

# Harmonising the Australian Standard AS4100: Steel Structures

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# Presentation Sequence

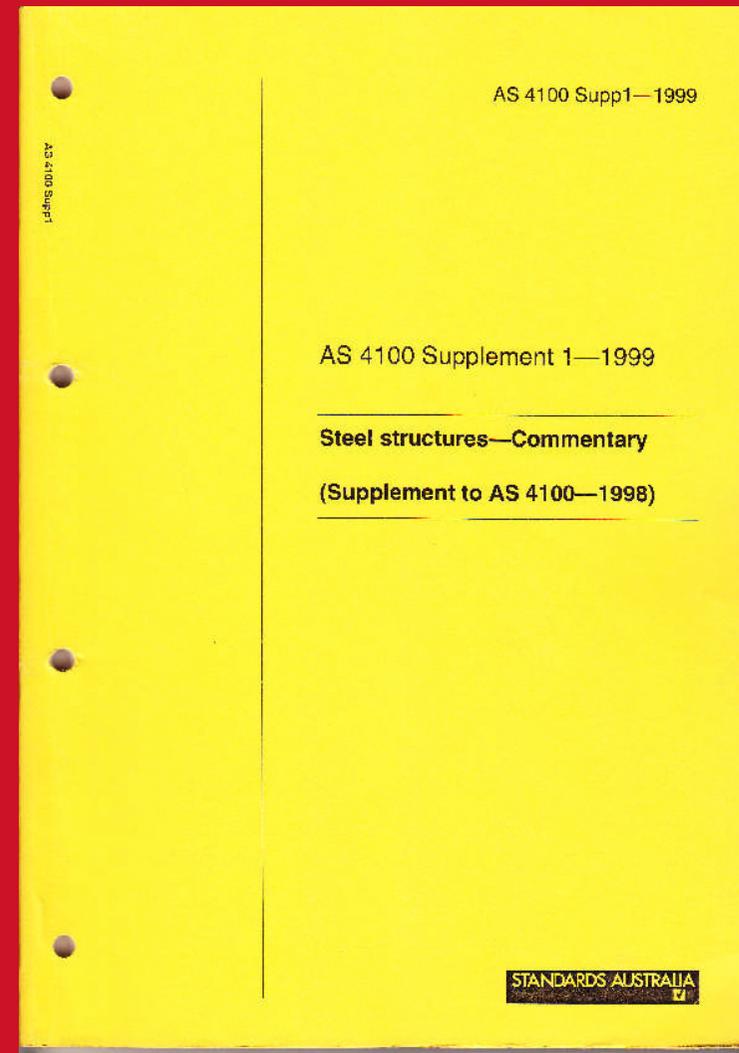
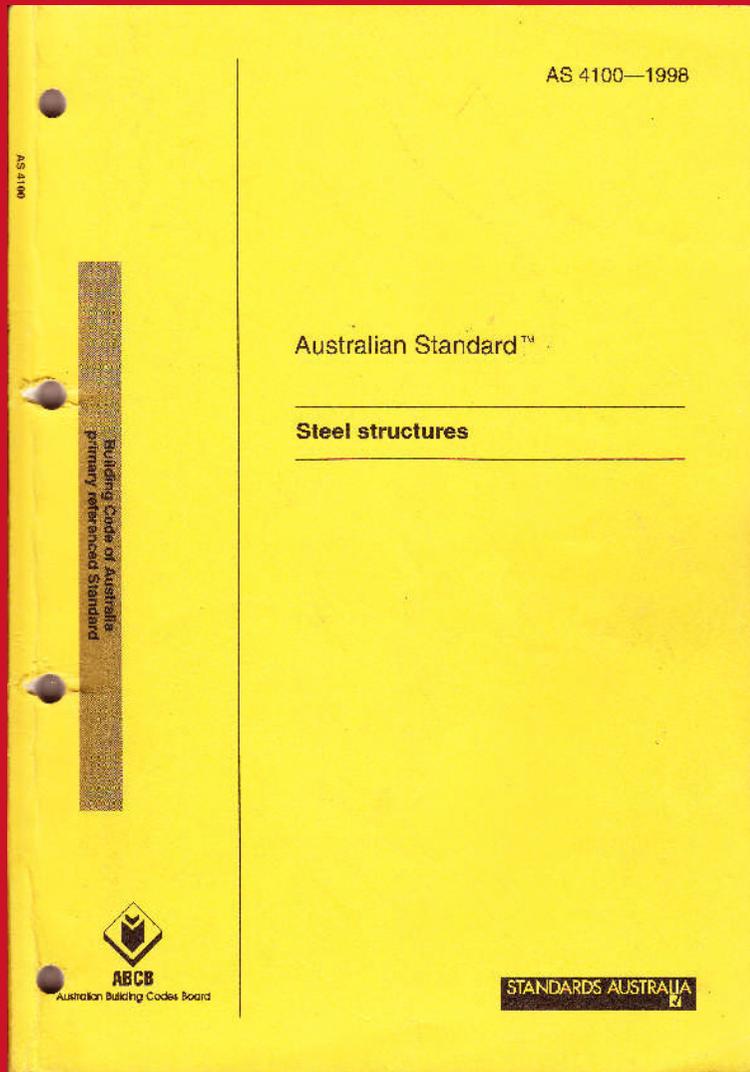
- History of the development of AS4100
- International Standards
- Three alternatives to harmonisation
- Comparison and differences between the International Standards
- Issues related to International Standards
- Costs and benefits
- Financing
- Alternative means of publication
- Conclusions





