BONDEK® DESIGN SOFTWARE

USER GUIDE
FOR DESIGN PROFESSIONALS

Welcome to the LYSAGHT BONDEK® Design Software User Guide. Our design software will significantly assist a qualified engineer arrive at a solution which speeds the design process for floors and slabs.

BONDEK® works as composite slab saving on concrete and reinforcement costs.

Download your free copy of the software from: http://professionals.lysaght.com/products/bondek

BACKGROUND

Our newest release of supporting software and the Design and Construction Manual for BONDEK® Structural Steel Decking incorporates Lysaght's latest research and development work. Improved design and testing methods have again pushed BONDEK® Structural Steel Decking to the forefront. New formwork tables are optimised for steel frame construction but are also suitable for concrete frame construction and masonry walls.

This User Manual is designed to provide you with basic familiarity about LYSAGHT BONDEK® Design Software to enable you to quickly understand and start using this powerful tool. The software is able to perform major tasks normally performed at a structural consultant's office. Use LYSAGHT BONDEK® Design and Construction Manual with its set of tables for typical designs. The software will help when input parameters are different from those listed for tables or the user wants to check several different options.

LYSAGHT BONDEK® is a profiled zinc-coated high tensile steel decking for use in the construction of composite floor slabs. It has been successfully used in countless buildings throughout Australia. The profile has been specifically developed for Australian high tensile steels.

It can be used as formwork during construction and as a reinforcement system in composite slabs.

Our increased understanding of composite slabs, together with testing in our NATA-accredited laboratory and leading Australian universities, has paid off with an optimised product, which provides significant cost savings for projects.

The built-in properties of high tensile steel are maximised in the design and fabrication of the deck profiles which result in products with high strength-to-weight ratio. LYSAGHT BONDEK® is currently one of the most popular structural steel decking profiles in Australia for typical applications.

SCOPE

This manual provides information on the design of formwork, propping, composite slabs and design for fire and some information for composite beams.

LYSAGHT BONDEK® Design Software is developed to Australian Standards (AS) whenever possible, Eurocodes have been used when certain design procedures are not available in Australian Standards.

CONDITIONS OF USE

This publication contains technical information on the following grades of LYSAGHT BONDEK®:

- LYSAGHT BONDEK® 0.6mm thickness
- LYSAGHT BONDEK® 0.75mm thickness
- LYSAGHT BONDEK® 0.9mm thickness
- LYSAGHT BONDEK® 1.00mm thickness

Additionally, LYSAGHT BONDEK® Design Software allows you to get quicker and more economical solutions with a range of options. Call Steel Direct on 1800 641 417 to obtain additional copies of the Design and Construction Manual and User Guide to BONDEK® Design Software.

Where we recommend use of third party materials, ensure you check the manufacturer's requirements. Diagrams are used to explain the requirements of a particular product. Adjacent construction elements of the building that would normally be required in that particular situation are not always shown. Accordingly aspects of a diagram not shown should not be interpreted as meaning these construction or design details are not required. You should check the relevant Codes associated with the construction or design.

WARRANTIES

Our products are engineered to perform according to our specifications only if they are installed according to the recommendations in this manual and our publications. Naturally, if a published warranty is offered for the product, the warranty requires specifiers and installers to exercise due care in how the products are applied and installed and are subject to final use and proper installation. Owners need to maintain the finished work.

PREFACE

LYSAGHT BONDEK® Design Software is a user-friendly Microsoft Excel®-based software for the design of composite concrete slabs with LYSAGHT BONDEK® structural decking. It is suitable for steel frame construction and masonry supports.

It is a tool developed with latest information to assist a competent engineer with the most competent solution.

The software should be used to design composite slabs in conjunction with the LYSAGHT BONDEK® Design & Construction Manual.

www.lysaght.com

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BONDEK® DESIGN SOFTWARE

1.0 Introduction

The software offers following additional design options as compared to tables:

- Two major design options: Design and Design/Check. The first option will perform design with the minimum possible slab thickness; the second one will check the chosen slab thickness and design the rest of the parameters.
- Selection of exposure classifications (A1, A2, B1 and B2).
- 25, 32 and 40 MPa concrete grades.
- Superimposed dead load (G_{sdl}) other than 1 kPa.
- Other than office types of imposed loads.
- For negative, positive fire and shrinkage reinforcement, use D500N or D500L.
- User specified bar diameter.
- Specified number of continuous spans (two-span, three-span etc.).
- Degree of control for shrinkage and temperature effects.
- All fire rating periods: 30, 60, 90, 120, 180 and 240 min.
- Variable loads due to weight of stacked materials during construction stage.
- Design with relaxed crack control requirements for flexure.
- Support width.
- User specified concrete cover.

The software is developed as a powerful tool to minimise time and calculations by a consulting engineer to complete the job. However, it is essential for the user to have:

- Good knowledge of structural engineering.
- Familiarity with design of composite concrete slabs.
- Sound knowledge of local regulations and load requirements.

This warning symbol means the user shall take care before proceeding further.

This symbol means that the user shall refer to the relevant Australian Standard or Eurocode for more information.

This symbol means that there is more information on this topic in other chapters.

This symbol means that this is important information. The user shall ensure they understand before proceeding.

2.0 Getting Started

2.1. COMPUTER REQUIREMENTS

To run LYSAGHT BONDEK® Design Software your computer must have Microsoft Excel® 2000 or a later version, on Windows® platform.

2.2 INSTALLING LYSAGHT BONDEK® DESIGN SOFTWARE

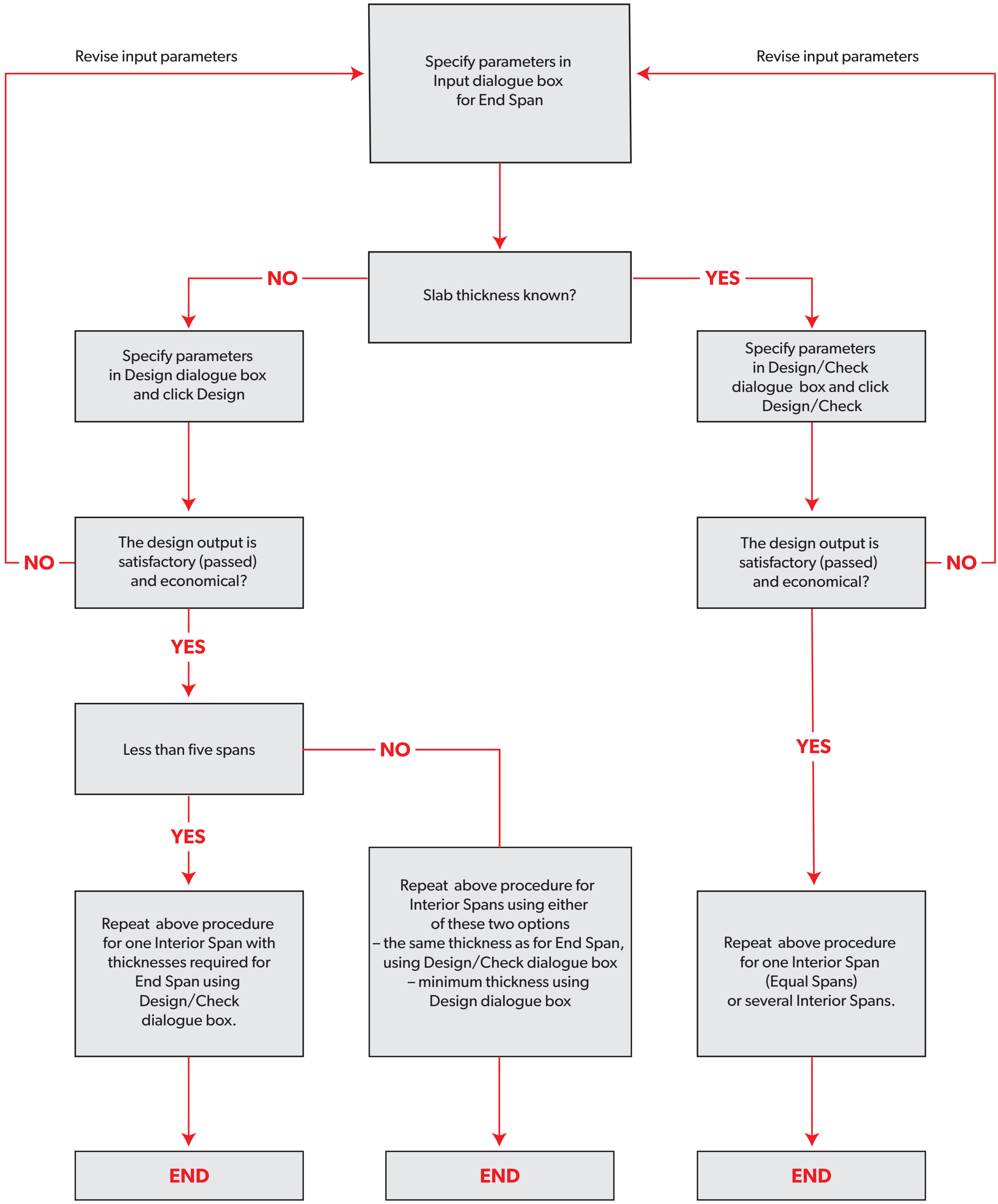
The LYSAGHT BONDEK® Design Software can be downloaded from: http://professionals.lysaght.com/products/bondek

The on-line file folder also contains the LYSAGHT BONDEK® User Guide and Design and Construction Manual in .pdf format.

