The Art and Zen Of Guard Design

Professional Engineers and Geoscientists of BC

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Is the Code Reasonable?

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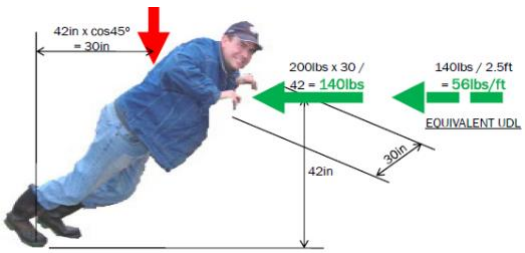
A little physics:



A little math:
140 lbs / 2.5 ft width = 56 lbs / ft
Code requires 50 lb/ft

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How does that work?

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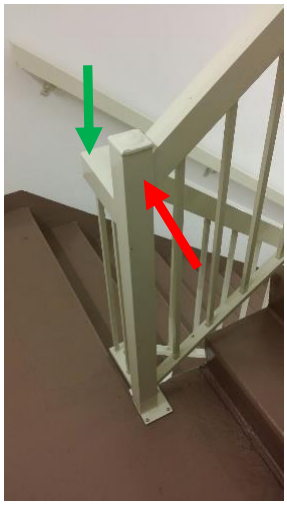

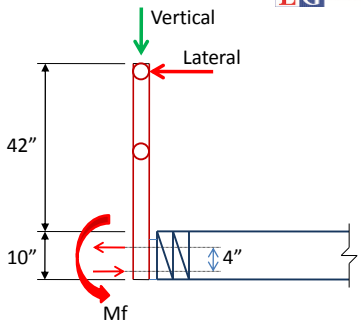

M_F = 15,900 in-lbs

$T_F = M_F / 4” = 3,975$ lbs

V_F = 100 plf * 4ft = 400 lbs

Continuity of Responsibility The Design Guide

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Div.10 - Specialties

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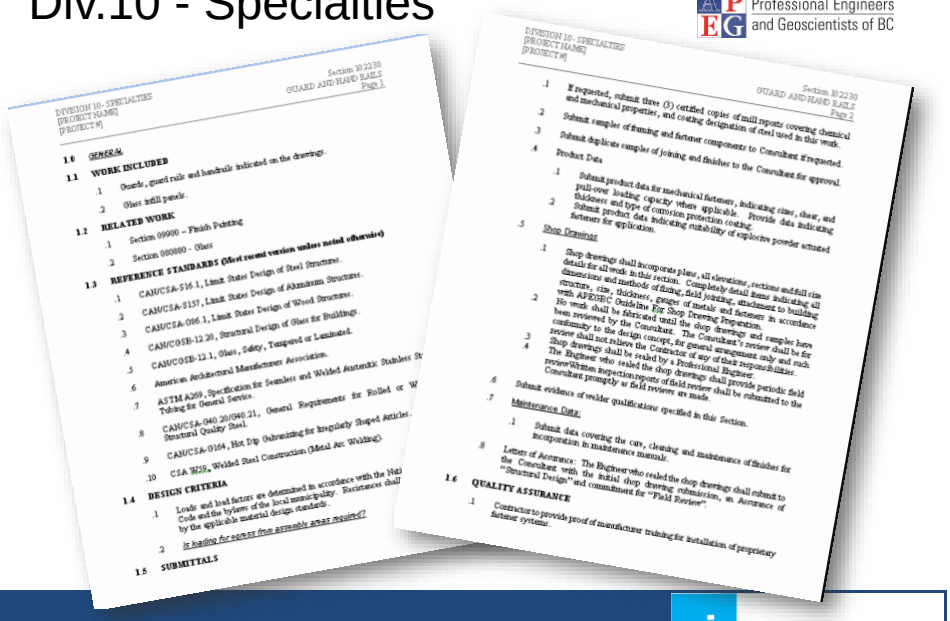

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Testing Guidelines for Guards

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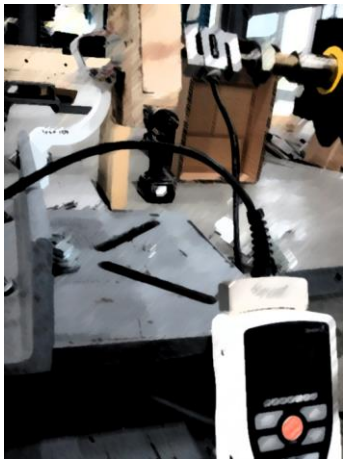
Loads to be based on NBC 4.1.5.15.

