	181.86	137.89	85.85	25.75	-42.41	-108.67	-181.10
1/R	-4E-08	3E-08	9E-08	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	2E-07	1E-07	3E-08	-5E-08	-1E-07	-2E-07
Load	-1E-05	2E-05	5E-05	9E-05	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	1E-04	6E-05	2E-05	-3E-05	-7E-05	-6E-05
Load x dist	-0.001	0.009	0.0559	0.1552	0.2826	0.4317	0.5922	0.7539	0.9066	1.0399	1.1437	1.2076	1.2216	1.1753	1.0585	0.8478	0.5636	0.1798	-0.294	-0.738	-0.622
End slope	0.0012																				0.0009
Span	0	0.63	1.25	1.93	2.56	3.10	3.56	3.91	4.16	4.28	4.29	4.18	3.95	3.63	3.21	2.71	2.16	1.57	0.97	0.45	0
Cant	0	10.15	10.33	10.50	10.61	10.64	10.59	10.43	10.16	9.78	9.27	8.65	7.91	7.08	6.15	5.14	4.07	2.97	1.86	0.90	0
	0	**0.63**	**1.25**	**1.93**	**2.56**	**3.10**	**3.56**	**3.91**	**4.16**	**4.28**	**4.29**	**4.18**	**3.95**	**3.63**	**3.21**	**2.71**	**2.16**	**1.57**	**0.97**	**0.45**	**0**

Project	**Spreadsheets to BS 8110**		**REINFORCED CONCRETE COUNCIL**		
Client	**Advisory Group**		Made by	Date	Page
Location	**Level 2 - Beam on Grid 7**	**DEFLECTION CALCULATIONS (ii)**	**RMW**	**01-Sep-99**	**82**
	POST-TENSIONED ANALYSIS & DESIGN to BS 8110:1997		Checked	Revision	Job No
	Originated from RCC42.xls on CD	© 1999 RCC	**chg**	**-**	**R68**

SPAN 2		As(b) = 2262		d = 484		h = 525		bw = 1800		bf = 3000		hf = 200		$bd^3/12$ = 2E+10							
Distance	0	550	1100	1725	2350	2975	3600	4225	4850	5475	6100	6725	7350	7975	8600	9225	9850	10475	11100	11725	12350
Elementb	275	550	588	625	625	625	625	625	625	625	625	625	625	625	625	625	625	625	625	625	313
d'	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
As(t)	6283	6283	6283	6283	6283	6283	6283.2	6283.2	6283.2	6283.2	6283.2	6283.2	6283.2	6283.2	6283.2	6283	6283	6283	6283	6283	6283
TRANFORMED SECTION PROPERTIES at TRANSFER						E = 21.72		m = 9.21		m - 1 = 8.21											
A	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06
A.Yt	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08
Yt	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77	225.77
Yb	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23	299.23
Ixx	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10
TRANFORMED SECTION PROPERTIES - LONG TERM						E = 7.41		m = 26.99		m - 1 = 25.99											
A	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06
A.Yt	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08
Yt	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79	218.79
Yb	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21	306.21
Ixx	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10	4E+10
TRANFORMED SECTION PROPERTIES - IMPOSED						E = 27.54		m = 7.26		m - 1 = 6.26											
A	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06	1E+06
A.Yt	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08	3E+08
Yt	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63	226.63
Yb	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37	298.37
Ixx	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10
DEFLECTIONS at TRANSFER																					
M (SLS 2)	435.9	434.7	331.9	166.7	20.2	-107.7	-216.9	-307.5	-379.5	-432.8	-467.5	-483.5	-480.9	-459.6	-419.7	-361.1	-283.9	-188.1	-73.6	6.7	0.0
1/R	7E-07	7E-07	5E-07	3E-07	3E-08	-2E-07	-3E-07	-5E-07	-6E-07	-7E-07	-7E-07	-7E-07	-7E-07	-7E-07	-6E-07	-5E-07	-4E-07	-3E-07	-1E-07	1E-08	7E-21
Load	0.0002	0.0004	0.0003	0.0002	2E-05	-1E-04	-2E-04	-3E-04	-4E-04	-4E-04	-4E-04	-5E-04	-5E-04	-4E-04	-4E-04	-3E-04	-3E-04	-2E-04	-7E-05	6E-06	2E-18
Load x dist	0.0249	0.1985	0.3238	0.2714	0.0448	-0.302	-0.737	-1.226	-1.737	-2.236	-2.691	-3.068	-3.335	-3.458	-3.406	-3.143	-2.639	-1.859	-0.771	0.0741	3E-14
End slope	-1E-03																				-0.002
Span	0	-0.61	-1.45	-2.58	-3.81	-5.06	-6.24	-7.29	-8.16	-8.81	-9.20	-9.32	-9.15	-8.70	-7.97	-7.00	-5.82	-4.47	-3.01	-1.50	0
Cant	0	-28.96	-28.48	-28.11	-27.84	-27.58	-27.26	-26.81	-26.18	-25.33	-24.22	-22.83	-21.16	-19.21	-16.98	-14.51	-11.83	-8.97	-6.01	-3.00	0
	0	**-0.61**	**-1.45**	**-2.58**	**-3.81**	**-5.06**	**-6.24**	**-7.29**	**-8.16**	**-8.81**	**-9.20**	**-9.32**	**-9.15**	**-8.70**	**-7.97**	**-7.00**	**-5.82**	**-4.47**	**-3.01**	**-1.50**	**0**
DEFLECTIONS - LONG TERM																					
M (SLS 7)	-332.7	-129.7	-34.6	10.3	51.4	88.7	122.2	151.9	177.7	199.8	218.0	232.5	243.1	249.9	253.0	252.2	247.6	239.2	227.0	163.2	0.0
1/R	-1E-06	-5E-07	-1E-07	4E-08	2E-07	3E-07	4E-07	6E-07	7E-07	7E-07	8E-07	9E-07	9E-07	9E-07	9E-07	9E-07	9E-07	9E-07	8E-07	6E-07	1E-20
Load	-3E-04	-3E-04	-7E-05	2E-05	0.0001	0.0002	0.0003	0.0003	0.0004	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0004	4E-18
Load x dist	-0.046	-0.144	-0.082	0.0408	0.2772	0.6054	1.0092	1.472	1.9776	2.5095	3.0514	3.5869	4.0996	4.5732	4.9912	5.3373	5.595	5.7481	5.7802	4.3894	5E-14
End slope	0.0021																				0.0044
Span	0	1.28	2.74	4.46	6.15	7.78	9.27	10.60	11.70	12.55	13.11	13.36	13.28	12.85	12.06	10.91	9.39	7.52	5.31	2.77	0
Cant	0	53.61	52.64	51.58	50.50	49.36	48.08	46.63	44.96	43.04	40.83	38.31	35.46	32.25	28.69	24.77	20.48	15.84	10.85	5.54	0
	0.0	**1.3**	**2.7**	**4.5**	**6.2**	**7.8**	**9.3**	**10.6**	**11.7**	**12.6**	**13.1**	**13.4**	**13.3**	**12.8**	**12.1**	**10.9**	**9.4**	**7.5**	**5.3**	**2.8**	**0.0**
DEFLECTIONS - IMPOSED																					
M (SLS 4-7)	-460.7	-367.5	-281.0	-191.1	-109.8	-37.3	26.4	81.4	127.6	165.1	193.9	213.9	225.1	227.6	221.3	206.3	182.5	150.0	108.8	58.8	0.0
1/R	-6E-07	-4E-07	-3E-07	-2E-07	-1E-07	-5E-08	3E-08	1E-07	2E-07	2E-07	2E-07	3E-07	3E-07	3E-07	3E-07	3E-07	2E-07	2E-07	1E-07	7E-08	1E-21
Load	-2E-04	-2E-04	-2E-04	-1E-04	-8E-05	-3E-05	2E-05	6E-05	1E-04	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	8E-05	4E-05	3E-19
Load x dist	-0.021	-0.135	-0.221	-0.251	-0.197	-0.085	0.0724	0.2619	0.4714	0.6884	0.9005	1.0951	1.2598	1.382	1.4493	1.4492	1.3691	1.1967	0.9194	0.5246	4E-15
End slope	-2E-04																				0.001
Span	0	-0.03	0.09	0.36	0.72	1.13	1.55	1.97	2.35	2.66	2.90	3.04	3.09	3.02	2.85	2.57	2.20	1.73	1.20	0.61	0
Cant	0	11.56	11.14	10.79	10.54	10.33	10.15	9.95	9.71	9.41	9.04	8.57	8.00	7.32	6.53	5.64	4.65	3.58	2.43	1.23	0
	0	**-0.03**	**0.09**	**0.36**	**0.72**	**1.13**	**1.55**	**1.97**	**2.35**	**2.66**	**2.90**	**3.04**	**3.09**	**3.02**	**2.85**	**2.57**	**2.20**	**1.73**	**1.20**	**0.61**	**0**

RCC51 Column Load Take-down & Design.xls

Conventional column load take downs by hand can be time-consuming. This spreadsheet emulates conventional column design to BS 8110[2] by providing on separate sheets: load take down from inputs of location, dimensions, levels and loads to give design axial loads and moments per floor. RCC51.xls is intended as a stand-alone column design spreadsheet for use when a sub-frame analysis is not available or is unwarranted. As in COLUMN! within RCC11.xls, this spreadsheet determines the area of steel required (A_s).

The spreadsheet is set up in such a way that one column size (input in CDES!) is used throughout the height of the column location and that the critical section for design occurs where axial load is at its maximum.

The example is based on *Designed and detailed* [15] but differs in several respects:

- Seven storeys used in the example rather than three (in order to demonstrate automatic input adequately)
- No special account taken of roof loadings (in order to demonstrate automatic input adequately)
- All columns are taken as 4.00 m long (again, in order to demonstrate automatic input adequately)
- Load distribution according to BS 8110: Part 1, Clause 3.8.2.3, i.e. reaction factors of ½ are used for loads from adjacent spans rather than results of analysis or using shear force factors from BS 8110: Part 1 Tables 3.5 and/or 3.12.
- No double counting of floor slabs due to allowances for floor slabs in design of, therefore reactions from, edge beams spanning parallel to floor slab span.

As a default the level with maximum axial load with concurrent maximum moment, i.e. the bottom level, is chosen for consideration in DESMMNTS! (derivation of design moments) and CDES! (design). The user may investigate other levels by choosing the appropriate level in the combo-box on the right hand side of CDES!.

Unbraced columns may be designed, but the spreadsheet demands some input of applied moment in LOADTD! in the appropriate axis. If the column is unbraced then it must be part of a stability frame – if only nominally – with moments that should be input as applied moments in LOADTD!

LOADTD!

Input is self explanatory but, in order to facilitate use of this spreadsheet, some degree of automation has been introduced. It is vital that input data is hand checked to ensure the loads are described properly. It is also advised that a clean version of the spreadsheet should be used for each column analysed and designed (i.e. reload the base spreadsheet each time).

Please note when inputting a location for numbered gridlines to start with an apostrophe, i.e. use !2 - 3 (otherwise 2 - 3 will give the result of -1!). Cantilevers may be dealt with by inputting no beam on the appropriate axis but inputting additional loads and moments (under '*At column position, other applied loads* (e.g. loads from cantilevers)'). Note that, so far as the column is concerned, cantilever moments will relieve (or even exceed fixed end) beam moments and should be specified as negative moments.

As explained under *Operator Instructions* deleting a level will 'grey out' subsequent columns and set spans to 0.0 m. Enter data (and delete any subsequent hatches, #####) or equate cells to previous cells (avoid copying cells across) to get up to 10 levels of load take down. Deleting or setting a value of 0 in columns G to P will 'grey out' values to the right, which will be set at 0.0. Generally, input values are carried through to the right. Red figures or red backgrounds mean inconsistent or incorrect data entries. Overwrite if incorrect.

Slab spans may be parallel to x or y, or two-way spanning. Troughed slabs may be modelled by using the topping thickness for the slab and adding widths of ribs within a bay to the width of the beam.

Some input (highlighted in magenta) defaults to values from other sheets. For instance column dimensions are input in CDES! The user may immediately see whether the design is viable or not and change dimensions accordingly. These cells are not protected so can be overwritten: **beware**.

For troughed slabs use topping thickness and aggregate width of ribs with width of beam.

Reduction factors for live load to according to BS 6399: Part 1[19] Clause 5.2 are automatically applied to axial load unless specified otherwise.

DESMMNTS!

The basic design procedure is covered in BS 8110: Part 1 Clause 3.8. In order to determine design moments several inputs are required:

- Values of b for braced and unbraced columns, see Clause 3.8.1.6 and Table 3.19 as shown below and Table 3.20 as shown on next page

Table 3.19 Values of β for braced columns

End condition at top	End condition at bottom 1	2	3
1	0.75	0.80	0.90
2	0.80	0.85	0.95
3	0.90	0.95	1.00

Table 3.20 Values of β for unbraced columns			
End condition at top	**End condition at bottom**		
	1	**2**	**3**
1	1.20	1.30	1.50
2	1.30	1.50	1.80
3	1.60	1.80	--
4	2.20	--	--

Essentially:

Condition 1 – column monolithically connected to beam at least as deep as the column in the plane considered (or foundation specifically designed for moment)

Condition 2 – column monolithically connected to beams or slabs shallower than the column in the plane considered

Condition 3 – column connected to members which will provide some nominal restraint

Condition 4 – column unrestrained

- Whether the column is braced or un-braced – see BS 8110: Part 1, Clause 3.8.1.5.
- In order to evaluate N_{uz} and thus K accurately, an initial assessment of the area of reinforcement, A_s, is required. An indication of the probable percentage of reinforcement is given (automation of this figure would cause a circular reference error in the spreadsheet). If A_s is set at 0% then effectively K = 1, which is conservative (see BS 8110: Part 1, equation 33 and definitions under Clause 3.8.1.1).

CDES!

As in COLUMN! within RCC11.xls, this sheet designs symmetrical rectangular columns where both axial load, N, and design moment, M_x or M_y (see BS 8110: Part 1, Clause 3.8.2, 3 and 4) have been calculated from previous sheets. CDES! iterates x/h to determine where the neutral axis lies. The sheet includes stress and strain diagrams to aid comprehension of the final design (please refer to notes regarding COLUMN! in RCC11.xls).

The spreadsheet is set up in such a way that one column size (input in CDES!) is used throughout the height of the column location and that the critical section for design occurs where axial load is at its maximum. Other levels can be investigated by choosing the appropriate level from the combo-box located under *Operating Instructions*. Always ensure that the size of column designed is correct for the level under consideration.

For simplicity, where three or more bars are required in the top and bottom of the section, a (rotationally) symmetrical arrangement of reinforcement is proffered, i.e. top and bottom reinforcement with additional side bars. The argument goes that using the critical axis method of BS 8110 to determine areas of steel in bi-axially bent columns implies that the bars are in the corners of the element. Therefore 'additional' side bars help ensure this is so. Counter-arguments suggest these additional bars are unnecessary. Bresaler's load contour check $[(M_x/M_{ux})^a + (M_y/M_{uy})^a \leq 1.0$, where $a = 2/3 + 5N/3N_{uz}]$, used in CP 110[20] is **not** adopted in this spreadsheet but may be investigated using RCC53.xls.

The use of T40s in such small columns would not normally be advocated. However, the choice of T32s would lead to the use of either 6T32s (5.6%, OK) or, using the (rotationally) symmetrical arrangement, 8T32 (7.7%, no good). Reference to RCC53.xls. suggests that 6T32 would satisfy Bresaler's load contour check. The use of C45 concrete would make 4T32s sufficient.

Some input (highlighted in magenta) defaults to values from other sheets. These cells are not protected so can be overwritten: **beware**.

Ltdcalcs!

This sheet shows workings for the load take-down and is not necessarily intended for printing out other than for checking purposes. Load distribution works according to BS 8110: Part 1, Clause 3.8.2.3 – *"...axial force in a column may be calculated on the assumption that beams and slabs transmitting force into it are simply supported".*

Stiffs!

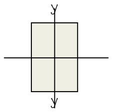
This sheet shows workings for beam and column stiffnesses and is not necessarily intended for printing out other than for checking purposes.

In the determination of section properties, beams are considered full height – beam widths are deducted from slab widths. Moment distribution works according to BS 8110: Part 1, Clause 3.2.1.2.5 – *"... beams possess half their actual stiffness".*

Project	**Spreadsheets to BS 8110**		REINFORCED CONCRETE COUNCIL	
Client	**Advisory Group**	Made by	Date	Page
Location	**Edge Column B1 (akin to D&D)**	mmw	1-Sep-99	85
	COLUMN LOAD TAKE DOWN & DESIGN FOR SYMMETRICALLY REINFORCED RECT. COLUMNS BENT ABOUT TWO AXES TO BS 8110:1997	Checked	Revision	Job No
	Originated from RCC51.xls on CD © 1999 BCA for RCC	chg	-	R68

INPUT

Location Edge Column B1 (akin to D&D)

Orientation A-B x  x B-C H

1-2 (y) / n/a (y)

concrete density, kN/m^3 24.0
γ_{fgk} 1.40
γ_{fqk} 1.60

Dimensions

				Level	7	6	5	4	3	2	1
Spans	Cl to Cl	A-B	m		5.00	5.00	5.00	5.00	5.00	5.00	5.00
		B-C	m		5.00	5.00	5.00	5.00	5.00	5.00	5.00
		1-2	m		8.00	8.00	8.00	8.00	8.00	8.00	8.00
		n/a	m		0.00						
Slab	thickness (solid)		mm		175	175	175	175	175	175	175
	span direction, (ll to) x, y or b				x	x	x	x	x	x	x
Beams	width	A-B	mm		300	300	300	300	300	300	300
	depth o/a	A-B	mm		350	350	350	350	350	350	350
	width	B-C	mm		300	300	300	300	300	300	300
	depth o/a	B-C	mm		350	350	350	350	350	350	350
	width	1-2	mm		300	300	300	300	300	300	300
	depth o/a	1-2	mm		500	500	500	500	500	500	500
	width	n/a	mm		0						
Column below				(col above)							
	H (ll to yy)		mm	0	300	300	300	300	300	300	300
	B (ll to xx)		mm	0	300	300	300	300	300	300	300
Height (fl. to floor.)			m	0.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Loads (characteristic uno)

				Level 7	6	5	4	3	2	1
Slab	(inc swt)	gk	kN/m2	5.00	5.00	5.00	5.00	5.00	5.00	5.00
		qk	kN/m2	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Beams	(swt)	gk	kN/m	included	included	included	included	included	included	included
	line loads (-extra over slab loads and beam selfweight)									
	A-B	gk	kN/m	5.0	5.0	5.0	5.0	5.0	5.0	5.0
		qk	kN/m	0.0						
	B-C	gk	kN/m	5.0	5.0	5.0	5.0	5.0	5.0	5.0
		qk	kN/m	0.0						
	1-2	gk	kN/m	0.0						
		qk	kN/m	0.0						
	n/a	gk	kN/m	0.0						
		qk	kN/m	0.0						
At column position, other applied loads (eg loads from cantilevers)										
		Gk	kN (char)	0.0						
		Qk	kN (char)	0.0						
		Mxx	kNm (ult)	0.0						
		Myy	kNm (ult)	0.0						

Loads per floor			7	6	5	4	3	2	1
Floor	Gk	kN	140.7	140.7	140.7	140.7	140.7	140.7	140.7
Floor	Qk	kN	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Column below	Gk	kN	8.6	8.6	8.6	8.6	8.6	8.6	8.6

OUTPUT

		Column level	7 to 6	6 to 5	5 to 4	4 to 3	3 to 2	2 to 1	Below 1
Cumulative loads in column.									
	Gk	kN	149.3	298.6	447.9	597.2	746.5	895.8	1045.1
	Qk	kN	80.0	160.0	240.0	320.0	400.0	480.0	560.0
	Qk redn	factor	1.0	0.9	0.8	0.7	0.6	0.6	0.6
	Qk red*	kN	80.0	144.0	192.0	224.0	240.0	288.0	336.0
	N	kN	337	648	934	1194	1429	1715	2001
Moments in column									
about x-x Mxx	top	kNm	134.6	108.6	108.6	108.6	108.6	108.6	108.6
about y-y Myy	top	kNm	1.5	1.3	1.3	1.3	1.3	1.3	1.3
Mxx	bottom	kNm	108.6	108.6	108.6	108.6	108.6	108.6	
Myy	bottom	kNm	1.3	1.3	1.3	1.3	1.3	1.3	

Project	**Spreadsheets to BS 8110**	**REINFORCED CONCRETE COUNCIL**	
Client	**Advisory Group**	Made by **rmw**	Date **24-Nov-99**	Page **86**
Location	**Edge Column B1 (akin to D&D)**	Checked **chg**	Revision **-**	Job No **R68**

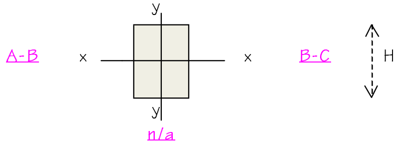
COLUMN LOAD TAKE DOWN & DESIGN FOR SYMMETRICALLY REINFORCED RECT. COLUMNS BENT ABOUT TWO AXES TO BS 8110:1997

Originated from RCC51.xls on CD © 1999 BCA for RCC

INPUT

Location Edge Column B1 (akin to D&D)

Level considered: Bottom (Max N) **Orientation** 1-2



Dimensions

		about x-x	about y-y
h (ll to yy)	mm	300	-
b (ll to xx)	mm	-	300
lo, clear height	mm	3500	3650
ß	value	0.90	0.95
Braced or Unbraced?	B or U	B	B

Column properties

fcu		35
fy		460
cover to link	mm	30
Max sized main bar	mm	40
Probable percentage As	%	2.00%
link diameter	mm	10

Loads

Axial	N	kN	2001	-
Moments	top	kNm	108.6	1.3
	bottom	kNm	0.0	0.0

OUTPUT

Design criteria

N	kNm	2001
M	kN	109.0
about		X-X

PR F

S n n			
	mm	3150	3467.5
S		10.50	11.56
m m		15.0	15.0
D m		S	
m		S	S
		x x	y y
n n			
y 0.05	m	30.0	
/			m
	mm	240	240
		2204.1	2204.1
		630.0	630.0
K		0.12	0.12
' '	mm	240	240
		0.0 6	0.104
	mm	3.3	4.0
	m	0.0	0.0
Eq 32 35			
m 1	m	0.0	0.0
	m	65.2	0.
=0 / >20	m	65.2	0.
=0 / >3		65.2	0.
D m m	m		
2	m	10 .6	1.3
+	m	65.2	0.
1+ /2	m	0.0	0.0
m	m	30.0	/
x m m	m	10 .6	1.3

n n (cont) about x-x about y-y

D m m	unbraced columns		
2+100%	kNm	n/a	n/a
m	kNm	n/a	n/a
x m m	kNm	n/a	n/a
n n			
	kNm	108.6	1.3
		about x-x	about y-y
		Short	Short
		Braced	Braced

Biaxial bending

Mx/h'	0.453	
My/b		0.005
I direction	X-X	
N/bhfcu	0.64	
ß	0.30	

Maximum design moment

= 10 .6+0.30*240/240*1.3

= kNm 109.0 -

Project **Spreadsheets to BS 8110**	REINFORCED CONCRETE COUNCIL		
Client **Advisory Group**	Made by **rmw**	Date **1-Sep-99**	Page **87**
Location **Edge Column B1 (akin to D&D)**	Checked **chg**	Revision **-**	Job No **R68**
COLUMN LOAD TAKE DOWN & DESIGN FOR SYMMETRICALLY REINFORCED RECT. COLUMNS BENT ABOUT TWO AXES			
Originated from RCC51.xls on CD © 1999 BCA for RCC			

INPUT

Level designed: Bottom (Max N)

Axial load, N	2001	kN	fcu	35	N/mm²
Moment, M	109.0	kNm	fy	460	N/mm²
about	X-X	axis	fyv	460	N/mm²
Height, h (ll to yy, L'r to xx)	300	mm	γm	1.05	steel
Breadth, b (ll to xx)	300	mm	γm	1.5	concrete
Max bar diameter	40	mm	Link Ø	10	mm
cover (to link)	30	mm			

CALCULATIONS

from M As = {M - 0.67fcu.b.dc(h/2 - dc/2)}/[(h/2-d').(fsc+fst).gm]

from N As = (N - 0.67fcu.b.dc/gm) / (fsc - fst) As = Ast = Asc: dc=min(h,0.9x)

d' =	60	mm	.67fcu/gm =	15.6	N/mm²
d =	240	mm	fy/gm =	438.1	N/mm²
critical about X-X axis:...... h=	300	mm			
b=	340	mm			

from iteration, neutral axis depth, x, =	253.6	mm	
dc	228.2	mm	
0.67.fcu.b.dc/gm	1070.3	kN	
Steel comp strain	0.00267		
Steel tens strain	-0.00019		
Steel stress in comp. face, fsc	438	N/mm2	(Comp. stress in reinf.)
Steel stress in tensile face, fst	-37	N/mm2	(Tensile stress in reinf.)
from M, As =	1958	mm2	
from N, As =	1957	mm2	**OK**

As req'd = 1957mm² T&B:- **PROVIDE 4T40**

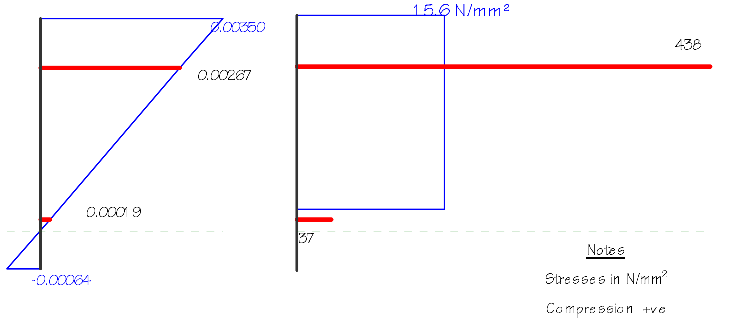
(ie 2T40 T&B - 2514mm²T&B) - 5.59% o/a - @180cc.)

Links : - **PROVIDE T10 @300**

OK

Strain diagram **Stress diagram**

about X-X axis



RCC52 Column Chart Generation.xls

This spreadsheet generates axial load:design moment interaction charts for symmetrically reinforced rectangular columns. It checks the capacity of the columns with various arrangements of reinforcement against input load cases of axial load and **uniaxial** bending

Within RCC11.xls, COLUMN! allows the user to determine the area of steel required from inputs of axial load and moment about the x - x axis. Another approach, adopted in BS 5400[21] and CP 110[20] and more suited to the grouping of columns on particluar projects and adopted here by RCC52.xls, is to give an interaction chart. This shows axial load against moment for symmetrical sections of specified size, strength and reinforcement. It works on the premise of calculating the moment and axial load capacities of a section with assumed amounts of reinforcement and assumed neutral axis depth. Iterations of neutral axis depth give data for the Axial load:Moment interaction chart for the specified section. The spreadsheet also checks the reinforcement required for input load cases. The user may try different arrangements of reinforcement.

RCC52.xls assumes that the moments input in the load cases have already been adjusted, if necessary, for bi-axial bending. For many side and all corner columns, there is no choice but to design for bi-axial bending, and the method given in Clause 3.8.4.5 must be adhered to, i.e. RCC53.xls should be used.

MAIN!

Main! contains all input and output data,

Bending is assumed to be about the x - x, i.e. horizontal axis, and the input moment is assumed to be the *maximum design moment* as defined in BS 8110 i.e. including M_{add} etc and in the correct orientation.

Where more than two bars are required per face, the user may choose to specify a similar arrangement of bars on the side faces in order to avoid confusion in detailing and fixing. In this respect, there is also a question regarding design. To an extent all columns are bi-axially bent and BS 8110 directs that bi-axially bent columns are effectively designed about one axis only (by adding moment in the critical direction to account for moment in the non-critical direction). By implication the second axis is not designed specifically. One reason for adding side bars (when three, four or more bars are required T & B) in square(ish) sections, is to ensure that the second axis is catered for. Ideally with BS 8110, the resultant axis should be found and calculations done accordingly. But this presumes that the arrangement of bars is known to start with. With BS 5400 and CP 110 checks are carried out on a chosen section about both axes. Bi-axially bent columns are dealt with in RCC53.xls

The chart shows lines for $0.1f_{cu}A_c$ and M_{min}. The user should be aware that all load cases should be within the boundaries of these lines.

Calcs!

Calcs! Shows the derivation of the charts where moment capacity is calculated at intervals of neutral axis depth from n.a. depth for N = 0 to n.a. depth for $N = N_{bal}$, then at intervals from n.a. depth for $N = N_{bal}$ to n.a. depth for $N = N_{uz}$.

Cases!

Cases! identifies the smallest bar diameter that satisfies each of the load cases.

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by RMW	Date 30-Aug-99	Page 89
Location	Columns at A1, A2 etc	Checked chg	Revision -	Job No R68

COLUMN CHART FOR SYMMETRICALLY REINFORCED RECTANGULAR COLUMNS BENT ABOUT THE X-X AXIS TO BS 8110:1997

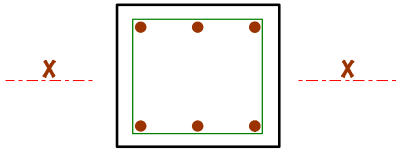
Originated from 'RCC52.xls' on CD © 1999 BCA for RCC

MATERIALS

fcu	35	N/mm²	γm	1.05	steel	Cover	30	mm
fy	460	N/mm²	γm	1.5	concrete	h agg	20	mm

SECTION

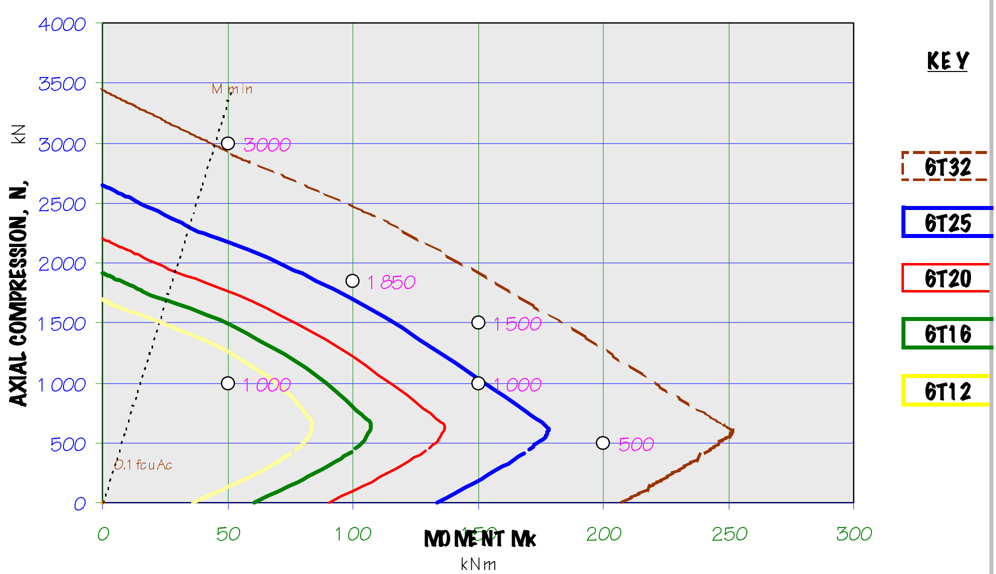
h	300	mm
b	300	mm
with	3	bars per face
All bars in	300	wide faces



BAR ARRANGEMENTS

Type	Bar Ø	Asc %	Link Ø	Bar c/c	Nbal (kN)	Nuz (kN)	Checks
T	40	8.38	10	90.0			Asc >6%
T	32	5.36	8	96.0	715.0	3445.6	ok
T	25	3.27	8	99.5	703.3	2651.3	ok
T	20	2.09	6	104.0	703.4	2203.3	ok
T	16	1.34	6	106.0	701.2	1916.6	ok
T	12	0.75	6	108.0	700.6	1693.7	ok

N:M INTERACTION CHART for 300 x 300 column, grade C35, 30 mm cover and 3 bars on 300 mm faces



LOAD CASES

Load case	N (kN)	Mx (kNm)	
A1 top	500	200	6 T32
A1 bot	1850	100	6 T32
A2 bot	3000	50	No Fit
4	1500	150	6 T32
5	1000	150	6 T25
6	1000	50	6 T12

RCC53 Column Design.xls

RCC53.xls generates column design charts for symmetrically reinforced rectangular columns bent about **two** axes and checks input load cases.