On your hard disc, create a directory (folder) called LYSAGHT BONDEK® Design Software, and place the downloaded files from http://professionals.lysaght.com/products/bondek into the folder. Run the software, in the usual way, by double-clicking on the icons.

Ensure you enable Macros before proceeding with LYSAGHT BONDEK® Design Software. The security settings for Microsoft Excel® shall be set to medium to low level when applicable.

3.0 Software Flowchart for the Design of Continuous Spans



4.0 LYSAGHT BONDEK® Software Menu

LYSAGHT BONDEK® Design Software Menu options are built into Excel **Menu** on the top of the screen.

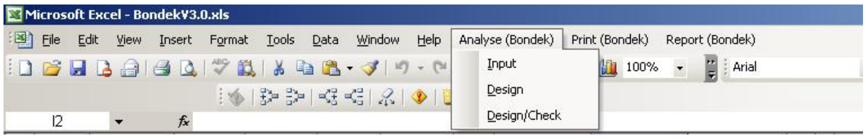
Excel **Menu** may look different from what is shown below.

There are three additional **Menu** options:

- **Analyse**
- **Print**
- **Report**

Figure 1

Analyse Menu.



HELP

Analyse Menu has three submenu options:

- **Input**
- **Design**
- **Design/Check**

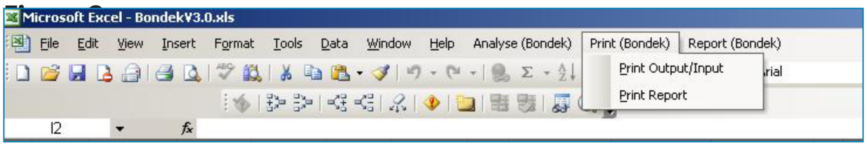
These options will be described in details in further chapters.

When the software is opened, the **Input** dialogue box will appear on the screen automatically (see cover page). For the second and consecutive runs, the user shall access the **Input** dialogue box through **Menu**.

Print Menu allows the user to print **Output/ Input** information or **Report**.

Figure 2

Print Menu.

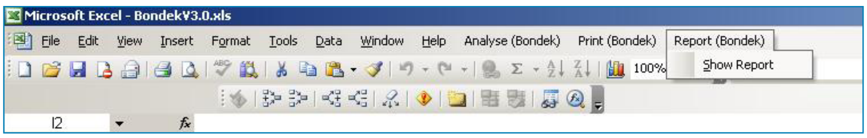


HELP

Report Menu will generate detailed a design report which is described in more detail in Chapter 10.

Figure 3a

Report Menu.

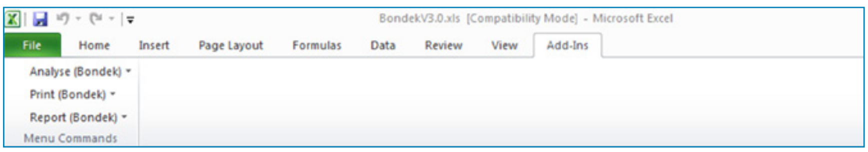


It shall be noted that **Menu** options are available only when LYSAGHT BONDEK® Design Software Excel file is activated.

* For Microsoft Excel® 2007 or later versions, the extra functional tabs described above can be accessed at the **Add-ins** ribbon.

Figure 3b

Analyse Menu. Excel® 2007 onwards.



5.0 Input dialogue box

5.1 GENERAL

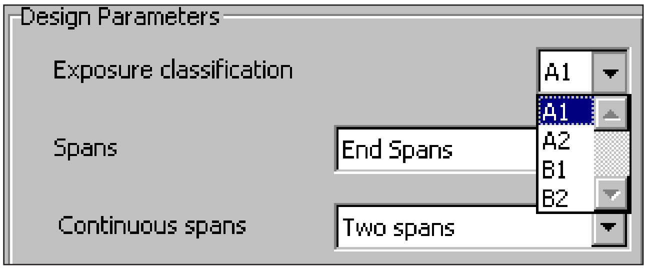
Input dialogue box is designed for quick and easy data entry. The user shall normally just choose one of the available options. If required input information is missed or incorrect, the warning message would appear on the screen.

5.2 CONDITIONS OF EXPOSURE

The **Exposure Classification** shall be specified as required by AS 3600:2009 Clause 4.3

Figure 4

Exposure classification.



5.3 SPANS

The user may specify **Single Spans** or **Continuous Spans** depending on the project.

Increased slab thickness may be required in many instances when continuous slabs are designed as a series of simply supported spans.

If the span is a Continuous one, the user may run the software several times: for **End Spans** and **Interior Spans** separately. If the continuous span is a **Two spans** then there is no option for **Interior Spans**, both spans are end ones. It shall be noted that **Continuous Spans** refer here to composite concrete slabs only, LYSAGHT BONDEK® formwork spans are specified in **Design** and **Design/Check** dialogue boxes.

Figure 5

Spans.

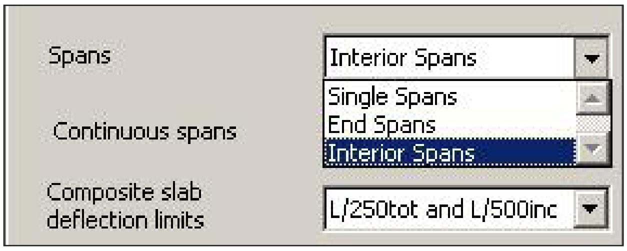
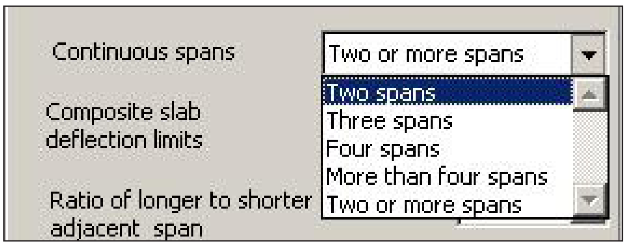


Figure 6

Continuous Spans.



End Spans and **Interior Spans** may be designed with a different thickness to get the most economical design. However, the first **Interior Span** from the end support shall always have the same thickness as the **End Span**.

When the slab has less than five spans the user shall run **End Spans** first using **Design Menu** option to get the minimum possible slab thickness.
Then **Interior Spans** shall be designed with the slab thickness obtained for **End Spans** using **Design/Check Menu** option.

When the slab has five or more spans, the thickness of Interior Spans other than first **Interior Span** may be specified independently from **End Spans**.

See flowchart.

Figure 7

Spans.

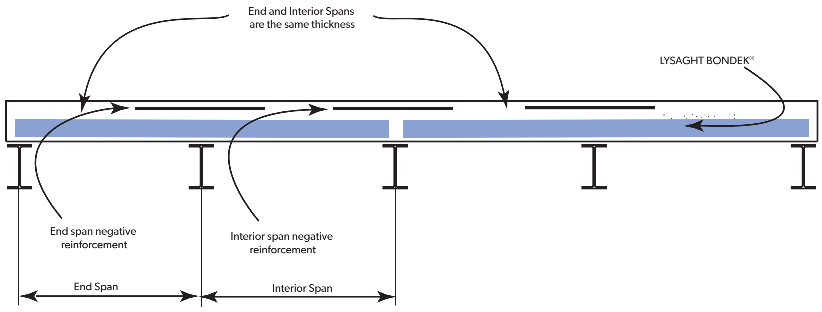
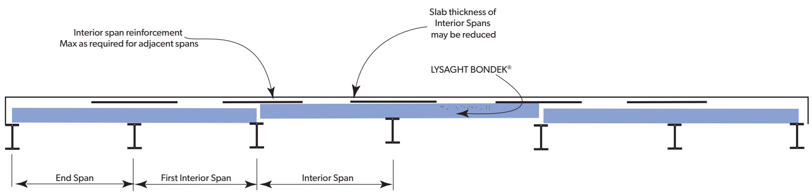


Figure 8

Spans.