Factored load of 1.67 x Specified load
→ without yielding of assembly (Ø = 0.9)

Factored load of 2 x Specified load
→ ductile failure mode (Ø = 0.75)

Factored load of 2.25 x Specified load
→ brittle failure mode (Ø = 0.67)



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Interpreting Test Results

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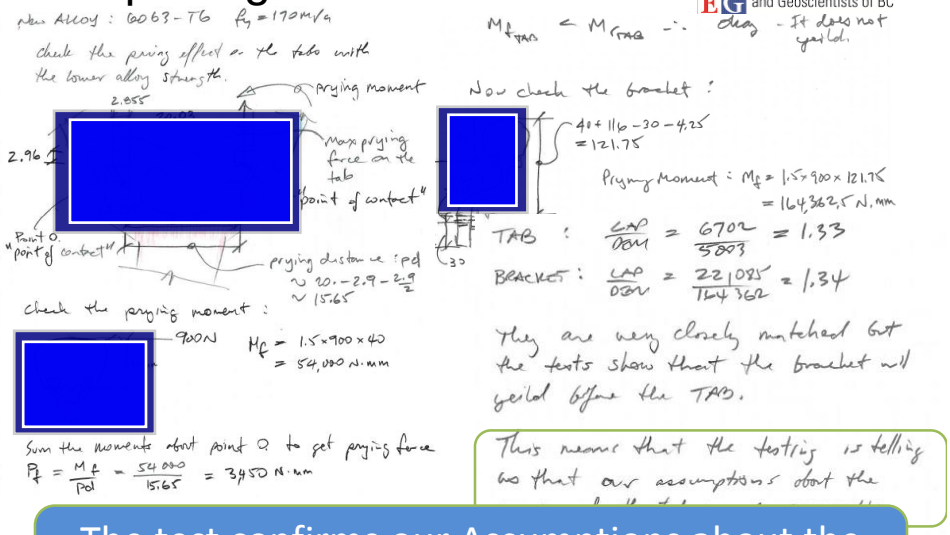

The test confirms our Assumptions about the prying failure in the tab.

Guards in Wood Frame

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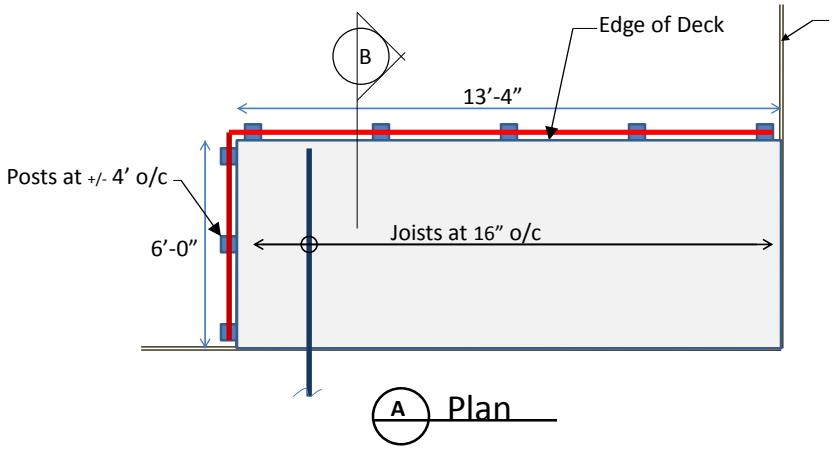

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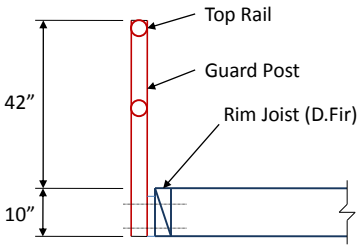

B Typical Guardrail Section

Design of top rail (assume elastic)

$M_F = (wf*L^2)/8 = [(100plf)(1.5)(48”)^2]/8$
$= 43,200$ in-lbs
Determine required S, $Mr = \phi S Fy$
$S = Mr / (\phi Fy) = 43.2$in-kip / (0.9*50ksi)
$= .96in^3$ ($15.7E3$ mm^3)
→ HSS 2-1/2” x 2-1/2” x 3/16”, S=18.7E3 mm^3

