J.B. SPEED SCHOOL OF ENGINEERING

Masonry Walls and Energy Codes –Alternative Energy Code Compliant Designs for Single Wythe Masonry Structures in Hawaii Session 3 September 2019 – Hawaii

W. Mark McGinley, Ph. D., PE FASTM, FTMS

1

Introduction

- Compliance with the increasing stringent prescriptive code provisions is becoming increasingly more difficult, and new solutions are necessary.
- The recent Hawaiian adoption of IECC 2015 complicated cost effective energy efficient design in this state by now prescriptively requiring continuous insulation for exterior masonry walls. – Residential & Non. (solid grouting)

2

Introduction

- Discuss two phase investigation of energy efficient design of typical structures that use exterior masonry and concrete walls.
- Phase 1 – Looked at prescriptive approach, R , U and Com Check Trade off approaches
- Phase 2 - looked at whole building energy analysis and alternative approaches.

3

IECC Prescriptive R table

TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, b]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.044	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.031	U-0.031	U-0.029	U-0.029	U-0.029	U-0.029
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021
Walls, above grade																
Mass	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.061	U-0.061	U-0.061
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.039	U-0.052	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.057	U-0.064	U-0.052	U-0.045	U-0.045
Wood framed and other[c]	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036	U-0.036
Walls, below grade																
Below-grade wall[c]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.092	C-0.092	C-0.092	C-0.092
Floors																
Mass[d]	U-0.322[e]	U-0.322[e]	U-0.107	U-0.087	U-0.076	U-0.076	U-0.076	U-0.074	U-0.074	U-0.064	U-0.064	U-0.057	U-0.055	U-0.051	U-0.055	U-0.051
Joist/framing	U-0.066[e]	U-0.066[e]	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033
Slab-on-grade floors																
Unheated slabs	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.54	F-0.54	F-0.54	F-0.54	F-0.54	F-0.52	F-0.40	F-0.40	F-0.40	F-0.40
Heated slabs[f]	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.65	F-0.65	F-0.65	F-0.65	F-0.58	F-0.58	F-0.55	F-0.55	F-0.55	F-0.55
Opaque doors																
Swinging	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37

4

International Energy Conservation Code

IECC Section C 402 - prescriptive R requirements for building envelopes.

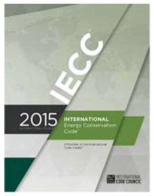
Zone 1 minimum thermal resistance (R) values - mass walls above grade (typical masonry walls) - minimum continuous insulation R= 5.7 °F. ft^2.hr/BTU. IECC Section C402.2.3 indicates that any integral insulation of CMU block cannot be used to meet this continuous R requirement.

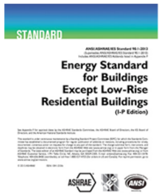
Footnote c in this table indicates that partially grouted (32" O.C.) ASTM C 90 block walls do not need continuous insulation if the ungrouted cells of the block are filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-f^2 °F.

5

International Energy Conservation Code

IECC Allows use of ASHREA 90.1 Instead of IECC





"C401.2 Application. Commercial buildings shall comply with one of the following:
1. The requirements of ANSI/ASHRAE/IESNA 90.1.
2. The requirements of Sections C402 through C405. In addition, commercial buildings shall comply with SectionC406 and tenant spaces shall comply with Section C406.1.1.
3. The requirements of Sections C402.5, C403.2, C404, C405.2, C405.3, C405.4, C405.6 and C407. The building energy cost shall be equal to or less than 85 percent of the standard reference design building."

6

ASHREA 90.1 Prescriptive R table

Table 5.5-1 Building Envelope Requirements for Climate Zone 1 (A,B,C)*

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20 c.i.	U-0.039	R-25 c.i.	U-0.218	R-3.8 c.i.
Metal Building[a]	U-0.041	R-10 + R-19 FC	U-0.041	R-10 + R-19 FC	U-0.115	R-10
Attic and Other	U-0.027	R-38	U-0.027	R-38	U-0.081	R-13
Walls, above Grade						
Mass	U-0.580	NR	U-0.151[b]	R-5.7 c.i.[b]	U-0.580	NR
Metal Building	U-0.094	R-0 + R-9.8 c.i.	U-0.094	R-0 + R-9.8 c.i.	U-0.352	NR
Steel Framed	U-0.124	R-13	U-0.124	R-13	U-0.352	NR
Wood Framed and Other	U-0.089	R-13	U-0.089	R-13	U-0.292	NR
Wall, below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel Joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood Framed and Other	U-0.282	NR	U-0.282	NR	U-0.282	NR

For Climate Zone 1 shows that mass walls above grade (CMU walls) do not require insulation when used in nonresidential construction.

7

Energy Code Compliance – IECC – Hawaii – Phase 1

Prescriptive → R-value table
Prescriptive → U-factor table

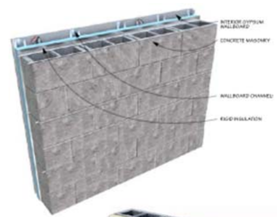
Trade-off Envelope → COMcheck

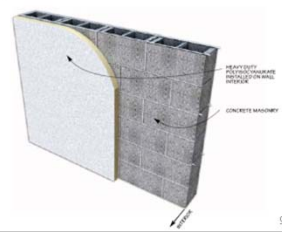
8

Prescriptive R-Value Compliance

Continuous interior insulation:
• R 5.7 – Use 1.5 inches of Expanded Polystyrene - stucco ext. With finishes as shown - Solid grouting

•Using U–factor – 0.151
Can reduce ¾”of insulation.

