Santee Cooper Shotcrete Repair in Moncks Corner

by W.L. Snow, Sr.

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Santee Cooper, also known as The South Carolina Public Service Authority, is a major electrical supplier with corporate headquarters located in Moncks Corner, just north of Charleston, South Carolina. The co-operative entered into a contract in June 1987 to construct a three story annex to their main corporate headquarters. The structure was typical for this part of South Carolina in that the foundation rested on piling and the main structure was a concrete frame. It was unusual because all of the structural concrete was exposed.

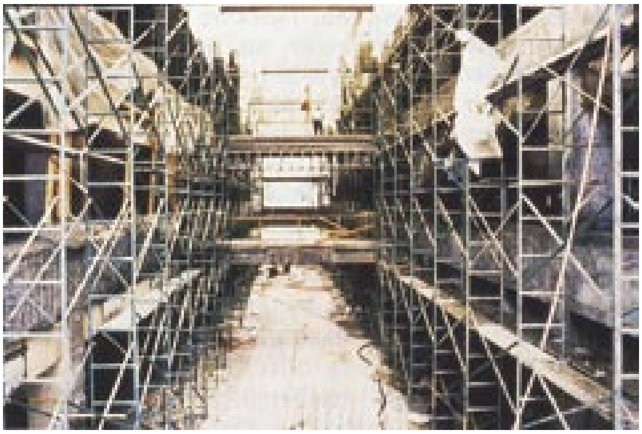
During the fall of 1988, construction on the annex was halted due to apparent deviation from the original architectural and possibly structural design intent. Several options for remedial action were discussed by the owner, the architect, the construction manager, and the various contractors involved. They considered several solutions, including complete demolition, hand patching, covering unsightly concrete with aluminum panels, sheetrock, paint, and shotcrete.

Demolition was ruled out due to several factors including cost and time constraints (the owner needed the building). Hand patching of concrete was ruled out because of the massive extent of the problem and because of technical deficiencies that made this repair impractical. Covering the areas up was ruled out as this would completely alter the architectural intent of the structure. (This structure is an annex to a similar existing structure.) Shotcrete was finally settled on.

When the various options were being discussed, a full service concrete repair contractor was consulted for repair recommendations. In January 1989, Palmetto Gunite Construction Co., Inc. entered into an agreement with Santee Cooper to perform the concrete repairs and the retrofit required to render the structure useable.

The building was designed to be an architectural concrete structure — beams, columns, slabs, shear walls and supporting infrastructure were to be left exposed in the finished building to show the world how functional and esthetically pleasing reinforced structural concrete really is.

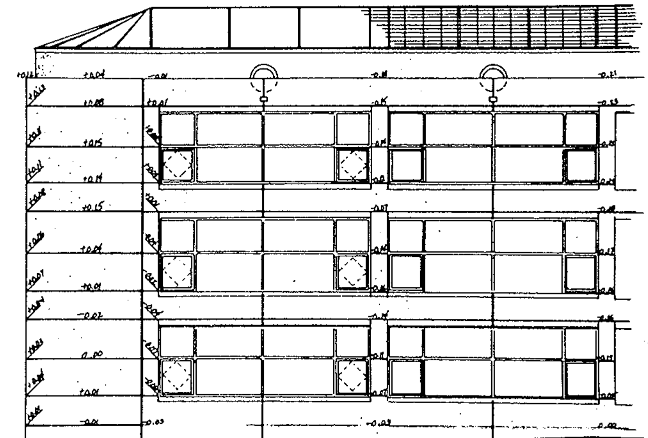
The original construction began as most buildings are in this region, by driving the foundation piling. Following construction of the foundations the building started to rise



Interior atrium during construction

Surface area prepared for shotcrete placement

Interior forms for reveals



Elevation drawing showing deviations from plane

out of the ground, the concrete being placed into conventional wooden forms using pumps and in some cases a crane and bucket. Apparently, all was progressing as planned until problems were encountered somewhere between the stripping of forms and the initial efforts at installing the windows. Since I was not present during the original construction, speculation as to what caused the problems would be inappropriate.

The problems were varied. They included:

- Slightly honeycombed concrete.
- Voids in the concrete at inappropriate places.
- Misplaced steel with insufficient cover.
- Wood, sawdust, and other trash left in forms.
- Severe honeycombed concrete.
- Concrete members that appeared to have moved or deflected after the concrete was placed.
- Window openings out of square significantly more than the windows meant to go in the openings.
- Architectural reglets and members out of intended alignment.
- Walls not plumb.
- Walls, columns, and slabs with variations of as much as several inches from the described plane.

The problems listed should be descriptive enough to show that corrective action was warranted. Shotcrete was chosen as the repair method after determining that it was the only method capable of meeting all of the criteria:

- Aesthetics similar to the original design.
- Speed of application over a large area.
- Structural capabilities as good as the originally designed conventionally placed concrete.
- Bonding capabilities superior to any other construction method known.

The methods used were simple and standard for this type of repair. The most troublesome difficulties occurred while determining the extent of the deficiencies and how far the repairs had to go to satisfy the original design intent. The actual repair began in Jan. 1989 and was made adhering to the following procedures:

Step 1 — Surveying and establishing grades

The extent of the variance from grade was difficult to determine due to the massive extent of the problem and the complexity and interdependence of various architectural aspects (columns must line up vertically and horizontally, windows must be reasonably square, reglets and other "lines-of-site" must be consistent throughout the structure, etc.) A licensed surveyor was retained to establish exactly what was there and to aid the contractor by providing control points for establishing final grades. Final grades were established after considering the most economical combination of removing what was there or adding more material, all the while meeting the original design intent and use of the member in question.