RCC53.xls also gives interaction charts, showing axial load against moment for the critical axis for symmetrical rectangular sections of specified size, strength and reinforcement arrangement. The user may try different arrangements of reinforcement. It also provides designs for input load cases, which are plotted on the relevant x- or y-axis chart.

RCC53.xls takes account of any side-bars.

Philosophy of design for bi-axially bent columns

When preparing this spreadsheet, there was some discussion about the interpretation of BS 8110 with respect to bi-axially bent columns and the provision of side bars.

For simplicity, where three or more bars are required in the top and bottom of the section, it appears to be common practice, in small- to medium-sized columns at least, to provide a (rotationally) symmetrical arrangement of reinforcement, i.e. to provide additional side bars. The argument goes that using the critical axis method of BS 8110 to determine areas of steel in bi-axially bent columns implies that the bars are in the corners of the element. Therefore 'additional' side bars help ensure that this is so.

There is a counter argument to suggest that the design procedure for bi-axially bent columns in BS 8110 makes the precaution of adding additional side bars unnecessary.

Rafiq[22] argues that the Bresaler's load contour check, as used in CP 110[20] should be adopted to ensure a safe design for biaxially bent columns otherwise designed to BS 8110, as shown below.

$(M_x/M_{ux})^a + (M_y/M_{uy})^a \leq 1.0$, where $a = 2/3 + 5N/3N_{uz}$

The project's Advisory Group requested that this check should be included in the spreadsheets for biaxially bent columns.

MAIN!

MAIN! contains all input data and gives designs for the input load cases.

Guidance for the input is given within the spreadsheet but users should be familiar with BS 8110: Part 1, Clause 3.8. There is a facility to input up to six user-specified load cases. The input moments under *LOADCASES* are *the initial end moments due to ultimate design loads* as defined in BS 8110 about the appropriate axes. The spreadsheet calculates the the additional design ultimate moment induced by deflection of column (M_{add}), the critical direction for bi-axial bending and the design moment.

CHARTS!

CHARTS! shows two charts, one chart for when M_{xx} is critical and one for when M_{yy} is critical. These Axial load:Moment interaction charts for the specified section also show relevant input load cases. The load cases are identified by axial load only (a quirk of Excel!).

The charts show lines for $0.1 f_{cu}A_c$ and M_{min} (i.e. $e_{min}N$). The user should be aware that all load cases should be within the boundaries of these lines. Due to a quirk in Excel, load cases can any be identified by axial load, N, on the charts.

Xcal! and Ycal!

These sheets show the derivation of the charts where moment and axial load capacity is calculated at intervals of neutral axis depth (in intervals from n.a. depth for N = 0 to n.a. depth for $N = N_{bal}$, then in intervals from n.a. depth for $N = N_{bal}$ to n.a. depth for $N = N_{uz}$.).

Cases!

Cases! identifies the smallest bar diameter that satisfies each of the load cases. Clause 3.8.3.2 is included for both directions (columns K & L) and the spreadsheet decides which axis is dominant.

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL	
Client	Advisory Group	Made by: RMW	Date: 30-Aug-99
Location	Ground floor columns at B1, B2 etc	Page: 91	
	SYMMETRICALLY REINFORCED RECTANGULAR COLUMN DESIGN, BENT ABOUT TWO AXES TO BS 8110:1997	Checked: chg	Revision: -
	Originated from RCC53.xls' on CD © 1999 BCA for RCC	Job No: R68	

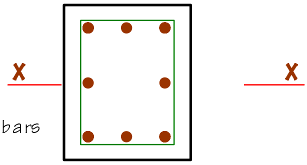
MATERIALS

fcu	35	N/mm²	γm, steel	1.05	Cover to link	30	mm
fy	460	N/mm²	γm, conc	1.5	h agg	20	mm

SECTION

h	400	mm
b	300	mm
with	3	bars per 300 face
and	3	bars per 400 face

ie. 400 x 300 columns with 8 bars



RESTRAINTS

	Lo (mm)	Top Condition	Btm Condition	Braced ?	β	Le (mm)	Slenderness	Status
X-AXIS	3600	F	F	N	1.2	4320	Lex/h = 10.80	Column is
Y-AXIS	3600	F	F	N	1.2	4320	Ley/b = 14.40	SLENDER

LOADCASES

	AXIAL N (kN)	TOP MOMENTS (kNm) Mix	Miy	BTM MOMENTS (kNm) Mix	Miy
B1	3500	90.0	25.0	90.0	25.0
B2	3000	80.0	60.0	80.0	60.0
Loadcase 3	1000	100.0	35.0	100.0	35.0
Loadcase 4	1200	50.0	150.0	50.0	150.0
Loadcase 5	500	220.0	90.0	220.0	90.0
Loadcase 6	2500	35.0	25.0	35.0	25.0

BAR ARRANGEMENTS

Bar Ø	Asc %	Link Ø	BAR CENTRES (mm) 300 Face	400 Face	Nuz (kN)	Checks
T 40	8.38	10	90	140	0	Asc >6% (3.12.6.2)
T 32	5.36	8	96	146	4594	ok
T 25	3.27	8	100	150	3535	ok
T 20	2.09	6	104	154	2938	ok
T 16	1.34	6	106	156	2556	ok
T 12	0.75	6	108	158	2258	ok

DESIGN MOMENTS (kN

	K	X AXIS Madd	Mx	Y AXIS Madd	My	COMBINED Axis	M'	REBAR	maxV *
B1	0.297	24.2	114.2	32.3	57.3	X	138.4	8T32	98.9
B2	0.432	30.3	110.3	40.4	100.4	Y	123.9	8T32	101.7
Loadcase 3	0.965	22.5	122.5	30.0	65.0	X	187.9	8T20	72.4
Loadcase 4	0.921	25.8	75.8	34.4	184.4	Y	220.3	8T32	101.0
Loadcase 5	1.000	11.7	231.7	15.6	105.6	X	359.5	No Fit	
Loadcase 6	0.395	23.1	58.1	30.7	55.7	Y	68.4	8T25	87.5

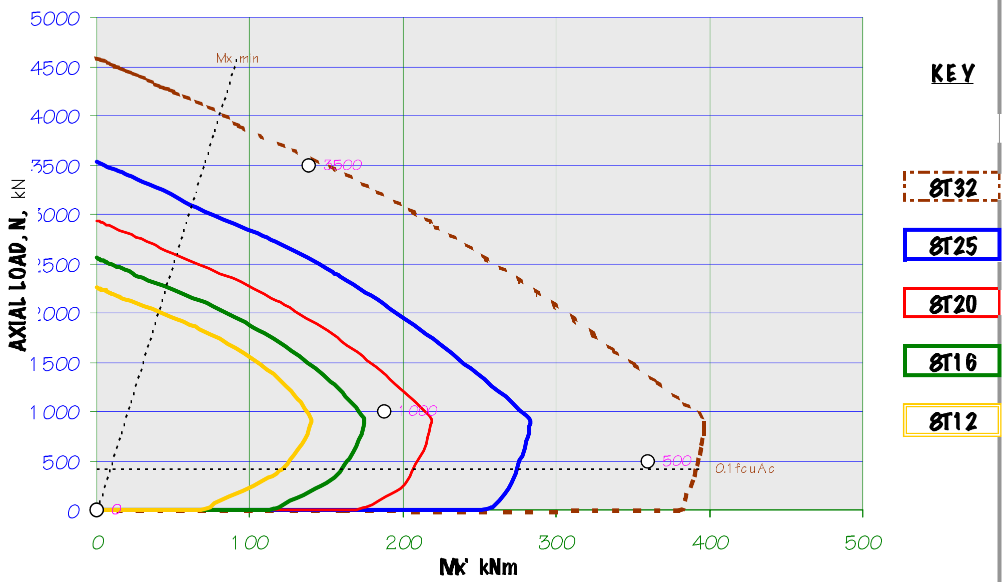
SEE CHARTS ON NEXT SHEET

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by RMW	Date 30-Aug-99	Page 92
Location	Ground floor columns at B1, B2 etc			
	SYMMETRICALLY REINFORCED RECTANGULAR COLUMN DESIGN, BENT ABOUT TWO AXES TO BS 8110:1997	Checked chg	Revision -	Job No R68

Originated from RCC53.xls' on CD © 1999 BCA for RCC

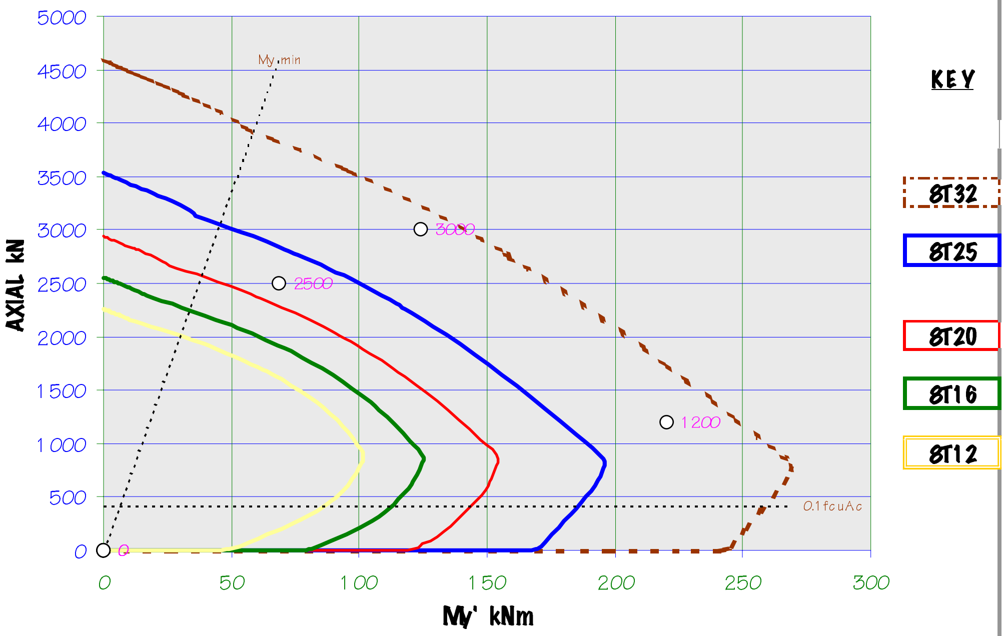
N:M interaction chart: Mx' critical

400 x 300 column (h x b), grade C35, 30 mm cover



N:M interaction chart: My' critical

400 x 300 column (h x b), moment about yy axis), Grade C35, 30 Cover



RCC61 Basement Wall.xls

This spreadsheet designs simple retaining basement walls and is intended for walls up to 3.5 m high. It is based on complying with BS 8002: 1994[4] and BS 8004: 1986[23]. It may also be used to design walls to comply with CECP 2[6] and BS 8007[5]. The spreadsheet has been developed with both the BS 8002 and the conventional (CECP 2) methods in mind. On balance, the spreadsheet provides reasonable flexibility and in doing so, encourages the designer to employ his/her own engineering judgement and interpretation of the codes.

The spreadsheet is intended to cover only short walls and to help 'general' engineers who, from time to time, design retaining walls as part of a wider interest in structures, rather than the specialists. The 3.5 m wall height is an arbitrary limit set for a short wall which is intended to cover over 90% of the cases encountered in 'general' structural designs. Although many of the design principles still apply to higher walls, criteria such as wall movements and the validity of the assumptions made (e.g. no wall friction) require further consideration and investigation.

The effects of compaction pressures can be generated using idealised imposed / surcharged loads. Residual lateral pressure calculations were considered to be too complicated to be covered in the spreadsheet.

Many cells are referred to in formulae by *names*; for example, DATA!C24 is given the name H which is used in formulae at M50:N50, Diagrams!D146:D150, etc. A list of names and where they are defined can be seen by referring to Insert\ Name\ Define in Excel.

Input is required on three sheets.

The spreadsheet is laid out in a very similar manner to RCC62.xls.

DATA!

This single sheet consists of the main inputs.

Most inputs, which are in blue and underlined, should be self-explanatory. The top diagram defines most input parameters. A simplistic diagram shows the geometry of a section of the wall and base.

The spreadsheet is based on a number of assumptions, which should be assessed as being true or erring on the safe side in each case. These assumptions are:

- Wall friction is zero
- Minimum active earth pressure = 0.25qH
- Granular backfill is used
- The spreadsheet is not intended for walls over 3.5 m high

STABILITY! details other assumptions, i.e:

- The wall idealised as a propped cantilever (i.e. pinned at top and fixed at base)
- The wall is braced
- Maximum slenderness of wall is limited to 15, i.e. [$0.9 \times (H_e - T_b/2)/T_w < 15$]
- Maximum ultimate axial load on wall is limited to $0.1f_{cu}$ times the wall cross-sectional area
- Design span = Effective wall height = $H_e - (T_b/2)$
- -ve moment is hogging (i.e. tension at external face of wall)
- +ve moment is sagging (i.e. tension at internal face of wall)
- ' Wall MT ' is maximum +ve moment on the wall
- Estimated lateral deflections are used for checking the PD effects.

Factors for g_f can be set at 1.4 or 1.6 in accordance with BS 8110 or may be set to 1. The designer has, and should have, the final decision and responsibility to select the load factors he or she feels are suitable to the design conditions. Under *Operating Instructions* a number of checks are carried out and problems highlighted.

An estimate of reinforcement per metre length of wall and base is given.

Further details about DATA! can be seen under the description for RCC62.xls.

STABILITY!

STABILITY! calculates the overturning and restoring moments, sliding and resisting forces on a section together with ground bearing pressures and factors of safety. Failures are highlighted.

Factors of safety against overturning and sliding are required as input. As noted in the sheet, wall and/ or surcharge loads may have stabilising effects. By using the boxes in column L the user should toggle between maximum and minimum values to ascertain worst case(s) (perhaps this will be automated some time).

In the case of sliding, where sliding resistance of the base alone is insufficient, the user may choose, outside of the spreadsheet, to rely on a propping force through the basement slab.

DESIGN!

The first page of this sheet tabulates moments and shears.

Input of eccentricity of vertical load, reinforcement diameters and centres is required for main bending steel on both internal and external faces and for transverse reinforcement. The spreadsheet works on the principle of checking a proposed section and reinforcement arrangement rather than proposing an arrangement of reinforcement.

The second page details the design of both outer and inner parts of the base. Again, the spreadsheet works on the principle of checking a proposed section, and input of both reinforcement diameter and centres is required for both main bending and transverse reinforcement.

WEIGHT!

This sheet shows the build up to the estimate of reinforcement weight given. The figures should be treated as approximate estimates only as they cannot deal with the effects of designers' and detailers' preferences, rationalisation, etc.

Diagrams!

Diagrams! shows data for the charts used in other sheets but is not necessarily intended for printing out other than for checking purposes.

Crack width!

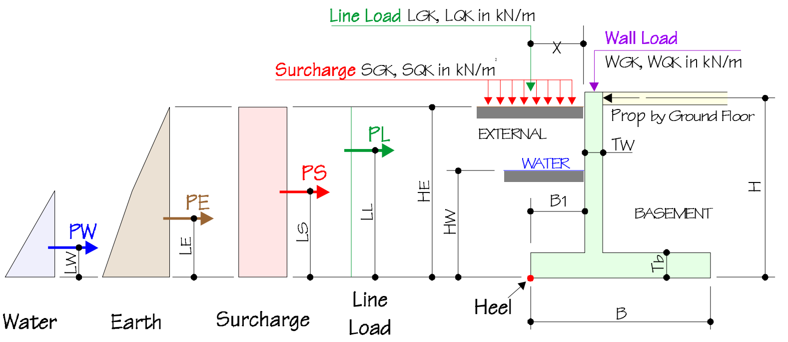
This sheet shows calculations to determine crack widths in the wall. It is not necessarily intended for printing out, other than for checking purposes.

Project	Spreadsheets to BS 8110 etc	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: rc	Date: 30-Aug-99	Page: 95
Location	Grid line 2	Checked: chg	Revision: -	Job No: R68

Basement wall design to BS8110:1997, BS8002:1994. BS 8004:1986 etc.

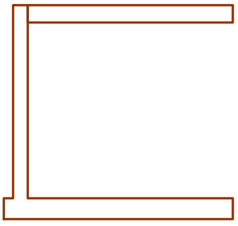
Originated from 'RCC61 BasementWall.xls' on CD ©1999 BCA for RCC

IDEALISED STRUCTURE and FORCE DIAGRAMS **DESIGN STATUS : VALID**



DIMENSIONS (mm)

H =	3500	B =	3500	Tw =	225
Hw =	0	Bl =	150	Tb =	350
He =	2500				



Wall Geometry

MATERIAL PROPERTIES

fcu =	35	N/mm^2	γm =	1.50	concrete
fy =	460	N/mm^2	γm =	1.05	steel
Cover to tension reinforcement (co) =				40	mm
Max. allowable design surface crack width (W) =				0.3	mm
Concrete density =				24.0	kN/m3

SOIL PROPERTIES

Design angle of int'l friction of retained mat'l (Ø) =	30	degree	
Design cohesion of retained mat'l (C) =	0	kN/m2	(Only granular backfill considered, ie "C" = 0)
Density of retained mat'l (γ) =	20	kN/m3	
Submerged Density of retained mat'l (γs) =	13.33	kN/m3	(default=2/3 of γ), only apply when Hw >0
Design angle of int'l friction of base mat'l (Øb) =	20	degree	= 20.00
Design cohesion of base mat'l (Cb) =	0	kN/m2	
Density of base mat'l (γb) =	10	kN/m3	
Allowable gross ground bearing pressure (GBP) =	150	kN/m2	

ASSUMPTIONS

a) Wall friction is zero

b) Minimum active earth pressure = 0.25 γH

c) Granular backfill

h) Design not intended for walls over 3.5 m high

LOADINGS (unfactored)

Surcharge load -- live (SQK) =	10	kN/m2
Surcharge load -- dead (SGK) =	10	kN/m2
Line load -- live (LQK) =	15	kN/m
Line load -- dead (LGK) =	20	kN/m
Distance of line load from wall (X) =	250	mm
Wall load -- live (WQK) =	50	kN/m
Wall load -- Dead (WGK) =	50	kN/m

LATERAL FORCES

Ko = 0.50 default Ko = (1 - SIN Ø) = 0.50

Kac = 1.41 $= 2Ko^{0.5}$

Force (kN)		Lever arm (m)		γ_f	Ultimate Force (kN)
PE =	31.25	LE =	0.833	1.40	43.75
PS(GK) =	12.50	LS =	1.25	1.40	17.50
PS(QK) =	12.50	LS =	1.25	1.60	20.00
PL(GK) =	10.00	LL =	2.29	1.40	14.00
PL(QK) =	7.50	LL =	2.29	1.60	12.00
PW =	0.00	LW =	0.00	1.40	0.00
Total	**73.75**				**107.25**

Project	Spreadsheets to BS 8110 etc	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by rc	Date 30-Aug-99	Page 96
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EXTERNAL STABILITY

STABILITY CHECK : OK

ANALYSIS - Assumptions & Notes

1) Wall idealised as a propped cantilever (i.e. pinned at top and fixed at base)
2) Wall is braced.
3) Maximum slenderness of wall is limited to 15, i.e [0.9*(He-Tb/2)/Tw < 15]
4) Maximum Ultimate axial load on wall is limited to 0.1 fcu times the wall cross-sectional area
5) Design Span (Effective wall height) = He - (Tb/2)
6) -ve moment is hogging (i.e. tension at external face of wall)
+ve moment is sagging (i.e. tension at internal face of wall)
7) " Wall MT. " is maximum +ve moment on the wall.
8) Estimated lateral deflections are used for checking the PΔ effect.

UNFACTORED LOADS AND FORCES

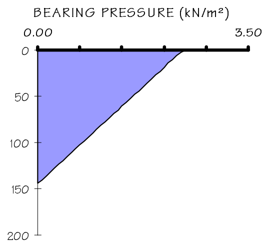
Lateral Force	Force (kN)	Lever arm to base (m)	Base MT. (kNm)	Wall MT. (kNm)	Reaction at Base (kN)	Reaction at Top (kN)	Estimated Elastic Deflection Δ (mm)
PE =	26.98	0.78	-11.46	4.27	24.14	2.84	0.2
PS(GK) =	11.62	1.16	-5.72	2.90	9.28	2.35	0.2
PS(QK) =	11.62	1.16	-5.72	2.90	9.28	2.35	0.1
PL(GK) =	10.00	2.12	-5.25	5.79	5.22	4.78	0.3
PL(QK) =	7.50	2.12	-3.94	4.34	3.91	3.59	0.1
PW =	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Total	**67.73**		**-32.07**	**20.19**	**51.82**	**15.90**	**0.8**

GROUND BEARING FAILURE

LOAD CASE: Wall Load MAX
Surcharge MIN

Taking moments about centre of base (anticlockwise "+")

Vertical FORCES	(kN)	Lever arm (m)	Moment (kNm)
Wall load =	100	1.49	148.75
Wall (sw) =	17.01	1.49	25.30
Base =	29.40	0.00	0.00
Earth =	6.45	1.68	10.80
Water =	0.00	1.68	0.00
Surcharge =	1.50	1.68	2.51
Line load =	20.00	0.00	0.00
Σ V =	**174.36**		Σ Mv = **187.37**



MOMENT due to LATERAL FORCES, **Mb** = -22.42 kNm

RESULTANT MOMENT, **M = Mv + Mb** = 164.95 kNm

ECCENTRICITY FROM BASE CENTRE, **M/V** = 0.95 m

MAXIMUM GROSS BEARING PRESSURE = **144.58** kN/m^2 **<150 OK**

SLIDING AT BASE (using overall factor of safety instead of partial safety factor) F.O.S = 1.50

SUM of LATERAL FORCES, P = 51.82 kN

BASE FRICTION, F_b = - (V TANØb + B.Cb) = -63.46 kN

Factor of Safety, F_b /P = 1.22 <1.50 FAIL .. but

therefore, LATERAL RESISTANCE to be provided by BASEMENT SLAB = 14.27 kN

Project	Spreadsheets to BS 8110 etc	REINFORCED CONCRETE COUNCIL			
Client	Advisory Group	Made by	Date	Page	
Location	Grid line 2	rc	30-Aug-99	97	
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STRUCTURAL DESIGNS (ultimate)

DESIGN CHECKS : OK

BS8110 reference

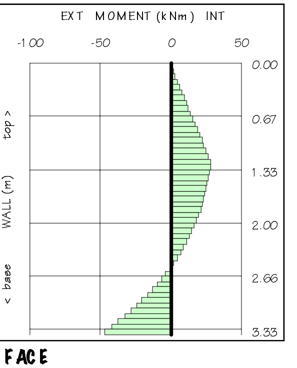
WALL (per metre length)

AXIAL LOAD CAPACITY (Limited to 0.1 fcu) = **787.50** kN **>150** **OK** 3.4.4.1

Lateral Force	Force (kN)	γ_f	Ultimate Force (kN)	Ult. Moment at base (kNm)	Ult. Shear at base (kN)	Ult. Shear at top (kN)
PE =	26.98	1.40	37.77	-16.04	33.79	3.98
PS(GK) =	11.62	1.40	16.27	-8.00	12.99	3.28
PS(QK) =	11.62	1.60	18.60	-9.15	14.85	3.75
PL(GK) =	10.00	1.40	14.00	-7.35	7.30	6.70
PL(QK) =	7.50	1.60	12.00	-6.30	6.26	5.74
PW =	0.00	1.40	0.00	0.00	0.00	0.00
Total	**67.73**		**98.64**	**-46.84**	**75.19**	**23.45**

Design Bending Moments

On INTERNAL face due to lateral forces, M_{int} =	27.76	kNm
On EXTERNAL face due to lateral forces, M_{ext} =	-46.84	kNm
Eccentricity of AXIAL LOADS =	125	mm
LATERAL DEFLECTION " Δ " =	0.8	mm
Due to eccentricity of axial loads, M_{ecc} =	98.4	kNm
Due to PΔ effect, M_p =	0.67	kNm
Total Mmt on INTERNAL face (M_{int}+0.5M_{ecc}+M_p) =	**77.6**	kNm
Total Mmt on EXTERNAL face (M_{ext}+0.5M_{ecc}) =	**-96.1**	kNm



		EXTERNAL FACE		INTERNAL FACE				
WALL REINFORCEMENT :	Min. As =	293		293		mm^2		Table 3.25
	ϕ =	25		20		mm		
	centres =	225	**<241**	225	**<255**	mm	**OK**	3.12.11.2.7(b)
	As =	2182	**>293**	1396	**>293**	mm^2	**OK**	
MOMENT of RESISTANCE :	d =	172.5		175		mm		
	z =	142		155		mm		3.4.4.4
	As' =	0		0		mm^2		3.4.4.4
	M_{res} =	**135.7**	**>96.05**	**95.1**	**>77.65**	kNm	**OK**	

		BASE of WALL		TOP of WALL				
SHEAR RESISTANCE:	As =	2182	ϕ =	12	@ 225 mm 503	mm^2/m		
	100As/bd =	1.26%	=	0.29%				
	vc =	0.94		0.57		N/mm^2		Table 3.8
	V_{res} =	**162.8**	**>75.19**	**100.4**	**>23.45**	kN	**OK**	3.5.5.2

CRACK WIDTH TO BS8007:	X =	78.56	mm	εm =	0.00052			BS8007
NOTE: Temp. & shrinkage effects not included	Acr =	111.65	mm	W =	**0.09**	**<0.30 mm**	**OK**	App. B.2

REINFORCEMENT SUMMARY for WALL

	Type	ϕ mm	centres mm	As mm^2	Min. As mm^2	
EXTERNAL FACE	T	20	225	1396	293	**OK**
INTERNAL FACE	T	25	225	2182	293	**OK**
TRANSVERSE	T	10	225	349	293	**OK**

Project	**Spreadsheets to BS 8110 etc**	REINFORCED CONCRETE COUNCIL		
Client	**Advisory Group**	Made by	Date	Page
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	Basement wall design to BS8110:1997, BS8002:1994 BS 8004:1986 etc.	Checked	Revision	Job No
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OUTER BASE (per metre length)

BS8110 reference

γ_f =	1.50	(ASSUMED)				
Ult. Shear =	10.35	kN	(AT d from FACE of WALL)			
Ult. MT. =	1.66	kNm	TENSION - BOTTOM FACE			

BOTTOM REINFORCEMENT :

Min. As =	455	mm^2			Table 3.25
ϕ =	12	mm			
centres =	225	mm	**<762**	**OK**	
As =	503	mm^2	**>455**	**OK**	

MOMENT of RESISTANCE :

d =	304	mm			
Z =	289	mm			3.4.4.4
As' =	0	mm^2			
Mres =	**63.60**	kNm	**>1.66**	**OK**	

SHEAR RESISTANCE :

100As/bd =	0.29%				
vc =	0.42	N/mm^2			Table 3.8
Vres =	**126.35**	kN	**>10.35**	**OK**	3.5.5.2

CHECK CRACK WIDTH IN ACCORDANCE WITH BS8007 :

X =	60.69	mm	ε_m =	-0.00166					BS8007
Acr =	115.54	mm	W =	**-0.38**	mm	**<0.30**	**OK**		App. B.2

INNER BASE (per metre length)

Ult. Shear =	-71.40	kN	(AT d from FACE of WALL)	
Ult. MT. =	49.77	kNm	TENSION - BOTTOM FACE	

BOTTOM REINFORCEMENT :

Min. As =	455	mm^2			Table 3.25
ϕ =	12	mm			
centres =	225	mm	**<762**	**OK**	
As =	503	mm^2	**>455**	**OK**	

MOMENT of RESISTANCE :

d =	304	mm			
Z =	289	mm			
As' =	0	mm^2			
Mres =	**63.60**	kNm	**>49.77**	**OK**	3.4.4.4

SHEAR RESISTANCE :

100As/bd =	0.17%				
vc =	0.42	N/mm^2			Table 3.8
Vres =	**126.35**	kN	**>71.40**	**OK**	3.5.5.2

CHECK CRACK WIDTH IN ACCORDANCE WITH BS8007 :

X =	60.69	mm	ε_m =	-0.00033				BS8007
Acr =	115.54	mm	W =	**-0.07**	mm	**<0.30**	**OK**	App. B.2

REINFORCEMENT SUMMARY for BASE

	Type	ϕ mm	centres mm	As mm^2	Min. As mm^2	
TOP	T	12	225	503	455	**OK**
BOTTOM	T	12	225	503	455	**OK**
TRANSVERSE	T	12	225	503	455	**OK**

RCC62 Retaining Wall.xls

RCC62.xls designs simple retaining walls with stems up to 3.0 m high. The spreadsheet has been developed with both the BS 8002 and the conventional (CECP 2) methods in mind. On balance, the spreadsheet provides reasonable flexibility and, in doing so, encourages the designer to employ their own engineering judgement and interpretation of the codes. It is based on complying with BS 8002: 1994(4) and BS 8004: 1986(23). It may also be used to design retaining walls to complying with CECP 2(6) and BS 8007(5).

The spreadsheet is intended to cover only short walls and to help 'general' engineers who, from time to time, design retaining walls as part of a wider interests in structures rather than the specialists. The 3.0 m wall height is an arbitrary limit set for short wall which is intended to cover over 90% of the cases encountered in general structural designs. Although many of the design principles still apply to higher walls, criteria such as wall movements and the validity of the assumptions made (e.g. no wall friction) require further consideration and investigation. For instance, with reference to pressures, the engineer is expected to judge between using the default of k_a (active coefficient) or inputting a larger figure relating to k_o (at rest coefficient).

The effects of compaction pressures can be generated using idealised imposed/ surcharged loads. Residual lateral pressure calculations were considered to be too complicated to be covered in the spreadsheet.

Stability analysis is done about the toe of the base. (Stability analysis taken about toe of nib is ignored; the nib is a section sticking down from general level of the base, and stability analysis about its toe gives strange answers). Global slope stability checks are not undertaken in the spreadsheet and should be addressed using other means.