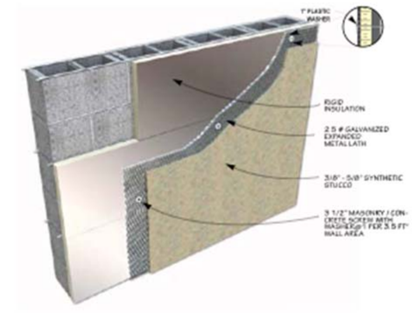




9

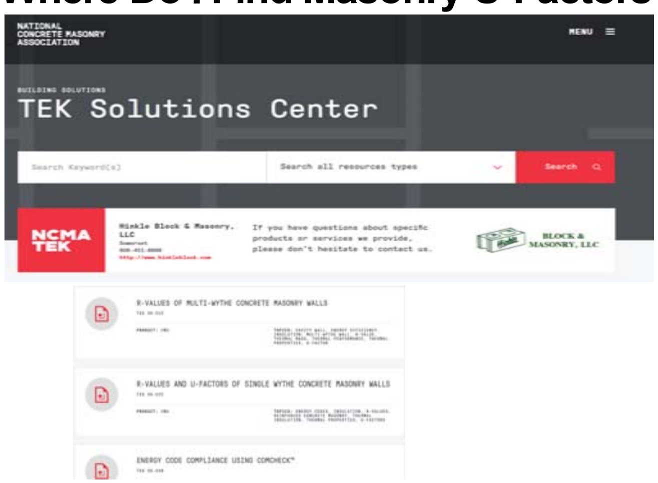
Prescriptive R-Value Compliance - Hawaii

Continuous exterior insulation:
•R 5.7 – Use 1.5 inches of Expanded Polystyrene - stucco ext. – Solid grouting
•Using U–factor – 0.151
Can reduce ¾”of insulation.
•



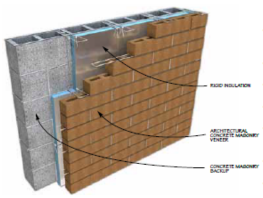
10

Where Do I Find Masonry U-Factors?



Many wall configurations addressed in Catalogue

Assembly 1-9: Continuous insulation in cavity, 4-in. concrete masonry veneer



- For assemblies with clay brick veneer, subtract 0.50 from the R-values listed. For 4-in. solid concrete masonry veneer, subtract 0.53.
- Note that R-values for assemblies with polyisocyanurate include a reflective air space (i.e. polyisocyanurate is foil-faced and the foil-faced side faces the air space).
- When using closed-cell spray polyurethane foam insulation, use one approved for contact with water.
- Thermal mass exposed to the conditioned space maximizes the benefits of thermal mass.
- Masonry exposed on both the interior and exterior provides maximum durability.
- The cavity width can be varied to accommodate various insulation thicknesses, achieving a wide range of R-values.
- Reinforcement and grouting schedule has little effect on assembly R-values
- Cavity insulation can reduce heat loss and moisture movement due to air leakage when joints between the insulation boards are sealed.
- "Lightly reinforced" = grout 8 ft o.c. both vertically and horizontally (or vertical reinforcement only at 48 in. o.c.). "Heavily reinforced" = grout 32 in o.c. vertically and 48 in. o.c. horizontally (or vertical reinforcement only at 24 in. o.c.).

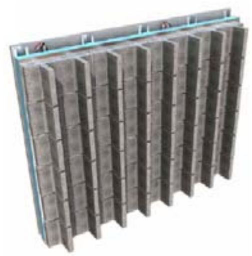
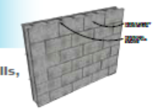


Figure 2.1: 2-web wall-section cut-away illustrating interior web configuration

SINGLE WYTHE CONCRETE MASONRY ASSEMBLIES
CELL INSULATION



Assembly 2-1: Polyurethane foamed-in-place insulation in ungrouted cells, exposed masonry (interior and exterior)

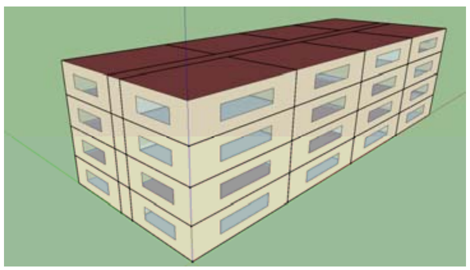
Concrete Masonry Assembly R-Values (hr·ft²·°F/Btu) and U-Factors (Btu/hr·ft²·°F)

Density of CMU, PCF	6-in. Concrete Masonry				8-in. Concrete Masonry			
	Ungrouted	Lightly Reinforced	Heavily Reinforced	Fully Grouted	Ungrouted	Lightly Reinforced	Heavily Reinforced	Fully Grouted
85	9.48 (0.105)	5.45 (0.183)	3.64 (0.275)	1.77 (0.564)	12.97 (0.077)	6.84 (0.146)	4.40 (0.227)	2.07 (0.483)
95	8.37 (0.119)	5.01 (0.200)	3.40 (0.294)	1.69 (0.592)	11.41 (0.088)	6.28 (0.159)	4.10 (0.244)	1.96 (0.509)
105	7.36 (0.136)	4.59 (0.218)	3.18 (0.315)	1.62 (0.619)	9.98 (0.100)	5.75 (0.174)	3.83 (0.261)	1.87 (0.535)
115	6.43 (0.155)	4.19 (0.239)	2.97 (0.337)	1.55 (0.645)	8.69 (0.115)	5.25 (0.191)	3.58 (0.279)	1.79 (0.559)
125	5.61 (0.178)	3.82 (0.262)	2.78 (0.360)	1.49 (0.670)	7.53 (0.133)	4.78 (0.209)	3.34 (0.299)	1.72 (0.583)
135	4.88 (0.205)	3.47 (0.288)	2.59 (0.386)	1.44 (0.693)	6.51 (0.154)	4.34 (0.230)	3.12 (0.321)	1.65 (0.605)

