Structural and Environmental Engineering Analysis

of

300 E Main St Ave, Missoula, Montana

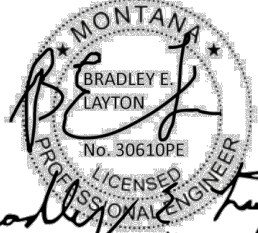(4/7/22)

prepared by

Bradley Layton PhD PE

of

Human Powered Future PLLC

for

SBS Solar

April 7, 2022

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Roof Structure Photo Observations

I performed a site visit on Thursday, March 31, 2022 with James Gillison and Steve Carlson and took relevant photos of the structure. From our walkdown of the northern-most flat roof and the shingled gable roof, where the system is being proposed to be located, the roof appears to be in a condition suitable for a ballast mount (flat membrane roof with proper padding and walkways) and penetrating mount (gabled shingled roof).
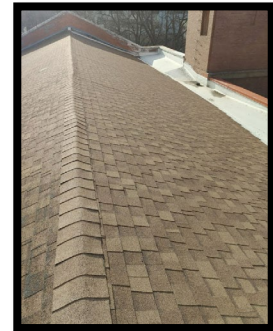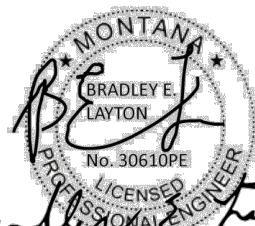
Figure 1. 300 N Main St, Missoula, MT. Flat with ~¼"-12 N-S pitch, and gabled shingled roof.

The cricketing is sufficiently stiff to support the distributed weight of the UNIRAC RM10 ballast system as designed by Ralph Walters of SBS and redesigned by me on April 7, 2022 using a risk category of III (**Figure 2**), ASCE 7-16, and Exposure B "In Town."

April 7, 2022

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2 *Figure 2. Screenshot of UNIRAC project ID 0C70CA36 highlighting that a Risk Category III is for*

3 *buildings that are highly populated such as commercial buildings, schools, and government*

4 *buildings.*

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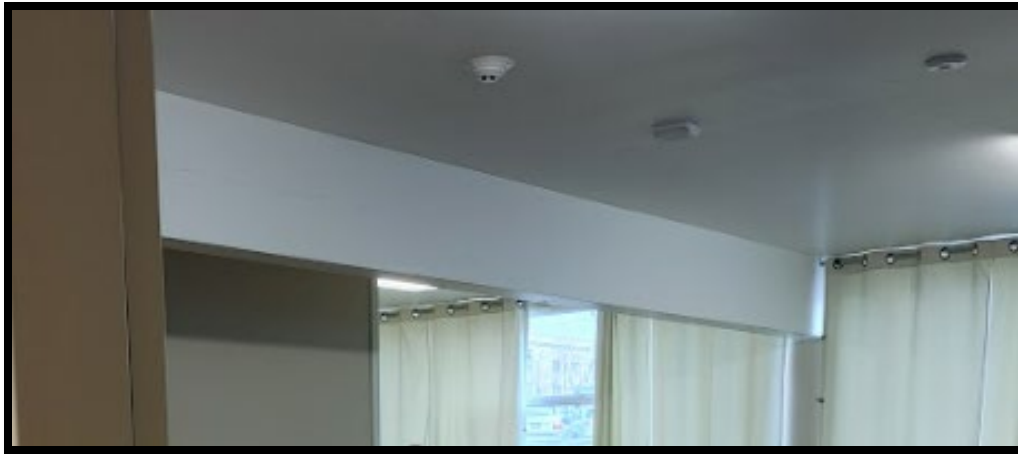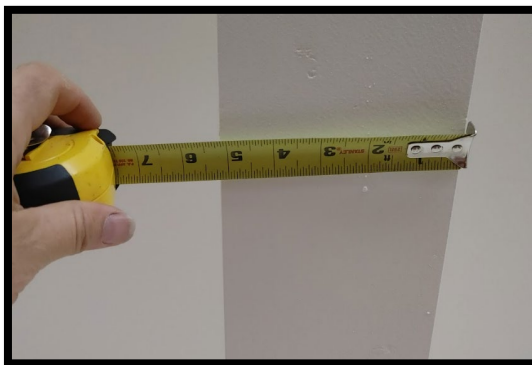
Figure 3. *Photograph of the dimensions of the NS-running 5 ×17 interior beams supporting the flat roof of the First United Methodist Church.*

