

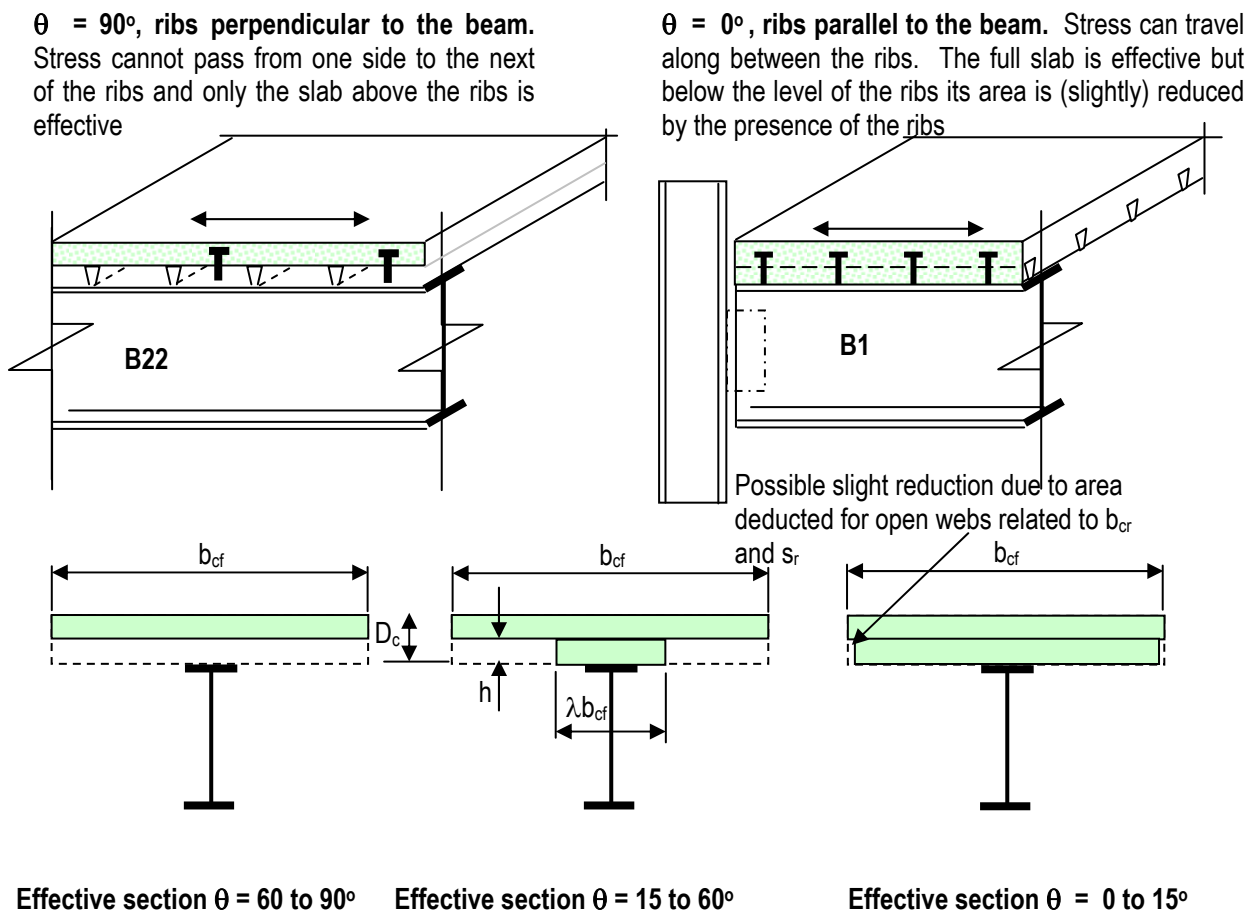
Appendix II Theory and discussion - composite beams

