shotcrete MAGAZINE
A quarterly publication of the American Shotcrete Association
VOLUME 21, NUMBER 4 • FALL 2019
www.shotcrete.org

# Common Test Panel Mistakes

*By Dennis Bittner*

Frequently, shotcrete contractors are required to shoot test panels at the beginning as well as throughout projects. Several tests are performed from these panels; however, compressive strength testing is the most common. This article will primarily address compressive strength testing. At some point, every contractor has missed a required break strength on a core extracted from one of their panels. Frequently, those bad results are not caused by bad material or poor workmanship. They are caused by poor test panel handling and improperly performed test standards. Often, the causes of those bad test results could have been easily avoided. Let's discuss some of the more common test panel mistakes witnessed in the field.

## ASTM STANDARDS

There are two ASTM standards that govern the panels: ASTM C1140/C1140M, "Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels," and ASTM C1604/C1604M, "Standard Test Method for Obtaining and Testing Drilled Cores of Shotcrete." ASTM C1140/C1140M covers producing the test panels, and ASTM C1604/C1604M covers extracting and testing cores from the panels. Every shotcrete contractor should be extremely familiar with both standards.

*Fig. 1: Field test panel being properly gunned on site*

The first step is to get into the right mindset. Contractors often have the attitude of "it's just a test panel, it's not that important, it's the actual structure that matters." It should be noted that panel is how you will be evaluated, and ultimately, how you will be paid. The material needs to be placed in the panels no differently than it is placed on the project. That means using the same equipment, techniques, and most importantly the care that are used on the structure. Do not take shooting test panels lightly.

## PROPER PANEL CONSTRUCTION

Panels need to be constructed on 3/4 in. (19 mm) plywood—any thinner and the panel will bow during the application process. It is not recommended to build panels any larger than necessary. Additional size means additional weight and makes the panels more difficult to handle. A 2 x 2 ft (0.6 x 0.6 m) panel will yield nine cores or three breaks, a break strength being the average of three cores. If more cores are necessary, it is recommended to shoot two smaller panels rather than one larger panel. Occasionally, the contractor is required to shoot mockup panels containing reinforcing bar for visual grading. If this is the case, separate panels not containing reinforcing bar should be constructed for compressive strength testing. Compressive samples should not be taken from panels containing reinforcing bar. Coring and cutting through the reinforcing bar put excessive movement and vibration through the shotcrete and can result in microfractures forming throughout the panel.

## PROPER HANDLING OF PANELS

Additionally, panels need to be cured as soon as possible after shooting. Ideally, panels should be stored in a moist room. However, moist rooms generally are not located on jobsites, and it is difficult to move freshly shot panels without damaging them. When a moist room is not practical, panels should be covered and wrapped, and a spray-applied curing agent or wet cure should be used. Panels

should not be exposed to direct sunlight, as this will dry them out prematurely and can cause early-age plastic shrinkage cracking. Once completed, panels should not be moved any more than necessary. Every time a panel is moved when the concrete is relatively green is an opportunity for microfractures to form or other damage to occur. Do not strip the forms from the panel. This exposes more of the shotcrete to air and causes evaporation and, again, can lead to more potential for early-age plastic shrinkage cracking. Additionally, with no reinforcement in the panel, the wooden form becomes the reinforcement. Once the wood is stripped, you are left with a sizeable, heavy piece of unreinforced shotcrete. The sample will then bow and flex every time it is moved and this can physically damage the panel. The best policy is to shoot it, cure it, protect it, and then leave untouched until you are ready to extract cores.

*Fig. 2: Specimen that has not been cut to 90 degrees in a break machine*

*Fig. 3: Type of break indicative of a point load as a result of a core that has not been cut to 90 degrees*

## EXTRACTING PANEL CORES

Once the panel has reached a specified age, it is time to extract cores for compressive testing. Great care must be taken when extracting cores. Per ASTM C1140/C1140M, specimens should be extracted no more than 2 hours before testing. If you are required to perform 7- and 28-day tests, take only the 7-day cores at the 7-day mark. Come back at 28 days for the 28-day specimens—do not extract the 28-day specimens at the 7-day mark. These specimens are relatively small in size and dry out quickly once removed from the panel, resulting in low breaks. Also, early-age testing of shotcrete can be difficult. Occasionally, a 1-day strength is required. Because the material is still very green at that point, extra care must be taken when coring the panel. Typically, an accelerator is used in the mixture when 1-day breaks are required. Cores with a minimum diameter of 3 in. (75 mm) should not be taken from the area within the depth of the panel plus 1 in. (25 mm) from the edges of the panel. For example, if your panel is 3.5 in. (88.9 mm) deep, then you should avoid coring within 4.5 in. (114 mm) from the panel edges to avoid sampling trapped rebound.