Design of posts

$M_F = (Pf*L) = [(225$ lf)(1.5)(42” + 10”/2)
$= 15,900$ in-lbs
Determine required S, $Mr = \phi S Fy$
$S = Mr / (\phi Fy) = 15.9$in-kip / (0.9*50ksi)
$= .35in^3$ ($5.7E3$ mm^3)
Use same section as top trail
→ HSS 2-1/2” x 2-1/2” x 3/16”

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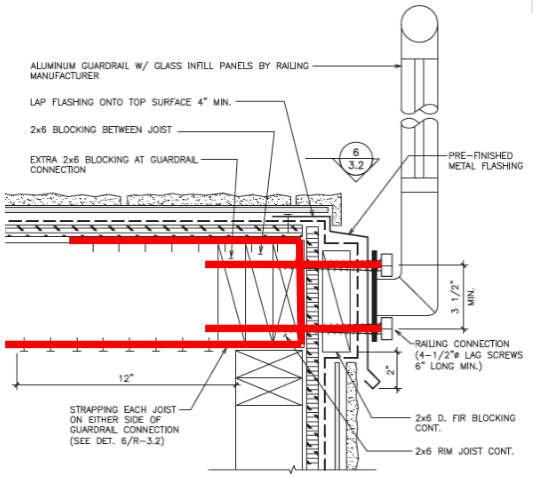

3 / 3.2 GUARDRAIL CONNECTION
3" = 1'-0"

Connection Design

$M_F = 15,900$ in-lbs
$T_F = M_F / 4” = 3,975$ lbs
$V_F = 100$ plf * 4ft = 400 lbs

Try ½” Lag screws:

Shear Resistance, Qr
$Q_r = Q’_r * n_{Fe} * n_R * K’ = 3.19kN*2*2*K’$
$K’ = K_D K_{SF} K_T = (1.0)(1.0)(1.0)$
$Q_r = 2,870$ lb > V_F -OK-

Withdrawal Resistance, Prw
$Prw = P’rw*Lt*nF*K’*J_E$
$= 102(N/mm)*(3*38mm)*2*K’*J_E$
$K’ = K_D K_{SF} K_T = (1.0)(1.0)(1.0)$
$J_E = 1.0$
Prw = 5,228 lb > T_F -OK-

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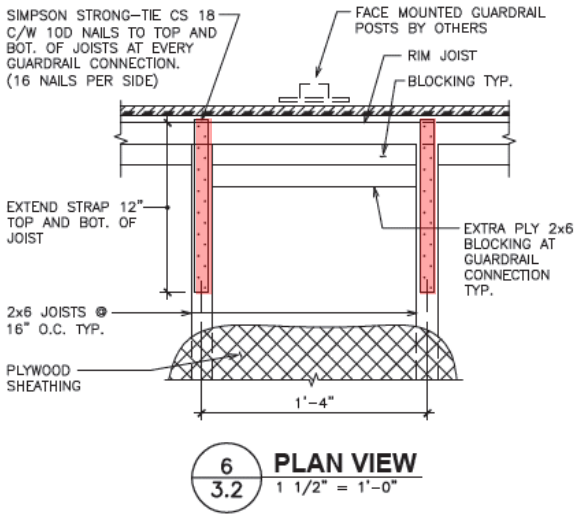
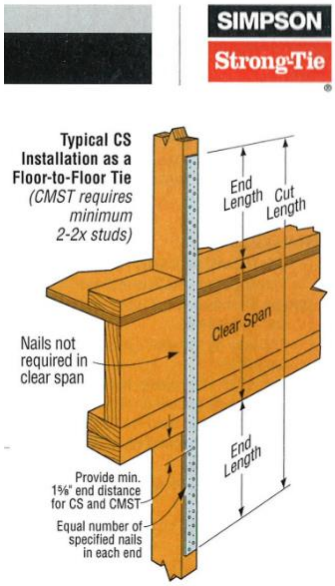
Base Building





