medium-profile tile was attached directly to the deck. The reduction in heat transfer is due in part to the thermal mass of the tile and in part to the thermal resistance across the air space and to the thermally induced convection.

Effect of cool colors, thermal mass and batten arrangement. The Tile Roofing Institute (TRI) and its affiliates reconfigured the tile roof and attic assemblies on the ESRA to further assess the effects of cool color roofs, thermal mass, and placement of batten and double-batten systems under the tile. The double batten arrangement used for the flat tile (SR13E83) was removed and the tile[3] attached directly to the deck to judge the effect of the tile's thermal mass. Data for a hot August week (Fig. 1) show that the heat transfer for conventionally pigmented flat tile laid directly on the deck was only about 45% that measured for the control shingle. Previous tests of the same tile placed on double battens (offset 1.5 in [0.038 m]) showed similar rankings among the various tile roofs (Miller et al. 2005a). A recent field study by Wilcox (2007) elevated similar flat concrete tiles already on 1 by 2-in. battens an additional ⅜ in (0.0093 m) above the roof deck based on recommendations from TRI (2002, 6, 20). Wilcox's results with the additional ⅜-in (0.0093-m) air space showed no improvement over the original batten system. Results herein imply that the thermal mass of the flat-tile roof predominates, and the tile may need be elevated further than 1½ in (0.38 m) off the deck for convection to have more effect.

Three medium-profile concrete tile roofs were configured: (1) direct to the roof deck and tile painted with an infrared reflective cool color pigmented coating (SR37E93); (2) on battens (1 by 1-in. nominal lumber) with cool color pigments (SR37E93); and (3) on double battens (1 by 1-in. nominal lumber) with tile having conventional color pigments (SR10E93). The cool color medium-profile tile on battens showed slightly lower heat transfer across the deck. All three medium-profile tiles showed less heat transfer across the roof deck than with the flat tile (Fig. 1). Most important, though, is the observation that as the cool color tile is moved further away from the deck (i.e., lain directly on the deck compared with offset from deck using batten (0.75 in [0.019 m], the roof's thermal performance improves. The medium-profile tile with conventional color pigments and on double battens (1.5 in [0.038 m]) showed deck heat transfer very similar to that of the cool color tile attached directly to the deck. The finding agrees in trend with similar work by Beal and Chandra (1995), who field-tested two identical medium-profile concrete tile roofs; one tile roof was direct-nailed and the other was offset mounted about 1½ in. (0.038 m) above the deck. Beal and Chandra (1995) measured an 11% reduction in the daytime heat flux penetrating the concrete tile roof on double battens compared with the adjacent direct-nailed tile roof.

High-profile tile. A high-profile tile with conventional terra-cotta color pigments (SR34E83) was tested on battens (1 by 1-in. nominal lumber). The terra-cotta tile slightly out-performed all medium-profile tile configurations. Two roofs—one with high-profile concrete tile having a splotchy terra-cotta finish (SR26E86) and the other with a high-profile clay tile with cool color pigments (SR54E90)—were each placed on 1¼ in. (0.032 m) of extruded polystyrene (EPS) insulation adhered to the deck using a spray polyurethane adhesive. The additional R_{US}-6.25 (R_{SI}-1.1) of EPS insulation under the high-profile splotchy terra-cotta tile helped drop peak day heat transfer by 85% of that measured for the control shingle roof. Doubling the solar

[3] The underside of the flat tile is hollow, and the placement of tile allows for a small but closed air space formed by overlapping tile.