How to Choose a Roof Color in Denver

Evidence-based Decisions on Sound Building Science

CODES | STANDARDS

Reflective roof mandates in climate zones 4 and above (Denver is in climate zone 5) have already been proposed ***and rejected*** in the following national model codes and standards:

- ✔ **City & County of Denver Building Codes Review Committee in 2015**
- ✔ ASHRAE 189.1 (a national model green building standard) in 2013;
- ✔ ASHRAE 90.1 (a national model energy efficiency standard) in 2009;
- ✔ IECC (International Energy Conservation Code) in 2013;
- ✔ IGCC (International Green Construction Code) in 2014

Evolving energy codes and green building codes mandate cool roofs in the southern regions of the U.S., particularly Climate Zones 1-3. Disagreement persists about the appropriate approach for Zone 4 and moving north (Denver is in climate zone 5).

Roofing assemblies/systems are complex, involving

OVER 50 considerations![8]

- ✔ Structure
- ✔ Interior Usage
- ✔ Geography
- ✔ Orientation
- ✔ Climatic Impacts
- ✔ Desired Longevity
- ✔ Environmental Impacts

Good roofing practice must be the dominant criterion in any roof design. The licensed design professional, architect, engineer, building owner, facility manager or roofing contractor should have the latitude to select the right product, system, and assembly available on the market.

2 Reasons White Roofs Become Problematic in Northern Climates *(like Denver)*

A number of unintended consequences,[7] such as uncertainties in the actual urban heat island and global warming benefits,[2] and a collective consideration of all of the issues does lend support to a pragmatic or "selective use" approach for cool roofs as called for by Jacobson and TenHoeve (2011).[2]

1 LOSS OF ENERGY SAVINGS BENEFITS & HIGHER COSTS

While the modifications to the Green Roof Ordinance don't specifically mention the white reflective roofs provision as contributing to the energy efficiency of the building, since these misunderstandings sometimes exist, we felt it important to set the record straight.

In northern climates there is sometimes a fine line between an "energy saving" or an "energy wasting" roof system. A study[7] found that *"...the fantastic energy savings demonstrated are dependent on unrealistic assumptions used in the study and are of great uncertainty."*

The erosion of cool roof benefits in northern climates occurs with the heating penalty of a cool roof during the heating season. The estimated annual energy savings (+) or losses (-) range from about +$0.02/ft^2 to –$0.02/ft^2 for commercial and residential buildings in various cities or regions within Climate Zones 3 through 5.[4]

2 POTENTIAL FOR INCREASED MOISTURE ACCUMULATION RISK IN THE ROOF SYSTEM

Some researchers recommend that roof systems using a cool roof in northern climates like Denver should be designed based on *"...hygrothermal simulations in order to avoid critical water content in the construction... a darker color roof surface should be considered."*[1]

In a study where a roof system's solar absorptivity (the inverse of reflectance) was decreased from 0.6 to 0.3, the roof system changed from one that was annually drying to one that was showing annually increasing moisture levels. The increase in roof reflectivity reduced the solar-driven inward drying effect to a point where it was unable to keep up with moisture accumulations occurring during winter.[5]

UNINTENDED CONSEQUENCES OF COOL/WHITE ROOFS

INCREASE IN GLOBAL WARMING. Reflected heat into the atmosphere may increase global warming potential.[2]

NEGATIVE IMPACT ON AIR QUALITY. Heat island mitigation, like other control measures, can produce both positive and negative effects. Urban cooling affects not only vertical but also horizontal mixing, advection and flow patterns. Urban cooling can cause reduced vertical and horizontal mixing, which can lead to increased ozone concentrations and higher temperatures downwind of urban cooling and thus potentially higher ozone in these areas.[3]

CHANGES IN RAINFALL PATTERNS. White roofs reflect heat back up into the atmosphere and change the evapotranspiration rate, which results in less precipitation in some geographic areas, while increasing precipitation in others, have an unintended effect on rainfall patterns.[7]

References:

1. Bludau, Zirkelbach, Kunzel (2009), "Condensation Problems in Cool Roofs", Interface, RCI, August 2009
2. Jocobson, M., Ten Hoeve, J., "Effect of Urban Surfaces and White Roofs on Global and Regional Climate", Journal of Climate, 2011.
3. Taha, Haider (2015). "Meteorological, emissions and air-quality modeling of heat-island mitigation...", International Journal of Low-Carbon Technologies 2015, 10, 3–14
4. Konopacki, S & Gartland, L & Akbari, Hashem & Rainer, L. (1998). Demonstration of energy savings of cool roofs.
5. Wilen, J. P. (2014). "It's a Wash", Professional Roofing
6. Kunzel, H.M., Zirkelbach, D., and Schafaczek, B. (2012). "Modelling the effect of air leakage in hygrothermal envelope simulation," BEST 3 Conference, Atlanta, GA
7. Yang, J. et al. (2013). Unintended Consequences, A Research Synthesis Examining the Use of Reflective Pavements to Mitigate the Urban Heat Island Effect, Arizona State University, National Center of Excellence for Smart Innovations
8. Please see the full list of considerations in the full text of comments submitted to the Task Force or on the ERA website.

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