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# AS4100:1998 with Commentary





## History of the Development of AS 4100:1998 Steel Structures

- First edition AS CA1 1933 based on Canadian A16 and BS 449 and AISC rules at that time (revised 1939)
- Superseded by permissible stress AS1250 in 1972
- AS4100 first published in Limit States format in 1990
- Limit States methodology based on AISC LRFD  $\phi$  factors
- Calibration of  $\phi$  factors based on Australian materials data
- Republished in 1998 after 4 Amendments
- Amendment No. 1 published 29<sup>th</sup> February, 2012



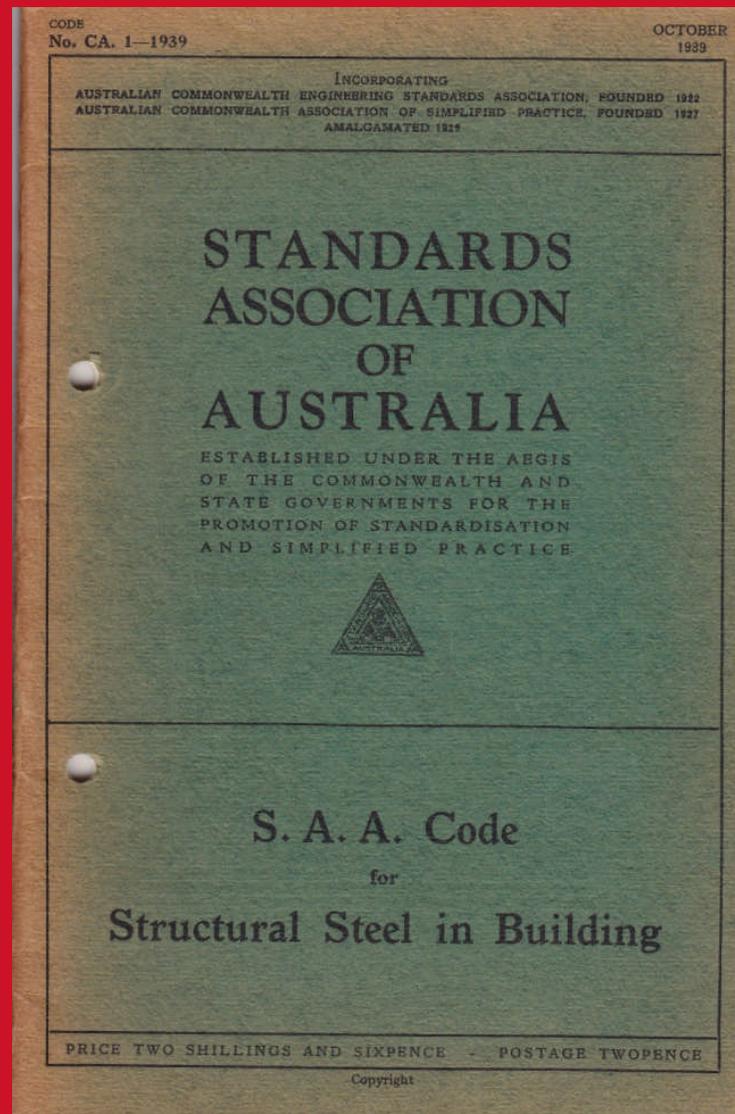
## Amendment No. 1 2012 (29<sup>th</sup> February 2012)

- Revisions to AS/NZS 1163, AS/NZS 3678, AS/NZS 3679 reflected in Sections 2 and 10
- Revisions to AS/NZS 1554.1, AS/NZS 1554.4 and AS/NZS 1554.5 reflected in Sections 9 and 10
- Section 13 Earthquake brought into line with AS 1170.4
- Quench and Tempered Steels included by adding AS3597 to listed steel
- Block shear included in Section 9 Connections
- Typographical errors corrected



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# 1939 Edition of AS CA1



# Eurocode 3 Steel Structures

- British version BS EN 1993-1 General rules and rules for buildings
- 12 parts EN 1993-1-1 to 1993-1-12
- National Annex (NA) British NA to BS EN 1993
- Concise Eurocodes prepared by Steel Construction Institute – P362 Steel Building Design
- Part 1993-1-1 General rules and rules for buildings
- Part 1993-1-5 Plated structural elements
- Part 1993-1-8 Design of joints

