Design Manual for M.C.M.E.L Railing System

FOR

DESIGNERS, ENGINEERS, ARCHITECTS, CONTRACTORS & INSTALLERS.

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Digitech 3D inc.

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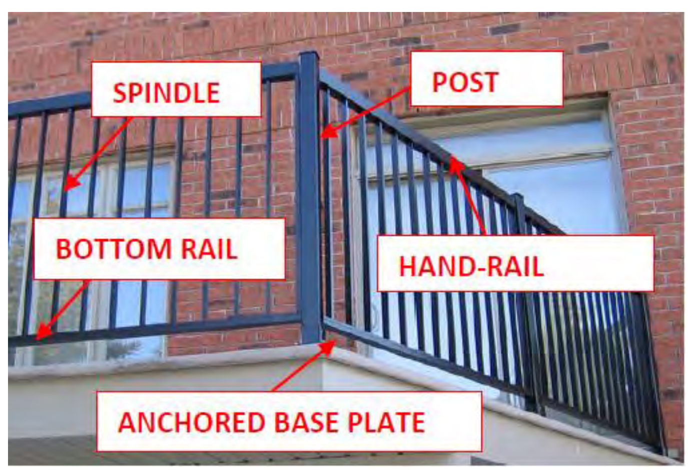
1 - USES OF RAILINGS AND INTIMITY PANELS

M.C.M.E.L. railing systems are used in homes and in residential, commercial, and industrial buildings to ensure safety on balconies, staircases, mezzanines or all structure over 2 steps.

M.C.M.E.L. railing systems consist specifically of vertical aluminum component parts, posts, which support horizontal and vertical loads. Loads are transferred to various floors by means of anchorages or screws. The handrails are the horizontal components connecting the posts that transfer the static and dynamic loads (horizontal and vertical) to them.

The spindles are the components that fill the necessary space for railing systems. They can be horizontal, vertical, or a combination of both. In M.C.M.E.L. system, these components can be constructed from different materials such as aluminum, glass panels or hybrid combination.

FIGURE 1: THE COMPONENT PARTS OF A RAILING



Aluminium components have several advantageous characteristics such as resistance to corrosion and bad weather, higher mechanical resistance and are relatively lightweight. Notably for these reasons, aluminium structure systems are widely used in the construction industry for the external perimeters of balconies, footbridges, staircases, etc.

M.C.M.E.L. is a family business that encourages a creative environment, and is always up-to-date on the newest industry developments so as to offer innovative products to its clients. The company distinguishes itself by offering products that are within reach of all budgets while recognized for their elegance, durability, ease of installation, and low maintenance.

This manual is a design and installation guide for engineers, architects, designers, and installers of aluminium and wooden platform structure recovered with aluminium boards. In this way, installers can determine the type of beams and spacing between them, the arrangement of component parts comprised in the system and the specifications for all anchoring as required.

Following codes are applicable in Platform system design:

- National Building code of Canada 2010
- Ontario Building Code 2012
- CAN/CSA-S157-05/S157.1-05 (R2010) - Strength Design in Aluminum

2 - TYPES OF M.C.M.E.L DECKING SYSTEMS

M.C.M.E.L. offers a decking system including boards and aluminum structure. It suits many applications such as platforms, decks, mezzanines, balconies and staircases. The structure can be designed with wood or with M.C.M.E.L aluminum extrusions. Boards are always fabricated with types of railing systems and intimity panels such as railings with basket spindles, with double handrails, with plain double handrails, with “Floret” ornaments and with double handrails with “Gothic” ornament (Figure 2). Handrails, posts and spindles are shown in Figures 3, 4 and 5 respectively.

FIGURE 2: M.C.M.E.L RAILING OPTIONS

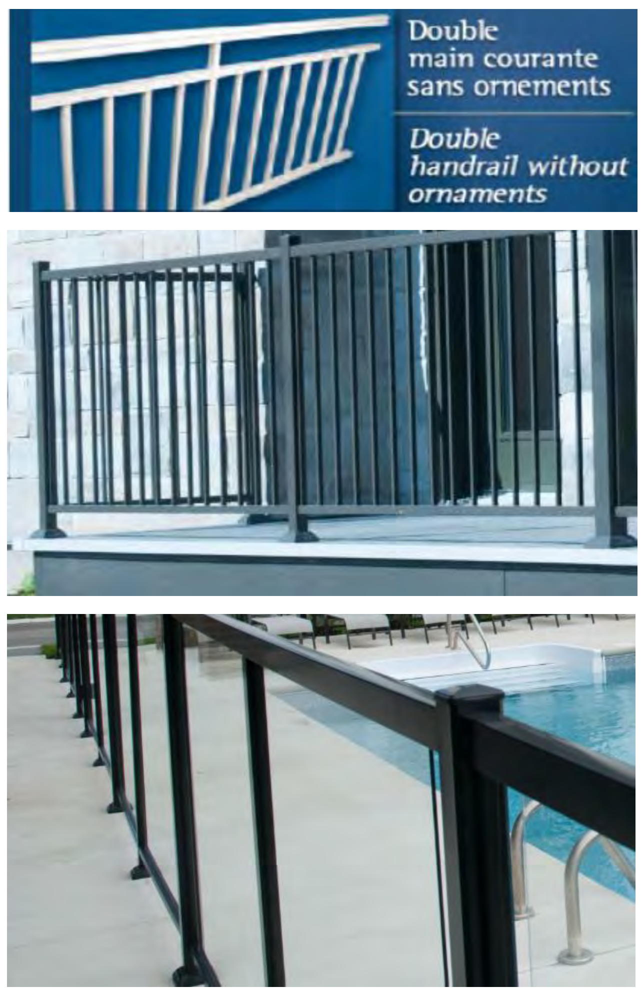
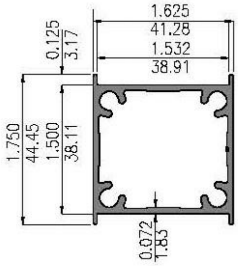
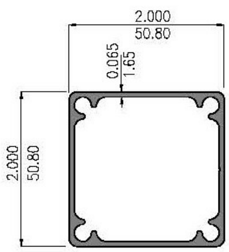


FIGURE 3: M.C.M.E.L POST OPTIONS

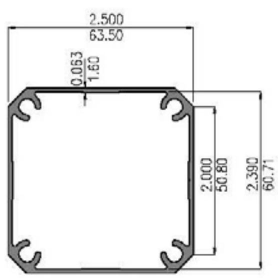
NOTCHED POST 1 5/8'' X 1 3/4''



POST 2'' X 2''



POST 2 ½'' X 2 ½''



POST 3'' X 3''

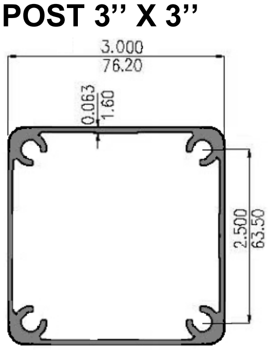
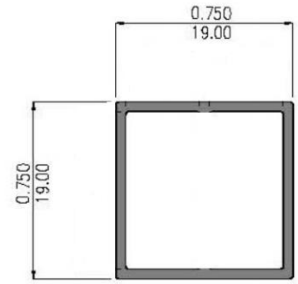
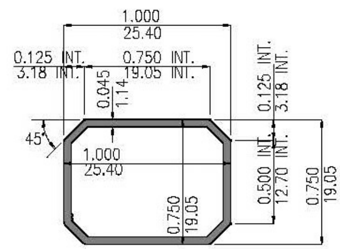


FIGURE 4: M.C.M.E.L SPINDLE OPTIONS

SPINDLE 3/4'' X 3/4''



SPINDLE 1'' X 3/4''



SPINDLE 1/2'' X 3/4''

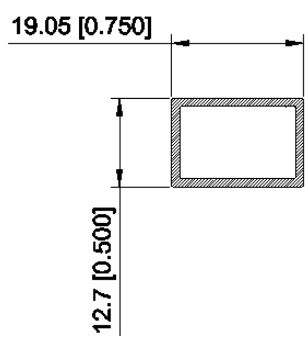
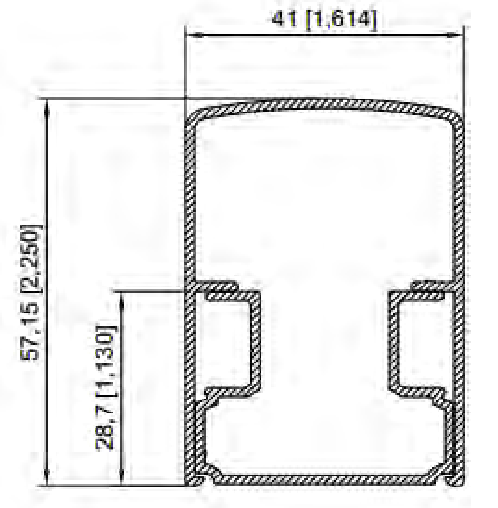


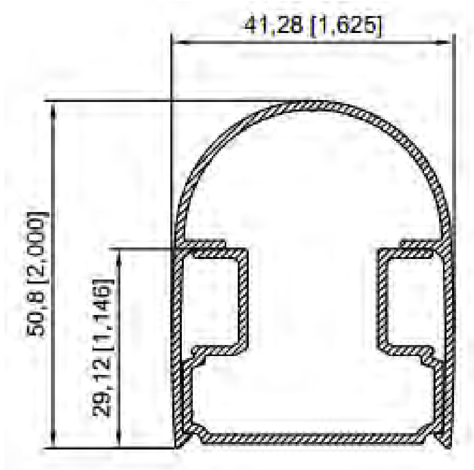
FIGURE 5: M.C.M.E.L HANDRAIL OPTIONS

DUCHESSE Model



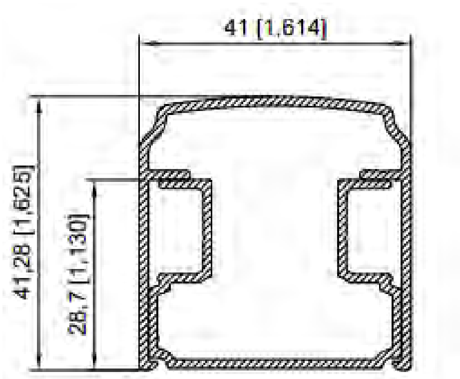
Handrail Dimensions: 1 5/8" x 2 5/8"
Available Posts: 2", 2 1/2" and 3"

