

User Guide

Concept version 5: Cost and Carbon

The Concept spreadsheet compares conceptual designs to Eurocode 2 for a wide range of concrete frame options, then ranks them in order of cost, programme or embodied carbon. It is intended to be used for selecting the most appropriate scheme for a concrete frame, and for determining initial 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.

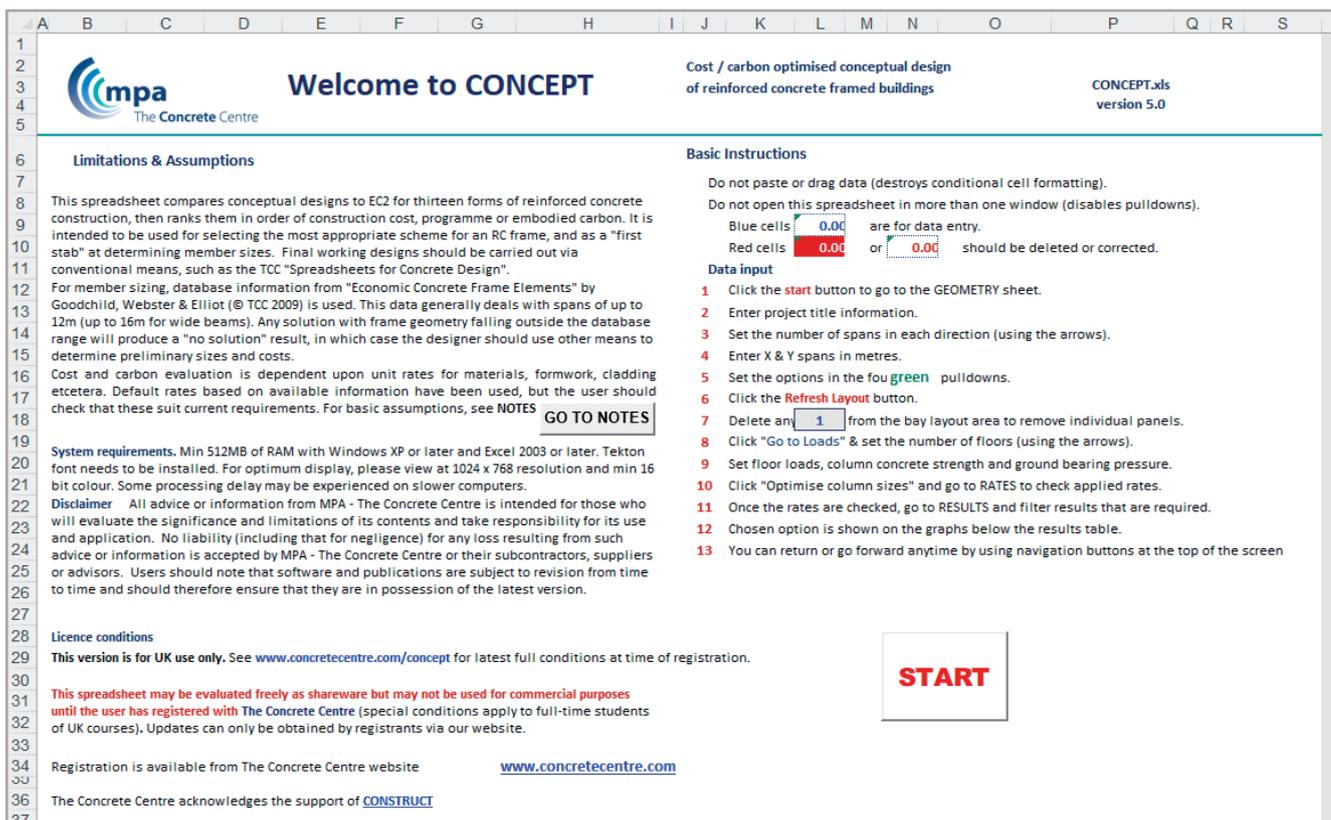
Cost and carbon evaluation is dependent upon unit rates for materials, formwork, cladding etc. Default rates based on available information have been used, but the user should check that these suit current requirements. For basic assumptions, see NOTES sheet.