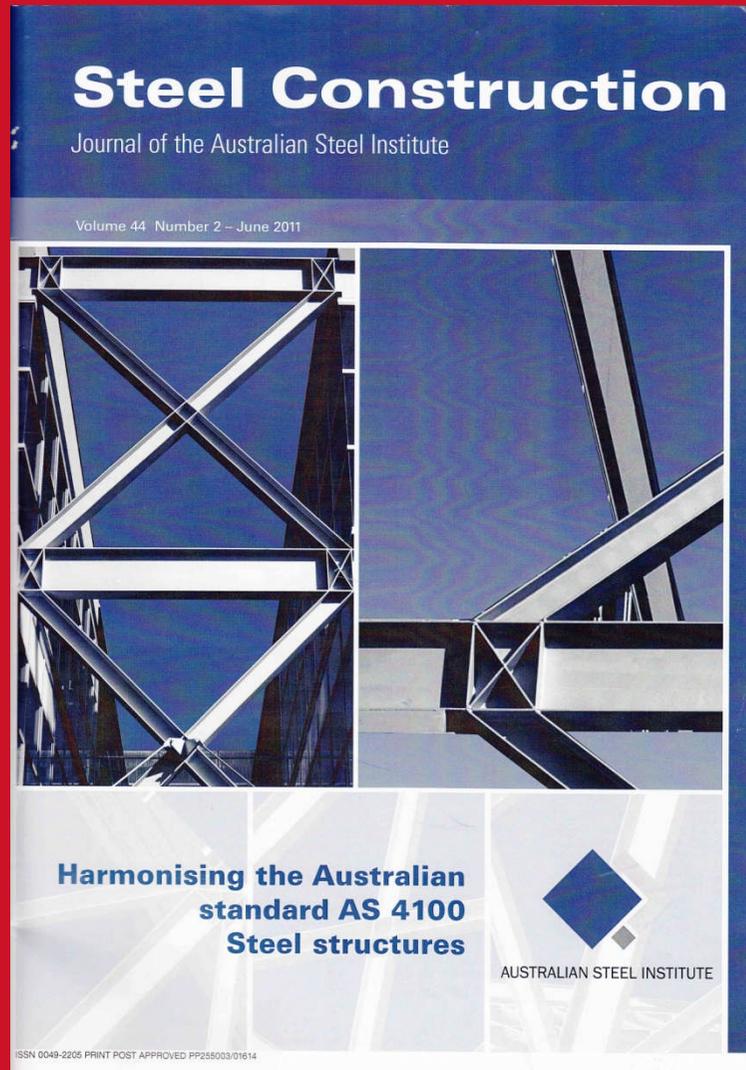
## Other International Standards

- American Institute of Steel Construction AISC-360-10  
Single concise document with Commentary
- Canadian Steel Structures Standard S16-09  
First limit states edition 1974  
Progressive alignment with AISC
- New Zealand NZS3404 Part 1 2009. Similar to AS 4100  
but with capacity design for seismic actions
- South Africa SANS 10162:2005 based on Canadian S16  
Recent loading code SANS 10160 based on Eurocode 1
- Switzerland SIA 263:2003 Steel Construction  
Based on Eurocode 3 but free standing document



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# Journal of the Australian Steel Institute



Volume 44 Number 2 – June 2011

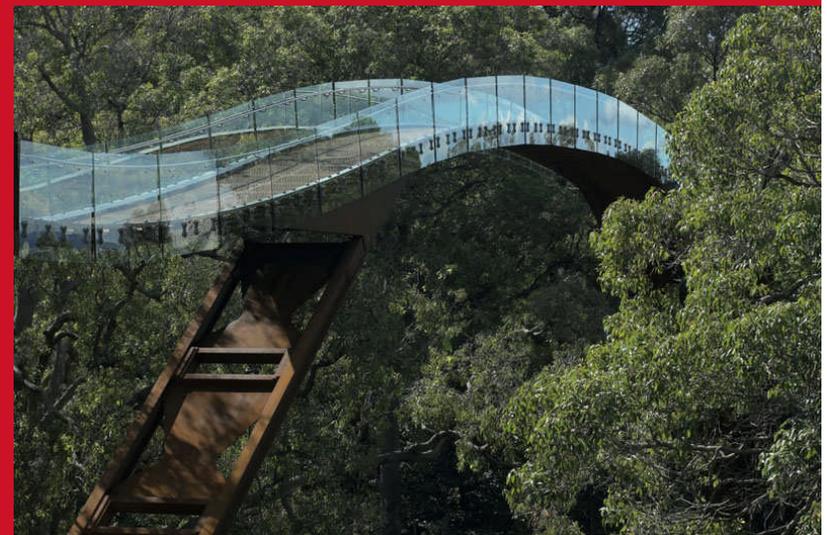
Includes all the details of this Presentation