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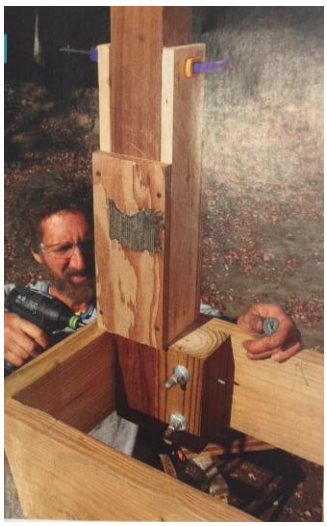

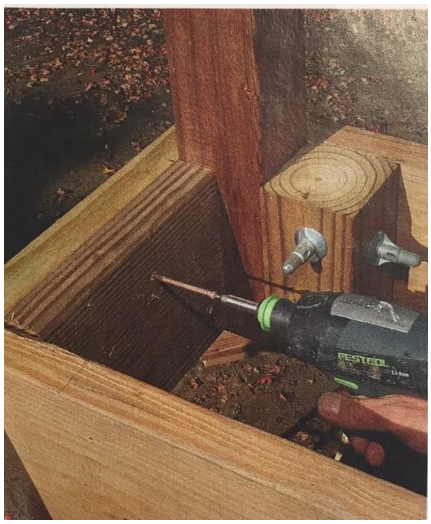

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Glass Acting as a Guard

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Glass Acting as a Guard

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A5. GLASS GUARDS AND BALUSTRADES

A5.1 When a brittle material with variable mechanical properties like glass is used as a structural component with the potential for catastrophic consequences in the event of failure, both increased load factors and alternative load paths are required in the design. For glass guards and balustrades the standard addresses these factors by the requirement for alternate lights to be assumed failed in the strength determination, and a rigid continuous guard over two or more lights.

