

# How to use Concept version 4: Cost and Carbon

The Concept spreadsheet compares conceptual designs to Eurocode 2 for 13 forms of reinforced concrete construction, then ranks them in order of cost, programme or embodied carbon. It is intended to be used for selecting the most appropriate scheme for an RC frame, and as a “first stab” at determining member sizes. Final working designs should be carried out via conventional means, such as by using The Concrete Centre’s RC Spreadsheets.

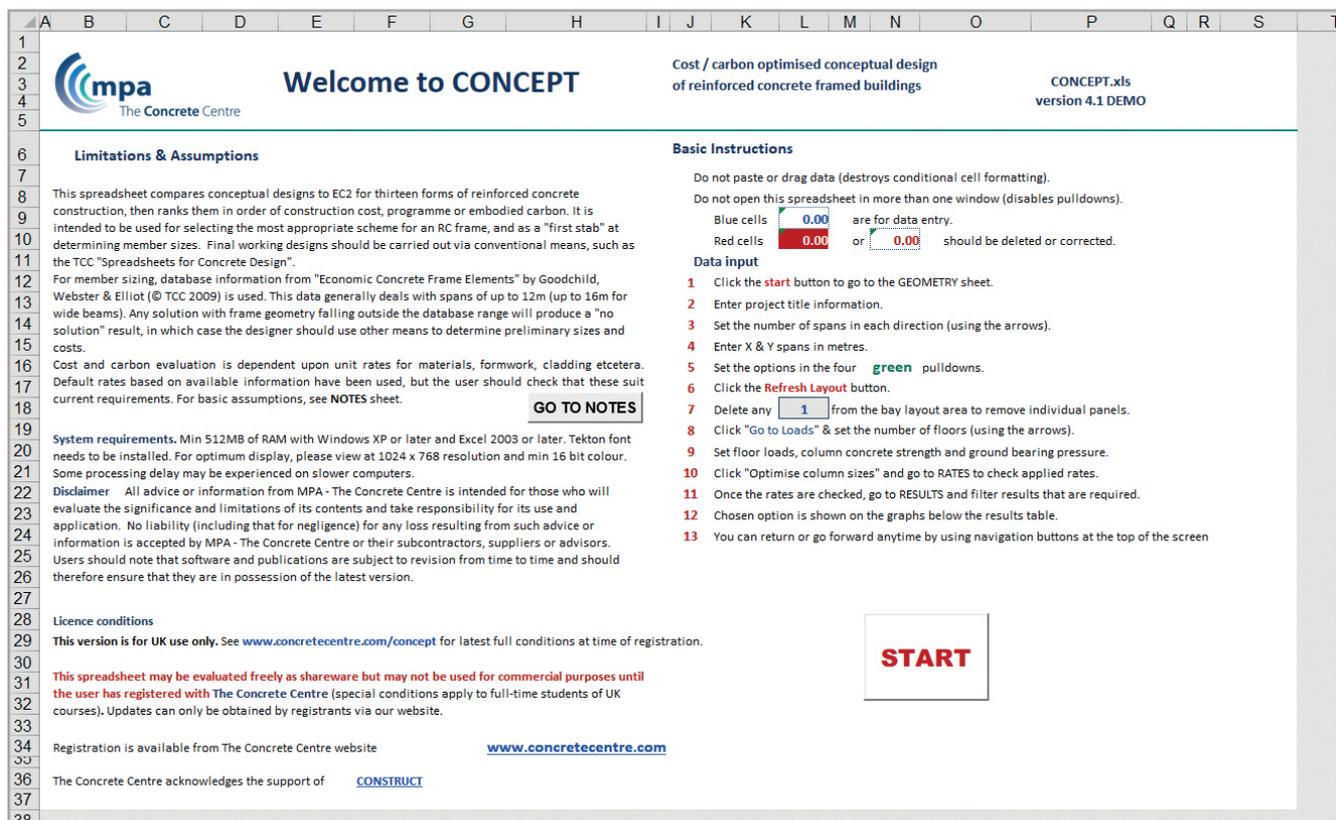
For member sizing, database information from *Economic Concrete Frame Elements*, published by The Concrete Centre, is used. This data generally deals with spans of up to 12m (up to 16m for wide beams). Any solution with frame geometry falling outside the database range will produce a “no solution” result, in which case the designer should use other means to determine preliminary sizes and costs.

Cost and carbon evaluation is dependent upon unit rates for materials, formwork, cladding etc. Default rates based on available information have been used, but the user should check that these suit current requirements. For basic assumptions, see NOTES sheet.

This document provides guidance on how to use the Concept software, with screen shots to indicate the information generated from each stage of the process. The software itself can be downloaded from [www.concretecentre.com/concept](http://www.concretecentre.com/concept).