Appendix 1

Detailed comparison of AS4100, Eurocode 3 Parts 1.1, 1.5 and 1.8 and AISC 360-10

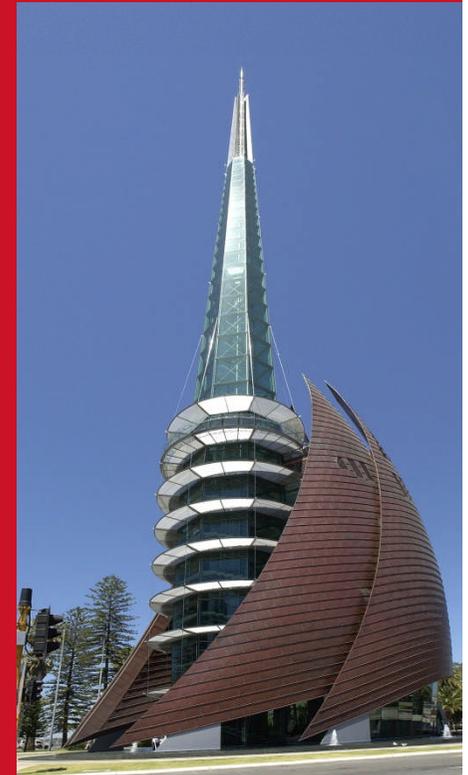
# Three alternatives to harmonisation and redevelopment of AS4100

1. Clause by clause revision and updating to align with the most recent Australian and overseas research (Evolution rather than Revolution)
2. Adoption of another international standard as the basis for further development of AS4100 (used previously for the Cold-Formed Steel Structures Standard AS/NZS 4600 and Stainless Steel Structural Members Standard AS/NZS 4673)
3. Replacement of AS4100 by EC3 or the AISC 360-10 Specification



# Advantages of Alternatives

1. Clause by clause revision allows the existing standard to be maintained with the least disruption but with less harmonisation
2. Adoption of another International Standard allows closer harmonisation but maintains the close links with other Australian materials, loading, welding and bolting standards
3. Replacement by EC3 or AISC 360 allows rapid harmonisation internationally but with considerable costs

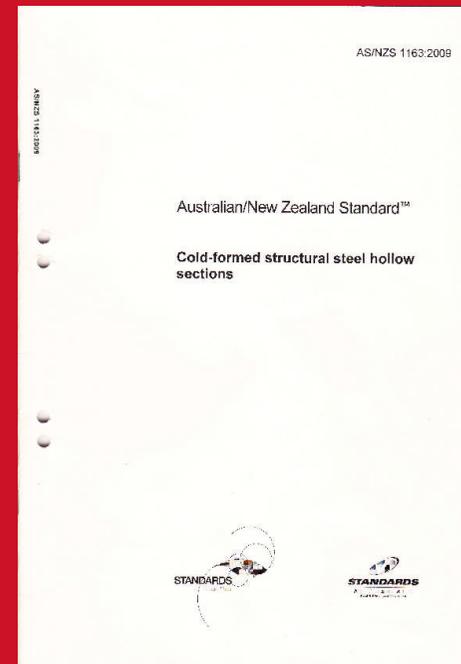
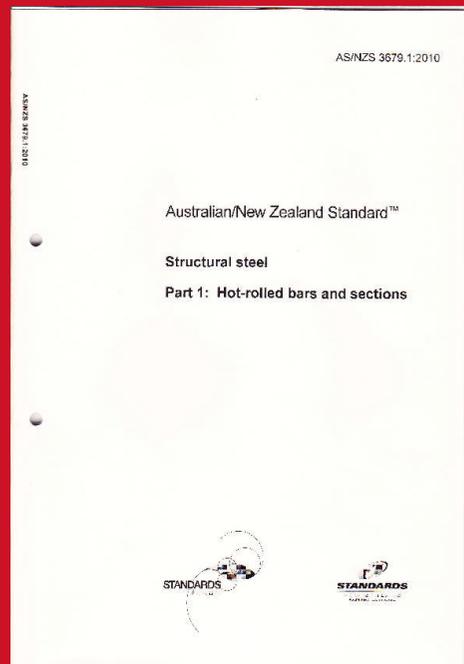


## Comparisons and differences between International Standards

- Appendix 1 of the ASI Journal provides a detailed comparison of the differences between AS 4100:1998, EC3 Parts 1.1 (General), 1.5 (Plates) and 1.8 (Joints), and AISC 360-10
- 24 different areas covered in Appendix 1 including materials, connections (bolts and welds), loads, structural analysis and stability, member design, brittle fracture, fatigue, fire, earthquake/seismic, fabrication, erection, high strength steel
- Very significant differences exist particularly between EC3 and AISC 360-10