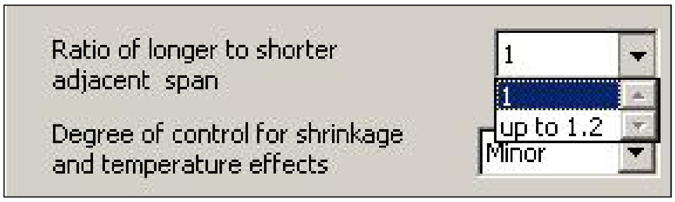


The user may specify all spans as equal spans and with maximum **Ratio of longer** to **shorter adjacent span** of 1.2.

For software options for irregular lay outs with higher ratios of adjacent spans, contact Steel Direct or your local technical sales representative for more information.

Figure 9

Ratio of Spans.



5.4 COMPOSITE SLAB DEFLECTION LIMITS

The software is developed for Span/250 **Composite slab deflection** limits due to total load and two options for deflections limits due to imposed loads:

- Span/500 is recommended by AS 3600:2009 Table 2.3.2 for concrete slabs which support brittle partitions like masonry walls, glass doors.
- No limits for slabs not supporting brittle partitions

Figure 10

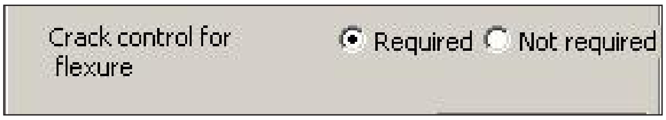
Composite slab deflection limits.

5.5 CRACK CONTROL FOR FLEXURE

Not required option may be used for areas of slabs fully enclosed within a building except for a brief period of weather exposure during construction and where it is assessed that wider cracks can be tolerated - according to AS 3600:2009 Clause 9.4.1. This option will design reinforcement as required for relaxed crack control. Items (a) and (b) of Clause 9.4.1

Figure 11

Crack control for flexure.



5.6 DEGREE OF CONTROL OF SHRINKAGE AND TEMPERATURE EFFECTS

Refer to AS 3600:2009 Clause 9.4.3 for shrinkage control requirements.

Figure 12

Shrinkage control.

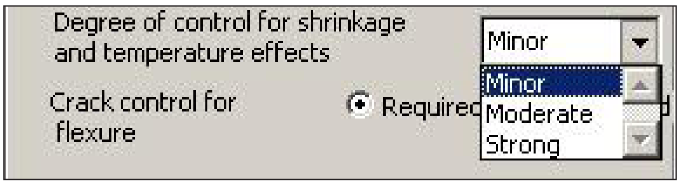


Figure 13

Environment for shrinkage strains.

It shall be noted that arid (interior) environment will result in higher shrinkage strains, which in turn may result in deeper slabs.

5.7 PROPERTIES OF MATERIALS

The minimum **Concrete** grade possible depends on **Exposure Classification**.

B2 classification will require minimum concrete grade of 40 MPa.

Figure 14

Concrete grades.

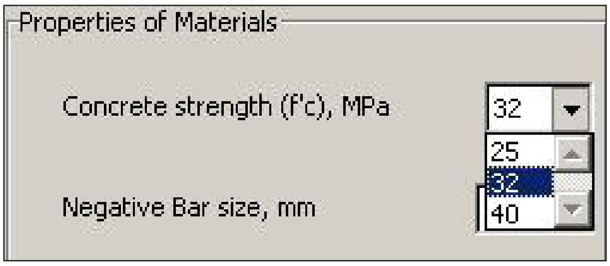


Figure 15

Negative bar sizes. Positive and fire bar sizes.

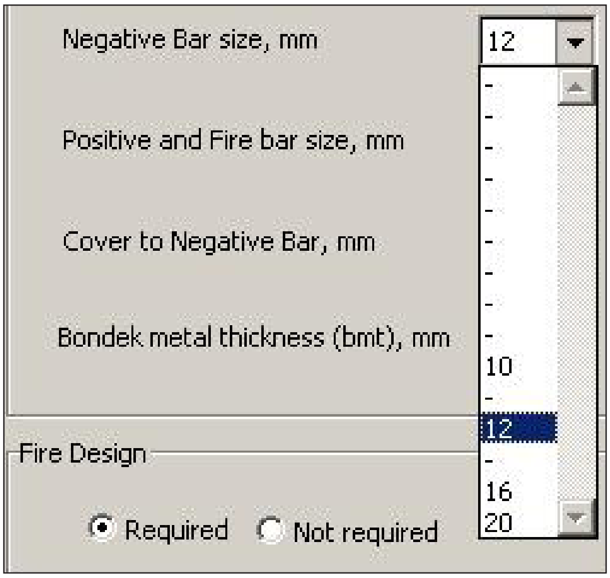


Figure 16

LYSAGHT BONDEK® BMT (base material thickness).

The software may design composite slabs using: 0.6, 0.75, 0.9 or 1.0 BMT sheets. The user may try 0.6 BMT for the first run. If the design is not economical (props are necessary), next run with increased BMT may be necessary.

5.8 COVER TO NEGATIVE BAR

Users shall specify appropriate covers to ensure that the concrete can be satisfactorily placed and compacted around reinforcement in accordance with the requirements of AS 3600:2009, Clause 17.1.3 and 4.10.

Figure 17

Cover to negative bar.

5.9 FIRE DESIGN

At this stage the user shall specify if the **Design for fire** is required or not.

The requirements for **Fire Reinforcement** and its location within the composite concrete slab is given in Section 8 of this manual.

Figure 18

Fire Design.

5.10 SHRINKAGE REINFORCEMENT

This reinforcement is necessary to control cracking due to shrinkage and temperature effects in transverse direction. **Shrinkage reinforcement** can be specified as mesh or bars.

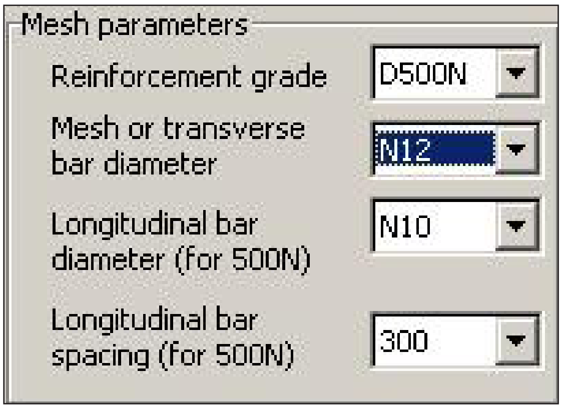
Users can specify the diameter of reinforcement and spacing for longitudinal bars if the reinforcement grade is D500N.

The detailed definition of **Shrinkage reinforcement** and its location within the composite concrete slab is given in AS 3600:2009 Clause 9.4.3.

If rectangular mesh (RL) is specified it shall be oriented such as more steel is spanning in transverse (perpendicular to sheeting) direction.

Figure 19

Shrinkage reinforcement.

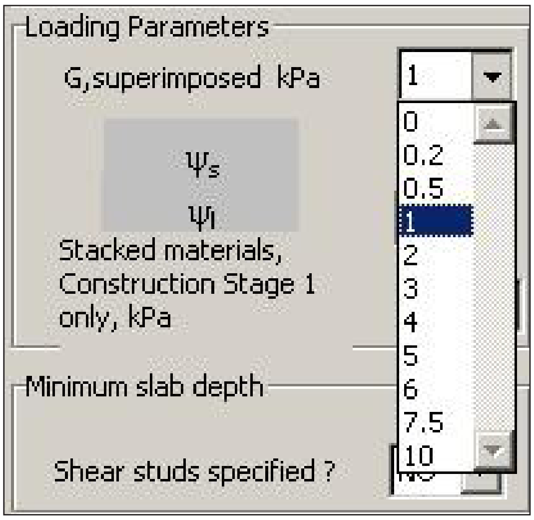


5.11 LOADING PARAMETERS

Superimposed dead load (G_{sdl}) is a load of permanent nature in addition to self weight of composite concrete slabs.

Figure 20

Superimposed dead load.



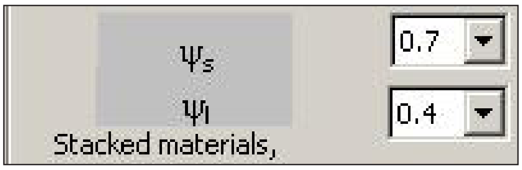
A | S

ψ_s and ψ_l are factors for **Live** (Imposed) **Loads**. **Live Load** itself shall be entered in **Design** or **Design/Check** dialogue boxes which are described in next Chapters.

Refer to AS 1170.0 : 2002 for more information.

Figure 21

ψ_s load factor.