Input is required on three sheets.

Many cells are referred to in formulae by names; for instance DATA!C23 is given the name H which is used in formulae at C56:D60, Diagrams!D88:D137, etc. The spreadsheet is laid out in a very similar manner to RCC61.xls.

DATA!

This single sheet consists of the main inputs. Most inputs, which are in blue and underlined, should be self-explanatory. The top diagram defines most input parameters.

The designer should determine the 'Design Soil Parameters' based on the combinations in BS 8002 which will give the worst credible loads i.e. the design values should be the lower of (a) the peak strength reduced by a mobilisation factor or (b) the critical state strength.

As default values, the earth pressure coefficients are calculated using the simplified Rankine's formula for smooth vertical walls based on values of the design soil parameters. Alternatively, the engineer can enter his or her own coefficients to suit the conditions of the design by overwriting the default values.

Maximum earth pressure occurs during service and not at ultimate limit state, as at ultimate limit state the actual earth pressure will be less. BS 8002(4) also uses a mobilisation factor on soil parameters, increasing load on the active side of the wall and reducing soil resistance on the passive side. In so doing, the code recommends that no further partial load factors are necessary in design of the structure. The above are not entirely compatible with BS 8110: Part 1, Table 2.1, nor to our knowledge have they been fully accepted by the general practising engineer. Many designers do seem to use the BS 8002 mobilisation factor as well as the traditional safety factors. Therefore the built-in partial load factors may be changed. Factors can be set at 1.4 or 1.6 in accordance with BS 8110 or may be set to 1.0. The designer has, and should have the final decision and responsibility to select the load factors he or she feels are suitable to the design conditions.

BS 8002 suggests that no additional factors of safety are required in checking of external stability (i.e. overturning and sliding) provided that the structure is in equilibrium and the 'worst credible loads' are used in the design.

For the calculation of bearing pressures, all partial load factors are switched to unity and the design checks are based on allowable ground bearing pressure, i.e. the permissible stress approach. The bearing pressure is then factored up with the partial load factors adopted from above for the design of concrete base. Bearing pressure is calculated using the concept of 'no tension' equilibrium, i.e. triangular stress blocks are used when eccentricity is outside the middle third.

BS 8002 has minimum surcharge and minimum unplanned excavation depth requirements. However in the spreadsheet, the surcharge loads are set as input data. The minimum 10 kN/m^2 limit in BS 8002 has not been used with the understanding that the BS 8002 committee is considering reducing the 10 kN/m^2 to 6 kN/m^2 for 3 m high walls.

The spreadsheet is based on a number of assumptions which should be assessed as being true or erring on the safe side in each case. These are:

- Wall friction is zero
- Minimum active earth pressure = 0.25qH. A minimum active pressure of 0.25H (made to be a function of soil property rather than an arbitrary value equivalent to approx. 5 kN/m^3 per m height) to cover conditions regarding tension cracks. However, this does not comply with BS 8002, which recommends that full hydrostatic pressure is used. As the majority of small

retaining walls have granular backfills, the cohesion value of retaining soil has been 'locked' to zero.

- Granular backfill is used. Even a small value of effective cohesion, c´, can significantly reduce active pressures. However, to acknowledge the fact that many retaining walls are built with granular backfill for drainage and to err on the side of caution, the spreadsheet assumes only cohesionless materials.
- The spreadsheet does not include checks on rotational slide/slope failure.
- The spreadsheet does not include checks on the effects of seepage of ground water beneath the wall.
- The spreadsheet does not include checks on deflection of the wall due to lateral earth pressures.
- The spreadsheet is not intended for walls over 3.0 m high.

Many engineers have reservations about including the effect of passive pressure in front of the wall and a warning message has been used to help ensure that passive pressure is considered only if it can be guaranteed that there will be no future excavation in front of the wall.

Under *Operating Instructions* a number of checks are carried out and problems are highlighted.

K_p is calculated using base material properties. Lever arm of passive reaction is measured from bottom base level downward. In the calculation of passive force, cohesion of the base material is also taken into consideration.

STABILITY!

STABILITY! calculates the overturning and restoring moments, sliding and resisting forces on a section together with ground bearing pressures and factors of safety. Failures are highlighted.

Required Factors of safety against overturning and sliding are required as input. In some circumstances, some loads may have stabilising effects. By using the check boxes to switch loads off and on, worse cases should be investigated by hand.

For stability calculations, overall factor of safety is used instead of partial safety factors **and fill on the external face of the wall is ignored.**

All loads are assumed to be static loads. Dynamic loads / vibration are not covered. However, at the discretion of the designer, dynamic effects may be modelled by factoring up static loads.

The equation for sliding assumes that passive pressure acts without movement. The user may consider that the situation is better modelled by applying a partial safety factor to passive pressure at cell K39.

Idealisation, rounding errors and assuming a triangular pressure diagram (which is not strictly correct) may lead to theoretical inaccuracies. Moments at the top of the wall may be small to the point of being indistinguishable on the Bending Moment Diagram – a problem of scale.

An estimate of reinforcement per metre length of wall is given.

DESIGN!

The first page of this sheet summarises the checks carried out for moment resistance, shear resistance, crack width and minimum reinforcement requirements.

Input of both reinforcement diameter and centres is required both for main bending steel and for transverse and secondary reinforcement: the spreadsheet works on the principle of checking a proposed section and reinforcement arrangement rather than proposing an arrangement of reinforcement.

The second page details the design of both outer and inner parts of the base. Again, the spreadsheet works on the principle of checking a proposed section and input of both reinforcement diameter and centres is required for both main bending and transverse reinforcement.

WEIGHT!

This sheet shows the build up to the estimate of reinforcement weight given. The figures should be treated as approximate estimates only as they cannot deal with the effects of designers and detailers preferences, 'rationalisation', etc.

Diagrams!

Diagrams! shows data for the charts used in other sheets but is not necessarily intended for printing out other than for checking purposes.

Crack width!

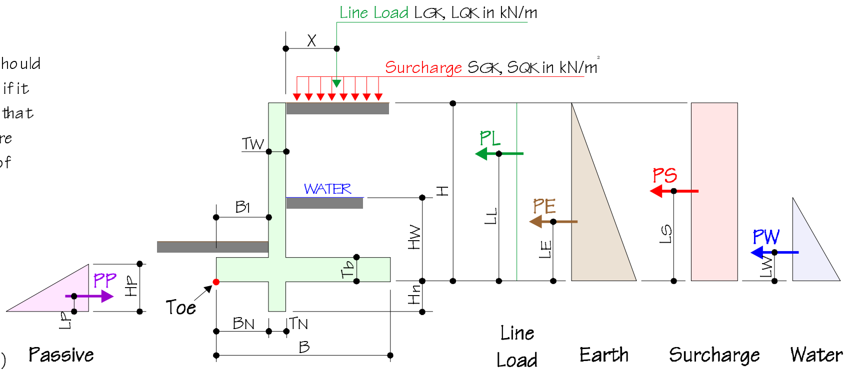
This sheet shows calculations to determine crack widths in the wall.

This check is included so the spreadsheet can also be used for design of water-retaining structures to BS 8007. For example a water tank may be looked at by setting H_w within DATA! to the water level of the tank, switching soil properties to 0 and crack width, at DATA!F31, to 0.3 mm. The crack width check to BS 8007 is the same as that to BS 8110.

Project	Spreadsheets to BS 8110etc	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
Location	Grid line 1	rc	30-Aug-99	101
	RETAINING WALL design to BS 8110:1997, BS 8002:1994 BS 8004:1986 etc.	Checked	Revision	Job No
	Originated from 'RCC62.xls' on CD ©1999 BCA for RCC	chg	-	R68

IDEALISED STRUCTURE and FORCE DIAGRAMS **DESIGN STATUS: VALID**

WARNING:
Passive pressure should only be considered if it can be guaranteed that there will be no future excavation in front of the wall.

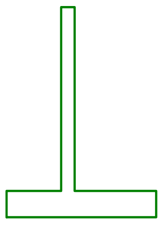


DIMENSIONS (mm)

H =	3200	B =	2750	Tw =	250
Hw =	100	Bl =	1000	Tb =	400
Hp =	200	BN =	0	TN =	0
Hn =	0				

MATERIAL PROPERTIES

fcu =	35	N/mm²	γm =	1.5	concrete
fy =	460	N/mm²	γm =	1.05	steel
			cover to tension steel =	50	mm
			Max allowable design surface crack width (W) =	0.3	mm
			Concrete density =	24	kN/m³



Wall Geometry

SOIL PROPERTIES

Design angle of int'l friction of retained mat'l (Ø) =	30	degree	
Design cohesion of retained mat'l (C) =	0	kN/m²	(Only granular backfil considered, "C" = zero)
Density of retained mat'l (γ) =	20	kN/m³	
Submerged Density of retained mat'l (γs) =	13.33	kN/m³	[default=2/3*γ (only apply when Hw 13.33
Design angle of int'l friction of base mat'l (Øb) =	20	degree	
Design cohesion of base material (Cb) =	10	kN/m²	
Density of base material (γb) =	10	kN/m³	
Allowable gross ground bearing pressure (GBP) =	200	kN/m²	

ASSUMPTIONS
a) Wall friction is zero
b) Minimum active earth pressure = 0.25γH
c) Granular backfill
d) Does not include check of rotational slide/slope fa
e) Does not include effect of seepage of ground water beneath the wall.
f) Does not include deflection check of wall due to lateral earth pressures
h) Design not intended for walls over 3.0 m high

LOADINGS

Surcharge load -- live (SQK) =	10	kN/m²
Surcharge load -- dead (SGK) =	10	
Line load -- live (LQK) =	15	kN/m
Line load -- dead (LGK) =	20	kN/m
Distance of line load from wall (X) =	1000	mm

LATERAL FORCES (unfactored)

Ka =	0.33	[default ka = (1 -SIN Ø)/(1 +SIN Ø)]	0.33
Kp =	2.04	[default kp = (1 +SIN Øb)/(1 -SIN Øb)]	2.04
Kpc =	2.86	[default kpc = $2kp^{0.5}$] =	2.86
Kac =	1.15	[$2ka^{0.5}$]	

	Force (kN)	Lever arm (m)	Moment about TOE (kNm)	γ_f	F_{ult} (kN)	M_{ult} (kNm)
PE =	34.12	LE = 1.067	36.41	1.40	47.77	50.97
PS(GK) =	10.67	LS = 1.60	17.07	1.40	14.93	23.89
PS(QK) =	10.67	LS = 1.60	17.07	1.60	17.07	27.31
PL(GK) =	6.67	LL = 2.36	15.74	1.40	9.33	22.03
PL(QK) =	5.00	LL = 2.36	11.80	1.60	8.00	18.89
PW =	0.05	LW = 0.03	0.00	1.40	0.07	0.00
Total	**67.17**		**98.09**		**97.17**	**143.10**
PP =	-6.12	(LP-HN) = 0.10	-0.60	1.00	-6.12	-0.60

Project	Spreadsheets to BS 8110etc	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: rc	Date: 26-Nov-99	Page: 102
Location	Grid line 1			
	RETAINING WALL design to BS 8110:1997, BS 8002:1994, BS 8004:1986 etc.	Checked: chg	Revision: -	Job No: R68
	Originated from 'RCC62.xls' on CD © 1999 BCA for RCC			

EXTERNAL STABILITY

STABILITY CHECKS : OK

OVERTURNING about TOE

F.O.S = 1.50

(using overall factor of safety instead of partial safety factor)

Overturning Moments

Lateral FORCE (kN)	Lever arm (m)	Moment (kNm)
PE = 34.12	LE = 1.07	36.40
PS(GK) = 10.67	LS = 1.60	17.07
PS(QK) = 10.67	LS = 1.60	17.07
PL(GK) = 6.67	LL = 2.36	15.74
PL(QK) = 5.00	LL = 2.36	11.80
PW = 0.05	LW = 0.03	0.00
Σ P = **67.17**		
Pp = -6.12	(LP-HN) = 0.10	-0.60
		Σ Mo = **97.48**

LOADING OPTION

(select critical load combination)

✓EARTH
- ☑ PS(GK)
- ☑ PS(QK)
- ☑ PL(GK)
- ☑ PL(QK)
- ☑ PW

Warning:

Under some conditions,surcharge & line loads may have stabilising effects on the structure, and it is recommended that stability checks should also be carried out without these loads.

Restoring Moments

Vertical FORCE (kN)	Lever arm (m)	Moment (kNm)
Wall = 16.80	1.13	18.90
Base = 26.40	1.38	36.30
Nib = 0.00	0.00	0.00
Earth = 84.00	2.00	168.00
Water = 0.00	2.00	0.00
Surcharge = 30.00	2.00	60.00
Line load = 35.00	2.25	78.75
Σ V = **192.20**		Σ Mr = **361.95**

Factor of Safety, Mr / Mo = 3.71 > 1.50 OK

SLIDING

(using overall factor of safety instead of partial safety factor) F.O.S = 1.50

Sum of LATERAL FORCES, P = **67.17** kN

PASSIVE FORCE, Pp x Reduction factor (1) = -6.12 kN — Red'n factor for passive force = 1.00

BASE FRICTION (Σ V TANØb + B Cb) = -97.46 kN

Sum of FORCES RESISTING SLIDING, Pr = **-103.58** kN

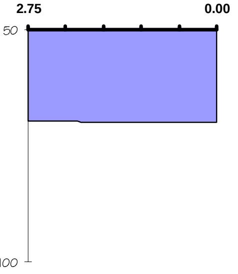
Factor of Safety, Pr / P = 1.54 > 1.50 OK

GROUND BEARING FAILU[RE]

Taking moments about centre of base (anticlockwise "+") :

Vertical FORCES (kN)	Lever arm (m)	Moment (kNm)
Wall = 16.80	0.25	4.20
Base = 26.40	0.00	0.00
Nib = 0.00	1.38	0.00
Earth = 84.00	-0.63	-52.50
Water = 0.00	-0.63	0.00
Surcharge= 30.00	-0.63	-18.75
Line load = 35.00	-0.88	-30.63
Σ V = **192.20**		Σ Mv = **-97.68**

BEARING PRESSURE (KN/m²)



Moment due to LATERAL FORCES, Mo = **97.48** kNm

Resultant Moment, M = Mv + Mo = **-0.20** kNm

Eccentricity from base centre, M / V = 0.00 m

Therefore, MAXIMUM Gross Bearing Pressure (GRP) = **70** kN/m² < 200 OK

Project	Spreadsheets to BS 8110etc	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: rc	Date: 30-Aug-99	Page: 103
Location	Grid line 1			
	RETAINING WALL design to BS 8110:1997, BS 8002:1994 BS 8004:1	Checked: chg	Revision: -	Job No: R68
	Originated from 'RCC62.xls' on CD ©1999 BCA for RCC			

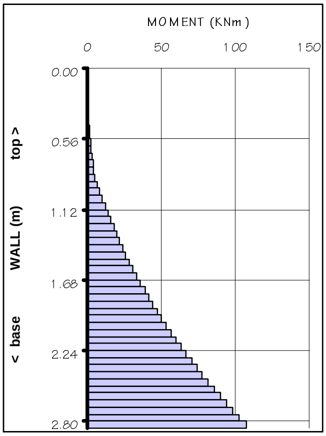
STRUCTURAL DESIGNS (ultimate)

DESIGN CHECKS : OK

WALL (permetre length)

	Force (kN)	Lever arm (m)	Moment (kNm)	γ_f	V ult (kN)	Mult (kNm)
EARTH	26.03	0.93	24.30	1.4	36.45	34.02
SURCHARGE(GK)	9.33	1.40	13.07	1.4	13.07	18.29
SURCHARGE(QK)	9.33	1.40	13.07	1.6	14.93	20.91
LINE LOAD(GK)	6.67	1.96	13.07	1.4	9.33	18.30
LINE LOAD(QK)	5.00	1.96	9.80	1.6	8.00	15.69
WATER	0.45	0.00	0.00	1.4	0.63	0.00
Total	**56.82**		**73.31**		**82.41**	**107.21**

BS8110 reference



Ultimate Bending Moment Diagram

MAIN REINFORCEMENT :

Min. As = 325 mm² — Table 3.25
ϕ = 16 mm
centres = 125 mm <220 OK — 3.12.11.2.7(b)
As prov = 1608 mm² >325 OK

MOMENT of RESISTANCE :

d = 192 mm
z = 169.46 mm — 3.4.4.4
As' = 0 mm²
Mres = **119.42** kNm >107.21 OK

SHEAR RESISTANCE :

100 As/bd = 0.84%
vc = 0.80 N/mm² — Table 3.8
V res = **153.74** kN >82.41 OK — 3.5.5.2

CHECK CRACK WIDTH IN ACCORDANCE WI

X = 75.21 mm
Acr = 77.27 mm
εm = 0.001636 — BS8007
W = **0.29** mm <0.30 OK — App. B.2

REINFORCEMENT SUMMARY for WALL

	Type	ϕ mm	Centres mm	As mm²	Min. As mm²	
VERTICAL EXT. FACE	T	10	200	393	325	OK
VERTICAL INT. FACE	T	16	125	1608	325	OK
TRANSVERSE	T	10	200	393	325	OK

Project	Spreadsheets to BS 8110etc	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: rc	Date: 30-Aug-99	Page: 104
Location	Grid line 1	Checked: chg	Revision: -	Job No: R68
	RETAINING WALL design to BS 8110:1997, BS 8002:1994, BS 8004:1			
	Originated from 'RCC62.xls' on CD © 1999 BCA for RCC			

OUTER BASE (per metre length)

BS8110 reference

γ_f = 1.46 (default= ultmt/ non-factored mt.) 1.46
V ult= 86.79 kN
M ult= 53.64 kNm (TENSION - BOTTOM FACE)

BOTTOM REINFORCEMENT :

Min. As =	520	mm^2			Table 3.25
ϕ =	12	mm			
centres =	200	mm	<762	OK	3.12.11.2.7(b)
Asprov =	565	mm^2	>520	OK	

MOMENT of RESISTANCE :

d =	344	mm			
z =	326.80	mm			3.4.4.4
As' =	0	mm^2			
Mres =	**80.96**	kNm	>53.64	OK	

SHEAR RESISTANCE:

100 As/bd =	0.16%				
vc =	0.40	N/mm^2			Table 3.8
V res =	**138.35**	kN	>86.79	OK	3.5.5.2

CHECK CRACK WIDTH IN ACCORDANCE WITH BS8007 :

X =	68.49	mm	εm =	-0.00076					BS8007
Acr =	108.61	mm	W =	**-0.18**	mm	<0.30	OK		App. B.2

INNER BASE (per metre length)

V ult= 81.20 kN
M ult = 89.46 kNm (TENSION - TOP FACE)

TOP REINFORCEMENT :

Min. As =	520	mm^2			Table 3.25
ϕ =	16	mm			
centres =	150	mm	<766	OK	3.12.11.2.7(b)
Asprov =	1340	mm^2	>520	OK	

MOMENT RESISTANCE :

d =	342	mm			
z =	323.22	mm			3.4.4.4
As' =	0	mm^2			
Mres =	**189.80**	kNm	>89.46	OK	

SHEAR RESISTANCE:

100 As/bd =	0.39%				
vc =	0.54	N/mm^2			Table 3.8
V res =	**184.02**	kN	>81.20	OK	3.5.5.2

CHECK CRACK WIDTH wrt BS8007 : (Temperature and shrinkage effects not included)

X =	99.03	mm	εm =	0.000222					BS8007
Acr =	86.81	mm	W =	**0.05**	mm	<0.30	OK		App. B.2

REINFORCEMENT SUMMARY for BASE

	Type	ϕ mm	Centers mm	As mm^2	Min. As mm^2	
TOP (DESIGN)	T	16	150	1340	520	OK
BOTTOM (DESIGN)	T	12	200	565	520	OK
TRANSVERSE	T	12	200	565	520	OK

RCC71 Stair Flight & Landing - Single.xls

RCC71.xls designs simply supported flights and landings to BS 8110. Input is required on two sheets.

FLIGHT!

This single sheet consists of the input and main output. Inputs are in blue and underlined and most should be self-explanatory.

Only simply supported spans are catered for. If flights are continuous with floors, the user should specify continuity steel over supports as appropriate. Calculations are done per metre width of flight. Input loads are assumed to be characteristic and acting vertically. They should account for any undercuts. Self-weight, moments and reactions are calculated automatically. The area of steel required, A_{sreq}, may be automatically increased to increase modification factors and satisfy deflection criteria. Where the stair flight occupies more than 60% of the span an increase in allowable span to depth ratios of 15% is included in accordance with Clause 3.10.2.2. Nominal top reinforcement may be specified in order to help overcome deflection problems. Dimensions are not checked for compliance with Building Regulations.

Ultimate, characteristic dead and characteristic imposed reactions are given below the indicative diagram.

LANDING!

Again, this single sheet consists of the input and main output. Input defauls in magenta have been derived from FLIGHT! but may be overwritten. Calculations are done per metre width of landing.

Inputs are underlined and most should be self-explanatory. As defaults, which can be overwritten, the material data and characteristic flight reactions carry over from FLIGHT! Self-weight, moments and reactions are calculated automatically. The maximum width of landing over which flight loads can be dispersed has been restricted to 1.8 m in the spirit of Clause 3.10.1.3. Reactions are ultimate, both total and per metre run. The area of steel required, A_s, can be automatically increased to satisfy deflection criteria.

Dias!

Dias! calculates the reinforcement sizes and reinforcement percentages for deflection modification factors used in FLIGHT! and LANDING!

Project	Spreadsheets to BS 8110		REINFORCED CONCRETE COUNCIL		
Client	Advisory Group		Made by	Date	Page
Location	South Staircase	FLIGHT	rmw	24-Nov-99	106
	STAIR FLIGHTS AND LANDINGS to BS 8110:1997		Checked	Revision	Job No
	Originated from Beta/trial version of RCC71.xls' on CD	© 1999 BCA for RCC	chg	-	R68

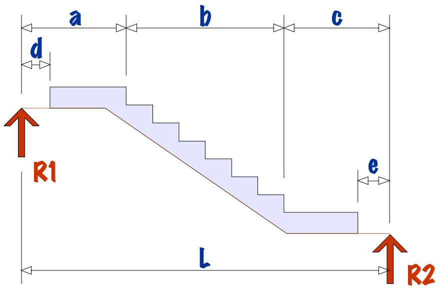
MATERIALS

fcu	35	N/mm²	γm	1.5	concrete	Min bar Ø =	10
fy	460	N/mm²	γm	1.05	steel	Max bar Ø =	16
h agg	20	mm	Density	23.6	kN/m³		
Cover	25	mm	*(Normal weight concrete)*			Nominal top steel ?	Y

DIMENSIONS

Sectional Elevation

a =	600	mm	landing A h =	175
b =	2500	mm	flight waist =	200
c =	1200	mm	landing B h =	200
d =	-600	mm		
e =	-100	mm		
Going =	250	mm	L =	4300
Rise =	1900	mm total		10 treads
Rise =	173	mm each step	Rake =	34.64 °



LOADING

Imposed	4.00	kN/m²	47.08 kN/m ult	37.81 kN/m ult
Flight finishes	1.60	kN/m²	(20.87 + 11.16)	(16.91 + 8.84)
Landing finishes	1.30	kN/m²		

DESIGN

LANDING A, gk = 4.13 + 1.30 = 5.43 kN/m² n = 1.4 x 5.43 + 1.6 x 4.0 = 14.00 kN/m²

FLIGHT, gk = 7.78 + 1.60 = 9.38 kN/m² n = 1.4 x 9.38 + 1.6 x 4.0 = 19.53 kN/m²

LANDING C, gk = 4.72 + 1.30 = 6.02 kN/m² n = 1.4 x 6.02 + 1.6 x 4.0 = 14.83 kN/m²

Zero shear is at 0.6 + (47.08 - 16.80) /19.53 = 2.151 m from left

M = 47.08 x 2.151 - 16.80 x 2.151 - 19.53 x 1.551²/2 = 41.64 kNm/m

d = 200 - 25 - 8 = 167 mm K = 0.0427 As = 599 mm²/m

PROVIDE T16 @ 300 B = 670 mm²/m

Enhanced by 8.5 % for deflection **T10 @ 300 T in span**

L/d = 4,300 /167 = 25.749 < 20.0 x 1.256 x 1.050 = 26.375 allowed **OK**

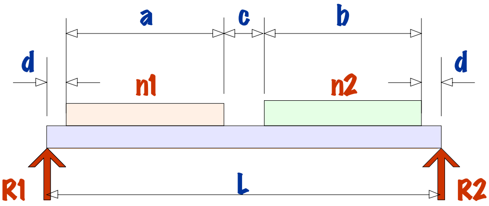
Project	**Spreadsheets to BS 8110**		REINFORCED CONCRETE COUNCIL		
Client	**Advisory Group**		Made by	Date	Page
Location	**South Staircase**	**LANDING**	**rmw**	**30-Aug-99**	**107**
	STAIR FLIGHTS AND LANDINGS to BS 8110:1997		Checked	Revision	Job No
	Originated from Beta/trial version of RCC71.xls' on CD	© 1999 BCA for RCC	**chg**		**R68**

MATERIALS

fcu	35	N/mm²	γm	1.5	concrete	Min bar Ø =	10
fy	460	N/mm²	γm	1.05	steel	Max bar Ø =	16
h agg	20	mm	Density	23.6	kN/m³		
Cover	25	mm	*(Normal weight concrete)*			Nominal top steel ?	Y

DIMENSIONS

a =	1200	mm	depth, h =	175	mm
b =	1200	mm	width, w =	1200	mm
c =	250	mm			
d =	175	mm	L =	3000	mm



LOADING

LANDING	Imposed	4.00	kN/m²	
	Finishes	1.50	kN/m²	
	Slab	4.13	kN/m²	
	gk	**qk**		
Flight **a** reaction	20.87	11.16	kN/m	
Flight **b** reaction	16.91	8.84	kN/m	

79.3 kN ult — 74.0 kN ult

66.1 kN/m ult — 61.6 kN/m ult

n = 1.4 x 5.63 + 1.6 x 4.0 = 14.28 kN/m²

n1 = (1.4 x 20.87 + 1.6 x 11.16)/1.20 = 39.23 kN/m²

n2 = (1.4 x 16.91 + 1.6 x 8.84)/1.20 = 31.51 kN/m²

DESIGN

Zero shear is at (66.11 - 2.50) /(14.28 + 39.23) + 0.175 = 1.364 m from left

M = 66.11 x 1.364 - 14.28 x 1.364²/2 - 39.23 x 1.189²/2 = 49.15 kNm/m

d = 175 - 25 - 8 = 142 mm K = 0.0696 As = 863 mm²/m

PROVIDE T16 @ 220 B = 914 mm²/m

Enhanced by 3.7 % for deflection **T10 @ 325 T in span**

L/d = 3,000 /142 = 21.127 < 20.0 x 1.018 = 21.450 allowed **OK**

RCC72 Stairs & Landings - Multiple.xls

This spreadsheet designs the flights and landings of a staircase in a stair core to BS 8110. It is assumed that flights are supported on the landings and that the landings are simply supported on bearings at each end.

STAIRCORE!

This single sheet consists of the input and main output. Inputs are in blue and underlined and most should be self-explanatory. Dimensions are not checked for compliance with Building Regulations. Simple supports are assumed. Calculations are done per metre width of flight and landing. Input loads are assumed to be characteristic and acting vertically. They should account for any undercuts. All stairs are assumed to start from flight 1. Superfluous flights and landings are blanked out. Self-weight, moments and reactions are calculated automatically. Where the stair flight occupies more than 60% of the span an increase in allowable span to depth ratios of 15% is included in accordance with Clause 3.10.2.2 and, as with other spreadsheets, the area of steel required may be automatically increased to satisfy deflection criteria. Ultimate reactions per metre are given.

Dias!

Dias! calculates the reinforcement sizes and reinforcement percentages for deflection modification factors used in STAIRCORE!

