Design Manual for M.C.M.E.L ALUMINUM STAIRCASE System

FOR

DESIGNERS, ENGINEERS, ARCHITECTS, CONTRACTORS & INSTALLERS.

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1 - USES OF STAIRCASES

M.C.M.E.L. aluminum staircase systems are used in homes and in residential, commercial, and industrial buildings to provide access to balconies, mezzanines or all structures over one floor.

M.C.M.E.L. aluminum staircase systems consist specifically of 2 aluminum stringers supporting aluminum steps. In some cases, if the length of the staircase exceeds a specified value, columns may be required which support exceeding vertical loads. Assembly is provided by stainless graded metal screws and by anchorages.

FIGURE 1: THE COMPONENT PARTS OF A RAILING

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

M.C.M.E.L. is a business that encourages creativity and development and offers innovative products to its clients. The company distinguishes itself by offering staircase systems 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 M.C.M.E.L. aluminium staircase systems. In this way, installers can determine the type of steps, the spacing of the columns, the arrangement of component parts comprised in the system and the specifications for all anchoring as required. To ensure the safety of the installation, the guidelines established in this manual should be followed.

Following codes are applicable in staircase system designs:

- CAN/CSA-A23.3-F04 (C2010) – Design of Concrete Structures
- National Building code of Canada 2010
- Ontario Building Code 2012
- CAN/CSA-S157-05/S157.1-05 (R2010) - Strength Design in Aluminum
- CAN/CSA-A23.3-F04 (C2010) – Design of Concrete Structures

2 - TYPES OF STAIRCASES

M.C.M.E.L. offers two types of staircases (S500 and S100) as shown in Figure 2. STRINGERS, STAIRS AND COLUMNS are shown in Figures 3, 4 and 5 respectively.

