Diamond grinding of concrete

World's hardest substance a best friend to concrete too

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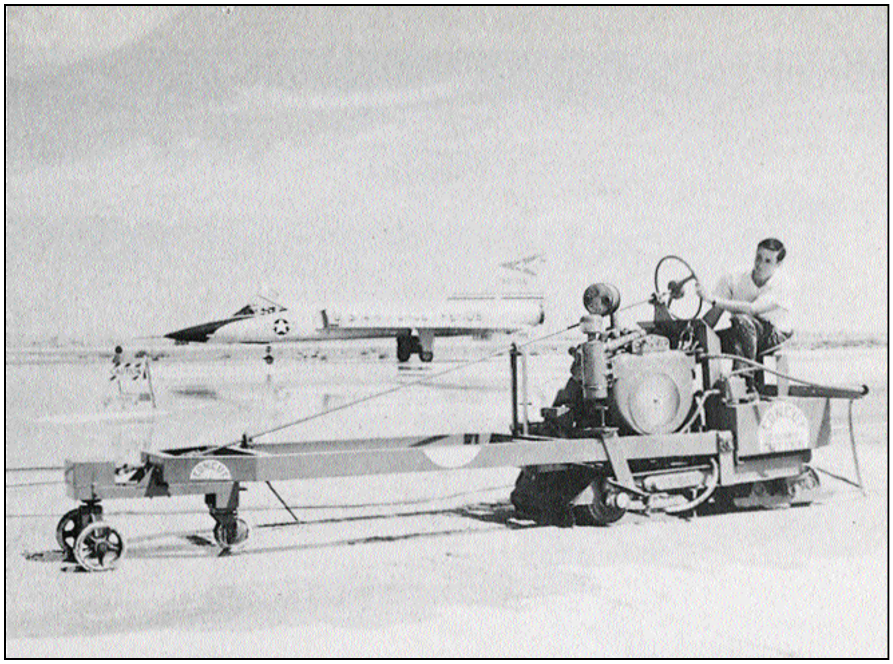
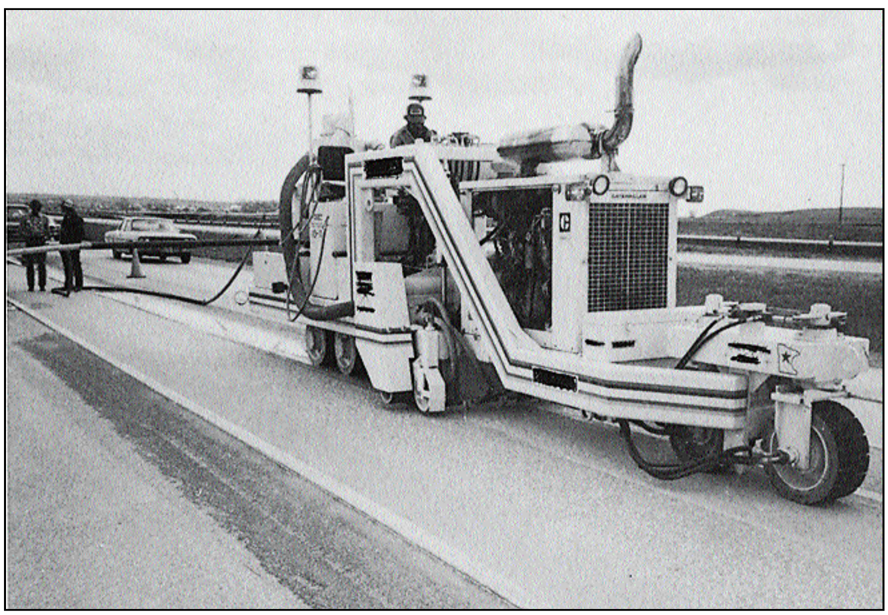


The original Bump Cutter invented 30 years ago bears little resemblance to modern diamond grinding machines. Diamond grinding was originally developed as a means of bringing new concrete pavements into profile tolerance. Now it is widely used to rehabilitate pavements as well.



