White Paper WP007

Energy Codes and Precast Concrete in Colorado

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Energy awareness and energy building codes are rapidly gaining recognition for the inherent gains in energy savings due to the reduction of consumption and energy loss. On May 31, 2013 the governor of Colorado received a letter from the Department of Energy indicating the need for the state to adopt current energy codes so that residents of Colorado and their employers can reap the benefits and advantages of the latest energy trends[1]. The Department of Energy has required each state to review current energy codes, policies, implementation of such codes, and to update them as appropriate.

On July 9, 2013 the State of Colorado provided the response that Colorado is a "home-ruled" state and that there is no state mandated building code or energy code[2]. However, local Colorado jurisdictions have adopted energy codes accounting for over 95% of the construction activity in Colorado, and as such, there is a belief that there is a strong state-wide energy awareness and active energy code implementation. In addition, the State of Colorado has adopted the International Energy Conservation Council 2012 (IECC) Code[3] for low rise residential, and American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc. 90.1-2010 (ASHRAE) Code[4] for non-residential buildings to be implemented in those jurisdictions that do not have local building codes. These are areas of Colorado that are required to be inspected by the Colorado Division of Housing, Housing Technology and Standards (HTS) for construction projects including hotels, motels, and multi-family home construction.

The adoption of IECC and ASHRAE prove that energy awareness and standards are being recognized and integrated into Colorado building codes. Along the Front Range, local jurisdictions have adopted 2003 and 2006 versions of IECC, with the City of Fort Collins leading the charge with the adoption of the 2009 version. Both IECC and ASHRAE are design codes intended to provide minimum requirements for the design of energy-efficient buildings and sizing of mechanical equipment, in an effort to lower energy demand and consumption.

Both IECC and ASHRAE base building energy requirements on 7 primary zones throughout the United States, with seperations for Marine (C), Dry (B), and Moist (A) climates. Colorado is covered predominately by zone 5B with zones 4B, 6B, and 7 making up the remainder of the state. The codes prescribe the required minimum R- Value and Thermal Transmittance, U-Value for the building envelop. The values are a function of the construction method and the building climate zone. Thermal Transmittance, U-Value is the inverse of R-Value.

The seven climate zones shown in the following image create specific code recommendations based on humidity, temperature, climate, and location per ASHRAE. The IECC version of this image is nearly identical.

Climate Zones for U.S.

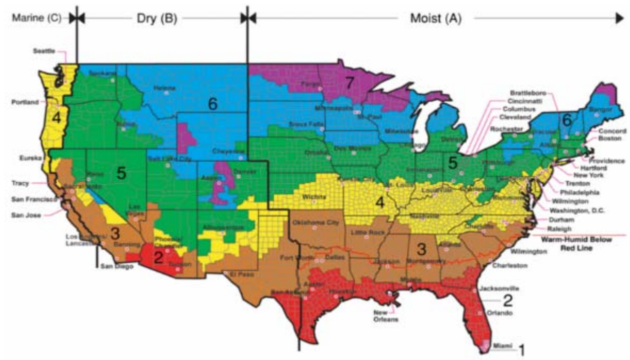

Figure 1: Climate Zones for U.S. locations from Figure B-1 of ASHRAE 90.1-07[5]

Both IECC and ASHRAE codes consider precast walls and insulated precast sandwich wall panels as *Mass Walls.* Mass Walls are considered better envelopes over other construction methods because the required thermal transmittance values are indicative of a higher energy efficiency. The U-Value of a Mass Wall is based on an assembly analysis of the entire wall panel, rather than determining the R-Value based on a single material thickness. ASHRAE prescribes a method to determine U-Values for assemblies of Mass Walls in Appendix A, Section 9. This is the same method that is presented in the Precast/Prestressed Concrete Institute's Design Handbook 7th Edition, Revised Zone Method R-Value Calculation for Precast Sandwich Panels Containing Metal Wythe Connectors [6].