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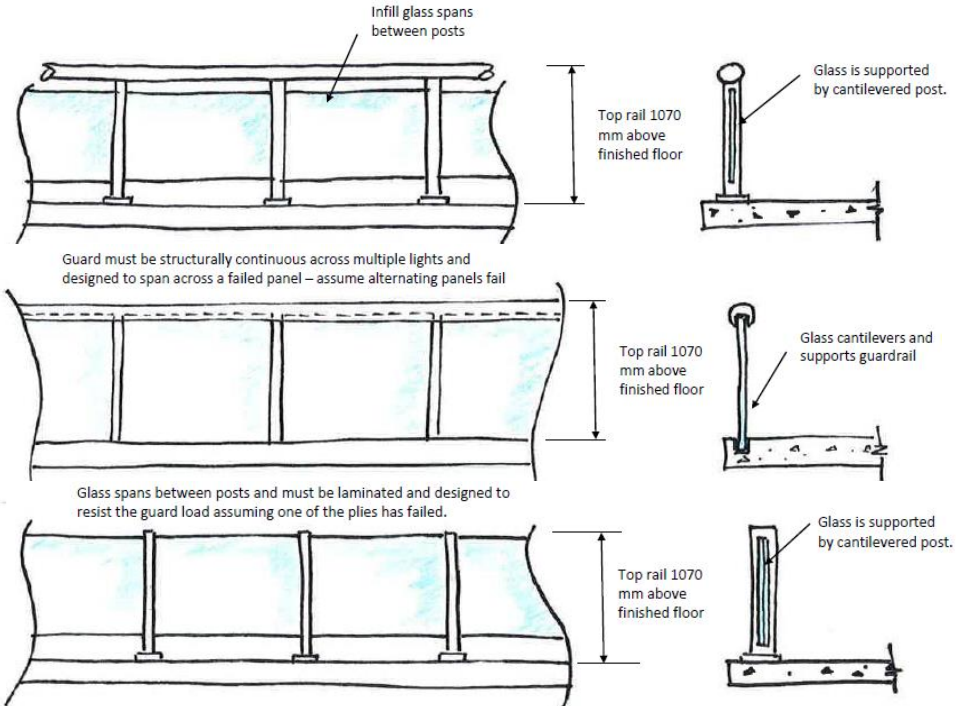
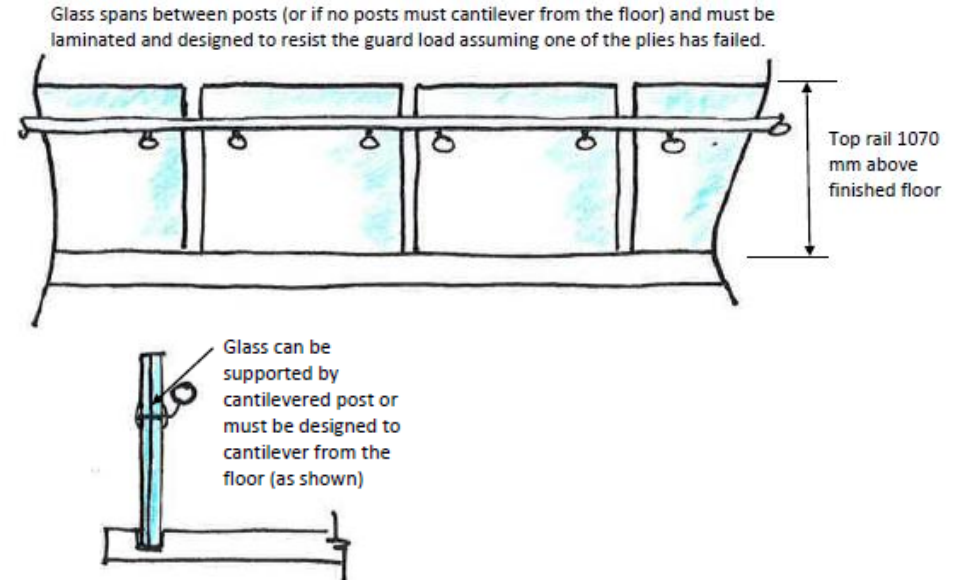
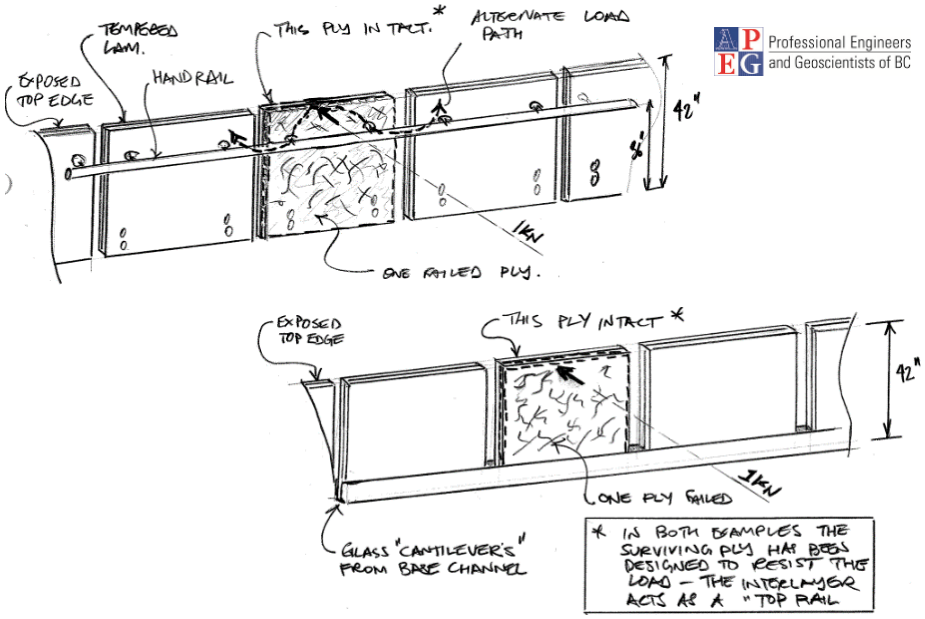

Infill glass spans between posts
Top rail 1070 mm above finished floor
Glass is supported by cantilevered post.
Guard must be structurally continuous across multiple lights and designed to span across a failed panel – assume alternating panels fail
Top rail 1070 mm above finished floor
Glass cantilevers and supports guardrail
Glass spans between posts and must be laminated and designed to resist the guard load assuming one of the plies has failed.
Top rail 1070 mm above finished floor
Glass is supported by cantilevered post.