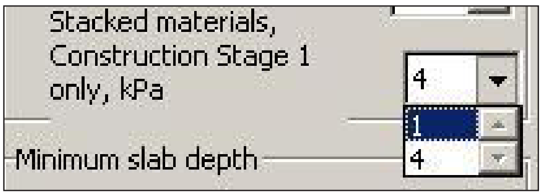
A | S

This is the weight of Storage loads as specified in AS 3610:1995, Clause 4.4.2.4 during construction stage before concrete is placed. The value of the Storage Load is 4 kPa. A 1 kPa option is available.

If load is less than 4 kPa is specified, it shall be clearly shown on formwork documentation and controlled on construction site.

Figure 22

Stacked materials.



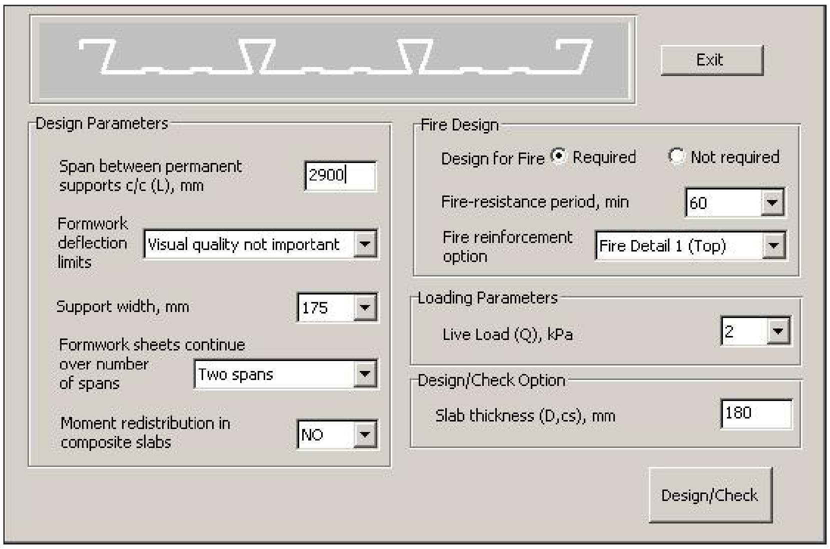
6.0 Design dialogue box

6.1 GENERAL

When the user entered all necessary parameters in the **Input** dialogue box, the next step would be to click **Design** or **Design/Check** button at the bottom of the **Input** dialogue box. This will open one or another dialogue box. The **Design** option is used when the user wants to design the slab to the very minimum slab thickness. **Design/Check** option shall be used when the possible slab thickness is known. (User controlled - See flowchart.)

Figure 23

Design dialogue box.



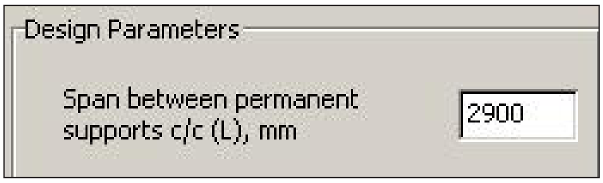
HELP

6.2 SLAB SPAN

The user shall type in the span length. It shall be centre-to-centre span, see Chapter 8 of this Guide for more details. The range of possible spans is from 1.4 to 6.0m.

Figure 24

Slab span.



A S

6.3 FORMWORK DEFLECTION LIMITS

Formwork deflection limits shall be specified as required by AS 3610:1995 and AS 2327.1. Span/240 (visual quality important) deflection limit is recommended for slabs in which good general alignment is required. It is suitable for a Class 3 or 4 surface finish.

L/130 (visual quality not important) deflection limit is suitable for Class 5 surface finish.

Figure 25

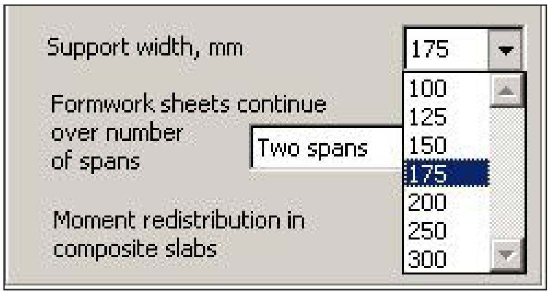
Formwork deflection limits.

6.4 SUPPORT WIDTH

This is a width of a supporting structure – steel beams. It is important to enter correct value – it may result in smaller BMT of the LYSAGHT BONDEK® formwork.

Figure 26

Support width.

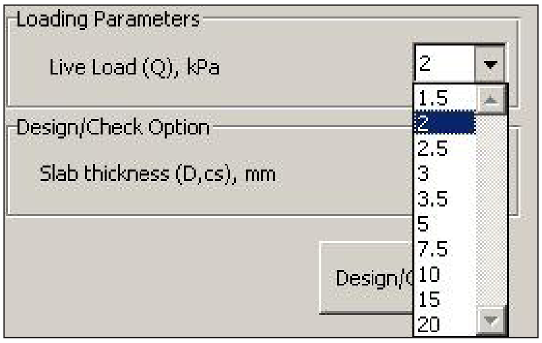


6.5 LIVE LOAD

Live Load (Q) shall be specified as required by AS 1170.1-2002.

Figure 27

Live load.



6.6 FIRE DESIGN

The user may specify **Fire-resistance** periods of **30, 60, 90, 120, 180** and **240** minutes as defined by AS 3600:2009 Section 5.

Figure 28

Fire design.

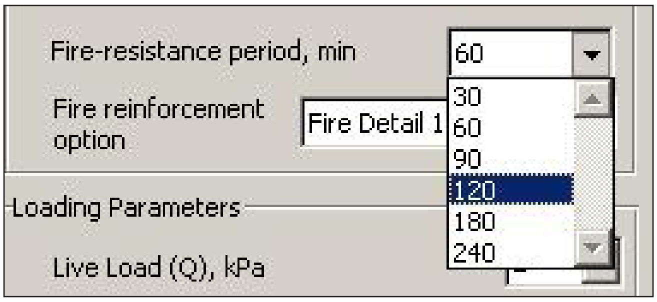


Figure 29

Fire reinforcement option.

7.0 Design/Check dialogue box

HELP

7.1 GENERAL

When the user has entered all necessary parameters in the Input dialogue box, the next step would be to click **Design** or **Design/Check** button at the bottom of the Input dialogue box. This will open one or another dialogue box. The **Design** option is used when the user wants to design the slab to the very minimum slab thickness. **Design/Check** option shall be used when the slab thickness is known (user controlled). It may be in a case when the architect specified the slab thickness for other than structural reasons or **Interior span**s shall be designed to the slab thickness as required for **End spans** – see Chapter 5.3 of this Guide and the flowchart.

This Dialogue box has the same options as **Design** dialogue box with an addition of **Slab thickness** option.

Figure 30

Design & Design/Check Options.

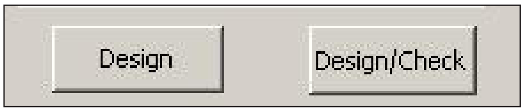
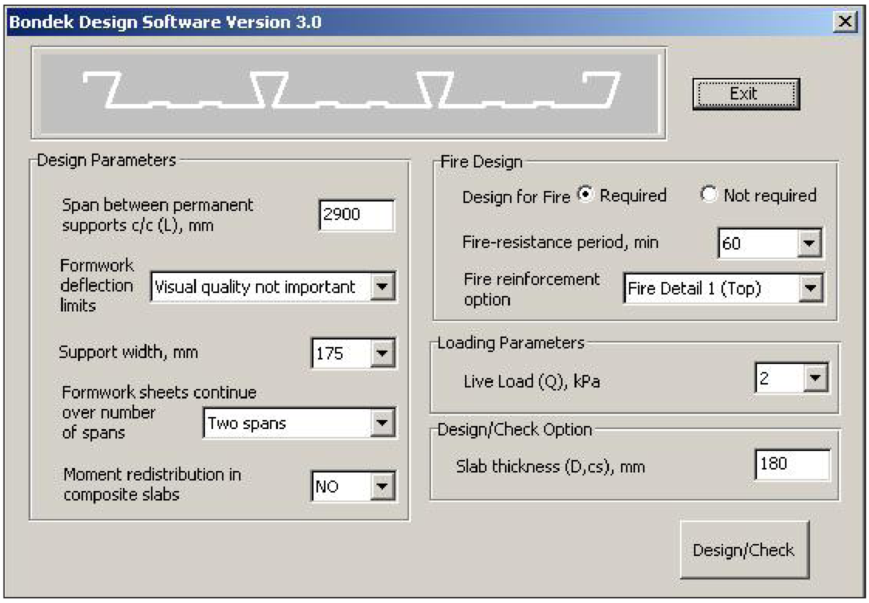


Figure 31

Design/Check dialogue box.



7.2 SLAB THICKNESS

The slab thickness may vary from 95 to 250mm. The user shall type in the necessary slab thicknesses. Slabs thicknesses of more than 250mm are considered as not practical. contact Steel Direct or your local technical sales representative to design slabs with more than 250mm thickness. (Contact details are on back cover.)