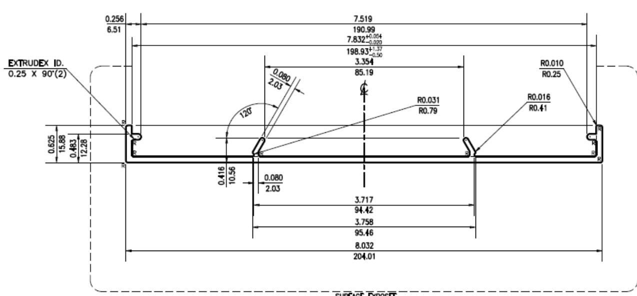
FIGURE 2: M.C.M.E.L STAIRCASES TYPES

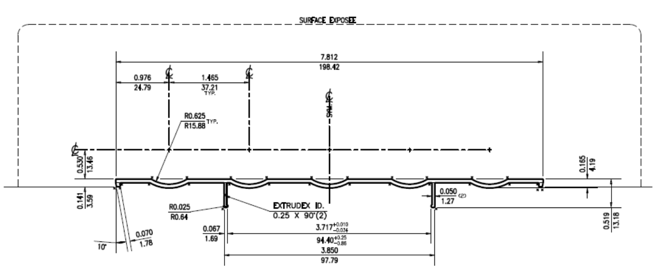
A) S500 STAIRS

B) S100 STAIRS

FIGURE 3: M.C.M.E.L STRINGER PARTS PROFILE

A) S500 STRINGER





B) S100 STRINGER

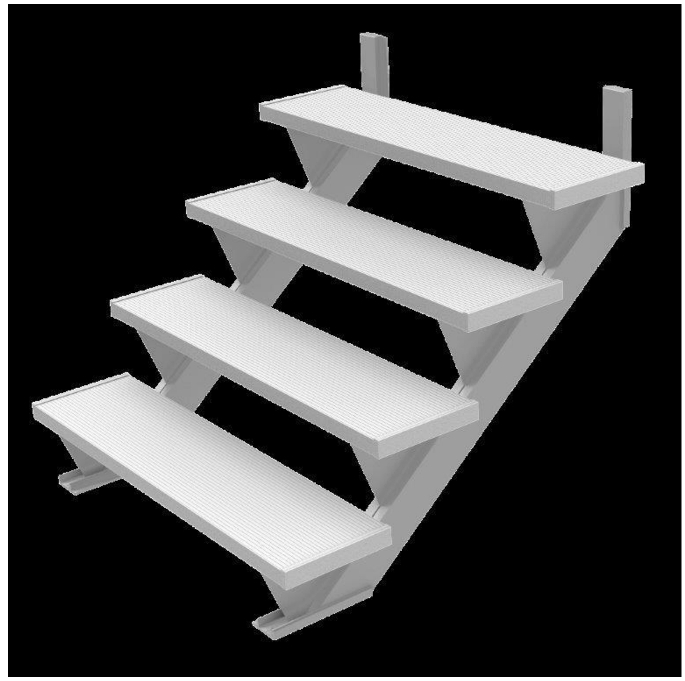


FIGURE 4: M.C.M.E.L STAIR PROFILE

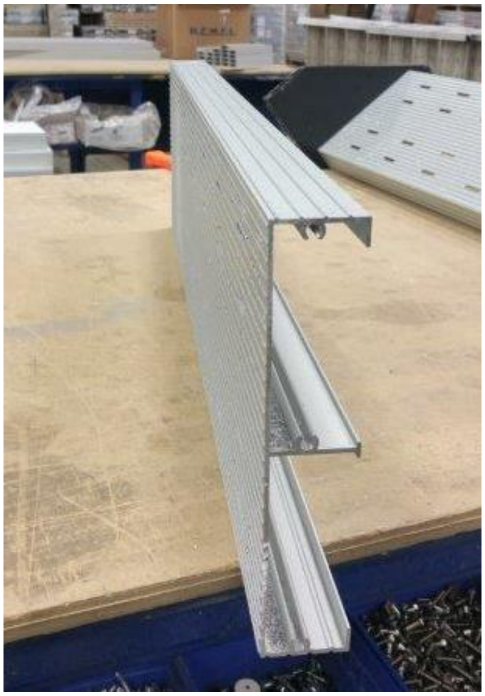
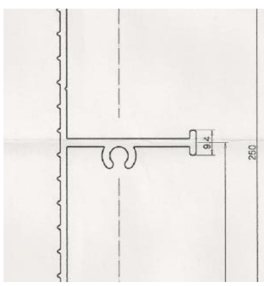


FIGURE 5: M.C.M.E.L COLUMN PROFILE



7 - DESIGN STAGES

7.1 Loading Type Determination

We consider two types of minimal specified loads, in accordance with the 4.1.5.14.1 sentence of the Ontario Building Code 2012, vertically on all horizontal exposed surfaces:

(1) Wd = 0.5 kPa on all horizontal surfaces

(2) Wl = 4.8 kPa on all horizontal surfaces

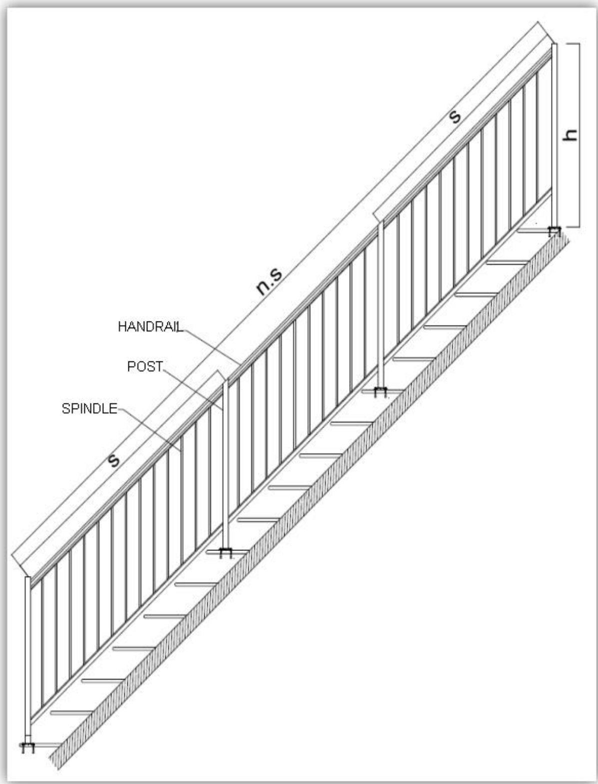
(3) Ws = 2.48 kPa on all horizontal surfaces

8 - DESIGN STAGES FOR STAIRCASE SYSTEMS

1. Determine the type of staircase to install: 100 or 500;
2. With Table DI003-006_MEP-9002_0, determine the step width;
3. Determine the maximum number of steps that can be aligned without a supporting column. The number of steps is based on the CNB applied by the project's site. For example, on a step's height of 7.75 in and a length of 12 in. with an overlap of 1 in.
4. If staircase exceeds the allowed length, divide the total length by the allowed length. You obtain the number of columns to install (i.e. 1.3 = 1, 2.5 = 2).
5. Install columns to divide the span of the stringer in equal parts, if possible. If not, you should obtain a span value less than the allowed length.