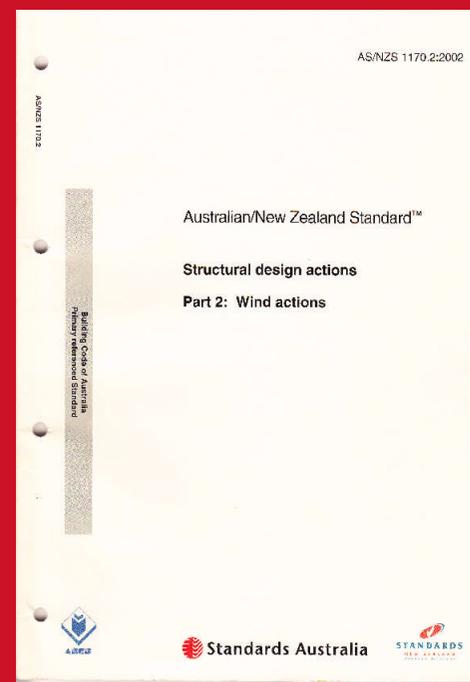
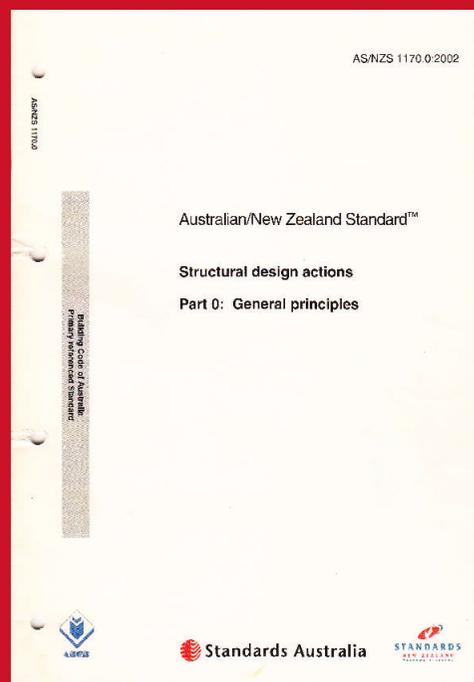
# Steel Materials

- AS 4100 uses AS/NZS Standards such as AS/NZS 3679.1 (Sections) and AS/NZS 1163 (Hollow Sections)
- EC3 uses EN such as EN10025, 10210 and 10219
- AISC uses ASTM including A36, A529, A500, A 514



# Loads and other actions

- AS4100 refers to the AS/NZS 1170 Series for Loads/Actions
- EC3 calls Eurocode 1 Actions on Structures
- AISC calls SEI/ASCE7 plus applicable building code

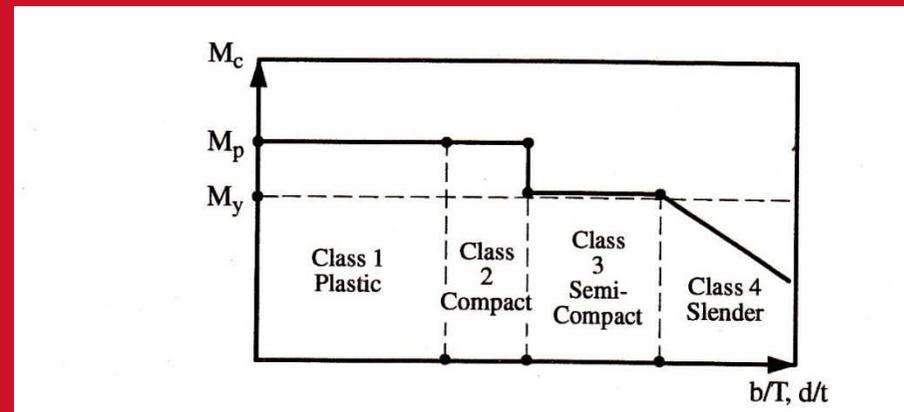
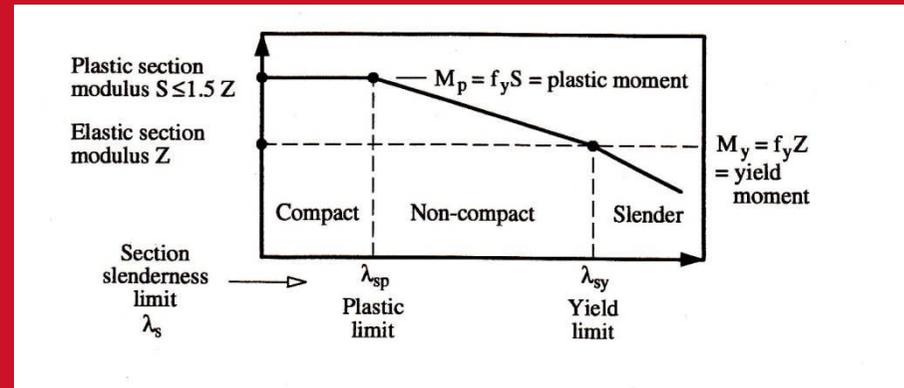