Project	**Spreadsheets to BS 8110**	REINFORCED CONCRETE COUNCIL		
Client	**Advisory Group**	Made by RMW	Date 24-Nov-99	Page 109
Location	**North Staircase**			
	REINFORCED CONCRETE STAIRCASES to BS 8110:1997	Checked chg	Revision -	Job No R68
	Originated from RCC72.xls on CD © 1999 BCA for RCC			

MATERIALS

fcu	35	N/mm²	γm	1.5	concrete
fy	460	N/mm²	γm	1.05	steel
h agg	20	mm	Density	23.6	kN/m³
Cover	20	mm	*(Normal weight concrete)*		

DIMENSIONS

No of Flights = 6

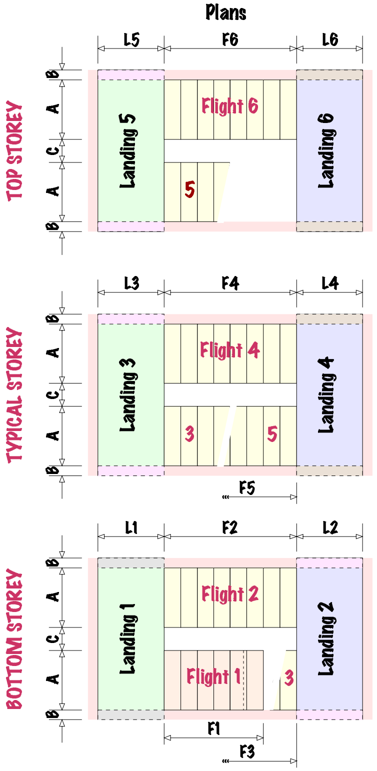
A = 1200 mm   B = 150 mm bearing

C = 250 mm   Going = 250 mm

L1 =	1200	mm	F1 =	2500	mm	10 treads
L2 =	1200	mm	F2 =	2500	mm	10 treads
L3 =	1200	mm	F3 =	2500	mm	10 treads
L4 =	1200	mm	F4 =	2500	mm	10 treads
L5 =	1200	mm	F5 =	2500	mm	10 treads
L6 =	750	mm	F6 =	2500	mm	10 treads

STOREY	HEIGHT	RISERS	RISE	RAKE
Lower	3500 mm	22	159.1 mm	32.5 °
Typical	3500 mm	22	159.1 mm	32.5 °
Upper	3500 mm	22	159.1 mm	32.5 °

Plans



LOADING

Imposed	4.00	kN/m²
Flight finishes	0.50	kN/m²
Landing finishes	1.30	kN/m²

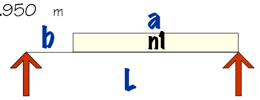
FLIGHT 1

Waist = 150 mm   a = 2.350 m

b = 0.600 m

L = 2.950 m

Waist 4.20
Steps 1.88
Finishes 0.50
6.57 kN/m²



n1 = 1.4x6.57+1.6x4.00   14.60 kN/m   22.06 kN/m

= 15.60 kN/m²

M = 22.06 x 1.414 / 2 = 15.60 kNm/m   d = 125 mm   K = 0.0285

As = 360 mm²   **PROVIDE 5 T10 @ 270 B** = 393 mm²   L/d = 23.600 < 28.213 allowed   **OK**

FLIGHT 2

Waist = 150 mm   a = 2.500 m   b = 0.600 m   c = 0.600 m

L = 3.700 m

Waist 4.20
Steps 1.88
Finishes 0.50
6.57 kN/m²   n2 = 15.60 kN/m²   19.50 kN/m   19.50 kN/m

M = 19.50 x (1.850 - 0.625) = 23.89 kNm/m   d = 124 mm   K = 0.0444

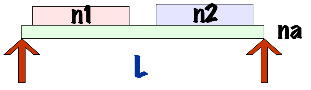
As = 557 mm²   **PROVIDE 8 T12 @ 150 B** = 905 mm²   L/d = 29.839 < 30.582 allowed   **OK**

As increased by 53.6 % for deflection

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by RMW	Date 24-Nov-99	Page 110
Location	North Staircase	Checked chg	Revision -	Job No R68
	REINFORCED CONCRETE STAIRCASES to BS 8110:1997			
	Originated from RCC72.xls on CD © 1999 BCA for RCC			

LANDING 1 +1.750 m

h = 150 mm L = 2.800 m



Self wt 3.54 n1 = 14.60/1.20 = 12.17 kN/m²
Finishes 1.30 n2 = 19.50/1.20 = 16.25 kN/m²
4.84 kN/m² na = 1.4x4.84+1.6x4.0 = 13.18 kN/m²

34.23 kN/m 36.77 kN/m

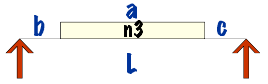
M = 36.77 x 1.310 - 11.31 - 12.39 = 24.48 kNm/m d = 124 mm K = 0.0455

As = 571 mm² **PROVIDE 6 T12 @ 220 B** = 679 mm² L/d = 22.581 < 25.639 allowed **OK**

As increased by 0.9 % for deflection

FLIGHT 3

Waist = 150 mm a = 2.500 m b = 0.600 m c = 0.600 m
L = 3.700 m



Waist 4.20
Steps 1.88
Finishes 0.50
6.57 kN/m² n3 = 15.60 kN/m²

19.50 19.50

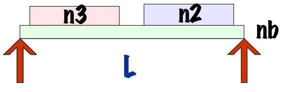
M = 19.50 x (1.850 - 0.625) = 23.89 kNm/m d = 124 mm K = 0.0444

As = 557 mm² **PROVIDE 8 T12 @ 150 B** = 905 mm² L/d = 29.839 < 30.582 allowed **OK**

As increased by 53.6 % for deflection

LANDING 2 +3.500 m

h = 150 mm L = 2.800 m



Self wt 3.54 n3 = 16.25 kN/m²
Finishes 1.30 n2 = 16.25 kN/m²
4.84 kN/m² nb = 13.18 kN/m²

37.95 37.95

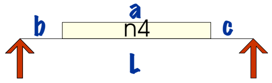
M = 37.95 x 1.400 - 12.91 - 14.14 = 26.08 kNm/m d = 124 mm K = 0.0485

As = 611 mm² **PROVIDE 6 T12 @ 220 B** = 679 mm² L/d = 22.581 < 23.899 allowed **OK**

As increased by 3.4 % for deflection

FLIGHT 4

Waist = 150 mm a = 2.500 m b = 0.600 m c = 0.600 m
L = 3.700 m



Waist 4.20
Steps 1.88
Finishes 0.50
6.57 kN/m² n4 = 15.60 kN/m²

19.50 19.50

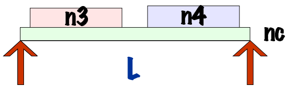
M = 19.50 x (1.850 - 0.625) = 23.89 kNm/m d = 124 mm K = 0.0444

As = 557 mm² **PROVIDE 8 T12 @ 150 B** = 905 mm² L/d = 29.839 < 30.582 allowed **OK**

As increased by 53.6 % for deflection

LANDING 3 +5.250 m

h = 150 mm L = 2.800 m



Self wt 3.54 n3 = 16.25 kN/m²
Finishes 1.30 n4 = 16.25 kN/m²
4.84 kN/m² nc = 13.18 kN/m²

37.95 37.95

M = 37.95 x 1.400 - 12.91 - 14.14 = 26.08 kNm/m d = 124 mm K = 0.0485

As = 611 mm² **PROVIDE 6 T12 @ 220 B** = 679 mm² L/d = 22.581 < 23.899 allowed **OK**

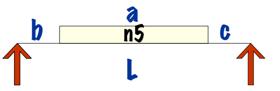
As increased by 3.4 % for deflection

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by RMW	Date 24-Nov-99	Page 111
Location	North Staircase	Checked chg	Revision -	Job No R68
	REINFORCED CONCRETE STAIRCASES to BS 8110:1997			
	Originated from RCC72.xls on CD © 1999 BCA for RCC			

FLIGHT 5

Waist = 150 mm   a = 2.500 m   b = 0.600 m   c = 0.600 m

L = 3.700 m



Waist	4.20	
Steps	1.88	
Finishes	0.50	
	6.57	kN/m²

n5 = 15.60 kN/m²   19.50   19.50

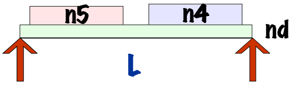
M = 19.50 x (1.850 - 0.625) = 23.89 kNm/m   d = 124 mm   K = 0.0444

As = 557 mm²   **PROVIDE 8 T12 @ 150 B** = 905 mm²   L/d = 29.839 < 30.582 allowed   **OK**

As increased by 53.6 % for deflection

LANDING 4 +7.000 m

h = 150 mm   L = 2.800 m



Self wt	3.54		n5 =	16.25	kN/m²
Finishes	1.30		n4 =	16.25	kN/m²
	4.84	kN/m²	nd =	13.18	kN/m²

37.95   37.95

M = 37.95 x 1.400 - 12.91 - 14.14 = 26.08 kNm/m   d = 124 mm   K = 0.0485

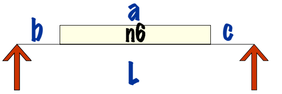
As = 611 mm²   **PROVIDE 6 T12 @ 220 B** = 679 mm²   L/d = 22.581 < 23.899 allowed   **OK**

As increased by 3.4 % for deflection

FLIGHT 6

Waist = 150 mm   a = 2.500 m   b = 0.600 m   c = 0.375 m

L = 3.475 m



Waist	4.20	
Steps	1.88	
Finishes	0.50	
	6.57	kN/m²

n6 = 15.60 kN/m²   18.24   20.77

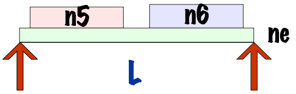
M = 18.24 x (1.769 - 0.585) = 21.61 kNm/m   d = 124 mm   K = 0.0401

As = 502 mm²   **PROVIDE 6 T12 @ 220 B** = 679 mm²   L/d = 28.024 < 29.072 allowed   **OK**

As increased by 27.0 % for deflection

LANDING 5 +8.750 m

h = 150 mm   L = 2.800 m



Self wt	3.54		n5 =	16.25	kN/m²
Finishes	1.30		n6 =	15.20	kN/m²
	4.84	kN/m²	ne =	13.18	kN/m²

37.65   36.99

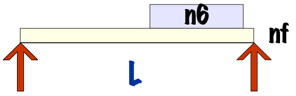
M = 37.65 x 1.377 - 12.49 - 13.69 = 25.65 kNm/m   d = 124 mm   K = 0.0477

As = 600 mm²   **PROVIDE 6 T12 @ 220 B** = 679 mm²   L/d = 22.581 < 24.346 allowed   **OK**

As increased by 2.7 % for deflection

LANDING 6 +10.500 m

h = 150 mm   L = 2.800 m



Self wt	3.54		n6 =	27.69	kN/m²
Finishes	1.30				
	4.84	kN/m²	nf =	13.18	kN/m²

26.46   43.66

M = 43.66 x 1.119 - 8.25 - 15.10 = 25.52 kNm/m   d = 125 mm   K = 0.0467

As = 592 mm²   **PROVIDE 5 T10 @ 160 B** = 393 mm²   L/d = 22.400 < 23.383 allowed   **OK**

As increased by 1.0 % for deflection

RCC81 Foundation Pads.xls

This spreadsheet designs simple pad foundations from input of material properties, dimensions and characteristic loads and moments. Single column bases and combined, *double* bases are catered for on separate sheets.

A diagram is provided to illustrate the dimensions: a chart showing scale plan views is provided to help ensure gross errors are avoided. The 'efficiency' diagrams are provided so that the user may gauge how hard the base is working in respect to allowable increase in ground bearing pressure, bending and shear in the two axes together with a measure on punching shear capacity. If the design is invalid, this chart should help identify the problem.

The spreadsheet does not allow for punching shear links – bending reinforcement is increased to ensure allowable shear, v_c, is adequate. The user should note that punching shear perimeters can jump from being rectangular to being two- or three-sided, leading to unexpectedly large increases in reinforcement for increases in base thickness. Information from BS 8110: Part 1, Clause 3.7.7.8 and Figure 3.19 has yet to be fully incorporated in this spreadsheet.

Warnings are given if columns encroach within 100 mm of an edge.

SINGLE!

Suggestions are made, under the *Operating Instructions* column, for the optimum plan size of the base.

Where two centres are given, e.g. 14 T16 @ 200 & 325 B2, the reinforcement is subject to BS 8110: Part 1, Clause 3.11.3.2 and different centres are required, bars need to be grouped closer in the central part of the base.

Det1!

This sheet shows workings and is not necessarily intended for printing out other than for checking purposes.

Allowable bearing pressure is taken as an allowable **increase** in bearing pressure and density of concrete – density of excavated material (i.e. *soil*) is used in the calculations. The program assumes that pads are embedded to depth H in the soil. A 25% over-stress is allowed where load cases include wind loads.

Design moments are generally those at the face of the column. Both sides of the column are checked for moment in each direction to ensure maxima are identified. Shear enhancement is allowed for both beam and punching shear.

Neither crack widths, factors of safety against sliding, nor water tables are catered for. Where resultant eccentricities are outside the base a warning message is given; the general status message is updated as well. Factors of safety against overturning are checked (minimum 1.5). Warnings are also given at the onset of an uplift situation.

DOUBLE!

In addition to graphs showing plan layout and 'efficiency', this sheet gives moment diagrams for the two principal axes. Design moments are taken at the edge of both column sections

Suggestions are made, under the *Operating Instructions* column, for the optimum plan size of the base and eccentricities given the column offsets from one another.

The user's attention is drawn to the fact that the analysis is done in two orthogonal directions. When column eccentricities are large in both directions the analysis may not account adequately for local effects (e.g. bottom cantilever moments on two sides of each column – loads in opposite corners gives bottom moments of 0 kNm). In such cases, it may be better to change the orientation of the base in such a way that eccentricity in one direction is minimal. Warnings about double eccentricities are given when the distances between column centrelines exceed 15% of the relevant base dimension in each orthogonal direction. Comparison with FE analysis suggests this is reasonable so long as the base is thick and rigid.

Det2!

This sheet shows workings and is not necessarily intended for printing out other than for checking purposes.

The notes for Det! above also apply.

Legends!

This sheet shows dimensions, axes, corners and notation used.

Graf!

This sheet comprises data for graphs for both SINGLE! and DOUBLE!

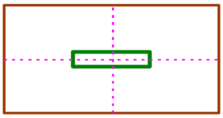
Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
Location	Level -1 Base B1	RMW	30-Aug-99	113
	PAD FOUNDATION DESIGN to BS 8110:1997 — Single column base	Checked	Revision	Job No
	Originated from RCC81.xls on CD — © 1999 BCA for RCC	chg	-	R68

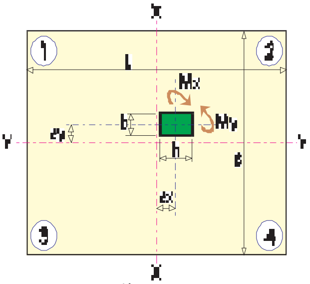
MATERIALS

fcu	35	N/mm²	h agg	20	mm	γ_c	1.5	concrete
fy	460	N/mm²	cover	50	mm	γ_s	1.05	steel
Densities - Concrete	23.6	kN/m³	Soil	18	kN/m³			
Bearing pressure	200	kN/m² (net allowable increase)						

DIMENSIONS mm

BASE		COLUMN	
L =	3300	h =	1200
B =	1800	b =	250
depth H =	450		
ex =	0	ey =	0



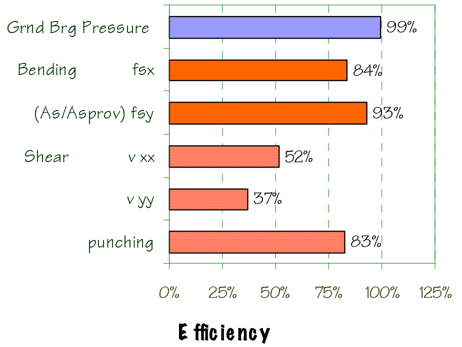


Key

COLUMN REACTIONS kN, kNm *characteristic* **Plot** (to scale)

	DEAD	IMPOSED	WIND
Axial (kN)	1001.0	128.0	
Mx (kNm)	-20.0		
My (kNm)			
Hx (kN)			
Hy (kN)			

STATUS VALID DESIGN



BEARING PRESSURES kN/m² *characteristic*

CORNER	1	2	3	4
no wind	198.7	186.5	198.7	186.5
with wind	198.7	186.5	198.7	186.5

REINFORCEMENT

Mxx =	275.0	kNm	Myy =	268.0	kNm
b =	1800	mm	b =	3300	mm
d =	392	mm	d =	378	mm
As =	1686	mm²	As =	1703	mm²
PROVIDE 9 T16 @225 B1			**PROVIDE 18 T12 @200 B2**		
As prov =	1810	mm²	As prov =	2036	mm²

BEAM SHEAR

Vxx =	329.4	kN at d from col face	Vyy =	361.4	kN at d from col face
v =	0.467	N/mm²	v =	0.290	N/mm²
or Vxx =	135.2	kN at 2d from col face	or Vyy =	31.2	kN at 2d from col face
v =	0.192	N/mm²	v =	0.025	N/mm²
vc =	0.451	N/mm²	vc =	0.392	N/mm²

PUNCHING SHEAR

d ave =	385	mm	u crit =	3600	mm
As prov =	0.210	%	v max =	1.441	N/mm² at col face
v =	0.350	N/mm²	vc =	0.424	N/mm²

Project	Spreadsheets to BS 8110		REINFORCED CONCRETE COUNCIL
Client	Advisory Group	Made by RMW	Date 30-Aug-99
Location	Base B3/B4 — Combined base	Checked chg	Revision -
	PAD FOUNDATION DESIGN to BS 8110:1997	Page 114	Job No R68

MATERIALS

fcu	35	N/mm²	h agg	20	mm	γ_c	1.5	steel
fy	460	N/mm²	cover	50	mm	γ_s	1.05	concrete

Densities - Concrete 23.6 kN/m³ Soil 18 kN/m³

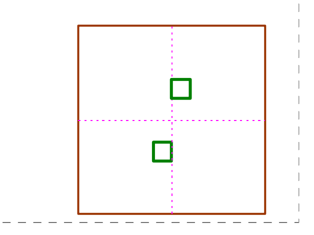
Bearing pressure 125 kN/m² (net allowable)

COLUMN REACTIONS kN, kNm *characteristic*

Column 1 (rhs)	DEAD	IMPOSED	WIND	Column 2 (lhs)	DEAD	IMPOSED	WIND
Axial	225.0	225.0	112.5	Axial	225.0	225.0	112.5
Mx				Mx			
My				My			50.0
Hx				Hx			
Hy				Hy			25.0

DIMENSIONS mm

BASE	COLUMN 1 (rhs)	COLUMN 2 (lhs)
L = 3000	h1 = 300	h2 = 300
B = 3000	b1 = 300	b2 = 300
depth H = 750		
Σex = 300	ex1 = 150	ex2 = 150
Σey = 1000	ey1 = 500	ey2 = 500

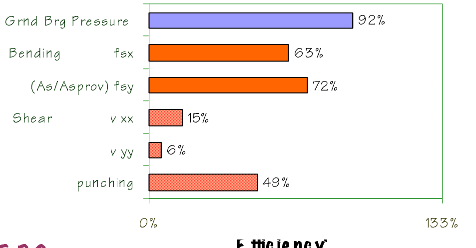


PLOT (to scale)

STATUS VALID DESIGN

BEARING PRESSURES kN/m² *characteristic*

CORNER	1	2	3	4
no wind	104.2	104.2	104.2	104.2
with wind	144.5	144.5	113.9	113.9



Efficiency

REINFORCEMENT

Btm	Mxx -	405.0	kNm	Myy -	251.7	
	b =	3000	mm	b =	3000	
	d =	692	mm	d =	676	
	As =	1406	mm²	As =	895	

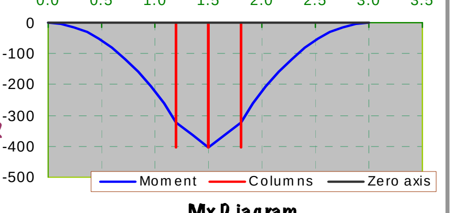
PROVIDE 15T16 @225 B1 & 15T16 @225 B2

As prov = 3016 mm² As prov = 3016

Top	Mxx +	0.0	kNm	Myy +	0.0
	d =	692	mm	d =	676
	As =	0	mm²	As =	0

PROVIDE 15T16 @225 T1 & 15T16 @225 T2

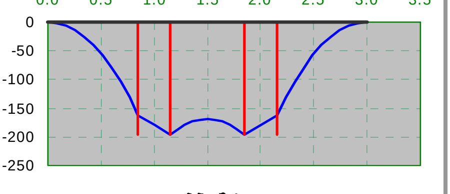
As prov = 3016 mm² As prov = 3016



Mx Diagram

BEAM SHEAR

Vxx =	228.6	kN at d	Vyy =	87.3
v =	0.110	N/mm²	v =	0.043
or Vxx =	0.0	kN at 2d	or Vyy =	0.0
v =	0.000	N/mm²	v =	0.000
vc =	0.372	N/mm²	vc =	0.375



My Diagram

PUNCHING SHEAR

d ave =	684	mm	u crit =	6000	mm
As prov =	0.147	%	vmax =	0.804	N/mm² at col face
v =	0.183	N/mm²	vc =	0.373	N/mm²

RCC91 One-way Solid Slabs (Tables).xls

Design is often undertaken using the moment and shear factors taken from BS 8110: Part 1, Tables 3.5 and/or 3.12. This series of spreadsheets uses factors for moment and shear based on these tables.

RCC91.xls designs simple one-way solid slabs to BS 8110. For three or more spans they use moment and shear factors from Table 3.12. The use of these factors is governed by Clause 3.7.2.7 (single load case and the conditions of Clause 3.5.2.3 are met {bays > 30 m^2, q_k > 1.25 g_k, q_k > 5.0 kN/m^2} and at least three bays of approximately equal span (the corresponding factors for beams also restrict use of the factors to where spans differ by no more than 15% of the maximum span)). Where the relevant conditions are not met, users are directed towards RCC31.xls where continuous beam analysis overcomes many of these caveats.

The design of single- and two-span slabs is also possible. The factors used for two-span slabs should be considered subject to the same conditions as for using the factors from Table 3.12 of BS 8110.

MAIN!

This single sheet consists of the input and main output. In itself it should prove adequate for the design of the simplest one-way solid slab designs. A nominal 1 m wide strip of slab is considered.

Inputs are underlined and most should be self-explanatory. End support condition determines the factors applied for bending. Simple charts show the spans, loads and indicative bending moments. The factors from Table 3.12 give rise to a single load case that has been subject to 20% redistribution: a bending moment envelope is inappropriate and the diagram is therefore indicative only. The factors used are given in the table below.

The factors used are based on continuous end supports. The two-span factors were derived by modelling the appropriate number of spans with a single loadcase of 4 kN/m dead and 5 kN/m imposed and allowing any one span to be 15% less than the input length (strictly according to BS 8110 this is applicable to beams only).

The area of steel required, A_s, may be automatically increased to reduce service stress, f_s, and to increase modification factors to satisfy deflection criteria. The option in line 42 to have top steel in spans influences modification factors used in deflection calculations.

As most contractors prefer prefabricated reinforcement mats might be considered.

To the right of the sheet are calculations. An approximate reinforcement density is given.

Weight!

Weight! gives an estimate of the amount of reinforcement required in a slab. Simplified curtailment rules, as defined in Clause 3.12 are used to determine lengths of bars. The figures should be treated as approximate estimates only as they cannot deal with the effects of designers' and detailers' preferences, rationalisation, the effects of holes etc, etc. It excludes supporting beams, trimming to holes etc. To the right of the sheet are calculations of length, etc.

Graf!

This sheet comprises data for graphs used in MAIN! It is not necessarily intended for printing out other than for checking purposes.

Bending moment and shear force coefficients

Coefficient		End supports	End spans	First int supports	Interior spans	Interior supports
Bending						
Simple support	1 span	0.00	0.125	~	~	~
	2 span	0.00	0.086	0.100	~	~
	3 span etc	0.00	0.075	0.086	0.063	(0.063)
Continous support	1 span	0.040	0.105	~	~	~
	2 span	0.040	0.066	0.100	~	~
	3 span etc	0.040	0.075	0.086	0.063	(0.063)
Shear						
	1 span	0.50		~		~
	2 span	0.46		0.60		~
	3 span ect	0.46		0.60		0.50

Project	Spreadsheets to BS 8110 & EC2	REINFORCED CONCRETE COUNCIL	
Client	Advisory Group	Made by: mmw	Date: 30-Aug-99 / Page: 116
Location	3rd Floor slab	Checked: chg	Revision: - / Job No: R68

1-WAY SOLID CONCRETE SLAB DESIGN to BS 8110:1997 Tab

Originated from RCC91.xls on CD ©1999 BCA for RCC

LOCATION Supports from grid A to grid F

End support condition is C (C)ontinuous or (S)imple

STATUS
VALID DESIGN

DIMENSIONS

N° of spans	N°	3
Max Span	m	7.200
Thickness, h	mm	200
cover	mm	20

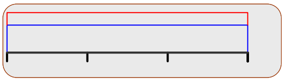
MATERIALS

fy	N/mm²	460	γ_s = 1.05
fcu	N/mm²	35	γ_c = 1.50
Density	kN/m³	23.6	

(Normal weight concrete)

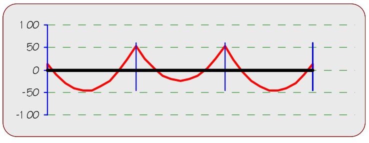
LOADING

Self Weight	kN/m²	4.72
Additional Dead	kN/m²	1.00
Total Dead, gk	kN/m²	5.72
Imposed Load, qk	kN/m²	2.50
Design load, n =	kN/m²	12.01



A F

Geometry and Loading



A F

Indicative Bending Moment Diagram

MAIN STEEL

		END SUPPORTS (A & F)	END SPANS	FIRST INT SUPPORTS	INTERIOR SPANS	INTERNAL SUPPORTS	BS 8110 Reference
Factor		0.040	0.075	0.086	0.063	0.000	Table 3.12
M	kNm/m	24.9	46.7	53.5	39.2	0.0	
d	mm	175	172	174	172	□	
K		0.023	0.045	0.051	0.038	□	M/bd²fcu
z		166.3	162.9	163.6	163.4	□	Clause 3.4.4.4
As	mm²/m	342	654	747	548	□	
Rebar		T	T	T	T	□	
Ø	mm	10	16	12	16	12	
@	mm c/c	225	150	150	225	□	
As prov	mm²/m	349	1340	754	894	□	
=	%	0.199	0.779	0.433	0.520	□	
Max S		535	532	534	532	□	Clause
subclause		(a)	(a)	(a)	(a)	□	3.12.11.2.7

DEFLECTION

		END SUPPORTS	END SPANS	FIRST INT SUPPORTS	INTERIOR SPANS	INTERNAL SUPPORTS	Reference
fs	N/mm²	300	150	304	188	□	Eqn 8
Top steel provided	% bd		0		0		
Comp Mod factor			1.000		1.000		Table 3.11
Tens Mod factor			1.651		1.632		Eqn 7
Perm L/d			43	As auto-increased	42.5	As auto-increased	Table 3.9
Actual L/d			41.8	by 86%	41.8	by 56%	

DISTRIBUTION STEEL As = 0.13% = 260 mm²/m (Table 3.25)

Provide T 10 at 300 = 262 mm²/m

SHEAR

		END SUPPORT	FIRST INT SUPPT	INTERNAL SUPTS	Reference
V	kN/m	39.8	51.9	□	Table 3.12
As prov	%	0.390	0.433	□	
v	N/mm²	0.231	0.298	□	equation 3
vc	N/mm²	0.638	0.659	□	Table 3.8

OUTPUT SUMMARY

	END SUPPORTS	END SPANS	FIRST INT SUPPORTS	INTERIOR SPANS	INTERNAL SUPPORTS	DISTRIBUTION
PROVIDE	T10 @225 T1	T16 @150 B1	T12 @150 T1	T16 @225 B1		T10 @300

CHECKS

BAR Ø < COVER	SINGLY REINFORCED	BAR SPACING	DEFLECTION	NO SHEAR LINKS	GLOBAL STATUS
OK	OK	OK	OK	OK	VALID DESIGN

RCC92 Ribbed Slabs (Tables).xls

This spreadsheet designs simple single-, two-span and multiple-span ribbed slabs to BS 8110: Part 1 using the moment and shear factors in, or in the case of single and two spans, consistent with Table 3.12 of BS 8110. The use of factors in Table 3.12 is governed by Clause 3.7.2.7 as follows.

- A single load case is assumed
- Conditions of 3.5.2.3 are met

  bays > 30 m^2,

  $q_k \not> 1.25g_k$,

  $q_k \not> 5.0$ kN/m^2 and
  at least three bays are of approximately equal span
- The corresponding factors for beams also restrict use of the factors to where spans differ by no more than 15% of the maximum span.

The factors used for two-span slabs should be considered subject to these same conditions. They were derived by modelling the appropriate number of spans with a single load case of 4 kN/m^2 dead and 5 kN/m^2 imposed, and allowing any one span to be 15% less than the input length (strictly according to BS 8110 this is applicable to beams only). The factors used are based on continuous end supports.

Where the relevant conditions are not met, users are directed towards RCC32.xls where continuous beam type analysis overcomes many of these caveats.

MAIN!

This single sheet consists of the input and main output. In itself it should prove adequate for the simplest ribbed slab designs. Inputs are underlined and most should be self-explanatory.

The option to have top steel in spans or not has bearings on whether shear links can be accommodated and on deflection calculations. The option to have links, minimal (or nominal) links or no links is a matter of choice for the designer. Most contractors prefer to prefabricate reinforcement for ribbed slabs on the ground or off-site: this means at least nominal links and nominal top steel are usually required.

- *Designed* links are taken to be those provided where $(v_c + 0.4) < v < 0.8\, f_{cu}^{0.5}$
- *Minimal* links are taken to be those that are required to provide shear resistance for $v_c < v < (v_c + 0.4)$
- *Nominal* links are those used if required for temporary support only in areas where $v < v_c$

Under *Bending*, the *Width of solid from CL* refers to the distance between centre line of support and the rib/solid intersection. It determines where shear and, at internal supports, hogging moment in ribs are checked. The user inputs preferred diameters of reinforcement in the rib. At supports, these bars usually need to be supplemented by intermediate bars to comply with either spacing rules or with hogging moments in the solid section of slab.

In spans, the area of steel required, A_s, may be automatically increased to reduce service stress, f_s, and to increase modification factors to satisfy deflection criteria.

An approximate reinforcement density is given. It excludes mesh, supporting beams, trimming to holes etc.

Please note that the bending moment diagrams are indicative only. The factors from Table 3.12 give rise to a single load case that has been subject to 20% redistribution: a bending moment envelope is inappropriate. The factors used are given in the table below.

The factors used are based on continuous end supports. The two-span factors were derived by modelling the appropriate number of spans with a single load case of 4 kN/m dead and 5 kN/m imposed and allowing any one span to be 15% less than the input length (strictly according to BS 8110 this is applicable to beams only).

DETAILS!

DETAILS! gives two pages of detailed calculations and references to BS 8110 justifying the output in MAIN! This sheet is intended as an explanation for the less experienced engineers and may prove useful for checking purposes.

Bending moment and shear force coeficients

Coefficient		End supports	End spans	First int supports	Interior spans	Interior supports
Bending	1 span	0.040	0.125	~	~	~
	2 span	0.040	0.086	0.100	~	~
	3 span etc	0.040	0.075	0.086	0.063	(0.063)
Shear	1 span	0.50		~		~
	2 span	0.46		0.60		~
	3 span etc	0.46		0.60		0.50

Maximum spacing, S_{max}, at supports is based on rib centres: usually two large bars are required in the top of the rib for moment at the rib/solid intersection and one, two or even three smaller bars (minimum T10) are required between to overcome spacing rules. Concentrating reinforcement with larger bars in the top of the rib raises the percentage steel in the rib at the rib/solid interface, thereby maximising v_c and reducing shear requirements.

In terms of curtailment, 50% of reinforcement for maximum sagging is taken as being $A_{s\ req'd}$ for bending, i.e. excluding any extra for deflection, etc. Figure 3.25 refers *to 'reinforcement for max. moment'*. Ribbed slabs are taken as being *"slabs"* so the 40% rule is applied. It is usually assumed that 'ribs' become 'beams' when they are at centres > 1.5 m.

Tapered links are assumed. Where required for shear resistance, links should be at maximum 0.75d centres.

Weight!

Weight! gives an estimate of the amount of reinforcement required in a slab. Simplified curtailment rules, as defined in Clause 3.12 are used to determine lengths of bars. The figures should be treated as approximate estimates only as they cannot deal with the effects of designers' and detailers' preferences, rationalisation, the effects of holes etc, etc. To the right of the sheet are calculations of length etc.

Graf!

This sheet comprises data for graphs used in MAIN!