Figure 32

Slab thickness.

8.0 Results window

8.1 GENERAL

The **Results window** will appear on the screen automatically when the user clicks the **Design** or **Design/Check** buttons on the relevant Dialogue box. Alternatively, the window may be opened by clicking on the **Results** worksheet at the bottom of the Excel window.

The window shows the design summary **(Design Output)** and the list of entered parameters in **Input, Design** or **Design/Check** dialogue boxes **(Input parameters)**.

Figure 33

Results window.

Bondek Typical

Design Output

Parameter	Notation	Spans: Single	End	Interior
Slab thickness	D,cs (mm)	180		
Top (negative) reinforcement over supports:	A's (mm^2)	Not applicable		
Pattern of negative reinforcement		Not applicable		
Concrete cover	c (mm)	30		
Transverse (shrinkage/temperature effects) reinforcement, additional for D500L, total for D500N	Ashr (mm^2)	220		
Fire reinforcement (additional to shrinkage and negative reinforcement)	Afire (mm^2)	0		
Bottom tensile (positive) reinforcement (additional to Bondek sheeting)	A+,mid (mm^2)	0		
Number of temporary props		1		

Input parameters

Type of Buildings	**Steel Frame**	Negative Reinforcement Diameter	**-**
Span Configuration	**Single Spans**	Negative Reinforcement Grade	**D500N**
Continuous Spans	**-**		
Exposure Classification	**A1**	D,cs	**180**
Ll/Ls	**-**		
Deflection Limits of	**Total <L/250**	Bondek sheeting	**0.75 mm**
Composite Slabs	**NO**		
L,eff, mm	**2900**	Q live load	**2 kPa**
Formwork Deflection Limits	**Visual quality not important**	G superimposed dead load	**1kPa**
Formwork sheets continue over number of spans	**Two spans**	Q weight of stacked materials construction stage 1	**4kPa**
		ψs	**0.7**
Crack control for shrinkage and temperature effects	**Minor**	ψl	**0.4**
		Fire Design	**Required**
Crack control for flexure	**-**	Fire Resistance Periods	**60 min**
f'c	**32MPa**		
Shrinkage Reinforcement Grade	**D500N**	Fire Reinforcement Options	**Fire Detail 2 (Bottom)**
Mesh or transverse bar diameter, mm	**N12**	Positive and Fire Reinforcement bar diameter, mm	**12mm**
Mesh longitudinal bar diameter, mm	**N10**	Environment for shrinkage	**Other**
Mesh longitudinal bar spacing, mm	**300**	Cover to top reinforcement, mm	**30**
		Support width, mm	**175**

The reinforcement types in the Design Output table is explained in the following Figures:

Figure 34

Typical slab cross section showing common terms.

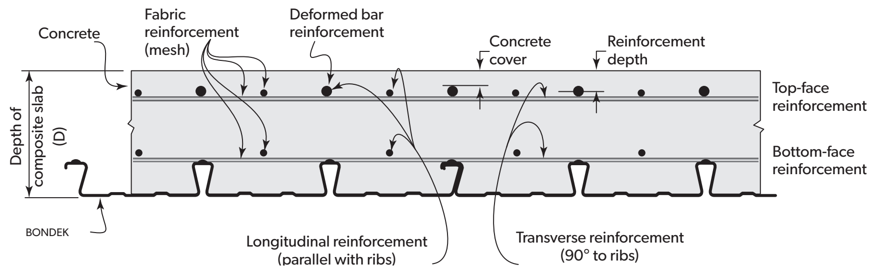


Figure 35

Pattern 1 for conventional reinforcement.

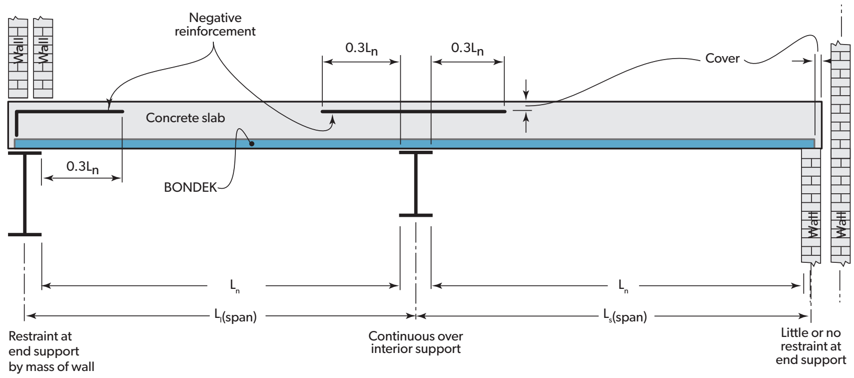
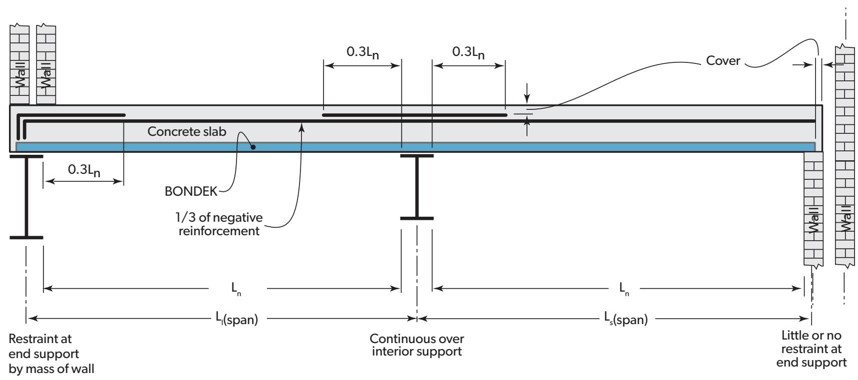


Figure 36

Pattern 2 for conventional reinforcement when imposed load exceeds twice the dead load.



1. Positive/bottom - Fire detail 2 reinforcement shall be placed within permissable zone as shown on Figure 39. Recommended bottom location of fire reinforcement is chosen for practical reasons (to place fire bars on transverse bars). See Figure 39. Lower location of fire bars with cover down to 20mm from soffit may give more economical results. Consult your local Technical Sales Representative for the most economical design.

2. Positive tensile reinforcement is given as extra area to fire reinforcement (Fire detail 2) and may be placed outside the permissible zone. Alternatively, fire bars (Fire detail 2) may be specified with increased diameter to satisfy requirements for positive tensile reinforcement.

Figure 37

LYSAGHT BONDEK® for single spans.

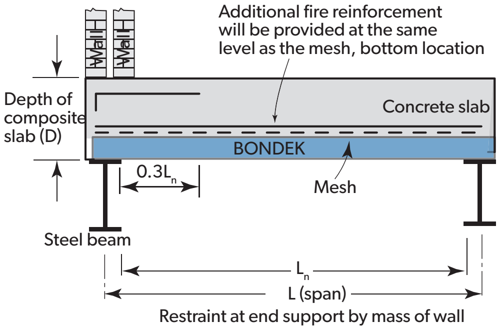
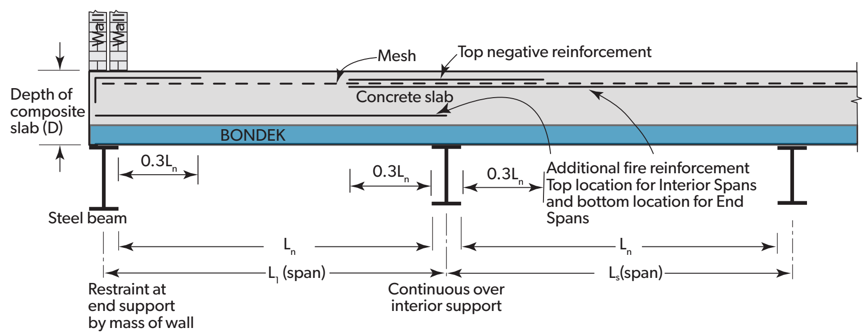


Figure 38

LYSAGHT BONDEK® continuous spans.



Note: 1/3 top negative reinforcement shall continue all over the span if ratio of live load to total dead load is more than 2.

Figure 39

Permissable zone for location of longitudinal fire reinforcement for Fire detail 2.

