WALL REMOVAL MONITOR

CAPABILITY STATEMENT

OCTOBER 2000

THE PROBLEM

One technique for the decontamination and decommissioning (D&D) of concrete structures within the Department of Energy and the nuclear industry is to remove a specific amount of material from the surface using a technique known as scabbling. The agency responsible for D&D of a facility, the contracting agency, generally specifies to the scabbling contractor the depth of material to be removed, e.g., 0.5 inch off the surface of a wall. Under current practice, measurements are made, before and after, at discrete points on the wall with laser-based survey instruments. Feedback is on the order of days, instead of hours or minutes. An obvious limitation to this technique is that there is no way to be sure that the contractor has met the specification between points, which can be a foot apart.

Another method to deal with the problem is to weigh the amount of concrete that is removed. If the density of the concrete is first measured from a small sample taken from the structure, they can then calculate the average depth of material removed. The feedback from this technique is almost immediate, but it does not take into account variations in depth of removal or density that can occur in practice.

Thus, a technique that can measure the amount of material removed over a given area and in near real time would benefit both the agency and the contractor. (With near real time feedback, the contractor can remove the correct amount of material the first time avoiding both repeating a costly visit and generating more waste than is warranted.) A Wall Removal Monitor has been developed at DIAL to serve this need. The monitor uses Fourier Transform Profilometry (FTP), which is an imaging technique that can measure the surface profile of an object, such as the ceiling tile in Figure 1.

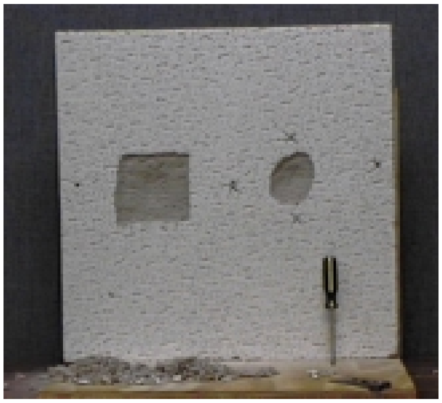
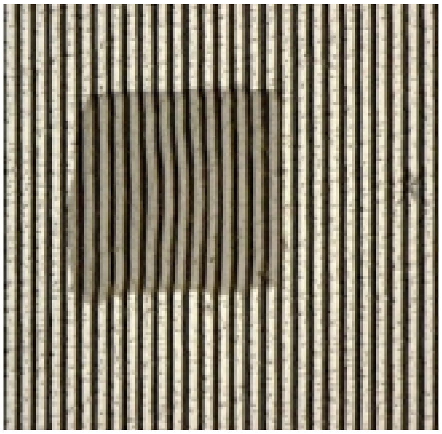


Figure 1 (above) Acoustical tile with gouged areas. Figure 2 (below) Grid lines, or pattern, projected onto left gouge of Figure 1.



THE TECHNOLOGY

The FTP technology, based on image processing techniques implemented at DIAL, can measure the profile of a surface. This is done by projecting a structured light pattern onto the surface. The pattern is shown in Figure 2 is distorted, or warped, by irregularities in the surface. Areas of the object that are closer to the camera cause the lines to squeeze together and areas farther from the camera cause the lines to spread apart. This difference in line spacing provides information on the shape, or profile, of the surface. If changes are being made to the surface then images of the surface need to be acquired, both before and after the change, from the same position. When the two images are compared then changes in height can be determined. It is particularly well suited, but not limited to, relatively flat surfaces.

Figure 3 is a color, contour plot showing depth as a function of location on the tile.The surface of the tile is relatively rough, which contributes to the noise in the image data from the FTP technique. Even so, this technique was able to accurately image the indentions gouged from its surface. The results are presented in different formats in Figures 3 and 4. Figure 4 is a composite of horizontal slices, or cross-sections, showing depth of the gouge as a function of distance across the tile. Each of these slices can be viewed independently so that the depth can be precisely determined as a function of vertical and horizontal position. The depth of the gouge is almost 12 mm. This

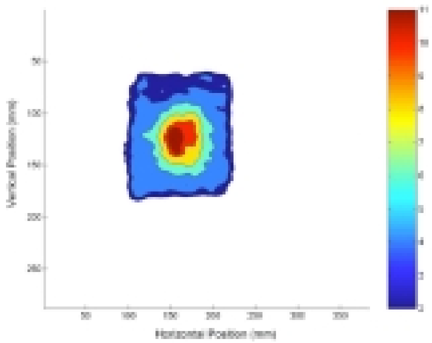


Figure 3. Color contour plot showing depth of removal from the left gouge of Figure 1.

this distance affects the size of the area value was validated by measuring it directly with a ruler. Notice the “grass” or “noise” in the Figure 4, approximately 1 mm in height, at locations away from the gouge. This is due to surface roughness and limits the resolution of the results. However, even on this rough surface the resolution is less than 1 mm.

The system consists of a standard slide projector, a digital camera, and a computer. The projector and the digital camera are mounted on a tripod which can be placed anywhere from two to 30 feet from the surface in question. However, being imaged; a larger area can be imaged by setting up farther away from the surface. A grid of lines is projected onto the surface and an image is captured with the digital camera. The image is processed on the computer in order to determine the profile information.

The Wall Removal Monitor can be operated in harsh environments, is easily calibrated in the field in a matter of seconds, and can run in near-real time. There are two basic measures which apply to the technique’s resolution and resolving ability. The spatial resolution (the distance between points on the surface) depends on the area of the surface being imaged. If a one square meter (10.7 square feet) area is imaged, the spatial resolution is 0.65 millimeters (0.03 inches). For comparison, the spatial resolution of the laser-based techniques is on the order of several inches or feet. In a typical application the laser-based surveying method would acquire approximately nine data points over the one square meter area while the Wall Removal Monitor would acquire 1.5 million data points over the same area. The resolution in the depth direction depends on several factors: the contrast of the grid lines; the size of the area being imaged; and the surface roughness. Taking these considerations into account, one millimeter (0.04 inch) is a reasonable estimate of the depth resolution for the concrete scabbling application. Resolving ability, or the ability to pick out or ignore small structures, is the other important measure associated with this technology and is dependent on the spacing of the grid lines. The closer together the lines, the smaller the pits and structures that can be seen.

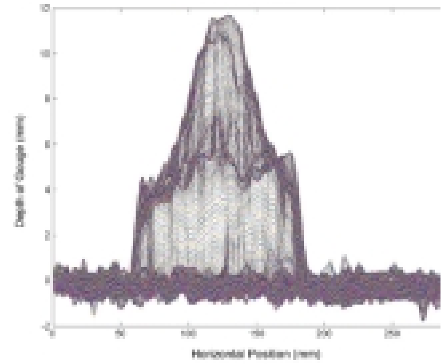


Figure 4. Vertical cross sections, or slices, through the material as referenced in Figure 3.

This technology has been custom tailored for the concrete scabbling application described above. The surface profile of a relatively large area can be determined (3 m x 4.5 m, or 10 ft x 15 ft) in just a few seconds. This technology will benefit the scabbling contractors by giving them fast feedback so that they can be sure that they have met the contract specifications before they leave the site, and at every point on the surface. It will benefit the contracting agency for the same reason and will allow them to move on to the next phase of the D&D process.

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