Density of CMU, PCF	10-in. Concrete Masonry				12-in. Concrete Masonry			
	Ungrouted	Lightly	Heavily	Fully Grouted	Ungrouted	Lightly	Heavily	Fully Grouted
85	17.44 (0.057)	8.20 (0.122)	5.05 (0.198)	2.28 (0.438)	21.91 (0.046)	9.44 (0.106)	5.66 (0.177)	2.50 (0.400)
95	15.32 (0.065)	7.56 (0.132)	4.74 (0.211)	2.18 (0.459)	19.22 (0.052)	8.75 (0.114)	5.33 (0.187)	2.39 (0.418)
105	13.36 (0.075)	6.96 (0.144)	4.45 (0.225)	2.08 (0.480)	16.74 (0.060)	8.09 (0.124)	5.03 (0.199)	2.29 (0.436)
115	11.59 (0.086)	6.38 (0.157)	4.17 (0.240)	2.00 (0.501)	14.50 (0.069)	7.45 (0.134)	4.74 (0.211)	2.21 (0.453)
125	10.01 (0.100)	5.84 (0.171)	3.92 (0.255)	1.92 (0.520)	12.49 (0.080)	6.84 (0.146)	4.46 (0.224)	2.13 (0.469)
135	8.61 (0.116)	5.32 (0.188)	3.67 (0.272)	1.86 (0.539)	10.71 (0.093)	6.25 (0.160)	4.20 (0.238)	2.06 (0.485)

*Assembly details page 37

Phase 1 - Evaluated 4 Prototype buildings typically using Masonry exterior Walls using COMCheck

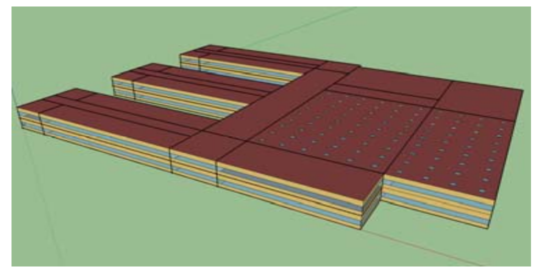


A. Midrise Apartment

The total floor area of the four story, DOE prototype midrise apartment building shown in Figure 1 is 33,741 ft² and it has an aspect ratio of 2.74. The window fraction for each orientation (north, south, east and west) is a constant 20%.

15

Phase 1 - Evaluated 4 Prototype buildings typically using Masonry exterior Walls using COMCheck

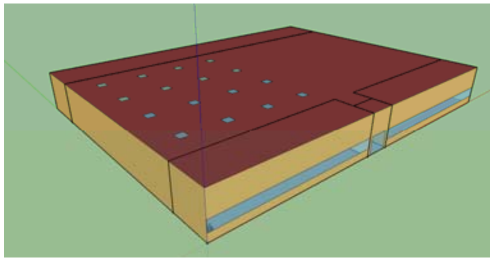


B. Secondary School

The total floor area of the two story, DOE defined secondary school building is 210,886 ft², with an aspect ratio of 1.4The window fraction for each orientation (north, south, east and west) was a constant 33%, with ribbon windows across all facades, on both floors. Floor to floor height is 13 ft.

16

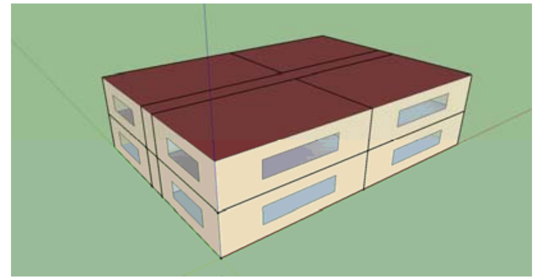
Phase 1 - Evaluated 4 Prototype buildings typically using Masonry exterior Walls using COMCheck



C. Stand-alone Retail
The total floor area of the one story, DOE prototype retail building is 24,692 ft^2, with an aspect ratio of 1.28 .The floor to ceiling height is 20 ft. The window fraction is 7.1% in total, with windows located on the street facing façade only.

17

Phase 1 - Evaluated 4 Prototype buildings typically using Masonry exterior Walls using COMCheck



D . Low-rise Apartment - The total floor area of the two story, low-rise apartment building is 8,435 ft^2, with an aspect ratio of 1.37. This structure was based on the midrise apartment, but modified to represent a low-rise construction configuration common in Hawaii. The window fraction for each orientation (north, south, east and west) was a constant 20%.