Both IECC and ASHRAE codes also recognize precast concrete as having an air permeability not greater than 0.004 cfm/ft^2, and as such, the precast panel is classified as an air barrier. This allows for thinner assemblies, made from a smaller set of construction materials, and reduces the number of overlapping trades on site.

In addition, Mass Wall building envelopes can be utilized as a simple way of reducing building heating and cooling loads. The large portion of concrete inside the building envelop acts as a storage device releasing and absorbing heat throughout the day and year. This cyclic behavior can lower peak energy demands, shift peak load times, and provide long-term energy savings.

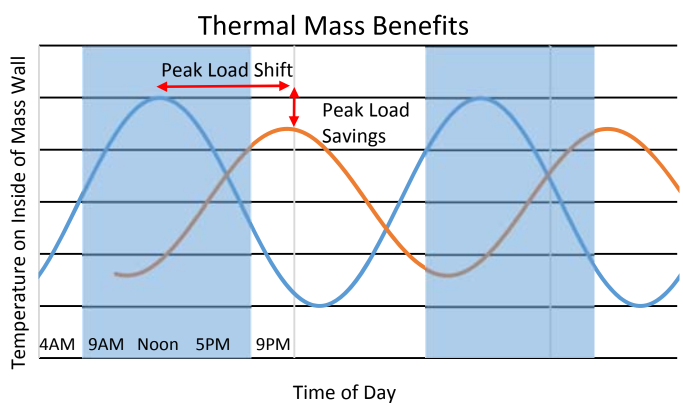

Figure 2: Thermal Mass Benefits

The following chart shows the required U-Values for the multiple zones in Colorado for a Mass Wall construction method with the equivalent R-Value noted in parenthesis.

Zone	Thermal Transmittance Requirements, U-Value (Btu/hr·ft²·°F)	
	IECC 2012	**ASHRAE 90.1 -2010**
4B	0.104 (R - 9.6)	0.104 (R - 9.6)
5B	0.078 (R - 12.8)	0.090 (R - 11.1)
6B	0.078 (R - 12.8)	0.080 (R - 12.5)
7	0.061 (R - 16.4)	0.071 (R - 14.1)

Table 1: Required U-Values for Mass Wall Construction

An important concept to note is that both IECC and ASHRAE require the insulation to be continuous. The term noted in both codes is Continuous Insulation, *c.i.* The intent is, with the exception of fasteners, the insulation is to be continuous throughout the building envelope and it is to be free of thermal bridging. Thermal bridging occurs when poor thermal insulating materials come into contact and allowing heat to flow through the path of least thermal resistance.

In the following example, an insulated sandwich wall panel is constructed with a 4" layer of 2# density EPS insulation that is sandwiched between two layers (wythes) of 3" normal weight concrete. The interior and exterior wythes in the diagram are connected with a fiber reinforced polymer to eliminate thermal bridging across the insulation. The panels have edge to edge insulation. The only difference between Panel Configuration A and B is a three inch solid zone around the perimeter of all three windows.

