Diamond Tools—An Engineers Best Friend

By George Seegebrecht, P.E.

Concrete sawing and drilling makes such a tremendous contribution to our projects but over time, we begin take it for granted. Many of us may not be aware of the benefits and time-saving techniques available for concrete renovation with the use of diamond tools. Concrete Sawing & Drilling Association (CSDA) contractors can tackle many jobs that help make our projects easier.

For instance, flat sawing or core drilling are used to create penetrations through walls allowing utility piping to pass from room to room or between floors. If historical renovations or new construction did not allow access for these penetrations, then access was likely made possible by flat sawing or core drilling. Engineers working together with a contractor and their cutting crew locate reinforcement on drawings or survey the area with ground penetrating radar (GPR), locating embedded utilities to avoid damage where possible and allow penetrations without compromising the structure. Many CSDA members offer GPR services, with several companies specializing in it.

Specifiers require drilling or sawing of concrete for a variety of reasons: demolition, extracting concrete laboratory samples, correcting construction errors and so on. At times, drilling or sawing can provide immediate information in the field.

Core drilling as part of a slab thickness verification can provide answers in a direct and collaborative manner when confirming non-destructive test (NDT) results using GPR (ASTM D 6432). A limited number of samples are drilled or cut to verify slab thickness, providing fast confirmation of radar indications when measured in accordance with ASTM C174 *Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores.* This provides confidence in the non-destructive measurements and thereby reducing the need to drill a relatively large number of samples.

Fig. 1 Close-line drilling along with explosive charges in alternating drill holes was used to remove deteriorated lock walls during rehabilitation.

Here are some other examples where sawing or drilling makes work in our industry more efficient, informative or even educational.

DEMOLITION PROJECT

The faces of deteriorated lock walls that provided over 60 years of service were removed to a depth where sound concrete was encountered (Figure 1). The wall faces were then recast with a high-quality concrete to re-establish original dimensions. Close-line drilling of approximately 2-inch diameter by 60-feet deep were drilled approximately three feet behind the existing lock wall face. Holes were alternately filled with explosive charges to quickly facilitate removal of the wall face.

Holes had to be plumb and equidistant to efficiently transmit the blasting energy

Fig. 2 Concrete core taken from the Hoover Dam constructed between 1931 and 1936.

between holes to 'unzip' the wall face upon controlled detonation. Poor drilling that resulted in greater distances between drill holes or holes that wandered too far or near to the wall face could have resulted in inefficient concrete removal. This could have increased the need for follow-up demolition methods that may have significantly slowed project progress, increased costs and created safety issues. The expertise of the drilling contractor and their drilling consistency was a vital component of the successful, efficient and safe removal of the deteriorated concrete. Drilling is probably not what most think of about similar locks, but it's a precision method of concrete modification that led to the success of this project. Most CSDA contractors would be able to perform this type of drilling.

HOOVER DAM CONCRETE SAMPLE

During construction of the Hoover Dam between 1931 and 1936, the Bureau of Reclamation drilled very large diameter cores from the dam of compressive strength. This dam is massive, with concrete containing a maximum-sized aggregate up to nine inches.

A residual benefit of this test specimen occurred when the Bureau of Reclamation gifted a trimmed section of one of these large cores to the Portland Cement Association (PCA). A slice from a three foot diameter core is exhibited in the PCA lobby in Skokie, Illinois (Figure 2).

Note the large aggregate (over nine inches top size) seen almost exclusively on such massive concrete structures. The larger aggregate size meant less cement was needed in the mix. A lower cement content (less expensive) led to a more economical concrete. Larger aggregate and less cement translate to less total water per cubic yard. Keeping a constant water-to-cement ratio means less water is needed in the mix translating to relatively smaller drying shrinkage and a corresponding reduction in concrete cracking. A lower cement content also means a reduction in the peak heat of hydration, an important consideration to minimize thermal related cracking when constructing a structure as massive as the Hoover Dam.

TRAFFIC BARRIERS

The next example could apply to any type of structure or element where additional information or confirmation is needed. We have all seen traffic barriers for instance while stuck in traffic. They help keep our cars on the road or protect us from oncoming vehicles in adjacent lanes. These barriers take a heavy beating from chemical application of aggressive deicers applied during winter, to impact damage from trucks and automobiles. Therefore, the integrity of these barriers is quite important.

However, when performance is not as expected everyone has questions. Examining the construction of typical specimens is helpful. Figures 3a and 3b show dissected barriers to examine if the fabrication procedures of the barrier were deficient.