1 Limit state criteria for prediction of the design capacity of a composite beam

Refer to AS2327.1 for symbols and nomenclature used in this appendix. You may choose to refer immediately to the 'Postscript' to this Appendix that provides a simplistic summary of the primary basis of this Appendix. Unlike AS3600, AS2327.1 does not explicitly declare the basis on which the design capacities shall be assessed. In place of this, Appendix D of AS2327.1 gives a series of formulae that predict the capacity in various situations. It is considered worthwhile to look behind these formulae to 'discover' the simple limit state criteria on which the formulae are based. The following represents some of the underlying logic behind the formulae

2 Effective sections

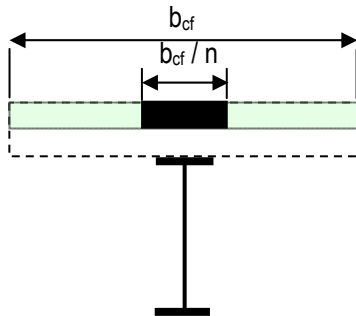
- **The effective section of the steel beam may need to be reduced to take account of the effects of local buckling.** Refer AS2327.1 CI 5.2.3. These provisions are essentially identical to those in AS4100 with some additional complexity for web members because of the wide range of positions of the neutral axis in a composite beam. It is always conservative to ignore the AS2327.1 provisions and apply the AS4100 provisions assuming a non composite beam. Note from the AISC Design Capacity Tables that nearly all standard sections are compact. When designing with standard sections it is normally safe to ignore local buckling issues and to take the effective steel section as being the full section.
- **The effective (concrete) flange width is defined in AS2327.1 CI 5.2.2.** This is quite different to the effective flange width of a reinforced concrete T beam in accordance with AS3600 (and generally smaller). The concrete below the level of the ribs may or may not contribute to the effective flange as shown.



3 Prediction of deflections and dynamic response.

The stiffness of the composite beam is assessed assuming linear elastic response of both the steel and the concrete and consequently normal methods may be used for finding the centroids and second moments of area of the (transformed) composite section.

$$\begin{aligned} \text{ie } Y_{\text{bar}} &= \Sigma A_i y_i / \Sigma A_i \\ \text{And } I_{\text{total}} &= \Sigma I_i + \Sigma A_i (y_i - Y_{\text{bar}})^2 \end{aligned}$$



The modular ratio $n = E_s / E_c$.

Refer to AS2327.1 Appendix B3.

For assessing short term deflections $E_{c,\text{short}}$ is the normal value from AS3600 ($E_c = \rho^{1.5} 0.043 f_{cm}^{0.5}$ with $f_{cm} = 1.1f_c + 4$)

To take account of creep when assessing long term deflections

$$E_{c,\text{long}} = E_{c,\text{short}} / 3.$$

For dynamic effects a value of $E_{c,\text{dyn}} = 1.35 \times E_{c,\text{short}}$ may be used.

Effective section transformed to steel

Corresponding to the three values of E_c there are three corresponding values of $I_{\text{transformed}}$. To account for some loss of stiffness due to 'shear slip' with partial shear connection, refer to AS2327.1 Cl B3.4.

4 The force in the concrete flange of a composite beam

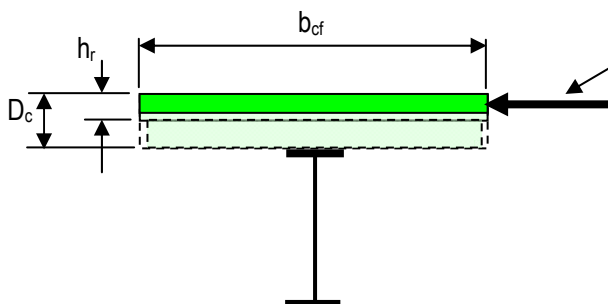
The force in the effective concrete flange of a composite beam at the strength limit state can be limited by three separate issues:

- The maximum force that the full area of the concrete flange can carry assessed as $0.85f_c \times A_{\text{eff}}$ (where A_{eff} is the sum of the effective areas above and below the level of the ribs).
- The maximum force that the steel can carry in tension (assuming all steel stressed to f_{sy}). That is the concrete force cannot exceed the total potential tension force in the steel beam.
- The maximum force that the shear studs can transfer across the steel to concrete shear interface

F_{cc} as defined in AS2327.1 is dependent on the first two issues as:

$$\begin{aligned} F_{cc} &= \text{Minimum of (Potential comp. force in concrete flange; Potential tension force in steel beam)} \\ &= \text{Minimum of } [(0.85 f_c A_{\text{eff}}) ; (2 \times A_{\text{flange}} \times f_{sy,\text{flange}} + A_{\text{web}} \times f_{sy,\text{web}})] \end{aligned}$$

When F_{cc} is less than $0.85f_c A_{\text{eff}}$ then it is assumed that the concrete stress stays at $0.85f_c$ while the stress block depth reduces thus lifting the position of the resultant F_{cc} . That is the full available effective flange is not used. The same process is used with shear stud capacity limits the force in the concrete to F_{cp} .



When F_{cc} is limited by the steel capacity then only a portion of the potentially effective flange is used. The stress in the concrete is assumed to stay at its full value ($0.85f_c$) while the depth of the stress block reduces thus raising the line of action of the resultant F_{cc} .

The maximum force that the shear studs can transfer across the steel to concrete shear interface is $n k_n \phi f_{vs}$ with:



Composite Design Example for Multistorey Steel Framed Buildings

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FIRST EDITION 2007 (LIMIT STATES)

National Library of Australia Cataloguing-in-Publication entry:

Durack, J.A. (Connell Wagner)

Kilmister, M. (Connell Wagner)

Composite Design Example for Multistorey Steel Framed Buildings

1st ed.

Bibliography.

ISBN 978-1-921476-02-0

1. Steel, Structural—Standards - Australia.
2. Steel, Structural—Specifications - Australia.
3. Composite, (Engineering)—Design and construction.
 - I. Connell Wagner
 - II. Australian Steel Institute.
 - III. Title

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Table of contents

Table of contents	iii
Preface	v
Section A: INPUT INFORMATION	1
A1. Client and Architectural Requirements	2
A2. Site Characteristics	4
A3. Statutory Requirements	5
A4. Serviceability	8
A5. Design Loads	9
A6. Materials and Systems	10
A7. Design Aids and Codes	11
Section B: CONCEPTUAL AND PRELIMINARY DESIGN	12
B1. Conceptual and Preliminary Design	13
B1.1 Consideration of alternative floor framing systems– Scheme A	14
B1.2 Consideration of alternative floor framing systems– Scheme B	15
B1.3 Framing system for horizontal loading – initial distribution of load	16
B1.4 Alternatives for overall distribution of horizontal load to ground	17
B2. Preliminary Slab Design	21
B3. From Alternatives to Adopted Systems	22
B3.1 Adopted floor framing arrangement	22
B3.2 Adopted framing arrangement for horizontal loading	23
B4. Indicative Construction Sequence and Stages	24
B4.1 The importance of construction stages in composite design	24
B4.1 Indicative construction sequence and construction stages	25
B4.2 Adopted construction sequence for design of erection columns	27
B4.3 Core construction alternatives	27
B4.4 Adopted construction method for the core	27
B5. Preliminary Sizing of Primary and Secondary Beams	28
B6. Plenum Requirements and Floor to Floor Height	30
B7. Preliminary Column Sizes and Core Wall Thickness	33
Section C: DETAILED DESIGN	35
C1. Detailed Design - Introduction	36
C2. Design Stages and Construction Loading	37
C3. Detailed Load Estimation After Completion of Construction	38
C3.1 Vertical loading	38
C3.2 Wind loading	39
C3.3 Seismic loading Not considered	40
C4. Erection Column Design	41
C4.1 Load distribution for erection column design	42
C4.2 Side Column C5 (typical of C5 to C10)	43
C4.3 End column C2 (typical of C2, C3, C12 and C13)	44
C4.4 Corner column C1 (typical of columns C1, C4, C11 and C14)	44
C5. Floor Beams – Construction Stage 1	45
C5.1 Secondary beams Group S1(11 050, 2800) (Beams B22 – B41, B43 – 48)	45
C5.2 Primary beams Group P1(9800, 5725) (Beams B1, B7 to B12, B18,	46
B19 – 21, B49 – 51 and B42)	46
C5.3 Primary beams Group P2(9250, 6600) (B2, B6, B13 and B17)	47
C6. Floor Beams – Construction Stage 3	48
C6.1 Secondary beams Group S1(11 050, 2800) (Beams B22 – 41, B43 – 48)	48
C6.2 Primary beams Group P1(9800, 5725) (Beams B1, B7 - B12, B18 – 21,	49
B49 – 51 and B42)	49
C6.3 Primary beams Group P2(9250, 6600) (Beams B2, B6, B13, B17)	49
C7 Floor Beam Design for Occupancy Loading	50
C7.1 Secondary beams Group S1(11 050, 2800) (Beams B19, B21, B22 - B41,	51
B43 – B49 and B51)	51