Figure 9: M.C.M.E.L Staircase

Figure 10: Handrail System – Design For Banisters

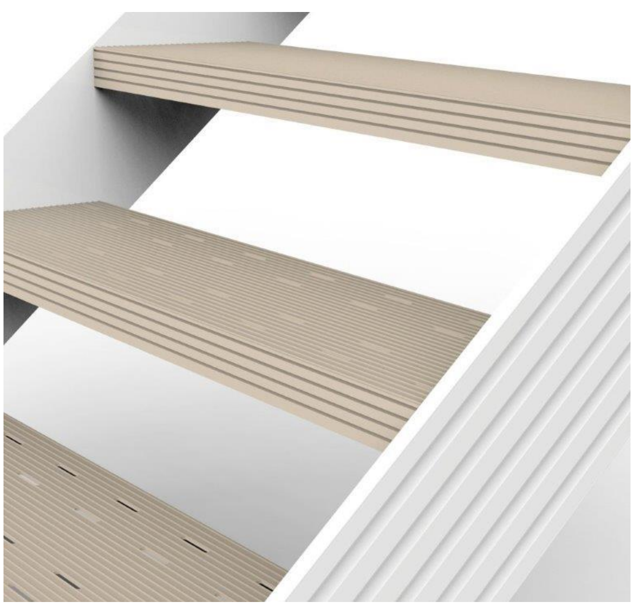


1) 5/16 #18 screws to assemble stringers and stairs.

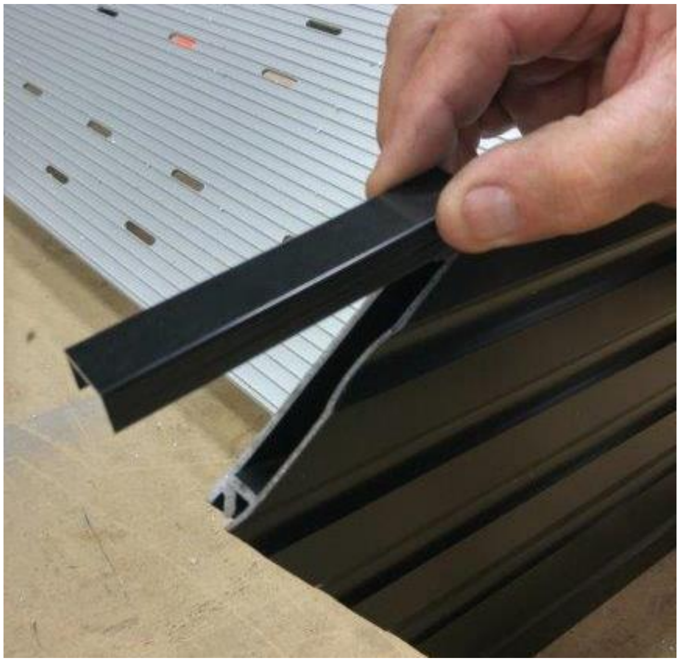
2) External cover.

3 – ASSEMBLY OF STAIRCASE

FIGURE 6: M.C.M.E.L S500 STAIRCASE



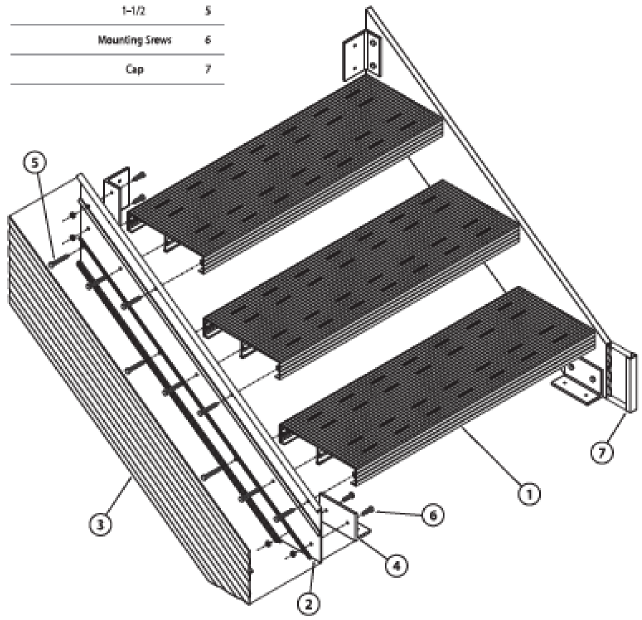
3) Aesthetic covers for screws on open edges (5/8 #10-16)