Prized throughout the world for its beauty and scarcity, the diamond is also the hardest substance known to man. Diamond saw blades can grind out-of-spec concrete flatwork to tolerance without causing any damage or lessening the structural integrity of the surface. They can also groove slabs to produce a skid-resistant texture, and have many repair applications.

In the diamond grinding process diamond saw blades are stacked together on one or more shafts. Usually from 160 to 195 blades per meter are required to produce a level surface with a corduroy-type texture. The water-cooled cutting assembly is mounted under a machine designed to precisely plane and level concrete. A vacuum pick-up bar removes the cutting residue and leaves the surface relatively clean and dry.

Early applications of diamond grinding

Diamond grinding was first used on concrete when Cecil W. Hatcher invented and built a machine that he aptly called the Bump Cutter. It was equipped with nearly 100 circular diamond saw blades mounted side by side on a single horizontal shaft. The machine was used initially to bring new concrete roads into profile tolerance. Even 30 years ago highway engineers demanded bump-free roads, and paving contractors were able to remove high spots by using Hatcher's invention. Apart from the comfort of traveling on a smooth and level surface, such a road also lasts longer. This is why many groups today are urging stringent enforcement of rideability specifications.

Diamond grinding also found early use in airport pavement construction. During the early years of jet aircraft, many airfields in the U.S. faced a problem. Runways built for propeller-driven aircraft jarred the faster jet planes, causing instru-

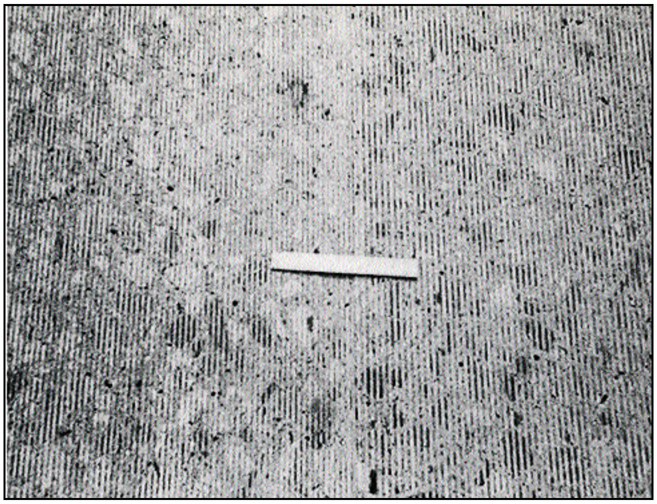


Figure 1. Diamond grinding produces a level and corduroy-like surface texture with a high coefficient of friction which improves braking and vehicle directional stability.

ments to go out of adjustment and sometimes damaging the plane's structural members. As a consequence, surface smoothness specifications became more rigid. At a military airfield in Arizona, a new landing strip built for jets in 1956 called for pavement surface variations to be ⅛ inch or less in every 16 lineal feet. (By way of comparison, highway engineers at that time often specified a profile tolerance of ⅛ inch in every 10 feet.) When the new runway failed to meet specifications for smoothness, diamond grinding solved the problem.

Although diamond grinding originated as a practical, economical way of bringing new concrete runways and highways into tolerance, the nation's deteriorating infrastructure soon brought diamond grinding into the forefront of rehabilitation efforts.

Diamond grinding for concrete pavement restoration

In the fall of 1965 the California Department of Highways engaged a grinding contractor to rehabilitate, on a test basis, a section of the San Bernardino Freeway east of Los Angeles. Several key questions were raised. Could diamond grinding rehabilitate old and out-of-tolerance highways? Would this technique eliminate the need for costly asphalt overlays?

Late in 1965 an author described the San Bernardino project. "Instead of being resurfaced with conventional means and materials, the older sections of the road are being ground by Bump Cutter machines equipped with diamond saw blades to produce a level and textured finish surface conforming to rigid state specifications. The innovation is significant because it may well be the forerunner of future reconditioning projects on concrete roads and runways throughout the United States, as well as the rest of the world."