# Structural Analysis and Stability

- AS4100 has 1st order moment amplification or 2<sup>nd</sup> order analysis with system length and notional horizontal force of 0.002 times vertical design load
- EC3 has global analysis with global and local imperfections and system lengths or partial global analysis with member stability checks or individual stability checks of equivalent members
- AISC 360-10 has the Direct Analysis Method (DAM) with system lengths and reduced stiffnesses ( $0.8EI$ ,  $0.8EA$ ). Effective lengths now in an Appendix

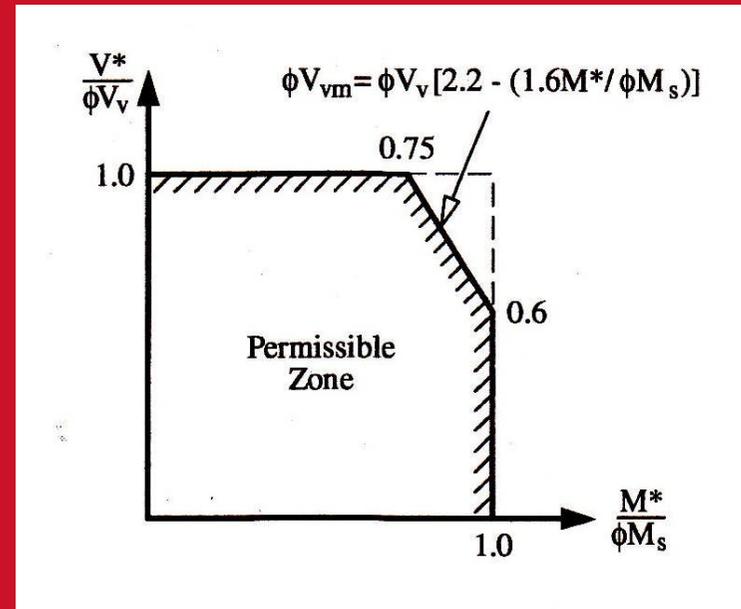
# Bending Section Capacity

- AS4100 and AISC both use 3 regions to define compact, non-compact and slender with a linear transition
- EC3 uses 4 Classes  
 Class 1 Plastic  
 Class 2 Plastic moment only  
 Class 3 First yield  
 Class 4 Slender



# Interaction of Shear and Bending

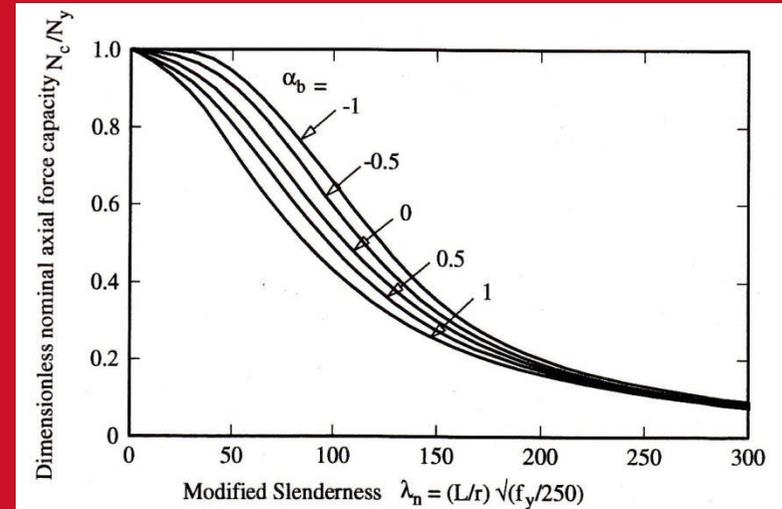
- In AS 4100, shear is reduced with moment over a limited range of moment  $M^* > 0.75 \phi M_s$
- In EC3, moment capacity is reduced with shear when shear exceeds 50% shear yield
- In AISC 360-10, there is no interaction



AS4100

# Compression Member Capacity

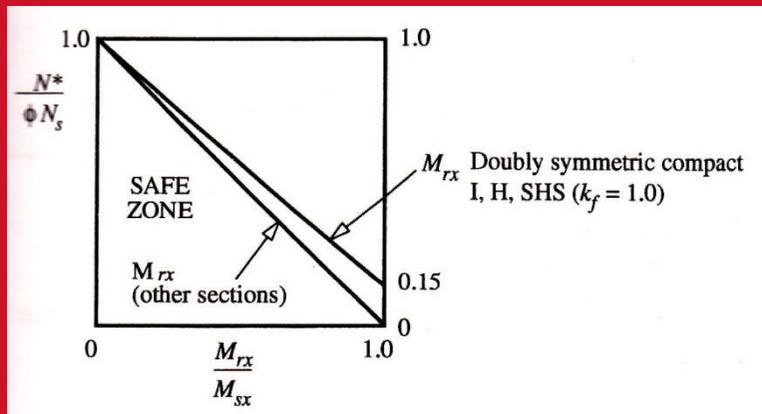
- AS4100 has 5 curves
- AISC 360-10 has 1 curve approximately equivalent to the AS 4100 -0.5 curve
- EC3 has 5 curves with Curve b approximately equivalent to the AS4100 central curve