4) 5/8 #10-16 screws

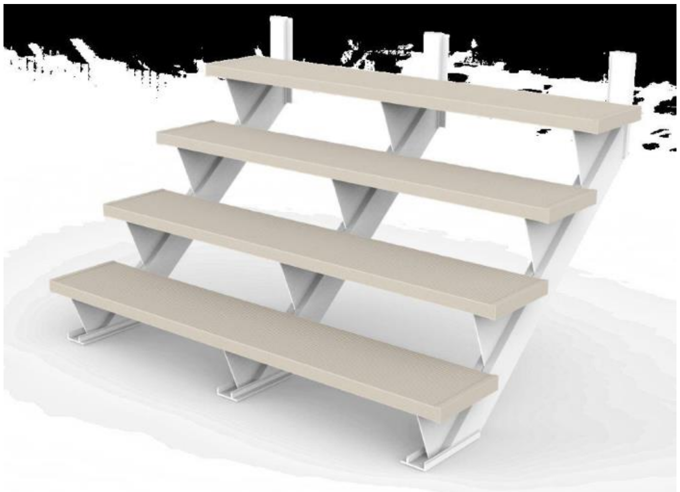
5) Assembly plan for S500 staircases

PART NO.	PART	KEY #
DE-ST	Stair Tread (knurled)	1
DE-SS	Stair Stringer	2
DE-SSC	Stair Stringer Cap	3
DE-LC	L-Channel	4
	1-1/2	5
	Mounting Srews	6
	Cap	7

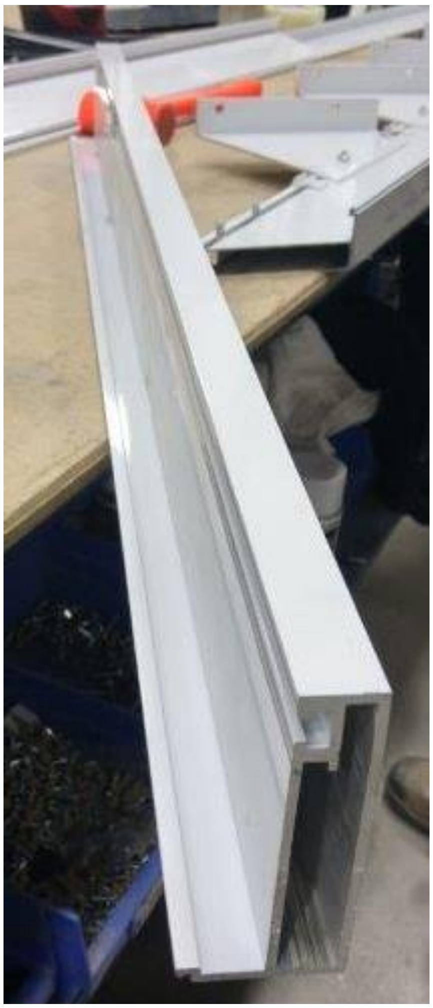


N.B. For information only

FIGURE 7: M.C.M.E.L S100 STAIRCASE



1) S100 Stringer extrusion



2) Screws in t-slot

3) S100 Stair support

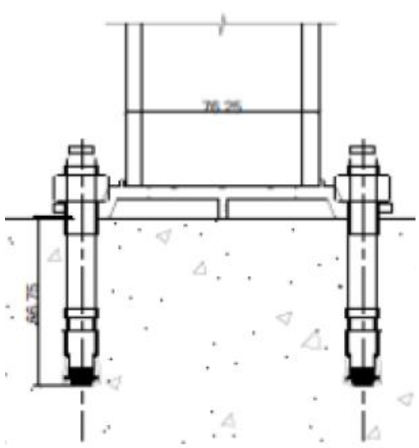
4) Assembly of stair supports on the S100 stringer

10 - COLUMN ANCHORING

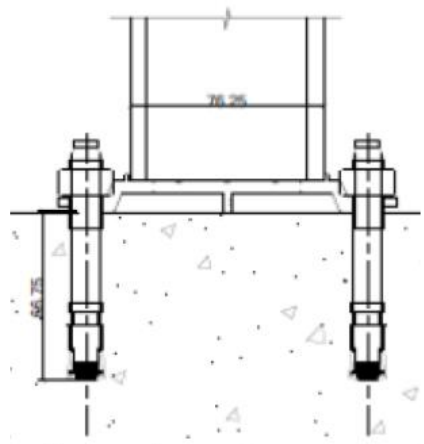
The anchorage of the base of columns to the ground is very important in order to ensure an adequate performance of the staircase system. According to the type of floor or ground (concrete or wood), it is essential to put an adequate anchorage system in place.

