MST BAR
MAXIMUM STRENGTH GFRP
Manufactured by MST Rebar Inc.

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Design Limitation and Tables for Below Grade (Basement) ICF Walls Reinforced with MST-BAR

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Structural Design – National and Provincial Codes and Stamps

Tacoma Engineers has completed the structural design of the Insulating Concrete Forms (ICF) basement walls reinforced with MST-BAR (manufactured by MST Rebar Inc.) for Part 9 Buildings in Canada, in accordance with:

- 2015 National Building Code of Canada (NBCC)
- CSA A23.3-14 – Design of Concrete Structures
- CSA S806-12 – Design and construction of building structures with fiber-reinforced polymers
- CSA S807-19 – Specification for fibre-reinforced polymers

In addition to the 2015 NBCC this design guide has also been reviewed and is certified for conformance to the Ontario Building Code as in effect January 2020 (OBC 2012 r2020).

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1. Introduction

The purpose of this design guide is to replace the vertical and horizontal steel reinforcement for below grade (basement) ICF walls supporting wood frame walls, floors, and roof as described in 2021 ICFMA Prescriptive Design for Part 9 Buildings in Canada with MST-BAR reinforcement manufactured by MST Rebar Inc. The 2021 ICFMA Design Manual was stamped by Tacoma Engineers Ltd on May 6, 2021. The enclosed tables are not valid with any other FRP bars other than MST-BAR.

2. Design Limitations and Parameters

2.1. The design tables included in this manual were determined based on the parameters provided in this document. These tables cannot be used if the proposed construction does not meet all the parameters provided in this document or in the tables.

2.2. Components with FRP material (e.g. MST-BAR) shall satisfy the fire performance requirements of the NBCC or other applicable building codes. The building shall satisfy the fire performance requirements of the NBCC, including fire resistance ratings, flame-spread rating, smoke development classifications, and noncomputability requirements. *These tables have been engineered by Tacoma Engineers Inc. for structural design only. Fire resistance ratings and other fire related items are outside the scope of these tables.*

2.3. This document does not address overall structure lateral (seismic/earthquake) design.

2.4. The design tables included in this manual are to be used in conjunction with 2021 ICFMA Design Manual. Refer to the 2021 ICFMA Design Manual for detailing the following ICF wall components:

Concentrated Point Loads on Foundation Walls
Lintel Reinforcing Steel
Reinforcement around Stair Openings
Laterally Unsupported Foundation Walls (Knee Wall) With Wood Framing Above
Wood Ledger Connection
Brick Ledger
Strip Footings

2.5. These tables only apply to residential buildings conforming to Part 9 of the 2015 National Building Code of Canada (NBCC).

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2.6. These tables only apply to below grade (basement) walls supporting wood frame walls, floors, and roof.

2.7. If the proposed construction does not meet the design or applicability of parameters noted herein, a local design professional shall be retained to prepare the design in accordance with applicable standards.

2.8. This design manual applies only to flat ICF walls (concrete core of uniform thickness). All walls must line up vertically.

2.9. In case this document conflicts with design codes, standards and building regulations, the code provisions shall apply.

2.10. The design and construction of all work shall conform to the latest editions of the NBCC, the local building code, local regulations and bylaws and the occupational health and safety act.

2.11. These tables have been designed to resist gravity and out of plane bending due to wind and soil pressure in accordance with the 2015 NBCC for the criteria indicated in the design limitations and in the design tables.

