

Contractor Setup Considerations for New Construction

By Ross King

The use of structural shotcrete in lieu of “form-and-pour” is growing rapidly in the urban concrete building construction and civil infrastructure sectors throughout North America. Although this method of casting concrete has been used successfully for over 25 years, the process is still relatively new and not yet totally understood by many seasoned concrete professionals from all disciplines.

By far, the biggest challenges/considerations when setting up a project for structural shotcrete are whether the structural and architectural specifications include provisions for shotcrete, and whether the owner/builder is already on board and has included shooting as part of the overall structure plan.



Structural shotcrete mockup

The following contractor setup considerations for structural shotcrete in new construction follow the initial decision to shoot:

- Consultant approval and mockup;
- Site-specific shoot plan;
- Shotcrete mixture design and delivery;
- Site logistics;
- Weather and environment;
- Reinforcing, formwork, and waterproofing; and
- Shoot and finish.

CONSULTANT APPROVAL AND MOCKUP

Regardless of whether a project is specified as structural shotcrete or approved as an alternate, a structural shotcrete specification is necessary but not always provided by the design team. When a shotcrete specification is not available, it is wise to work with the structural engineer to help develop a specification. Having a specification helps to confirm the engineer and contractor have the same expectations for quality shotcrete on the project. This extra effort helps to alleviate misunderstandings, and to teach the consultants the shotcrete process prior to construction.

Mockups for structural shotcrete are required for certain projects and special applications. When it comes to construction and design team members unfamiliar with structural shotcrete or a ready mix supplier without shotcrete mixture design performance history, a mockup is common. Once construction team players are familiar with shotcrete and the shotcrete contractor has past proven successful results, a mockup at times can be waived and grandfathered from previous projects subject to the same nozzlemen, equipment, and concrete supplier. When special structural situations arise like congested reinforcing bars, section thickness, odd shapes, and higher concrete strength, a mockup is highly recommended.

SITE-SPECIFIC SHOOT PLAN

One of the first things I push for is to call an individual structural shotcrete application a “shoot” versus a “pour” (the term used when using typical form-and-pour). What this does is to alert all involved that the wall we are casting is similar to a

pour, but is a shoot and has different factors that must be considered when planning the setup for structural shotcrete.

One of the most important first steps is to identify the specific locations to be shot versus form-and-pour. These shotcrete locations usually have been approved and agreed to structurally along with the mockup results. The combined overall concrete forming plan shows where shotcrete placement or traditional form-and-pour is best suited.

Once the specific structural shotcrete locations are identified, it is important to check for the following:

1. Required concrete strengths that may vary by location;
2. Concrete additives: rust inhibitor, C-1 silica fume, and integral waterproofing, all of which may vary by location; and
3. Reinforcing bar densities and clearances from formwork and the finished face of wall.

From all this information, an actual shoot drawing can be created showing individual locations and the proposed sequence of shooting. This is the perfect time to control and plan the size of each shoot so as to be not too big or small.

SHOTCRETE MIXTURE DESIGN AND DELIVERY

A proper shotcrete mixture design is key to a successful shoot for both in-place concrete quality and crew productivity. Identifying the proper mixture design for a specific application can depend on many factors. Many past *Shotcrete* magazine articles address this topic.

Even with the perfect mixture design, many onsite factors can affect mixture performance and must be considered in the shotcrete contractor setup plan before the shoot. These include:

1. Slump control, meaning what is the delivered slump and slump retention during discharge, versus the mixture design specifications;
2. What are the provisions for adjusting the load for too low or too high of a slump needed for proper shotcrete application?;
3. Temperature control by monitoring temperatures on arrival and at the end of each load, and giving feedback to quality control at the ready-mix supplier; and
4. Provisions for accelerators and hot water in cold weather conditions, and retarder and chilled water or ice in hot weather conditions.

Once the right shotcrete mixture is determined for the right location and is adjusted to suit the weather, it will all come down to the ready-mix truck delivery and service. Potentially waiting for delayed concrete trucks really needs to be addressed in the shotcrete setup plan. Concrete in the shotcrete pump, pipelines, and hoses becomes old while waiting and causes an increased risk of plugged lines or blowing out the line, slowing down the shotcrete operation, reducing productivity, and potentially taking away from a quality installation. We have found most clients and parties involved in the structural shotcrete operation do not take into consideration how important it is to maintain concrete delivery as per the order. Concrete delivery trucks arriving

too fast or early can also result in trucks waiting for an extended time. This can allow the concrete to get too old and potentially result in line blockage issues.

SITE LOGISTICS

Site logistics is primarily about the concrete pump location; the closer to the shoot, the better. Concrete delivery truck access to the concrete pump hopper is critical, and room for two trucks to the hopper is preferred for smooth transitions between trucks. Part of the pre-shoot setup plan that needs close attention is making sure that the pumping location is clear of other jobsite deliveries at the agreed start time, and prior to the scheduled concrete delivery time to allow for pump setup.