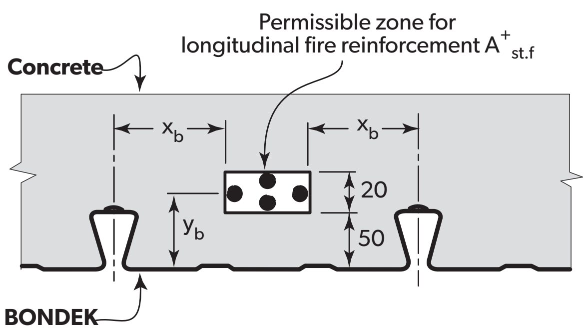
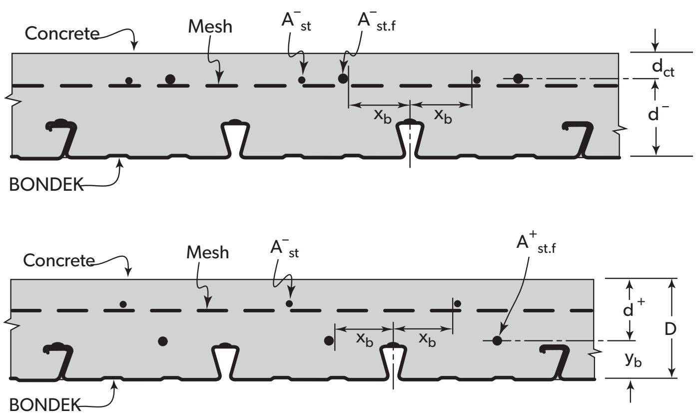


Figure 40

Details of reinforcement for fire design.



9.0 Warning messages

SLAB CANNOT BE DESIGNED TO SPECIFIED THICKNESS

This message means that the minimum possible slab thickness shall be more than specified by the user using Design/Check option. The user may:

- Increase slab thickness specified using Design/Check option
- Reduce minimum required slab thickness by:
- Increasing concrete grade
- Decreasing Tensile and Compression reinforcement bar size
- Increasing slab deflection limit to L/250

All input parameters shall be checked if adequate.

SLAB THICKNESS SHALL BE WITHIN 95MM TO 250MM

This means that slab thickness entered is not correct.

250mm is considered as the maximum practical slab thickness.

Contact Steel Direct if you still want to design deeper slabs.

THIS MEANS THAT THE SLAB SPAN ENTERED IS OUTSIDE ALLOWED LIMITS.

TENSILE & COMPRESSION REINFORCEMENT BAR SIZE HAVE NOT BEEN ENTERED

Self explanatory.

FIRE REINFORCEMENT BAR SIZE HAS NOT BEEN ENTERED

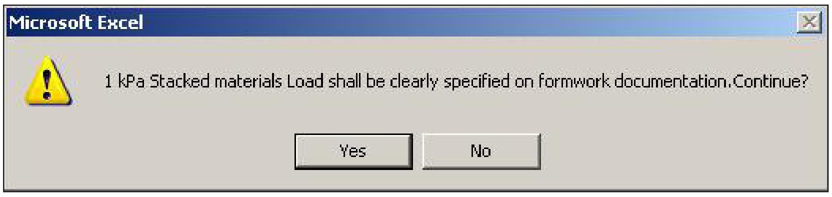
Self explanatory.

SPECIFY CORRECT NUMBER OF SPANS FOR CONTINUOUS SLABS

This message may appear when the user designs first continuous span as an end double span and then tries to design interior span (as double span). The interior span shall be specified for continuous slabs with three or more spans.

1 KPA STACKED MATERIALS LOAD SHALL BE CLEARLY SPECIFIED ON FORMWORK DOCUMENTATION. CONTINUE?

The user may choose Yes and continue with the design. However, 1 kPa load shall be clearly specified on design documentation and controlled on a construction site.

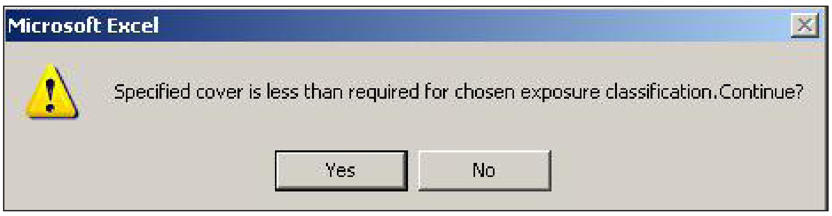


TRANSVERSE BAR SIZE HAS NOT BEEN ENTERED

Self explanatory.

SPECIFIED COVER IS LESS THAN REQUIRED FOR CHOSEN EXPOSURE CLASSIFICATION

Self explanatory. User may choose Yes and continue the design. However, the design is not according to the AS 3600:2009 as the cover is less than specified.



10.0 Report - Sample Pages

Bondek

Job Name: **Bondek Typical**

INPUT PARAMETERS:

Type of building			Steel frames
Span configuration			End Spans
Continuous spans			Two spans
Ratio of shorter to longer spans			up to 1.2
Slab thickness	Dc	mm	175
Density of concrete:	ρg	kg/m^3	2400
Concrete grade			32MPa
Concrete slab span, centre to centre	L	mm	2900
Exposure classification			A1
(AS 3600-2009, Table 4.3)			
Reinforcement (negative, positive, fire) grade			D500N
(AS 36000-2009, Table 3.2.1)			
Reinforcing (positive, fire) bar diameter		mm	12
Reinforcing negative bar diameter		mm	12
Deflection limits of composite slabs			Total <L/250
(AS 3600-2009, Table 2.3.2)			
Degree of control for shrinkage and temperature effects			Minor
Shrinkage mesh grade			D500L
(AS 3600-2009, Table 3.2.1)			
Mesh or transverse bar diameter			SL102
Mesh longitudinal bar diameter (if D500N)		mm	-
Mesh longitudinal bar spacing (if D500N)		mm	-
Concrete cover		mm	20
(AS 3600-2009, Table 4.10.3.2)			
Slab acting compositely with steel beams or used as diaphragm			NO
Environment for shrinkage strains			Arid (interior)
Formwork sheets continue over number of spans			Two spans
Formwork deflection limit			Visual quality not important
(AS 2327.1-2003, Clause C2)			
Bondek base metal thickness	t	mm	0.75
Permanent support width		mm	175
Superimposed dead load	Gsup	kPa	1
Live Load	Q	kPa	1.5
Load factor	ψ_s		0.7
Load factor	ψ_l		0.4
Construction loads due to to weight of stacked materials	M	kPa	4
(AS 3610-1995, Clause 4.4)			
Fire resistance level	FRL	min	60 min
(Building Codes of Australia)			
Load factor for imposed loads during fire			Fire Detail 1 (Top)
Full crack control for flexure is required			YES
(AS 3600-2009, Table 9.4.1)			

Formwork design

Number of temporary props			**1**
PROPERTIES OF BONDEK:			
Moment capacity in positive bending	ϕM^{+}_{u}	kNm	4.89
Negative bending moment at support	M^{-}_{u}	kNm	0.9
(used in partial plastic analysis)			
Shear (web crippling) capacity	ϕV_u	kN	25.2
Effective Second Moment of Area			
(for serviceability calcs.)	Ieff,ser	mm^4	284500.0
Yield stress	f_y	MPa	550.0
(AS/NZS 4600:2005, Table 1.5)			
Young's modulus of elasticity			200000
(AS/NZS 4600:2005, Table 1.4)			
DESIGN LOADS:			
Self weight of sheeting	G_{sh}	kPa	0.10
Self weight of concrete and reinforcement	G_c	kPa	4.35
Concentrated Live Load	Q_c	kPa	3.0
Concentrated Live Load UDL equivalent	$Q_{c,equiv}$	kPa	3.00
Load from stacked materials	M	kPa	4.0
Live Load	Q_{uv}	kPa	1.0
(AS 3610-1995, Clause 4.4)			
Concentrated point load	Q_p	kN	2.0
Self weight of reinforcement	Q_r	kPa	0.1
(AS 2327.1-2003, Clause F2)			
LOAD COMBINATIONS:			
Strength:			
Stage 1(before placing concrete):			
$F_{dIa} = 1.2*G_{sh}+1.5*Q_{uv}+1.5Q_M$		kPa	7.6
$F_{dIb} = 1.2*G_{sh}+1.5*Q_r+Q_p$			
Stage 2(after placing concrete):			
$F_{dIIa} = 1.2*G_{sh}+1.2G_c+1.5*Q_{uv}$		kPa	6.8
$F_{dIIb} = 1.2*G_{sh}+1.2G_c+Q_c$			8.3
Serviceability:			
$F_{def} = G_{sh}+G_c$		kPa	4.4
(AS 3610-1995, Table 4.5.1)			
DESIGN FOR STRENGTH:			
Maximum positive bending moment	M*	kNm	1.54
$M^* < \phi M^{+}_{u}$			**OK**
Maximum shear force	F^*_v	kN	5.7
$F^*_v < \phi V_u$			**OK**
Combined bending and shear			
Not applicable for partial plastic analysis			
DESIGN FOR SERVICEABILITY:			
Deflections	Δtot	mm	2.5
Deflection limits	$\Delta tot,max$	mm	11.2
$\Delta tot < MIN(\Delta tot,max)$			**OK**