2.12. Design is limited to one (1) floor below grade and a maximum of two (2) stories above grade.

2.13. The maximum building dimensions are(as allowed by Part 9 of NBCC):

Building Area	300 m^2	3200 ft^2
Maximum Building Dimension	24.4 m	80 ft
Building Aspect Ratio (Length:Width)	2.5:1	
Roof Clear Span	12.2 m	40 ft
Floor Clear Span	7.32 m	24 ft
Basement Wall Height	3.66m	12ft

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2.14. The maximum unfactored gravity loads are:

Roof Snow	4.0 kPa	84 psf
Floor Live	1.9 kPa	40 psf
Roof Dead	0.7 kPa	15 psf
Floor Dead	0.7 kPa	15 psf
Concrete Density	23.6 kN/m^3	150 lb/ft^3
Brick Veneer Density	20.0 kN/m^3	128 lb/ft^3

2.15. The lateral soil pressures against below grade walls are:

Area Surcharge (K_o = 0.5)	2.4 kPa	50 psf
Equivalent Fluid Density of Soil (K_o =1.0)	480 kg/m^3	30 pcf

3. Construction

3.1. ALL walls are laterally supported by the building foundation and floor system, designed by others.

3.2. Foundation walls shall be laterally supported at the top and bottom prior to backfilling.

3.3. Provide lateral support at the bottom of the foundation wall in accordance with NBCC 2015 part 9.15.4.4. Alternatively, dowel the wall to the footing as per 2021 ICFMA design manual.

3.4. The contractor shall make adequate provision for construction loads and temporary bracing to keep the structure plumb and in true alignment at all phases of construction.

3.5. Hydrostatic pressure due to water build-up has not been included in the design and analysis. Backfill shall be drained in accordance with NBCC 2015 9.4.4.6.

3.6. Surface grading around the foundation is to slope away from building to allow surface water to drain away.

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3.7. Provide adequate frost protection for all foundation walls and footings, both during construction and in the final installation.

3.8. Construction joints shall be made and located so as not to impair the strength of the structure. All specified reinforcing bars shall have minimum lap lengths across all construction joints.

3.9. Construction joints shall not be installed within 610 mm (2ft) of a wall opening.

3.10. It is the responsibility of the roof and floor designer to ensure adequate bearing for all framing members is provided on the concrete walls

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4. Concrete

4.1. Concrete work shall conform to the latest editions of CSA A23.1,2,3 for materials and workmanship.

4.2. The minimum 28-day compressive strength of concrete shall be 20 MPa.

4.3. Maximum size of aggregates in concrete walls with minimum concrete cover of 40mm, are to be 19mm (3/4") diameter. Maximum aggregate size shall be limited to 12.5mm (1/2") if the concrete cover is less than 40mm.

4.4. Concrete pours shall be terminated at locations of lateral support.

4.5. Use high frequency vibration to place all concrete. Extra care is needed when vibrating during concrete placement for the purpose of ensuring a homogenous aggregate distribution, without segregation.

4.6. Take adequate measures to protect concrete from exposure to freezing temperatures and precipitation at least seven days after concrete placement.

5. Reinforcing MST-BAR

5.1. MST-BAR Grade III Glass FRP (GFRP) bar manufactured by B&B Manufacturing is used for ICF wall reinforcement.

5.2. Properties of MST-BAR reinforcement shall meet the requirement of CSA S807-19.

5.3. Properties of MST-BAR reinforcement shall be provided by manufacturer in accordance with CSA S807-19.

5.4. Mechanical properties of reinforcing MSR-BAR are listed below as reported by the manufacturer.

MST-BAR	10M	15M
Minimum Tensile Strength	1000 MPa	1000 MPa
Young's Modulus	60 GPa	60 GPa
Cross Sectional Area (min.)	100 mm^2	200 mm^2

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5.5. Maintain a minimum concrete clear cover and reinforcement spacing of 40mm (1½") for all MST-BAR rebars.

5.6. Minimum bar lap length shall be:

a) 500 mm (20") for 10M bars b) 800 mm (32") for 15M bars

5.7. Guidance was taken from PCA 100-2017 Prescriptive Design of Exterior Walls for One- and Two-Family Dwellings where steel reinforcement does not meet the minimum requirements of CSA A23.3 Clause 14.1. References to research conducted by PCA for these conditions are included in PCA 100-2017.