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2 *Figure 4. Photograph of a typical roof joist of the First United Methodist Church during Mar 31,*

3 *2022 site visit. These ~2 ×8' pine E-W running joists support the wooden decking material.*

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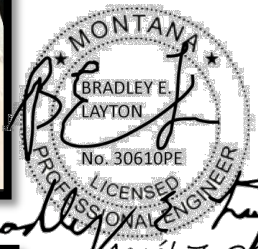
Figure 5. *Photograph of the gabled roof structure shows a substantial trussed structure comprised of ~6 ×12 lumber, ~1.5″ metal tension members, supporting wooden 2 ×10s at 16″ OC.*

I was also able to access the reviewed and revised the UNIRAC design [0C70CA36](1) as submitted to me by Ralph Walters of SBS solar, updating the environmental conditions to which stated the structure to have a windspeed of 115 mph, a snowload of 35 psf, a seismic Ss of 0.48, a wind exposure rating of B, and an MRI[2] of 25 years.

The theoretical lifting force is found by

$$F_L = \frac{1}{2} C_L \rho A v^2, \tag{1}$$

where C_L is the lift coefficient, ρ is air density, A is structure area, and v is wind velocity. The lift coefficient is typically found using thin airfoil theory[3] via

$$C_L = 2\pi\alpha. \tag{2}$$

Using module dimensions of $41.3'' \times 83.9''$, $v = 115$ mph results in a lift force of 37.1 psf, or a lift force of 892 pounds of force per module.

However, after discussing proprietary wind tunnel testing performed by UNIRAC with Chris Castillo and performing a revised design of Ralph Walters' preliminary design, and taking the considerations of ASCE 7-16 (**Figure 6**) into consideration, as well as a Structural Occupancy/Risk Category Risk Factor of III, I arrived at a design (See Engineering Recommendations).

Figure 6. While in the UNIRAC U-Builder design software, I confirmed that ASCE 7-16 is to be used as it references IBC 2018, which Missoula Building Code currently subscribes to.[4]

I then ran four [4] initial simulations of [UNIRAC project ID 0C70CA36](#), each of which produced unique psf and CMU values (**Figure 7**).

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[1] UNIRAC: https://design.unirac.com/project/design/rm/0c70ca36
[2] mean recurrence interval
[3] thin airfoil theory https://en.wikipedia.org/wiki/Airfoil#Thin_airfoil_theory
[4] Missoula Building Code: https://www.ci.missoula.mt.us/419/Code-Information

