Repairing a Stone Gear

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How do you fix a stone gear that has a chipped tooth and has surfaces roughened by acid erosion and covered in black grime?

You bring in an art conservator.

That was the decision made by Iowa State University, Ames when it was renovating Marston Hall. Originally the engineering building, the hall is more than 100 years old and is decorated with statues that include a stone spur gear.

The gear is part of a statue that's 8 feet tall. The statue is of a woman with her right hand on the gear. It's one of four statues that adorn the outside of Marston Hall. The other three are also of women. Called the Marston Muses, all four were made in the Greco-Roman style, with each woman wearing a toga.

Part of a statue, this stone gear was damaged by acid erosion, creating a more porous surface on which black grime accumulated.

Each statue represents a field of engineering. One statue is holding surveying equipment; it represents civil engineering. The statue with the spur gear represents mechanical engineering.

Being outdoors, the statues were exposed to wear and tear from weather. However, the wear and tear included damage that had been done in the past, damage likely done by a local, coal-fired power plant. The damage was acid erosion and black carbon deposits on the statues, including the gear.

The damage came from the chemical interaction between the statues' limestone and sulfur dioxide in the air. The limestone, the sulfur dioxide, and their interaction are described by Francis Miller, founder and directing conservator of Conserve ART LLC, Hamden, CT.

Miller and his assistants were brought in to repair the statues.

Each statue was carved from a block of limestone. The limestone consists of calcite shell fragments cemented by fine calcium particles. However, the fragments and particles are susceptible to acid erosion, like from sulfuric acid.

Present in the air, the sulfur dioxide mixed with moisture and created a mild sulfuric acid. Then, acid and limestone interacted, starting with the acid dissolving an amount of the limestone and ending with the creation of calcium sulfate: gypsum. However, gypsum deposits are relatively porous, so they can accumulate airborne particles, like pollutants. The result on the statues: "Black scales," Miller says.

With their surfaces roughened, the statues also accumulated organic growths: small plants.

To restore the statues, Miller and his team loosened the grime with a mist spray, then removed it with a light power washing. Next, they applied an ammonia solution to kill the organic growths and rinsed it off with water, then applied a special gel to dissolve the gypsum, then another gel to dissolve the organic growths that were deeper in the limestone.

However, the second gel included sodium hydroxide: lye. To dissolve the growths without damaging the stone, Miller and his team followed the second gel with a mildly acidic solution. Gel and solution neutralized each other.

With the cleaning done, Miller and his team strengthened the limestone by applying a pre-consolidant and a consolidant. The consolidant seeped into the limestone's pores and created silica gel bonds between its particles.

The two applications didn't change the limestone's appearance, and they help protect the stone from future erosion and pollutants. Also, the silica gels didn't completely seal the limestone. They allow water and water vapor to migrate and evaporate from the stone. "The last thing we want to do is seal the sculpture and then possibly have freeze-thaw damage from any trapped moisture," Miller says.

Like the rest of its statue, the gear was restored by art conservator Francis Miller. Free of grime, the gear can be better appreciated as a sculpture. "It's just beautifully carved" Miller says.

After the gels cured, Miller repaired the statues' cracks and chips, like the chip in the gear tooth. The cracks were repaired with grout.

The chips were repaired with a material that matched the limestone's color, porosity, and strength. However, the new material's bond with the original limestone is weaker than the limestone's bond with itself. So, if the material fails, it would fall off without taking any original limestone with it. That way, the material won't create new damage in the statues.

When the work was done, the statues looked pristine. Miller says the mechanical engineering statue is "dynamically designed" and its gear is very eye-catching: "That design element is very prominent."

Photos by Francis Miller, Conserve ART LLC. Marston Muses, 1903, Proudfoot and Bird Architects, Limestone. Commissioned by Iowa State College. In the Art on Campus Collection, University Museums, Iowa State University, Ames, Iowa. Location: Iowa State University, Marston Hall. U2011.472a-d.