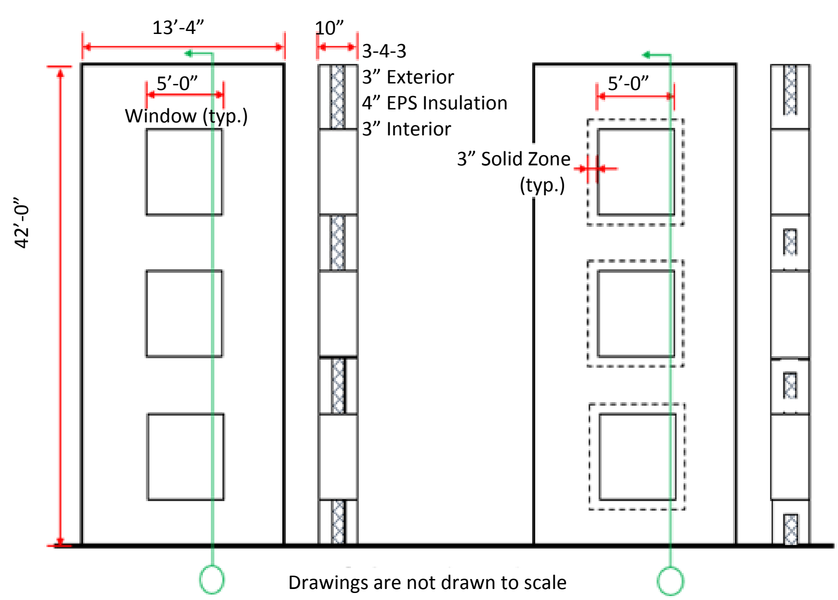

Figure 3: Wall Panel Elevation and Section View through Window

Panel Configuration	Assembly U-Value (Btu/hr·ft^2·°F)	Assembly R-Value (hr·ft^2·°F/Btu)
	Summer / Winter	Summer / Winter
A	0.049 / 0.049	20.4 / 20.3
B	0.083 / 0.085	12.0 / 11.7

Assumptions:
- Type IX EPS Insulation, 2# Density, R=4.76 per inch of insulation
- 150 pcf Normal Weight Concrete, R= 0.077 per inch of concrete
- Air Film Values:
  - Exterior: Summer U=0.25, Winter U=0.17
  - Interior: Summer / Winter U=0.68

Table 2: Calculated Assembly Values for Wall Panels in Figure 3

The solid zone window perimeter is the key factor in the performance of Panel B. In order to meet energy code requirements for our state, the use of continuous insulation is not only recommended, it is required. If the solid zone remains, during winter months the concrete around the window will be cold. This cold reacting with warm, moist, indoor air may cause condensation. These factors contribute to a decrease in indoor temperature and require higher energy consumption to counteract this thermal bridging impact. This impact is shown in the higher calculated U-Value for the mass wall assembly in Panel Configuration B. Again, a resulting lower U-Value is indicative of a higher insulating value.

When considering the Department of Energy's requirement for statewide energy code implementation, the cyclic benefits of Mass Wall building envelopes with continuous insulation are paramount in our climate zone. Mass Wall benefits include the storage and release of heat, contribution to energy savings and reduction in energy demand, and higher required U-Values over other construction methods. This higher required U-Value within the code for a Mass Wall over other construction methods demonstrates the energy benefits of this construction technique.

Colorado recognizes the significance of the energy codes due to the performance benefits and energy savings they provide. Integration of IECC and ASHRAE are being readily accepted and incorporated into new builds in the state.

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Includes subsidiary companies and insulated precast products manufactured by EnCon Utah, EnCon Washington, EnCon Colorado, EnCon Northwest, EnCon Field Services, Stresscon Corporation and Atlanta Structural.

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2. Hanger, Rick. (2013) Re: State Certification of Residential and Commercial Building Energy Codes. Denver, CO: Colorado Division of Housing. Retrieved October 15, 2013, from http://www.energycodes.gov/sites/default/files/documents/CO%20Certification%20of%20Commercial%20and%20Residential%20Building%20Energy%20Codes.pdf.

3. United States. International Code Council®. 2012 International Energy Conservation Code®. International Code Council®, 2004-2006.

4. United States. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.. ASHRAE Standard: Energy Standard for Buildings Except Low-Rise Residential Buildings, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 2010.

5. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.. Climate Zones for U.S. locations from Figure B-1 of ASHRAE 90.1-07. 2010. Retrieved October 16, 2013 from www.ASHRAE.org.

6. Byoung-Jun, Lee and Pessiki, Stephen. (2008) Revised Zone Method R-Value Calculation for Precast Sandwich Panels Containing Metal Wythe Connectors. Retrieved October 15, 2013 from http://www.pci.org/publications/pci_journal/2008/sept-oct/revised_zone_method_r-value_calculation_for_precast_concrete_sandwich_panels_containing_metal_wythe_connectors/.

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