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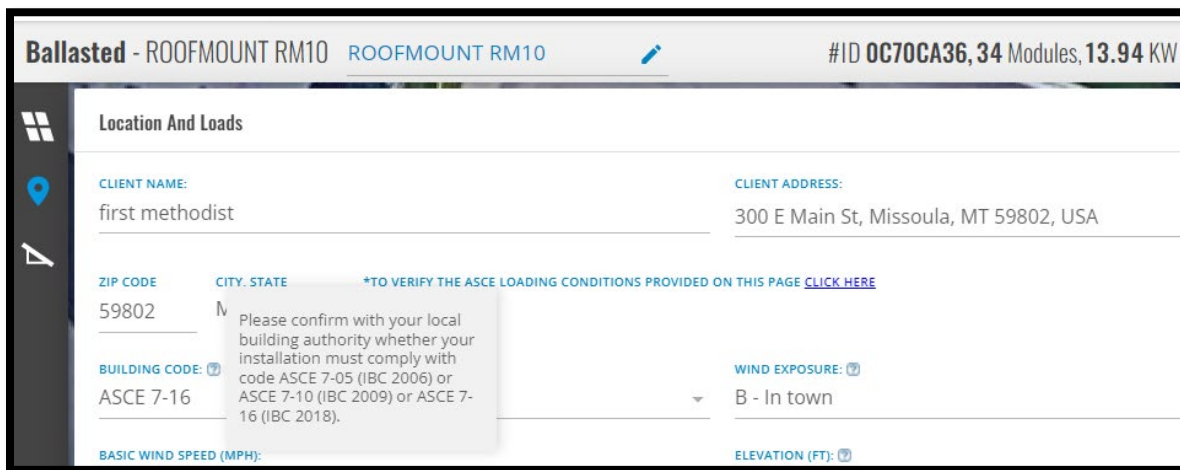
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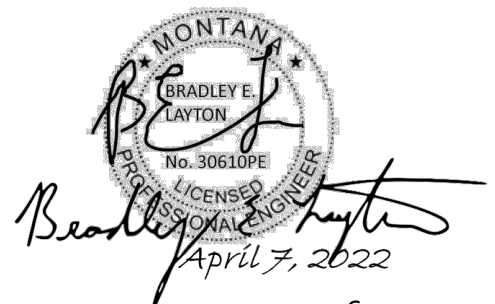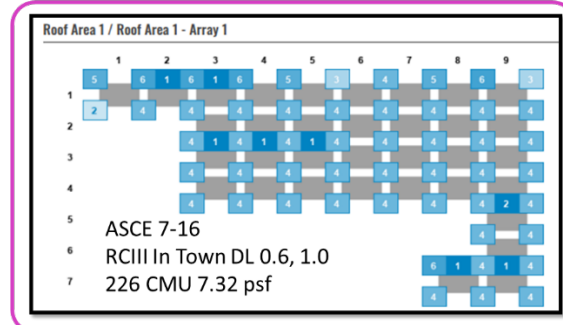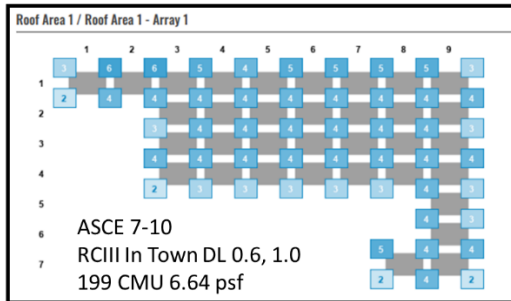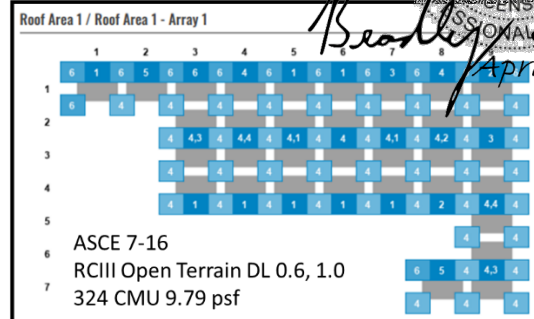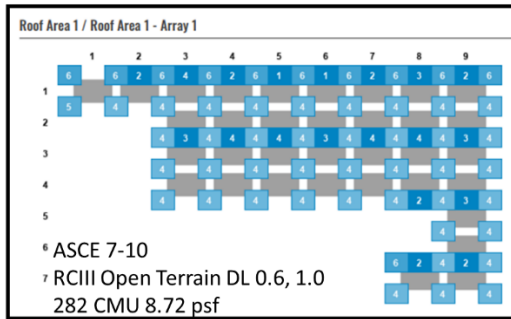*Figure 7. While in the UNIRAC U-Builder design software, I confirmed that ASCE 7-16 is to be used as it references IBC 2018, which Missoula Building Code currently subscribes to. These results were a result of using a building height of 50'. Highlighted is ASCE 7-16 per Missoula Building Code as well as Risk Category III as this is a public building, with Exposure B "In Town."*

Using a building height of 29′ (**Figure 8**) with ASCE 7-16, RCIII, In-Town, resulted in 5.75 psf and only 163 CMUs (**Figure 9**).