Glass spans between posts (or if no posts must cantilever from the floor) and must be laminated and designed to resist the guard load assuming one of the plies has failed.
Top rail 1070 mm above finished floor
Glass can be supported by cantilevered post or must be designed to cantilever from the floor (as shown)



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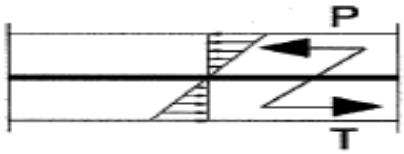

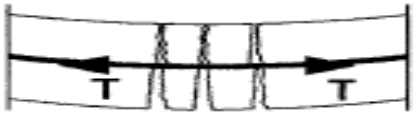

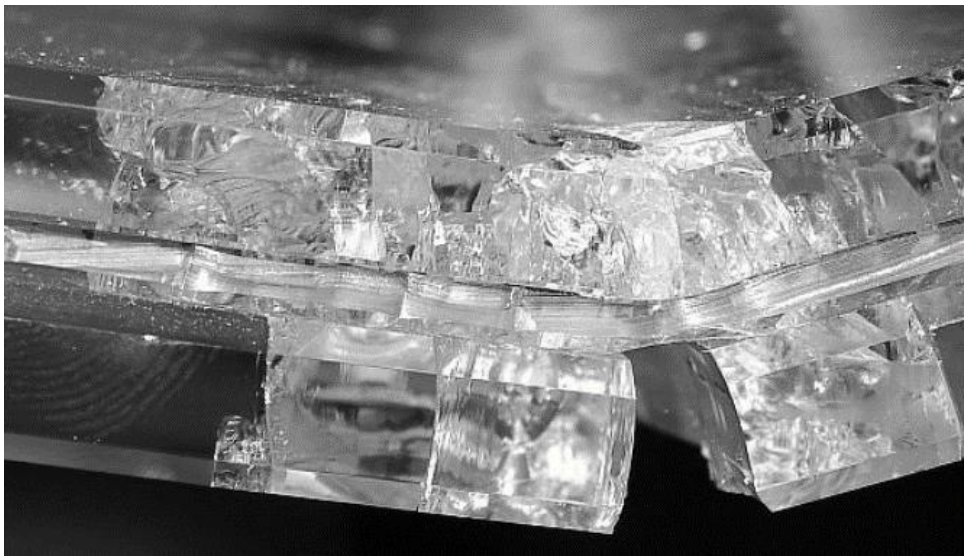

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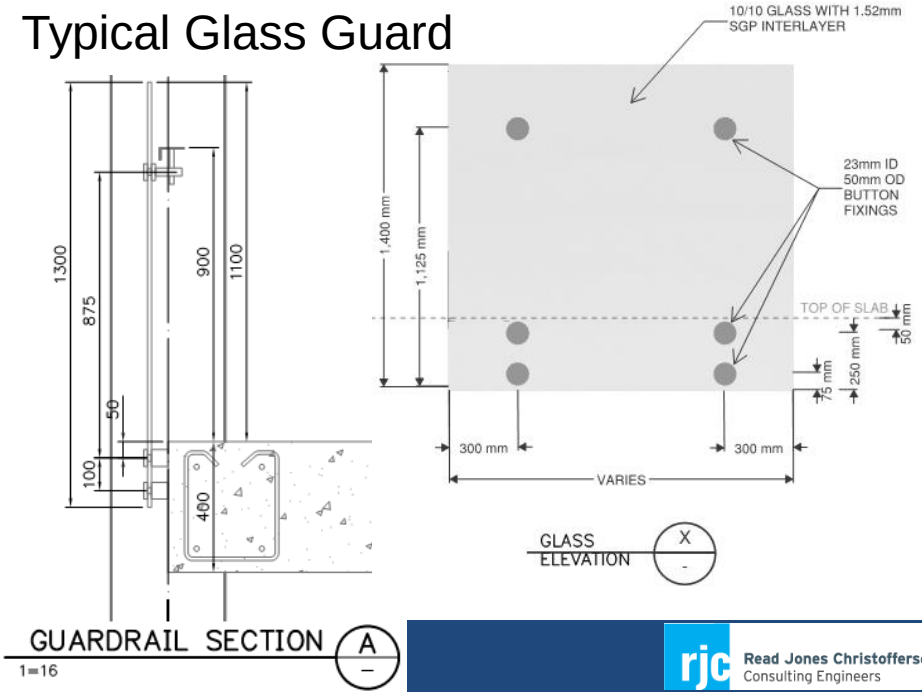
Typical Glass Guard