BARONNE Model



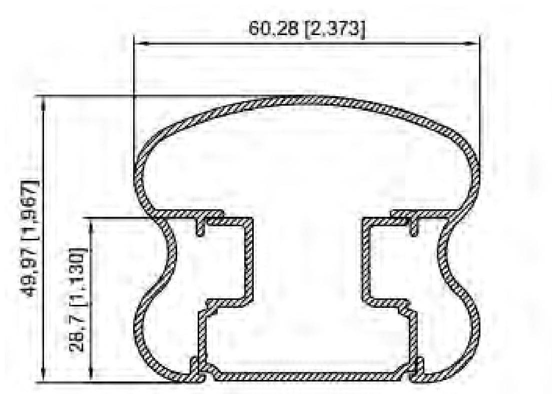
Handrail Dimensions: 1 5/8" x 2
Available Posts: 2", 2 1/2" and 3"

PRINCESSE Model



Handrail dimensions: 1 5/8" x 1 5/8"
Available Posts: 2", 2 1/2" and 3"

ROYAL Model



Handrail Dimensions: 2 3/8" x 2"
Available Post: 3"

NON-RESIDENTIAL BUILDINGS

3 - DESIGN STAGES

3.1 Loading Type Determination

We consider two types of minimal specified loads, in accordance with the 4.1.5.14.1, horizontally applied towards the exterior or the interior, on the minimal required height of a railing as follows:

3.1.1 - 1.0 kN Concentrated Load (in accordance with 4.1.5.14.1.b)

A concentrated load of 1.0 kN applied at any point for access ways to equipment platforms, contiguous stairs and similar areas where the gathering of many people is improbable.

3.1.2.A - 0.75 kN/m Uniform Linear Load (in accordance with 4.1.5.14.1.c)

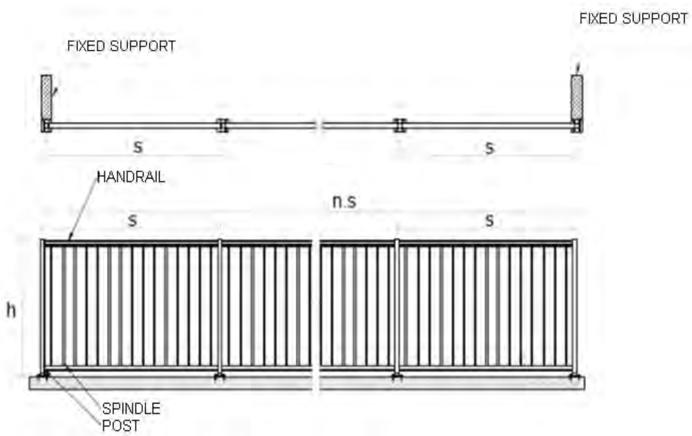
Uniform load of 0.75 kN/m applied horizontally on railings.

Moreover, for both cases, we separately apply a uniform vertical load of 1.5 kN/m on the railing in accordance with sentence number 4.1.5.14.4 of the Ontario Building Code. Also, a 0.9 kN concentrated load or a 0.7 kN/m load divided in two vertical and horizontal directions on the handrails, only for the handrail design in accordance with 3.4.6.5.12 sentence of Ontario Building Code 2012.

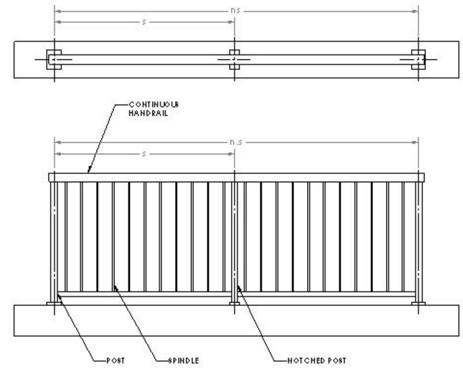
4 - DESIGN STAGE OF RAILING SYSTEMS

1) Choose the type of railing system;
2) If it is a railing system for:
   a) a public space (4.1.5.14 CNB2010), consider a usage load of 3 kN/m;
   b) a residential building of 3 stories or less, or an exterior railing for buildings of 2 residences or less (9.8.8.2 CNB 2015), consider a usage load of 0.5 kN/m;
   c) otherwise 0.75 kN/m;
3) According to the load combinations, calculate the factored load;
4) For a factored load of 1.125 kN/m (0.75 kN/m x 1,5, where 1.5 is the security factor) and according to the type of posts chosen, determine the number of sections (n) and the minimum spacing (s) according to Table 4;
5) If the height of the railing is other than 1.06m (42in) or 900 mm (36in), modify the spacing according to table 6.

FIGURE 6: M.C.M.E.L HANDRAIL OPTIONS



STANDARD HANDRAIL



CONTINUOUS HANDRAIL (Fig. shows one noched, but maximum of two noched 1 5/8 X 1 ¾ can be installed between Posts. Distance between posts written in tables must be respected)

TABLE 1 – LOAD NON-FACTORED 0.75 KN/M

TABLE 1.1 - REGULAR HANDRAIL - SPACING BETWEEN POSTS AT 0.75 KN/M

Number of sections (ns)		2"	2 ½"	3"
Height of 48"				
Spacing between the posts (s) *[mm(in)]*	N=1 (tested)	1524 (60)	1524 (60)	1524 (60)
	N=2 (simulated)	1524 (60)	1524 (60)	1524 (60)
	N≥3 (simulated)	1524 (60)	1524 (60)	1524 (60)
Height of 42"				
Spacing between the posts (s) *[mm(in)]*	N=1 (tested)	1524 (60)	1524 (60)	1524 (60)
	N=2 (tested)	1524 (60)	1524 (60)	1524 (60)
	N≥3 (simulated)	1524 (60)	1524 (60)	1524 (60)
Height of 36"				
Spacing between the posts (s) *[mm(in)]*	N=1 (simulated)	1829 (72)	1829 (72)	1829 (72)
	N=2 (simulated)	1829 (72)	1829 (72)	1829 (72)
	N≥3 (simulated)	1829 (72)	1829 (72)	1829 (72)

Table 1.2 - Continuous Handrail with spindles (2 posts with noched 1 5/8 x 1 ¾ post between) at 0.75 kN/m

Number of sections (ns)		Dist.	2 "	2 ½"	3"
Height of 48"					
Spacing between the posts (s) *[mm(in)]*	N=1 (tested)	Pot. À inter.	1067 (42)	1372 (54)	1372 (54)
		Pot. À pot.	2134 (84)	2744 (108)	2744 (108)
	N=2 (simulated)	Pot. À inter.	1067 (42)	1372 (54)	1372 (54)
		Pot. À pot.	2134 (84)	2744 (108)	2744 (108)
Height of 42"					
Spacing between the posts (s) *[mm(in)]*	N=1 (tested)	Post to notched	1067 (42)	1372 (54)	1524 (60)
		Post to Post	2134 (84)	2744 (108)	3048 (120)
	N≥2 (simul.)	Post to notched	1067 (42)	1372 (54)	1524 (60)
		Post to Post	2134 (84)	2744 (108)	3048 (120)
Height of 36"					
Spacing between the posts (s) *[mm(in)]*	N=1 (simul.)	Post to notched	1219 (48)	1524 (60)	1524 (60)
		Post to Post	2438 (96)	3048 (120)	3048 (120)
	N≥2 (simul.)	Post to notched	1219 (48)	1524 (60)	1524 (60)
		Post to Post	2438 (96)	3048 (120)	3048 (120)

Glass guardrails:

MCMEL also proposes glass panel guardrails. These guardrails meet the requirements of the National Building Code, for resistance and deformation under loads impose by Code. The tempered glass used is 6 mm thick. The tempered glass complies with to the CAN/CGSB-12.1 M90 standard. The maximum acceptable length of guardrails is presented in the following table 4.3

Table 1.3 - Continuous and standard Handrail with glass (2 posts with noched 1 5/8 x 1 ¾ post between) at 0.75 kN/m

Number of sections (ns)		Dist.	2 "	2 ½"	3"
Height of 42"					
Spacing between the posts (s) *[mm(in)]*	N=1 (tested)	Post to notched	1067 (42)	1372 (54)	1524 (60)
		Post to Post	2134 (84)	2744 (108)	3048 (120)
	N≥2 (simul.)	Post to notched	1067 (42)	1372 (54)	1524 (60)
		Post to Post	2134 (84)	2744 (108)	3048 (120)
Height of 36"					
Spacing between the posts (s) *[mm(in)]*	N=1 (simul.)	Post to notched	1219 (48)	1524 (60)	1524 (60)
		Post to Post	2438 (96)	3048 (120)	3048 (120)
	N≥2 (simul.)	Post to notched	1219 (48)	1524 (60)	1524 (60)
		Post to Post	2438 (96)	3048 (120)	3048 (120)

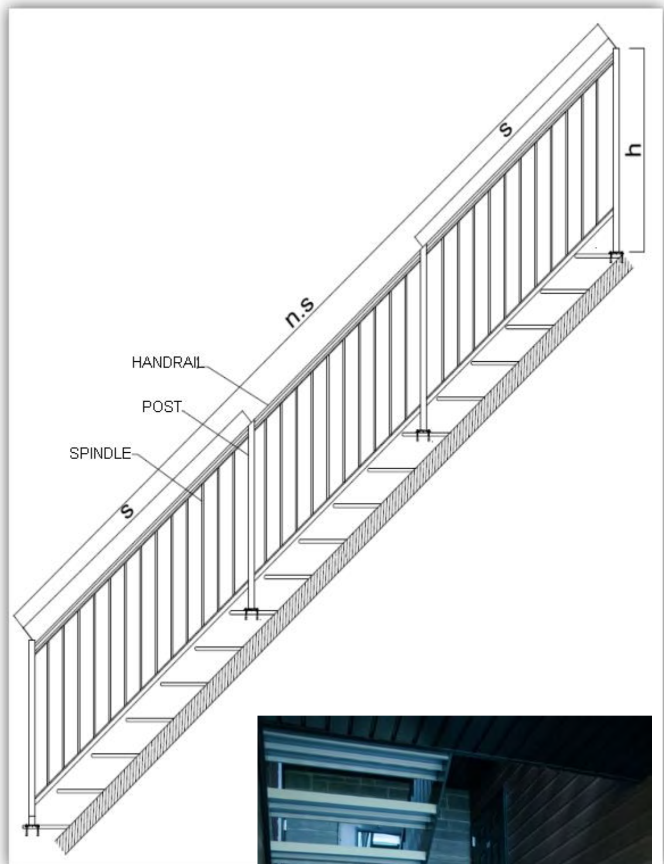


Figure 7: Design de systèmes de rampes pour patios

Important Note:

The handrail not supported by a foot support is always limited to 72 inches (1.8 m). A foot support is a spindle elongated to be attached to the floor.