5.8. Where the vertical wall reinforcement spacing exceeds maximum spacing requirements according to CSA A23.3 Clause 14.1 the design capacity is at least one third more than required.

5.9. Horizontal temperature and shrinkage reinforcing MST-BAR may be less than specified in CSA A23.3. This is due to ideal curing conditions within the ICF system, which reduce the risk of cracking. In addition, finishes are not applied directly to the concrete wall; therefore, the risk of potential cracks propagating to the surface of the finishes is minimized.

6. MST-BAR reinforcement distribution

6.1. Horizontal and vertical reinforcing is to consist of 10M or 15M continuous bars at spacing in accordance with the tables.

6.2. Provide one continuous horizontal bar at maximum 150mm (6") from the top of the wall and at all floor levels.

6.3. Tables BM. 1, provide the necessary distributed vertical and horizontal MST-BAR to resist the out-of-plane loads for below grade ICF walls with 6" tie spacing.

6.4. Tables BM. 2, provide the necessary distributed vertical and horizontal MST-BAR to resist the out-of-plane loads for below grade ICF walls with 8" tie spacing.

6.5. Interpolation within the tables is not permitted.

6.6. For walls below grade, the vertical reinforcing is to be placed on the inside face of the wall as shown in Detail B. 1. of 2021 ICFMA design manual

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6.7. Walls formed using 300mm (12”) forms shall have all distributed rebars placed in two equal layers. One layer is to be placed in the exterior third of the wall and the other layer in the interior third of the wall as shown in Detail A. 2. of 2021 ICFMA design manual.

6.8. Provide additional 2-10M horizontal and vertical MST-BAR around window openings.

6.9. Provide 600 mm (24”) × 600 mm (24”) horizontal bent dowel at each corner of the walls. Size and spacing of the dowel should match the horizontal reinforcement as per above and below grade tables.

7. Window Openings

7.1. The cumulative width of openings in below grade walls shall not be more than 25% of the total wall length.

7.2. No openings shall occur within 1.2m of interior and exterior corner of ICF walls (NBCC 9.20.17.3 and 4)

7.3. Openings in below grade walls shall not exceed a maximum width of 1.83m (6′-0") and a maximum height of 0.914m (3’-0”).

7.4. The length of solid wall between two openings in below grade walls shall be equal to the average width of the openings and at least 1.22m (4′-0").

7.5. A minimum of 2-10M bars is to be installed completely around all sides of openings.

7.6. Provide additional horizontal reinforcing steel directly above the opening as required for lintels.

7.7. Horizontal bars above and below the opening shall extend a minimum of 610mm (24") past opening.

7.8. Vertical bars on each side of the opening shall extend the full height of the wall.

7.9. Distributed vertical reinforcing MST-BAR that is interrupted by an opening shall be replaced by an equal amount of concentrated vertical MST-BAR with half placed on each side of the opening. The additional MST-BAR is to be evenly distributed within a distance equal to half the opening width, up to a maximum of 1.22m (4’-0”), from each side of the opening

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7.10. If the spacing of the additional concentrated vertical reinforcing required on each side of openings, described in the previous note, is less than 150mm (6"), a local design professional shall be retained to prepare the design in accordance with applicable standards

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Table BM.1. – Below Grade Wall Distributed MST-BAR Reinforcement for Seismic Zone Classification, Sa(0.2) ≤ 0.25 and Hourly Wind Pressure, q1/50 ≤ 1.05kPa, for ICF Walls with 6" Tie Spacing

