National Building Code

2003

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Part 4 of the National Building Code of Canada

National Building Code of Canada

- Model code for the design of buildings in Canada
- Developed by the NRC (CCBFC)
- Under the Constitution Act, provincial and territorial governments regulate building
- NBC not law unless officially adopted by a province, territory or city
- Provinces have input (PTCBS)

NBC - 2003

- Major Change to NBC
  - Objective Based Code
- Major Changes to Part 4
  - Harmonization of Return Periods and Importance Factors
    - Review of reliability index for factored loads and resistances
  - Companion Action Load Combinations
    - Re-definition of loads, factors & combinations

NBC - 2003

- Objective Based Code
  - Code objectives clearly defined
  - Promote innovation
  - Revisions easier to implement

  - 4.1.1.2.2)
    - Refers to *designer* as P.Eng. or Architect
    - Viewed as administrative - may not stay

2003 Code Format

- Two Divisions, A and B
- Division A
  - Compliance
  - Objectives
  - Functional Requirements
- Division B
  - Acceptable Solutions
    - Part 4
    - Other solutions with safety >= Part 4

Harmonizing Loads

- Wind
  - Annual probability of being exceeded
    - 1/100 for strength of post-disaster buildings
    - 1/30 for primary structural action
    - 1/10 for cladding and deflection or vibration
- Earthquake
  - Probability of exceedance of 10% in 50 years
  - Annual probability of being exceeded
    - 1/475

Harmonizing Loads

- **Earthquake (cont'd)**
  - Specified load includes a Seismic Importance Factor, I
    - I = 1.5 for post-disaster buildings
    - I = 1.3 for schools
    - I = 1.0 for all other buildings
- Snow 30 year return period, i.e.1/30
- Live Not Defined
- Dead Not Defined

Harmonizing Loads

- SCSD established a task group to study this issue of different methods of accounting for loads
  - Earthquake includes a seismic importance factor
  - Wind varies the return period which is another method of implementing an importance factor
  - Account for buildings used for shelter in time of disaster
  - Review of loads, load factors and load combinations

Loads

- Dead Load, D
  - permanent load due to weight of building components and vertical loads due to earth
- Live Load, L
  - variable load due to intended use and occupancy, including loads due to cranes and pressure of liquids in containers
- H
  - permanent load due to lateral earth pressure, including groundwater

Loads

- Snow Load, S
  - variable load due to snow and ice or rain
- Wind Load, W
  - variable load
- Earthquake Load, E
  - rare load
- P
  - permanent load due to prestress

Importance Factors

- Apply an importance factor to all variable loads, based on use and occupancy

Use and Occupancy	Importance Category
Low Hazard	**Low**
All Others	**Normal**
Emergency Shelter	**High**
Post-Disaster	**Post-Disaster**

Importance Factor - Wind

Importance Category	I_W	
	ULS	SLS
Low	0.8	0.75
Normal	1.0	0.75
High	1.15	0.75
Post Disaster	1.25	0.75

Importance Factor - Snow

Importance Category	I_s	
	ULS	SLS
Low	0.8	0.9
Normal	1.0	0.9
High	1.15	0.9
Post Disaster	1.25	0.9

Importance Factor - Earthquake

Importance Category	I_E	
	ULS	SLS*
Low	1.0	1.0
Normal	1.0	1.0
High	1.3	1.0
Post Disaster	1.5	1.0

* Lateral inter-storey deflection

Companion Action

- Turkstra's rule
  - Developed at University of Waterloo
  - Called it Companion Action
  - Used in the CHBDC, ASCE-7 and for the Confederation Bridge.
- We ask: What is the likely value of one of the variable loads when the other is at its extreme value?
- This likely value is the "arbitrary point-in- time value" or simply the "point-in-time value".