RESIDENTIAL BUILDINGS

5 - DESIGN STAGES

5.1 Loading Type Determination

We consider two types of minimal specified loads, in accordance with the 9.8.8.2 sentence of the Ontario Building Code, horizontally applied towards the exterior or the interior, on the minimal required height of a railing as follows:

5.1.1 - 1.0 kN Concentrated Load (in accordance with 9.8.8.2)

A concentrated load of 1.0 kN applied at any point for access ways to equipment platforms, contiguous stairs and similar areas where the gathering of many people is improbable.

5.1.2 – 0.5 kN/m Uniform Linear Load (in accordance with 9.8.8.2)

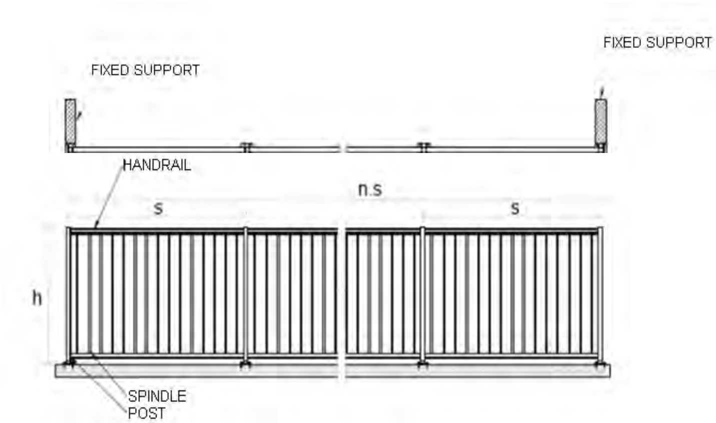
Uniform load of 0.5 kN/m applied horizontally on railings.

Moreover, for both cases, we separately apply a uniform vertical load of 1.5 kN/m on the railing in accordance with sentence number 9.8.8.2 of the Ontario Building Code. Also, a 0.9 kN concentrated load or a 0.7 kN/m load divided in two vertical and horizontal directions on the handrails, only for the handrail design in accordance with 3.4.6.5.12 sentence of Ontario Building Code 2012.

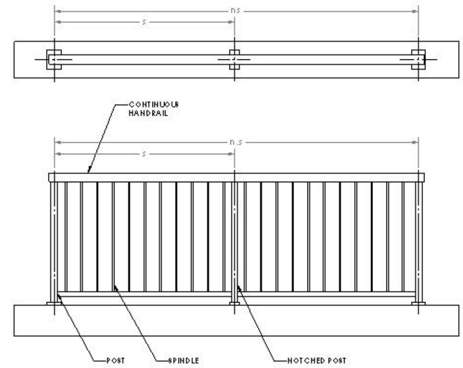
6 - DESIGN STAGE OF RAILING SYSTEMS

1) Choose the type of railing system;
2) If it is a railing system for:
   d) a public space (4.1.5.14 CNB2010), consider a usage load of 3 kN/m;
   e) a residential building of 3 stories or less, or an exterior railing for buildings of 2 residences or less (9.8.8.2 CNB 2015), consider a usage load of 0.5 kN/m;
   f) otherwise 0.75 kN/m;
3) According to the load combinations, calculate the factored load;
4) For a factored load of 0.75 kN/m (0.50 kN/m x 1,5, where 1.5 is the security factor) and according to the type of posts chosen, determine the number of sections (n) and the minimum spacing (s) according to Table 5;
5) If the height of the railing is other than 1.06m (42in) or 900 mm (36in), modify the spacing according to table 6.

FIGURE 8: M.C.M.E.L HANDRAIL OPTIONS



STANDARD HANDRAIL



CONTINUOUS HANDRAIL (Fig. shows one noched, but maximum of two noched 1 5/8 x 1 ¾ can be installed between Posts. Distance between posts written in tables must be respected)

TABLE 2 – LOAD NON-FACTORED 0.50 KN/M

TABLE 2.1 – REGULAR HANDRAIL - SPACING BETWEEN POSTS AT 0.50 KN/M

Number of sections (ns)		2"	2 ½"	3"
Height of 48"				
Spacing between the posts (s) [mm(in)]	N=1 (tested)	1829 (72)	1829 (72)	1829 (72)
	N=2 (simulated)	1829 (72)	1829 (72)	1829 (72)
	N≥3 (simulated)	1829 (72)	1829 (72)	1829 (72)
Height of 42"				
Spacing between the posts (s) *[mm(in)]*	N=1 (tested)	1829 (72)	1829 (72)	1829 (72)
	N=2 (simulated)	1829 (72)	1829 (72)	1829 (72)
	N≥3 (simulated)	1829 (72)	1829 (72)	1829 (72)
Height of 36"				
Spacing between the posts (s) *[mm(in)]*	N=1 (simulated)	1829 (72)	1829 (72)	1829 (72)
	N=2 (simulated)	1829 (72)	1829 (72)	1829 (72)
	N≥3 (simulated)	1829 (72)	1829 (72)	1829 (72)

TABLE 2.2 – CONTINUOUS HANDRAIL WITH SPINDLES (2 POSTS WITH NOCHED 1 5/8 X 1 ¾ POST BETWEEN) 0.50 KN/M

Number of sections (ns)			2 "	2 ½"	3"
Height of 48"					
Spacing between the posts (s) [mm(in)]	N=1 (tested)	Pot. À inter.	1067 (42)	1372 (54)	1372 (54)
		Pot. À pot.	2134 (84)	2744 (108)	2744 (108)
	N=2 (simulated)	Pot. À inter.	1067 (42)	1372 (54)	1372 (54)
		Pot. À pot.	2134 (84)	2744 (108)	2744 (108)
Height of 42"					
Spacing between the posts (s) *[mm(in)]*	N=1 (tested)	Pot. À inter.	1067 (42)	1372 (54)	1524 (60)
		Pot. À pot.	2134 (84)	2744 (108)	3048 (120)
	N=2 (tested)	Pot. À inter.	1067 (42)	1372 (54)	1524 (60)
		Pot. À pot.	2134 (84)	2744 (108)	3048 (120)
Height of 36"					
Spacing between the posts (s) *[mm(in)]*	N=1 (simulated)	Pot. À inter.	1219 (48)	1524 (60)	1524 (60)
		Pot. À pot.	2438 (96)	3048 (120)	3048 (120)
	N=2 (simulated)	Pot. À inter.	1219 (48)	1524 (60)	1524 (60)
		Pot. À pot.	2438 (96)	3048 (120)	3048 (120)

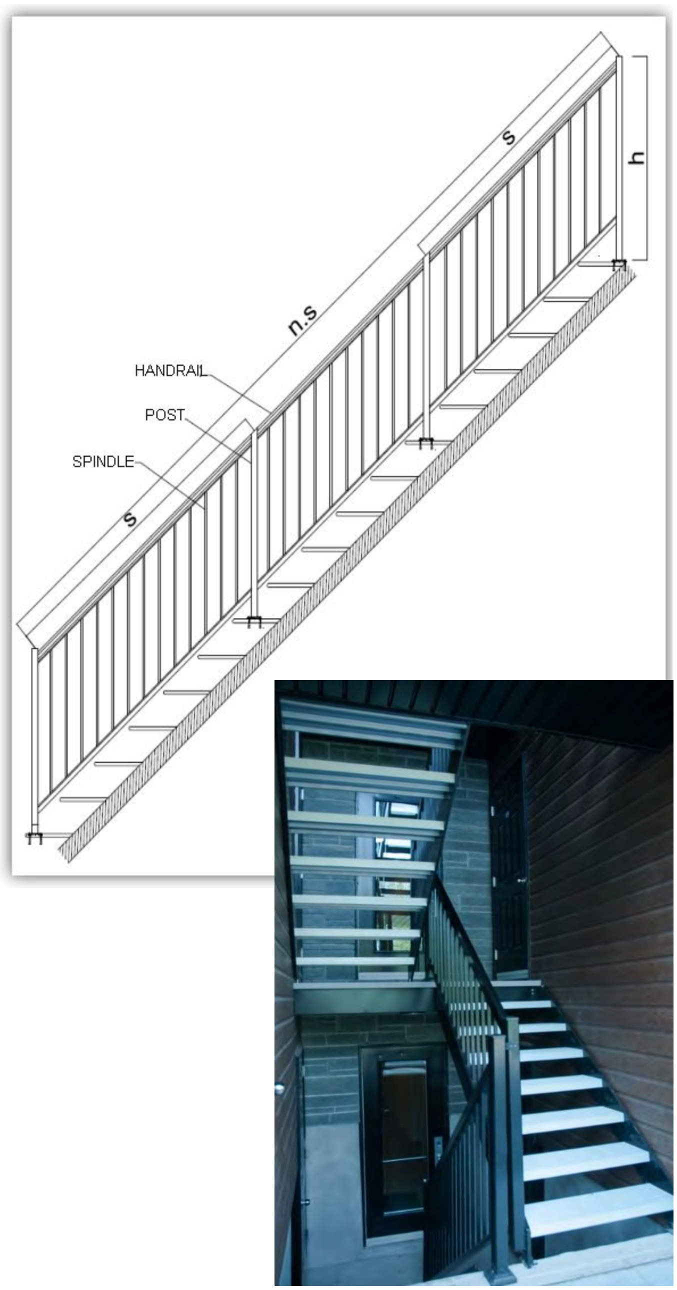
GLASS GUARDRAILS:

MCMEL also proposes glass panel guardrails. These guardrails meet the requirements of the National Building Code, for resistance and deformation under loads impose by Code. The tempered glass used is 6 mm thick. The tempered glass complies with to the CAN/CGSB-12.1 M90 standard. The maximum acceptable length of guardrails is presented in the following table 5.3

TABLE 2.3 – CONTINUOUS AND STANDARD HANDRAIL WITH GLASS (2 POSTS WITH NOCHED 1 5/8 X 1 ¾ POST BETWEEN) AT 0.50 KN/M

Number of sections (ns)		Dist.	2 "	2 ½"	3"
Height of 42" and 48"					
Spacing between the posts (s) *[mm(in)]*	N=1 (tested)	Post to notched	1524 (60)	1524 (60)	1524 (60)
		Post to Post	3048 (120)	3048 (120)	3048 (120)
	N≥2 (simul.)	Post to notched	1524 (60)	1524 (60)	1524 (60)
		Post to Post	3048 (120)	3048 (120)	3048 (120)
Height of 36"					
Spacing between the posts (s) *[mm(in)]*	N=1 (simul.)	Post to notched	1524 (60)	1524 (60)	1524 (60)
		Post to Post	3048 (120)	3048 (120)	3048 (120)
	N≥2 (simul.)	Post to notched	1524 (60)	1524 (60)	1524 (60)
		Post to Post	3048 (120)	3048 (120)	3048 (120)

FIGURE 9: HANDRAIL SYSTEM – DESIGN FOR BANISTERS

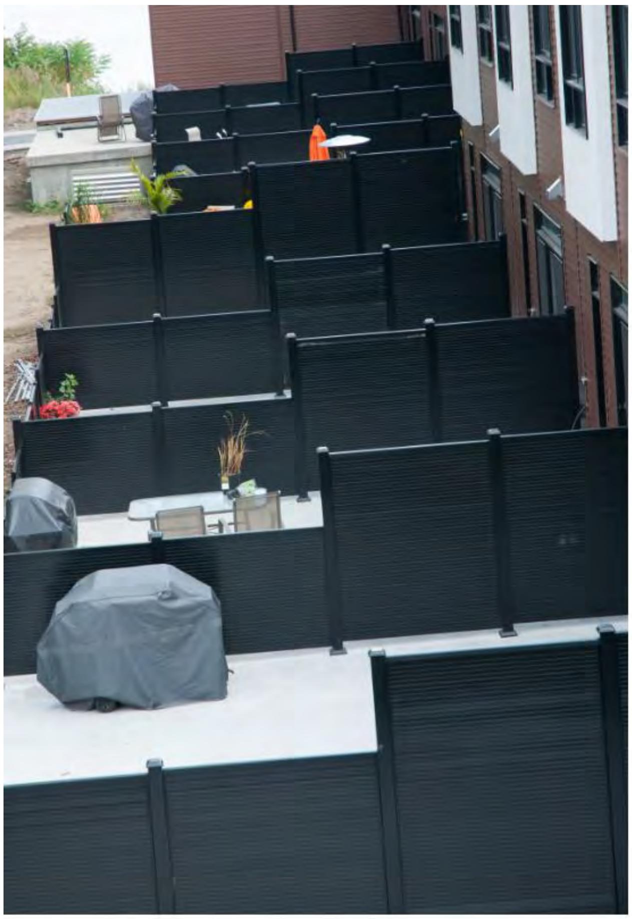


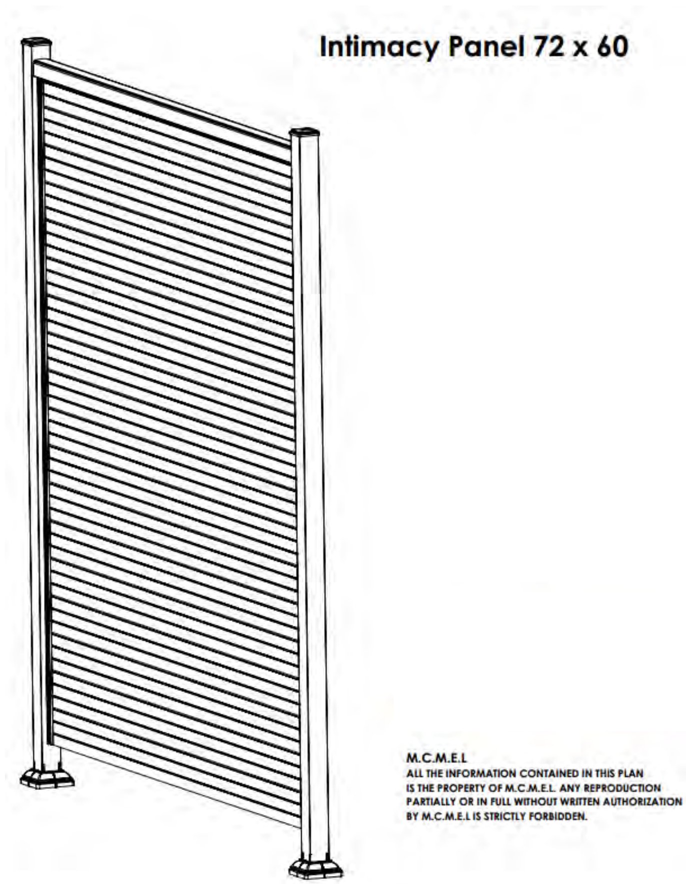
IMPORTANT NOTE:

The handrail not supported by a foot support is always limited to 72 inches (1.8 m). A foot support is a spindle elongated to be attached to the floor.

7 – INTIMITY PANELS

In most cases, the height of the ramps is 42" (1.06 m). In cases where the height is different, coefficients described in Table 5 should be used to modify the height.





Note : Anchorage should be conform to installation process at section 13.0 of Design Manual for M.C.M.E.L Railing System

INTIMACY PANEL 72 x 60

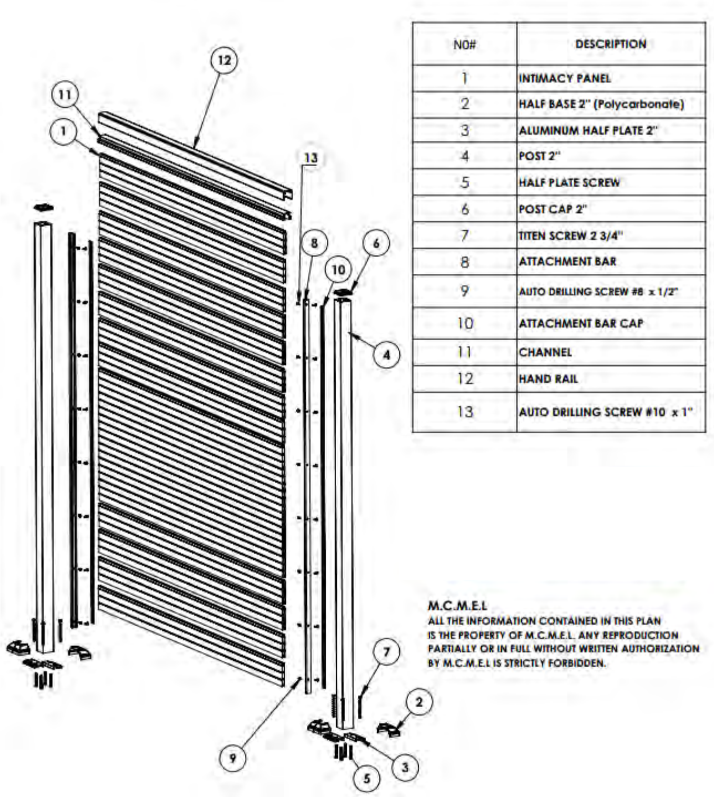


TABLEAU 3.1 PRIVACY PANELS SUPPORTING 100 KM/H WINDS

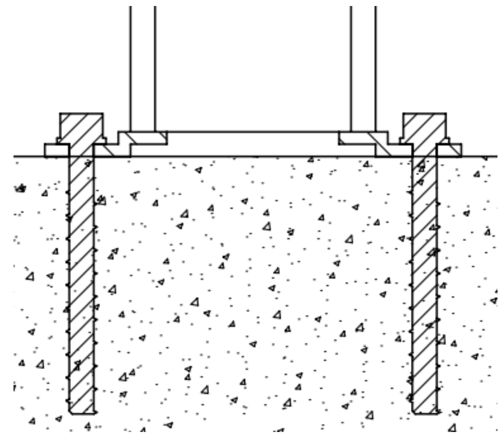
Length of sections stand alone, without wall or railing at ends			
Number of sections (ns)		2 ½"	3"
Height of 72"			
Spacing between the posts (s) *[mm(in)]*	N=1 (tested)	1524 (60)	1676 (66)
	N=2 (simulated)	1524 (60)	1676 (66)
	N≥3 (simulated)	1524 (60)	1676 (66)
Height of 96"			
Spacing between the posts (s) *[mm(in)]*	N=1 (simulated)	1524 (60)	1676 (66)
	N=2 (simulated)	1524 (60)	1676 (66)
	N≥3 (simulated)	1524 (60)	1676 (66)

Note : Anchorage should be conform to installation process at section 12.0 of Design Manual for M.C.M.E.L Railing System

8 - POST ANCHORING

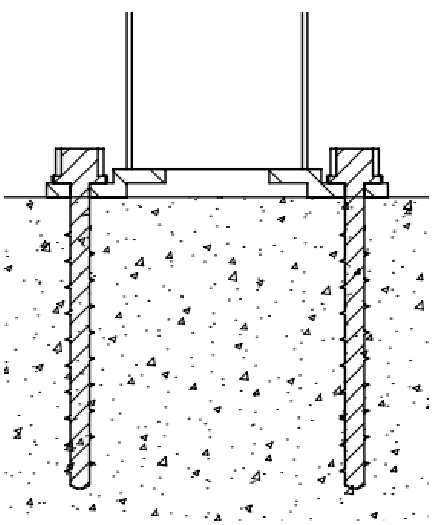
The anchorage of the base of the posts to the floor of the component part is very important to ensure an adequate performance of a railing system. According to the type of floor (concrete or wood) and the type of railing system, it is essential to put an adequate anchorage system into place.

