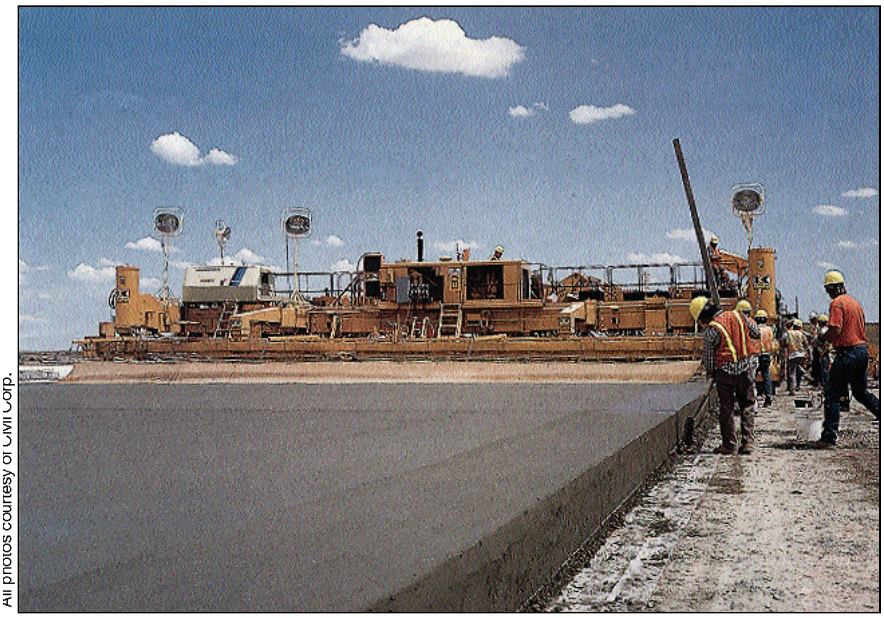
Denver's new International Airport



All photos courtesy of Civil Corp.

Kasler Corp.'s 50-foot-wide, four-track paver lays a 17-inch-thick mat. Joe O'Bryan, Kasler's equipment manager, estimates the machine places about 500 cubic yards per hour.

By Dan Brown

Slipform pavers are integral to massive project using 4.4 million cubic yards of concrete

Scheduled to open in December, Denver's new $2.7-billion International Airport will be the nation's second largest public works project, ranking behind the Boston Harbor Reclamation and Expressway Reconstruction project (*Concrete Construction*, June 1993, p.407).

Certainly, mixing, trucking, and placing 4.4 million cubic yards of concrete to construct 17-inch-thick slabs for an airport half the size of Denver itself has put contractors, materials, and equipment to a severe test. Denver city officials say the pace is equal to paving the 26 miles of roadway between Denver and Boulder with a four-lane highway every four days. Begun in May 1992, paving work is predicted to be completed on schedule in October 1993—just 18 months from start to finish.

As with any project of this size, problems have come up. For example, engineers and contractors have had to deal with expansive soils, shrinkage cracking in concrete, cement and aggregate shortages, clay in the aggregate, and incompatible concrete ingredients. Now, however, soils have been stabilized, concrete admixtures adjusted, material shortages resolved, and the few pavement panels that went awry have been replaced.

"We've compressed years of paving problems into an 18-month period, and we've solved them all," says Pete Stokowski, construction engineer of airfield pavements for the city of Denver. "Thanks to a spirit of cooperation among management, engineers, and dozens of contractors and quality control people, the quality of our pavements is excellent."

Design of the subgrade and pavement for runways, taxiways, and aprons consists of 5 feet of select, compacted subgrade topped with 1 foot of stabilized subgrade, an 8-inch layer of cement-treated base, and 17 inches of portland cement concrete.

To boost pavement life from 20 to 40 years, engineers at Isbill Associ-

ates, Denver, added 1 inch of concrete to the thickness required by the Federal Aviation Administration's design chart. The added inch helps ensure runway performance in several ways, says Carl Tebbens, engineering design supervisor for project managers Greiner / MKE Team. A thicker pavement adds "wear and tear" resistance and load-carrying ability. Isbill Associates performed the preliminary pavement design; the project management team, which consists of the City and County of Denver, Greiner / MKE, and their consultants, is supervising design and construction.