The randomly selected sample shown in Figure 3a was dissected for examination. The samples exhibited nearly defect-free formed surfaces. Looking beyond the surface, saw cutting revealed the concrete mix was thoroughly consolidated. The examined cut surface indicated uniform aggregate distribution and complete encapsulation of the reinforcing bars.

There are of course NDT methods that could be conducted to avoid turning such lightly reinforced barriers into swiss cheese. GPR (ASTM D 6432) or ultrasonic pulse velocity (ASTM C 597) would be well suited for surveying these lightly reinforced and easily accessible barriers. Refer to the list of potential tests to

Fig.3a Traffic barrier saw cut to provide visual examination of its cross-section.

consider in ACI 228 Table 3 for methods to determine concrete desired properties.

When adequate samples can be obtained, sacrificial members can be used to gather additional information. It presents an opportunity to verify actual conditions and learn things not readily seen at the surface. Such representative dissected samples can be shown to all parties to help the project team gain more insight or help explain existing quality and correct deficiencies in subsequently fabricated members. A cross-section may reveal if the materials, the mix proportions, construction, curing or maybe the aggressive service environment is a contributing factor to the distress exhibited.

Fig. 3b Slices through traffic barrier exhibit uniform aggregate distribution and good consolidation around reinforcing steel maintaining proper concrete cover.

SMALL DIAMETER CORES SHOW WHAT'S INSIDE

Concrete placed through congested reinforcing steel must pass between reinforcing bars and between bars and forms.

ACI 318 addresses nominal maximum aggregate size which should not exceed:

- One-fifth the narrowest dimension of a vertical concrete member
- Three quarters the clear spacing between reinforcing bars and between the reinforcing bars and forms
- One-third the depth of slabs

The concrete must be well consolidated, but also fully encapsulate reinforcing bars to fully engage them within the member. The previous examples were relatively lightly reinforced and not a problem for filling forms, allowing easy concrete placement and access for internal vibrators for concrete consolidation.

Fig 5. Half inch diameter probes used to assess integrity of interior concrete in congested members.

Fig. 4 Difficult conditions for concrete placement within forms and deficient consolidation in highly congested foundation.

However, some members like, nuclear related structures, sanitary tanks, transfer beams or massive foundations, may contain such congested reinforcement that concrete placement is difficult and access for internal vibrators is difficult as well. This can result in voids, rock pockets or honeycombing. Depending on the severity of these defects, testing will be required to assess the repairability of the member.

Figure 4 shows one example of congested reinforcement, where restricted concrete placement and consolidation resulted in voided and honeycombed concrete.

The next question is, what is the condition of the interior of such a member? If the interior is severely voided as well, there may not be a weakened case for salvaging the member and lowered confidence in future performance without problems during the intended service life.

Every case is different but it's reasonable to assume some verification may be needed. Highly congested members are not good candidates for GPR, as the steel will send signals from closely spaced bars that interfere with one another making interpretation inconsistent or unreliable.

Other NDT methods can be considered as listed in ACI 228, but a rough first look at the condition of the interior could be the drilling of small diameter holes that avoid reinforcing steel and give at least a qualitative look at the concrete intercepted in that probe hole. Closer inspection of the core hole with fiber optic can provide information on the condition of questionable concrete.

These are just brief examples of problems that could be encountered in the field.

There are a wide variety of problems that can require the ingenuity of the engineer in assessing its extent and severity. An engineer can benefit from teaming with an experienced and trained CSDA contractor during planning stages of an evaluation to develop an approach that best addresses the assessment of the cause of possible repairs to complete the project in as short of time frame as possible.

WHY SELECT A CSDA MEMBER?

Experience

CSDA members provide concrete coring and saw cutting services on a regular basis. They have worked on difficult projects before and this experience is valuable. They know the safety issues and common problems to be encountered.

CSDA publishes a magazine, *Concrete Openings*, the only magazine specifically for the concrete renovation and diamond tool industry. Here you will find interesting articles showcasing such projects to get an impression of the type of projects CSDA members routinely tackle.

Location

With over 500 member companies around the world, an experienced CSDA contractor will likely be close to a project. The CSDA member directory found online at **www.CSDA.org** lists member companies by state or country and includes their available services.

Training

CSDA provides its members with certification and training programs to provide a consistent level of expertise and professionalism on all projects.

Hopefully you will not run into many problems, but it can happen and understand CSDA is there to help.

If you are planning on attending the World of Concrete in Las Vegas, consider stopping by the CSDA booth and speak with CSDA staff. They will provide information about CSDA training and resources available to members. It could make your next project easier, safer and more cost effective.

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