It is to be noted that the resistance and good structural performance of a railing depend not merely on carrier component parts such as posts and handrails, but in large part to the anchoring of the posts to the floor surface. In the case of a wooden floor, it is also necessary to ensure that the floor in question is of a sufficient rigidity to bear the loads imposed by the railing posts. Here are the minimum recommended anchorages:



Post - 3 in x 3 in
4 x Titen ¼ X 2 ¾
Galvanized steel anchors

FIGURE 10: REQUIRED ANCHORAGES FOR A CONCRETE FLOOR – RAILING SYSTEM



Notched post 1 ¾" x 1 ¾"
4x Titen ¼" x 2 ¾"
Galvanized steel anchors

TABLE 4 - ULTIMATE LOADS FOR ANCHORS AND SCREW TESTING IN CONCRETE

POST	**3" x 3"**
Anchor	4 x Titan ¼ X 2 ¾
Ultimate Horizontal load applied at height 1067mm (42") of the post (according to tests carried out by the manufacturer M.C.M.E.L) Failure mode	1.67 kN (374 lbs) Bottom screws (connecting post and base plate) failure
Ultimate Horizontal load applied at height 1067mm (42") of the post **Failure mode (Not govern)**	>1.65kN (370 lbs) Anchor pullout and/or concrete failure

NEW!

Titen HD® Screw Anchor

Now Offering ¼" Diameter for Cracked and Uncracked Concrete

SIMPSON Strong-Tie®

The Titen HD® anchor is a patented, high-strength screw anchor for concrete and masonry. It is designed for optimum performance in both cracked and uncracked concrete, a requirement that the IBC places on post-installed anchors for use in seismic applications. The self-undercutting, non-expansion characteristics of the Titen HD anchor make it ideal for structural applications, even at reduced edge distances and spacings. Recommended for permanent applications in dry, interior, non-corrosive environments or temporary outdoor applications.

Cracked Concrete CODE LISTED

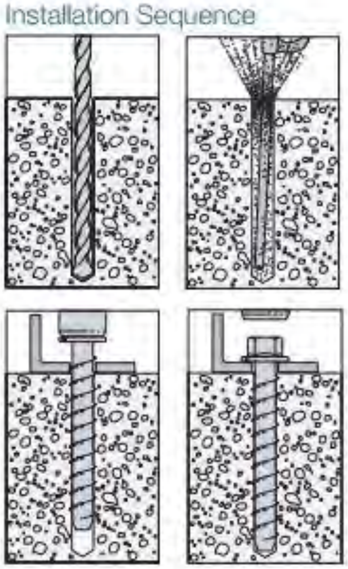
New ¼" Titen HD® Screw Anchor
U.S. Patent 5,674,035 & 6,623,228

Key Features:

- Qualified for static and seismic loading conditions in cracked and uncracked concrete
- Suitable for horizontal, vertical and overhead applications
- Installs with low torque for maximum efficiency
- Code-listed under the IBC/IRC in accordance with AC193 for cracked-concrete applications per ICC-ES ESR-2713
- Classified as a Category 1 anchor, the highest attainable anchor category

Size	Model No.	Drill Bit Dia. (in.)	Min. Fixture Hole Size	Quantity		UPC
				Box	Carton	
¼" x 1⅞"	THDB25178H	¼	⅜	100	500	707392403234
¼" x 2¾"	THDB25234H	¼	⅜	50	250	707392548010
¼" x 3"	THDB25300H	¼	⅜	50	250	707392951254
¼" x 3½"	THDB25312H	¼	⅜	50	250	707392853312
¼" x 4"	THDB25400H	¼	⅜	50	250	707392255345

Installation Sequence



Serrated teeth on the tip of the Titen HD® screw anchor facilitate cutting and reduce installation torque.

Additional Installation Information*

Titen HD Diameter (in.)	Wrench Size (in.)	Recommended Fixture Hole Size (in.)
¼	⅜	⅜ to 7/16

* Installation information and additional data for other Titen HD screw anchors may be found at www.strongtie.com.

Titen HD® Screw Anchor

SIMPSON Strong-Tie

Technical Information – Installation and Additional Data

¼" Titen HD® Anchor Installation Information and Additional Data[1, 4]

Characteristic	Symbol	Units	Nominal Anchor Diameter, d_a (in.)	
			¼	
Installation Information				
Drill Bit Diameter	d_{bit}	in.	¼	
Baseplate Clearance Hole Diameter	d_c	in.	⅜	
Maximum Installation Torque	$T_{inst,max}$	ft.–lb.	24[2]	
Maximum Impact Wrench Torque Rating	$T_{impact,max}$	ft.–lb.	125[3]	
Minimum Hole Depth	h_{hole}	in.	1¾	2⅝
Nominal Embedment Depth	h_{nom}	in.	1⅝	2½
Critical Edge Distance	c_{ac}	in.	3	6
Minimum Edge Distance	c_{min}	in.	1½	
Minimum Spacing	s_{min}	in.	3	
Minimum Concrete Thickness	h_{min}	in.	3¼	3½
Additional Data				
Anchor Category	category	—	1	
Yield Strength	f_{ya}	psi	100,000	
Tensile Strength	f_{uta}	psi	125,000	
Minimum Tensile and Shear Stress Area	A_{se}	in.²	0.0415	
Axial Stiffness in Service Load Range – Uncracked Concrete	β_{uncr}	lb./in.	202,000	
Axial Stiffness in Service Load Range – Cracked Concrete	β_{cr}	lb./in.	173,000	

1. The information presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D.
2. $T_{inst,max}$ is the maximum permitted installation torque for the embedment depth range covered by this table using a calibrated torque wrench.
3. $T_{impact,max}$ is the maximum permitted torque rating for impact wrench for the embedment depth range covered by this table.
4. Data for ¼" anchor is valid only for THDB25 series. For additional data on other Titen HD anchors, please visit www.strongtie.com.

¼" Titen HD® Anchor Tension Strength Design Data[1, 9]

Characteristic	Symbol	Units	Nominal Anchor Diameter, d_a (in.)	
			¼	
Nominal Embedment Depth	h_{nom}	in.	1⅝	2½
Steel Strength in Tension				
Tension Resistance of Steel	N_{sa}	lb.	5,195	
Strength Reduction Factor – Steel Failure	ϕ_{sa}	—	0.65[2]	
Concrete Breakout Strength in Tension[6,8]				
Effective Embedment Depth	h_{ef}	in.	1.19	1.94
Critical Edge Distance[6]	c_{ac}	in.	3	6
Effectiveness Factor – Uncracked Concrete	k_{uncr}	in.	30	24
Effectiveness Factor – Cracked Concrete	k_{cr}	—	17	
Modification Factor	$\psi_{c,N}$	—	1.0	
Strength Reduction Factor – Concrete Breakout Failure	ϕ_{cb}	—	0.65[7]	
Pullout Strength in Tension[8]				
Pullout Resistance, Uncracked Concrete (f'_c = 2,500 psi)	$N_{p,uncr}$	lb.	—[3]	4,555[4]
Pullout Resistance, Cracked Concrete (f'_c = 2,500 psi)	$N_{p,cr}$	lb.	—[3]	1,905[4]
Strength Reduction Factor – Pullout Failure	ϕ_p	—	0.65[5]	
Breakout or Pullout Strength in Tension for Seismic Applications[8]				
Nominal Pullout Strength for Seismic Loads (f'_c = 2,500 psi)	$N_{p,eq}$	lb.	—[3]	1,905[4]
Strength Reduction Factor – Breakout or Pullout Failure	ϕ_{eq}	lb.	0.65[5]	

1. The information presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D, except as modified below.
2. The value of ϕ applies when the load combinations of ACI 318 Section 9.2 are used. If the load combinations of ACI 318 Appendix C are used, refer to Section D.4.4 to determine the appropriate value of ϕ. Anchors are considered brittle steel elements.
3. Pullout strength is not reported since concrete breakout controls.
4. Adjust the characteristic pullout resistance for other concrete compressive strengths by multiplying the tabular value by $(f'_{c,specified} / 2{,}500)^{0.5}$.
5. The value of ϕ applies when both the load combinations of ACI 318 Section 9.2 are used and the requirements of Section D.4.3(c) for Condition B are met. If the load combinations of ACI 318 Appendix C are used, refer to Section D.4.4 to determine the appropriate value of ϕ.
6. The modification factor $\psi_{c,N}$ = 1.0 for cracked concrete. Otherwise, the modification factor for uncracked concrete without supplementary reinforcement to control splitting is either:
(1) $\psi_{c,N} = 1.0$ if $c_{a,min} \geq c_{ac}$ or (2) $\psi_{c,N} = \frac{c_{a,min}}{c_{ac}} \geq \frac{1.5h_{ef}}{c_{ac}}$ if $c_{a,min} < c_{ac}$
The modification factor, $\psi_{c,N}$ is applied to the nominal concrete breakout strength, N_{cb} or N_{cbg}.
7. The value of ϕ applies when both the load combinations of ACI 318 Section 9.2 are used and the requirements of Section D.4.3(c) for Condition B are met. If the load combinations of ACI 318 Section 9.2 are used and the requirements of Section D.4.3(c) for Condition A are met, refer to Section D.4.3 to determine the appropriate value of ϕ. If the load combinations of ACI 318 Appendix C are used, refer to Section D.4.4 to determine the appropriate value of ϕ.
8. For sand-lightweight concrete, in lieu of ACI 318 Section D.3.6, modify the value of concrete breakout strength, $N_{p,cr}$, $N_{p,uncr}$ and N_{eq} by 0.6. All-lightweight concrete is beyond the scope of this table.
9. Data for ¼" anchor is valid only for THDB25 series.