In recent years a considerable amount of diamond grinding has been done on the nation's Interstate Highway System. It is part of an overall concept called Concrete Pavement Restoration (CPR) and is a viable alternative to expensive overlays. CPR utilizes diamond grinding in conjunction with other techniques to cure individual causes of concrete pavement distress and, simultaneously, to stop deterioration of the pavement.

The various types of grinding machines used today smooth faulted highway joints to an impact-free surface by shaving away the high side of the joint and blending it in with the low side. The geometry of the equipment enables the cutter head to act like a rolling straightedge, blending high spots with low spots.

Grinding progresses systematically in rural or heavily traveled urban areas without impeding the flow of traffic. Only the immediate work area—often one lane—has to be closed. Many contractors are able to complete a lane mile of pavement in a normal work day.

Diamond grinding restores pavement cross-slope to the desired plane. The process also removes wheel path ruts caused by studded tires, improves pavement drainage, reduces hydroplaning and prevents build-up and puddles in wet weather. The corduroy texture (Figure 1) increases surface friction which improves braking and vehicle directional stability.

Other applications

Dams. Diamond grinding has also found applications at new dam sites. The very first was the Indian Valley Dam north of Sacramento, California. California engineers were convinced that spillways at other dams had been destroyed prematurely because the surface profile was out of tolerance. They believed that water pounding onto a rough concrete surface will ultimately lead to its destruction. Hence, they specified that no spillway

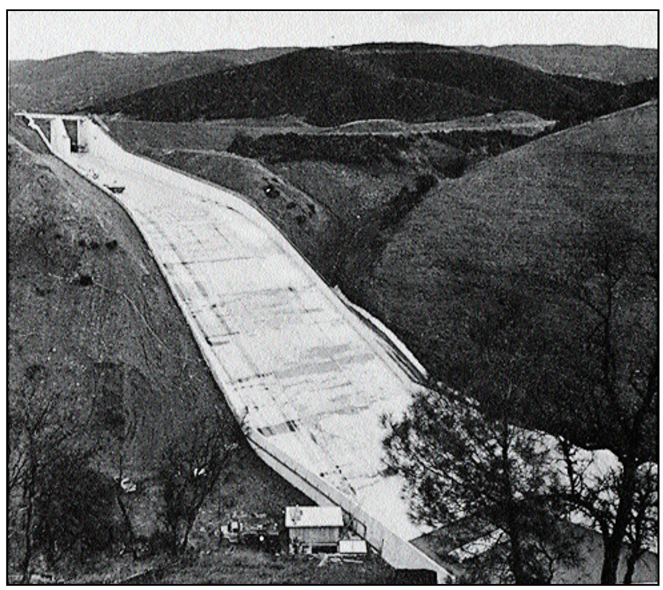


Figure 2. Approximately 60 feet wide and 300 feet long, this dam spillway slopes at a 46 degree angle. It did not meet specifications for slab smoothness but was ground into tolerance with diamond blades.

could be out-of-level more than ¼ inch in every 12 feet. The prime contractor had placed a 6-inch-thick concrete spillway that sloped sharply at a 46-degree angle (Figure 2), but it failed to meet the slab smoothness specification.

To grind down the uneven surface of the 60-foot by 300-foot-long spillway, the grinding subcontractor had to modify his grinder, a 13,000 pound machine. The front of the machine, which included the engine and drive mechanism, was elevated to keep the engine level. This also brought weight to bear on the diamond grinding head located at the seal of the machine below the driver's seat. This ensured that the diamond blades would make the required contact with the concrete spillway.

To keep the machine on the steeply sloped spillway and out of the water at the base, steel cables controlled by a hydraulically driven winch were attached to the rear of the machine.

Only out-of-tolerance spillway surfaces were ground. These were indicated to the machine operator by a sensing device. If a section of slab was level, the cutting head simply skimmed over the surface. The machine was able to shave down the bumps, which ranged from ½ to ⅝ of an inch, in a single pass.