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.

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 5.0

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

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.

Disclaimer All advice or information from MPA - The Concrete Centre 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 MPA - The Concrete Centre or their subcontractors, suppliers or advisors. Users should note that software and publications are subject to revision from time to time and should therefore ensure that they are in possession of the latest version.

Licence conditions
This version is for UK use only. See 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

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: 0.00 are for data entry.
Red cells: 0.00 or 0.00 should be deleted or corrected.

Data input

- 1 Click the **start** button to go to the GEOMETRY sheet.
- 2 Enter project title information.
- 3 Set the number of spans in each direction (using the arrows).
- 4 Enter X & Y spans in metres.
- 5 Set the options in the four **green** pull-downs.
- 6 Click the **Refresh Layout** button.
- 7 Delete an **1** from the bay layout area to remove individual panels.
- 8 Click "Go to Loads" & set the number of floors (using the arrows).
- 9 Set floor loads, column concrete strength and ground bearing pressure.
- 10 Click "Optimise column sizes" and go to RATES to check applied rates.
- 11 Once the rates are checked, go to RESULTS and filter results that are required.
- 12 Chosen option is shown on the graphs below the results table.
- 13 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 a choice of 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.

If you experience issues with the 'Refresh Layout' button, ensure you are using Concept on your primary screen - rather than a separate monitor.

CONCEPT Geometry

PROJECT: New Building
CLIENT: Client
DATE: 16/09/24
Project No.: 1000

CONCEPT.xls version 5.0

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

SET NUMBER OF BAYS *USE ARROWS*

Bays in X direction: 5 *max 18m* X from left

Bays in Y direction: 4 *max 18m* Y from top

STOREY HEIGHTS

Storey heights are: Floor to Ceiling

For Wide Beam solutions: Clear height is to: Beam soffit

Edge Columns: Square

For Wide Beam solutions (S6, S7, S10, S11, S15 & S16) a default width has been selected in S6.

SET STOREY HEIGHTS: 3.50 metres

Floor-floor height = 3.5 m plus slab & beam depth.

THE NUMBER OF FLOORS WILL BE SET ON THE NEXT SHEET

BAY LAYOUT

Gross area: 1,152 m²/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

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)

CONCEPT Geometry

PROJECT: New Building
 CLIENT: Client
 DATE: 16/09/24
 Project No.: 1000

CONCEPT.xls version 5.0

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

SET NUMBER OF BAYS *USE ARROWS*

Bays in X direction: 6 *max 16m* X from left

Bays in Y direction: 6 *max 16m* Y from top

Span (m): 7.500 7.500 7.500 7.500 7.500 7.500

STOREY HEIGHTS

Storey heights are: Floor to Ceiling

For Wide Beam solutions: Beam soffit

Clear height is to: Square

Edge Columns

For Wide Beam solutions (S6, S7, S10, S11, S15 & S16) a default width has been selected in S6.

SET STOREY HEIGHTS: 3.50 metres

Floor-floor height = 3.5 m plus slab & beam depth.

THE NUMBER OF FLOORS WILL BE SET ON THE NEXT SHEET

Refresh Layout

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

BAY LAYOUT

Gross area: 1,848 m²/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

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)

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: 16/09/24
 Project No.: 1000

CONCEPT.xls version 5.0

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

SET NUMBER OF BAYS *USE ARROWS*

Bays in X direction: 5 *max 16m* X from left

Bays in Y direction: 4 *max 16m* Y from top

Span (m): 7.500 7.500 7.500 7.500

STOREY HEIGHTS

Storey heights are: Floor to Ceiling

For Wide Beam solutions: Beam soffit

Clear height is to: Square

Edge Columns

For Wide Beam solutions (S6, S7, S10, S11, S15 & S16) a default width has been selected in S6.

SET STOREY HEIGHTS: 3.50 metres

Floor-floor height = 3.5 m plus slab & beam depth.