Companion Action

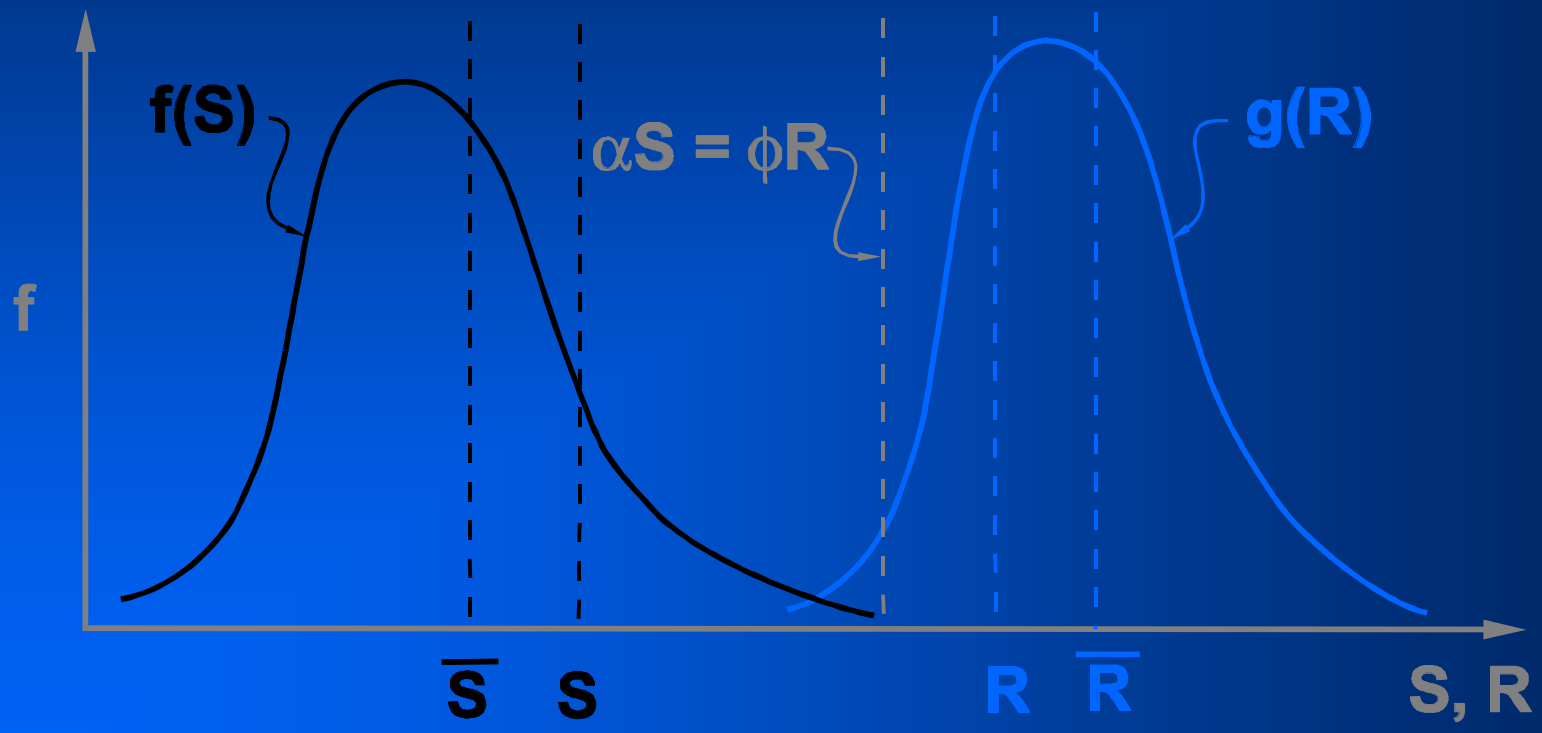
- Compare to Current Load Combination Factor:
  - $\alpha_D D + \gamma\psi (\alpha_L L + \alpha_W W + \alpha_T T)$
  - ψ = 1.0, 0.7, or 0.6
    - Same combination factor applies to all loads
  - γ = 0.8 or 1.0
    - Same importance factor applies to all loads

Companion Action

- Current Seismic Load Combinations
  - 1.0 D + γ(1.0 E)
  - 1.0 D + γ(1.0 L + 1.0 E)
  - 1.0 D + γ(0.5 L + 1.0 E)