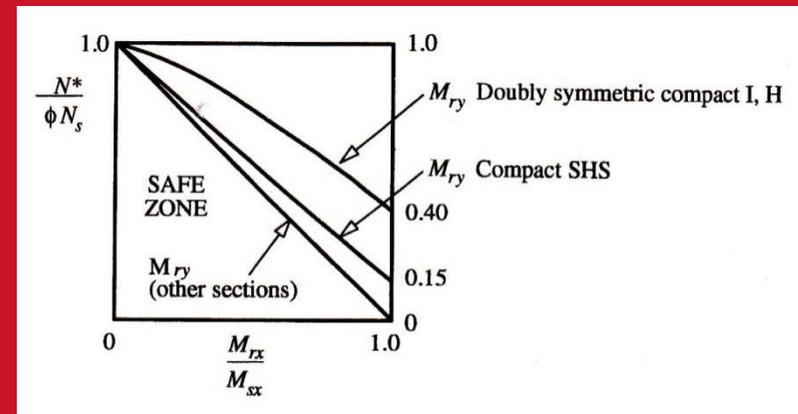
AS4100

# Combined Compression and Bending

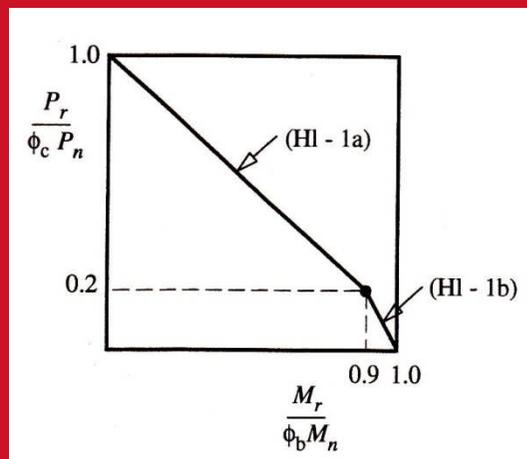
## AS 4100 Section Capacity Major axis



## Minor axis



## AISC 360-10



EC3 has linear interaction equations with interaction factors  $k$  in Annexes A and B

# Bolted connections

- AS 4100 only includes Grades 4.6 and 8.8 bolts  
Combined tension and shear by circular interaction
- EC3 has EN ISO standards for non-preloaded and pre-loaded bolts  
Linear interaction for tension and shear
- ASTM A307, A325 (HS), A449 (Q&T) and A490 (heat treated)  
Linear interaction for tension and shear



# Welded Connections

- AS 4100 uses the AS/NZS 1554 Series for welds which is closely related to AWS D1.1 used by the AISC 360-10
- EC3 includes EN 1993-1-8 (Joints) and includes orientation of fillet welds as for the AISC Specification



# Brittle Fracture

- Section 10 Brittle Fracture of AS 4100 has 8 steel types as specified in the welding standard AS/NZS 1554.1
- EN 1993-1-10 gives the selection for fracture toughness and through thickness properties
- AISC has no brittle fracture rules. Charpy V-Notch impact test requirements are given in the ASTM Specifications