THE NUMBER OF FLOORS WILL BE SET ON THE NEXT SHEET

Refresh Layout

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

BAY LAYOUT

Gross area: 927 m²/floor

MATRIX SHOWING LOCATION OF BAYS

1	1	1	1	1
1	1	1	1	1
1	1	1		1
1	1	1		

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)

For wide beam solutions (for one way slabs, ribbed slabs and troughed slabs), a default beam width is provided in Concept. Users may select an alternative width using the drop down in sheet S6 - this will change the width for all wide beam solutions (on sheets S7, S10, S11, S15 and S16).

Scheme 6 One-way Slab - Wide Beam, spanning in X (6) Valid

Slab Design See ECFE page 28

	Max Span	Design Span	uauidl	h	kg/m ³
	7.500	7.500	5.88	11.50	180
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0

uauidl	h (EFCE)	kg/m ³
5.63	177.5	74.0
9.38	192.5	101.0
13.13	201.5	121.5
16.88	221.5	127.0

Beam Design See ECFE pages 58-60 & 68-71

INTERNAL BEAMS $b_w = 2400$

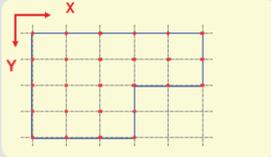
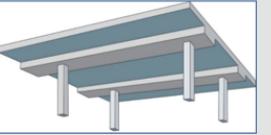
uauidl	h (EFCE)	Adjust	h	kg/m ³
5.88	94.88	293.5	1.000	300
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0

EDGE BEAMS in Y $b_w = 1200$

uauidl	h (EFCE)	Adjust	h	kg/m ³
5.88	55.43	301.8	1.000	300
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0

EDGE BEAMS in X $b_w = 600$

uauidl	h (EFCE)	Adjust	h	kg/m ³
5.88	16.90	298.5	0.837	250
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0

Navigation: WELCOME NOTES GEOMETRY Rates LOADS RESULTS Costs Carbon S1 S2 S3 S4 S5 S6 S7 S8

Scheme 6 One-way Slab - Wide Beam, spanning in X (6) Valid

Slab Design See ECFE page 28

	Max Span	Design Span	uauidl	h	kg/m ³
	7.500	7.500	5.88	11.50	180
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0
			0.00	0.00	0

uauidl	h (EFCE)	kg/m ³
5.63	177.5	74.0
9.38	192.5	101.0
13.13	201.5	121.5
16.88	221.5	127.0

Beam Design See ECFE pages 58-60 & 68-71

INTERNAL BEAMS $b_w = 2400$

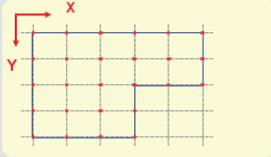
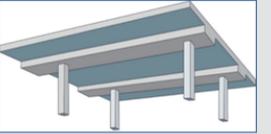
uauidl	h (EFCE)	Adjust	h	kg/m ³
5.88	94.88	293.5	1.000	300
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0

EDGE BEAMS in Y $b_w = 1200$

uauidl	h (EFCE)	Adjust	h	kg/m ³
5.88	55.43	301.8	1.000	300
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0

EDGE BEAMS in X $b_w = 600$

uauidl	h (EFCE)	Adjust	h	kg/m ³
5.88	16.90	298.5	0.837	250
0.00	0.00	0.0	0.000	0
0.00	0.00	0.0	0.000	0

Navigation: WELCOME NOTES GEOMETRY Rates LOADS RESULTS Costs Carbon S1 S2 S3 S4 S5 S6 S7 S8

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 / No.: 1000 New Building
CLIENT: Client
DATE: 16/09/24

CONCEPT.xls version 5.0

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	0.50	3.50	8.00
Level 2	0.50	3.50	8.00
Level 3	0.50	3.50	8.00
Level 4	0.50	3.50	8.00
Level 5	0.50	3.50	8.00

SET NUMBER OF FLOORS
5 max 15
Then Copy level 1 loads to all levels

MATERIAL PROPERTIES
Characteristic concrete strength for slabs α MPa
 f_{ck} fixed value 30
Characteristic concrete strength for columns
 f_{ck} 30 MPa
Ground Bearing at 150 kPa Service

CLICK to optimise

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

Based on Flat Slab Design

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 CEM IIB cement. This is typical in the industry for designated concretes, but the values are very dependent on the specification of the concrete. CEM IIIA and CEM IIIB cements will give significantly lower results for embodied carbon, but may affect setting times.