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

FIGURE 11: REQUIRED ANCHORAGES FOR A CONCRETE FLOOR – RAILING SYSTEM



Column
4 x Titan ¼ X 2 ¾
Galvanised steel anchors



Post - 3 in x 3 in
4 x Titan ¼ X 2 ¾
Galvanised steel anchors

Simpson Strong-Tie® Anchoring and Fastening Systems for Concrete and Masonry

SIMPSON Strong-Tie®

Titen HD® Mini *Screw Anchor for Concrete and Masonry*

Sharing the same features as the larger Titen HD® screw anchor (page 110), the Titen HD® Mini anchor provides an easy solution for jobs that call for smaller anchors. The self-undercutting, non-expansion characteristics are ideal for situations where minimum edge distance and reduced spacing is a concern. The patented cutting teeth and thread design enable the Titen HD Mini anchor to be installed quickly and with less effort than many other screw type anchors. Since there are no secondary setting steps involved, the Titen HD Mini screw anchor can be installed much more quickly than traditional expansion anchors.

U.S. Patent 5,674,035 & 6,623,228

FEATURES:

- Full-length threads undercut the concrete and effectively transfer loads into the base material.
- Specialized heat-treating process creates high hardness at the tip to facilitate cutting while the body remains ductile.
- Less spacing and edge distance required since the anchor does not exert expansion forces
- No special installation tools required. Holes can be drilled with rotary hammer or hammer drill with ANSI size bit. Anchors are installed with standard size sockets.
- Less installation time translates to lower installed cost.
- Removable, ideal for temporary anchorage.

MATERIAL: Carbon steel, heat treated

FINISH: Zinc plated

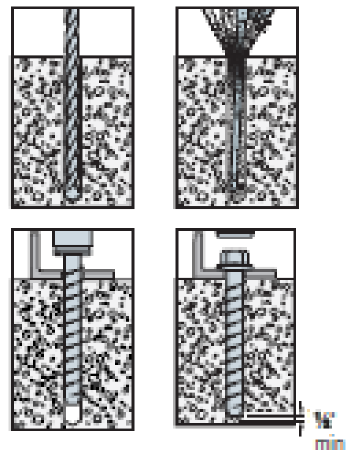
TEST CRITERIA: The Titen HD® Mini anchor has been tested in accordance with ASTM E488 standard test methods for tension and shear.

INSTALLATION:

Caution: Oversized holes in the base material will reduce or eliminate the mechanical interlock of the threads with base material and will reduce the anchor's load capacity. Use a Titen HD Mini screw anchor one time only. Installing the anchor multiple times may result in excessive thread wear and reduce load capacity.

- Drill a hole using the specified diameter carbide bit into the base material to a depth of at least ½" deeper than the required embedment depth.
- Blow the hole clean of dust and debris using compressed air.
- Insert the anchor through the fixture and into the hole.
- IMPORTANT: In normal-weight concrete, install with an applied torque of 15 ft-lbs for the ¼" Titen HD Mini and 25 ft-lbs for the ⅜" Titen HD Mini using a torque wrench, driver drill, hammer drill or cordless ¼" impact driver with a maximum permitted torque rating of 100 ft-lbs. In hollow CMU, do not use impact tools to install and use a manual applied torque of 10 ft-lbs.

Installation Sequence



Mechanical Anchors

Titen HD® Mini Anchor Product Data

Size	Model No.	Drill Bit Dia (in.)	Wrench Size (in.)	Recommended Fixture Hole Size (in.)	Quantity	
					Box	Ctn.
¼" x 1 ¾"	THD25134H	¼	⅜	5/16 – ⅜	100	500
¼" x 2 ¼"	THD25214H	¼	⅜	5/16 – ⅜	50	250
¼" x 3"	THD25300H	¼	⅜	5/16 – ⅜	50	250
⅜" x 1 ¾"	THD37134H	⅜	9/16	½ – 9/16	50	250
⅜" x 2½"	THD37212H	⅜	9/16	½ – 9/16	50	200

Tension Loads in Normal-Weight Concrete

Size In. (mm)	Drill Bit Dia. In.	Embed. Depth In. (mm)	Min. Spacing In. (mm)	Min. Edge Dist. In. (mm)	Tension Load			
					$f'_c \geq 2000$ psi Concrete		$f'_c \geq 4000$ psi Concrete	
					Ultimate lbs. (kN)	Allowable lbs. (kN)	Ultimate lbs. (kN)	Allowable lbs. (kN)
¼ (6.4)	¼	1 (25)	4 (102)	4 (102)	624 (2.8)	156 (0.7)	1,037 (4.6)	260 (1.2)
		1¾ (44)			1,768 (7.9)	440 (2.0)	2,256 (10.0)	565 (2.5)
⅜ (9.5)	⅜	1½ (38)	4 (102)	6 (152)	2,070 (9.2)	520 (2.3)	2,974 (13.2)	745 (3.3)