## Key screens and how to use Getting started

Open the .xls file using Microsoft Excel to view the 'Welcome' page and 'Enable content' when prompted - this will enable macros, which are required to run the tool. The welcome page gives an overview of how to use the software and assumptions and limitations of the spreadsheet. Users should note that cells with blue text are for data entry and cells with red text or with a red background indicate values to be deleted or corrected. It is important that cells are not copied and pasted as this may cause errors. From the welcome page, click 'START' to start entering the building geometry.



**Welcome to CONCEPT**  
Cost / carbon optimised conceptual design of reinforced concrete framed buildings  
CONCEPT.xls version 4.1 DEMO

**Limitations & Assumptions**

This spreadsheet compares conceptual designs to EC2 for thirteen forms of reinforced concrete construction, then ranks them in order of construction cost, programme or embodied carbon. It is intended to be used for selecting the most appropriate scheme for an RC frame, and as a “first stab” at determining member sizes. Final working designs should be carried out via conventional means, such as the TCC “Spreadsheets for Concrete Design”.

For member sizing, database information from “Economic Concrete Frame Elements” by Goodchild, Webster & Elliot (© TCC 2009) is used. This data generally deals with spans of up to 12m (up to 16m for wide beams). Any solution with frame geometry falling outside the database range will produce a “no solution” result, in which case the designer should use other means to determine preliminary sizes and costs.

Cost and carbon evaluation is dependent upon unit rates for materials, formwork, cladding etcetera. Default rates based on available information have been used, but the user should check that these suit current requirements. For basic assumptions, see NOTES sheet.

**GO TO NOTES**

**System requirements.** Min 512MB of RAM with Windows XP or later and Excel 2003 or later. Tekton font needs to be installed. For optimum display, please view at 1024 x 768 resolution and min 16 bit colour. Some processing delay may be experienced on slower computers.

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**Licence conditions**  
This version is for UK use only. See [www.concretecentre.com/concept](http://www.concretecentre.com/concept) for latest full conditions at time of registration.

This spreadsheet may be evaluated freely as shareware but may not be used for commercial purposes until the user has registered with The Concrete Centre (special conditions apply to full-time students of UK courses). Updates can only be obtained by registrants via our website.

Registration is available from The Concrete Centre website [www.concretecentre.com](http://www.concretecentre.com)

The Concrete Centre acknowledges the support of [CONSTRUCT](#)

**Basic Instructions**

Do not paste or drag data (destroys conditional cell formatting).  
Do not open this spreadsheet in more than one window (disables pull-downs).

Blue cells  are for data entry.  
Red cells  or  should be deleted or corrected.

**Data input**

- Click the **start** button to go to the GEOMETRY sheet.
- Enter project title information.
- Set the number of spans in each direction (using the arrows).
- Enter X & Y spans in metres.
- Set the options in the four **green** pull-downs.
- Click the **Refresh Layout** button.
- Delete any  from the bay layout area to remove individual panels.
- Click “Go to Loads” & set the number of floors (using the arrows).
- Set floor loads, column concrete strength and ground bearing pressure.
- Click “Optimise column sizes” and go to RATES to check applied rates.
- Once the rates are checked, go to RESULTS and filter results that are required.
- Chosen option is shown on the graphs below the results table.
- You can return or go forward anytime by using navigation buttons at the top of the screen

**START**

## Building geometry

The tabs at the top of the spreadsheet can be used to navigate through the spreadsheet.

Start by setting the number of bays in each direction using arrows, then define the span lengths for each bay.

Then define the storey heights – either clear height (floor to ceiling) or floor to floor. There are also options for wide beam solutions (measuring height to slab or beam soffit) and ribbed slabs (equalised or unequalised beam and rib depths). You can also choose square or rectangular edge columns.

You can add and remove panels (for example if you had an L-shaped building or a central atrium) by deleting or adding "1" to the relevant cell in the matrix below the Bay Layout diagram.

**CONCEPT Geometry**

PROJECT: New Building  
CLIENT: Client  
DATE: 01/08/20  
Project No.: 1000

CONCEPT.xls  
version 4.1 DEMO

**Geometry** | Loads | Rates | Results | Cost | Member sizes | View plan | View sections | 3D view

SET NUMBER OF BAYS  
Bays in X direction: 5 (USE ARROWS) | Span (m): 1 | max 16m X from left: 7.500 7.500 7.500 7.500 7.000  
Bays in Y direction: 4 (USE ARROWS) | max 16m Y from top: 7.500 7.500 7.500 7.500

STOREY HEIGHTS  
Storey heights are: Floor to Ceiling -  
For Wide Beam solutions: Clear height is to: Beam soffit -  
For Ribbed Slab solutions: Wide beam & slab depths: Do not equalise -  
Edge Columns: Square -  
SET STOREY HEIGHTS: 3.70 metres

Floor-floor height = 3.7 m plus slab & beam depth.