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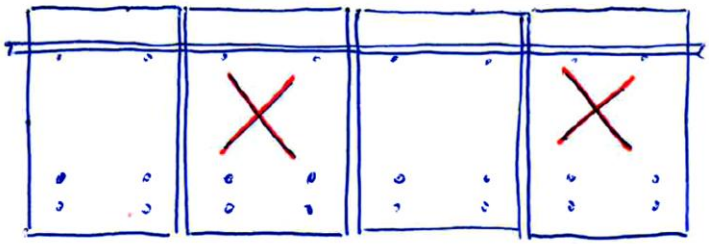

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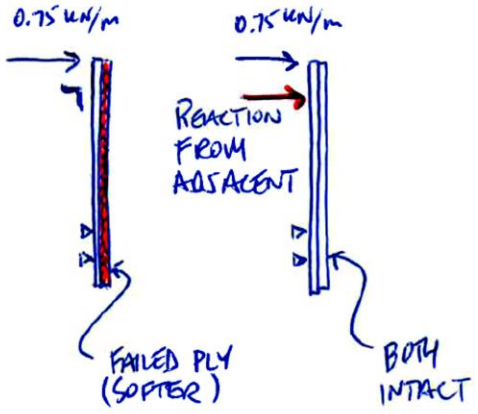

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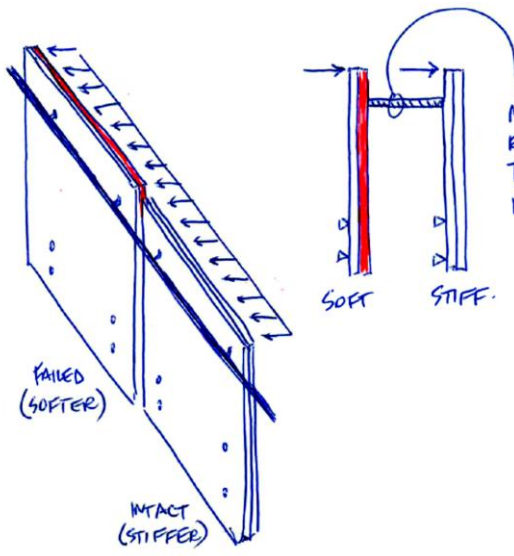

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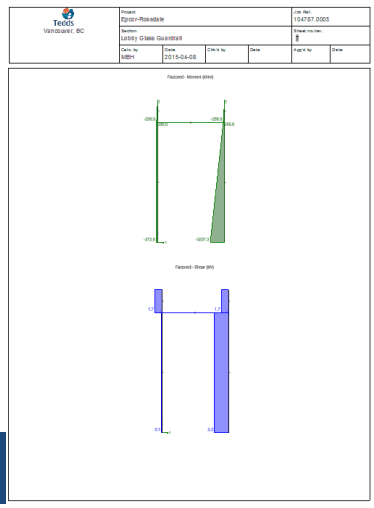

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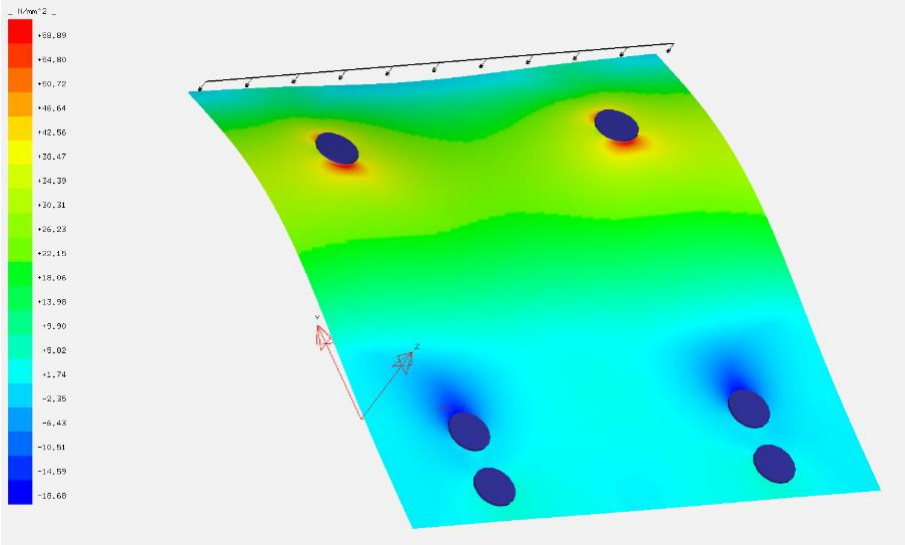