Runway pavements are designed for a 380,000-pound Boeing 767, estimating 32,400 equivalent annual departures for the 40-year design life. By comparison, 25,000 equivalent annual departures are used for the 16-inch pavement thickness needed for 20 years. The design requires flexural strength of the concrete to reach 750 psi at 28 days and 825 psi after 90 days.

Soil composition at Denver International Airport required adjustments in stabilization materials for the 1-foot-thick subgrade below the cement-treated base, according to Tebbens. Original plans called for the use of lime only in the 1-foot-thick stabilized subgrade. But because the soil for one of the runways was more granular than originally expected, engineers at CH2M-Hill and the project management team changed to cement stabilization for the east half of the 1-foot-thick subgrade on that particular runway and taxiway. "We started with the lime subgrade, but couldn't get enough strength, so we switched to cement," Tebbens says.

A reclaimer-stabilizer incorporates lime into subgrade for Mt. Carmel Sand and Gravel at a Denver International Airport parking lot.

For drainage adjacent to and under the crowned runways and taxiways, Isbill designed pavement shoulders using a 5-inch asphalt-treated permeable base layer under 10 inches of asphalt pavement. A perforated PVC drainage pipe runs under the shoulder's edge.

Balancing the mix

Vital to success with any paving project is the concrete mixture. At Denver International Airport, it must be stiff enough to hold an edge within ¼ inch of the surface plane—yet workable enough so that a paver can move the material smoothly and shape it easily. Surface smoothness must be within ¼ inch in 16 feet.

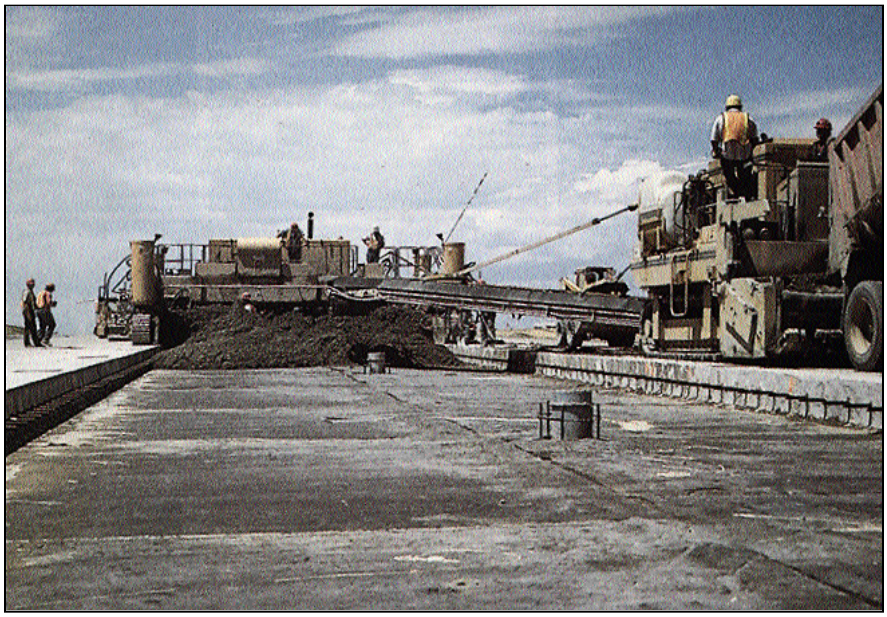
Paving airport runways, taxiways, and aprons is more precise than highway work, according to Mel Reeves, senior paving superintendent for Ball Ball & Brosamer Inc. a Danville, Calif., contractor. Reeves notes that interstate paving specifications generally permit a ¼-inch deviation over 10 feet and—because highway pavements don't cover the broad expanse that airport aprons do—placing slabs to grade and matching them is not as difficult.