THE NUMBER OF FLOORS WILL BE SET ON THE NEXT SHEET

**CLICK Refresh Layout**

TO REMOVE A PANEL delete 1 in the matrix on the right or enter 1 to reinstate

Do not paste or drag cells

**GO TO LOADS**

Gross area: 1,137 m<sup>2</sup>/floor

MATRIX SHOWING LOCATION OF BAYS

|   |   |   |   |   |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |

To retrieve data, open data file in normal way and click LOAD button within the data file (DO NOT change this filename)

# HOW TO USE CONCEPT VERSION 4: COST AND CARBON

**CONCEPT Geometry**

PROJECT: New Building  
CLIENT: Client  
DATE: 01/08/20  
Project No.: 1000

CONCEPT.xls version 4.1 DEMO

**Geometry** | Loads | Rates | Results | Cost | Member sizes | View plan | View sections | 3D view

SET NUMBER OF BAYS  
Bays in X direction: 6  
Bays in Y direction: 6

USE ARROWS

Span (m) 1  
max 16m X from left: 6.000  
max 16m Y from top: 6.000

6.000 6.000 6.000 6.000 6.000

6.000 6.000 6.000 6.000 6.000

STOREY HEIGHTS  
Storey heights are: Floor to Ceiling  
For Wide Beam solutions: Clear height is to: Beam soffit  
For Ribbed Slab solutions: Wide beam & slab depths: Do not equalise

SET STOREY HEIGHTS: 3.70 metres

Floor-floor height = 3.7 m plus slab & beam depth.

THE NUMBER OF FLOORS WILL BE SET ON THE NEXT SHEET

**CLICK Refresh Layout**

TO REMOVE A PANEL delete 1 in the matrix on the right or enter 1 to reinstate

Do not paste or drag cells

**GO TO LOADS**

To retrieve data, open data file in normal way and click LOAD button within the data file (DO NOT change this filename)

Gross area 1,190 m<sup>2</sup>/floor

MATRIX SHOWING LOCATION OF BAYS

|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 |

BAY LAYOUT

Once geometry has been entered, click 'Refresh Layout' and the image showing the bay layout will update. If you decide to make further changes, click 'Refresh Layout' again. Once you are happy with the geometry, click 'GO TO LOADS'.

**CONCEPT Geometry**

PROJECT: New Building  
CLIENT: Client  
DATE: 01/08/20  
Project No.: 1000

CONCEPT.xls version 4.1 DEMO

**Geometry** | Loads | Rates | Results | Cost | Member sizes | View plan | View sections | 3D view

SET NUMBER OF BAYS  
Bays in X direction: 4  
Bays in Y direction: 4

USE ARROWS

Span (m) 1  
max 16m X from left: 7.500  
max 16m Y from top: 7.500

7.500 7.500 7.500 7.500

7.500 7.500 7.500 7.500

STOREY HEIGHTS  
Storey heights are: Floor to Ceiling  
For Wide Beam solutions: Clear height is to: Beam soffit  
For Ribbed Slab solutions: Wide beam & slab depths: Do not equalise

SET STOREY HEIGHTS: 3.70 metres

Floor-floor height = 3.7 m plus slab & beam depth.

THE NUMBER OF FLOORS WILL BE SET ON THE NEXT SHEET

**CLICK Refresh Layout**

TO REMOVE A PANEL delete 1 in the matrix on the right or enter 1 to reinstate

Do not paste or drag cells

**GO TO LOADS**

To retrieve data, open data file in normal way and click LOAD button within the data file (DO NOT change this filename)

Gross area 699 m<sup>2</sup>/floor

MATRIX SHOWING LOCATION OF BAYS

|   |   |   |   |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 |

BAY LAYOUT

## Loading

On the loading page, first set the number of storeys using the arrows. Note that level 1 is the first suspended slab above ground floor.

Then set the material properties – the concrete strength for slabs and beams is a fixed value but the column strength may be increased. You can also input the ground bearing pressure if this is known – alternatively leave this as the default value.

Next input floor loading and then use the button below to copy the loading at level 1 to all levels - be careful not to copy and paste or drag cells as this will affect the running of the spreadsheet. You can then modify individual floor loading as required, for example roof loading.

Typical loads are provided for different buildings types within Concept – these loads are for information only and loading should be agreed with the client for each project.

Then 'CLICK to optimise': Once complete, click 'GO TO RESULTS'.

You can also go to the rates page from here if you want to alter the default values.