Project	**Spreadsheets to BS 8110**	REINFORCED CONCRETE COUNCIL		
Client	**Advisory Group**	Made by	Date	Page
Location	**2nd Floor slab**	mw	30-Aug-99	125
	RIBBED SLAB DESIGN to BS 8110:1997 using table 3.12 coeffic	Checked	Revision	Job No
	Originated from RCC92.xls on CD ©1999 BCA for RCC	chg	prelim	R68

LOCATION Supports from grid A to grid F

STATUS

VALID DESIGN

DIMENSIONS

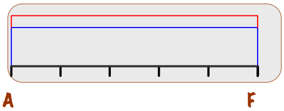
N° of spans	N°	5	rib width	mm	150
Max Span	m	7.200	rib centres	mm	750
depth o/a, h	mm	300	Side slope	1 in	10
topping depth, h	mm	100			
Top steel in spans ?		Y	Top cover (to links)	mm	35
Min No of bars	per rib	2	B/S cover (to links)	mm	25
Use Links?		Y	(Y)es, (N)o or (M)inimal		

MATERIALS

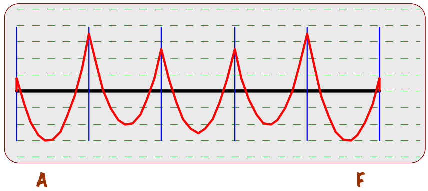
fcu	N/mm²	35	γ^c =	1.50
fy	N/mm²	460	γ^s =	1.05
fyv	N/mm²	250	Density kN/m³	24.0
h agg	mm	20	(Normal weight concrete)	

LOADING

Self Wt	kN/m²	4.00
+ Dead	kN/m²	1.50
Total Dead, gk	kN/m²	5.50
Imposed qk	kN/m²	5.00
Design load, n =	kN/m²	15.70



Geometry and Loading



Indicative Bending Moment Diagram

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL	
Client	Advisory Group	Made by: mmw	Date: 30-Aug-99
Location	2nd Floor slab from grids A to F	Page: 120	
	RIBBED SLAB DESIGN to BS 8110:1997 using table 3.12 coeffic	Checked: chg	Revision: prelim
	Originated from RCC92.xls on CD ©1999 BCA for RCC	Job No: R68	

DETAILED CALCULATIONS

ave bw	mm	170.0	self wt	kN/m²	3.49
rib area	m²	0.1090	E/O solid	kN/m²	0.52
			Total SW	kN/m²	4.00

Gk = 39.63 Qk = 36.00 F = 113.08 N = 15.705 kN/m width

MAIN STEEL		END SUPPORTS		END SPANS		FIRST INT SUPPORTS		INTERIOR SPANS		INTERNAL SUPPORTS	BS 8110 Reference
Factor		0.04		0.075		0.086		0.063		0.063	Table 3.12
M/m	kNm/m	32.6		61.1		70.0		51.3		51.3	- = -
M/rib	kNm	24.42		45.80		52.51		38.47		38.47	- = -
d	mm	254		259		249		261		249	
bf	mm	750		750		750		750		750	
K'		0.1320		0.1558		0.1320		0.1558		0.1320	3.4.4.4
Web MOR	kNm	50.7		62.2		48.7		63.1		48.7	Fig 3.3
Flange MOR	kNm	223.5		245.1		214.8		247.4		214.8	- = -
K		0.0144		0.0260		0.0323		0.0215		0.0236	3.4.4.4
z	mm	241.3		246.1		236.6		248.0		236.6	- = -
x	mm	28.2		28.8		27.7		29.0		27.7	- = -
d'	mm	41.0		45.0		37.0		45.0		36.0	
netfsc	N/mm²	0.0		0.0		0.0		0.0		0.0	Fig 3.3
Excess M	kNm	0.0		0.0		0.0		0.0		0.0	
As' req	mm²	0		0		0		0		0	
max fst	N/mm²	438.1		438.1		438.1		438.1		438.1	Fig 3.3
fst deflection	N/mm²	---		308.8		---		346.8		---	
As req	mm²	231		425		507		354		371	
bw/b		---		0.2267		---		0.2267		---	
Min %		0.13%		0.18%		0.13%		0.18%		0.13%	Table 3.25
Min As	mm²	293		92		293		92		293	
At EDGE of SOLID											
M/m	kNm/m	24.9	residual steel			38.1		residual steel		25.0	Table 3.13
M/rib	kNm	18.7	0.26%			28.5	0.26%	min %	0.26%	18.7	- = -
bf	mm	150	57			150	0	As resid	0	150	
K		0.0552	10			0.0877	10	Ø extra	10	0.0576	
z	mm	237.3	3			221.8	2	No	2	231.9	
x	mm	37.1	236			60.5	157	As prov	157	38.0	
netfsc	N/mm²	0.0				256.5				36.9	Fig 3.3
Excess M	kNm	0.0				0.0				0.0	
As' req	mm²	0				0				0	
fst	N/mm²	438.1				438.1				438.1	
As req	mm²	180				294				184	
TENSION STEEL											
Required	mm²	180		425		294		354		184	
Ø in rib	ok	10	ok	20	ok	20	ok	16	ok	20	
No		3		2		2		2		2	
As prov	mm²	236		628		628		402		628	
Clear dist	mm	54.4		54.2		97.8		62.2		97.8	between bars
Min S	ok	25.0	ok	25.0	ok	25.0	ok	25.0	ok	25.0	3.12.11.1
Max S	ok	200.7	ok	226.7	ok	300.0	ok	174.0	ok	300.0	3.12.11.2.4
COMPRESSION STEEL											
Required		170		0		127		0		106	Table 3.25
Ø	ok	20	ok	8	ok	12	ok	8	ok	10	
No		2		2		2		2		2	
As' prov	mm²	628		101		226		101		157	
= %	ok	1.455	ok	0.228	ok	0.534	ok	0.227	ok	0.371	
Clear dist	mm	55.6		123.0		70.8		123.0		74.6	between bars
Min S	ok	25.0	ok	25.0	ok	25.0	ok	25.0	ok	25.0	3.12.11.1

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
Location	2nd Floor slab from grids A to F	mw	30-Aug-99	121
	RIBBED SLAB DESIGN to BS 8110:1997 using table 3.12 coeffici	Checked	Revision	Job No
	Originated from RCC92.xls on CD ©1999 BCA for RCC	chg	prelim	R68

DEFLECTION

		END SUPPORTS	END SPANS		FIRST INT SUPPORTS	INTERIOR SPANS		INTERNAL SUPPORTS	BS 8110 Reference
fs	N/mm²	234.2	207.4		143.4	270.1		90.0	Eqn 8
Base ratio			20.80			20.80			3.4.6.3/4
Tens Mod			1.791			1.593			Table 3.10
Comp Mod			1.071			1.070			Table 3.11
Perm L/d			39.894			35.466			3.4.6.3
Actual L/d			27.799	ok		27.586	ok		3.4.5.1
As req increased by			17.8%			12.6%			

RIB SHEAR

			END SUPPORTS		FIRST INT SUPPORTS		INTERNAL SUPPORTS		NOMINAL		
Factor			0.46		0.6		0.5				Table 3.12
V max	kN/m		52.01		67.85		56.54				- = -
V rib	kN/m		37.24		44.99		36.51				
v	N/mm²		0.8625		1.0630		0.8626				Eqn 3
vc	N/mm²		0.8975		0.9080		0.9080				Table 3.8
(v-vc)bv	N/mm		68.0		68.0		68.0		68.0		Table 3.7
Link Ø		ok	6	ok	6	ok	6	ok	6		3.12.7.1
@	mm		191		187		187		196		Spacing
adjust to	mm		175		175		175		175		Spacing
for	mm		0		795		75		---		from solid
adjust to	mm		0		875		175		---		from solid
As Dist		ok	130.8	ok	121.8	ok	121.8	ok	125.4	OK	3.4.5.5
As' Dist		ok	0	ok	0	ok	0	ok	0	OK	3.12.7.2

RCC93 Flat Slabs (Tables).xls

This spreadsheet designs simple rectangular flat slabs to BS 8110: Part 1 using moment and shear factors from Table 3.12. The use of these factors is also governed by Clause 3.7.2.7 as shown below.

- A single load case is assumed
- The conditions of 3.5.2.3 are met

  bays > $30m^2$,

  $q_k \ngtr 1.25g_k$,

  $q_k \ngtr 5.0$ kN/m^2 and

  at least three bays are of approximately equal span
- The corresponding factors for beams also restrict use of the factors to where spans differ by no more than 15% of the maximum span.

Where the relevant conditions are not met, users are directed towards RCC33.xls where sub-frame analysis overcomes many of the caveats made in the code restricting the use of bending moment and shear factors from Table 3.12.

The spreadsheet does **not** currently allow for holes or drops. If holes are considered critical then the user is directed towards using RCC21.xls (sub-frame analysis) and allowing for holes in breadths used. Note should also be made of Clause 3.7.5. Punching shear can be checked using RCC13.xls.

It does not cater for single or two-span cases.

MAIN!

This single sheet consists of the input and main output. In itself it should prove adequate for the simplest flat slab designs.

Most inputs should be self-explanatory. A location plan helps with definition of dimensions. The number of spans is altered by changing the number of grid line inputs: deleting the end grid line name will decrease the number of spans. A combo-box is used to switch between the continuous and simply supported end support/slab connection factors. Note the effect on column transfer moments. Edge distance, C, is actually from centreline of column to edge of slab.

'Double penult' means penultimate in both directions, i.e. internal column of corner bay.

Please note that the bending moment diagrams are indicative only. The factors from Table 3.12 give rise to a single load case that has been subject to 20% redistribution: a bending moment envelope is therefore inappropriate.

DETAILS!

DETAILS! gives detailed calculations and references to BS 8110 justifying the output in MAIN! This sheet is intended as explanation for the less experienced engineers and may prove useful for checking purposes.

Column transfer moments are limited to $M_{t\ max}$ see Clause 3.7.4.2 and equation 24

A basic deflection ratio of 26 x 0.9 (see Clauses 3.4.6.1 and 3.7.8) is used in line 189 etc. Some engineers like to use a higher basic deflection ratio (rather than 26 in the code) to offset any potential problems with deflection of partitions and especially of cladding.

Traditional shear links can be very time consuming on site, so in order to minimise the number of links the centres are maximised at 0.75d (see line 226 et seq). Additional bars may be necessary to act as carriers to these links if top and bottom bars cannot be arranged at the preferred spacings. Consideration should also be given to using proprietary systems.

Weight!

Weight! gives an estimate of the amount of reinforcement required in a slab. Simplified curtailment rules, as defined in Clause 3.12 are used to determine lengths of bars. The figures should be treated as approximate estimates only as they cannot deal with the effects of designers' and detailers preferences', rationalisation, the effects of holes etc, etc. Additional link carrier bars are not included

Xdia! And Ydia!

In these sheets each bending moment is designed using a different size bar (with different effective depths, d). The largest bar (i.e. minimum number of bars) consistent with maximum specified diameter and maximum spacing rules is identified and used in DETAILS! Thus a least bars solution is given. The Xdia! and Ydia! pages find the maximum diameter that can be used while complying with spacing rules. The sheet finds which of Clause 3.12.11.2.7 (a) or (b) applies. This has quite a dramatic effect on rationality of the bars and spacings. A detailer can always reduce bar diameters and/or close-up spacing if he or she wishes provided that overall areas of steel are at least maintained.

Project	**Spreadsheets to BS 8110**	REINFORCED CONCRETE COUNCIL	
Client	**Advisory Group**	Made by **rmw**	Date **30-Aug-99** / Page **123**
Location	**ECBP Typical floor to BS8110**	Checked **chg**	Revision **-** / Job No **R68**

SIMPLIFIED FLAT SLAB DESIGN to BS 8110:1997 Cl 3.7.2.7 (Table 3.12)

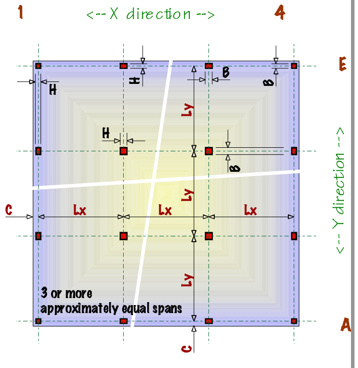
Originated from RCC93.xls on CD ©1999 BCA for RCC

STATUS **VALID DESIGN**

LOCATION						
	NS Grids on lines	1	2	3	4	
	EW Grids on lines	A	B	C	D	E

DIMENSIONS		X	Y			
Nº of spans	Nº	3	4	slab depth, h	mm	250
Span, L	m	7.500	7.499	Top cover	mm	25
Edge dist, C	mm	125	125	Btm cover	mm	25
		from C/L column		Edge supports are		CONTINUOUS

COLUMNS		Internal	Edge	Corner
H	mm	400	400	400
B	mm	400	250	250

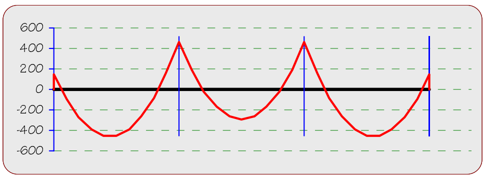


Legend

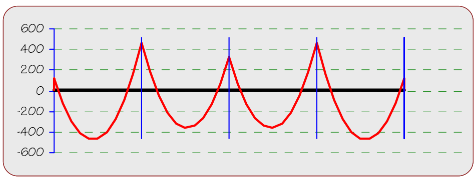
MATERIALS					
fcu	N/mm²	37	h agg	20	mm
fy	N/mm²	460	γm	1.05	steel
max bar Ø	mm	20	γm	1.5	concrete
fyv	N/mm²	250	Density	23.6	kN/m³
			(Normal weight concrete)		

LOADING					
Self Wt	kN/m²	5.90	erim Load	8.85	kN/m
+ Dead	kN/m²	1.50			
Total Dead, gk	kN/m²	7.40	DEFLECTION CONTROL		
Imposed qk	kN/m²	2.50	Min % top steel in col strips	0.13	%
Design load, n	kN/m²	14.36	Same in top of middle strips?	N	

Indicative Bending Moments - X Direction (kNm per bay)



Indicative Bending Moments - Y Direction (kNm per bay)



MAIN STEEL	INTERNAL COLUMN STRIPS		MIDDLE STRIPS		PERIMETER COLUMN STRIPS	
X DIRECTION	b	REBAR	b	REBAR	b	REBAR
END SUPPORTS	0.575	7 T20 @75 T1	6.924	12 T16 @575 T1	0.413	4 T20 @100 T1
END SPANS	3.750	12 T20 @300 B1	3.750	10 T20 @350 B1	2.000	12 T20 @150 B1
PENULTIMATE SUPPORTS	3.750	13 T20 @200 : 400 T1	3.750	7 T16 @525 T1	2.000	10 T20 @125 : 250 T1
INTERIOR SPANS	3.750	9 T20 @400 B1	3.750	8 T20 @450 B1	2.000	9 T20 @200 B1
INTERIOR SUPPORTS	3.750	9 T20 @300 : 600 T1	3.750	7 T16 @525 T1	2.000	7 T20 @200 : 400 T1
Y DIRECTION						
END SUPPORTS	0.575	6 T20 @75 T2	6.925	12 T16 @575 T2	0.450	5 T20 @75 T2
END SPANS	3.750	19 T20 @175 B2	3.751	16 T20 @225 B2	2.000	26 T20 @75 B2
PENULTIMATE SUPPORTS	3.750	15 T20 @175 : 350 T2	3.751	8 T16 @450 T2	2.000	11 T20 @175 : 350 T2
INTERIOR SPANS	3.750	13 T20 @275 B2	3.751	11 T20 @325 B2	2.000	16 T20 @100 B2

SHEAR (ultimate)	Grid Ref	Vt kN	LINKS Arrangement	Link Zone Width H	x Breadth B
INTERNAL	None	0.0	0	0	0
PENULTIMATE	C2 etc	888.4	R12 @150 EW	1788	1788
PENULTIMATE	None	0.0	0	0	0
DOUBLE PENULTIMATE	B2 etc	969.2	R12 @150 EW	1825	1825
SIDE INTERNAL	None	0.0	0	0	0
SIDE INTERNAL	C1 etc	477.9	R10 @150 EW	969	1538
PENULTIMATE SIDE	A2 etc	525.7	R12 @150 EW	1044	1687
PENULTIMATE SIDE	B1 etc	525.7	R12 @150 EW	1015	1630
CORNER	A1 etc	287.9	R8 @150 EW	925	775

CHECKS

BAR Ø > COVER **OK**
SINGLY REINFORCED **OK**
BAR SPACING **OK**
DEFLECTION **OK**
SHEAR LINKS **OK**

GLOBAL STATUS **VALID DESIGN**

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: rmw	Date: 13-Oct-99	Page: 124
Location	ECBP Typical floor to BS8110	Checked: chg	Revision: -	Job No: R68
	SIMPLIFIED FLAT SLAB DESIGN to BS 8110:1997 Cl 3.7.2.7 (Table 3.12)			
	Originated from RCC93.xls on CD © 1999 BCA for RCC			

DETAILED CALCULATIONS

BS 8110 Reference

GENERAL										
	internal hc	0.451	m	edge hc	0.357	m	corner hc	0.357	m	3.7.1.4
	Lx	7.500	m	Ly	7.499	m	Min As	325	mm²/m	3.7.1.1

MAIN STEEL - X DIRECTION

		END SUPPORTS	END SPANS	PENULTIMATE SUPPORTS	INTERIOR SPANS	INTERIOR SUPPORTS	
F		807.6		807.6		807.6	
0.15Fhc		43.23		54.68		54.68	
Total Mu	kNm	147.5	454.3	466.2	381.6	326.9	3.7.2.7
INTERNAL COLUMN STRIPS							
b	m	0.575	3.750	3.750	3.750	3.750	figs 3.12&3.13
Mu	kNm	147.5	249.9	349.7	209.9	245.2	3.7.2.10
d	mm	215	215	215	215	215	
K'		0.156	0.156	0.156	0.156	0.156	3.4.4.4
K		0.150	0.039	0.055	0.033	0.038	3.4.4.4
z	mm	169.6	204.3	201.1	204.3	204.3	3.4.4.4
As	mm²	1986	2792	3970	2346	2740	3.4.4.4
As shear	mm²	440		1767		0	
Def enhancement			1.293		1.180		
As min	mm²	1986	3610	3970	2767	2740	table 3.25
Ø	mm	20	20	20	20	20	
No bars	No	7	12	13	9	9	
@	mm	75	300	200	400	300	
& @	mm	~	~	400	~	600	3.7.3.1
As prov	mm²	2199	3770	4084	2827	2827	
=	mm²/m	3825	1005	1089	754	754	
=	%	1.779	0.468	0.507	0.351	0.351	
fs	N/mm²	276.9	227.1	372.6	254.4	371.5	E ¶n 8
Max S	mm	163	471	265	645	384	3.12.11.2.7
subclause		(b)	(b)	(b)	(a)	(b)	3.12.11.2.7
MIDDLE STRIPS							
b	m	6.924	3.750	3.750	3.750	3.750	figs 3.12&3.13
Mu	kNm	36.9	204.4	116.6	171.7	81.7	3.7.2.10
d	mm	217	215	217	215	217	
K'		0.156	0.156	0.156	0.156	0.156	3.4.4.4
K		0.003	0.032	0.018	0.027	0.013	3.4.4.4
z	mm	206.2	204.3	206.2	204.3	206.2	3.4.4.4
As	mm²	408	2285	1291	1919	905	3.4.4.4
Def enhancement			1.293		1.180		
As min	mm²	2250	2954	1291	2264	1219	table 3.25
Ø	mm	16	20	16	20	16	
No bars	No	12	10	7	8	7	
@	mm	575	350	525	450	525	
As prov	mm²	2413	3142	1407	2513	1407	
=	mm²/m	348	838	375	670	375	
=	%	0.161	0.390	0.173	0.312	0.173	
fs	N/mm²	51.9	223.0	351.5	234.2	246.5	E ¶n 8
Max S	mm	651	645	651	645	651	3.12.11.2.7
subclause		(a)	(a)	(a)	(a)	(a)	3.12.11.2.7

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
Location	ECBP Typical floor to BS8110	mw	30-Aug-99	125
	SIMPLIFIED FLAT SLAB DESIGN to BS 8110:1997 Cl 3.7.2.7 (Table 3.12)	Checked	Revision	Job No
	Originated from RCC93.xls on CD © 1999 BCA for RCC	chg	-	R68

MAIN STEEL - X DIRECTION, continued

		END SUPPORTS	END SPANS	PENULTIMATE SUPPORTS	INTERIOR SPANS	INTERIOR SUPPORTS	BS 8110 Reference
PERIMETER COLUMN STRIPS							
F		510.2		510.2		510.2	
0.15Fhc		27.31		27.31		27.31	
Mu	kNm	93.2	184.8	243.5	157.8	172.9	3.7.2.10
b	m	0.413	2.000	2.000	2.000	2.000	figs 3.12&3.13
d	mm	215	215	215	215	215	
K'		0.156	0.156	0.156	0.156	0.156	3.4.4.4
K		0.132	0.054	0.071	0.046	0.051	3.4.4.4
z	mm	176.6	201.2	196.4	203.3	202.2	3.4.4.4
As	mm^2	1205	2096	2830	1772	1952	3.4.4.4
As shear	mm^2	211		2437		0	
Defenhancement			1.756		1.495		
As min	mm^2	1205	3681	2830	2650	1952	table 3.25
Ø	mm	20	20	20	20	20	
No bars	No	4	12	10	9	7	
@	mm	100	150	125	200	200	
& @	mm	~	~	250	~	400	3.7.3.1
As prov	mm^2	1257	3770	3142	2827	2199	
=	mm^2/m	3046	1885	1571	1414	1100	
=	%	1.417	0.877	0.731	0.658	0.511	
fs	N/mm^2	294.0	170.5	345.3	192.2	340.3	Eqn 8
Max S	mm	163	334	198	396	287	3.12.11.2.7
subclause		(b)	(b)	(b)	(b)	(b)	3.12.11.2.7

MAIN STEEL - Y DIRECTION

		END SUPPORTS	END SPANS	PENULTIMATE SUPPORTS	INTERIOR SPANS	INTERIOR SUPPORTS	
Total Mu	kNm	121.3	454.2	466.2	381.6	326.9	
INTERNAL COLUMN STRIPS							
b	m	0.575	3.750	3.750	3.750	3.750	figs 3.12&3.13
Mu	kNm	121.3	249.8	349.6	209.9	245.2	3.7.2.10
d	mm	195	195	195	195	195	
K'		0.156	0.156	0.156	0.156	0.156	3.4.4.4
K		0.150	0.047	0.066	0.040	0.046	3.4.4.4
z	mm	153.8	184.1	179.4	185.3	184.3	3.4.4.4
As	mm^2	1801	3097	4449	2586	3036	3.4.4.4
As shear	mm^2	404		1796		1129	
Defenhancement			1.879		1.570		
As min	mm^2	1801	5818	4449	4060	3036	table 3.25
Ø	mm	20	20	20	20	20	
No bars	No	6	19	15	13	10	
@	mm	75	175	175	275	275	
& @	mm	~	~	350	~	550	3.7.3.1
As prov	mm^2	1885	5969	4712	4084	3142	
=	mm^2/m	3278	1592	1257	1089	838	
=	%	1.681	0.816	0.645	0.559	0.430	
fs	N/mm^2	293.0	159.1	361.9	194.2	370.4	Eqn 8
Max S	mm	163	385	214	461	314	3.12.11.2.7
subclause		(b)	(b)	(b)	(b)	(b)	3.12.11.2.7

Project	Spreadsheets to BS 8110		REINFORCED CONCRETE COUNCIL			
Client	Advisory Group		Made by	Date	Page	
Location	ECBP Typical floor to BS8110		mw	30-Aug-99	126	
	SIMPLIFIED FLAT SLAB DESIGN to BS 8110:1997 Cl 3.7.2.7 (Table 3.12)		Checked	Revision	Job No	
	Originated from RCC93.xls on CD	© 1999 BCA for RCC	chg	-	R68	

MAIN STEEL - Y DIRECTION, continued

		END SUPPORTS	END SPANS	PENULTIMATE SUPPORTS	INTERIOR SPANS	INTERIOR SUPPORTS	BS 8110 Reference
MIDDLE STRIPS							
b	m	6.925	3.751	3.751	3.751	3.751	figs 3.12&3.13
Mu	kNm	30.3	204.4	116.5	171.7	81.7	3.7.2.10
d	mm	197	195	197	195	197	
K'		0.156	0.156	0.156	0.156	0.156	3.4.4.4
K		0.003	0.039	0.022	0.033	0.015	3.4.4.4
z	mm	187.2	185.3	187.2	185.3	187.2	3.4.4.4
As	mm²	370	2519	1421	2116	997	3.4.4.4
Defenhancement			1.879		1.570		
As min	mm²	2251	4732	1421	3322	1219	table 3.25
Ø	mm	16	20	16	20	16	
No bars	No	12	16	8	11	7	
@	mm	575	225	450	325	525	
As prov	mm²	2413	5027	1608	3456	1407	
=	mm²/m	348	1340	429	921	375	
=	%	0.177	0.687	0.218	0.473	0.190	
fs	N/mm²	47.0	153.7	338.8	187.7	271.5	Eqn 8
Max S	mm	591	473	591	585	591	3.12.11.2.7
subclause		(a)	(b)	(a)	(a)	(a)	3.12.11.2.7
PERIMETER COLUMN STRIPS							
F		510.2		510.2		510.2	
0.15Fhc		27.31		27.31		27.31	
Mu	kNm	93.2	184.7	243.5	155.2	172.9	3.7.2.10
b	m	0.450	2.000	2.000	2.000	2.000	figs 3.12&3.13
d	mm	195	195	195	195	195	
K'		0.156	0.156	0.156	0.156	0.156	3.4.4.4
K		0.147	0.066	0.087	0.055	0.061	3.4.4.4
z	mm	154.8	179.5	174.0	182.2	180.6	3.4.4.4
As	mm²	1374	2349	3194	1944	2185	3.4.4.4
As shear	mm²	238		2230		1417	
Defenhancement			3.421		2.449		
As min	mm²	1374	8034	3194	4760	2185	table 3.25
Ø	mm	20	20	20	20	20	
No bars	No	5	26	11	16	7	
@	mm	75	75	175	100	275	
& @	mm	~	~	350	~	550	3.7.3.1
As prov	mm²	1571	8168	3456	5027	2199	
=	mm²/m	3491	4085	1728	2514	1100	
=	%	1.790	2.095	0.886	1.289	0.564	
fs	N/mm²	268.2	88.2	354.3	118.6	380.8	Eqn 8
Max S	mm	163	271	159	327	233	3.12.11.2.7
subclause		(b)	(b)	(b)	(b)	(b)	3.12.11.2.7

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by	Date	Page
Location	ECBP Typical floor to BS8110	mw	30-Aug-99	127
	SIMPLIFIED FLAT SLAB DESIGN to BS 8110:1997 Cl 3.7.2.7 (Table 3.12)	Checked	Revision	Job No
	Originated from RCC93.xls on CD ©1999 BCA for RCC	chg	-	R68

DEFLECTION - X DIRECTION

		PERIMETER END SPANS	INTERNAL END SPANS	PERIMETER INTERIOR SPANS	INTERNAL INTERIOR SPANS	BS 8110 Reference
As req	mm²	3239	5077	2731	4265	
As prov	mm²	5341	6912	4084	5341	
fs	N/mm²	186.0	225.3	205.1	244.9	Eqn 8
K ave		0.043	0.035	0.037	0.030	
As' prov	mm²	670	1256	670	1256	
100As'/bd	%	0.080	0.078	0.080	0.078	
Comp Mod		1.026	1.025	1.026	1.025	Eqn 9
Tens Mod		1.519	1.499	1.552	1.517	Eqn 7
Perm L/d		36.48	35.96	37.27	36.39	3.4.6.1+3.7.8
Actual L/d		34.88	34.88	34.88	34.88	
As enhanced		75.6%	29.3%	49.5%	18.0%	

DEFLECTION - Y DIRECTION

		PERIMETER END SPANS	INTERNAL END SPANS	PERIMETER INTERIOR SPANS	INTERNAL INTERIOR SPANS	
As req	mm²	3608	5616	3002	4701	
As prov	mm²	10681	10996	6754	7540	
fs	N/mm²	103.6	156.6	136.3	191.2	Eqn 8
K ave		0.053	0.043	0.044	0.036	
As' prov	mm²	670	1256	670	1256	
100As'/bd	%	0.089	0.086	0.089	0.086	
Comp Mod		1.029	1.028	1.029	1.028	Eqn 9
Tens Mod		1.643	1.621	1.670	1.614	Eqn 7
Perm L/d		39.55	38.99	40.19	38.82	3.4.6.1+3.7.8
Actual L/d		38.46	38.46	38.46	38.46	
As enhanced		242.1%	87.9%	144.9%	57.0%	

PUNCHING SHEAR

		INTERNAL	PENULT	DOUBLE PENULT	SIDE INTERNAL	SIDE INTERNAL	
		None	C2 etc	B2 etc	None	C1 etc	
Vt	kN	0.0	888.4	969.2	0.0	477.9	
Veff/Vt	kN	1.15	1.15	1.15	1.40	1.40	table 3.13
ave d	mm	205.0	205.0	205.0	205.0	205.0	3.7.6.3
ave As	%	0.390	0.468	0.576	1.096	1.171	
at 1.5d from column face							
H	mm	1015	1015	1015	633	633	
B	mm	1015	1015	1015	865	865	3.7.7.6
u 0	mm	1600	1600	1600	900	900	3.7.7.6
v max	N/mm²	0.000	3.107	3.390	0.000	3.615	Eqn 27
V	kN	0.0	1004.7	1097.5	0.0	658.0	
u	mm	4060	4060	4060	2130	2130	3.7.7.6
v	N/mm²	0.000	1.207	1.319	0.000	1.507	
vc	N/mm²	0.622	0.661	0.708	0.878	0.897	Eqn 28
Links ?		No	Yes	Yes	No	Yes	table 3.9
Links at 0.5d & 1.25d							
Sv	mm EW	0	150	150	0	150	3.7.7.6
Asv req	mm²	0	3216	3758	0	1445	3.7.7.5
Total u	mm	0	6070	6070	0	3235	
Ø	mm	0	12	12	0	10	
Number		0	41	41	0	22	
Asv prov	mm²	0	4637	4637	0	1728	
solve for H&B crit (v = vc)							3.7.7.6
H crit	mm	0	1788	1825	0	969	
B crit	mm	0	1788	1825	0	1537	
Additional 0.75d perimeter		0	2	2	0	2	

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL			
Client	Advisory Group	Made by	rmw	Date	13-Oct-99
Location	ECBP Typical floor to BS8110	Page	128		
	SIMPLIFIED FLAT SLAB DESIGN to BS 8110:1997 Cl 3.7.2.7 (Table 3.12)	Checked	chg	Revision	-
	Originated from RCC93.xls on CD © 1999 BCA for RCC	Job No	R68		

PUNCHING SHEAR, continued		CORNER	SIDE PENULT	SIDE PENULT	BS 8110 Reference
		A1 etc	A2 etc	B1 etc	
Vt	kN	287.9	525.7	525.7	
Veff/Vt	kN	1.25	1.40	1.40	table 3.13
ave d	mm	205.0	205.0	205.0	3.7.6.3
ave As	%	1.604	1.206	1.333	
at 1.5d from column					
H	mm	633	633	633	
B	mm	633	865	865	3.7.7.6
u O	mm	575	900	900	3.7.7.6
v max	N/mm²	3.038	3.978	3.978	
V	kN	352.7	725.0	724.9	
u	mm	1265	2130	2130	3.7.7.6
v	N/mm²	1.360	1.660	1.660	
vc	N/mm²	0.996	0.906	0.937	Eqn 28
Links ?		Yes	Yes	Yes	table 3.9
Links at 0.5d & 1.25d					
Sv	mm EW	150	150	150	3.7.7.6
Asv req	mm²	436	2349	2067	3.7.7.5
Total u	mm	1867.5	3235	3235	
Ø	mm	8	12	12	
Number		13	22	22	
Asv prov	mm²	653	2488	2488	
solve for H&B crit (v = vc)					3.7.7.6
H crit	mm	924	1043	1015	
B crit	mm	774	1686	1630	
Additional 0.75d perimeters		0	2	2	

RCC94 Two-way Slabs (Tables).xls

This spreadsheet designs restrained two-way solid slabs in accordance with BS 8110: Part 1 using moment and shear factors from equations 14 to 20 (i.e. Tables 3.14 and 3.15). Input is required on the first two sheets.