Titen HD® Screw Anchor

SIMPSON Strong-Tie®

Technical Information – Strength Design Data

¼" Titen HD® Anchor Shear Strength Design Data[1]

Characteristic	Symbol	Units	Nominal Anchor Diameter, d_a (in.)	
			¼	
Nominal Embedment Depth	h_{nom}	in.	1⅝	2½
Steel Strength in Shear				
Shear Resistance of Steel	V_{sa}	lb.	2,020	
Strength Reduction Factor – Steel Failure	ϕ_{sa}	—	0.60[2]	
Concrete Breakout Strength in Shear[5,6]				
Nominal Diameter	d_a	in.	¼	
Load Bearing Length of Anchor in Shear	l_e	in.	1.19	1.94
Strength Reduction Factor – Concrete Breakout Failure	ϕ_{cb}	—	0.70[3]	
Concrete Pryout Strength in Shear[5]				
Coefficient for Pryout Strength	k_{cp}	—	1.0	
Strength Reduction Factor – Concrete Pryout Failure	ϕ_{cp}	—	0.70[4]	
Steel Strength in Shear for Seismic Applications				
Shear Resistance of Single Anchor for Seismic Loads	V_{eq}	lb.	1,695	
Strength Reduction Factor – Steel Failure	ϕ_{eq}	—	0.60[2]	

1. The information presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D, except as modified below.
2. The value of ϕ applies when the load combinations of ACI 318 Section 9.2 are used. If the load combinations of ACI 318 Appendix C are used, refer to Section D.4.4 to determine the appropriate value of ϕ. Anchors are considered brittle steel elements.
3. The value of ϕ applies when both the load combinations of ACI 318 Section 9.2 are used and the requirements of Section D.4.3(c) for Condition B are met. If the load combinations of ACI 318 Section 9.2 are used, and the requirements of Section D.4.3(c) for Condition A are met, refer to Section D.4.3 to determine the appropriate value of ϕ. If the load combinations of ACI 318 Appendix C are used, refer to Section D.4.4 to determine the appropriate value of ϕ.
4. The value of ϕ applies when both the load combinations of ACI 318 Section 9.2 are used and the requirements of Section D.4.3(c) for Condition B are met. If the load combinations of ACI 318 Appendix C are used, refer to Section D.4.4 to determine the appropriate value of ϕ.
5. Data for ¼" anchor is valid only for THDB25 series. For additional data on other Titen HD anchors, please visit www.strongtie.com.
6. For sand-lightweight concrete, in lieu of ACI 318 Section D.3.6, modify the value of concrete breakout strength by 0.6. All-lightweight concrete is beyond the scope of this table.

¼" Titen HD® Tension and Shear Strength Design Data in the Soffit of Normal-Weight or Sand-Lightweight Concrete over Metal Deck[1,2,8]

Characteristic	Symbol	Units	Nominal Anchor Diameter, d_a (in.)			
			Lower Flute		Upper Flute	
			¼		¼	
Nominal Embedment Depth	h_{nom}	in.	1⅝	2½	1⅝	2½
Effective Embedment Depth	h_{ef}	in.	1.19	1.94	1.19	1.94
Pullout Resistance, Concrete on Metal Deck (Cracked)[3,4]	$N_{p,deck,cr}$	lb.	420	535	655	1,195
Pullout Resistance, Concrete on Metal Deck (Uncracked)[3,4]	$N_{p,deck,uncr}$	lb.	995	1,275	1,555	2,850
Steel Strength in Shear, Concrete on Metal Deck[3]	$V_{sa,deck}$	lb.	1,335	1,745	2,010	2,420
Steel Strength in Shear, Seismic	$V_{sa,deck,eq}$	lb.	870	1,135	1,305	1,575

1. The information presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D, except as modified below.
2. Concrete compressive strength shall be 3,000 psi minimum. The characteristic pullout resistance for greater compressive strengths shall be increased by multiplying the tabular value by $(f'_{c,specified}/3{,}000)^{n}$.
3. For anchors installed in the soffit of sand-lightweight or normal-weight concrete over metal deck floor and roof assemblies, as shown in Figure A, calculation of the concrete breakout strength may be omitted.
4. In accordance with ACI 318 Section D.5.3.2., the nominal pullout strength in cracked concrete for anchors installed in the soffit of sand-lightweight or normal-weight concrete over metal deck floor and roof assemblies $N_{p,deck,cr}$ shall be substituted for $N_{p,cr}$. Where analysis indicates no cracking at service loads, the normal pullout strength in uncracked concrete $N_{p,deck,uncr}$ shall be substituted for $N_{p,uncr}$.
5. In accordance with ACI 318 Section D.6.1.2(c), the shear strength for anchors installed in the soffit of sand-lightweight or normal-weight concrete over metal deck floor and roof assemblies $V_{sa,deck}$ and $V_{sa,deck,eq}$ shall be substituted for V_{sa}.
6. Minimum edge distance to edge of panel is $2h_{ef}$.
7. The minimum anchor spacing along the flute must be the greater of $3h_{ef}$ or 1.5 times the flute width.
8. Data for ¼" anchor is valid only for THDB25 series. For additional data on other Titen HD anchors, please visit www.strongtie.com.

Titen HD® Screw Anchor

SIMPSON Strong-Tie

Technical Information – Installation and Additional Data

¼" Titen HD® Tension and Shear Strength Design Data in the Topside of Normal-Weight or Sand-Lightweight Concrete over Metal Deck

Design Information	Symbol	Units	Nominal Anchor Diameter
			¼"
Nominal Embedment Depth	h_{nom}	in.	1⅝
Effective Embedment Depth	h_{ef}	in.	1.19
Minimum Concrete Thickness	$h_{min,deck}$	in.	2½
Critical Edge Distance	$c_{ac,deck,top}$	in.	3¾
Minimum Edge Distance	$c_{min,deck,top}$	in.	3½
Minimum Spacing	$s_{min,deck,top}$	in.	3½

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N.

1. For anchors installed in the topside of concrete-filled deck assemblies, as shown in Figure B, the nominal concrete breakout strength of a single anchor or group of anchors in shear, V_{cb} or V_{cbg}, respectively, must be calculated in accordance with ACI 318 D.6.2, using the actual member thickness, $h_{min,deck}$, in the determination of A_{vc}.
2. Design capacity shall be based on calculations according to values in the tables featured on pages 2 and 3 of this flier.
3. Minimum flute depth (distance from top of flute to bottom of flute) is 1½ inch (see Figure B).
4. Steel deck thickness shall be minimum 20 gauge.
5. Minimum concrete thickness ($h_{min,deck}$) refers to concrete thickness above upper flute (see Figure B).

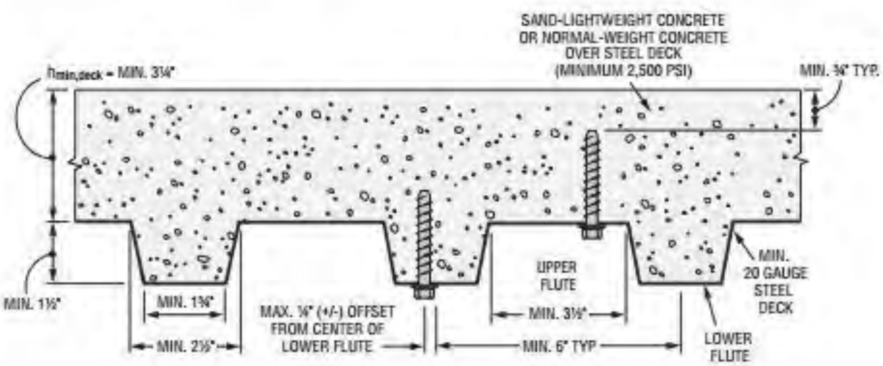


Figure A. Installation in the Soffit of Concrete-Filled Profile Steel Deck Floor and Roof Assemblies

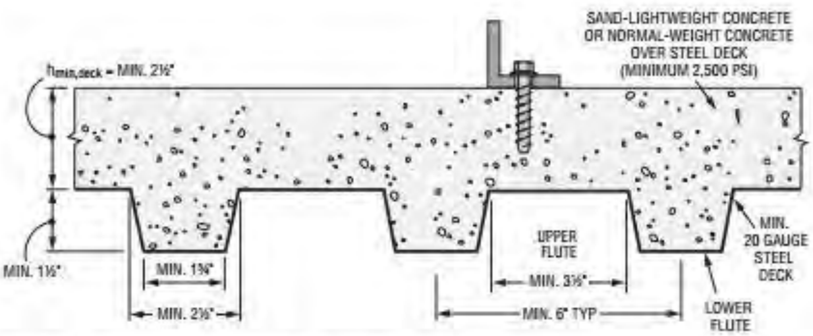


Figure B. Installation in the Topside of Concrete-Filled Deck Assemblies

This flier is effective until December 31, 2016, and reflects information available as of April 1, 2015. This information is updated periodically and should not be relied upon after December 31, 2016; contact Simpson Strong-Tie for current information and limited warranty or see www.strongtie.com.