**CONCEPT**  
The Concrete Centre **Loads** (GBP & column  $f_{ck}$ )

PROJECT: New Building  
CLIENT: Client  
DATE / No.: 01 August 2020

CONCEPT.xls  
version 4.1 DEMO

1000

Geometr | **Loads** | Rates | Results | Cost | Member sizes | View plan | View sections | 3D view

Level 1 is first suspended floor above ground

|         | Superimposed      | Imposed (Live Load) | Edge        |
|---------|-------------------|---------------------|-------------|
|         | Dead UDL $kN/m^2$ | UDL $kN/m^2$        | Load $kN/m$ |
| Level 1 | 0.85              | 2.50                | 6.00        |
| Level 2 | 0.85              | 2.50                | 6.00        |
| Level 3 | 0.85              | 2.50                | 6.00        |
| Level 4 | 0.85              | 2.50                | 6.00        |
| Level 5 | 0.85              | 2.50                | 6.00        |
| Level 6 | 0.85              | 2.50                | 6.00        |

**SET NUMBER OF FLOORS**  
6 max 15

**MATERIAL PROPERTIES**  
Characteristic concrete strength for slabs and beams  
fck fixed value 30 MPa

Characteristic concrete strength for columns  
fck 30 MPa

Ground Bearing Pressure  
set 150 kPa

**CLICK to optimise**

Copy level 1 loads to all levels  
Do not paste or drag cells

**BACK TO GEOMETRY** | **GO TO RATES** | **RESULTS**

## Rates

The rates page includes information on unit costs, embodied carbon per cubic metre and programme data. Recommended values are provided – these are based on information from industry and are the default values within the spreadsheet. Users can input their own values based on information available from the project team such as the contractor or quantity surveyor.

The embodied carbon values can be changed depending on the proposed concrete specification. The recommended values given are based on a concrete using CEMIIIB cement. This is typical in the industry for designated concretes, but the values are very dependent on the specification of the concrete. CEMIIIA and CEMIIIB cements will give significantly lower results for embodied concrete, but may affect setting times.

| EMBEDDED CARBON VALUES                    |  |  |   |  |  |   |
|---|--|--|---|--|--|---|
| Concrete density:                         |  | 2,400 kg/m <sup>3</sup>                |   |  |  |   |
| Steel density:                            |  | 7,850 kg/m <sup>3</sup>                |   |  |  |   |
| EMBEDDED CARBON VALUES - 'cradle-to-gate' |  |  | VALUES RECOMMENDED BY TCC               |  |  |   |
| Material                                  | A1-A3                                    | A1-A3                                  | Material                                | A1-A3                                    | A1-A3                                  |   |
| <b>Concrete</b>                           |  |  |   |  |  |   |
| C30/37                                    | 230 kgCO <sub>2e</sub> /m <sup>3</sup>   | 96 kgCO <sub>2e</sub> /t               | C30/37                                  | 230 kgCO <sub>2e</sub> /m <sup>3</sup>   | 96 kgCO <sub>2e</sub> /t               |   |
| C32/40                                    | 240 kgCO <sub>2e</sub> /m <sup>3</sup>   | 100 kgCO <sub>2e</sub> /t              | C32/40                                  | 240 kgCO <sub>2e</sub> /m <sup>3</sup>   | 100 kgCO <sub>2e</sub> /t              |   |
| C35/45                                    | 250 kgCO <sub>2e</sub> /m <sup>3</sup>   | 104 kgCO <sub>2e</sub> /t              | C35/45                                  | 250 kgCO <sub>2e</sub> /m <sup>3</sup>   | 104 kgCO <sub>2e</sub> /t              |   |
