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

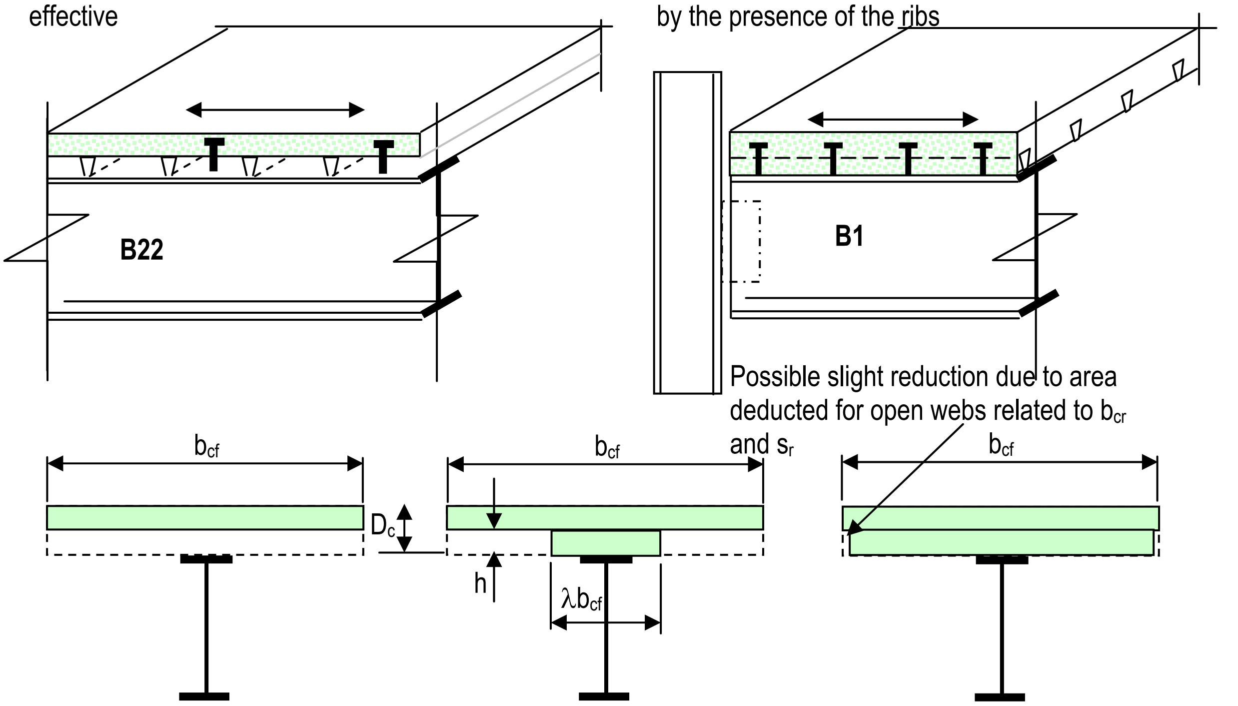
2 Effective sections

- **The effective section of the steel beam may need to be reduced to take account of the effects of local buckling.** Refer AS2327.1 Cl 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 Cl 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.

θ = 90°, ribs perpendicular to the beam. Stress cannot pass from one side to the next of the ribs and only the slab above the ribs is effective

θ = 0°, ribs parallel to the beam. Stress can travel along between the ribs. The full slab is effective but below the level of the ribs its area is (slightly) reduced by the presence of the ribs



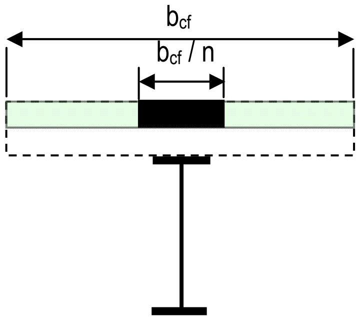
Effective section θ = 60 to 90° **Effective section θ = 15 to 60°** **Effective section θ = 0 to 15°**

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.

ie $Y_{bar} = \Sigma A_i y_i / \Sigma A_i$

And $I_{total} = \Sigma I_i + \Sigma A_i(y_i - Y_{bar})^2$



The modular ratio $n = E_s / E_c$.
Refer to AS2327.1 Appendix B3.
For assessing short term deflections $E_{c.short}$ 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 $E_{c.long} = E_{c.short} / 3$.
For dynamic effects a value of $E_{c.dyn} = 1.35 \times E_{c.short}$ may be used.

Effective section transformed to steel

Corresponding to the three values of E_c there are three corresponding values of $I_{transformed}$. 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 $0.85f'_c \times A_{eff}$ (where A_{eff} is the sum of the effective areas above and below the level of the ribs).

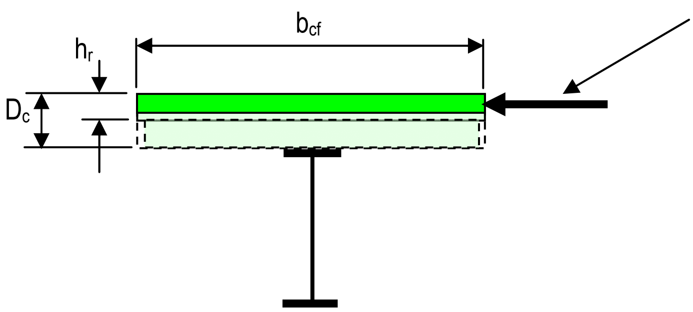
- The maximum force that the steel can carry in tension (assuming all steel stressed to f_{sy}). That is the concrete force cannot exceed the total potential tension force in the steel beam.

- 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:

F_{cc} = Minimum of (Potential comp. force in concrete flange; Potential tension force in steel beam)
= Minimum of $[(0.85\, f'_c\, A_{eff})\ ;\ (2 \times A_{flange} \times f_{sy.flange} + A_{web} \times f_{sy.web})]$

When F_{cc} is less than $0.85f'_c A_{eff}$ 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 $nk_n\phi f_{vs}$ with:

AUSTRALIAN STEEL INSTITUTE
(ABN)/ACN (94) 000 973 839

Composite Design Example for Multistorey Steel Framed Buildings

Published by: AUSTRALIAN STEEL INSTITUTE

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

Table of contents