See Notes Below

*See page 13 for an explanation of the load table icons

Shear Loads in Normal-Weight Concrete

Size In. (mm)	Drill Bit Dia. In.	Embed. Depth In. (mm)	Min. Spacing In. (mm)	Min. Edge Dist. In. (mm)	Shear Load			
					$f'_c \geq 2000$ psi Concrete		$f'_c \geq 4000$ psi Concrete	
					Ultimate lbs. (kN)	Allowable lbs. (kN)	Ultimate lbs. (kN)	Allowable lbs. (kN)
¼ (6.4)	¼	1 (25)	4 (102)	4 (102)	1,104 (4.9)	275 (1.2)	2,136 (9.5)	535 (2.4)
		1¾ (44)			2,443 (10.9)	610 (2.7)	—	610 (2.7)
⅜ (9.5)	⅜	1½ (38)	4 (102)	6 (152)	2,912 (13.0)	730 (3.2)	3,668 (16.3)	915 (4.1)

1. The allowable loads are based on a safety factor of 4.0.
2. The minimum concrete thickness is 1 ½ times the embedment depth.
3. Tension and Shear loads may be combined using the straight line interaction equation (n=1).

Tension and Shear Loads in 8-inch Lightweight, Medium-Weight and Normal-Weight Hollow CMU

Size In. (mm)	Drill Bit Dia. In.	Embed. Depth[4] In. (mm)	Min. Edge Dist. In. (mm)	Min. End Dist. In. (mm)	8-Inch Hollow CMU Loads Based on CMU Strength			
					Tension Load		Shear Load	
					Ultimate lbs. (kN)	Allowable lbs. (kN)	Ultimate lbs. (kN)	Allowable lbs. (kN)
Anchor Installed in Face Shell (See Figure 1)								
¼ (6.4)	¼	1½ (38)	4 (102)	4⅝ (117)	520 (2.3)	105 (0.5)	1,240 (5.5)	250 (1.1)
⅜ (9.5)	⅜	1½ (38)	4 (102)	4⅝ (117)	720 (3.2)	145 (0.6)	1,240 (5.5)	250 (1.1)

1. The tabulated allowable loads are based on a safety factor of 5.0 for installations under the IBC and IRC.
2. Values for 8-inch wide, lightweight, medium-weight, and normal-weight CMU.
3. The minimum specified compressive strength of masonry, f'_m, at 28 days is 1,500 psi.
4. Embedment depth is measured from the outside face of the concrete masonry unit and is based on the anchor being embedded an additional ½" through the 1 ¼" thick face shell.
5. Allowable loads may not be increased for short-term loading due to wind or seismic forces. CMU wall design must satisfy applicable design standards and be capable of withstanding applied loads.
6. Set drill to rotation-only mode when drilling into hollow CMU.
7. Do not use impact wrenches to install in hollow CMU.