18

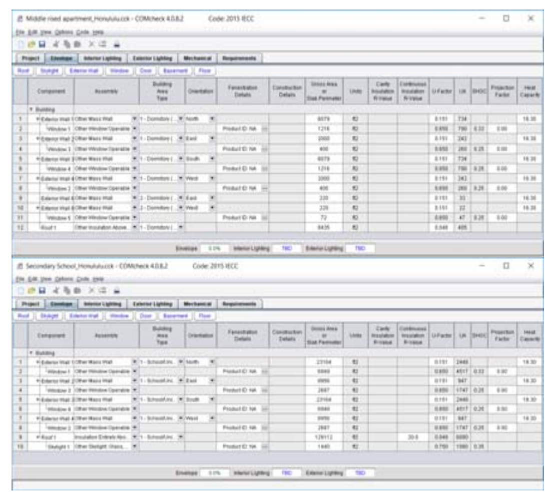
COMcheck

- easy way to take advantage of trade-offs, ie, increase roof insulation to reduce wall or window requirements.
- program shows if the envelope complies, and how close it is to compliance
- allows individual elements to be tweaked for compliance, revisions are quick and easy.
- **Trade offs are for envelope only**

From NCMA Presentation

19

COMcheck



20

COMcheck

- The trade-off analysis clearly shows that, for the four prototype buildings investigated, no reasonable amount of roof insulation, or more thermally resistant windows could be used to make uninsulated fully grouted exterior concrete masonry or bare concrete walls code compliant through a trade-off analysis alone.

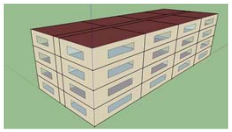
21

Phase 2 Whole Building Analysis - Using 4 Prototypes

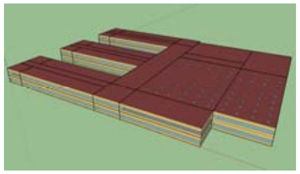
- Energy Budget method requires same yearly energy cost of prototype configured to prescriptive requirements.
- Used Openstudio and Energy plus Programs – Looked at changes in envelopes and building systems that were expected to be minimum costs.
- Also conducted a economic analysis

22

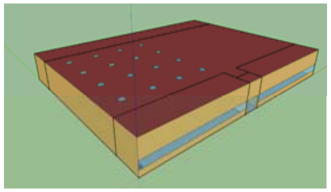
Phase 2 Whole Building Analysis



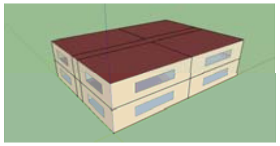
A . Mid-rise Apartment



B. Secondary School



C. Stand-alone Retail



D . Low-rise Apartment

23

Baseline Configuration

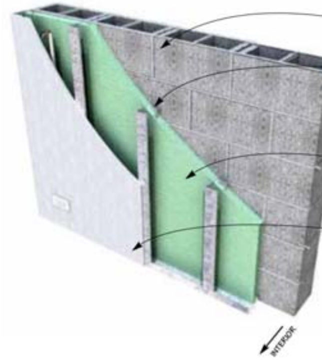


Figure 5 CMU Walls (8 in.) with Wall Insulation + 0.5 in. Gypsum Board

24

Baseline Exterior Wall

Table 1 Critical Exterior Wall Assembly Configuration Properties

Type of Wall	Wall Configurations	Conductivity (Btu·in/hr·ft²·R)	Specific Heat (Btu/lb·R)	U factor (Btu/ft²hR)
Fully Grouted 105 pcf 8" CMU	Solid Grouted	8.400	0.209	0.528
Fully Grouted 120 pcf 8" CMU	Solid Grouted	9.600	0.211	0.566
Fully Grouted 130 pcf 8" CMU	Solid Grouted	10.7	0.220	0.591
Partially Grouted 8" CMU	Cells Insulated	3.248	0.162	0.294
Poured Concrete 120 pcf	Limestone Concrete	7.900	0.210	0.537
Poured Concrete 130 pcf	Sand and Gravel or Stone Aggregate Concrete	9.400	0.210	0.588
Poured Concrete 150 pcf	Sand and Gravel or Stone Aggregate Concrete	14.900	0.210	0.721

25

Exterior Wall

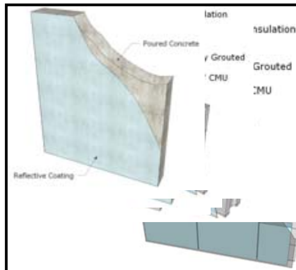


Figure 10 Exterior CMU Wall Case A

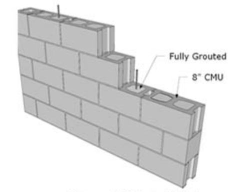


Figure 11 Exterior Wall Cases 105/120/130FM_B&D&F&G&H

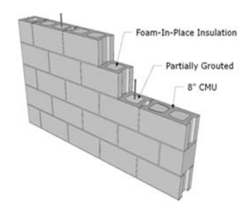


Figure 12 Exterior Wall Cases 105PM_B&D&F&G&H

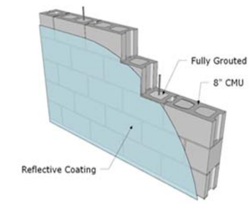


Figure 13 Exterior Wall Cases

26

Exterior Wall

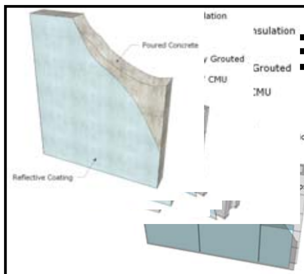


Figure 10 Exterior CMU Wall Case A

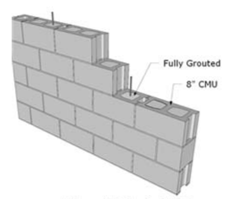


Figure 11 Exterior Wall Cases 105/120/130FM_B&D&F&G&H

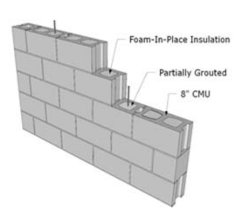


Figure 12 Exterior Wall Cases 105PM_B&D&F&G&H

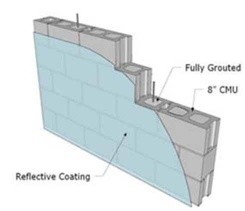


Figure 13 Exterior Wall Cases

27

Baseline Exterior Wall

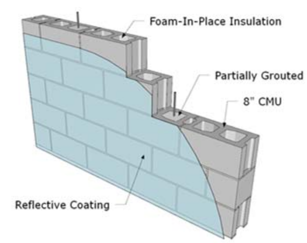


Figure 18 Exterior Wall Assumed when Calculating Target U-factor (Fully Grouted)