MAIN!

This single sheet consists of the input and main output. In itself it should prove adequate for the design of restrained two-way slabs. Inputs are underlined and most should be self-explanatory.

Self-weight, moment and shear factors are calculated automatically. The use of the factors is also governed by Clause 3.5.3.5 (similar loads on adjacent spans, similar spans adjacent). Where the relevant conditions are not met, users are directed towards Clause 3.5.3.6 or alternative methods of analysis (e.g. sub-frame analysis). Whilst ultimate reactions to beams are given, shear per se is not checked as it is very rarely critical.

The dimension l_y must be greater than l_x: bays where $l_x > l_y$ are invalid. It is recognised that B1 can be parallel to l_y and the user should specify in which layers the top and bottom reinforcement are located (see D33 and H33). In line 32 the user is asked to specify the diameter of reinforcement to be used. This reinforcement should be provided at the required centres in accordance with Clause 3.5.3.5 (1) to (6). (Middle strips and column strips, torsion reinforcement at corners where an edge or edges is/are discontinuous.) The spreadsheet highlights whether additional reinforcement for torsion is required or not. As noted under *Deflection*, the area of steel required, A_{sreq}, may be automatically increased in order to reduce service stress, f_s, and increase modification factors to satisfy deflection criteria.

An approximate reinforcement density is given. This is approximate only and excludes supporting beams, trimming to holes, etc.

Weight!

Weight! gives an estimate of the amount of reinforcement required in a slab. Simplified curtailment rules, as defined in Clause 3.12, are used to determine lengths of bars. The figures should be treated as approximate estimates only as they cannot deal with the effects of designers' and detailers' preferences, rationalisation, the effects of holes, etc, etc. To the right of the sheet are calculations of length, etc.

Support widths are required as input as they affect curtailments and lengths.

Project	Spreadsheets to BS 8110 & EC2		REINFORCED CONCRETE COUNCIL		
Client	Advisory Group		Made by	Date	Page
Location	32nd floor - corner panel	F to G: 1 to 2	RMW	13-Oct-99	130
	2-WAY SPANNING INSITU CONCRETE SLABS to BS 8110:1997 (Table 3.14)		Checked	Revision	Job No
	Originated from RCC94.xls on CD	© 1999 BCA for RCC	chg	-	R68

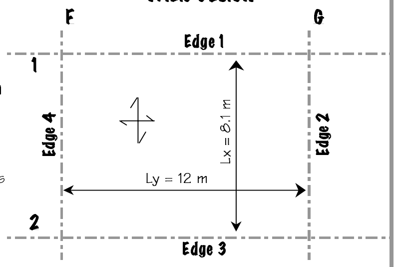
DIMENSIONS

short span, lx	m	8.10
long span, ly	m	12.00
h	mm	250
Top cover	mm	20
Btm cover	mm	20

MATERIALS

fcu	N/mm²	40	γ_c= 1.50
fy	N/mm²	460	γ_s= 1.05
Density	kN/m³	23.6	
(Normal weight concrete)			

STATUS **VALID DESIGN**



LOADING *characteristic*

Self weight	kN/m²	5.90		
Extra dead	kN/m²	1.50		
Total Dead, gk	kN/m²	7.40	γf=	1.40
Imposed, qk	kN/m²	5.00	γf=	1.60
Design load, n	kN/m²	18.36		

EDGE CONDITIONS

Edge 1	D	C = Continuous
Edge 2	D	D = Discontinuous
Edge 3	C	
Edge 4	C	

See Figure 3.8 and clauses 3.5.3.5-6

MAIN STEEL		SHORT SPAN	LONG SPAN	EDGE 1 Free	EDGE 2 Free	EDGE 3 Continuous	EDGE 4 Continuous	BS8110 Reference
ßs		0.058	0.034	0.000	0.000	0.077	0.045	Table 3.14
M	kNm/m	69.8	41.0	0.0	0.0	93.0	54.6	
d	mm	222.0	208.0	225.0	208.0	222.0	208.0	
k'		0.156	0.156	0.156	0.156	0.156	0.156	
k		0.035	0.024	0.000	0.000	0.047	0.032	
Z	mm	210.9	197.6	213.8	197.6	209.7	197.6	3.4.4.4
As req	mm²/m	755	473	0	0	1013	631	
As min	mm²/m	325	325	325	325	325	325	Table 3.25
As deflection	mm²/m	966	605	~	~	~	~	
Ø	mm	16	12	10	12	16	12	
Layer		B 1	B 2	T 1	T 2	T 1	T 2	
@	mm	200	175	225	325	175	175	
As prov	mm²/m	1005	646	349	348	1149	646	
=	%	0.453	0.311	0.155	0.167	0.518	0.311	%
S max	mm	616	636	685	636	397	530	Clause
Subclause		(b)	(a)	(a)	(a)	(b)	(b)	3.12.11.2.7
DEFLECTION								
fs		230	225	0	0	270	299	Eqn 8
Mod factor		1.437						Eqn 7
Perm L/d		37.37	Actual L/d	36.49	As enhanced 27.9% for deflection control			Table 3.10

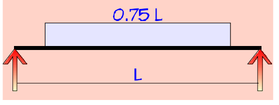
TORSION STEEL

			BOTH EDGES DISCONTINUOUS X		BOTH EDGES DISCONTINUOUS Y	ONE EDGE DISCONTINUOUS X		ONE EDGE DISCONTINUOUS Y	
Ø	mm	10							
As req	mm²/m		349	566			325		3.5.3.5
As prov T	mm²/m				348	349		348	
Additional As T req	mm²/m		326		328	0		0	
As prov B	mm²/m		1005		646	1005		646	

Bottom steel not curtailed in edge strips at free edges

SUPPORT REACTIONS (kN/m char uno) *(See Figure 3.10)* Sum ßvx = 0.888 Sum ßvy = 0.660 Table 3.15

		EDGE 1 1, F-G	EDGE 2 G, 2-1	EDGE 3 2, F-G	EDGE 4 F, 2-1
ßv		0.355	0.264	0.533	0.396
Dead	kN/m	21.29	15.82	31.93	23.74
Imposed	kN/m	14.38	10.69	21.57	16.04
Vs	kN/m	52.8	39.3	79.2	58.9



equations 19 & 20

OUTPUT/SUMMARY

	SHORT SPAN	LONG SPAN	EDGE 1 1, F-G	EDGE 2 G, 2-1	EDGE 3 2, F-G	EDGE 4 F, 2-1
PROVIDE MAIN STEEL	T16 @ 200 B1	T12 @ 175 B2	T10 @ 225 T1	T12 @ 325 T2	T16 @ 175 T1	T12 @ 175 T2

ADDITIONAL TORSION STEEL		CORNER 2	CORNER 3	CORNER 4
	0	G1	G2	F2
X direction	0	5 T10 T		
Y direction	0	5 T10 T		

placed in edge strips

CHECKS

Lx > Ly	BAR Ø < COVER	SINGLY REINFORCED	MIN SPACING	MAX SPACING	DEFLECTION	GLOBAL STATUS
OK	OK	OK	OK	OK	OK	VALID DESIGN

RCC95 Continuous beams (Tables).xls

The spreadsheet designs multiple-span rectangular or flanged beams. It uses design ultimate bending moment and shear force factors from Table 3.5 of BS 8110: Part 1. As such its use should be limited, as defined by Clause 3.4.3, to where:

- $Q_k \ngtr G_k$
- Uniform loads are placed
- Variations in span < 15% l_{max}.

The intention is to provide the design of a simple continuous beam on one sheet of A4. (Admittedly extra sheets are used for explanation.)

MAIN!

The input requirements are self-explanatory. Answering "Y" to *Support in alt layer* will incur additional cover to top bars at supports (of the same size as those being designed at that location) to allow for beams in the other direction. Users should ensure effective depths, d, are correct (see DETAIL!D15, etc.).

The choice between rectangular, L or T beam is made via a combo-box to the right hand side.

When considering span reinforcement, the spreadsheet will, where necessary, automatically increase reinforcement in order to lower service stresses and enhance allowable span to depth ratios. The diagrams for loading and for bending moment are indicative only (the moment factors in Table 3.5 do not give rise to a moment envelope).

The example is taken from *Designed and detailed* [15].

DETAIL!

For first time users and young engineers, further detail of the calculations undertaken is given on the sheet named DETAIL!, pages 2 and 3 of the print-out.

Weight!

This sheet estimates the weight of reinforcement in the beam when designed according to normal curtailment rules as defined in BS 8110. The estimate is repeated at the bottom of MAIN!. Workings are shown on the right hand side of the sheet. The estimate may be printed out using File/print or the print button on the normal toolbar.

It should be recognised that different engineers' and detailers' interpretations of these clauses, different project circumstances and requirements will all have a bearing on actual quantities of reinforcement used.

Graf!

This sheet provides data for the charts in MAIN! and is not intended for formal printing.

Project	**Spreadsheets to BS 8110**	REINFORCED CONCRETE COUNCIL	
Client	**Advisory Group**	Made by: **rmw**	Date: **13-Oct-99** / Page: **132**
Location	**D&D: Edge beam Grid 1** from A to J	Checked: **chg**	Revision: **-** / Job No: **R68**
	CONTINUOUS CONCRETE BEAM DESIGN to BS 8110:1997 Table 3.5		
	Originated from RCC95.xls on CD © 1999 BCA for RCC		

LOCATION Supports: from grid A to grid J

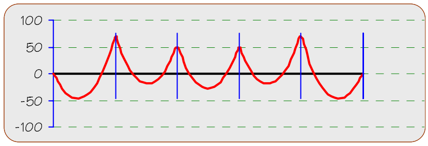
STATUS
VALID DESIGN

DIMENSIONS

Nº of spans	Nº	5	Shape		L BEAM	
Max Span	m	5.00	Top cover	mm	40	
depth, h	mm	350	Bottom cover	mm	40	
bw	mm	300	Side cover	mm	40	
hf	mm	175	Support steel in alt layer ?		Y	
bf	mm	650				

MATERIALS

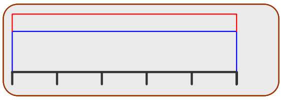
fcu	N/mm²	40	γm = 1.50	
fyl	N/mm²	460	γm = 1.05	
fyv	N/mm²	250	Density kN/m³	23.6
h agg	mm	20	(Normal weight concrete)	



Indicative Bending Moment Diagram

LOADING

Self Wt	kN/m	1.2
+ Dead	kN/m	10.9
Total Dead, gk	kN/m	12.1
Imposed qk	kN/m	5.0
Design load, n =	kN/m	25.0



Geometry and Loading

BENDING

		END SUPPORTS (A & J)	END SPANS	FIRST INT SUPPORTS	INTERIOR SPANS	INTERNAL SUPPORTS		BS8110 Reference
M	kNm	0.0	56.2	68.7	43.7	50.0		Table 3.5
d	mm	276	290	270	292	270		
bf	mm	300	650	300	650	300		3.4.1.5
As	mm²	0	466	643	360	454		3.4.4.4
As'	mm²	0	0	0	0	0		3.4.4.4
Deflection								
L/d Max			38.68		36.78			3.4.6.3
Actual L/d			17.24 **OK**		17.12 **OK**			3.4.6.1
Tension reinforcement								
Ø		16	20	20	16	20		
No		**2 Top**	**2 Btm**	**3 Top**	**2 Btm**	**2 Top**		
As prov	mm²	402	628	942	402	628		
=	%	0.49	0.72	1.16	0.46	0.78		
Compression reinforcement								
Ø		16	12	12	12	12		
No		**2 Btm**	**2 Top**	**2 Btm**	**2 Top**	**2 Btm**		
As' prov	mm²	402	226	226	226	226		
=	%	0.49	0.26	0.28	0.26	0.28		

SHEAR

		OUTER SUPT	FIRST INT SUPT	INT SUPT	NOMINAL	
V	kN/m	56.2	75.0	68.7	~	Table 3.5
v	N/mm²	0.646	0.926	0.849	~	Eqn 3
vc	N/mm²	0.570	0.858	0.749	~	Table 3.8
Link Ø	mm	10	10	10	10	
Legs	No	2	2	2	2	
@	mm	200	200	200	200	

OUTPUT/SUMMARY

	END SUPPORTS	END SPANS	FIRST INT SUPPORTS	INTERNAL SPANS	INTERNAL SUPPORTS
PROVIDE Main reinforcement	**2 T16 T** **Nominal B**	**2 T12 T** **2 T20 B**	**3 T20 T** **Nominal B**	**2 T12 T** **2 T16 B**	**2 T20 T** **Nominal B**
Links from CL of support	**2 R10 @ 200** **for 800**	**2 R10 @ 200**	**2 R10 @ 200** **for 600**	**2 R10 @ 200**	**2 R10 @ 200** **for 600**

CHECKS

BAR Ø < COVER	SINGLE LAYERS	BAR SPACING	DEFLECTION	SHEAR LINKS	GLOBAL STATUS
OK	**OK**	**OK**	**OK**	**OK**	**VALID DESIGN**

Project	Spreadsheets to BS 8110	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: rmw	Date: 13-Oct-99	Page: 133
Location	D&D: Edge beam Grid 1 from A to J	Checked: chg	Revision: -	Job No: R68
	CONTINUOUS CONCRETE BEAM DESIGN to BS 8110:1997 Table 3.5			
	Originated from RCC95.xls on CD © 1999 BCA for RCC			

DETAILED CALCULATIONS

Gk = 60.70 Qk = 25.00 F = 124.98 kN

MAIN STEEL

			END SUPPORTS		END SPANS		FIRST INT SUPPORTS		INTERIOR SPANS		INTERNAL SUPPORTS	BS 8110 Reference
Factor			0.00		0.09		0.11		0.07		0.08	Table 3.5
M	kNm		0.0		56.2		68.7		43.7		50.0	- = -
d	mm		276		290		270		292		270	
bf	mm		300		650		300		650		300	3.4.1.5
K'			0.1558		0.1558		0.1558		0.1558		0.1558	Fig 3.3
Web Mres	kNm		142.4		157.2		136.3		159.4		136.3	- = -
Flange Mres	kNm		---		411.5		---		415.6		---	- = -
K			0.0000		0.0257		0.0786		0.0197		0.0571	3.4.4.4
z	mm		262.2		275.5		243.9		277.4		251.6	- = -
x	mm		30.7		32.2		58.0		32.4		40.9	- = -
d'	mm		78		56		76		56		72	
net fsc	N/mm²		0.0		0.0		0.0		0.0		0.0	Fig 3.3
Excess M	kNm		0.0		0.0		0.0		0.0		0.0	
As' req	mm²		0		0		0		0		0	
fst	N/mm²		438.1		438.1		438.1		438.1		438.1	Fig 3.3
As req	mm²		0		466		643		360		454	
bw/b			---		0.4615		---		0.4615		---	
Min %			0.20%		0.13%		0.20%		0.13%		0.20%	Table 3.25
Min As			210		137		210		137		210	

DEFLECTION

fs	N/mm²		0.0		227.4		209.3		274.5		221.4	Eqn 8
Base ratio					22.00				22.00			3.4.6.3/4
Tens Mod					1.628				1.549			Table 3.10
Comp Mod					1.080				1.079			Table 3.11
Perm L/d					38.678				36.778			3.4.6.3
Actual L/d					17.241	ok			17.123	ok		3.4.6.1

TENSION STEEL

As	mm²		210		466		643		360		454	
Ø	mm		16	ok	20	ok	20	ok	16	ok	20	
No			2		2		3		2		2	
As prov	mm²		402		628		942		402		628	
Clear dist	mm		168.0		160.0		70.0		168.0		160.0	between bars
Min S		ok	25.0	ok	25.0	ok	25.0	ok	25.0	ok	25.0	3.12.11.1
Max S		ok	300.0	ok	206.7	ok	224.5	ok	171.2	ok	212.3	Table 3.28
												3.12.11.2.4

COMPRESSION STEEL

Required	mm²		314		188		188		188		121	Table 3.25
Ø		ok	16	ok	12	ok	12	ok	12	ok	12	
No			2		2		2		2		2	
As' prov	mm²		402		226		226		226		226	
= %		ok	0.486	ok	0.260	ok	0.279	ok	0.258	ok	0.279	
Clear dist	mm		168.0		176.0		176.0		176.0		176.0	between bars
Min S		ok	25.0	ok	25.0	ok	25.0	ok	25.0	ok	25.0	3.12.11.1

Project	Spreadsheets to BS 8110		REINFORCED CONCRETE COUNCIL		
Client	Advisory Group		Made by	Date	Page
Location	D&D: Edge beam Grid 1 from A to J		rmw	13-Oct-99	134
	CONTINUOUS CONCRETE BEAM DESIGN to BS 8110:1997 Table 3.5		Checked	Revision	Job No
	Originated from RCC95.xls on CD	© 1999 BCA for RCC	chg	-	R68

SHEAR

			OUTER SUPPORT		FIRST INT SUPPORT		INTERNAL SUPPORT		NOMINAL		
Factor			0.45		0.60		0.55		~		Table 3.5
V	kN		56.2		75.0		68.7		~		- = -
v	N/mm²		0.646		0.926		0.849		~		Eqn 3
vc	N/mm²		0.570		0.858		0.749		~		Table 3.8
(v-vc)bv	N/mm		120.0		120.0		120.0		120.0		Table 3.7
Link Ø		ok	10	ok	10	ok	10	ok	10		3.12.7.1
Legs		ok	2	ok	2	ok	2	ok	2		
@	mm		218		203		203		218		3.12.7.1
Adjust to	mm		200		200		200		200		
for	mm		0		0		0		---	from cl of supt	
Adjust to	mm		800		600		600		---		
As Dist		ok	0.0	ok	90.0	ok	0.0	ok	0.0		3.4.5.5
As' Dist		ok	0.0	ok	0.0	ok	0.0	ok	0.0		3.12.7.2

SPREADSHEETS TO EC2

Eurocode 2

At the time of writing (November 1999), we are advised that the base document, Eurocode 2: *Design of concrete structures, Part 1: General rules and rules for buildings*, DD ENV 1992-1-1: 1992[3] is due for revision into an EN in the near future. The spreadsheets presented here are in accordance with this document but development of other spreadsheets has not perhaps been as extensive as first envisaged. Nonetheless, the spreadsheets presented here cover all the fundamental elements of in-situ concrete and should give users a good understanding of the current ENV and provide the basis for an understanding of the final EN document.

It is hoped that the production of spreadsheets to the final version of EC2 will occur at some later date.

Eurocode 2, *Design of concrete structures*, has not been widely adopted by UK industry. The process of converting to a new design Code of Practice is slow and expensive, and EC2 will be adopted only when there is commercial advantage in doing so. Mainland Europeans, in contrast, seem more enthusiastic, and there is a danger of the UK becoming isolated and uncompetitive in Europe. While several books on the subject have been published, there are very few design aids. The availability of these spreadsheet files will help address this need.

These spreadsheets have called for some interpretation of the ENV. The provision for boxed values and the National Application Document mean that many factors hidden away in the BS 8110 versions are documented on a separate sheet allowing later amendment.

Terminology employed will be generally familiar to UK engineers, although there are some new words. Thus 'loads' are referred to as 'actions'; 'bending moments' and 'shear forces' are called 'internal forces and moments'; 'superimposed loads' are 'variable loads'; and 'self-weight' and 'dead loads' are referred to as permanent loads

In EC2, a number of numerical values appear within boxes. These numbers are for guidance only as each EU member state is required to fix the values that will apply in its jurisdiction. The 'boxed' values are determined by National Application Documents (the UK NAD is part of reference 3) and are shown in a separate sheet within the spreadsheets. Concrete strength in EC2 refers to the cylinder strength (f_{ck}), which is used throughout the EC2 spreadsheets. The relationship between cylinder and cube strengths is shown below.

Relationship between cylinder and cube strengths

Property	Strength class						
	C20/25	C25/30	C30/37	C35/40	C40/50	C45/50	C50/60
f_{ck} (cylinder)	20	25	30	35	40	45	50
f_{cu} (cube)	25	30	37	40	50	50	60
E_{cm}	29	30.5	32	33.5	35	36	37

Notes regarding EC2

In his *Comparison of design requirements in EC2 and BS 8110*, Narayanan[24] gave the following outline description of EC2.

General layout

DD ENV 1992-1-1[3]: Part 1 is broadly comparable to BS 8110: Parts 1 and 2. EC2 comprises principles and rules of application. Principles are general statements, definitions, other requirements, and analytical models for which no alternative is permitted. The rules of application are generally recognised rules that follow the principles and satisfy their requirements.

Frame analysis

There are slightly differences in the partial safety factors for loads. ENV 1992 uses factors of 1.35 for dead loads and 1.5 for imposed loads. Corresponding values in BS 8110 are 1.4 and 1.6.

Section analysis

The spreadsheets take a pragmatic approach to the design of sections to ENV 1992. Thus a simplified rectangular stress block, Figure 4.4, is used (and particularly in the case of columns, not the more complicated consideration of strains in Figure 4.11).

Lever arm, z is restricted to 0.95 x effective depth. This limit is derived from BS 8110 and avoids dangers associated with theoretically over-shallow neutral axis depths.

Redistribution of moments in continuous structures

EC2 permits redistribution of moments in non-sway structures subject to the maintenance of equilibrium between the distributed moment and applied loads. The maximum redistributed moment to the moment before the distribution is limited to 70%., and to 85% after distribution .

Shear

Applied shear force (V_{sd}) is compared with three values for the resistance (V_{Rd}).

V_{Rd1} represents the shear capacity of concrete alone; V_{Rd2} is the shear resistance determined by the capacity of the notional concrete struts; and V_{Rd3} is the capacity of a section with shear reinforcement.

Deformation

The ENV 1992 span depth/ratio check is similar to that in BS 8110. For each type of member, it provides two values, one for highly stressed members and another for lightly stressed members. In this context, members with less than 0.5% reinforcement are considered lightly stressed members, and members with 1.5% reinforcement are considered highly stressed. More rigorous approaches may be used if required.

Detailing

Formulae for calculating basic lap lengths are similar to those in BS 8110, but ENV 1992 uses marginally lower bond stress.

Minimum percentages of reinforcement

There is hardly any difference between the two Codes in the minimum longitudinal reinforcement in beams and slabs. However for criteria for minimum reinforcement to control cracking is different.

Familiarisation: outline description

The layout and workings of the spreadsheets to EC2 are in line with those in the previous section, *Spreadsheets to BS 8110.* Descriptions of the spreadsheets to EC2 are given in the following pages. The *Introduction* (page 2*),* and *General notes* (page 3) are common to the use of all spreadsheets in this publication.

RCCe11 Element Design.xls

RCCe11.xls includes sheets for designing

- Solid slabs
- Rectangular beams and
- T beams (and ribbed slabs) for bending
- Beam shear
- Columns with axial load and bending about one axis.

RCCe11.xls designs elements to Eurocode 2: Part 1: 1992[3]. It is assumed that loads, moments, shears, etc, are available for input from hand calculations or from analysis from elsewhere. Span-to-depth ratios and other 'boxed' values are taken from the UK National Application Document (part of reference 3).

SLAB!

This sheet designs a section of solid slab in a single simply supported span, in a continuous end or internal span, at supports or as a cantilever. Workings and references to clause numbers are given to the right hand side of the sheet.

Input should be self-explanatory. Terminology may differ from the BS 8110 version: for instance the term d is the redistribution factor (i.e. 1 – redistribution percentage/100). Concrete cylinder strength, f_{ck}, is changed using the combo-box to the right hand side.

In spans, the location of the section being designed has a bearing on deflection limitations, and the appropriate location should be chosen from the combo-box to the right hand side. Similarly, the user should choose from the list of usage *(dwelling, office/store, parking etc.)*, which governs the proportion of imposed load affecting long-term deflection. EC2 requires the input of the relationship between dead and imposed loading. This is done at cells G9 and G10. When appropriate the sheet will automatically increase amounts of reinforcement in order to lower service stresses and enhance allowable span-to-depth ratios.

The example is taken from *Worked examples for the design of concrete buildings*[25] (to EC2) which itself is based on the 1985 version of *Designed and detailed*. Discrepancies in numbers may be ascribed to differences in f_{ck} and differences between tabular and calculated values of x/d.

RECT~BEAM!

This sheet designs a rectangular beam in a single simply supported span, in a continuous end or internal span, at supports or as a cantilever. These choices have a bearing on deflection limitations and the user should choose the appropriate location from the combo-box to the right hand side. The user should similarly choose from the list of usage *(dwelling, office/store, parking, etc.)*, which governs the proportion of imposed load affecting long-term deflection. This sheet will, where necessary, automatically increase reinforcement in order to lower service stresses and enhance allowable span to depth ratios. Again, input of the relationship between dead and imposed loading is required in cells D12 and D13.

y_2 is the quasi-permanent load factor applied to imposed loads in calculations of deflection. The factors are 0.2 for dwellings, 0.3 for offices, 0.6 for parking areas and 0.0 for snow and wind.

The example is taken from *Worked examples for the design of concrete buildings*[25] (to EC2) which itself is based on the 1985 version of *Designed and detailed*.

TEE~BEAM!

This sheet designs a rectangular beam in a single simply supported span, in a continuous end or internal span, at supports or as a cantilever. These choices have a bearing on deflection limitations and the user should choose the appropriate location from the combo-box to the right hand side. Choosing between end and interior spans alters maximum allowable flange width. The user should similarly choose from the list of usage *(dwelling, office/store, parking)* which governs the proportion of imposed load affecting long-term deflection. This sheet will, where necessary, automatically increase reinforcement in order to lower service stresses and enhance allowable span-to-depth ratios. Again, input of the relationship between dead and imposed loading is required in cells D12 and D13. The user may also choose between a T beam and an inverted L beam.

The example is taken from *Worked examples for the design of concrete Buildings* (to EC2) which itself is based on the 1985 version of *Designed and detailed* .

SHEAR!

This sheet designs beams for shear.

Input is (we hope) self-explanatory. The value of shear force, V_{sd}, used can, provided there is diagonal compression and continuity of tension reinforcement for at least 2.5 d from the face of support, be evaluated at d from the face of support (see Clause 4.3.2.2(10)). The UDL is the relevant ultimate uniformly distributed load.

The sheet designs the links required at the section considered. If the beam loading is considered to be uniformly distributed, the ultimate UDL, n, can be entered under *n* to give the distance for which this arrangement is required before reverting to nominal link arrangement.

COLUMN!

This spreadsheet designs symmetrically reinforced rectangular columns bent about one axis where both axial load, N, and maximum design moment, M_x, are known. It is based on EC2 Figure 4.4 and Clause 4.2.1.3(12). It iterates x/h to determine where the neutral axis lies. The sheet includes stress and strain diagrams to aid comprehension of the final design. Workings and references are shown to the right hand side of the sheet.

For simplicity, where three or more bars are required in the top and bottom of the section, it is assumed that a symmetrical arrangement will be required for the side faces (see the argument included within the commentary for the BS 8110 version, page 19).

Input is self-explanatory. The sheet assumes that the moment entered has already been adjusted, if necessary, for bi-axial bending (see *Worked examples for the design of concrete buildings*[25] p137). Under Calculations, a is a stress block shape factor, similar to the 0.67 factor used in BS 8110.

Theoretical shortfalls in area of up to 2% are considered to be acceptable.

The example is taken from *Worked examples for the design of concrete buildings*[25] (to EC2) which itself is based on the 1985 version of *Designed and Detailed*. Discrepancies in numbers may be ascribed to differences in f_{ck} and differences between tabular and calculated values of x/d.

BOX!

This sheet is for reference only. It lists those values specific for the UK use of EC2, and gives their descriptions.

Section design to Eurocode 2 (DD ENV 1992-1-1 : 1992)

SOLID SLABS

Originated from RCCe11.xls on CD © 1999 BCA for RCC

REINFORCED CONCRETE COUNCIL | DETR Environment Transport Regions

INPUT

Location **1st Floor, Span H-J**

M	kNm/m	20.2	fck	N/mm²	30	γ_c = 1.50
δ		1.00	fyk	N/mm²	460	γ_s = 1.15
span	mm	500	gk	kN/m²	4.70	
h	mm	175	qk	kN/m²	4.00	
Bar Ø	mm	12				
cover	mm	20	to this steel			

Section location INTERIOR SPAN

OUTPUT

1st Floor, Span H-J

	d = 175 - 20 - 12/2 = 149.0 mm
Equn A9	x = [149 - (149² - 1600/0.68 x 20.2 x 1.5/30)½]/0.8 = 10.3 mm
Equn A8	(x/d) limit = 0.448 x/d actual = 0.069 < 0.448 ok
4.2.1.3.3(12)	z = 149 - 0.4 x 10.3 = 144.9 mm
	As = 20.2E6/460/144.9 x 1.15 = 349 > As min = 224 mm²/m
5.4.2.1.1	As min = 1.5 x 149 = 224 mm²/m
4.4.2.2	As crack = 400 x 0.8 x 3 x 175/2 / 460 = 183 mm²/m
	As def = 23 mm²/m
	Provide T12 @ 300 = 377 mm²/m
Table 1 NAD	ψ_2 = 0.3 (Office/Store)
4.4.3.2(4)	fs = 460 x 5.90/12.35 x 349/377/1.15 = 176.7 N/mm²
	Modification factor = 250/176.7 = 1.4146
Table 7 NAD	Permissible L/d = 1.4146 x 37.117 = 52.505
	Actual L/d = 500/149 = 3.356 ok

Section design to Eurocode 2 (DD ENV 1992-1-1 : 1992)

RECTANGULAR BEAMS

Originated from RCCe11.xls on CD

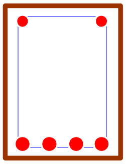
INPUT

Location **1st Floor, Span 2**

Beam type SUPPORT

M	kNm	268.0	fck	30	N/mm²	γc	1.50
δ		0.70	fyk	460	N/mm²	γs	1.15
span	mm	8000					
h	mm	500					
b	mm	300					
gk	kN/m	25.80					
qk	kN/m	20.00					
$\psi 2$ =	0.3	Office/Store					

REBAR	Ø	COVER
Tension	25	35
Comp'n	25	35
Side	--	35



OUTPUT

1st Floor, Span 2

Effective depth, d = 500 - 35 - 25/2 = 452.5 mm

Neutral axis, x = [452.5-(452.5² -2E6x268x1.5/0.85/300/30)½]/0.8 = 171.0 mm

(x/d) limit = 0.208 x/d actual = 0.378 > 0.208, x = 94.1 mm

Lever arm, z = 452.5 - 0.4 x 94.1 = 414.9 mm

d' = 35 + 25/2 = 47.5 mm

Gross fsc = 346.7 N/mm² from strain diagram

Net fsc = 346.7 - 0.85 x 30 /1.5 = 329.7 N/mm²

Excess M = 268 - 159.3 = 108.7 kNm

Compession steel, As' = 108.7E6 /329.7 /(452.5 - 47.5) = 814 mm²

PROVIDE 2 T25 COMPRESSION STEEL = 982 mm²

Steel stress, fst = 400.0 N/mm² from strain diagram

Tension steel, As = 1.15E6 x 159.3/414.9/400.0 + 813.9 x 329.7/400.0 = 1631 mm²

5.4.2.1.1 As min = 1.5 x 300 x 500 = 204 mm²

4.4.2.2 As crack = 0.4 x 0.8 x 3 x 500/2 x 300/460 = 133 mm²

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PROVIDE 4 T25 TENSION STEEL = 1963 mm²

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Section design to Eurocode 2 (DD ENV 1992-1-1 : 1992)

SIMPLE TEE & L BEAMS

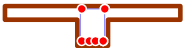
Originated from RCCe11.xls on CD

INPUT Location **1st Floor, Span 3 to 4**

M kNm 325.0 Beam type END SPAN

δ		1.00	fck	30	N/mm²	γc	1.50
span	mm	8000	fyk	500	N/mm²	γs	1.15
h	mm	500					
b_w	mm	300					
b_f	mm	1660					
h_f	mm	175					
gk	kN/m	25.80					
qk	kN/m	20.00	ψ2 = 0.3	Office/Store			

REBAR	Ø	COVER
Tension	25	35
Comp'n	12	35
Side	--	35



OUTPUT **1st Floor, Span 3 to 4**

Effective depth, d = 500 - 35 - 25/2 = 452.5 mm

Neutral axis, x = [452.5-(452.5² -2E6x325x1.5/0.85/300/30)½]/0.8 = 32.8 mm

(x/d) limit = 0.448 x/d actual = 0.072 ok

Lever arm, z = 452.5 - 0.4 x 32.8 = 439.4 > 0.95d = 429.9 mm

Tension steel, As = 1.15E6 x 318.0 /429.9 /434.8 + 17111555.9 x 0.0 /434.8 = 1741 mm²

5.4.2.1.1 As min = 1.5 x 300 x 452.5 = 204 mm²

4.4.2.2 As crack = 0.4 x 0.8 x 3 x 140171/500 = 229 mm²

for deflection, As def = 1367 mm²

PROVIDE 4 T25 TENSION STEEL = 1963 mm²

.