C7.2	Primary beams Group P1(9800,5725) (Beams B1, B7 to B12, B18)	58
C7.3	Primary beams group P2(9050, 6600) (Beams B2, B6, B13, B17)	63
C8.	Assessment of Dynamic Performance of Floor System	69
C8.1	Definition of the dynamic assessment process	69
C8.2	Application of the dynamic assessment process	73
C9	Final Slab Design	79
C9.1	Slab design for the office areas	79
C9.2	Slab design for the compactus areas	80
C10.	Longitudinal Shear Reinforcement Design	81
C10.1	Introduction	81
C10.2	Proprietary longitudinal shear reinforcement products	83
C10.3	Secondary beams group S1, B22 typical – longitudinal shear design	84
C10.4	Internal primary beams group P2, (B2 typical) longitudinal shear design	85
C10.5	Primary beams P1, (B1 typical) – longitudinal shear design	87
C10.6	Perimeter beams B19 to 21 and B49 to 51	88
C11.	Floor System Design Review and Final Decisions	89
C11.1	Floor design review	89
C11.2	Final floor framing plan and deck reinforcement	90
C12.	Final Design of RC Columns	91
C13.	Detailed Design of the Core	91
C13.1	Preliminary discussion and statement of limitations of this section	91
C13.2	Basic modelling of the core using beam elements	92
C13.3	The Space Gass Analysis Model	96
C13.4	Model verification and static deflections for W_s	97
C13.5	Dynamic analysis for natural frequency of building	98
C13.6	Interpretation and application of stress resultants from Space Gass	100
C13.7	Further investigation of the core using a Strand7 finite element model	102
C13.8	Review of core investigations	105
C14.	Steel Connection Design	106
C14.1	Can it be built?	106
C14.2	Representative connections	108
C14.3	Web side plate connection design for $V^* = 142$ kN	108
C14.4	Flexible end plate connection for $V^* = 279$ kN	112
C14.5	B2 to core web side plate connection for $V^* = 308$ kN	113
C14.6	Column splice for a load of $N^* = 1770$ kN	114
C14.7	Column base plate for a load of $N^* = 1770$ kN	115
C15.	Web Penetrations	116
C16.	Some Final Thoughts and Disclaimers	117
	Appendix I Theory and discussion – composite slabs	119
	Appendix II Theory and discussion - composite beams	133
	Appendix III Dynamic assessment of the floor system	149
	Appendix IV Theory and discussion steel connections	163
	Appendix V Corrosion and fire protection	175