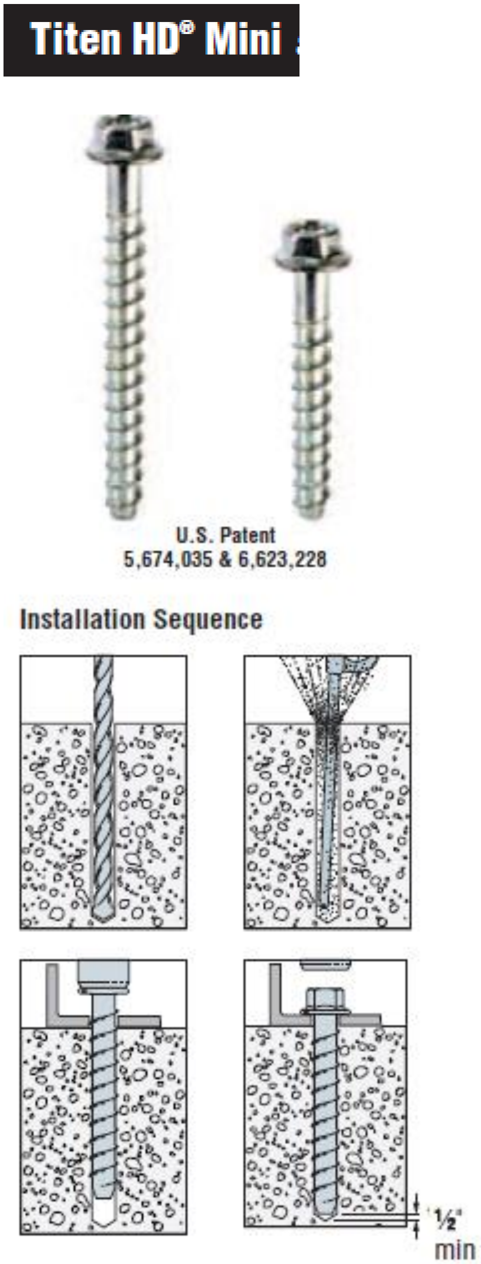
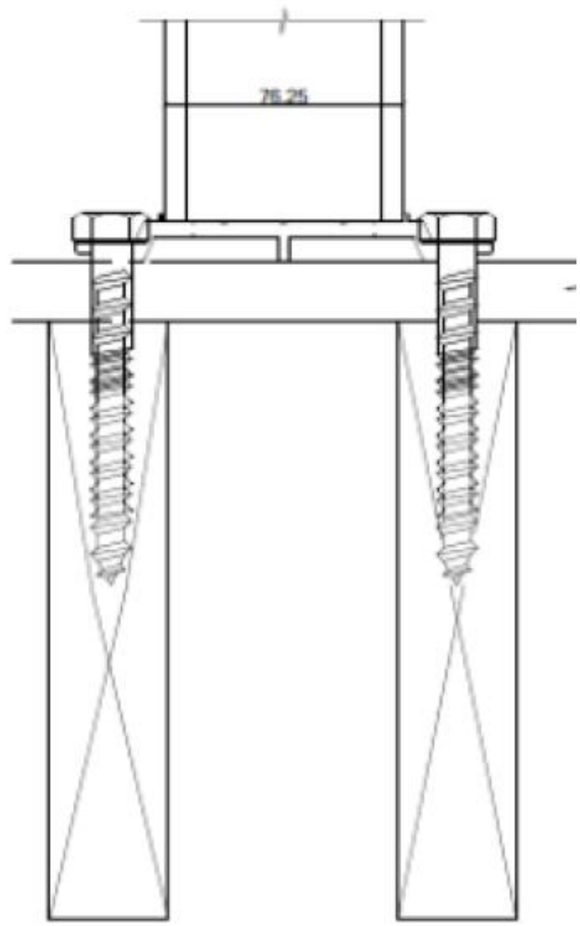


Figure 12: Required Anchorage For Wooden Floor



Column
4 x Lag screw 5/16 X 4 in
Galvanised steel

DESIGN AND TECHNICAL INFORMATION ABOUT COMPONENTS

3 - PHYSICAL PROPERTIES

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

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

The properties of the sections of the component parts used for M.C.M.E.L staircase systems, columns and stringers are shown in Tables 1, 2 and 3. The mechanical and physical properties of components of the staircase systems are used in order to evaluate the bearing capacity of these component against the stress of the external loads imposed by the Codes.

4 - MECHANICAL PROPERTIES

Mechanical properties of the staircase 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 (page 11).

TABLE 1: SECTION PROPERTIES OF STRINGER (SEE FIGURE 3 FOR COMPLETE SECTION PROPERTIES) (6063-T54 ALLOY)

	S16284 (0.100 in) + S16285 (0.070 in)
A	1029 mm^2
Ixx	3.98E+6 mm^4
Vr	51.4 kN
Mr	3.64 kN*m

TABLE 2: SECTION PROPERTIES OF HANDRAIL (SEE FIGURE 4 FOR COMPLETE SECTION PROPERTIES)

	MCM0002-JG (0.118 in)
A	1176 mm^2
Ixx	2.5E+5 mm^4
Vr	58.8 kN
Mr	0.57 kN*m

5 - DESIGN PROCEDURE

5.1 LOADS

Loads applied on the staircase systems, according to the Ontario Building Code 2012, are mentioned in Chapter 4, Rule of Calculation. Loads to consider are the excess loads due to usage. 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.

5.1.1 SPECIFIED EXCESS LOADS DUE TO USAGE

The excess load from usage according to the 4.1.5.14 section of the Ontario Building Code 2012 and CNBC 2010 are the following:

(1) Wd = 0.5 kPa on all horizontal surfaces

(2) Wl = 4.8 kPa on all horizontal surfaces

(3) Ws = 2.48 kPa on all horizontal surfaces

(4) In Table 3 (page 11), all loads have been added with ponderation according to CNBC 2010 and the Ontario Building Code 2012.

6 - STRUCTURAL ANALYSES

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

- Staircase system geometry such as height, length and column spacing;
- Different types of staircase system components such as steps, stringers and columns;
- Limit conditions: the type of connection and attachment at the staircase system ends as well as the anchorage stiffness of the columns to ground.
- The staircase continuity, handrail, and post relative stiffness, etc.

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

According to the Ontario Building Code 2012, a linear static structural analysis is carried out by the SolidWorks software (See Figure 8 for an example of the analysis).