Service stress, fs = 500 x 31.80 /64.83 x 1741 /1963 /1 /1.15 = 189.1 N/mm²

Modification factor = 250/189 x 7000/8000 x 0.800 = 0.926

Table 7 NAD Permissible L/d = 0.926 x 23.482 = 21.737

Actual L/d = 8000 /452.5 = 17.680 ok

.

.

.

.

.

.

Section design to Eurocode 2 (DD ENV 1992-1-1 : 1992)

BEAM SHEAR

Originated from RCCe11.xls on CD

Btm curtailment <= 50%

INPUT Location **1st Floor, Span 2 at 2E**

f_{ck}	N/mm²	30	γ_c 1.50	**d**	**b**
f_{ywk}	N/mm²	250	γ_s 1.15	440	300

Main Steel	**Link Ø**	**Legs**	**Side cover**	**VSd**	**n**
Ø 25	12	2	30	248.0	64.8
No 2	mm	No	mm	kN	kN/m

OUTPUT **1st Floor, Span 2 at 2E**

A_s = 982 mm² = 0.744%

τ_{Rd} = 0.340 N/mm² from table 4.8

V_{Rd1} = 0.340 x 1.160(1.2+40x0.0074) x 300 x 440/1000 = 78.0 kN

V_{Rd2} = 0.3 x 0.55 x 30 x 300 x 440/1000 = 653.4 kN

V_{sd}/V_{Rd2} = 248 /653.4 = 0.380

V_{wd} = 1000(248 - 78.0) = 170039 N

A_{sw}/s = 170039 x 1.15 /0.9 /250 /440 = 1.9752 > 0.6650 min

s requ = 226.2 /1.9752 = 115 mm < s max = 264 (5.4.2.2)

s crack = 300 (Table 4.13)

PROVIDE 2 legs R12 @ 100

Provide for distance of 1500 mm

then nominal links = 2 legs R12 @ 250

Section design to Eurocode 2 (DD ENV 1992-1-1 : 1992)

COLUMN DESIGN

SYMMETRICAL RECTANGULAR COLUMN DESIGN
MOMENTS ABOUT X AXIS ONLY

Originated from RCCe11.xls on CD

INPUT

Location	Column 2E				
Axial load, N	1807	kN	fck	32	N/mm²
Moment, M	27.0	kNm	fyk	460	N/mm²
height, h	300	mm	Max bar Ø	20	mm
breadth, b	300	mm	Link Ø	10	mm
cover (to link)	25	mm	γc	1.50	concrete
			γs	1.15	steel

CALCULATIONS

from M $As = [M - \alpha f_{ck}.b.d_c(h/2 - d_c/2)] / [(h/2-d').(f_{sc}+f_{st}).\gamma_c]$

from N $A_s = (N - \alpha f_{ck}.b.d_c) / [(f_{sc} - f_{st}).\gamma_c]$ $A_{sc} = A_{st} = A_s$ $d_c = \min(h, 0.8x)$

d' =	45	mm	$\alpha.f_{ck}/\gamma_c$ =	18.1	N/mm²
d =	255	mm	f_{yk}/γ_m =	400.0	N/mm²
from iteration, neutral axis depth, x =	350.2	mm	dc =	280.1	mm
$\alpha.f_{cu}.b.d_c/\gamma_c$ =	1523.9	kN			
Steel comp strain =	0.00275				
Steel tens strain =	-0.00086				
fsc =	400	N/mm²	(Comp. stress in reinf.)		
fst =	-172	N/mm²	(Tensile stress in reinf.)		
from M, As =	495	mm²	from N, As =	495	mm²

OK

OUTPUT

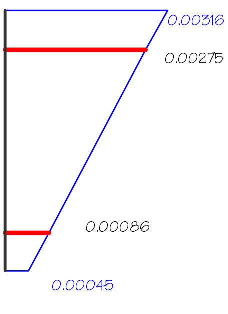
Column 2E

Requires 495mm² T&B:- **PROVIDE 4T20**

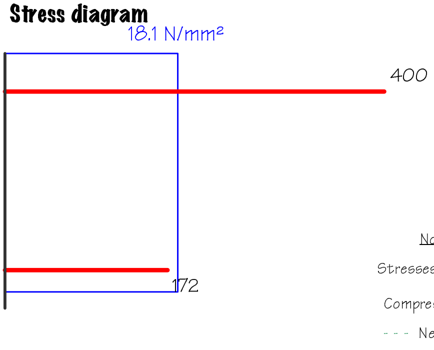
(ie 2T20 T&B - 628mm² T&B - 1.40% o/a, @210 c/c.)

Links : - **PROVIDE T10 @ 225**

Strain diagram



Stress diagram



Notes

Stresses in N/mm²

Compression +ve

- - - Neutral axis

Section design to Eurocode 2 (DD ENV 1992-1-1 : 1992)

EC2/NAD BOXED VALUES

 see also BOXVAL

EC2 Ref	Function	Value	
Table 2.2	γ_G	1.35	*dead load factor*
Table 2.2	γ_Q	1.5	*imposed load factor*
Table 2.3	γ_c	1.5	*concrete*
Table 2.3	γ_s	1.15	*steel*
Table 4.8	f_{ck} max	40	*shear limit*
4.2.1.3 (12)	α	0.85	*stress block factor*
4.4.2.2 (3)	fct_{eff}	3	*concrete tension*
4.3.2.3 (1)	k	1	*curtailment factor*
4.3.2.3 (1)	ρL	0.02	*steel ratio limit*
4.3.4.5.2 (1)	v_{Rd2}/v_{Rd1}	2.0	*punching limit*
4.3.4.5.2 (1)	$v_{Rd2}/\sqrt{f_{ck}}$	0.9	*punching*
Equn 4.58	change at	1.6	*punching*
5.4.2.1.1	Equn 5.14	0.6	*min steel*
5.4.2.1.1	Equn 5.14	0.0015	*min steel*
5.4.2.1.1 (2)	A_s/A_c max	0.04	*max steel*
5.4.2.2 (9)	s max	800	*max trans link spacing*
5.4.3.2.1 (4)	S max	500	*max slab spacing*
5.4.3.2.1 (4)	S/h max	3	*max slab spacing*
5.4.3.3 (2)	% of Tab 5.5	100%	*slab shear*
Equn 5.13	%As min	0.3%	*min column steel*

TABLE 1 (NAD)

	ψ0	ψ1	ψ2
1	0.5	0.4	0.2
2	0.7	0.6	0.3
3	0.7	0.7	0.6

TABLE 7 (NAD) = Table 4.14

0	0.15	0.5	1.5
1	34	25	18
2	44	32	23
3	38	35	25
4	41	30	21
5	14	10	7

TABLE 4.8

20	25	30	35	40
0.26	0.3	0.34	0.37	0.41

RCCe21 Subframe Analysis.xls

RCCe21.xls analyses sub-frames in accordance with Eurocode 2: Part 1: 1992[3].

Spans may be of two different profiles to simulate varying section inertia.

Inputs are required on two sheets.

MAIN!

This single sheet consists of the main inputs.

Most inputs should be self-explanatory. In cell D9 etc, 'segment' refers to the length of the section measured from the left-hand support. If this is less than the span length, the cell below will show the remainder of the span as a second segment. The dimension of the flange width, b_f, is automated to be either b_w + 0.07 x span for L beams or b_w + 0.14 x span for T beams.

Unwanted data cells are 'greyed out'. The use of C, K, or E can alter the characteristics of a support from cantilever to knife-edge to encastré. Remote ends of columns at supports may be *F* for fixed, otherwise and by default, *P* for pinned. Extraneous data is highlighted in red or by messages in red. Beneath *Operating Instructions* a number of checks, mainly for missing entries, are carried out and any problems are highlighted. At the bottom of the sheet there is a simplistic but scale arrangement and loading diagram. This is given to aid data checking. Great care should be taken to ensure that this sheet is completed correctly for the case in hand. It may prove prudent to write down expected values for bending moments at each support before progressing to ACTIONS!

Ultimate and characteristic support reactions are given at the bottom of the sheet

ACTIONS!

This sheet shows bending moment and shear force diagrams from the analysis undertaken in Analysis! The user is required to input desired amount of redistribution to the initial moments in line 27. Cell L14 allows three types of distribution according to the user's preferences.

The sheet also provides elastic and redistributed ultimate shears and column moments according to the various load cases.

Analysis!

This sheet details the moment distribution analysis carried out but is not necessarily intended for printing out other than for checking purposes.

Graf!

This sheet comprises data for graphs used on other sheets, particularly in ACTIONS! It is not necessarily intended for printing out other than for checking purposes

Segs!

This sheet calculates non-prismatic Fixed End Moments used in other sheets notably in Analysis!. Separately, for each load type and for unit load, it calculates the simply supported bending moments at 1/20 points then numerically integrates the Area Moment diagram to find the Fixed End Moments. This sheet is not necessarily intended for printing out other than for checking purposes.

Project	Spreadsheets to BS 8110 & EC2	REINFORCED CONCRETE COUNCIL	
Client	Advisory Group	Made by: rmw	Date: 25-Nov-99 / Sheet No: 146
Location	Spine Beam - SCHEME 4	Checked: chg	Revision: - / Job No: R68

SUBFRAME ANALYSIS TO EC2 (DD ENV 1992-1-1 : 1992)

Originated from RCCe21.xls' on CD © 1999 BCA for RCC

SPANS

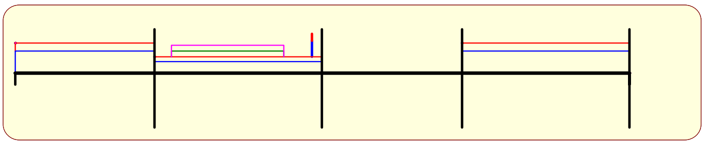
LOCATION from grid C to grid E

	L (m)	Segment (m)	H (mm)	bw (mm)	hf (mm)	Type	bf (mm)	
SPAN 1	6.000	3.200	600	400		R	400	on LHS of span
		2.800	500	666	150	T	1506	on RHS of span
SPAN 2	7.200	5.400	600	400		R	400	on LHS of span
		1.800	450	400		R	400	on RHS of span
SPAN 3	6.000	6.000	450	400		R	400	
SPAN 4	7.200	7.200	600	400		R	400	
SPAN 5								
SPAN 6								

SUPPORTS

	ABOVE				BELOW			
	Length (m)	H (mm)	B (mm)	End Cond	Length (m)	H (mm)	B (mm)	End Cond
Support 1	K					300		
Support 2	3.600	450	450	F	4.500	450	450	F
Support 3	3.600	400	400	F	4.500	400	400	F
Support 4	3.600	400	400	F	4.500	400	400	F
Support 5	3.600	400	400	F	4.500	400	400	F
Support 6								
Support 7								

LOADING DIAGRAM



LOADING PATTERN

	min	max
DEAD	1.0	1.35
IMPOSED		1.5

LOADING (characteristic)

Span 1	Dead Load	Imposed Load	Position from left	Loaded Length
UDL	97.27	36.00	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 2				
UDL	50.00	25.00	~~~~~	~~~~~
PL 1	72	30	6.750	~~~~~
PL 2				~~~~~
Part UDL	47.27	11.00	0.750	4.800
Span 3				
UDL			~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				

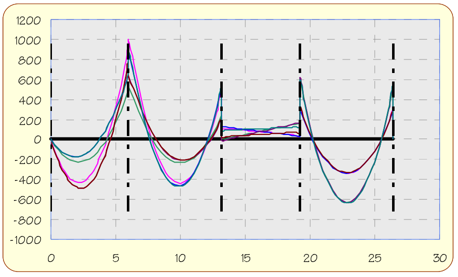
Span 4	Dead Load	Imposed Load	Position from left	Loaded Length
UDL	97.27	36.00	~~~~~	~~~~~
PL 1				~~~~~
PL 2				~~~~~
Part UDL				
Span 5				
UDL				
PL 1				
PL 2				
Part UDL				
Span 6				
UDL				
PL 1				
PL 2				
Part UDL				

REACTIONS

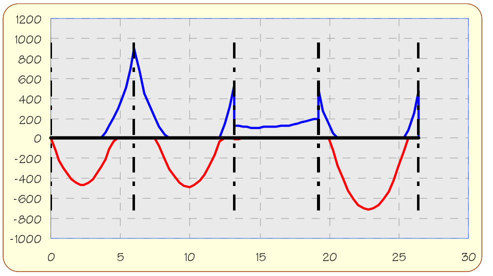
SUPPORT	1	2	3	4	5
MAX ULTIMATE	413.7	1365.2	645.0	705.3	664.3
MIN ULTIMATE	172.9	741.9	240.3	341.9	339.1
Characteristic Dead	210.1	723.8	303.8	360.5	344.6
Char. Imposed	86.7	258.7	156.6	146.9	132.7

Project	Spreadsheets to BS 8110 & EC2	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: rmw	Date: 13-Oct-99	Page: 147
Location	Spine Beam - SCHEME 4, from C to E	Checked: chg	Revision: -	Job No: R68
	SUBFRAME ANALYSIS TO EC2 (DD ENV 1992-1-1 : 1992)			
	Originated from RCCe21.xls' on CD © 1999 BCA for RCC			

BENDING MOMENTS (kNm ultimate)



C **Elastic Moments** E

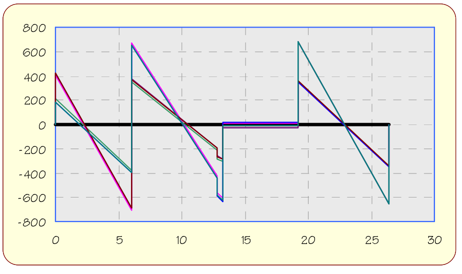


C **Redistributed Envelope** E

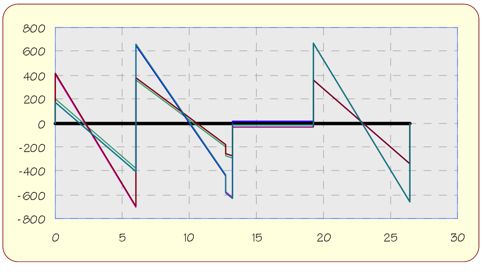
SUPPORT No	1	2	3	4	5			
Elastic M		994.9	534.5	620.5	528.6	~	~	kNm
Redistributed M		895.4	534.5	496.4	475.7	~	~	kNm
Column face M	-18.5	751.0	410.7	366.1	346.6	~	~	
ßb	1.000	0.900	1.000	0.800	0.900	~	~	
Redistribution	10.0%	10.0%		20.0%	10.0%			

SPAN No	1	2	3	4			
Elastic M	491.01	468.03	11.26	636.29	~	~	kNm
Redistributed M	461.68	481.84	11.26	714.81	~	~	kNm
ßb	0.940	1.030	1.000	1.123	~	~	

SHEARS (kN ultimate)



C **Elastic Shears** E



C **Redistributed Shears** E

SPAN No	1		2		3		
Elastic V	426.6	711.4	673.9	631.6	16.2	29.7	kN
Redistributed V	413.7	705.2	660.1	629.8	15.2	35.3	kN

SPAN No	4						
Elastic V	680.7	657.1					kN
Redistributed V	670.0	664.3					kN

COLUMN Ms (kNm ultimate)		1	2	3	4	5
ADJACENT SPANS	Above		34.5	-225.4	253.7	-290.5
LOADED	Below		27.6	-180.3	202.9	-232.4
ODD SPANS	Above		-78.1	-98.6	136.3	-153.5
LOADED	Below		-62.5	-78.9	109.0	-122.8
EVEN SPANS	Above		132.4	-239.6	265.0	-139.8
LOADED	Below		105.9	-191.7	212.0	-234.9

RCCe41 Continuous Beams (A & D).xls

The spreadsheet allows for the design of multiple-span rectangular or flanged beams using sub-frame analysis to derive moments and shears according to the current version of Eurocode 2: Part 1: 1992[3].

The intention is to provide the design and analysis of up to six spans of continuous beams with columns above and below. There are three main sheets: MAIN!, ACTIONS! and SPANS! Input is required on each of these three sheets.

MAIN!

This sheet contains user input of materials, frame geometry and load data, for up to six spans. Users should note that with values of concrete strength of f_{ck} > 35 N/mm^2 (equivalent to f_{cu} > 45 N/mm^2), limiting values of x/d and consequently m_{lim} (limiting applied moment ratio) are affected dramatically.

The example is taken from *Worked examples for the design of concrete buildings*[25] (to EC2) which itself is based on the 1985 version of *Designed and detailed*. In order to reflect the latter publication, the spreadsheet has been set up with the beams being considered as rectangular in both the analysis and design.

Users should note that the maximum permitted flange widths are calculated from points of contraflexure on the BM diagrams, and may therefore change with modifications in loading.

ACTIONS!

ACTIONS! includes bending moment and shear force diagrams, summaries of moments and shears and user input for amounts of redistribution. Users should ensure that the amounts of redistribution are always considered, as there are no default values.

SPANS!

This sheet designs reinforcement for bending in spans and supports and for shear in the spans. User input is required for reinforcement sizes. The size used at a right support is carried through to the left support of the next span. However different numbers of bars may be designed, as support moments (including cantilever moments) are considered at the face of the support (see Bar!). Non-existent spans are greyed out.

The reinforcement areas required for ultimate span moments can be automatically increased in order to enhance span-to-depth ratios. EC2 Clause 4.4.3.2P(4), appears to give the unlimited possibility to reduce service stress and increase span-to-depth ratios, but the spreadsheet does not allow any increase in span-to-depth ratios greater than 100%. The effectiveness of increasing the area of reinforcement depends on the extent of cracking. The effect is marginal if the section is substantially uncracked, i.e. slabs, but is more significant for beams. Beeby and Narayanan's *Designers handbook to EC2*, p182)[26] gives some modification factors based on parametric studies.

Weight!

This sheet estimates the weight of reinforcement in the beam as designed according to curtailment in EC2. Workings are shown on the right hand side of the sheet. The estimate may be printed out using File/print or the print button on the normal toolbar. It should be recognised that different engineers' and detailers' interpretations of these clauses, different project circumstances and requirements, will all have a bearing on actual quantities used. A print-out of this sheet is reproduced.

Analysis!

This sheet shows the moment distributions used in the analysis of the beam: it is not intended for formal printing.

Bar!

For first time users and young engineers, further detail of the calculations undertaken and EC2 references are given. Moments at ¼ span points are used to determine the top reinforcement in spans. A print-out of this sheet is reproduced.

Graf!

This sheet provides data for the charts in MAIN! and ACTIONS!: it is not intended for formal printing.

Box!

Many values used in EC2 are subject to national ratification. This is signified by them appearing within boxes in the main document. These 'box' values are defined in the National Application Document (part of DD ENV 1992-1-1 1992)[3] and those used within the spreadsheet are presented within Box!

Project	Spreadsheets to EC2	REINFORCED CONCRETE COUNCIL		
Client	Advisory Group	Made by: rmw	Date: 16-Nov-99	Page: 149
Location	*Worked Examples*: Main beam Grids C to H	Checked: chg	Revision: -	Job No: R68

CONTINUOUS BEAM ANALYSIS & DESIGN to EC2 (DD ENV 1992-1-1 : 1992)

Originated from RCCe41.xls on CD

MATERIALS **STATUS OK**

fck	32	N/mm²	dg	20	mm
fyk	500	N/mm²	γs	1.15	
fywk	250	N/mm²	γc	1.50	

COVERS (to links)

Top cover	20	mm
Btm cover	20	mm
Side cover	20	mm

SPANS

	L (m)	h (mm)	bw (mm)	hf (mm)	Type	bf (mm)
SPAN 1	8.00	500	300	175	R	300
SPAN 2	6.00	500	300	175	R	300
SPAN 3						
SPAN 4						
SPAN 5						
SPAN 6						

LOADING PATTERN

	min	max
DEAD	1.0	1.35
IMPOSED		1.5

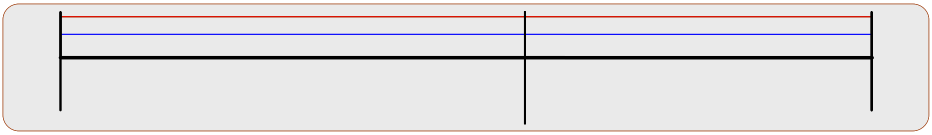
REBAR LAYERING

Support steel in alt layer ? N

SUPPORTS

	ABOVE (m)	H (mm)	B (mm)	End Cond	BELOW (m)	H (mm)	B (mm)	End Cond
Support 1	3.500	300	300	F	4.000	300	300	P
Support 2	3.500	300	300	F	5.000	300	300	P
Support 3	3.500	300	300	F	4.000	300	300	P
Support 4								

LOADING DIAGRAM



LOADING UDLs (kN/m²) PLs (kN) Position (m)

	Dead Load	Imposed Load	Position from left	Loaded Length	Dead Load	Imposed Load	Position from left	Loaded Length
Span 1								
UDL	25.8	20.0	~~~~~	~~~~~			~~~~~	~~~~~
PL 1				~~~~~				~~~~~
PL 2				~~~~~				~~~~~
Part UDL								
Span 2								
UDL	25.8	20.0	~~~~~	~~~~~			~~~~~	~~~~~
PL 1				~~~~~				~~~~~
PL 2				~~~~~				~~~~~
Part UDL								
			~~	~~~~~			~~~~~	~~~~~
				~~				~~~~~
				~~				~~~~~

REACTIONS (kN)

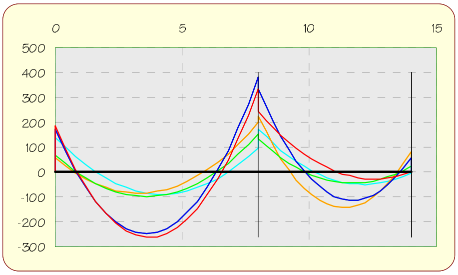
SUPPORT	1	2	3
ALL SPANS LOADED	241.9	506.4	159.3
ODD SPANS LOADED	241.9	399.1	32.5
EVEN SPANS LOADED	79.6	352.3	163.4
MAX ULTIMATE	241.9	506.4	163.4
Characteristic Dead	92.7	209.3	59.2
Characteristic Imposed	77.9	149.2	55.7

Project	Spreadsheets to EC2		Made by: rmw	Date: 13-Oct-99
Client	Advisory Group		Checked: chg	Revision: -
Location	Worked Examples: Main beam Grids C to H		Page: 150	Job No: R68
	CONTINUOUS BEAM ANALYSIS & DESIGN to EC2 (DD ENV 1992-1-1 : 1992)			

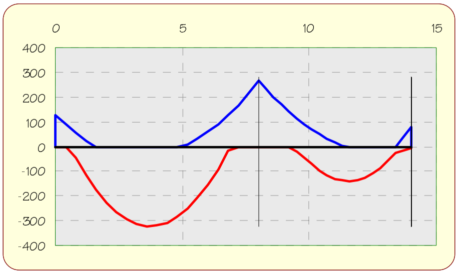
REINFORCED CONCRETE COUNCIL

Originated from RCCe41.xls on CD

BENDING MOMENTS (kNm)



Elastic Moments

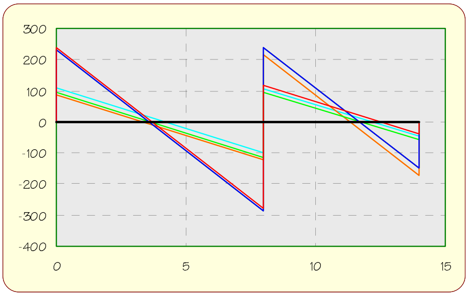


Redistributed Envelope

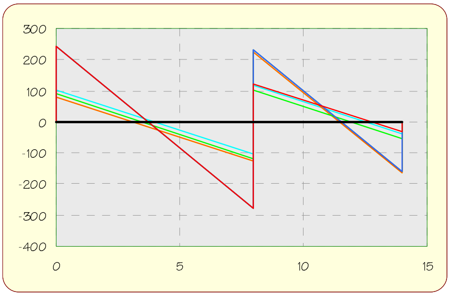
SUPPORT No	1	2	3				
Elastic M	183.4	382.3	81.3	~	~	~	kNm/m
Redistributed M	128.3	267.6	81.3	~	~	~	kNm/m
ßb	0.700	0.700	1.000	~	~	~	~
Redistribution	30.0%	30.0%					

SPAN No	1	2				
Elastic M	262.7	144.3	~	~	~	~
Redistributed M	323.0	139.1	~	~	~	~
ßb	1.230	0.964	~	~	~	~

SHEARS (kN)



Elastic Shears



Redistributed Shears

SPAN No	1		2			
Elastic V	240.5	285.8	240.2	171.0	~	~
Redistributed V	241.9	276.7	229.6	163.4	~	~

SPAN No						
Elastic V	~	~	~	~	~	~
Redistributed V	~	~	~	~	~	~

COLUMN MOMENTS (kNm ult)		1	2	3
ALL SPANS LOADED	Above	103.1	-33.5	-34.3
	Below	67.7	-17.6	-22.5
ODD SPANS LOADED	Above	110.7	-61.1	1.2
	Below	72.6	-32.1	0.8
EVEN SPANS LOADED	Above	33.5	14.3	-49.1
	Below	22.0	7.5	-32.2

Project	**Spreadsheets to EC2**	REINFORCED CONCRETE COUNCIL		
Client	**Advisory Group**	Made by **rmw**	Date **13-Oct-99**	Page **151**
Location	**Worked Examples: Main beam Grids C to H**	Checked **chg**	Revision **-**	Job No **R68**
	CONTINUOUS BEAM ANALYSIS & DESIGN to EC2 (DD ENV 1992-1-1 : 1992)			
	Originated from RCCe41.xls on CD © 1999 BCA for RCC			

SPAN 1

			LEFT	CENTRE	RIGHT
ACTIONS	M	kNm	113.1	323.0	241.8
	δ		0.70	1.23	0.70
DESIGN	d	mm	460.0	452.0	455.5
	As	mm²	596	1996	1341
	As'	mm²	0	0	522
TOP STEEL	Layer 1		3 T 16	3 T 12	3 T 25
	Layer 2				
	As prov	mm²	603	As' prov 339	As prov 1473
BTM STEEL	Layer 1		3 T 16	3 T 32	2 T 32
	Layer 2				
	As' prov	mm²	603	As prov 2413	As' prov 1608
DEFLECTION			L/d 17.70	Allowed 37.23 . .	
SHEAR	Vsd	kN	232.2	**LINK Ø**	267.0
	VRd1	kN	66.8	12	78.5
	VRd2	kN	715.4	**NOMINAL**	708.4
	s req	mm	163	340	141
LINKS			**R12 @ 150 for 1950**	**R12 @ 250**	**R12 @ 125 for 2500**
	legs	No	2	2	2
CHECKS	% As		ok	ok	ok
	Cover		ok	ok	ok
	min S		ok	ok	ok
	max S		ok	ok	ok
	Links		ok	ok	ok
	Main bars		ok	ok	ok
	max V		ok		ok
	Deflection			ok	

SPAN 2

			LEFT	CENTRE	RIGHT
ACTIONS	M	kNm	249.6	139.1	57.5
	δ		0.81	0.96	1.00
DESIGN	d	mm	457.5	457.5	464.0
	As	mm²	1419	748	300
	As'	mm²	74	0	0
TOP STEEL	Layer 1		3 T 25	2 T 25	3 T 12
	Layer 2				
	As prov	mm²	1473	**As' prov** 982	**As prov** 339
BTM STEEL	Layer 1		3 T 12	2 T 25	3 T 12
	Layer 2				
	As' prov	mm²	339	As prov 982	As' prov 339
DEFLECTION			L/d 13.11	Allowed 56.49 . .	
SHEAR	Vsd	kN	219.9	**LINK Ø**	153.7
	VRd1	kN	78.7	10	63.6
	VRd2	kN	711.5	**NOMINAL**	721.6
	s req	mm	132	236	209
LINKS			**R10 @ 125 for 2000**	**R10 @ 225**	**R10 @ 200 for 1000**
	legs	No	2	2	2
CHECKS	% As		ok	ok	ok
	Cover		ok	ok	ok
	min S		ok	ok	ok
	max S		ok	ok	ok
	Links		ok	ok	ok
	Main bars		ok	ok	ok
	max V		ok		ok
	Deflection			ok	

Project & location Spreadsheets to EC2 : Worked Examples: Main beam Grids C to H: to EC2 **SPAN 1**

CONTINUOUS BEAM ANALYSIS & DESIGN to EC2 (DD ENV 1992-1-1 : 1992) Originated from RCCe41.xls on CD

Span	8.00 m	h 500 mm	Top cover	32	mm to main steel	Job No R68
R	beam	bw 300 mm	Btm cover	32	mm to main steel	by rmw
	to EC2	hf 175 mm	Side cover	32	mm to main steel	Date 29-Nov-99
		Ac 150000				