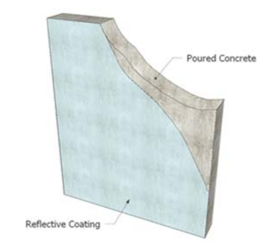


Figure 19 Exterior Wall Assumed when Calculating Target U-factor (concrete)

28

Whole Building Analysis Configurations

ALL CASE A (Include 105/120/130 pcf Fully Grouted CMU (105/120/130FM), 105 pcf Partially Grouted CMU (105PM), 120/130/150 pcf Poured Concrete (120/130/150 PC)) - The U-factor - 0.151 Btu/ft^{2}hR). (Code minimum)

Case B
105 pcf Full Grouted CMU (105FM) CASE B -U-factor - 0.528 Btu/ft^{2}hR.
120 pcf Full Grouted CMU (120FM) U-factor -0.566 Btu/ft^{2}hR.
130 pcf Full Grouted CMU (130FM) - 0.591 Btu/ft^{2}hR.
105 pcf Partially Grouted CMU (105PM) -U-factor- 0.294 Btu/ft^{2}hR.
120 pcf Poured Concrete walls (120PC) -U-factor 0.537 Btu/ft^{2}hR.
130 pcf Poured Concrete walls (130PC) -U-factor 0.588 Btu/ft^{2}hR.
150 pcf Poured Concrete walls (150PC) -U-factor 0.721 Btu/ft^{2}hR.

29

Whole Building Analysis Configurations

Case C – For all "C" cases, the exterior surface reflectance of the walls was increased to 0.64. (consistent with Hawaii Energy Code amendments for exceptions for lightweight walls).

Case D - Overhangs with a Projection Factor (PF) of 0.3 are added to all fenestrations in the basic (Case B) configurations.

Case E - Combined the Overhang of Case D and the increased wall reflectance of Case B.

Case F - Approximately twice the roof insulation was applied to the basic (CASE B) configurations (Roof U-factor decreased to 0.146 W/m2K (0.026 Btu/ft2hR).

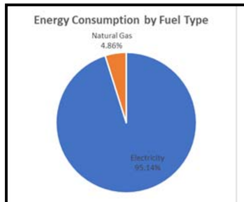
30

Whole Building Analysis Configurations

Case G - Lighting is a significant part of total energy use in most buildings, the impact of more efficient lighting was investigated. Although conventional wisdom suggests that LED lighting is much more efficient than conventional systems, a recent study by the DOE ("LED Replacements for Four-Foot Linear Fluorescent Lamps)[1], suggests that some fluorescent lamps can have similar luminaire efficacy (lumens/watt) as LEDs. Therefore, in this research, we assumed that there would only be a 10% reduction in lighting energy with LED lighting.

Case H – Higher efficiency HVAC systems were investigated. In this case, the HVAC system efficiency in the basic building configuration (case B) was increased. As per Trane product catalogs, models were listed that showed an increase from the Code minimum values of about 8% (based on EERE values). Thus, the HVAC coefficient of performance (COP) was increased by 8% in the EnergyPlus models.

31



...hole Building Analysis

...seline energy use

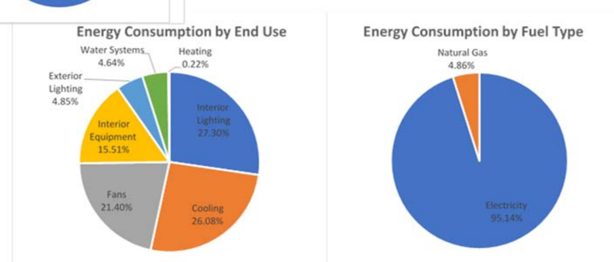
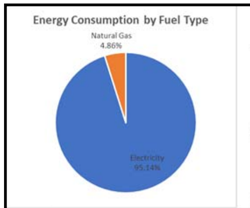


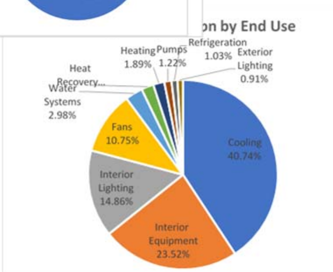
Figure 24 a) Stand-alone Retail Energy Use Break Down b) Stand-alone Retail Energy Use by Fuel

32

hole Building Analysis

seline energy use





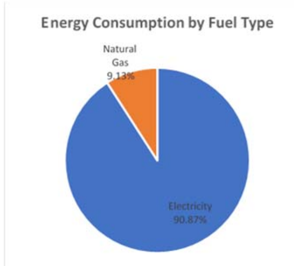
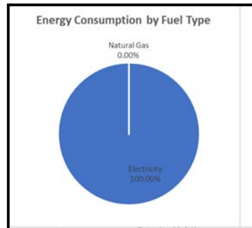