Limit States Design

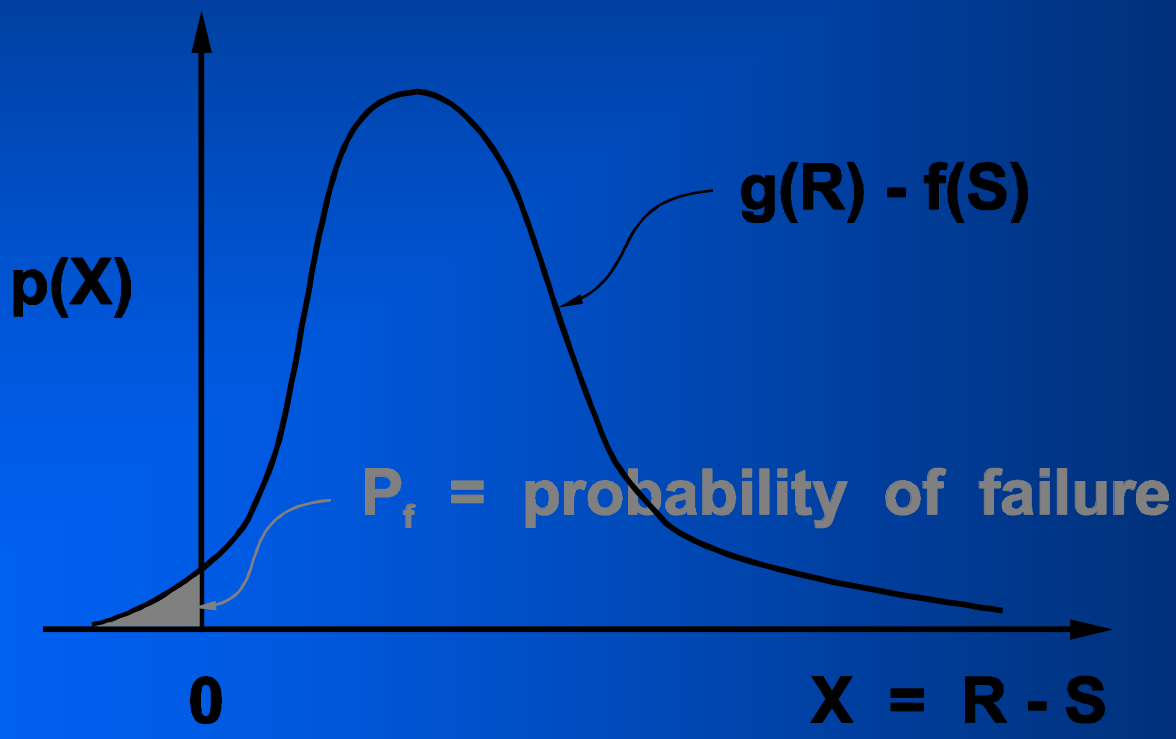
- Ultimate Limit States



Limit state just satisfied

Limit States Design

- Statistical Analysis of Safety



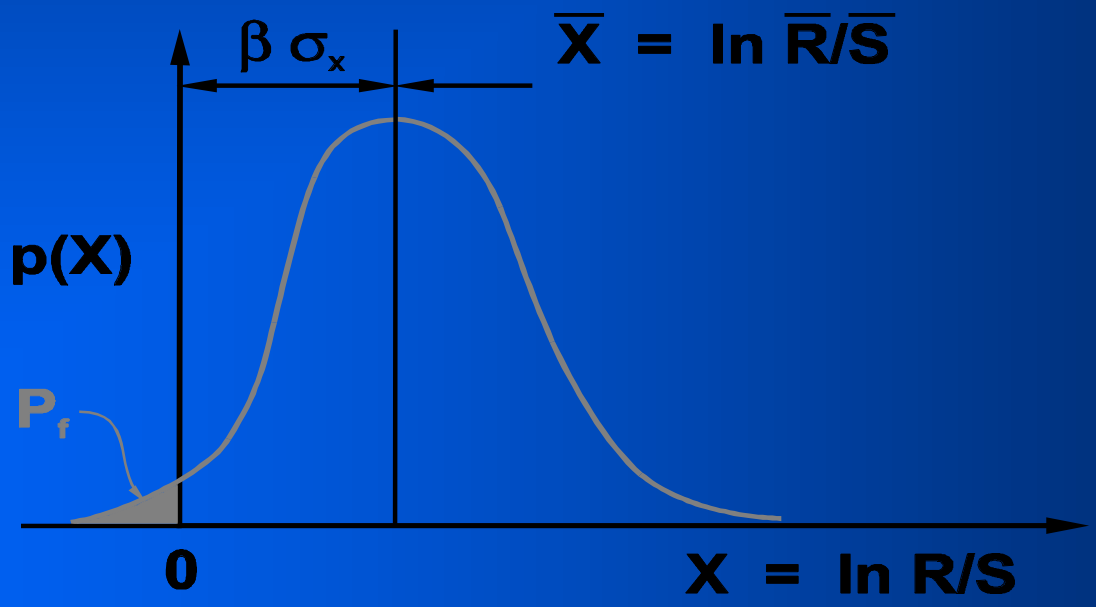
Limit States Design

- **Statistical analysis of safety**

  Let X = ln R/S s_x = standard deviation of X

  Set distance from 0 to the mean value as b times s_x.

  Thus, b is the reliability index.



Reliability Index

- 1995 Code examined to calibrate new loads (return periods) and load factors.
  - Live load that includes both use and occupancy and snow load is conservative
  - Reliability indices for the combination of dead load and snow load are smaller than other load combinations. OK for concrete but not for steel.
  - Combination of dead, wind and snow for steel: reliability index > 3, except where snow load dominates

Reliability Index & Load Factors

- 2003
  - Target Reliability Index of 3.0
  - Return period of 50 years
- Snow
  - Large variability in load
  - New calibration gave load factor = 1.7
    - Specified snow load increases by 25%
  - Decided to remain with LF = 1.5
    - Specified snow load now ~ 10% larger than 1995

Changes

- Snow
  - Reduction of wind exposure factor, Cw, tightened. Cannot reduce from 1.0 for Importance categories High and Post-Disaster.
  - Drift criteria for curved roofs
- Wind
  - Addition of Cgi, internal gust factor. Cg was 1.0 or 2.0.
    - Cgi = 2.0, or a value determined by detailed calculation which accounts for opening sizes, internal volume and envelope flexibility.

Changes

- Wind (continued)
  - Exposure factor, Ce, clarified.
  - Paragraph 37 of User's Guide
    - Categories 1, 2 and 3 clarified.
    - Category 1: Cpi reduced, Cgi increased
    - Category 2: Cpi reduced, Cgi increased
    - Category 3: Cpi as is, Cgi may be reduced
- New Tables for Figures B-14 and B-15
  - Windward, leeward, side wall and roof clarification

Other Changes

- WSD gone
- Masonry standard now only LSD, no WSD
- Factored resistance of soil for design of foundations
- Crane loads as per new S16
- Steel building systems added to 4.3

Summary

- Objective-based
- Harmonization of return periods and importance factors.
- Companion Action approach - revised loads, load factors and load combinations