   F-A-THDB2515 4/15 exp. 12/16

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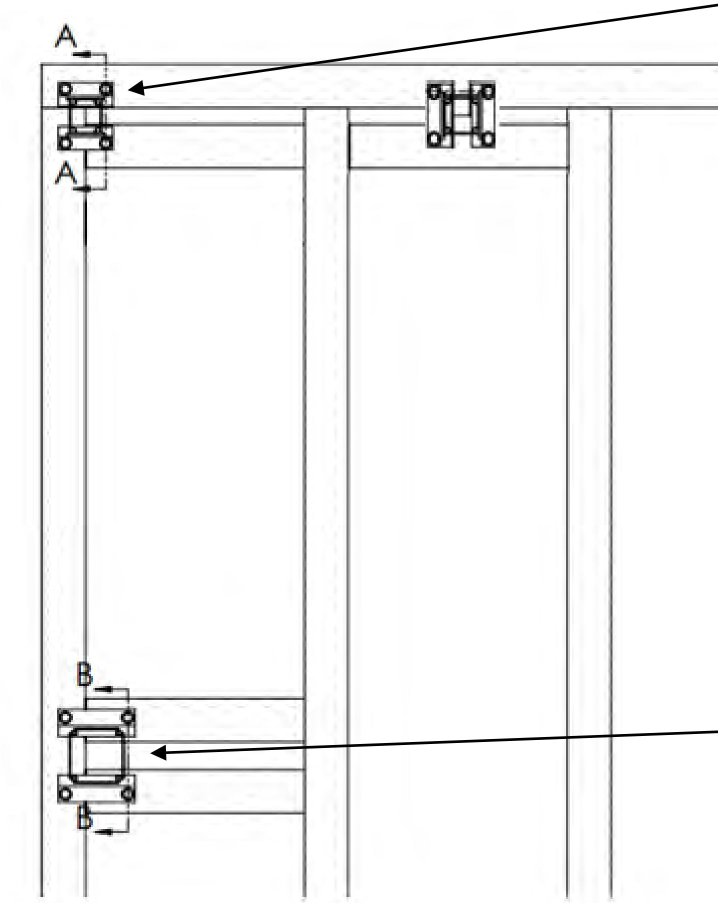
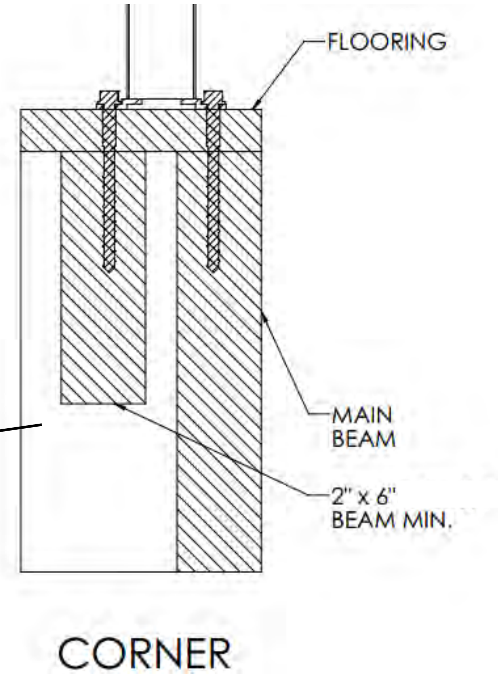
www.strongtie.com

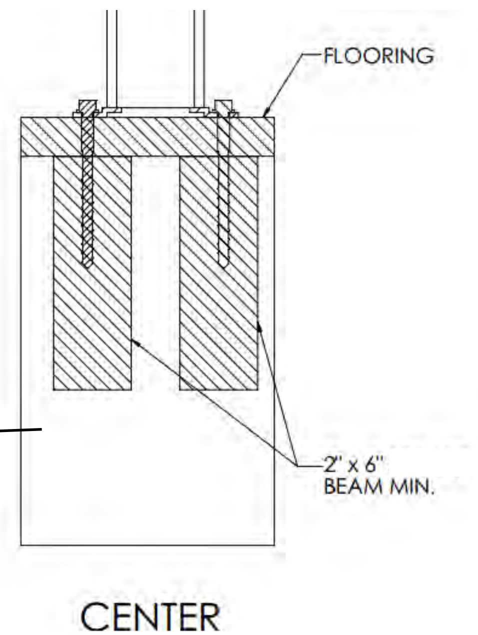
FIGURE 11: REQUIRED ANCHORAGES FOR A WOODEN FLOOR – BALUSTRADE SYSTEM

When the railing is used on deck frame maiden with wood, composite or solid PVC, the anchors must be installed in transverse 2” x 6” (one of these materials) beams between the main beams of the structure. The following images show how to position these beams.

The image below shows the position of the posts and the transverse 2” x 6”x beams.

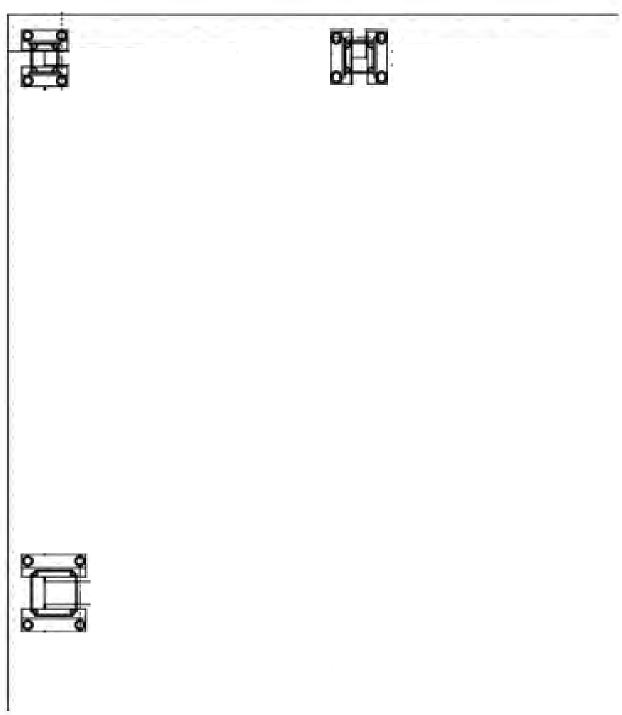






For every type of post
4 x Lag screw 5/16 X 4 in
Galvanized steel
2” x 6” spruce beam min. (vertically). These beams must be screwed to the structure with a minimum of 6 wood screws #8 on each end.

FIGURE 12: ANCHORING PLATES CONFIGURATION – FOR ALL TYPES OF FLOOR



IMPORTANT NOTE: it is very important to make sure that posts are install in correct orientation to insure a maximal resistance of the guardrail. In every case, anchoring plates should be oriented perpendicularly to the direction of the handrail (see figure 13). For corners, the orientation has no importance because there is an handrail in both directions, as shown in the figure 13. These orientations should be respected for all types of floor.

DESIGN AND TECHNICAL INFORMATION ABOUT COMPONENTS

9 - PHYSICAL PROPERTIES

Conforming to CSA standard S175-05 calculation of aluminium structures, the physical characteristics of aluminium alloys are the following:

	Duchesse	Princesse	Princesse Plus	Baronne	Royale
A mm2 (in2)	226.54 (.351)	178.89 (0.277)	317.26 (0.492)	174.83 (0.271)	274.89 (0.426)
Ixx mm4 (in4)	0.209 (0.502)	0.078 (0.19)	0.22 (0.528)	0.099 (0.237)	0.134 (0.32)
Sxx mm3 (in3)	6.1 (0.381)	3.9 (0.237)	6.7 (0.40)	4.5 (0.274)	5.3 (0.32)
Iyy mm4 (in4)	0.129 (0.311)	0.11 (0.264)	0.14 (0.336)	0.118 (0.283)	0.176 (0.422)
Syy **mm3 (in3)**	6.5 (0.396)	5.4 (0.33)	7.0 (0.427)	5.9 (0.36)	5.9 (0.36)

- Modulus of elasticity, E= 70,000 MPa
- Shearing module, G= 26,000 MPa
- Linear coefficient of thermal expansion, α = 24 x 10-6 /°C
- Poisson coefficient, v =0,33
- Density, ρ =2700 kg/m3

The properties of the sections of the component parts used for M.C.M.E.L platform systems are shown in Tables 1, 2 and 3. See annex 1 for full section properties for aluminum boards. The mechanical and physical properties of components of the railing system are used in order to evaluate the bearing capacity of these components against the stress of the external loads imposed by Codes.

10 - MECHANICAL PROPERTIES

Mechanical properties of the railing system components used in M.C.M.E.L products are in accordance with the CAN/CSA-S157-05/S157.1-05 R2010) - Strength Design in Aluminum and appear in Table 3.

TABLE 5 - SECTION PROPERTIES OF POSTS (SEE FIGURE 3 FOR COMPLETE SECTION PROPERTIES) (6063-T54 ALLOY)

	1 ¾'' notched	2''	2 ½''	3''
A mm2 (in2)	353.7 (0.548)	399 (0.62)	469 (0.78)	504.4 (0.78)
Ixx mm4 (in4)	0.074 (0.177)	0.15 (0.36)	0.27 (0.65)	0.42 (1.0)
Sxx mm3 (in3)	3.8 (0.23)	6.0 (0.37)	8.7 (0.53)	11 (0.67)

TABLE 6 - SECTION PROPERTIES OF HANDRAILS (SEE FIGURE 5 FOR COMPLETE SECTION PROPERTIES)

TABLE 7 - SPECIFICATION OF ALUMINUM ALLOY USED FOR M.C.M.E.L PRODUCTS

	Fu	Fy traction	Fy Compression
6063-T5	150 MPa (21.8 ksi)	110 MPa (16.0 ksi)	110 MPa (16.0 ksi)
6063-T5 (posts)	205MPa (29.8 ksi)	170 MPa (24.7 ksi)	170 MPa (24.7 ksi)
6063-T54 (posts)	230 MPa (33.4 ksi)	205 MPa (29.8 ksi)	205 MPa (29.8 ksi) 3

11 - DESIGN PROCEDURE

11.1 LOADS

Loads applied on the railing systems, according to Ontario Building Code 2012, are mentioned in chapter 4, Rule of Calculation. Loads to consider are the excess loads due to usage. For model with glass (tempered, heat strengthened and laminated), the load includes loads due to the wind. Other loads, such as the permanent load, snow load, and seismic load, are negligible because of the low magnitude of these loads in relation to excess loads due to usage or the wind.