| C40/50                                    | 260 kgCO <sub>2e</sub> /m <sup>3</sup>   | 108 kgCO <sub>2e</sub> /t              | C40/50                                  | 260 kgCO <sub>2e</sub> /m <sup>3</sup>   | 108 kgCO <sub>2e</sub> /t              |   |
| C45/55                                    | 270 kgCO <sub>2e</sub> /m <sup>3</sup>   | 113 kgCO <sub>2e</sub> /t              | C45/55                                  | 270 kgCO <sub>2e</sub> /m <sup>3</sup>   | 113 kgCO <sub>2e</sub> /t              |   |
| C50/60                                    | 280 kgCO <sub>2e</sub> /m <sup>3</sup>   | 117 kgCO <sub>2e</sub> /t              | C50/60                                  | 280 kgCO <sub>2e</sub> /m <sup>3</sup>   | 117 kgCO <sub>2e</sub> /t              |   |
| <b>Hollowcore</b>                         |  |  |   |  |  |   |
| 150                                       | 50 kgCO <sub>2e</sub> /m <sup>2</sup>    | 335 kgCO <sub>2e</sub> /m <sup>3</sup> | 150                                     | 50 kgCO <sub>2e</sub> /m <sup>2</sup>    | 335 kgCO <sub>2e</sub> /m <sup>3</sup> | EPO (for 150mm, 200, 450mm – recalculated according to UK Precast Concrete Hollowcore Flooring) ( <a href="http://bit.ly/2GSX6Ct">http://bit.ly/2GSX6Ct</a> ) |
| 200                                       | 57 kgCO <sub>2e</sub> /m <sup>2</sup>    | 285 kgCO <sub>2e</sub> /m <sup>3</sup> | 200                                     | 57 kgCO <sub>2e</sub> /m <sup>2</sup>    | 285 kgCO <sub>2e</sub> /m <sup>3</sup> |   |
| 250                                       | 65 kgCO <sub>2e</sub> /m <sup>2</sup>    | 261 kgCO <sub>2e</sub> /m <sup>3</sup> | 250                                     | 65 kgCO <sub>2e</sub> /m <sup>2</sup>    | 261 kgCO <sub>2e</sub> /m <sup>3</sup> |   |
| 300                                       | 75 kgCO <sub>2e</sub> /m <sup>2</sup>    | 251 kgCO <sub>2e</sub> /m <sup>3</sup> | 300                                     | 75 kgCO <sub>2e</sub> /m <sup>2</sup>    | 251 kgCO <sub>2e</sub> /m <sup>3</sup> |   |
| 350                                       | 85 kgCO <sub>2e</sub> /m <sup>2</sup>    | 244 kgCO <sub>2e</sub> /m <sup>3</sup> | 350                                     | 85 kgCO <sub>2e</sub> /m <sup>2</sup>    | 244 kgCO <sub>2e</sub> /m <sup>3</sup> |   |
| 400                                       | 95 kgCO <sub>2e</sub> /m <sup>2</sup>    | 238 kgCO <sub>2e</sub> /m <sup>3</sup> | 400                                     | 95 kgCO <sub>2e</sub> /m <sup>2</sup>    | 238 kgCO <sub>2e</sub> /m <sup>3</sup> |   |
| 450                                       | 105 kgCO <sub>2e</sub> /m <sup>2</sup>   | 234 kgCO <sub>2e</sub> /m <sup>3</sup> | 450                                     | 105 kgCO <sub>2e</sub> /m <sup>2</sup>   | 234 kgCO <sub>2e</sub> /m <sup>3</sup> |   |
| <b>Reinforcement</b>                      |  |  |   |  |  |   |
| f <sub>yk</sub> = 500 N/mm <sup>2</sup>   | 5,103 kgCO <sub>2e</sub> /m <sup>3</sup> | 650 kgCO <sub>2e</sub> /t              | f <sub>yk</sub> = 500 N/mm <sup>2</sup> | 5,103 kgCO <sub>2e</sub> /m <sup>3</sup> | 650 kgCO <sub>2e</sub> /t              |   |
| <b>Tendons</b>                            |  |  |   |  |  |   |
| f <sub>yk</sub> = 1860 Mpa                | 7,850 kgCO <sub>2e</sub> /m <sup>3</sup> | 1,000 kgCO <sub>2e</sub> /t            | f <sub>yk</sub> = 1860 Mpa              | 7,850 kgCO <sub>2e</sub> /m <sup>3</sup> | 1,000 kgCO <sub>2e</sub> /t            |   |