Having a clear, safe workspace zone in front of the wall to be shot needs to be part of the setup plan, and monitored for every mobilization. A plan for waste management and disposal bins is always a preconstruction setup plan item that needs to be considered.

WEATHER AND ENVIRONMENT

The weather, both hot and cold, affects structural shotcrete in a similar manner as casting concrete floors. Standards for



Wall tarping/hoarding

hot and cold weather are covered in several ACI documents, as well as by many past shotcrete-specific ASA articles. Setup planning should make clear which methods have been selected for each weather condition, and who is responsible for all material and equipment to be onsite prior to shooting. With inexperienced contractors, often the basic steps for weather protection are not planned for, so at the end of the day, nothing is done to protect the exposed shotcrete wall. This leads to questions of what happened to the exposed surfaces in the morning.

Curing for a shotcrete wall should follow the same specifications as for cast concrete floors and vertical elements. The same advance planning for material and equipment as required for hot or cold weather protection also applies to curing.

Protection from the rain is a common problem and again must be discussed and planned for ahead of time. This should be a part of the shotcrete contractor setup plan and should include:

1. A decision on what method of tarping will be used and how to secure against the wind;
2. Quantity of tarping that must be onsite prior to shooting, and allocated for the shotcrete operation;
3. A jobsite understanding of who is responsible to install; and
4. Use of clear tarps or opaque tarps (if supplemental lighting is available) to not restrict the ability to clearly see all the locations being shotcreted under the tarps.

REINFORCING, FORMWORK, AND WATERPROOFING

A big consideration for the shotcrete contractor setup plan is that the work done by others can have a very negative affect on the quality of the finished structural shotcrete application. If this work is not planned correctly and checked prior to shotcreting, there is a potential for poor-quality work that is often blamed on bad nozzle technique when, in fact, the nozzleman is hindered by poorly installed reinforcing bar, formwork, or waterproofing.

Reinforcing bar spacing and splices should be done per ACI 506.2, "Specification for Shotcrete." But if the reinforcing bar is irregularly spaced or bunched up in certain locations, it can create the risk of shadowing and should be covered in the shotcrete setup plan and site kick-off meeting. Proper clearance of the reinforcing bar from the back form, bulkheads, and finished face is a very common issue and needs to be addressed ahead of time in the shotcrete setup meeting and continuously monitored

during all shotcrete operations. Reinforcing bar must also be tied securely and anchored to prevent movement during shotcrete placement.

Formwork, when used with shotcrete, requires less strength as compared to form-and-pour. Setup planning should consider the lighter requirements for shotcrete, but care must be taken that this reduced strength is understood and not taken too far where formwork is unstable in the wind, or moves and vibrates during shotcrete placement. Formwork should also be constructed to give the nozzlelemen full access to the shot surfaces. This usually requires keeping formwork bracing away from the shot face.

Formwork should extend a minimum of 2 ft (0.6 m) and preferably 4 ft (1.2 m) beyond the ends and top of the wall to protect from the hazard and messiness created by overspray.

Waterproofing that is a part of the receiving surface needs to be securely fastened to the primary substrate (commonly the excavation shoring or a blindside application). The setup plan should detail the waterproofing fastener type and spacing to properly restrain the sheet-type material from moving in and out during shotcrete placement, which could result in shotcrete fallouts or voids.

Gauge or shooting wires to define the final surface need to be included in the setup plan along with provisions for scaffolding where a wall height is over the reach of nozzlelemen from the floor.

SHOOT AND FINISH

The last step in the structural shotcrete setup plan is the shoot itself. A checklist of items included in the nozzling and finishing setup plan should include:

1. ACI-certified nozzlelemen and supervisors present with all site-specific shoot plan information in hand;
2. Proper equipment sizing, including air compressor, air and delivery hoses, nozzles, piping, and inventory of all finishing tools;
3. Clear understanding of the expected level of finish and control joint depth and spacing required;
4. Tailgate meeting with shotcrete crew to review safety, shotcrete nozzle plan, and sequence, including weather protection and curing;
5. Preshoot check of reinforcing bar rigidity and clearances;
6. Establish communication with the concrete supplier to control service and confirm mixture;
7. Monitor concrete temperature, initial set time, and cohesion characteristics of the mixture to control shotcrete benching heights and timing for subsequent lifts and finishing time;



Properly installed reinforcing bar, formwork, and waterproofing

8. Clean up and waste management process with next day provision to complete if necessary; and
9. Next-day formwork removal inspection to review and critique the mixture performance, reinforcing bar clearances, and nozzling results.

CONCLUSIONS

The final consideration, and the best test of the structural shotcrete setup plan, is the client and consultant feedback. This feedback will certainly point to the necessity and hopefully success of a good setup plan. The feedback should also help to identify where any refinements or additional procedures need to be included in the next project shotcrete setup plan. Shotcrete construction can produce high-quality, durable structural concrete. Thoughtful pre-planning can make the shotcrete placement smoother in the wide variety of weather and field conditions we routinely experience on our job sites.



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