Wall Height m (ft)	Backfill Height	Vertical MST-BAR (Size and Spacing) — Backfill Equivalent Fluid Density 480 kg/m^3 (45 pcf)			
		150 mm (6") Wall	200 mm (8") Wall	250 mm (10") Wall	300 mm (12") Wall
2.44 (8.0)	1.22 (4.0)	10M @ 450 (18)	10M @ 750 (30)	10M @ 900 (36)	10M @ 900 (36)
	1.53 (5.0)	10M @ 450 (18)	10M @ 750 (30)	10M @ 900 (36)	10M @ 900 (36)
	1.83 (6.0)	15M @ 750 (30)	10M @ 600 (24)	10M @ 750 (30)	10M @ 900 (36)
	2.13 (7.0)	15M @ 450 (18)	15M @ 750 (30)	10M @ 600 (24)	10M @ 750 (30)
	2.44 (8.0)	15M @ 450 (18)	15M @ 600 (24)	10M @ 450 (18)	10M @ 600 (24)
2.74 (9.0)	1.22 (4.0)	15M @ 750 (30)	10M @ 600 (24)	10M @ 900 (36)	10M @ 900 (36)
	1.53 (5.0)	15M @ 750 (30)	10M @ 450 (18)	10M @ 750 (30)	10M @ 900 (36)
	1.83 (6.0)	15M @ 450 (18)	15M @ 900 (36)	10M @ 600 (24)	10M @ 900 (36)
	2.13 (7.0)	15M @ 450 (18)	15M @ 750 (30)	10M @ 450 (18)	10M @ 750 (30)
	2.44 (8.0)	15M @ 150 (6)	15M @ 600 (24)	15M @ 750 (30)	15M @ 900 (36)
	2.74 (9.0)	15M @ 150 (6)	15M @ 450 (18)	15M @ 600 (24)	15M @ 900 (36)
3.05 (10.0)	1.22 (4.0)	15M @ 600 (24)	10M @ 600 (24)	10M @ 900 (36)	10M @ 900 (36)
	1.53 (5.0)	15M @ 450 (18)	15M @ 900 (36)	10M @ 750 (30)	10M @ 900 (36)
	1.83 (6.0)	15M @ 300 (12)	15M @ 750 (30)	10M @ 600 (24)	10M @ 750 (30)
	2.13 (7.0)	15M @ 150 (6)	15M @ 600 (24)	10M @ 450 (18)	10M @ 600 (24)
	2.44 (8.0)	15M @ 150 (6)	15M @ 450 (18)	15M @ 600 (24)	15M @ 900 (36)
	2.74 (9.0)		15M @ 450 (18)	15M @ 450 (18)	15M @ 750 (30)
	3.05 (10.0)		15M @ 300 (12)	15M @ 450 (18)	15M @ 600 (24)
3.35 (11.0)	1.22 (4.0)	15M @ 450 (18)	10M @ 450 (18)	10M @ 750 (30)	10M @ 900 (36)
	1.53 (5.0)	15M @ 300 (12)	15M @ 900 (36)	10M @ 600 (24)	10M @ 900 (36)
	1.83 (6.0)	15M @ 150 (6)	15M @ 750 (30)	10M @ 450 (18)	10M @ 750 (30)
	2.13 (7.0)	15M @ 150 (6)	15M @ 600 (24)	15M @ 750 (30)	15M @ 900 (36)
	2.44 (8.0)		15M @ 450 (18)	15M @ 600 (24)	15M @ 750 (30)
	2.74 (9.0)		15M @ 300 (12)	15M @ 450 (18)	15M @ 600 (24)
	3.05 (10.0)		15M @ 300 (12)	15M @ 300 (12)	15M @ 450 (18)
	3.35 (11.0)		15M @ 150 (6)	15M @ 300 (12)	15M @ 450 (18)
3.66 (12.0)	1.22 (4.0)	15M @ 150 (6)	10M @ 450 (18)	10M @ 600 (24)	10M @ 900 (36)
	1.53 (5.0)	15M @ 150 (6)	15M @ 750 (30)	10M @ 600 (24)	10M @ 750 (30)
	1.83 (6.0)	15M @ 150 (6)	15M @ 750 (30)	10M @ 450 (18)	10M @ 600 (24)
	2.13 (7.0)		15M @ 600 (24)	15M @ 750 (30)	15M @ 900 (36)
	2.44 (8.0)		15M @ 450 (18)	15M @ 600 (24)	15M @ 750 (30)
	2.74 (9.0)		15M @ 300 (12)	15M @ 450 (18)	15M @ 600 (24)
	3.05 (10.0)		15M @ 300 (12)	15M @ 300 (12)	15M @ 450 (18)
	3.35 (11.0)		15M @ 150 (6)	15M @ 300 (12)	15M @ 300 (12)
	3.66 (12.0)		15M @ 150 (6)	15M @ 150 (6)	15M @ 300 (12)
Horizontal Reinforcement	Block Height of 12" and 18"	10 M @ 900 (36)	10 M @ 900 (36)	10 M @ 900 (36)	10 M @ 900 (36)
	Block Height of 16"	10 M @ 800 (32)	10 M @ 800 (32)	10 M @ 800 (32)	10 M @ 800 (32)