## Results

When you reach the results page – first check if there are any actions. If there are, you can click the buttons below to go back to the relevant pages and address them.

Below the table there are notes explaining what each parameter is based on and which elements are included.

At the top of the table, you can click to rank the options based on different parameters – cost, programme and embodied carbon – this will then sort the schemes based on this parameter – a traffic light systems shows you how the different parameters compare.

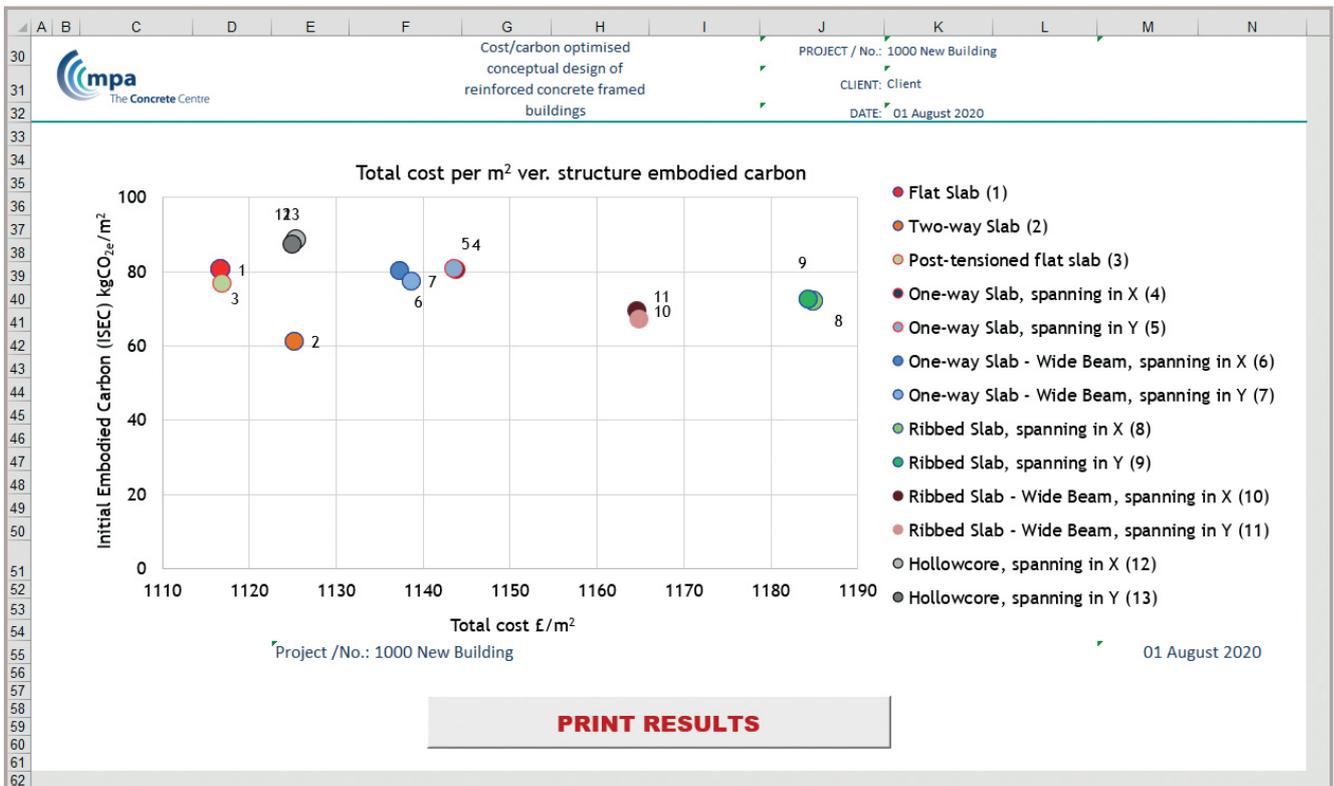
| CONCEPT Results (summary)                    |                   |                              |                   |            |                                |  |                               |                       |   |  |  |              |  |  |
|--|-------------------|------------------------------|-------------------|------------|--------------------------------|--|-------------------------------|-----------------------|---|--|--|--------------|--|--|
| Geometry                                     |                   |                              | Loads             |            |                                | Rates  |                               |                       | Results                                 |  |  | Cost summary |  |  |
| Total Cost (selected solution) = £15,685,566 |                   |                              |                   |            |                                | Time = 38.0 weeks (estimate for superstructure only) |                               |                       | GIFA = 14,780 m <sup>2</sup>            |  |  |              |  |  |
| Solution                                     | Construction cost | Cost per m <sup>2</sup> GIFA | Construction time | Total cost | Total cost m <sup>2</sup> GIFA | Structure Cost                                       | Structure m <sup>2</sup> GIFA | Superstructure ISEC   | Superstructure ISEC per GIFA            |  |  |              |  |  |
|  | £k                | £/m <sup>2</sup>             | Days              | £k         | £/m <sup>2</sup>               | £k   | £/m <sup>2</sup>              | £/m <sup>2</sup> GIFA | kgCO <sub>2</sub> e/m <sup>2</sup> GIFA |  |  |              |  |  |
| 59 Post-tensioned flat slab                  | £15,787k          | £1,068                       | 209               | £15,699k   | £1,061                         | £1,466k  | 899                           | 1,129                 | 76.4                                    |  |  |              |  |  |
| 51 Flat Slab                                 | £15,687k          | £1,061                       | 222               | £15,687k   | £1,061                         | £1,583k  | 1,107                         | 1,189                 | 80.4                                    |  |  |              |  |  |
| 513 Hollowcore, spanning in Y                | £15,682k          | £1,061                       | 235               | £15,783k   | £1,068                         | £1,611k  | 1,109                         | 1,282                 | 86.8                                    |  |  |              |  |  |
| 52 Two-way Slab                              | £15,498k          | £1,049                       | 261               | £15,802k   | £1,069                         | £1,063k  | 672                           | 899                   | 60.8                                    |  |  |              |  |  |
| 512 Hollowcore, spanning in X                | £15,716k          | £1,063                       | 235               | £15,817k   | £1,070                         | £1,627k  | 1,110                         | 1,310                 | 88.6                                    |  |  |              |  |  |
| 57 One-way Slab - Wide Beam, spanning in X   | £15,789k          | £1,068                       | 248               | £15,991k   | £1,082                         | £1,395k  | 894                           | 1,130                 | 76.4                                    |  |  |              |  |  |
| 56 One-way Slab - Wide Beam, spanning in X   | £15,791k          | £1,068                       | 248               | £15,992k   | £1,082                         | £1,395k  | 894                           | 1,189                 | 80.5                                    |  |  |              |  |  |
| 55 One-way Slab, spanning in Y               | £15,874k          | £1,074                       | 248               | £16,076k   | £1,088                         | £1,362k  | 892                           | 1,192                 | 80.7                                    |  |  |              |  |  |
| 54 One-way Slab, spanning in X               | £15,875k          | £1,074                       | 248               | £16,077k   | £1,088                         | £1,365k  | 892                           | 1,192                 | 80.6                                    |  |  |              |  |  |
| 510 Ribbed Slab - Wide Beam, spanning in X   | £15,986k          | £1,082                       | 294               | £16,391k   | £1,109                         | £1,291k  | 887                           | 1,028                 | 69.5                                    |  |  |              |  |  |
| 511 Ribbed Slab - Wide Beam, spanning in Y   | £16,006k          | £1,083                       | 274               | £16,411k   | £1,110                         | £1,305k  | 888                           | 1,008                 | 68.2                                    |  |  |              |  |  |
| 58 Ribbed Slab, spanning in X                | £16,263k          | £1,100                       | 274               | £16,670k   | £1,128                         | £1,335k  | 890                           | 1,055                 | 71.4                                    |  |  |              |  |  |
| 59 Ribbed Slab, spanning in Y                | £16,297k          | £1,103                       | 274               | £16,702k   | £1,130                         | £1,366k  | 892                           | 1,097                 | 74.2                                    |  |  |              |  |  |