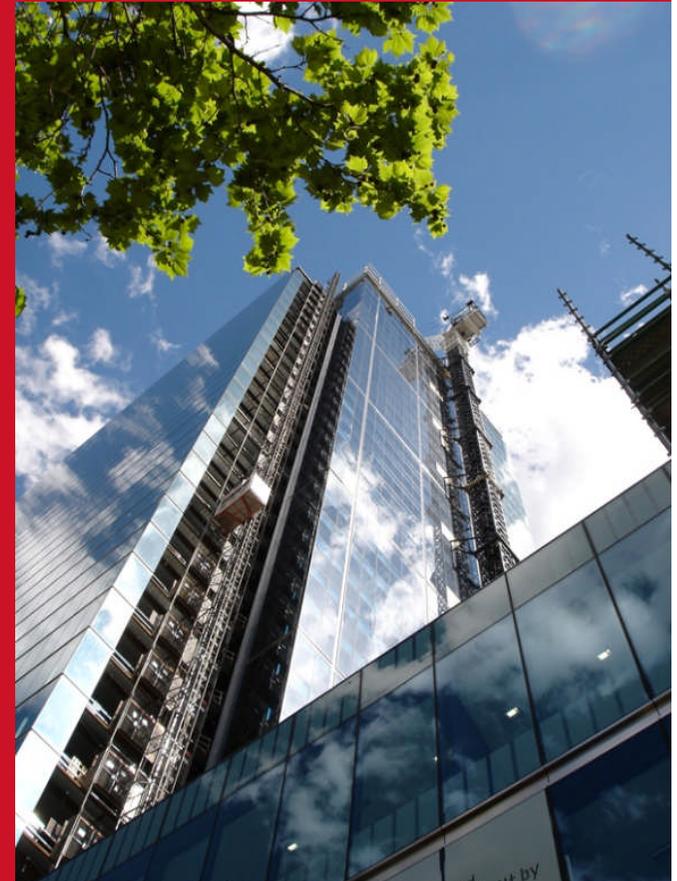
# Fatigue

- AS4100 follows European practice with its detail categories
- AISC practice was used previously in AS1250:1981
- Designing for fatigue is completely different from usual structural design. In a fatigue situation, linear, detailed stress analysis is everything. The usual, slightly casual attitude to stress redistribution, yield line theory, limit state philosophy (and load path with adequate strength is sufficient) is entirely inappropriate to fatigue based design.
- Another option is for fatigue (over and above good detailing practice incorporated in AS 4100) being referenced in an entirely different code

- AS/NZS 1170 Part 0 gives load combinations for fire
- Much of fire research and fire protection materials used in Australia are British and European
- North American Practice of fire tests on restrained specimens is quite different from Australia, NZ and UK to date
- NZS 3404 is leveraging off EN 1993-1-2 Structural Fire Design

# Earthquake/Seismic

- AS 4100 Section 13 aligned with AS 1170.4 Earthquake Actions in Australia and NZS 1170.5 Earthquake Actions in NZ
- EC3 calls Eurocode 8 EN 1998 for Design of structures for earthquake
- Separate Specification ANSI/AISC 341 for Seismic Provisions for Structural Steel Buildings



# Fabrication and Erection

- AS 4100 tolerances in-line with Australian practice.  
Tensioned bolt procedures included.  
Plumbing of buildings included.
- EC3 calls EN 1090 Execution of Steel Structures  
Technical Requirements
- AISC 360 calls the AISC Code of Standard Practice  
for dimensional tolerances and vertical plumbing limits.  
Bolt pretension given in Section J13 Design of Connections





## Issues Related to Adoption of International Standards

- It is quite clear that a steel design standard has extensive links to a suite of materials, loading, bolting, welding, and other practice standards such as fire, fabrication and erection in that country/region.
- The close interlinking of the elements of the suite makes the adoption of parts of one with parts of another very difficult.
- If an international standard is adopted, all related parts must be consistently adopted
- The only practical way seems to be Alternative 1

# Costs of Alternatives

		Alternative 1 Evolution	Alternative 2 Adoption	Alternative 3 Replacement
1	Direct cost of preparation of the standard	Medium	High	Medium
2	Costs of re-education of engineering profession	Low	High	High
3	Costs of new and revised software	Low	Medium	Medium
4	Costs of supporting documentation and design aids	Low	High	Medium/High
5	Costs associated with interlinked standards	Low	Low	High
6	Long term cost of not aligning internationally	High	Medium	Low

# Benefits of Harmonisation

- Opening to international trade in goods and services
- Industry can compete directly on design to international standards such as large oil and gas, and resources projects
- Larger consulting firms have a smaller number of design platforms
- Latest research already incorporated in the standard
- Australia must have input to the standards if they are to be adopted

## Financing of rewrite of Standard

- All alternatives have considerable \$ costs
- Alternative 1 will cost at least A\$100k per annum for 3 years to adapt both local and international research for inclusion in AS4100
- Alternative 2 will cost at least A\$500k total and maybe more based on the history of the development of AS 4100:1990
- Alternative 3 will cost at least A\$500k. The financing of the interlinked standards revisions depends substantially on Standards Australia adopting a policy to proceed in this direction.

## Alternative Means of Publication

- Since AS4100:1998 is copyrighted by Standards Australia, it would not be possible to perform Alternative 1 and publication of this standard outside Standards Australia umbrella.
- If Alternative 2 was followed, then it may be possible to prepare it and publish it either through Standards Australia, or the Australian Steel Institute.
- For Alternative 3, the international standard and its national application document (in the case of EC3) could be published by Standards Australia. This would then allow a document such as the British Concise Eurocode P362 to be prepared by the ASI as was done by the Steel Construction Institute.

# Conclusions

- There is a need to update and harmonise the Australian Steel Structures Standard AS4100.
- Three ways to achieve international harmonisation are:

**Alternative 1 - Clause by Clause Revision of AS 4100**

**Alternative 2 – Adoption of another international standard for the further development of AS4100**

**Alternative 3 - Replacement of AS4100 by a widely adopted International Standard such as EC3 or AISC**

## Conclusions continued

- The close interlinking of the elements of the suite makes the adoption of parts of one with parts of another very difficult.
- It is concluded that the only practically feasible way forward seems to be by Alternative 1.
- Connected to this is the need to progressively update all of the related AS/NZS materials, welding and bolting standards to more closely align with international standards.



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# Thank you