11.1.1 SPECIFIED EXCESS LOADS DUE TO USAGE

The excess load from usage per 4.1.5.14 section of Ontario Building Code 2012 following:

1) *The minimum specified horizontal load applied inward or outward at the minimum required height of every required guard shall be,*
   a) *3.0 kN/m for open viewing stands without fixed seats and for means of egress in grandstands, stadia, bleachers and arenas,*
   b) *a concentrated load of 1.0 kN applied at any point for access ways to equipment platforms, contiguous stairs and similar areas where the gathering of many people is improbable, and*
   c) *a distributed load of:*
      i. *0.5 kN/m or a concentrated load of 1.0 kN applied at any point, whichever governs, for interior residential railings and exterior residential railings of a building of 2 residences of less;*
      ii. *0.75 kN/m or a concentrated load of 1.0 kN applied at any point, whichever governs for locations other than those described in Clauses a), b) and c) i.*
2) *Individual elements within the guard, including solid panels and pickets, shall be designed for a load of 0.5 kN applied over an area of 100 mm by 100 mm located at any point in the element or elements so as to produce the most critical effect.*
3) *The loads required in Sentence (2) need not be considered to act simultaneously with the loads provided for in Sentences (1) and (4).*
4) *The minimum specified load applied vertically at the top of every required guard shall be 1.5 kN/m and need not be considered to act simultaneously with the horizontal load provided for in Sentence (1).*

3.4.6.5. Handrails

12) *Handrails and their supports shall be designed and constructed to withstand the loading values obtained from the no concurrent application of,*
   a) *a concentrated load not less than 0.9 kN applied at any point and in any direction for all handrails, and*
   b) *a uniform load not less than 0.7 kN/m applied in any direction to handrails not located within dwelling units.*

Please note that 4.1.5.14.1.a cases are excluded from this manual and designer shall consult M.C.M.E.L for further information.

11.2 LOAD COMBINATION

In cases where the only load is the surcharge due to usage, the Ontario Building Code 2012 defines load combination as follows:

- Resistance calculation to the ultimate limit states: 1.5 L
- Deflection calculation to the serviceability limit state: 1.0 L

For the glass panel included railing, the following combinations are considered:

1. Resistance calculation to the ultimate limit states: max (1.5L, 1.4W)
2. Deflection calculation to the serviceability limit state: max (L, W)

L: surcharge, according to the Ontario Building Code 2012
W: wind load, according to the Ontario Building Code 2012
It should be noted that the code doesn't require the combination of wind loads and surcharges simultaneously.

12 - STRUCTURAL ANALYSES

The load distribution and the structural analysis of the different railing systems are determined in accordance with the following parameters:

- The railing system geometry such as height and post spacing;
- Different types of railing system components such as handrails, posts, handrail base, low rail and bars;
- The limit conditions: the type of connection and attachment at the railing system ends as well as the anchorage stiffness of the posts in the ground.
- The handrail's continuity, handrail, and post relative stiffness, the type of spindle, its spacing, etc.

Structural design and verification has been performed according CAN/CSA-S157-05/S157.1-05 (R2010) - Strength Design in Aluminum, CAN/CSA-A23.3-F04 (C2010) – Design of Concrete Structures, CAN/CGSB-12.20-M89 Structural Design of Glass for Buildings.

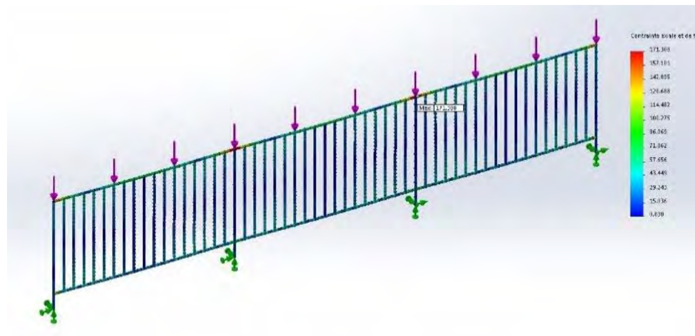
According to the Ontario Building Code 2012, the structural analysis is carried out by the SolidWorks software, a linear analysis to the limit states (See Figure 6 for an example of our analysis).

Design tables, 4 and 5, are prepared based on the analysis results considering different posts, the factored load or real load if guard has been tested, and the spacing between posts. These calculation tables were established for a 1.06 m (42 in) railing height.

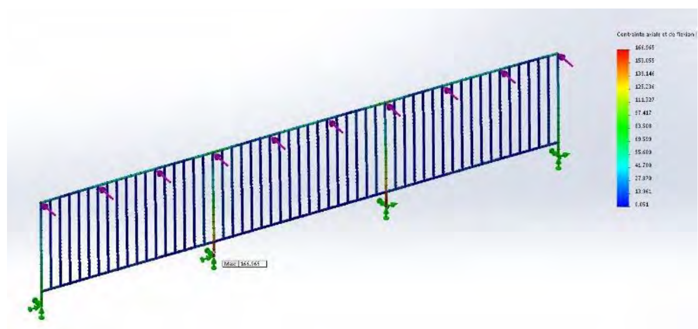
For a different height, the designer should do a more in-depth analysis.

According to the 4.1.5.14.2 sentence of Ontario Building Code 2012, a 0.5 kN load is horizontally applied on the spindles or on the glass railing and it is exerted on 100 x 100mm square. According to our analysis, all M.C.M.E.L railing systems can resist an applied load and it is not necessary for any verification by the designer in order to fulfill this code requirement.

FIGURE 13: AN EXAMPLE OF SIMULATION:
A) UNIFORM VERTICAL LOAD 1.5 KN/M
B) UNIFORM HORIZONTAL LOAD 0.75 KN/M
C) CONCENTRATED LOAD OF 1.0 KN



(a)



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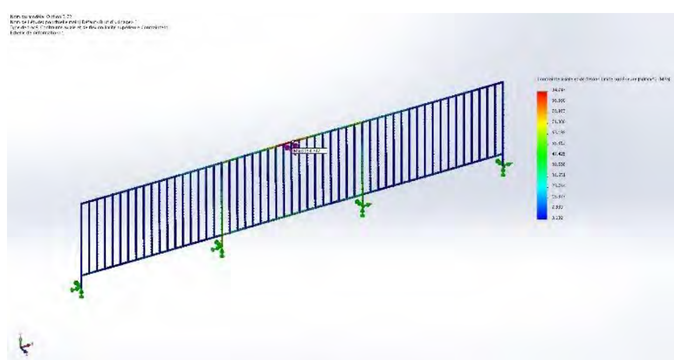

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13 - REQUIREMENTS OF STANDARD CNB2010 (Reference)

The National Building code (CNB 2010, Chapter 3 concerning protection against fire, safety of occupants and accessibility, and Section 3.4 concerning the requirements relative to emergency exits):

13.4.6.5 Handrails

Staircases must be equipped with a handrail on at least one side and, if its size is 1,100 mm or more, with a handrail on each side.

1) If the required size for a ramp or a flight of stairs is greater than 2,200 mm, it is necessary to plan for one or several uninterrupted intermediary handrails spanning from one landing to the other with the interval between two handrails being no greater than 1,650 mm.
2) The handrails must be easy to grasp along their entire length and:
   a) If they have a circular section, must have a diameter of at least 30 mm and at most 43 mm; or
   b) If they have a non-circular section, must have a perimeter of at least 100 mm and at most 125 mm and a transverse section of which the largest dimension is at most 45mm.
3) The height of the staircase handrail and railing must be measured perpendicularly from the top of the handrail:
   a) To a tangent at the nosing of the staircase steps serviced by the handrail (see note A-9.8.7.4.); or
   b) to the surface of the ramp, of the floor or of the landing serviced by the handrail. Subject to the qualifications of Paragraphs 6) and 7), staircase handrails and railings must have a height:
      i. of at least 865 mm; and
      ii. of at most 965 mm.
4) It is not mandatory for handrails installed in addition to the minimum required handrails to conform to Paragraph 5).
5) When railings are required, landing handrails must not be higher than 1,070 mm.
6) Except when it is interrupted by change-of-direction railings or by door openings, at least one handrail must continue for the entire length of the staircase or ramp, including landings (see Appendix A).
7) Handrails must finish in a way that does not impede the passing of pedestrians or constitute a risk (see note A-3.4.6.5 8).
8) Staircases and ramps must have at least one side-handrail that extends horizontally for at least 300 mm at each end (see note A-3.4.6.5. 8).
9) The clearance between handrails and all surfaces located behind them must be:
   a) at least 50 mm; or
   b) 60 mm if the surface located behind the handrails is rough of abrasive.
10) Handrails and their supports must be calculated and built to resist the highest of the following loads:
    a) a concentrated load of at least 0.9 kN applied at any given point and in any given direction, for all handrails; or
    b) a uniform load of at least 0.7 kN/m applied in any given direction, for handrails that are not located inside a building.
11) It is necessary to install handrails on both sides of a ramp.

13.4.6.6. RAILINGS

1) All emergency exits must be protected on each side by a wall or a firmly attached railing.
2) Subject to the qualifications in Paragraph 4), railings for emergency exit stairways must be of a height of at least 920 mm measured perpendicularly from the nosing of the step to the top of the railing, and of at least 1,070 mm to the periphery of the landings.
3) Railings for emergency exit ramps and their landings must be of a height of at least 1,070 mm measured perpendicularly from the surface of the ramp to the top of the railing.
4) Railings for outdoor staircases and landings of more than 10 m above the adjacent ground must be of a height of at least 1,500 mm measured perpendicularly from the surface of the landing or the nosing of the step to the top of the railing.
5) The openwork sections of the railing of an emergency exit must not allow the passage of a spherical object of more than 100 mm in diameter, unless it can be demonstrated that openwork sections with dimensions greater than this limit do not present a risk.
6) Stairwell windows with a support of at least 900 mm high in relation to the nosing of the step or a

height of at least 1,070 mm in relation to a landing must:

a) be protected by a railing whose upper part is located:
   i. at a height of about 900 mm in relation to a line linking the nosing of the steps or;
   ii. at least 1070 mm above the landing; or
b) be subject to and designed to resist lateral loads for railings and walls mentioned in Articles 4.1.5.1.4. and 4.1.5.1.6.

7) Railings must be designed in such a manner that no component part, support or opening situated between 140 and 900 mm above the level protected by these railings thereby permits climbing, unless it can be demonstrated that the position and dimension of the openwork sections that surpass this limit do not present a risk.