If diamond grinding had not been done on the spillway or had proved unsuccessful, the only alternative would have been to destroy the new slab and start all over.

Test track. Diamond grinding came to the rescue at a new concrete test track in Ohio. The 7½-mile oval track has flat straightaways and unusually steep, elevated turns. The smoothness of the parabolic surface failed to meet specifications for smoothness tolerance of ⅛ inch in every 10 feet of length. This was attributed to cold weather that prevailed during much of the paving work and to the steepness of the elevated slopes.

To bring the surface into tolerance a concrete grinding specialist was hired. The project involved grinding approximately 500,000 square feet of concrete, including sections of straightaways, transition areas approaching curves and the elevated slopes.

Superflat concrete floors. What may well be one of the flattest concrete floors in the U.S. can be found in a 110,000-square-foot warehouse built a few years ago in Arizona. This facility utilizes the turret track concept, which conserves and maximizes storage space by allowing higher stacking of merchandise in narrow aisles. Sometimes called a narrow-aisle warehouse, the structure features aisles that are 6 feet wide instead of the 10 feet found in conventional warehouses. Shelves can extend 45 feet high instead of the usual 16 feet.

During construction of the building the slope of the floor had to be carefully monitored and measured. Specifications called for the floor to be level to within 1⁄24 inch along an aisle that spans approximately 200 feet. This is critical because the turret trucks, which weigh nearly 20,000 pounds and handle loads as heavy as 2,000 pounds, depend on a perfectly level floor for maximum operating efficiency.

Figure 3. This concrete curb was higher than the adjacent slab and could have caused trip-and-fall accidents. A machine with a diamond grinding wheel was used to grind down the protruding curb.

After the concrete had hardened, a profileograph measuring device was pulled over the surface, producing a readout of the floor's exact profile contour. The readout indicated exactly where corrective action should be taken.

To meet the tight specifications, a compact diamond grinding machine was employed. Removal rates averaged between 1⁄16 and ⅛ inch of new concrete floor. In all, the concrete floor required 100 hours of grinding. It was time-consuming due to continual measuring of the floor. An area would be ground, the slurry removed and then the floor would be measured. This procedure was repeated several times until the specified tolerances were achieved.

Rain-damaged surfaces. Although experienced contractors never trust the weather or the weather forecast, they can't predict what's coming any better than anyone else. This was illustrated during construction of a new 6-lane concrete bridge deck, approximately 100 feet wide and 2000 feet long.

A contractor poured an 800-foot-long by 50-foot-wide section of the bridge in a single day. Because of the size of the pour he had used a retarder in the concrete. But contrary to all forecasts, the weather turned quite cold and a heavy rainstorm followed about 24 hours after completion of the pour. As the contractor began covering the deck with plastic sheets, he realized that the pour had not hardened completely and that his men were leaving footprints on the deck surface. Since his main concern was to protect the concrete, he continued placing the cover over the full length and width of the deck. A remedy for the footprints would have to be found later.

The remedy was diamond grinding. The grinding operation produced a smooth, flat surface and removed the footprints, some of which measured ¾ inch in depth. The grinding contractor started grinding on a Friday morning and completed the job by Sunday afternoon.

Miscellaneous applications. Diamond grinding has been used on other jobs, both large and small. A deteriorated silicon carbide asphaltic overlay was removed from a parking deck in Missouri by using a grooving-texturing machine equipped with diamond saw blades. Initially, the plan had been to apply a new overlay over the scarified surface. However, the grooving machine left a highly textured surface that was safe and aesthetically pleasing as well. A clear sealer was applied and no further work was needed.

Sidewalks sometimes settle, causing concrete curbs to protrude above adjacent sidewalks. Trip-and-fall accidents at these locations can be prevented by diamond grinding the curb so it's flush with the sidewalk (Figure 3).

Regardless of job size, there are many opportunities to take advantage of diamond grinding. Before opting for jackhammers to correct imperfections, consider the possibilities of grooving or grinding.

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