Composite slab design

MATERIAL PROPERTIES AND SLAB GEOMETRY:

Yield stress of mesh reinforcement	f_y	MPa	500
Bondek sheeting yield stress	$f_{y,sh}$	MPa	550
Yield stress of reinforcing bars	$f_{y,bar}$	MPa	500
Longitudinal shear capacity *(EN 1994-1-1:2005, Clause B.3.6)*	$\tau_{u,Rd}$	MPa	431.11
Ratio of compressed stress block	γ		0.826
Long term shrinkage and creep factor *(AS 3600-2009, Clause 8.5.3.2)*	k_{sc}		1.646
Modulus of elasticity of concrete *(AS 3600-2009, Clause 3.1.2)*	E_c	MPa	28600
Shrinkage induced tensile stress *(AS 3600-2009, Clause 8.5.3.1)*	σ_{cs}	MPa	0.7982
Depth of Bondek	h_r	mm	55
Distance from centroidal axis of Bondek to extreme fibre in tension	$y_{sh,eff}$	mm	13.643
Effective cross-sectional area of Bondek *(EN 1994-1-1:2005, Clause 9.7.2)*	A_{pe}	mm^2	1200.75

LOADING:

Concrete slab self weight (concrete, reinforcement and sheeting)	G	kPa	4.30
Superimposed Dead Load	G_{sup}	kPa	1
Live Load	Q	kPa	1.5

LOAD COMBINATIONS:

Strength: 1) Fu=1.2*G + 1.5*Q (all spans, adjucent, alternate spans)	kPa	8.61
1) Fu=1.5*G (the rest of spans)	kPa	6.36
(AS/NZS 1170.0:2002) *(AS 3600-2009, Clause 2.4.4)*		
2) Fu=1.35*G + 1.5*Q (all spans, adjucent, alternate spans)	kPa	9.40
2) Fu=1.5*G (the rest of spans)	kPa	7.15
(EN 1990:2002, Section 6)		
Deflections:		
Total propped $F_{s,tp} = (1+k_{sc})G + (\psi_s + k_{cs}\psi_l)Q$	kPa	16.06
Total unpropped $F_{s,tup} = (1+k_{sc})G_{sup} + (\psi_s + k_{cs}\psi_l)Q$	kPa	N/A
Incremental propped $F_{s,ip} = k_{sc}G + (\psi_s + k_{cs}\psi_l)Q$	kPa	10.76
Incremental unpropped $F_{s,iup} = k_{sc}G_{sup} + (\psi_s + k_{cs}\psi_l)Q$	kPa	N/A
(AS 3600-2009, Clause 8.5)		

DESIGN FOR STRENGTH:

Area of additional positive reinforcement	$A_{,pos}$	mm^2	**0**
Area of mesh in longitudinal direction contributing to sagging bending resistance	$A_{.mesh}$	mm^2	**0**
Area of additional negative reinforcement over supports	$A_{,neg}$	mm^2	**110**
ACTION EFFECTS:			
Bending Moment at 1/6 span	M_2**	kNm	3.4
Bending Moment at 1/3 span	M_3**	kNm	5.4
Bending Moment at 1/2 span	M_4**	kNm	6.1
Maximum shear force at end support	V_{esp}*	kN	9.1
(EN 1990;2002, Section 6)			
Bending Moment at interior supports	M_{isp}**	kNm	9.0
Maximum shear force at interior support	V_{isp}*	kN	14.1
(AS/NZS 1170.0:2002)			
(AS 3600-2009, Clause 2.4.4)			
POSITIVE SHEAR CAPACITY :			
Basic design shear strength	$\tau_{u,Rd}$	MPa	431.11
Effective depth of cross-section	d_p	mm	161.357
Reinforcement ratio	ρ_l		0.0010
Effective area of reinforcement in tension	Aeff	mm^2	147.4
Shear parameter	ν		0.54
Design concrete strength in compression	f_{cd}	MPa	21.3
Characteristic concrete strength in compression	f_{ck}	MPa	32
Design shear resistance	V_{Rd1}	kN	87.2
Design shear resistance	V_{Rd2}	kN	744.5
(EN 1992-1-1:2004, Clause 4.3.2.3)			
V_{esp}*<MIN(V_{Rd1},V_{Rd2})			**OK**
SAGGING BENDING RESISTANCE :			
Reduction factor for sheeting	γ_{M1}		1.1
Reduction factor for reinforcement	γ_s		1.15
Reduction factor for concrete	γ_c		1.5
Design value of compressive force in concrete flange with full shear connection	N_{cf}		600.375
Design value of compressive force in concrete flange at 1/6 span	$N_{c,2}$	kN	118.6
at 1/3 span	$N_{c,3}$	kN	274.8
at 1/2 span	$N_{c,4}$	kN	431.1
Plastic section modulus of effective Bondek cross section	Z_{eff}	mm^3	15916.25
Design value of plastic resistance moment of ondek effective cross-section	M_{pa}	kNm	8.0
Reduced plastic resistance moment of Bondek at 1/6 span	$M_{pr,2}$	kNm	8.0
at 1/3 span	$M_{pr,3}$	kNm	5.4
at 1/2 span	$M_{pr,4}$	kNm	2.8
(EN 1994-1-1:2005, Clause 9.7.2)			
Parameters without contribution of additional positive reinforcement:			
Distance between plastic neutral axis and extreme fibre of concrete in compression at 1/6 span	$x_{p1,2}$	mm	6.5
at 1/3 span	$x_{p1,3}$	mm	15.2
at 1/2 span	$x_{p1,4}$	mm	23.8
Lever arm at 1/6 span	$z_{1,2}$	mm	164.3
at 1/3 span	$z_{1,3}$	mm	148.4
at 1/2 span	$z_{1,4}$	mm	140.9
Design value of resistance of composite slab at 1/6 span	$M_{Rd,2}$	kNm	27.4
at 1/3 span	$M_{Rd,3}$	kNm	46.2
at 1/2 span	$M_{Rd,4}$	kNm	63.5
x<0.4D at 1/6 span			**OK**
at 1/3 span			**OK**
at 1/2 span			**OK**
(EN 1994-1-1:2005, Clause 9.7.2)			

DESIGN FOR STRENGTH:

Parameters with contribution of additional positive reinforcement:			
Tension force in positive reinforcement	N_{as}	kN	0.0
Distance between plastic neutral axis and extreme			
fibre of concrete in compression at 1/6 span	$x_{p1,2}$	mm	6.5
at 1/3 span	$x_{p1,3}$	mm	15.2
at 1/2 span	$x_{p1,4}$	mm	23.8
Lever arm for Bondek at 1/6 span	$z_{1,2}$	mm	164.3
at 1/3 span	$z_{1,3}$	mm	148.4
at 1/2 span	$z_{1,4}$	mm	140.9
Lever arm for positive reinforcement at 1/6 span	$z_{2,2}$	mm	101.2
at 1/3 span	$z_{2,3}$	mm	96.9
at 1/2 span	$z_{2,4}$	mm	92.6
Design value of resistance of composite slab			
at 1/6 span	$M_{Rd,2}$	kNm	27.4
at 1/3 span	$M_{Rd,3}$	kNm	46.2
at 1/2 span	$M_{Rd,4}$	kNm	63.5
$x<0.4D$ at 1/6 span			OK
at 1/3 span			OK
at 1/2 span			OK
(EN 1994-1-1:2005, Clause 9.7.2)			
Positive reinforcement is at yield at 1/6 span			OK
at 1/3 span			OK
at 1/2 span			OK
(EN 1994-1-1:2005, Clause 9.7.2)			
Final sagging bending resistance:			
at 1/6 span	$M_{Rd,2}$	kNm	27.4
at 1/3 span	$M_{Rd,3}$	kNm	46.2
at 1/2 span	$M_{Rd,4}$	kNm	63.5
$M2^*<M_{Rd,2}$			**OK**
$M3^*<M_{Rd,3}$			**OK**
$M4^*<M_{Rd,4}$			**OK**

NEGATIVE SHEAR CAPACITY :

Distance from extreme compression fibre of concrete to centoid of outermost layer of tensile reinforcement	do	mm	148.0
Cross sectional area of tension reinforcement	A_{st}	mm^2	464.0
Shear strengh excluding shear reinforcement *(AS 3600-2009, Clause 8.2.7.1)*	ϕV^-_{uc}	kN	76.9
Shear srength limited by web crushing *(AS 3600-2009, Clause 8.2.6)*	$\phi V^-_{u.max}$	kN	663.2
$V_{isp}^*<MIN(\phi V^-_{uc},\phi V^-_{u.max})$			**OK**

HOGGING BENDING RESISTANCE :