The airport's smoothness specification also includes a California profilograph requirement that is the same on runways—a total of 7 inches per mile outside the tolerance band—as for interstate highways. For taxiways, the specification is 9 inches per

Ken Norin, left, and Randy Hardman observe Interstate Highway Construction's paving train: a placer-spreader, paver, and texture-cure machine.

mile. All five paving contractors visited reported profilograph readings ranging from 0.018 inch to 4 inches outside the band. Those five paving contractors include some of the nation's top concrete paving contractors: Ball Ball & Brosamer, Kasler Corp., Bangert Bros., Interstate Highway Construction, and H.B. Zachry.

For stiffness, the slump specification for machine-placed paving at Denver International Airport is between ½ inch and 1½ inches. Each contractor is responsible for the mix proportions of its paving concrete. A typical mix, per cubic yard, includes 6 ounces air-entrainment admixture, 17.5 ounces water-reducing agent, 470 pounds portland cement, 118 pounds fly ash, 1,210 pounds sand, 1,984 pounds coarse aggregate, 215 pounds water.



Bangert Bros. places concrete on a 25-foot-wide pour. A trimmer-conveyor transfers concrete from dump trucks to the paver.

Paving operations

For the 150-foot-wide runways and 75-foot-wide taxiways, paving contractors are using three widths of slipform pavers: 25, 38, and 50 feet.

In areas for slower moving aircraft, such as aprons, concourse work, east and west perimeter taxiways and both ends of runways, transverse dowel bars are being installed for load transfer under sawed joints for controlled cracking. At runway midsections, where aircraft land and take off, loads are more dynamic than static, so transverse steel is not used, explains Gary Mass, a concrete engineer with Greiner/MKE. Instead, aggregate in the concrete is sufficient to carry loads across sawed joints 4¼ inches deep and spaced at 20- and 25-foot intervals.

Paving contractors are drilling holes and inserting epoxy-coated load-transfer dowels into slab sides to form construction joints. For paving lanes of 38 to 50 feet wide, tie bars are set on support baskets parallel to the paving direction and midway across the slab. Joints are then sawcut directly over tie bars to maintain panels in as square a shape as possible.

Batching concrete from two plants—one a double-drum with a 12-cubic-yard capacity and the other a double-drum with a 9-cubic-yard capacity—Ball Ball & Brosamer has placed up to 11,000 cubic yards in one day, according to paving manager Al Lohr. Two four-track pavers, both placing concrete 25 feet wide, were used to achieve that rate.

As did most of the concrete pavers, Ball Ball & Brosamer used wire lines for paver guidance. "Generally speaking, we mostly use wire here," says Ken Norin, a paving equipment specialist with Technical Resources Inc., a consulting subcontractor to the project management team. "It's more accurate than string because it doesn't stretch as much."

At one of the concourses, Interstate Highway Construction was delivering concrete from both sides of a pilot slab to a four-track, 25-foot-wide paver with dual oscillat-

Denver International Airport Gives Contractors Quality Control Responsibility

Unlike most heavy construction projects, where the owner shandle their own quality control or subcontract for it, the project management team at Denver International Airport has placed the responsibility with the contractors.

All tests of aggregates, soil densities, concrete, bridges, and pavements are included in construction contracts at the airport. Contractors in turn often sub out the testing. Working in parallel on the same materials, the project management team runs its own tests—approximately 10% of the number the contractor runs—for correlation purposes to gain assurance of contractor test accuracy, according to Hassan Barzegar, Interstate Highway Construction's quality control manager.

Interstate Highway Construction (IHC) has $145 million of work in six projects at the airport. Barzegar has assigned one quality control supervisor to each of IHC's two road projects, one to its two airfield projects, and one for two parking lot projects. A total of 24 people work in quality control for IHC; the remainder are field inspectors.

Three subcontractors run tests for IHC: Aguirre Engineering, Ground Engineering, and GTG Fox. Test results are reported to Barzegar, who in turn reports them to the project management team's resident engineer.

"This program is good for us," Barzegar says. "We have more control over our time. If we want to change something, we don't have to wait as long for approvals and inspectors to get here, and we can test sooner than required—to catch problems early, for example, with aggregates, before they reach the production stage."

ing screeds, which move laterally to smooth the pavement. On one side a material transfer-placing machine with a belt conveyor moved concrete onto the grade; from the other side a placer-spreader distributed material in front of the paver. Interstate Highway Construction used the belt conveyor machine to offset concrete placed by the placer-spreader, to keep a balanced head in front of the paver.