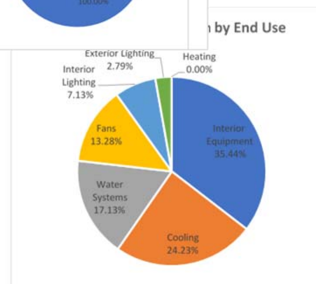
Figure 25 a) Secondary School Energy Use Break Down b) Secondary School Energy Use by Fuel

33

hole Building Analysis

eline energy use





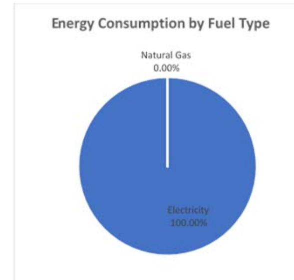
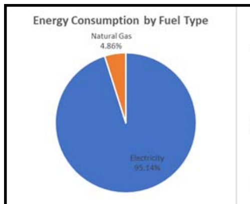


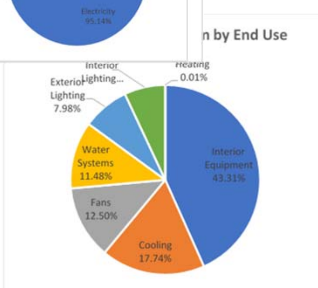
Figure 26 a) Mid-rise Apartment Energy Use Break Down b) Mid-rise Apartment Energy Use by Fuel

34

hole Building Analysis

seline energy use





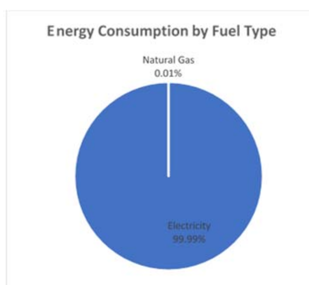
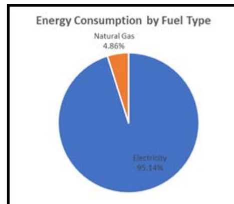


Figure 27 a) Low-rise Apartment Energy Use Break Down b) Low-rise Apartment Energy Use by Fuel

35

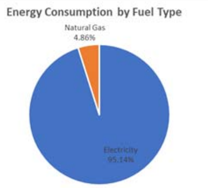
hole Building Analysis

Retail Energy Analyses - Partial



			Site (GJ)	Electric Consumption (kWh)	Gas Consumption (MBtu)	Electric Peak Demand (kW)	Gas Peak Demand (kBtu/hr)	Change (%)	Net Cost ($)	Energy Saved ($/Year)	Payback Period (Year)
			9.23	332747.26	58.14	84.51	100.23				
			5.69	362581.23	58.19	92.71	105.17	8.5%	-234383	-7460	31.4
			1.89	333554.37	57.9	86.78	111.27	0.2%	-183705	-195	944.1
Fully Grouted 8"CMU (105pcf)	0.528	105FM_D	1360.36	360828.51	58.18	93.16	105.15	8.0%	-232003	-7022	33.0
		105FM_E	1255.9	331889.7	57.97	87.26	103.75	-0.3%	-181325	219	-
		105FM_F	1341.91	355700.73	58.18	90.3	107.19	6.6%	-169523	-5740	ø
		105FM_G	1316.84	348747.42	58.15	89.15	104.67	4.6%	*	*	*
		105FM_H	1337.91	354587.06	58.19	89.68	105.17	6.2%	*	*	*
Fully Grouted 8"CMU (120pcf)	0.151	120FM_A	1260.17	333008.73	58.13	84.49	100.38				
	0.566	120FM_B	1373.34	364430.67	58.19	92.98	106.08	9.0%	-234383	-7857	29.8
		120FM_C	1262.87	333813.64	57.95	86.81	100.54	0.2%	-183705	-196	938.1
		120FM_E	1257.26	332258.95	57.94	87.3	100.53	-0.2%	-181325	193	-
Partially Grouted 8" CMU (Cells Insulated)	0.151	120PM_A	1261.75	333421.53	58.22	84.24	101.32				
	0.294	120PM_B	1294.54	342517.31	58.27	87.23	104.07	2.6%	-230576	-2275	101.3
		120PM_C	1246.22	329184.87	57.96	84.44	100.1	-1.2%	-179898	1067	-
		120PM_D	1288.99	340972.56	58.28	87.75	103.85	2.2%	-228196	-1890	120.8
		120PM_E	1243.52	328433.51	57.97	85.04	100.09	-1.4%	-177518	1255	-
		120PM_F	1288.7	340852.76	58.41	85.43	104.3	2.1%	-165716	-1864	ø
		120PM_G	1242.29	328010.81	58.25	83.59	103.51	-1.5%	*	*	*
		120PM_H	1268.62	335318.59	58.27	84.5	104.07	0.5%	*	*	*