Neutral axis parameter, (mesh reinforcement included)	$k_{u,tot}$		0.07
Neutral axis parameter, (only additional neg. reinforcement)	$k_{u,neg}$		0.02
Bending moment capacity, (mesh reinforcement included)	ϕM^-_{tot}	kNm	21.3
Bending moment capacity, (only additional neg. reinforcement)	ϕM^-_{neg}	kNm	6.5
Shrinkage mesh is at yield			**TRUE**
Bending moment capacity, final	ϕM^-_{final}		21.3
Characteristic tensile strength of concrete	f_{ct}	MPa	3.4
Minimum ultimate strengh in bending	$\phi M^-_{uo,min}$	kNm	21.0
$k_{uo} < 0.36$			**OK**
$\phi M^-_{final} > MAX(\phi M^-_{uo,min}; M_{isp}^*)$			**OK**
(AS 3600-2009, Clause9.1.1, 8.1.1 to 8.1.6)			

DESIGN FOR SERVICEABILITY:

DEFLECTIONS:

Deflection limit for total loads	Δ_{tot}	mm	11.6
Deflection limit for incremental loads	Δ_{inc}	mm	5.8
Second moment of area, Bondek	$I_{ef,sh}$	mm^4	658248
Depth of concrete cross section in compression, positive	$y^+_{cc,uncracked}$	mm	88.8
Gross second moment of area of concrete cross section, positive	I^+_g	mm^4	487486330
Depth of concrete cross section in compression, positive	$y^+_{cc,cracked}$	mm	43.7
Cracked second moment of area of concrete cross section, positive	$I^+_{cracked}$	mm^4	149235649
Bending moment causing cracking, positive	M^+_{cr}	kNm	14.67
Bending moment based on short term serviceability load, positive	M^+_s	kNm	4.11
Effective second moment of area of concrete cross section, positive	I^+_{ef}	mm^4	487486330
Depth of concrete cross section in compression, negative	$y^-_{cc,uncracked}$	mm	85.0
Gross second moment of area of concrete cross section, negative	I^-_g	mm^4	438781237
Depth of concrete cross section in compression, negative	$y^-_{cc,cracked}$	mm	146.0
Cracked second moment of area of concrete cross section, negative	$I^-_{cracked}$	mm^4	53464757
Bending moment causing cracking, negative	M^-_{cr}	kNm	17.13
Bending moment based on short term serviceability load, negative	M^-_s	kNm	5.74
Effective second moment of area of concrete cross section, negative	I^-_{ef}	mm^4	263268742
Effective second moment of area of concrete, total	I_{ef}	mm^4	375377536
Deflections due to total load, propped	$\delta_{tot,pr}$	mm	0.7
Deflections due to total load, unpropped	$\delta_{tot,unpr}$	mm	N/A
Deflections due to incremental load, propped	$\delta_{inc,pr}$	mm	0.5
Deflections due to incremental load, unpropped	$\delta_{inc,unpr}$	mm	N/A
(AS 3600-2009, Clause 8.5.3)	$\delta_{tot,pr} < \Delta_{tot}$		**OK**
	$\delta_{tot,unpr} < \Delta_{tot}$		**N/A**
	$\delta_{inc,pr} < \Delta_{inc}$		**OK**
	$\delta_{inc,unpr} < \Delta_{inc}$		**N/A**

TRANSVERSE REINFORCEMENT TO CONTROL SHRINKAGE AND TEMPERATURE EFFECTS:

Total area of shrinkage reinforcement necessary	$A_{shrink, tot}$	mm^2	210
Additional to specified area of shrinkage reinforcement necessary	A_{shrink}	mm^2	**0**

(AS 3600-2009, Clause 9.4.3.4)

CRACK CONTROL FOR FLEXURE

Minimum tensile reinforcement in addition to specified mesh	$A_{,min}$	mm^2	**0**
(AS 3600-2009, Clause 9.1.1)			
(AS 3600-2009, Clause 9.4.1)			
Area of mesh in tensile zone	$A_{,mesh, ten}$	mm^2	354
Maximum steel stress for flexure	f_{st}	MPa	296.72064
Area of concrete in the tensile zone	A_{ct}	mm^2	85231
Critical zone applies			FALSE
Minimum area of reinforcfement in a tensile zone	$A_{,st,min}$	mm^2	**0.000**
Maximum spacing	s	mm	167.6
Maximum spacing is satisfactory			**TRUE**
Bending moment at serviceability	$M^*_{s,prop}$	kNm	6.67
Bending moment at serviceability (ψ=1)	$M^*_{s.1,prop}$	kNm	7.15
Critical moment for cracking	$M_{,crit}$	kNm	15.36
Steel stress	$f_{,scr.prop}$	MPa	104.76
Steel stress (ψ=1)	$f_{,scr.prop(1)}$	MPa	112.19
$f_{,scr} < f_{,st}$			TRUE
$f_{,scr1} < 0.8 f_{,sy}$			TRUE
Final crack control			**TRUE**

(AS 3600-2009, Clause 9.4)

Fire design

Fire detail 1 (top):			
Reinforcement mesh capacity reduction factor	R^{-}_{mesh}		1.00
Fire reinforcing bars capacity reduction factor	R^{-}_{st}		1.000
Concrete capacity reduction factor at support	$R^{-}_{ct,A}$		0
Concrete capacity reduction factor at point of top of negative reinforcement termination	$R^{-}_{ct,B}$		0
Distance from centoid of top negative reinforcement to to outer fibre of concrete in compression at support	y^{-}_{b}	mm	149
Fire load			
$w_f = 1.0^*G+\psi_c Q$	wf	kPa	5.90
Ineffective depth of concrete exposed to fire	$a_{,ineff}$	mm	0.00
Neutral axis parameter at support			
k<0.4			TRUE
Bending moment capacity at support	$\phi M^{-}_{uo,A}$	kNm	6.22
Bending moment capacity at poit of negative reinforcement termination	$\phi M^{-}_{uo,B}$	kNm	0.00
Distance from mesh reinforcement centroid to to outer fibre of concrete in compression at mid span	d^{+}_{mesh}	mm	27.25
Distance from bar reinforcement centroid to to outer fibre of concrete in compression at mid span	d^{+}_{bars}	mm	26.00
Concrete capacity reduction factor at mid span	$R^{+}_{ct,C}$		1.00
Bending moment capacity at mid span	$\phi M^{+}_{uo,C}$	kNm	14.85
Hinge A bending moments at:			
Point A (support)	$M_{,A}$	kNm	6.22
Point B (termination of reinforcement)	$M_{,B}$	kNm	-0.85
Point C (mid span)	$M_{,C}$	kNm	-3.48
Hinge B bending moments at:			
Point A (support)	$M_{,A}$	kNm	7.44
Point B (termination of reinforcement)	$M_{,B}$	kNm	0.00
Point c (mid span)	$M_{,C}$	kNm	-3.04
Structural adequacy, Hinge A			TRUE
Structural adequacy, Hinge B			N/A
Final results			**TRUE**
Fire detail 2 (bottom):			
Reinforcement mesh capacity reduction factor	R^{-}_{mesh}		1.00
Fire reinforcing bars capacity reduction factor	R^{-}_{st}		1
Concrete capacity reduction factor at support	$R^{-}_{ct,A}$		0
Concrete capacity reduction factor at point of top of negative reinforcement termination	$R^{-}_{ct,B}$		0
Distance from centoid of top negative reinforcement to to outer fibre of concrete in compression at support	y^{-}_{b}	mm	149
Fire load			
$w_f = 1.0^*G+\psi_c Q$	wf	kPa	5.90
Ineffective depth of concrete exposed to fire	$a_{,ineff}$	mm	6.00
Neutral axis parameter at support			
k<0.36			TRUE
Bending moment capacity at support	$\phi M^{-}_{uo,A}$	kNm	6.22
Bending moment capacity at poit of negative reinforcement termination	$\phi M^{-}_{uo,B}$	kNm	0.00
Distance from fire reinforcement centroid to to outer fibre of concrete in compression at mid span	d^{+}_{fire}	mm	N/A
Concrete capacity reduction factor at mid span	$R^{+}_{ct,C}$		1.00
Bending moment capacity at mid span	$\phi M^{+}_{uo,C}$	kNm	14.85
Hinge A bending moments at:			
Point A (support)	$M_{,A}$	kNm	6.22
Point B (termination of reinforcement)	$M_{,B}$	kNm	-0.85
Point C (mid span)	$M_{,C}$	kNm	-3.48
Hinge B bending moments at:			
Point A (support)	$M_{,A}$	kNm	7.44
Point B (termination of reinforcement)	$M_{,B}$	kNm	0.00
Point c (mid span)	$M_{,C}$	kNm	-3.04
Structural adequacy, Hinge A			TRUE
Structural adequacy, Hinge B			N/A
Final results			**TRUE**

11.0 Software

Download your free copy of BONDEK® Design Software from:

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