It is important that the right drill and bit are chosen to take cores. A seated or saddled drill must be used. Do not use a handheld drill. Diamond bits must be used. It is extremely important that the bit goes straight down at a 90-degree angle and does not chatter. Should the bit chatter or any other problem arise, back off and start a completely new core—do not continue to drill in your current location on the panel. Any type of irregular movement from the bit can damage the specimen, and that specimen needs to be abandoned. Once extracted, verify that the samples are at 90-degree angles. When a sample does not sit straight up and down, the compression testing machine will exert uneven pressure on the sample. If the ends of the cores do not conform to the perpendicularity and planeness requirements of ASTM C39/C39M, they should be sawn or ground to meet those requirements or capped in accordance with ASTM Practice C617. This point loading frequently results in the corners of the cylinder breaking first when put under stress and not being representative of the strength across the full cross section of the core. Additionally, if an edge of the sample is not flat and level, it needs to be saw-cut and made flat. It is a misconception that compressive testing machines are self-leveling. They will match the angle of the top of the core—they will not level the core. Cores with bearing surfaces that are out of level will also generate lower break strengths due to point loading.

It is recommended that cores have a minimum diameter of 3 in. Remember, core bits are measured by the outside dimension of the bit, so subtract 1/4 in. (6 mm) to

determine the core size. A 3 in. core requires a 3-1/4 in. (83 mm) bit. On some jobsites, panels are shot to a depth of 6 in. (152 mm). Using a 3 x 6 in. sample, we have a length-to-diameter ratio of 2:1. In that case, the break strength is directly recorded. In many cases, panels are shot to a depth of less than 6 in., resulting in a different length-to-diameter ratio. When this happens, a correction factor, located in ASTM C1604/C1604M, Section 8.8.1, must be used. For example, a core is 3 x 3.75 in. (75 x 95 mm), giving a length-to-diameter ratio of 1.25. The correction factor is 0.93. So, if a core of that size has a break at 10,000 psi (69 MPa), we apply the 0.93 correction factor and the actual recorded break is 9300 psi (64 MPa).

## TESTING LAB

Finally, do not assume your testing lab is performing all tests correctly. Many testing labs are unfamiliar with shotcrete, and therefore unfamiliar with some of the subtle differences between obtaining and testing shotcrete cores versus concrete cylinders. It is a good practice to visit the lab you intend to use before testing begins. Review ASTM C1604/C1604M and ASTM C1140/C1140M. If they are storing the panels at the lab, review their curing procedures.

Make sure the testing lab understands not to take cores from the edges of the panels, and make sure if a strength correction factor is used, it is the correct one. If they are performing the core extraction, review the equipment needs and coring procedures. Verify the core ends are truly perpendicular to the axis before testing.

## CONCLUSIONS

Testing errors can cause a lot of avoidable grief, anger, and frustration for everyone. So, in the event of a low compressive strength break, review the panel production, protection, and curing procedures as well as the testing methods to identify any possible errors before moving on to blame either material or workmanship issues. Always take adequate time, thought, and care to get accurate panel test results. This is often how your work is graded on the project and is often tied to getting paid. The small investment in time and effort to make panel production and testing truly representative of your quality shotcrete work will make your projects more productive, higher quality, and ultimately more profitable in the future.

***Dennis Bittner*** *is the National Sales Manager–Infrastructure for The QUIKRETE Companies. He has been involved in both wet- and dry-mix process projects in multiple arenas of shotcrete construction, with an emphasis on bridge and tunnel projects for state departments of transportation and the rail industry. In addition to being an ASA member, Bittner served on the ASA Board of Directors. He can be reached at dbittner@quikrete.com.*