36

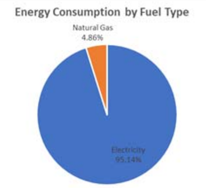


hole Building Analysis

School Energy Analyses- Partial

			te (GJ)	Electric Consumption (kWh)	Gas Consumption (MBtu)	Electric Peak Demand (kW)	Gas Peak Demand (kBtu/hr)	Difference (%)	Net Cost ($)	Energy Saved ($/Year)	Payback Period (Year)
			8	3178901.22	1090.71	778.63	869.78				
			92	3364014.31	1116.02	811.49	1038.88	5.5%	-1188422	-47038	25.3
Fully Grouted 8"CMU (105pcf)	0.528	105FM_C	12714.9	3212337.67	1090.45	786.74	970.02	1.0%	-931466	-8351	111.5
		105FM_D	13078.43	3316795.19	1078.58	792.79	1004.07	3.8%	-1129166	-34110	33.1
		105FM_E	12524.39	3168140.03	1060.69	768.11	945.38	-0.6%	-872210	3591	-
		105FM_F	13166.46	3334857.83	1100.39	800.4	985.35	4.5%	-851906	-39280	ø
		105FM_G	12976.34	3278013.43	1114.16	791.29	1028.84	3.0%	*	*	*
		105FM_H	13200.52	3339736.81	1116.02	803.65	1038.88	4.8%	*	*	*
Fully Grouted 8"CMU (120pcf)	0.151	120FM_A	12593.65	3178322.45	1091.59	779.42	867.28				
	0.566	120FM_B	13324.74	3371894.93	1124.04	816.54	1060.24	5.8%	-1188422	-49367	24.1
		120FM_C	12730.72	3215417.35	1094.94	789.43	984.7	1.1%	-931466	-9374	99.4
		120FM_E	12556.28	3176329.66	1062.97	767.21	939.53	-0.3%	-872210	1357	-
Fully Grouted 8"CMU (130pcf)	0.152	130FM_A	12598.15	3178932	1093.77	777.77	863.32				
	0.591	130FM_B	13418.9	3398715.21	1121.77	809.11	1053.88	6.5%	-1188422	-56004	21.2
		130FM_C	12769.86	3226513.65	1094.17	784.71	974.42	1.4%	-931466	-12125	76.8
		130FM_E	12586.59	3184245.28	1064.69	765.87	940.87	-0.1%	-872210	-674	-
Partially Grouted 8"CMU (Cells Insulate d)	0.151	120PM_A	12602.25	3182026.68	1087.1	775.74	854.84				
	0.294	120PM_B	12874.97	3259852.18	1080.04	786.53	923.16	2.2%	-1169150	-19245	60.8
		120PM_C	12521.71	3164384.37	1070.96	774.42	890.13	-0.6%	-912194	4895	-
		120PM_D	12680.99	3214442.71	1051.13	767.54	890.46	0.6%	-1109894	-7025	158.0

37

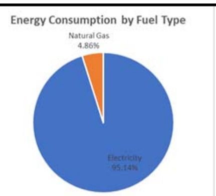


hole Building Analysis

artment Energy Analysis - Partial

				Electric Consumption (kWh)	Gas Consumption (MBtu)	Electric Peak Demand (kW)	Gas Peak Demand (kBtu/hr)	Difference (%)	Net Cost ($)	Energy Saved ($/Year)	Payback Period (Year)
				400398.66	0.03	99.21	0.71				
				445292.91	0.06	109.14	1.62	11.2%	-307070	-11224	27.4
Fully Grouted 8"CMU (105pcf)	0.528			412515.1	0.04	103.67	2.26	3.0%	-240677	-3029	79.4
		105FM_D	1580.89	439119.52	0.05	109.64	1.59	9.7%	-298363	-9681	30.8
		105FM_E	1465.54	407083.41	0.04	103.5	2.2	1.7%	-231970	-1671	138.8
		105FM_F	1595.51	443181.99	0.06	108.86	1.44	10.7%	-284913	-10697	26.6
		105FM_G	1588.09	441119.29	0.05	108.4	1.65	10.2%	*	*	*
		105FM_H	1571.61	436542.46	0.06	107.32	1.62	9.0%	*	*	*
Fully Grouted 8"CMU (120pcf)	0.151	120FM_A	1440.5	400129.41	0.03	99.1	0.63				
	0.566	120FM_B	1601.4	444817.21	0.05	109.15	1.64	11.2%	-307070	-11173	27.5
		120FM_C	1491.04	414165.85	0.04	104.17	2.4	3.5%	-240677	-3509	68.6
		120FM_E	1459.56	405421.52	0.04	103.07	2.18	1.3%	-231970	-1323	175.3
Fully Grouted 8"CMU (130pcf)	0.151	130FM_A	1439.83	399942.99	0.03	99.02	0.63				
	0.591	130FM_B	1603.45	445386.63	0.06	110.18	1.63	11.4%	-307070	-11315	27.1
		130FM_C	1478.82	410771.94	0.04	103.79	1.94	2.7%	-240677	-2661	90.4
		130FM_E	1459.76	405478.24	0.04	103.36	2.11	1.4%	-231970	-1338	173.4
Partially Grouted 8"CMU (Cells Insulated)	0.151	120PM_A	1438.64	399611.13	0.04	98.86	0.58				
	0.294	120PM_B	1505.56	418198.21	0.04	103.28	0.81	4.7%	-302091	-4647	65.0
		120PM_C	1440.81	400215.41	0.04	100.37	1.23	0.2%	-235697	-151	1560.2
		120PM_D	1485.51	412629.77	0.04	102.58	0.76	3.3%	-293384	-3255	90.1
		120PM_E	1420.76	394645.21	0.03	99.9	1.18	-1.2%	-226990	1242	-
		120PM_F	1496.94	415804.91	0.04	102.94	0.62	4.1%	-279934	-4048	69.1
		120PM_G	1490.54	414028.24	0.04	102.49	0.8	3.6%	*	*	*
		120PM_H	1477.24	410331.08	0.04	101.76	0.81	2.7%	*	*	*