EMBEDDED CARBON VALUES									
Concrete density:		2,380 kg/m ³							
Steel density:		7,850 kg/m ³							
EMBEDDED CARBON VALUES - 'cradle-to-gate'					VALUES RECOMMENDED BY TCC				
Material	A1-A3		A1-A3		Material	A1-A3		A1-A3	
Concrete					Concrete				
C30/37	230	kgCO _{2e} /m ³	97	kgCO _{2e} /t	C30/37	230	kgCO _{2e} /m ³	97	kgCO _{2e} /t
C32/40	240	kgCO _{2e} /m ³	101	kgCO _{2e} /t	C32/40	240	kgCO _{2e} /m ³	101	kgCO _{2e} /t
C35/45	250	kgCO _{2e} /m ³	105	kgCO _{2e} /t	C35/45	250	kgCO _{2e} /m ³	105	kgCO _{2e} /t
C40/50	260	kgCO _{2e} /m ³	109	kgCO _{2e} /t	C40/50	260	kgCO _{2e} /m ³	109	kgCO _{2e} /t
C45/55	270	kgCO _{2e} /m ³	113	kgCO _{2e} /t	C45/55	270	kgCO _{2e} /m ³	113	kgCO _{2e} /t
C50/60	280	kgCO _{2e} /m ³	118	kgCO _{2e} /t	C50/60	280	kgCO _{2e} /m ³	118	kgCO _{2e} /t
Hollowcore					Hollowcore				
150	50	kgCO _{2e} /m ²	335	kgCO _{2e} /m ³	150	50	kgCO _{2e} /m ²	335	kgCO _{2e} /m ³
200	57	kgCO _{2e} /m ²	285	kgCO _{2e} /m ³	200	57	kgCO _{2e} /m ²	285	kgCO _{2e} /m ³
250	65	kgCO _{2e} /m ²	261	kgCO _{2e} /m ³	250	65	kgCO _{2e} /m ²	261	kgCO _{2e} /m ³
300	75	kgCO _{2e} /m ²	251	kgCO _{2e} /m ³	300	75	kgCO _{2e} /m ²	251	kgCO _{2e} /m ³
350	85	kgCO _{2e} /m ²	244	kgCO _{2e} /m ³	350	85	kgCO _{2e} /m ²	244	kgCO _{2e} /m ³
400	95	kgCO _{2e} /m ²	238	kgCO _{2e} /m ³	400	95	kgCO _{2e} /m ²	238	kgCO _{2e} /m ³
450	105	kgCO _{2e} /m ²	234	kgCO _{2e} /m ³	450	105	kgCO _{2e} /m ²	234	kgCO _{2e} /m ³
Reinforcement					Reinforcement				
f _{yk} = 500 N/mm ²	5,652	kgCO _{2e} /t	720	kgCO _{2e} /t	f _{yk} = 500 N/mm ²	5,652	kgCO _{2e} /t	720	kgCO _{2e} /t
Tendons					Tendons				
f _{yk} = 1860 MPa	7,850	kgCO _{2e} /t	1,000	kgCO _{2e} /t	f _{yk} = 1860 MPa	7,850	kgCO _{2e} /t	1,000	kgCO _{2e} /t

Source: BRMCA (2020). Based on a typically available CEMII mix

Source: EPD (for 150mm, 200-450mm – recalculated according to UK Precast Concrete Hollowcore Flooring) [http://bit.ly/2GSX6Cr]

Source: UK CARES (2024). Understanding UK average embodied carbon emissions for steel reinforcing bar. [https://shorturl.at/qFF6n]

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.