NOTES:

1. For highlighted data, where the below grade wall meets all the requirements of NBC Part 9 for a solid concrete foundation wall and supports only wood frame construction above, a 20MPa unreinforced wall is adequate as per 2015 NBC table 9.15.4.2.A. Provide the reinforcing shown for walls supporting ICF walls above or with brick veneer supported with the brick ledge form.
2. Below grade walls supporting "Drained Earth" in accordance with 2015 NBC 9.4.4.6 may be designed for an equivalent fluid pressure of 480 kg/m^3.
3. This table is to be used in conjunction with the "Design Limitations and parameters" and "Below Grade Reinforcement Placement drawing of 2021 ICFMA design manual

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Table BM.2. – Below Grade Wall Distributed MST-BAR Reinforcement for Seismic Zone Classification, Sa(0.2) ≤ 0.25 and Hourly Wind Pressure, q1/50 ≤ 1.05kPa, for ICF Walls with 8" Tie Spacing

Wall Height m (ft)	Backfill Height	Vertical MST-BAR (Size and Spacing) — Backfill Equivalent Fluid Density 480 kg/m^3 (45 pcf)			
		150 mm (6") Wall	200 mm (8") Wall	250 mm (10") Wall	300 mm (12") Wall
	1.22 (4.0)	10M @ 400 (16)	10M @ 800 (32)	10M @ 800 (32)	10M @ 800 (32)
2.44	1.53 (5.0)	10M @ 400 (16)	10M @ 800 (32)	10M @ 800 (32)	10M @ 800 (32)
(8.0)	1.83 (6.0)	15M @ 600 (24)	10M @ 600 (24)	10M @ 800 (32)	10M @ 800 (32)
	2.13 (7.0)	15M @ 400 (16)	15M @ 800 (32)	10M @ 600 (24)	10M @ 800 (32)
	2.44 (8.0)	15M @ 400 (16)	15M @ 600 (24)	10M @ 400 (16)	10M @ 600 (24)
	1.22 (4.0)	15M @ 800 (32)	10M @ 600 (24)	10M @ 800 (32)	10M @ 800 (32)
2.74	1.53 (5.0)	15M @ 800 (32)	10M @ 600 (24)	10M @ 800 (32)	10M @ 800 (32)
(9.0)	1.83 (6.0)	15M @ 400 (16)	15M @ 800 (32)	10M @ 600 (24)	10M @ 800 (32)
	2.13 (7.0)	15M @ 400 (16)	15M @ 800 (32)	10M @ 600 (24)	10M @ 800 (32)
	2.44 (8.0)	15M @ 200 (8)	15M @ 600 (24)	15M @ 800 (32)	15M @ 800 (32)
	2.74 (9.0)		15M @ 400 (16)	15M @ 600 (24)	15M @ 800 (32)
	1.22 (4.0)	15M @ 600 (24)	10M @ 600 (24)	10M @ 800 (32)	10M @ 800 (32)
3.05	1.53 (5.0)	15M @ 400 (16)	15M @ 800 (32)	10M @ 800 (32)	10M @ 800 (32)
(10.0)	1.83 (6.0)	15M @ 400 (16)	15M @ 800 (32)	10M @ 600 (24)	10M @ 800 (32)