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Glass Guard with Top Rail

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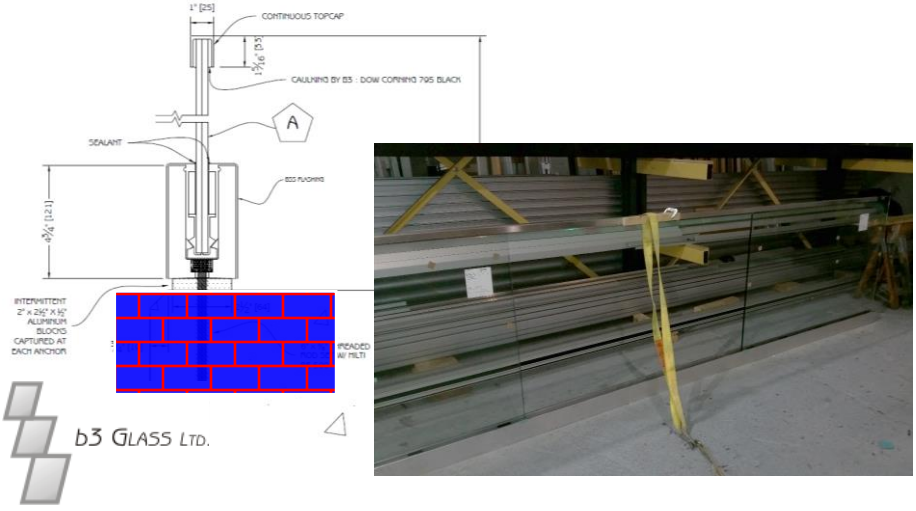

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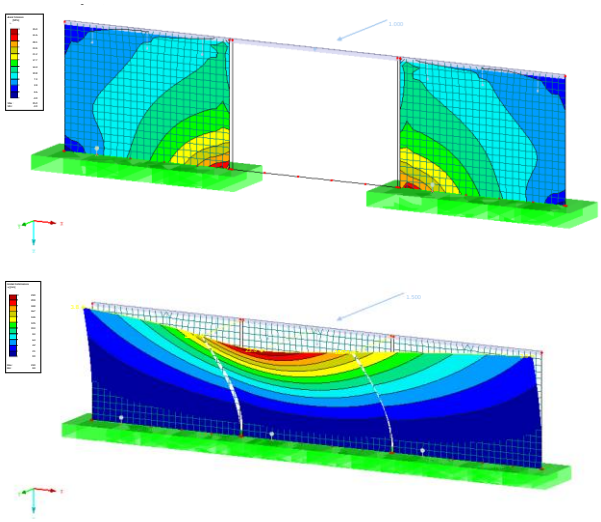

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Ontario Building Code

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Location of Glass in a *Guard*	Type of Glass Required
Glass located beyond the edge of a floor or within 50 mm of the edge of a floor	Heat strengthened laminated glass
Glass located more than 50 mm inward from the edge of a floor	Heat strengthened laminated glass
	Heat soaked tempered glass
Glass located more than 150 mm inward from the edge of a floor	Heat strengthened laminated glass
	Heat soaked tempered glass
	Tempered glass not more than 6 mm thick

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NBC 2015

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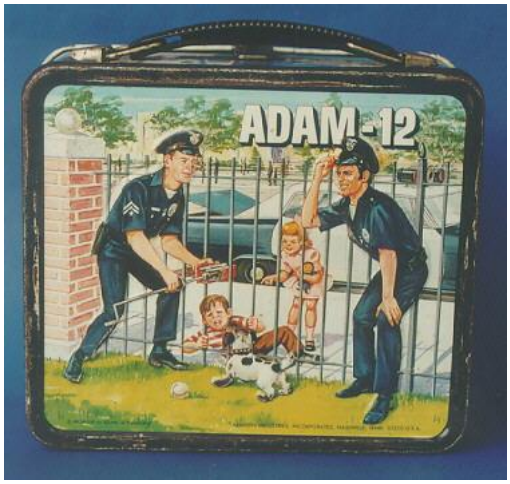
Proposed changes

Maximum deflection of individual elements shall not exceed l/360 from a 0.1 kN load

Inward load to be half the outward design load.



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