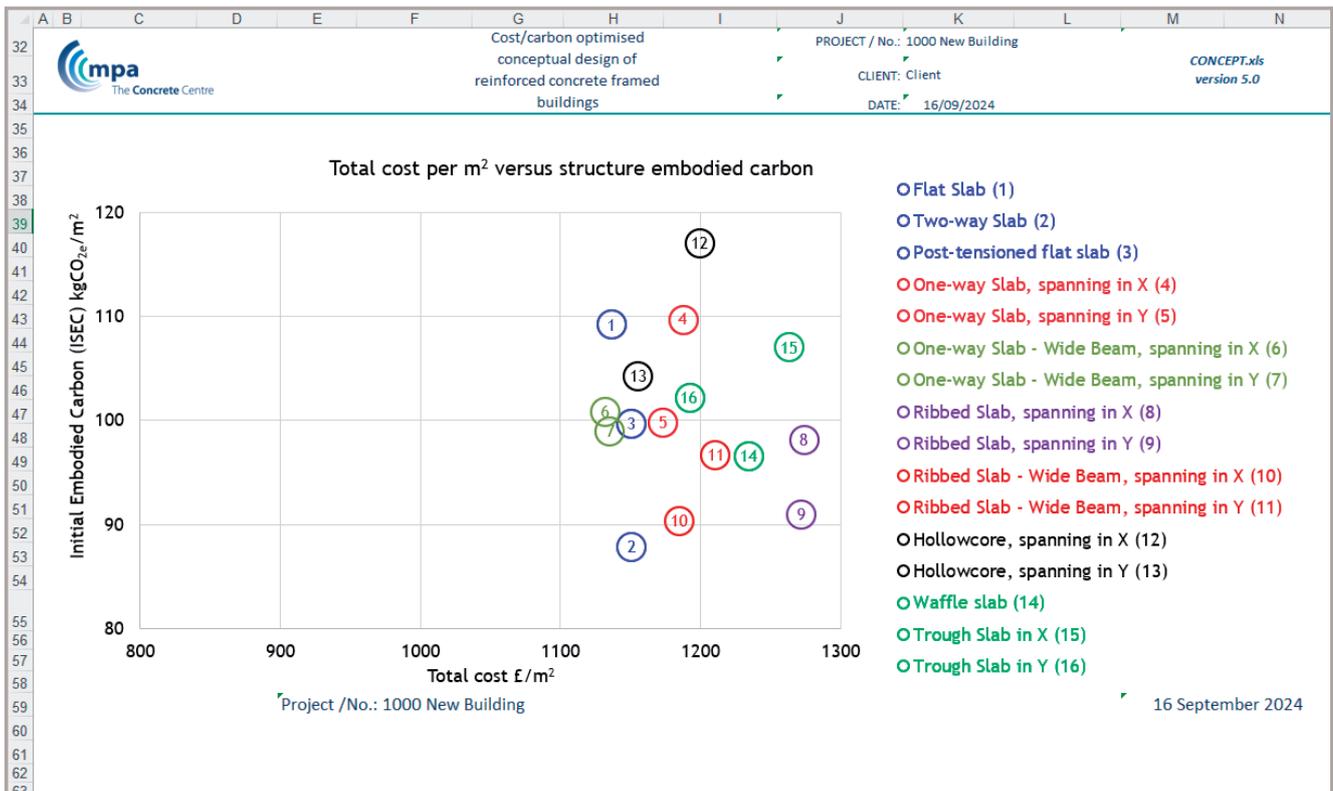
Below the table there are notes explaining what each parameter is based on and which elements are included.