	2.13 (7.0)	15M @ 200 (8)	15M @ 600 (24)	10M @ 400 (16)	10M @ 600 (24)
	2.44 (8.0)		15M @ 400 (16)	15M @ 600 (24)	15M @ 800 (32)
	2.74 (9.0)		15M @ 400 (16)	15M @ 400 (16)	15M @ 600 (24)
	3.05 (10.0)		15M @ 200 (8)	15M @ 400 (16)	15M @ 600 (24)
	1.22 (4.0)	15M @ 400 (16)	10M @ 400 (16)	10M @ 800 (32)	10M @ 800 (32)
3.35	1.53 (5.0)	15M @ 400 (16)	15M @ 800 (32)	10M @ 600 (24)	10M @ 800 (32)
(11.0)	1.83 (6.0)	15M @ 200 (8)	15M @ 800 (32)	10M @ 400 (16)	10M @ 800 (32)
	2.13 (7.0)		15M @ 600 (24)	15M @ 800 (32)	15M @ 800 (32)
	2.44 (8.0)		15M @ 400 (16)	15M @ 600 (24)	15M @ 800 (32)
	2.74 (9.0)		15M @ 400 (16)	15M @ 400 (16)	15M @ 600 (24)
	3.05 (10.0)		15M @ 300 (12)	15M @ 400 (16)	15M @ 400 (16)
	3.35 (11.0)		15M @ 200 (8)	15M @ 200 (8)	15M @ 400 (16)
	1.22 (4.0)	15M @ 200 (8)	10M @ 400 (16)	10M @ 600 (24)	10M @ 800 (32)
3.66	1.53 (5.0)	15M @ 200 (8)	15M @ 800 (32)	10M @ 600 (24)	10M @ 800 (32)
(12.0)	1.83 (6.0)		15M @ 800 (32)	10M @ 400 (16)	10M @ 600 (24)
	2.13 (7.0)		15M @ 600 (24)	15M @ 800 (32)	15M @ 800 (32)
	2.44 (8.0)		15M @ 400 (16)	15M @ 600 (24)	15M @ 800 (32)
	2.74 (9.0)		15M @ 200 (8)	15M @ 400 (16)	15M @ 600 (24)
	3.05 (10.0)		15M @ 200 (8)	15M @ 200 (8)	15M @ 400 (16)
	3.35 (11.0)		15M @ 200 (8)	15M @ 200 (8)	15M @ 400 (16)
	3.66 (12.0)			15M @ 200 (8)	15M @ 200 (8)
Horizontal Reinforcement	Block Height of 12" and 18"	10 M @ 900 (36)	10 M @ 900 (36)	10 M @ 900 (36)	10 M @ 900 (36)
	Block Height of 16"	10 M @ 800 (32)	10 M @ 800 (32)	10 M @ 800 (32)	10 M @ 800 (32)

NOTES:

1. For highlighted data, where the below grade wall meets all the requirements of NBC Part 9 for a solid concrete foundation wall and supports only wood frame construction above, a 20MPa unreinforced wall is adequate as per 2015 NBC table 9.15.4.2.A. Provide the reinforcing shown for walls supporting ICF walls above or with brick veneer supported with the brick ledge form.
2. Below grade walls supporting "Drained Earth" in accordance with 2015 NBC 9.4.4.6 may be designed for an equivalent fluid pressure of 480 kg/m^3.
3. This table is to be used in conjunction with the "Design Limitations and parameters" and "Below Grade Reinforcement Placement drawing of 2021 ICFMA deisgn manual".