Design Tables 3 and 4 (page 11 and 12) are prepared based on the analysis results considering different steps, the factored load or real load if the staircase has been tested, and the spacing between columns. These calculation tables were established for a step width of 1 m (39 in).

For a different width, the designer should perform a more in-depth analysis.

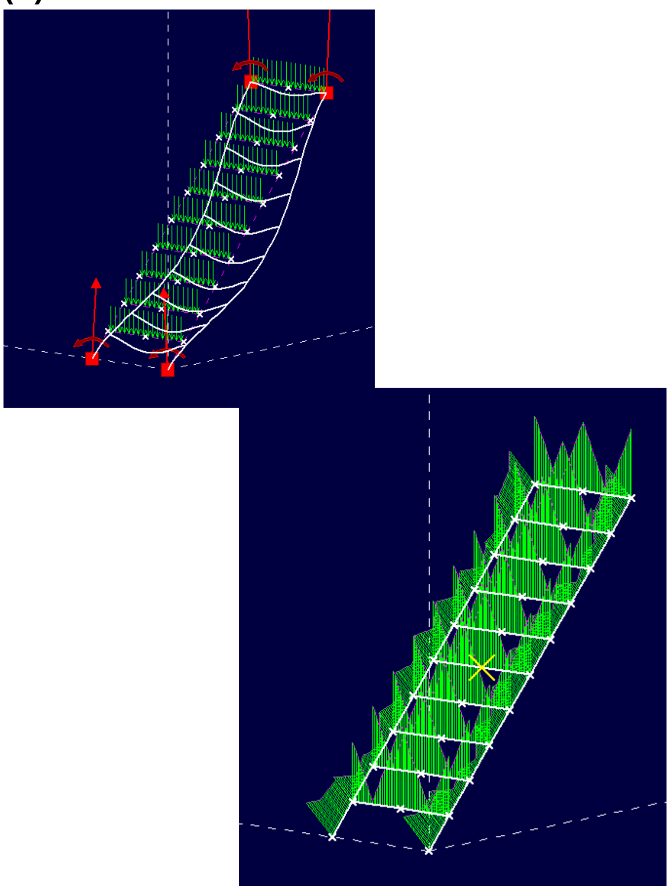
FIGURE 8: AN EXAMPLE OF SIMULATION:

A) UNIFORM LOAD: 7.78 KPA (1 KN/M) (35 MPA)

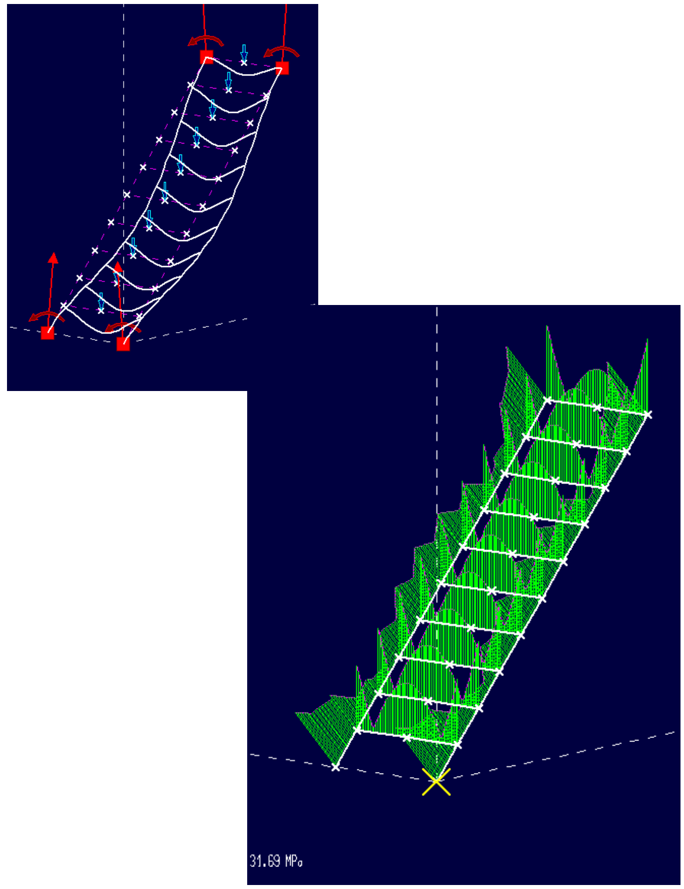
B) CONCENTRATED LOAD: 1.0 KN (32 MPA)

C) UNIFORM LOAD: 7.78 KPA ON A STAIR

(A)



(B)



(C)