H.B. Zachry, which had 250,000 cubic yards of pavement under contract when the project was visited, was running two pavers at 38 feet wide. A heavier unit—the same one used for Dallas-Ft. Worth Airport paving 20 years ago—got most of the mainline runway duty, according to project engineer Brian Salerno, while the lighter one did fill-ins and shorter runs.

Zachry has two batch plants, a single-drum and a double-drum unit. The single drum produces 27 batches per hour and the double drum (with a 9-cubic-yard capacity per drum) produces 35 batches per hour.

Bangert Bros. used a placer-spreader, a belt conveyor, and dump trucks to spread concrete for its 25-foot-wide paver. Paving foreman Charlie Cook likes the placer-spreader because it creates a more consistent head of concrete in front of the paver; it also hikes production by 10% to 20%, because the paver can move at a more uniform speed.

Kasler Corp.'s 12-cubic-yard-capacity mixer discharges a load of concrete into a waiting dump truck. The company has a contract to place 190,000 cubic yards of concrete at Denver International Airport.

For meeting grades and making smoothness specifications, Cook has found it helpful to grind the tracklines on each side of a filler lane. "We ran a few sections without grinding, and there were a few too many bumps," says Cook. Bangert's profilograph readings were running within 15% to 20% of specifications. Last year, Bangert paved 4,000 cubic yards on some days.

One of the most productive pavers at Denver International Airport is Kasler Corp.'s 50-foot-wide heavy-duty paver. Twin 12-cubic-yard-capacity drums batch ¾-inch-slump concrete for the paver, according to paving superintendent George Butorovich. A side-feed unloader takes concrete from trucks and distributes it in front of the paver.

The guillotine sideform angles, or batter, are hydraulically adjustable on the paver, as is sideform lateral movement at both top and bottom. Crown control is computerized, and the paver can transition from flat to crown position and back again using pre-programmed settings that control crown angle hydraulically.

Guillotine sideforms are pressure compensated. By setting a constant hydraulic pressure on the sideforms, they can rise and fall to follow a grade, says Joe O'Bryan, Kasler's equipment manager. Kasler has 190,000 cubic yards to place at Denver International Airport and plans to bring in a second paver to meet its deadline.

"I like the 50-foot width," O'Bryan says. "It eliminates setting an additional wire, and eliminates a construction joint. We should easily get 500 cubic yards an hour with it."

Working at night because it's the only time they can get concrete, crews for Hensel Phelps Construction Co. are paving aprons with ready mix for a United Airlines maintenance hanger. The company has a 70,000-cubic-yard contract, and is working a placer-spreader in front of a 25-foot-wide, four-track paver. "Our biggest challenge is to be finished by August 23, to allow a 28-day cure before planes land here on October 2," says equipment manager George Stephens. Production is averaging about 1,500 cubic yards in 6 to 6½ hour shifts per night.

Dan Brown is a freelance construction writer in Des Plaines, Ill.

CONTRACTOR PAVING EQUIPMENT LIST:

Ball Ball & Brosamer: CMI SF-350 paver, CMI SF-550 paver, Gomaco 9500 trimmer-placer, R.A. Hanson belt placer, CMI MTP-400 material transfer-placer, CMI TR-500 base spreader.

Bangert Bros.: Gomaco 9500 trimmer-placer, Agitor dump trucks, CMI placer spreader, CMI SF-550 paver, Gomaco TC-400 texture-cure bridge.

Hensel Phelps: CMI SF 350 paver, CMI PS-350 placer-spreader, CMI TC-250 texture-cure machine.

Interstate Highway Construction: two CMI MTP-400 material transfer-placers, CMI PS 450 placer spreader, CMI Super 500 paver, CMI SF-550 paver, CMI SF-450 paver, two CMI SF-350 pavers, CMI 175 paver, CMI TC-250 texture-cure machine.

Kasler Corp: CMI 50-foot-wide 550B paver, Guntert Zimmerman side-feed unloader.

H.B. Zachry: Gomaco 3000 paver, Guntert Zimmerman 38-foot-wide paver.

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