

4 on the Floor

For maintaining a 487,000-sq.ft. floor in a engine-building factory, diamonds can be a plant manager's best friend. Find out how the process works and plan to save \$1.50-\$5.00 per ft.



The second of five World Engine plants, built by the Global Engine Manufacturing Alliance (GEMA), opened in Dundee, MI on October 13, 2006. If you haven't heard of GEMA, it's a low-profile joint venture developed by three high-profile auto makers: Daimler Chrysler, Hyundai Motor Co., and Mitsubishi Motors Corp. Fortunately, their goal is not to take over the world...but close. The GEMA mission is to build the most cost efficient, energy saving motor in the biggest, most efficient, energy saving plant operation in the world. Hyundai took the design lead, but the Chrysler group also added some of its expertise in intake manifold control valves, and Dual Variable Valve Timing (VVT). Annual production is estimated to reach 1.8 million four-cylinder engines, including production sites in Asan and Hwasung, South Korea, and Shiga, Japan.

The World Engine manufacturing park in Dundee is composed of two 487,000 square foot facilities approximating the size of 20 football fields with North and South employee service facilities, a plant management and operations facility and the GEMA world headquarters building. The North plant, opened last year in Sept. 2005 opened its doors for production of 1.8-liter, 2.0-liter and 2.4-liter engines; and the South plant, which just opened in October of 2006, is being equipped for a 2007 startup. Combined the facilities will have the capacity to build 840,000, four-

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cylinder engines annually.

The advanced modular crossover facilities were designed to carry the heaviest loads required while remaining flexible enough to handle all potential manufacturing operations. The engine plants had to have strong and stable concrete floors due to the required precision operations of the massive process machinery, trenches and flumes. The interior slabs on-grade utilized 25,000 cubic yards of concrete. Maintenance of the floors, in a dirty business like engine building was going to be a big issue.

Step one: Diamond segments are bonded in a metallic matrix for use in heavy-duty polishing equipment.	Step two: These diamond abrasives embedded in a plastic or resin matrix fine-grind the concrete surface.	Step three: A process called "lapping" uses ever-finer grits of polishing disks to refine the sheen.	Step four: During the final polishing step, a commercial polishing compound is spread onto the surface to give the floor a bit more sheen.
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The management team met in early 2003 to begin work on the plants. Holly F. DuMont, a facilities architect for DaimlerChrysler's AME Core Facility & Launch Building Group, proposed diamond-polished concrete rather than the standard clear sealer and/or a two-part epoxy paint to cover the World Engine plant's nearly one million square feet of steel pin reinforced manufacturing floors. "Polished concrete is not burnished or buffed with a pan or a polished topcoat of chemical hardener that simply wears off. This is the real thing concrete slabs specifically designed to be ground and polished with diamonds like granite producing a lifetime shine," said DuMont.

Lessons Learned During Manufacturing



"Bottom line - without a clearly documented Polished Concrete scope of work and specification for Industrial and Architectural Slabs a general contractor will assume traditional methods of construction resulting in wasted time and money." said DuMont.

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The general contractor on the South Plant paid great attention and adjusted their sequence of construction accordingly. By working closely with DuMont and using the "critical path" method to address the revised flow of construction they were able to make it all work. "The construction schedule is a bit reversed with polished concrete. As soon as the building envelope is completed, depending on weather, and all the overhead trades have installed as much of their infrastructure as possible you pour, finish, wet cure, grind and polish the concrete. Do not put up any interior walls until the slab(s) have been polished and cleaned. Reinforce any heavy interior wall locations with a thickened slab rather than a typical footing eliminating the two feet or so of finished slab running along the wall that is tough to work and therefore to polish" said DuMont.

The general contractor; working closely with the concrete provider, followed up with a methodical installation plan divided by traditional disciplines facilitating the construction speed while avoiding potential problems. Since "out-of-the-box" thinking encourages higher risk taking, there certainly were many obstacles to overcome. But if Holly DuMont had to choose one very important lesson learned during the construction of the GEMA Facilities it was the following: "In the case of the concrete contractor hiring the polishing contractor: the general contractor must listen to the polished concrete experts. When a problem is identified in the field by the polisher, the concrete contractor can no longer assume, because they have been placing concrete for 35 plus years, that they know all. They must listen to and address all issues. They must discuss all

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aspects of the job with the polishing contractor upfront, avoiding costly mistakes.

"A typical over worked, blackened slab with 3' of its perimeter void of any cream and fines is not what polishing contractors are looking for" explained DuMont. "We were fortunate on the South Plant with a general contractor and concrete provider who assigned knowledgeable individuals with flexible project management and superintendent skill sets" In addition, the general contractor must be ready to apply their years of experience in the field to rethinking the construction milestone dates and schedules.