**Notes:**  
 CONSTRUCTION COST includes ALL COST (material, construction, prelims & external works, mechanical & electrical, cladding, & allows for stairs, shear walls) - see Cost Summary.  
 TOTAL COST includes CONSTRUCTION COSTS + COST OF TIME DIFFERENCE  
 STRUCTURE COST includes SLAB, BEAMS, COLUMNS, GROUND FLOOR SLAB, FOUNDATIONS  
 ISEC - Initial Superstructure Embodied Carbon (A1-A3) - includes SLAB, BEAMS, COLUMNS, GROUND FLOOR SLAB

**See if actions required:**  
 Column sizes not optimised  
 Re-optimize for changes

**Return to column optimisation**   **Change the strength of concrete for columns**

The graph below is provided further down the results page and is another way to identify the optimum solution for your project.



For each option, you can export different views: plan, section and 3D view. The scheme displayed is selected using the drop down menu.

|  |  |                                 |
|--|--|---------------------------------|
| Chosen option:<br><b>One-way Slab - Wide Beam, spanning in X</b><br><i>For further details of solution 6, see sheet S6</i> | Choose the best option or select a scheme:<br><b>One-way Slab - Wide Beam, spanning in X (</b> | Total cost<br>Construction cost |
|--|--|---------------------------------|



**CONCEPT**  
 Plan view  
 Chosen solution: **One-way Slab - Wide Beam, spanning in X**

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 version 4.1 DEMO

195 solid slab

Internal beams in X, 300 x 2400 in Y

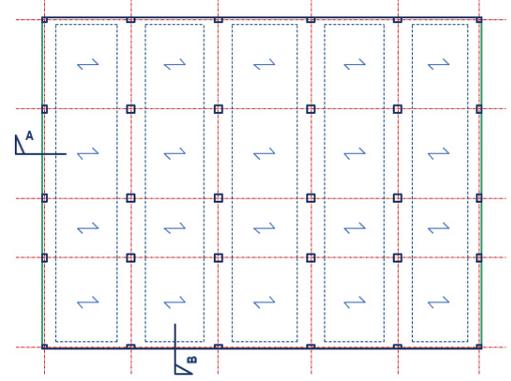
Edge beams 300 x 600 in X, 300 x 1200 in Y

Columns: 650 x 650 internal, 650 x 375 edges, 425 x 425 corners

(beam sizes: depth x width)

Y  
↑ → X

Plan at Level 1 (of 13)      Project 1000



01 August 2020

The costs all include pad foundations. These are sized for the flat slab scheme and the same cost per kN of load is used in the other cases. An internal column load is provided to allow designers to do their own foundation designs, for example using The Concrete Centre spreadsheets for pile caps. If the designer adopts this approach, the foundation cost can be set to zero in the rates page.

## How the scheme designs are developed

Concept is based on The Concrete Centre's *Economic Framed Elements (ECFE)* publication and the following assumptions. ECFE contains charts and data that present economic sizes for many types of concrete elements over a range of common loadings and spans. In producing the charts and data, many assumptions have been made. These are more fully described in Section 7 of the ECFE handbook.



### Material grades

C30/37 grade concrete and rebar with  $f_{yk} = 500 \text{ N/mm}^2$  are assumed for all beams and slabs, except post-tensioned flat slabs where concrete grade is assumed as C32/40.

Concrete for columns may be set at grades between C30/37 and C50/60 via the drop-down menu on the LOADS sheet.

### Slab design

Concept uses the data provided in the ECFE tables to determine the required slab depth and reinforcement rate based on the span and applied ultimate distributed load (audl) inputs. These will be based on the maximum span and maximum applied load and interpolation is used for spans and loads which are not listed in the tables.

The calculated slab depth required is rounded up to the nearest 5mm and the reinforcement rate is rounded up to the nearest  $1 \text{ kg/m}^3$ .

