INTRODUCTION

A new generation of roofing products is being introduced to the market to bring relief to homeowners and utilities alike. The addition of cool color pigments to paints is reducing the amount of energy needed to cool buildings, which in turn helps power companies reduce hot-weather energy consumption. Cool color pigments will also positively impact the environment by helping reduce carbon dioxide emissions, metropolitan heat buildups, and urban smog.

Industry researchers, including those working with the U.S. Department of Defense, developed the first prototype cool color pigments for military camouflage to match the visible and the near-infrared reflectance of background foliage. The high infrared reflectance of these pigments, which blocks the penetration of near-infrared radiation into the paint, can be exploited to manufacture roofing materials that reflect more sunlight than do conventionally pigmented roofing products.

The U.S. Department of Energy's (DOE's) Buildings Technologies Program provided funding for the Building Envelope Program at Oak Ridge National Laboratory (ORNL) to assess the benefits of infrared-blocking color pigments (IrBCPs) for the thermal performance of granular stone-coated metal roofs. DOE funded the work because of (1) the durability of stone-coated metal roofs (which are manufacturer-warranted for 50 years); (2) the potential benefit in cooling energy savings to be achieved by exploiting the use of IrBCPs; and (3) the potential energy benefits derived from venting the roof deck.

To examine the effects of cool color pigments, a steep-slope roof assembly was constructed for field testing and documenting the energy savings and durability of roof products exploiting the use of IrBCPs. The metal roofing manufacturers and pigment (colorant) manufacturers selected appropriate IrBCPs; applied them to stone-coated metal shakes, S-mission tile, and painted metal roof products; and field-tested the prototypes on a steep-slope roof assembly located at the ORNL Buildings Technology Center (BTC).

The BTC completed one year of field testing stone-coated shakes and S-mission tile and is reporting the results for completion of the DOE Milestone Task D8.

The stone-coated metal product has a multiplicity of profiles but was tested using S-mission tile and shake profiles. The base metal is made of 26-gauge Zincalume "Plus," a pre-primed galvanized steel that is coated with a layer of stone chips (Fig. 1). An acrylic base coat and an overglaze are applied to seal the product. Parker, Sonne, and Sherwin (2002) demonstrated that a Florida home with a "white reflective" barrel-shaped concrete tile roof used 22% less cooling energy annually than an identical

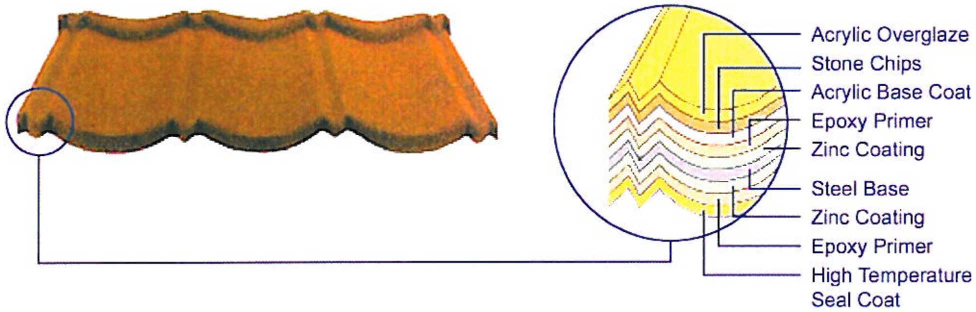

Fig. 1. The composition of a commercially available stone-coated metal roof product.

adjacent home with a dark absorptive asphalt shingle roof. The cost savings due to the reduced use of comfort cooling energy was about $120, or about 6.7¢ per square foot per year.

The venting of the underside of a roof cover also provides thermal benefits for comfort cooling. Residential roof tests by Beal and Chandra (1995) demonstrated a 45% reduction in the daytime heat flux penetrating a counter-batten tile roof as compared to a direct-nailed shingle roof. Parker, Sonne, and Sherwin (2002) observed in their study that a barrel-shaped terra-cotta tile with moderate solar reflectance reduced the home's annual cooling load by about 8% of the base load measured for an identical adjacent home with an asphalt shingle roof. These reported energy savings are in part attributed to a thermally driven airflow within the air channel formed by the underside of the tile and the roof deck. The airflow is driven by buoyancy and/or wind forces. The air channel also provides an improvement in the insulating effect of the roofing system. The heat transfer can switch from conduction to single-cell convection to Bénard cell convection depending on the aspect ratio made by the underside of the tile and the roof deck, the slope of the roof, and the weather. The coexistence and competition between the various modes of heat transfer requires experimental measurements and numerical simulations to model and accurately predict the heat flows observed for subtile venting. Therefore, a combined experimental and analytical approach was conducted, with one year of field data collected that included summer and winter exposure of the stone-coated metal products.