A place such as San Diego, where the temperature is eternally 70ºF and the sun is continually shining. The reality is that California’s climates vary more than any other state in the union. From the high elevation areas of the Sierra Nevada Mountains to the hot, desert areas of Death Valley, California contains every microclimate. The sheer size of the state also is an issue. There are nearly 700 miles of cool coastal climate starting in Santa Barbara and going north to Crescent City on the Oregon border, which provide rugged remote areas that have a marine layer for most of the year. Although Mark Twain has been incorrectly credited with the quote, “The coldest winter I ever spent was a summer in San Francisco,” there is truth in the statement.

As an agency, the California Department of Transportation (Caltrans) is asking the question, “How can warm-mix asphalt (WMA) technology benefit us the most?” While there has been extensive research on warm mix in dense-graded asphalt concrete applications, Caltrans is realizing that its usage of WMA may lead in other directions. Currently, Caltrans is evaluating warm mix with open-graded friction coarse (OGFC) and rubberized asphalt concrete (RAC) applications, in addition to night paving and projects that involve long hauls.

To date, there have been seven
successful WMA placements in the state. Four of these applications were with an OGFC using a polymer-modified binder, two were placed with RAC and one was a standard dense-grade material. There are additional projects planned in 2009 and 2010 involving WMA and open-graded rubberized asphalt (RAC-O) concrete.

Open-graded invitation

OGFC is a common maintenance treatment used to increase roadway safety during wet weather by providing better surface drainage, increased skid resistance and better visibility. Contrary to popular belief, it does rain in California, and in areas like the north coastal regions, rainfall may exceed 40 in. per year.

Caltrans' standard specification for OGFC using an unmodified PG binder requires an ambient paving temperature of 70°F and rising. In the coastal climates, as well as urban areas, which require night paving for most projects, these temperatures are not feasible even in the summer months. These conditions precipitate a change to use polymer-modified binders, which by specification allows an ambient paving temperature of 55°F and rising. In addition to OGFC design mandates for some roadways, by the year 2013 Caltrans also will be required to use RAC in 35% of its total statewide asphalt concrete production.

Due to the difficulty of placing OGFC and RAC projects in marginal conditions, Caltrans feels the use of WMA can help with the placement and longevity of these projects. By having more workable mixes after longer hauls in lower temperature conditions, the state will end up with longer-lasting, more cost-effective placements and projects.

Heavy weighting

In 2007, Caltrans initiated a Heavy Vehicle Simulator (HVS) study in conjunction with the University of California Pavement Research Center (UCPRC). The objective of this accelerated pavement testing is to determine the long-term rutting, fatigue and moisture sensitivity of various WMA technologies in comparison to a control section. The three WMA technologies that participated in the study were Etotherm by MeadWestvaco, Advera WMA by PQ Corp. and Sasobit by Sasol Wax. The mixes were produced and the sections constructed at the Graniterock facility in Aromas, Calif.

The first phase of HVS testing began in October 2007, with laboratory testing following in December 2007. Phase 1 was completed in June 2008, and it appears that the WMA technologies have had no detrimental or measurable effect on the hot-mix materials. Phase 2 of the testing is ongoing and is focused on moisture sensitivity.

With the HVS and lab testing under way, Caltrans decided to move forward with field projects. Between April and September 2008, six of the seven aforementioned projects were placed. The exception was a gap-graded RAC WMA
project that was placed on a shoulder of Highway 152 near Gilroy, Calif. This trial project was completed in July 2006 in cooperation with Granite Rock and Sasobit and was considered the first small step toward the use of warm mix in Caltrans. Over two years later, the section is still performing well.

The first mainline placement in California was accomplished in District 3 north of Sacramento on S.R. 70 in early April. District Materials Engineer (DME) Joseph Peterson, elected to try WMA on a temporary detour while a re-alignment of S.R. 70 was under way. The detour consisted of dense-graded material combined with a PG 64-16 asphalt binder. The lift thickness ranged from 1 to 4 in. placed in three successive lifts with minimal cooling time between layers. Challenges were provided by the 15% daily truck traffic and the fact that the section was located on a hill that required trucks to accelerate then immediately decelerate to a signalized intersection at the bottom. The DME wanted to test the early rutting potential of WMA technology under particularly adverse conditions.

The contractor supplier for this project, Granite Construction, chose to use the Evotherm technology. All work was completed in a single eight-hour shift and then opened to traffic. After 24 hours, the section was examined to look for signs of early rutting. There was no indication of rutting in the pavement. After four months, the section was removed and there were no signs of deformation or wear.

The OGFC projects were placed using various WMA technologies in coastal climates. On Highway 1 near Morro Bay, a demonstration project using OGFC with a PG 58-34 PM binder evaluated three warm-mix technologies against a control section. The technologies used were Advera WMA, Evotherm and Sasobit. The weather was cool and overcast, and the haul was approximately one hour from the plant to the site. After nine months, the project is holding up well and the sections will be reassessed after the winter. Lessons learned from the construction sequencing and phasing on this project were incorporated into the specifications of subsequent projects.

After observing the successful demonstration project in Morro Bay, District 1 Materials Engineer Michael Stapleton and Maintenance Engineer Dave Chang saw the potential for WMA technology to combat some of the weather-related paving challenges and long-haul distances that they face in their area. Typically in the north coast, the pavement life of thin-lift maintenance treatments is shortened by these adverse placement conditions.

In the months following, three WMA projects were completed, with the culmination occurring in September in Point Arena, Calif. The project included material being delivered three to four hours after it was produced at the hot-mix facility. Placement conditions consisted of ambient temperatures barely above 50°F with heavy fog and mist. The supplier elected to use the Evotherm warm-mix technology.

Despite the long haul, the production temperatures were still lowered by 20°F to 30°F at the hot-mix facility, and compaction took place as low as 165°F. The mat was still tender below 165°F, so traffic could not immediately be placed on the mat until it cooled further. Overall, the WMA improved the placement and appearance of the OGFC under difficult paving conditions.

The last project of the year involved RAC-G with WMA on I-5 in the central valley of the state. The asphalt supplier, George Reed Inc., requested to use an Astec Double Barrel Green system to lower temperatures during production and placement of RAC-G. The material produced was placed in the shoulder section of I-5. Production and placement temperatures were reduced by 25°F to 35°F. Two weeks later, the Astec Double Barrel Green system was combined with Evotherm technology. Mix and placement temperatures were further reduced by an additional 30°F with the use of both technologies. Caltrans is still in the process of evaluating the Astec Double Barrel Green technology for further use in the state.

**RAC it up**

In 2009, a RAC-O project with three warm-mix technologies and a control section will be constructed on S.R. 94 in San Diego County. For this project, Caltrans also is looking at the environmental benefits of warm-mix technology by monitoring emissions during production.

Caltrans has seen the benefits of WMA in a variety of paving applications and will continue to look at the technologies as they evolve. As new technologies come to the state, Caltrans will need to evaluate these technologies based on previous performance and independent testing data. Evaluation of WMA technologies under different conditions will continue into 2009 and 2010, as the districts find more applications for warm-mix technologies and its benefits.

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