Grades were set using a combination of forms and line wires. Corners, reglets, slabs, windows and such were set using custom made forms. Large flat work was shot to grade using line wires and then hand finished. (Line wires are piano wire set at a grade corner or plane in line with desired planes or existing forms).

Step 2 — Bush-hammering

All surfaces were chipped if needed and bush-hammered using hand-held pneumatic chipping hammers (15 lb [6.8 kg]) fitted with 2 in. (51 mm) bush-hammer bits. Bush-hammering was performed to provide a surface conducive to chemical and mechanical bonding of the new shotcrete to the existing concrete. Although this process was relatively costly, it was deemed essential in this application to achieve the required results.

Step 3 — Sandblasting

The surfaces were sandblasted to remove dust and laitance left after the chipping operation. Laitance is a film formed on the surface when concrete initially sets up that will prevent shotcrete from bonding to the existing concrete. Sandblasting

Underside of beam with sawdust before repair began

Honeycombed column-to-beam connection before repair

was performed using standard equipment and medium coarse grade sandblast sand.

Step 4 — Washing

The surfaces were then washed with water under high pressure (1500 psi [10,300 kPa]) to remove all sand and dust from sandblasting operations. Again, this was necessary to provide a clean surface to insure proper and complete bonding between the old and new materials.

Step 5 — Attaching fabric

2 x 2 in. (51 x 51 mm) welded wire fabric was attached and anchored to all surfaces. This was done to aid bonding and to reduce surface cracking due to various causes such as temperature and premature drying under the extreme conditions of this project. The mesh aids bonding because of the mechanical fastening of the anchors to the existing concrete and the wire mesh, which will subsequently be an integral part of the repair material.

Step 6 — Saturating

All surfaces were saturated at least overnight with soaker hoses before application of shotcrete. This step was essential for two reasons:

• South Carolina can be very hot during the summer months and as the temperature fluctuates between the mid 70s at night to the upper 90s in the day, tremendous amounts of energy can be stored in a concrete structure such as this. By continually wetting the surface, the temperature in the immediate vicinity of the repair can be stabilized and somewhat lowered. This is especially true at the surface interface of the old and new materials, which is essential for a proper bond.

• Water saturation provides a medium (water) for the cement particles to flow through into the parent material (existing concrete). This is the essence of the chemical and physical bonding procedure. The process happens because the shotcrete is applied at zero slump.

Only enough potable water is added to facilitate hydration of the cement in the shotcrete. Cement particles will seek out excess water in an effort to further the hydration process. If the excess water is located in the parent material, the cement will migrate into the material and create a fringe of cement physically within the existing concrete. At the completion of the hydration process, this hardened fringe will represent the meshing of the old and new materials. This is a somewhat simplistic but intuitive explanation of the bonding process. An understanding of the mechanics of a bond will make it obvious to the reader that the saturation water is important in the successful repair procedure.

Step 7 — Shotcreting

Although the shotcreting stage was obviously important it was almost anti-climatic compared to the immense preparation required. For example, of the work force of up to 87 people at the height of construction, only about 20 were used for this stage of the repair.

The care, experience, and attention to detail of the nozzelmen and finishers can not be understated. Equally, if not more important, was the same need for care, experience, and attention to detail of each of the preparatory stages. The motto of "Preparation, Preparation, Preparation" followed by the repair contractor was at times tedious to all involved from the owner to the laborers and everyone in between. This same tedious adherence to the basics was also essential to a successful repair.

Completed column with reveal

Shotcrete was applied using the dry-mix method. C-33 concrete sand and Type I portland cement were mixed using volumetric batching equipment. Sand was maintained at 4 to 6 percent moisture and was checked daily.

After mixing, the dry material was fed into rotary delivery machines, which in turn fed the material into 1 ½ in. (38 mm) diameter hoses. The material was then propelled through the hoses pneumatically to the nozzle for discharge onto the walls and other receiving surfaces. Water was not introduced to the mix until the mix reached the nozzle immediately before being applied to the final position. The water added had to be enough to ensure full hydration of the mix and had to be constant and homogeneous throughout the matrix but the amount was limited by the need to keep the mix at zero slump.

A thorough understanding of this statement will begin to give the reader a real appreciation of the skills the nozzleman must demonstrate in practicing his craft. In addition to his responsibilities in controlling the mixing water, the nozzleman must ensure that all reinforcement is thoroughly encased, that no rebound material is trapped or encased in the freshly placed material, and that the material is placed thick enough but not so thick that sloughing occurs.

Completed Santee Cooper headquarter's annex

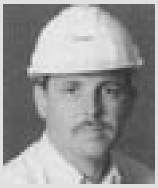
Step 8 — Curing

The final stage of the repair was the same as for all freshly placed concrete — curing. Wet curing was chosen for this project for many obvious reasons, not the least of which was the unknown of whether or not to apply a coating such as paint to the final surfaces. Wet curing was carried out for a minimum of seven days over all repaired surfaces using the same soaker hoses used in Step 6. The repairs were completed in Dec. 1989.

The final structure can be seen today as an example of the successful repair of a major structure using shotcrete. This structure had been determined to be totally unacceptable for its intended use without the repairs.

The main conclusion to be drawn from this project is the acceptability and desirability of the shotcrete method of concrete repair on major structures. No longer labeled as only a swimming pool product, this application is being demonstrated for what it is: a truly viable and versatile repair and construction placement method.

Selected for reader interest by the editors.



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