MAIN STEEL			**LEFT**	**.25L**		**SPAN**		**RIGHT**	EC2 Ref
M CL	kNm		128.3	Top steel check				267.6	
M face	kNm		113.1	58.6		323.0		241.8	
δ			0.700	0.700		1.230		0.700	
d	mm		460.0	462.0		452.0		455.5	
bf	mm		300	300		300		300	
x lim	mm		95.7	94.7		202.5		94.7	2.5.3.4.2
x	mm		59.6	29.9		199.4		138.9	4.2.1.3.3
Conc MOR	kNm		175.6	174.9		326.9		172.2	4.2.1.3.3
z	mm		436.2	438.9		372.3		417.6	- = -
d'	mm		40.0	48.0		38.0		48.0	
net fsc	N/mm²		212.0	0.0		416.6		327.2	Fig 4.4
Excess M	kNm		0.0	0.0		0.0		69.6	
As' req	mm²		0	0		0		522	
fst	N/mm²		434.8	434.8		434.8		434.8	Fig 4.4
As req	mm²		596	307		1996		1341	
bt	mm		300	300		300		300	5.4.2.1.1
As min	mm²		207	208		203		205	Equn 5.14
As crack	mm²		245	216		230		245	Equn 4.78
As deflection	mm²					856		0	4.4.3.2
DEFLECTION CHECK									
fs	N/mm²		280.6			135.2		277.5	4.4.3.2 (4)
ρ	%					1.779		1.078	Table 7
Base ratio						23.00		0.00	(NAD)
Mod factor						1.619		0.788	4.4.3.2
Perm L/d						37.2		0.0	- = -
Actual L/d					ok	17.7	ok	0.0	
T NSI N ST									
Re ired	mm²		596			1996		1341	
Ø 1	mm	ok	16		ok	32	ok	25	
Ø 2	mm		0			0		0	
Max No layer			5			3		4	5.4.2.1.1
No 1			3			3		3	
=	mm²		603			2413		1473	
No 2		ok	0		ok	0	ok	0	
s prov	mm²		603			2413		1473	
= %	%	ok	0.402		ok	1.608	ok	0.982	
Clear dist	mm		94.0			70.0		80.5	between bars
Min S	mm	ok	25.0		ok	32.0	ok	25.0	5.2.1.1 (3)
Max S	mm	ok	133.2		ok	299.1	ok	128.1	Table 4.12
PR SSI N ST									
Re ired	mm²		603			307		603	5.4.2.1
Ø 1	mm	ok	16		ok	12	ok	32	
Ø 2	mm		0			0		0	
Max No layer			6			6		3	
No 1			3			3		2	
=	mm²		603			339		1608	
No 2		ok	0		ok	0	ok	0	
s prov	mm²		603			339		1608	
= %	%	ok	0.402		ok	0.226	ok	1.072	
Clear dist	mm		94.0			100.0		172.0	between bars
Min S	mm	ok	20.0		ok	25.0	ok	32.0	5.2.1.1 (3)
SH AR				τRd =		0.35			
Vsd at face	kN		232.2	k =		1		267.0	
ρL			0.437%	ν =		0.54		1.078%	4.3.2.3
VRd1	kN		66.8	Asw/s min =		0.67		78.5	(4.18)
VRd2	kN		715.4			**Nominal**		708.4	(4.19)
Vsd/VRd2			0.325			0.232		0.377	
Vwd	kN		165.4			97.5		188.6	
Asw/s req	mm		1.3896			~~~		1.5998	(4.23)
s req	mm		163			340		141	
s max	mm		276			273		273	(5.17-19)
s crack	mm		200			~~~		200	Table 4.13
Link Ø	mm	ok	12		ok	12	ok	12	
Legs		ok	2		ok	2	ok	2	
@	mm		163			273		141	
Adjust to	mm		150			250		125	
for (UDL only)	mm		2077			~~~		2614	from cl
for (with PL)	mm		2077			~~~		#N/A	- = -
Adjust to	mm		1950			~~~		2500	from face
s trans lim	mm		460.0			452.0		455.5	5.4.2.2 (9)
s trans	mm	ok	248.0		ok	248.0	ok	248.0	

Project & location	Spreadsheets to EC2 : Worked Examples: Main beam Grids C to H: to EC2	SPAN 2
	CONTINUOUS BEAM ANALYSIS & DESIGN to EC2 (DD ENV 1992-1-1 : 1992) Originated from RCCe41.xls on CD	© 1999 BCA for RCC

Span 6.00 m	h 500 mm	Top cover	30	mm to main steel	Job No R68
R beam	bw 300 mm	Btm cover	30	mm to main steel	by rmw
to EC2	hf 175 mm	Side cover	30	mm to main steel	Date 29-Nov-99
	Ac 150000				

MAIN STEEL	Units		LEFT	.25L		SPAN		RIGHT	EC2 Ref
M CL	kNm		267.6	Top steel check				81.3	
M face	kNm		249.6	113.2		139.1		57.5	
δ			0.808	0.8079412		0.964		1.000	
d	mm		457.5	457.5		457.5		464.0	
bf	mm		300.0	300.0		300.0		300.0	
x lim	mm		134.7	134.7		191.7		207.9	2.5.3.4.2
x	mm		143.3	60.0		74.7		29.2	4.2.1.3.3
Conc MOR	kNm		236.6	236.6		317.8		344.5	4.2.1.3.3
z	mm		403.6	433.5		427.6		440.8	- = -
d'	mm		36.0	42.5		42.5		36.0	
net fsc	N/mm²		416.6	185.9		283.8		0.0	Fig 4.4
Excess M	kNm		13.0	0.0		0.0		0.0	
As' req	mm²		74	0		0		0	
fst	N/mm²		434.8	434.8		434.8		434.8	Fig 4.4
As req	mm²		1419	600		748		300	
bt	mm		300	300		300		300	5.4.2.1.1
As min	mm²		206	206		206		209	Equn 5.14
As crack	mm²		245	179		215		245	Equn 4.78
As deflection	mm²		0			195			4.4.3.2
DEFLECTION									
fs	N/mm²		254.3			133.1		131.7	4.4.3.2 (4)
ρ	%		1.073			0.715			Table 7
Base ratio			0.00			30.06			(NAD)
Mod factor			0.983			1.879			4.4.3.2
Perm L/d			0.0			56.5			- = -
Actual L/d		ok	0.0		ok	13.1			
TENSION STEEL									
Required	mm²		1419			748		300	
Ø 1	mm	ok	25		ok	25	ok	12	
Ø 2	mm		0			0		0	
Max No/layer			4			4		6	5.4.2.1.1
No 1			3			2		3	
=	mm²		1473			982		339	
No 2		ok	0		ok	0	ok	0	
As prov	mm²		1473			982		339	
= %	%	ok	0.982		ok	0.654	ok	0.226	
Clear dist	mm		82.5			190.0		102.0	between bars
Min S	mm	ok	25.0		ok	25.0	ok	25.0	5.2.1.1 (3)
Max S	mm	ok	157.1		ok	308.7	ok	323.4	Table 4.12
COMPRESSION STEEL									
Required	mm²		245			600		245	5.4.2.1
Ø 1	mm	ok	12		ok	25	ok	12	
Ø 2	mm		0			0		0	
Max No/layer			7			4		7	
No 1			3			2		3	
=	mm²		339			982		339	
No 2		ok	0		ok	0	ok	0	
As' prov	mm²		339			982		339	
= %	%	ok	0.226		ok	0.654	ok	0.226	
Clear dist	mm		102.0			190.0		102.0	between bars
Min S	mm	ok	20.0		ok	25.0	ok	20.0	5.2.1.1 (3)
SHEAR				τRd =		0.35			
Vsd at face	kN		219.9	k =		1		153.7	
ρL			1.073%	ν =		0.54		0.244%	4.3.2.3
VRd1	kN		78.7	Asw/s min =		0.67		63.6	(4.18)
VRd2	kN		711.5			Nominal		721.6	(4.19)
Vsd/VRd2			0.309			0.200		0.213	
Vwd	kN		141.2			78.7		90.1	
Asw/s req	mm		1.1928			~~~		0.7507	(4.23)
s req	mm		132			236		209	
s max	mm		275			275		278	(5.17-19)
s crack	mm		300			~~~		300	Table 4.13
Link Ø	mm	ok	10		ok	10	ok	10	
Legs		ok	2		ok	2	ok	2	
@	mm		132			236		209	
Adjust to	mm		125			225		200	
for (UDL only)	mm		2178			~~~		1157	from cl
for (with PL)	mm		2178			~~~		#N/A	- = -
Adjust to	mm		2000			~~~		1000	from face
s trans lim	mm		457.5			457.5		464.0	5.4.2.2 (9)
s trans	mm	ok	250.0		ok	250.0	ok	250.0	

The main folders Admin, ByOthers and UserGuid, are provided in order to help the user. The folder hierarchy, together with sub-folders and the spreadsheet files, is shown in the screen dump below.

Admin

Under the Admin folder will be found several folders and files associated with the use of the spreadsheets.

Acrobat folder (and sub-folders)

To read and print from the fully illustrated Userguid.pdf you need to have Adobe Acrobat ® Reader (version 3.0 or above) on your computer. Use Windows Explorer to check your hard disk for a folder called Acrobat.

If Reader is not there, then for Windows 95, 98 and NT install it from the CD-ROM, E:\Admin\Acrobat\PC\32bit\Setup.exe. If E is not your CD-ROM drive, substitute the correct letter. Double click on Setup.exe, the self extracting installer file, which will install the software onto your hard disc.

TheFonts

This folder contains the font files:

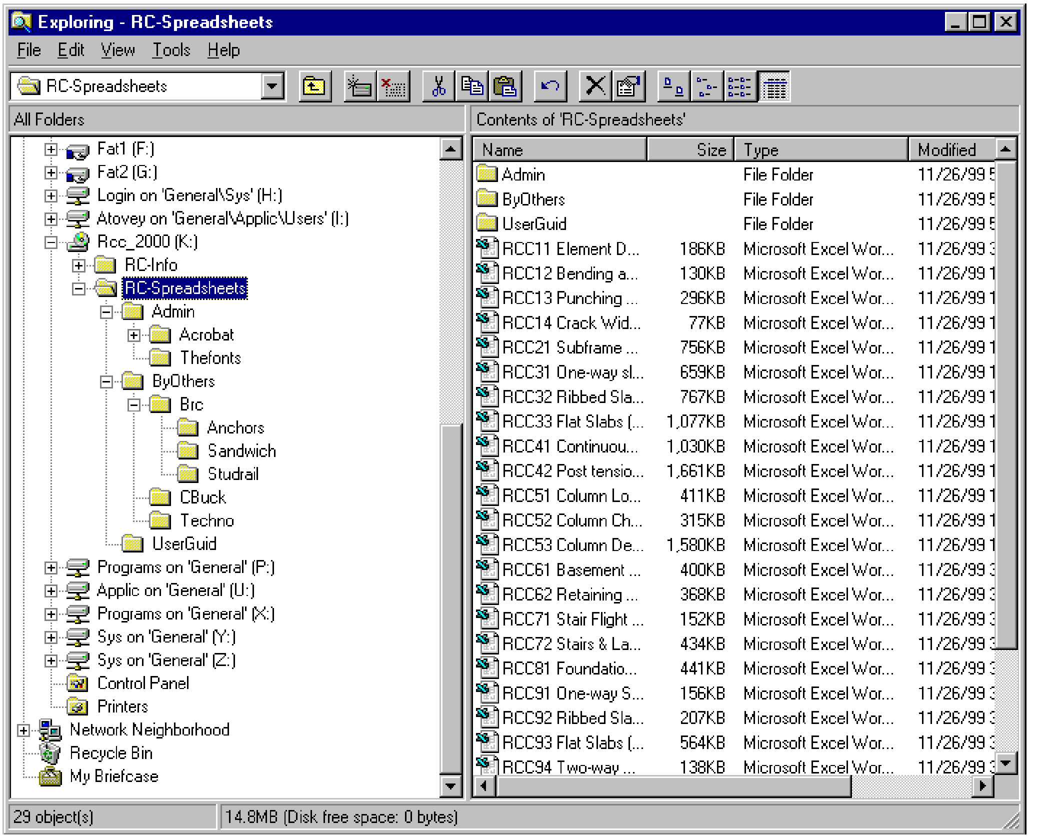
- Tekton~i.ttf
- Tekton~n.ttf
- Marker.ttf

These fonts have been included in order to give users access to the fonts intended for the spreadsheets.

These condensed fonts were used in the spreadsheets in order to emulate a designer's handwriting and to allow an adequate amount of information to be shown across the page and in each cell. As described under *Fonts* in *Using the spreadsheets for the first time* (see page 11), unless the appropriate fonts and default font size have been installed, the appearance on screen will be different from the publication and from that intended. Column width and cell overlap problems may occur unless the correct fonts and default font size are installed.

To the best of our knowledge these fonts are copyright-free.

Screen dump from Windows Explorer



Printreg.xls

This spreadsheet is included to provide:

- A means for finding set-up / printing discrepancies between computers
- An initial check on users' set-ups
- A print-out for registration

A copy is shown on page 155. Its use should be self explanatory.

Readme.doc & Readme.txt

Essential for initial users of the spreadsheets in both Word and text formats.

ByOthers

The BCA and RCC disclaim any responsibility for programs by others. These programs and files are provided to help dissemination. They are subject to the authors' conditions of use.

BRC

This suite of programs is provided by BRC – Concrete Connections, for use in the design of their proprietary lifting anchors, anchors for sandwich panels and Studrail (a punching shear system). The anchor and sandwich panel software was authored by DEHA Ankersysteme, Germany. The Studrail files are joint BRC/DEHA Ankersysteme software. The programs are provided as freeware (i.e. free software). For further information please contact: BRC – Concrete Connections, Mansfield, Tel: 01623 440472, Fax: 01623 559758, email: GaryNice@concrete-connections.co.uk. www.brc-uk.co.uk

Anchors

The program DHT-2E suggests positions and types of anchors for lifting various precast concrete products - slabs, walls, pipes etc. With a graphical interface and output the program should prove easy to use. Some text is in German.

To load the program to your hard disk, use the setup file/ Byothers/ Brc/ Anchors/ Setup.exe. Files will be saved under a folder deha/ on your hard disk drive. To run the program use Windows Explorer and successively double click deha/ dht20e/ DHT-2E.

Sandwich

This program indicates the anchor positions needed to support the outer facing layer of a concrete sandwich wall panel and designs the fixing anchors to suit. The graphical program outputs design calculations and drawings showing the type and position of the fixings required. Start by using Defaults and work through Facing layer to Design.

To run the program direct from the CD-ROM run Byothers/ Brc/ Anchors/ Dehas-e or copy the folder to the hard disk.

Studrail

This program designs Studrail reinforcement for punching shear around a column or pile and prints out the full design calculation and drawings.

To load the program to your hard disk, use the setup file Byothers/ Brc/ Studrail/ Setup.exe – a folder will be created in the directory of your choice. To run the program use Windows Explorer and successively double click Studrail/ Studrail.exe or select the icon "Studrail" in the program menu.

CBuck

This folder contains Barsched.xlt, a spreadsheet template for the scheduling of steel for the reinforcement of concrete to BS 4466: 1989 and Amendment No 1. The aim of the spreadsheet is to reduce the time taken to produce a bar schedule, eliminate arithmetical errors, reduce scheduling errors, increase compliance with the BSI specified format for bar scheduling and perhaps become the basis for electronic data interchange. The spreadsheet presents a familiar interface to the user who has produced schedules by hand and it is simple to use. It will guide the user through the scheduling process while checking the input is in accordance with British Standard requirements.

A complementary template, Shape99.xlt is also provided.

These templates are made available as shareware (see page 13) by their author. For further information, including registration details, corporate customisation etc., e-mail: bar.schedule@newscientist.net. A support web site is available at http://users.newscientist.net/bar.schedule/.

Techno

Pile Loads991112-.xlt is a spreadsheet template to determine distribution of load in piles beneath rigid rafts or pile caps. Loads induced in n-piles beneath m-sided polygon subjected to moments Mxx, Myy and p-number of vertical loads can be calculated.

Co-ordinates from an origin at a convenient point describe the position of each pile node and load. Using the specified thickness and density of the raft or pile cap, the self-weight of the m-sided polygon is calculated by the template itself and included in the analysis.

In order to use this template (see Excel documentation), please copy the file to:

C:\Program Files\ Microsoft Office\ Template

To use the program, start Excel 97 and choose:

File/ New and Select PileLoads991112-.xlt

With care, the file may also be used as if it were a normal .xls file.

The spreadsheet includes three examples having 2, 3 and 4 plies. To add a node, load or pile, click the apprpriate *Add* button at the top of the sheet. To delete a node, load or pile, position the cursor in any cell in its row and then click the appropriate *Delete* button. To include additional pile caps for analysis, click *Add Sheet* button at top of the screen.

Shaded cells in the input and output mean that they are *user input* and the unshaded cells are *spreadsheet results.* For further details refer to Notes! within the spreadsheet. Pile Loads991112-.xlt is made available as shareware. For further information, including registration details and disclaimers, refer to Terms! within the spreadsheet.

UserGuid

UserGuid.doc: 'Word' file of User Guide

This file formed the basis of the printed User Guide. It may be loaded, read and printed out by using Word 97 or subsequent releases. While it has been superceded by thr .pdf file, it is included to provide help to allow parts of the document to be printed or for use as a basis for comment.

UserGuid.pdf: 'Adobe Acrobat' file of the User Guide

This file presents the User Guide in full colour. Adobe Acrobat Reader v 3.0 or later will be required to read and interrogate the .pdf file. Acrobat Reader is available on the CD-ROM (see above). The file has been included to provide help and to allow colour printing of parts of the document.

To **RCC**

fax to 01344 761214 or
send to RCC, Telford Avenue, Crowthorne, Berkshire, RG45 6YS

from **A B See , N G Neer & Partners** **Date 26-Nov-99**

re **Spreadsheets to BS8110 & EC2: formatting, registration etc** **1 of 1**

Dear User,

This spreadsheet has been included for three main reasons:

1 a means for finding set-up / printing discrepancies
2 an initial check on users' set-ups -
3 a printout for registration -

Please check one of the boxes above and complete the information below by overwriting blue text as far as you are able. Please do not change anything else. In the case of 1 or 2 above, compare with printed version in accompanying User Guide and in the case of difficulty print and fax a copy. In the case of 3, registration, please print out and send this completed form with your remittance.

many thanks

C H Goodchild
11-Nov-99

Your name	**A B See**
Company	**N G Neer & Partners**
Address	Address 1
	Address 2
	Town
	County
	(If not UK, Country &) Postcode
Phone	eg 01344 762676
Fax	eg 01344 761214
E-mail	eg ngneer@home.co.uk
Nature of business	eg Consulting Engineers
No of employees	eg 12
Your computer	eg Dell Optiplex GXi
Monitor	eg Samsung 17GL
Printer	eg HP Laserjet II
If registering, remittance enclosed.	eg £58.75 (=£50.00 + VAT)

In Excel, default font name	eg Arial	The name of the font in cell N21 or default (see Tools\ Options \General,) if different please. Font name and size (from left hand side of Formatting toolbar)
In Excel, default font size	eg 12	
Fonts		
Is this Arial?	Arial	Check in font box in Formatting Toolbar (View /Toolbars /Formatting). If not load these fonts into your font directory (Usually C\Windows\Fonts)
Is this Tekton?	Tekton	
Is this Tekton italic?	*Tekton*	
Is this Marker?	**Marker**	
Excel release		
8.0e	8.0a	If <8.0a users may experience difficulties
Operating System		
Windows (32-bit) NT 4.00	Windows (32-bit) 4.00	
Recalculation mode		If not automatic see Tools\ Options\ Calculation
Automatic	Automatic	
Test	#ABCabc¶5678	

Make cheques payable to 'BCA'. Send together with a copy of this printout to RCC, Telford Avenue, Crowthorne, Berkshire, RG45 6YS

Registration includes acceptance of the 'Conditions of Use' as defined in the User Guide Spreadsheets for concrete design to BS 8110 and EC2

References

1 Goodchild, C.H. *Economic concrete frame elements*. British Cement Association, Crowthorne, 1997. 128 pp.

2 BRITISH STANDARDS INSTITUTION. BS 8110: 1997. *Structural use of concrete. Part 1. Code of practice for design and construction*. British Standards Institution, London, 1997.

3 BRITISH STANDARDS INSTITUTION. DD ENV 1992-1-1: 1992. *Eurocode 2: Design of concrete structures. Part 1: General rules and rules for buildings*. Includes the UK National Application Document. British Standards Institution, London, 1992.

4 BRITISH STANDARDS INSTITUTION. BS 8002: 1994. *Code of practice for earth retaining structures*. British Standards Institution, London, 1994.

5 BRITISH STANDARDS INSTITUTION. BS 8007: 1987. *Code of practice for design of concrete structures for retaining aqueous liquids*. British Standards Institution, London, 1987.

6 INSTITUTION OF STRUCTURAL ENGINEERS ET AL. *Earth retaining structures*. (Civil Engineering Code of Practice No. 2.) Institution of Structural Engineers, London, 1975. 224 pp.

7 MACLEOD, I.A. ET AL. Information technology for the structural engineer. *The Structural Engineer*, Vol. 77, No.3, 2 February 1999. pp. 23 - 25.

8 STANDING COMMITTEE ON STRUCTURAL SAFETY. *Standing Committee on Structural Safety, 10th report, July 1992 – June 1994*. SETO Ltd, London, 1994. 32 pp.

9 ANSLEY, M. Liability concerns require adaptable software. *Concrete International*, Vol. 19, No. 12, December 1997. pp. 37, 38.

10 KHAN, S. Techno Consultants Ltd, Manchester. Correspondence with authors, May 1999.

11 MOSLEY, W.H. & BUNGEY, J.H. *Reinforced concrete design* (4th edition). Macmillan, Basingstoke, 1990. 392 pp.

12 REYNOLDS, C.E. & STEEDMAN, J.C. *Reinforced concrete designer's handbook* (10th edition). E&FN Spon, London, 1998. 448 pp.

13 ALLEN, A.H. *Reinforced concrete design to BS 8110 simply explained*. E&FN Spon, London, 1988. 256 pp.

14 THE CONCRETE SOCIETY. *Post-tensioned concrete floors – Design Handbook,* Technical Report No 43. The Concrete Society, Slough (now Crowthorne), 1994. 162 pp.

15 HIGGINS, J.B. & ROGERS, B.R. *Designed and detailed (BS 8110:1997)*. British Cement Association Crowthorne, 1998. 28 pp.

16 KHAN, S. & WILLIAMS, M. *Post-tensioned concrete floors*. Butterworth Heinnemann, Oxford, 1995. 312 pp.

17 CEMENT AND CONCRETE ASSOCIATION. *Basic data for the prediction of shrinkage and creep*. Training note TDH 2391. Cement and Concrete Association (now British Cement Association), Slough (now Crowthorne), 11 pp.

18 WYATT, T A. *Design guide on the vibration of floors*. Pub. No. 076, Steel Construction Institute, Ascot, 1989. 43 pp.

19 BRITISH STANDARDS INSTITUTION. BS 6399: Part 1: 1996. *Loading for buildings. Code of practice for dead and imposed loads.* British Standards Institution, London, 1996.

20 BRITISH STANDARDS INSTITUTION. CP 110: 1972. *Code of practice for the structural use of concrete*. British Standards Institution, London, 1972.

21 BRITISH STANDARDS INSTITUTION. *BS 5400: 1988. Steel, concrete and composite bridges*. British Standards Institution, London, 1988.

22 RAFIQ, M.Y. AND SOUTHCOMBE, C. Genetic algorithms in optimal design and detailing of reinforced concrete biaxial columns supported by a declarative approach for capacity checking. *International Journal of Computers and Structures*, 69 (1998), pp 443 - 457.

23 BRITISH STANDARDS INSTITUTION. BS 8004: 1986. *Code of practice for foundations*. British Standards Institution, London, 1986.

24 NARAYANAN, R S. Comparison of design requirements in EC2 and BS 8110. *The Structural Engineer*, Vol. 67, No 11, 6 June 1989, pp. 218 - 227.

25 BEEBY, A.W. ET AL. *Worked examples for the design of concrete buildings.* British Cement Association, Crowthorne, 1994. 256 pp.

26 BEEBY, A.W. & NARAYANAN, R.S. *Designers handbook to Eurocode 2 Part 1.1: Design of concrete structures*. Thomas Telford Ltd, London, 1994. 242 pp.

Further reading

1 INSTITUTION OF STRUCTURAL ENGINEERS; INSTITUTION OF CIVIL ENGINEERS. *Manual for the design of reinforced concrete building structures*. London, ISE, London, 1985. 88 pp.

2 REYNOLDS, C.E. & STEEDMAN, J.C. *Examples of the design of reinforced concrete buildings to BS 8110* (4th edition). E&FN Spon, London, 1992. 320 pp.

3 MOSLEY, W.H. Et Al. *Reinforced concrete design to Eurocode 2 (EC2)*. Macmillan, London, 1996. 426 pp.

SYMBOLS

Please note that definitions relating to retaining and basement walls and many of those relating to post-tensioned design are contained within the relevant spreadsheets.

Abbre-viation	Unit	Explanation
(B or S)		Beam or slab (re PT)
(L, R, B)		Stressing ends left, right and bottom (re PT)
(B, U)		Prestressing system bonded or unbonded (re PT)
~		Not applicable/ no result
~~ or ~~~~~		No input required
µ		Coefficient of friction
A_c	mm²	Area of concrete section
a_{cr}	mm	Distance from point considered to nearest longitudinal bar (Crack widths: usually from surface half way etween bars to bar)
A_p	mm²	Area of prestressing strand/tendon
A_s	mm²	Area of (tension) steel
$A_{s'}$	mm²	Area of compression steel
$A_{s\ min}$	mm²	Minimum area of steel required
$A_{s\ prov}$	mm²	Area of steel provided
$A_{s\ req'd}$	mm²	Area of steel required
A_{sv}	mm²	Area of shear reinforcement
b	mm	Width, effective width, breadth (in RCC51.xls both or two-way spanning)
b_f	mm	Breadth of flange
B, Btm		Bottom
b_e	mm	Breadth of effective moment strip
b_v	mm	Breadth of section
b_w beam	mm	Average web width of a flanged
char		Characteristic (load)
Cl		Centreline (of support)
CO	mm	Cover (crack widths)
Comp		Compression
d	mm	Effective depth
d'	mm	Depth to compression reinforcement
d_c	mm	Depth of compression zone (column design)
Def		Deflection
Dia		Diameter
E/O		Extra over
E_{c28}	N/mm²	Modulus of elasticity of concrete (at 28 days)
E_{ci}	N/mm²	Modulus of elasticity of concrete at initial stressing (re PT)
E_p	N/mm²	Modulus of elasticity of prestressing strand/tendon (re PT)
e	mm	Eccentricity
e_{min}	mm	Minimum eccentricity
F	kN	total design ultimate load on the full width of panel
f_{ci}	N/mm²	Characteristic concrete strength at initial stressing (re PT)
f_{ck}	N/mm²	Characteristic concrete cylinder strength (EC2)
f_{cu}	N/mm²	Characteristic concrete strength
FEM		Fixed end moment
f_s	N/mm²	(Estimated in-) service stress of reinforcement in a section
f_{sc}	N/mm²	(In-) service stress of reinforcement in a section: compression
f_{st}	N/mm²	(In-) service stress of reinforcement in a section: tension
fy	N/mm²	Characteristic steel strength (bending reinforcement)
f_{yv}	N/mm²	Characteristic steel strength (link reinforcement)
G_k	kN	Characteristic dead load
g_k	kN	Characteristic dead load per unit area
h, H	mm	Height
h_c	mm	Effective diameter of column (design of flat slabs)
h_f	mm	Thickness of flange
h_f	mm	Height of flange
K		M/bd^2f_{cu} - used to determine whether compression reinforcement is required or not
K		Wobble factor (re PT)
K'		Factor determining whether compression reinforcement is required
L	m, mm	Span
L/d		Span:depth
l_x	m, mm	Length along x axis, length of shorter side (two-way slab panel or flat slab panel)
L_x	m, mm	Span in x direction
l_y	m, mm	Length along y axis, length of longer side (two-way slab panel or flat slab panel)
MOR	kNm	Moment of resistance
M(e) all	kNm	Elastic moment all spans loaded

M(r) even	kNm	Redistributed moment even spans loaded
Moment, M	kNm	Design ultimate moment at a section
M_{add}	kNm	Additional design ultimate moment induced by deflection of column
M_{min}	kNm	Moment due to axial load acting at minimum eccentricity
M_{res}	kNm	Moment of resistance
M_s	kNm	Service moment (crack widths)
m_{sx}	kNm/m	Maximum design ultimate moments in span or at support in strips of unit width and length l_x. Likewise m_{sy}
M_t	kNm	Design moment transferred between slab and column
M_x	kNm	Design moment about x - x axis
N	kN	Design ultimate axial load
n	kN/m²	Total design ultimate load per unit area
n. a.		Neutral axis
n/a		Not applicable
No		Number
f	mm	Bar diameter, maximum bar diameter
o/a		Overall
Perim		Perimeter
PL		Point load
PT		Post tensioned (concrete)
Q_k	kN	Characteristic imposed load
q_k	kN	Characteristic imposed load per unit area
R		Grade 250 reinforcement, mild steel
R/H	%	Relative Humidity (re PT)
Rel%	%	Relaxation (re PT)
s	mm	Spacing (of links or bars)
SLS		Serviceability limit state
s_v	mm	Spacing of links
T		Top, Grade 460 reinforcement
Tens		Tension
UDL		Uniformly distributed load
ULS		Ultimate limit state
ult		Ultimate
uno		Unless noted otherwise
V	kN	Design ultimate shear force
v	N/mm²	Shear stress at a section
v_c	N/mm²	(Allowable) design shear stress
v_c'	N/mm²	(Allowable) design shear stress corrected for axial load (e.g. column design)
V_{eff}	kN	Design effective shear including allowance for moment transfer (flat slabs, punching shear)

V_{Rd1}	kN	Maximum design shear force **without** reinforcement (EC2)
V_{Rd1}	kN	Maximum design shear force **with** reinforcement (EC2)
V_{Sd}	kN	Design shear (EC2)
v_{sx}	kNm/m	Maximum design shear in strips of unit width and length lx
V_t	kN	Design ultimate shear transferred to column (flat slabs, punching shear)
w	mm	Crack width
W/C ratio		Water:cement ratio (re PT)
W_k	kN	Characteristic wind load
w_k	kN	Characteristic wind load per unit area
x	mm	Depth to neutral axis
x or y		Spanning parallel to x or y
Y/N		Yes/ no
z	mm	Lever arm
a		Modular ratio (usually E_s/E_c, approximately 15)
b_b		Redistribution factor - the ratio: (moment at a section after redistribution / moment at the section before redistribution)
e		Strain
g_m		Average strain (crack widths)
g_c		Partial safety factor for strength of material: concrete
g_m		Partial safety factor for strength of material. (See relevant Code)
g_s		Partial safety factor for strength of material: steel
r		Proportion of steel reinforcement
s_c	N/mm²	Allowable compressive (long term) stress in concrete (re PT)
s_{ic}	N/mm²	Allowable compressive stress in concrete at initial stressing (re PT)
s_{it}	N/mm²	Allowable tensile stress in concrete at initial stressing: (re PT)
s_t	N/mm²	Allowable (long term) tensile stress in concrete (re PT)
t_{Rd}	N/mm²	Basic shear strength (EC2)
Y_2		Quasi-permanent load factor applied to imposed loads in calculations of deflection (EC2)
z	%	Damping, (usually 2% to 8%) (re PT)
m		Coefficient of friction
m_{lim}		Limiting value of applied moment ratio for singly reinforced sections (ENV EC2)

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