### Beam design

The beam (web) width is determined first by checking the minimum width having a viable solution based on the tables in ECFE. Tables are provided for rectangular, L-beams and T-beams of different widths, typically at 300mm intervals. Users may wish to refer to these for further information. Note: for wide beam solutions, the widths are not minimised and instead based on recommended widths from ECFE.

Beam depths are determined in the same way as slab depths, with the following adjustments:

- when  $\text{audl} < 50 \text{ kN/m}$ , the value determined from ECFE is multiplied by  $\sqrt{\text{audl}/50}$
- beam depth must be greater than slab depth + 50mm

The calculated beam depth is rounded up to the nearest 25mm and the reinforcement rate is reduced by a factor of  $\sqrt{h_{\text{required}}/h_{\text{actual}}}$ .

### Additional assumptions for two-way slab solutions

Internal X and Y beams are assumed to have the same web width.

Edge X and Y beams are assumed to have the same web width.

### Column design

Internal and corner columns are assumed to be square. The user may select square or rectangular edge columns - for rectangular columns, the larger dimension will be the same as the internal column dimension and the smaller dimension will be reduced.

The maximum reinforcement percentage in any column is assumed to be approximately 4%.

Internal columns are sized assuming the axial load,  $N = N_{uz}$  and using a reinforcement percentage of 3.5% (i.e. the columns are designed for the minimum moment).

Edge columns are initially sized using a reinforcement percentage of 4% and by estimating  $N_{\text{max}}$  (using  $N_{\text{max}} = N_{\text{bal}} + 0.85(N_{uz} - N_{\text{bal}})(n-1)/7$ , where  $n$  = number of storeys supported). Tabulated values of  $N_{\text{max}}$  are then looked up from a database to match  $N_{\text{applied}}$ .

An algorithm for derivation of rebar simplifies design by adopting a linear interpolation between  $N_{uz}$  and  $N_{\text{bal}}$ .

Final sizes of edge and corner columns are then optimised by operating a macro button.

### Foundation design

Pad foundations are assumed in the design. They are sized for the flat slab scheme and a cost per kN is calculated. This is then used to calculate the cost of the foundations for the other schemes.

The depth of the pad is calculated as  $0.195 \times \text{plan dimension}$  (assumed square) and the reinforcement rate is taken as  $50 \text{ kg/m}^3$ .

The assumed net ground bearing pressure = ground bearing pressure (GBP) - 6 (ground slab) -  $0.006 \times \text{pad depth}$ .

If other foundations types are proposed, the unit cost may be overridden on the 'Rates' sheet.

## How the rates are calculated

The rates for the cost calculations are taken from industry averages in June 2020. Costs can and do change, but normally the relative costs between elements is similar over time. All the cost rates can be changed to reflect the costs at a particular time and location. The carbon rates given in the table of recommended values are also industry averages calculated in June 2020. These rates will change over time and are highly dependent on the type of cement chosen for the concrete.

### Cost calculations

The costs are calculated from the unit rates multiplied by the quantities of formwork, reinforcement, strand and concrete worked out for the different scheme designs. The cost of the foundations are calculated from sizing pad footings for the flat slab scheme, converting this to a cost per kN carried and then applying this to the other options. The costs of the other works are calculated on the basis of a percentage of the total. These percentages can be changed in the Rates section.

Costs for each solution include cladding and an allowance for stairs, shear walls and ground slab, preliminaries, finishes and M&E. Differential costs of construction time are also calculated.

Concept allows the user to rank the different schemes according to construction cost, construction time, total cost, structural cost and superstructure embodied carbon. A traffic light system enables users to compare multiple parameters visually to identify the optimum solution for their project.

### Construction time

Times for the construction of each floor are calculated from floor area and rates.

To the construction time for all floors, the following are then added:

- A mobilisation period of 10 days.
- A lead-in time for the first group of nine columns.
- A lead-out time for curing and striking the last sector.
- A demobilisation period of five days.

Construction time is calculated directly only for the flat slab solution, and fixed time differentials per floor are added for other forms of construction.

### Carbon calculations

Concrete calculations are based on material quantities calculated as described in the previous section.

Carbon calculations cover cradle-to-gate (A1-A3) impact for all materials, for the superstructure (does not include foundations, but does include ground floor slab). Users can set carbon values for the concrete to be used, however recommended values are included on the Rates sheet.

Cradle-to-gate carbon impact is equivalent to the A1-A3 module introduced in BS EN 15978:2011 and BS EN 15804:2012+A2:2019, explained in detail in RICS professional standard and guidance *Whole life carbon assessment for the built environment* (2017).

Concept Version 4 can be downloaded for free at [www.concretecentre.com/concept](http://www.concretecentre.com/concept).

The *Economic Concrete Frame Elements* publication, upon which the Concept software is based, can be purchased from [www.concretecentre.com/publications](http://www.concretecentre.com/publications).

If you have any queries on the use of Concept, or on the results it generates, please send your enquiry to [info@concretecentre.com](mailto:info@concretecentre.com).

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