Figure 8. The First United Methodist Church NE addition has 2.5 stories above ground and is thus less than 30' high.
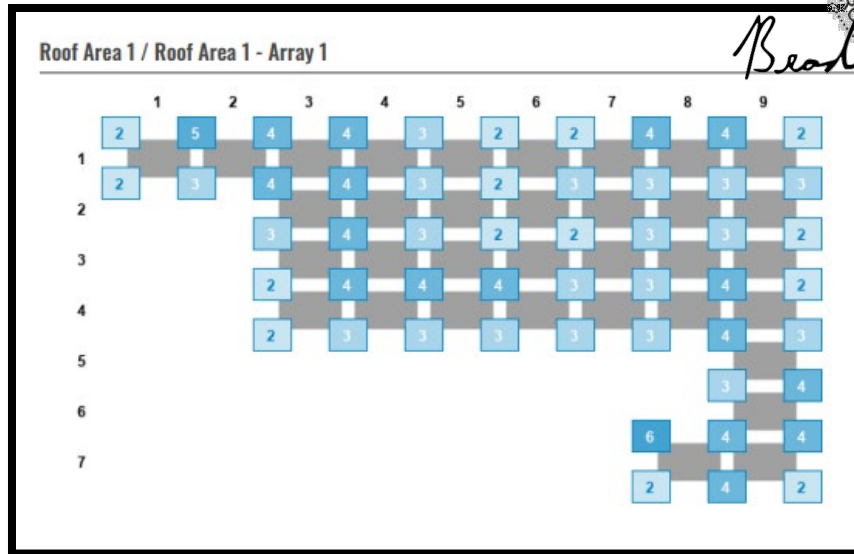
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Roof Area 1 / Roof Area 1 - Array 1

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Figure 9. By reducing the building height from 50′ to 29′, which is a more accurate assessment of the array height, the CMU count drops significantly.

I validated the selection of "In Town" which is Surface Roughness B, urban and suburban areas, wooded areas, or other terrain with numerous, closely spaced obstructions that have the size of single-family dwellings or larger in the prevailing upwind direction of greater than 1,500 ft (Sampson 2020), (**Figure 10**).
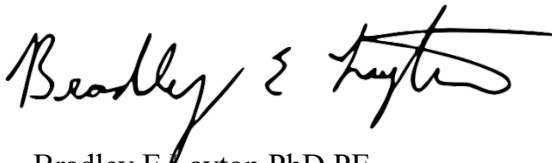
Figure 10. Measuring the distance from the First Methodist United Church to the open terrain of the Clark Fork River in the easterly (Hellgate Canyon prevailing wind) direction of at least 1,500′ to confirm and justify In Town wind exposure condition.
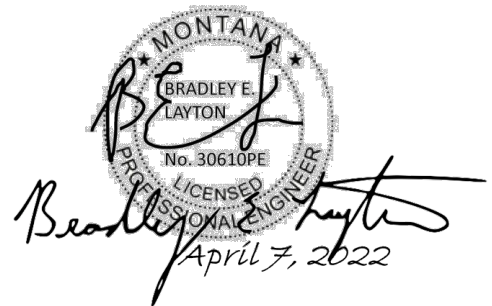
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Engineering Recommendations

1) Comply with NFPA 690 2017.

2) Use at least six [6] CMUs on all N-edge bays of the array and four [4] CMUs elsewhere.

3) Provide adequate padding to minimize environmental wear between the ballast mounts and the roof membrane.

4) Provide a walkway surface to provide traction for maintenance workers and emergency responders.
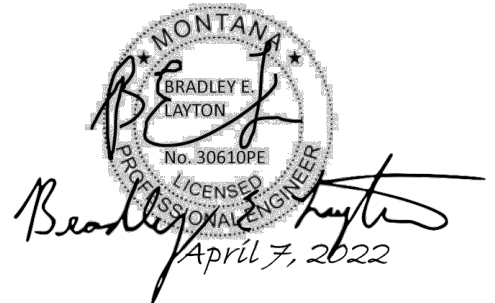
5) No modifications to the structure are required.

Please do not hesitate to contact me with additional questions or concerns.

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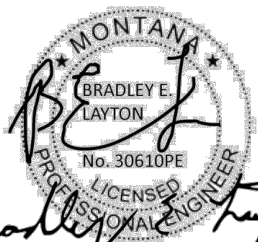
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1 Glossary

2   CMU – concrete mass unit – 4'' × 8'' × 16'', 32 lb concrete block

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References

Sampson, M. (2020, May 3, 2020). "Determination of Wind Exposure Category and Basic Wind Speed for B332 and Other Facilities Located within Superblock." from https://www.osti.gov/servlets/purl/1630401.

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