Holly DuMont believes that the polished concrete expert can save all involved time and dollars by avoiding numerous construction "assumptions" that lead to a variety of problems, improve the installation flow of the subcontractors and assist the construction manager, general contractor, designer of record, and the owner by helping to minimize confusion while meeting the scheduled completion dates.

Polishing concrete is similar to sanding wood. Heavy-duty polishing machines equipped with progressively finer grits of diamond-impregnated segments or disks (akin to sandpaper) are used to gradually grind down surfaces to the desired degree of shine and smoothness. The process begins with the use of coarse diamond segments bonded in a metallic matrix. These segments are coarse enough to remove minor pits, blemishes, stains, or light coatings from the floor in preparation for final smoothing. Depending on the condition of the concrete, this initial rough grinding is generally a three- to four-step process. The next steps involve fine grinding of the concrete surface using diamond abrasives embedded in a plastic or resin matrix. Crews use ever-finer grits of polishing disks (a process called "lapping") until the floor has the desired sheen. For an extremely high-gloss finish, a final grit of 1500 or finer may be used. Experienced polishing crews know when to switch to the next-finer grit by observing the floor surface and the amount of material being removed.

During the final polishing step, some contractors spread a commercial polishing

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compound onto the surface to give the floor a bit more sheen. These compounds also help clean any residue remaining on the surface from the polishing process and leave a dirt-resistant finish. There are not published standards for polished concrete, but it is generally agreed that the concrete must be polished through the sequence of disks ending with 1800-3500 grit diamonds to be considered polished concrete. At this level the concrete will exhibit a glossy sheen and high reflectivity without the use of a topical coating.

A diamond ground (flat) slab polished to a 400 grit (NW3) level will yield an minimum additional 35 percent reflected light as compared to traditional sealed or painted floors offering no more than 7 percent regardless of floor color. This is not the perception of more light often attributed to white or light colors but the actual light reflected back into the facility as measured with a specular gloss measurement device. Illumination for the GEMA manufacturing facilities is provided with ribbon windows and suspended metal halide (400 Watt) pendant fixtures. The GEMA quartz floor was polished to a 100 grit level (NW1) allowing 12 fixtures per bay to provide the light levels of 15 fixtures.

Once the floors were completed, DuMont had a clear understanding as to the care and maintenance of the polished concrete floors. "The minimal maintenance required over the life of the PC floor was one of the things that attracted me to the polished concrete concept." explained DuMont.

In manufacturing plants daily maintenance includes chemicals, strippers, degreasers and other expensive non-environmentally friendly products for daily and weekly cleaning. Heavy abrasives are a common method of cleaning rough concrete floors that catch and hold dirt, grease, and tire marks etc. "With polished concrete all you need is neutral PH soap, clean water and a soft nylon head on a standard scrubbing machine" said DuMont.

After the extraordinary efforts made to ensure the success of the finished product DuMont was concerned that the maintenance staff would fall back on traditional cleaning products and methods. "The facility management company at GEMA approached the new PC floors as if they were polished granite and began a successful cleaning program immediately" said DuMont. "The minimal requirements to maintain PC translate to further costs-savings by requiring fewer man hours, no costly detergents or degreasers, the elimination of annual chemical top-coats touch up and or removal and replacement of epoxy paint over the life time of the floor " said Mike Strohschein owner/engineer construction representative.

Throughout the construction of the plant floors, there were a number of problems encountered. The fact that the industrial slabs were designed poured and finished in a manner that would yield the best surface to be ground and polished was a brand new idea to everyone involved. The rule of the day is edge of slab to edge of slab - with consistency in the fines and cream at the surface and the tested FF(floor flatness) and FL (floor level) being of prime focus. Most often the polishing of concrete floors is an after thought costing upwards of \$12 a square foot. With the proper planning a flat, impervious, shiny, maintenance free floor can cost as little as \$.88 a square foot.

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An example of a more serious problem occurred during the polishing of the North plant during the winter of 2004. "The internal combustion engines of the concrete placing and finishing equipment and portable direct fired heaters inside the enclosed building shell all produce carbon dioxide (CO₂). The CO₂ sits low over the new slab as it is heavier than air and is absorbed into the bleed water to form carbonic acid. This acid reacts with the calcium hydroxide found in the curing slab causing carbonation" explained DuMont. The polisher came on site to inspect the slabs at seven days after wet cure, recognized the soft porous surface and modified their means and methods to properly accommodate the new slab. "At 10 days post wet cure they were out grinding the floor with a different diamond head selection and revised methods of grinding and polishing that resulted in a tight, durable, dust free, reflective floor requiring minimal maintenance for the life of the slab" said DuMont.

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