38

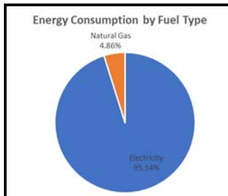


hole Building Analysis

artment Energy Analysis - Partial

				Electric Consumption (kWh)	Gas Consumption (MBtu)	Electric Peak Demand (kW)	Gas Peak Demand (kBtu/hr)	Percentage Difference (%)	Extra Cost ($)	Energy Saved ($/Year)	Payback Period (Year)
				145394.46	0.06	36.13	0.66				
				157785.72	0.07	38.96	0.73	8.5%	-97300	-3098	31.4
Grouted 8"CMU (105pcf)	0.528			147077.23	0.06	37.15	0.87	1.2%	-76262	-421	181.3
		105FM_D	561.33	155905.65	0.07	38.77	0.71	7.2%	-94518	-2628	36.0
		105FM_E	523.55	145414.62	0.06	37	0.84	0.0%	-73480	-5	14579.3
		105FM_F	565.41	157037.47	0.07	38.86	0.73	8.0%	-75143	-2911	25.8
		105FM_G	563.04	156379.36	0.07	38.74	0.71	7.6%	*	*	*
		105FM_H	558.77	155192.17	0.07	38.43	0.73	6.7%	*	*	*
Fully Grouted 8"CMU (120pcf)	0.197	120FM_A	523.09	145285.01	0.06	36.08	0.66				
	0.566	120FM_B	568	157757.29	0.07	38.97	0.73	8.6%	-97300	-3118	31.2
		120FM_C	527.6	146539.2	0.06	37.01	0.86	0.9%	-76262	-314	243.2
		120FM_E	525.34	145912.71	0.06	37.15	0.85	0.4%	-73480	-157	468.2
Fully Grouted 8"CMU (130pcf)	0.197	130FM_A	522.77	145197.58	0.06	36.04	0.66				
	0.591	130FM_B	568.8	157977.96	0.07	39	0.74	8.8%	-97300	-3174	30.7
		130FM_C	527.52	146516.64	0.06	37.08	0.87	0.9%	-76262	-308	247.7
		130FM_E	521.62	144879.37	0.06	36.93	0.84	-0.2%	-73480	101	-
Partially Grouted 8"CMU (Cells Insulated)	0.197	120PM_A	522.08	145005.39	0.06	36.02	0.66				
	0.294	120PM_B	538.02	149432.32	0.06	37.06	0.7	3.1%	-95722	-1107	86.5
		120PM_C	516.3	143400.91	0.06	36.06	0.64	-1.1%	-74684	401	-
		120PM_D	531.22	147544.03	0.06	36.81	0.69	1.8%	-92940	-635	146.4
		120PM_E	509.91	141624.77	0.06	35.88	0.64	-2.3%	-71902	845	-
		120PM_F	535.09	148617.15	0.06	36.95	0.7	2.5%	-73565	-903	81.5
		120PM_G	532.93	148018.62	0.06	36.84	0.69	2.1%	*	*	*
		120PM_H	529.68	147116.04	0.06	36.63	0.7	1.5%	*	*	*

39



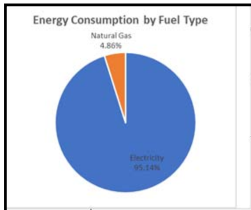
hole Building Analysis

oating alone

Exterior Wall U-factors for Code
ith Reflective Coatings

	Wall Type	Target U factor (Btu/ft²hrF)
Stand-alone Retail	Solid Grouted	0.534
	Partially Grouted	0.474
	Poured Concrete	0.568
Secondary School	Solid Grouted	0.402
	Partially Grouted	0.418
	Poured Concrete	0.397
Mid-rise Apartment	Solid Grouted	0.369
	Partially Grouted	0.338
	Poured Concrete	0.391
Low-rise Apartment	Solid Grouted	0.380
	Partially Grouted	0.344
	Poured Concrete	0.397

40



...hole Building Analysis

...d, foamed and coated masonry walls

	3 Web CMU	2 Web CMU	1 Web CMU
Stand-alone Retail	85.7%	86.0%	86.4%
Secondary School	70.5%	73.1%	74.5%
Mid-rise Apartment	48.9%	54.7%	57.4%
Low-rise Apartment	50.5%	56.1%	58.7%

41

Conclusions

- For all four prototypes (Stand-alone retail, secondary schools, mid-rise apartments and low-rise apartments), adding reflective coating is an efficient method for reducing the energy use in Hawaii's climate. In a number of exterior wall configurations, this reflective coating alone is sufficient to produce equivalent energy performance.

42

Conclusions

- Combining reflective coatings with overhangs produce code compliant configurations for the Stand-alone retail, and secondary school prototype buildings. For solidly grouted CMU walls, overhangs and coatings produce yearly energy use values within 1% of the baseline values in all cases and prototypes. They are thus very close to being code compliant.

43

Conclusions

- Reflective coatings and window shades (overhangs) have the greatest impact on energy use in the range of building types investigated. In every case addressed, the coatings and overhangs were able to reduce the yearly energy consumption values either below the baseline configuration (and code compliant), or to low enough levels of energy consumption that the difference between the baseline energy yearly costs would take well beyond the typical building design life to payback

44


J.B. SPEED SCHOOL OF ENGINEERING
THANK YOU !
QUESTIONS?
MIH
Masonry Institute of Hawaii
MIH
Masonry Institute of Hawaii
45