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			Member sizes			View plan			View sections			3D view		
Click on RANK to Select the Leading Lowest Cost Category																										
Gross Internal Floor Area = 4,636 m ²																										
Solution	Construction cost	Cost per m ² GIFA	Construction time	Total cost	Total cost m ² GIFA	Structure Cost	Structure m ² GIFA	Structure ISEC	Structure ISEC per GIFA	See if actions required:																
	£k	£/m ²	Days	£k	£/m ²	£k	£/m ²	kgCO _{2e} /m ²	kgCO _{2e} /m ²																	
10 S14 Waffle Slab (14)	£5,433k	£1,172	105.5	£5,482k	£1,183	£321k	609	597	85.7																	
11 S2 Two-way Slab (2)	£5,337k	£1,108	105.5	£5,186k	£1,119	£326k	£70	398	85.8																	
12 S9 Ribbed Slab, spanning in Y (9)	£5,732k	£1,236	105.5	£5,781k	£1,247	£357k	£77	419	90.3																	
13 S8 Ribbed Slab, spanning in X (8)	£5,739k	£1,238	105.5	£5,788k	£1,249	£359k	£77	420	90.7																	
14 S11 Ribbed Slab - Wide Beam, spanning in Y (11)	£5,458k	£1,177	105.5	£5,507k	£1,188	£352k	£76	428	92.4																	
15 S10 Ribbed Slab - Wide Beam, spanning in X (10)	£5,466k	£1,179	105.5	£5,516k	£1,190	£353k	£78	431	98.0																	
16 S3 Post-tensioned flat slab (3)	£5,296k	£1,142	95.5	£5,285k	£1,140	£426k	£92	459	99.0																	
17 S7 One-way Slab - Wide Beam, spanning in Y (7)	£5,185k	£1,118	95.5	£5,209k	£1,124	£371k	£80	461	99.4																	
18 S6 One-way Slab - Wide Beam, spanning in X (6)	£5,193k	£1,120	95.5	£5,217k	£1,125	£371k	£80	462	99.6																	
19 S18 Trough Slab - spanning in Y (18)	£5,588k	£1,205	105.5	£5,637k	£1,216	£387k	£83	474	102.2																	
20 S15 Trough Slab - spanning in X (15)	£5,589k	£1,206	105.5	£5,638k	£1,216	£389k	£84	476	102.7																	
21 S13 Hollowcore, spanning in Y (13)	£5,287k	£1,140	90.5	£5,299k	£1,143	£470k	£101	482	103.9																	
22 S12 Hollowcore, spanning in X (12)	£5,310k	£1,145	90.5	£5,322k	£1,148	£473k	£102	485	104.6																	
23 S5 One-way Slab, spanning in Y (5)	£5,412k	£1,167	95.5	£5,437k	£1,173	£391k	£84	486	104.8																	
24 S4 One-way Slab, spanning in X (4)	£5,419k	£1,169	95.5	£5,444k	£1,174	£392k	£85	487	105.0																	
25 S1 Flat Slab (1)	£5,196k	£1,121	85.5	£5,196k	£1,121	£460k	£99	494	106.6																	

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

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CONCEPT
Chosen solution: **One-way Slab - Wide Beam, spanning in Y**
CONCEPT.xls
version 5.0

165 solid slab
Internal beams 325 x 2400 in X
Edge beams 325 x 1200 in X, 225 x 600 in Y
Columns:
400 x 400 internal, 275 x 275 edges in X, 350 x 350 edges in Y, 300 x 300 corners

(beam sizes: depth x width)

Y
↑ → X

Plan at Level 1 (of 5) Project /No.: 1000 New Building 16 September 2024

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 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 user may select the beam width on sheet S6.

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_{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_{max} are then looked up from a database to match N_{applied} .

An algorithm for derivation of rebar simplifies design by adopting a linear interpolation between N_{uz} and N_{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 $0.195 \times$ plan dimension (assumed square) and the reinforcement rate is taken as 50 kg/m^3 .

The assumed net ground bearing pressure = ground bearing pressure (GBP) - 6 (ground slab) - $0.006 \times$ 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, so the recommended rates may still be used for comparison purposes. 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 based on industry data and commentary and further information on data sources is provided within the tool. These rates will change over time and are highly dependent on the type of cement chosen for the concrete and the source of the reinforcing and prestressing steel.

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 outlined in BS EN 15978:2011 and BS EN 15804:2012+A2:2019.

Concept Version 5 can be downloaded for free at 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.

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

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