Life before ICRI

By Donald Kearney

This is the second in a two-part article on repairing aging, normally reinforced, concrete garage structures existing in aggressive weather environments. *Part 1: The Designer's Perspective* was published in the April 2016 issue of STRUCTURE® magazine.

The Contractor's Perspective

Over the last 30 years, the author worked in the concrete restoration industry as an engineer, owner's representative and, for the past 20 years, on the contracting side. In that time, these experiences provided valuable perspectives of all sides of this issue, but more importantly a true appreciation of the practicalities that need to be considered in the field of concrete restoration.

Many of the earliest garages constructed in the first part of the twentieth century are no longer in existence, having been demolished due to age or re-development activities or even transformed into office space over the years. A few have survived without extensive remodeling or remediation; and these garages offer a glimpse, like a museum, into the history of the concrete repair industry in its innovations, failings and successes over the course of time. Repairs performed using gypcrete, drypack, early bag mixes, epoxy mortar and even polyurethane base coat (extended with sand) are still evident today. Too often, people jump to conclusions as to the failure of a material or application technique without investigating the true causes. There is not a single material, nor application process, in use today that has not endured failures. In these cases, a systematic analysis of all materials and processes is required to determine the root cause.

Many organizations, specifically the American Concrete Institute (ACI) and International Concrete Repair Institute (ICRI), have devoted significant amounts of time and resources in preparing guidelines for good practices and procedures for the concrete repair industry. These guidelines should be referenced and consulted with any concrete repair project.

Bid and Pre-Construction

Specialty contractors in the field of concrete repairs generally get introduced to a project at the budget or subsequent bid phase. Design engineers will at times seek a contractor's assistance with project budgets or help with phasing of complex garages. Time allocated to the bid process is limited, dependent upon the size and complexity of the projects, as this is a non-compensatory task. Engineers who have spent weeks and possibly months on the design assume that contractors have spent a similar amount of time in preparing their bid. With a bid period of generally two weeks, allotted time can be measured in hours or, at maximum, days.

When bidding a project, the restrictions imposed can be as important as, and at times of greater significance than, the work itself. Phasing, work hours, traffic control, site logistics, and schedule can have significant impacts on the price. The owner and their consultant have a variety of contract types at their disposal for bidding purposes.

Unit Price Contract

The Unit Price contract is the most common form of contract adopted by the experienced consultant. Site soundings, testing and sometimes exploratory demolition provide the consultant with sufficient information to develop a detailed scope and bid quantities. A well-defined scope and working parameters will generally provide very competitive bids from experienced contractors. This is the contract form primarily recommended by ICRI and forms the basis for their technical bulletin *Guide for Methods of Measurement and Contract Types for Concrete Repair Work*.

Time and Material

Time and Materials contracts are best suited to emergency work, where the consultant has not been afforded the time to perform due diligence and develop a proper scope of work.

Lump Sum

Lump Sum contracts are rarely used in the concrete repair industry, as the work scope cannot be fully established and the potential for latent conditions makes this a very risky proposition for a prospective contractor. In the event that an experienced contractor is presented with this situation, a large contingency is generally incorporated which in turn is bad for the owner. The alternates of an aggressive or underbid proposal from the contractor will quickly result in dissatisfaction among all parties.

The Players

As with any contract, a successful outcome is heavily dependent upon all parties working closely together and the owner obtaining a successful end product, while at the same time the contractor makes a fair market value profit.

Owners typically want a quick start to their garage repair projects, so the pre-construction process (which includes permitting, submittals, schedules and phasing plans) needs to be expedited. The contractor also needs to review the documents, drawings and details carefully, and issue any RFIs where they foresee problems or conflicts.

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Construction

Upon capture of the garage project and the first work phase, it is critical that the contractor mark out all repair areas in conjunction with the Engineer of Record (EOR). This allows for more accurately sequenced and scheduled work. Of equal importance is to establish what the deteriorated areas are exhibiting and to see whether alterations in approach to the specified repairs are required. Too often, inexperienced engineers adhere strictly to the specification as opposed to using it as a guide. A lack of experience and recognition of varying conditions can result in a poor repair strategy. The use of boiler plate specifications, not specific to the job at hand, can also be problematic. The author has seen specifications where a clause has been inserted restricting demolition hammers to 12 pounds. The impracticality of this is akin to cutting your lawn with scissors. In both cases it can be done, but the cost and time impacts are prohibitive.

Identifying Repair Areas

Sounding and demarcation of defective areas of concrete are generally performed by chain drag, with more precise soundings performed with a hand held hammer. Markings are generally located approximately 6 inches beyond the delaminated edge to ensure that the extent of unsound concrete and any suspect areas are captured in the repair. The first dilemma often faced by the EOR is curtailing the quantities while still ensuring that sufficient concrete is being removed to achieve a durable repair. Patches should follow a regular shape and acute angles should be avoided. Many times concrete demolition is not permitted beyond the corroded length of the bar in an effort to minimize quantities, but this may result in development of accelerated deterioration at the new bond line (often referred to as the halo effect). Too often, a review of concrete repairs previously undertaken in a garage indicates deterioration of areas just beyond, and sometimes extending back into, recently installed patches.

Congested reinforcing over a beam after demolition.

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Demolition

For most contractors, it is both preferable and more efficient to sawcut in advance of the main demolition. Care needs to be exercised with this approach, as nicking or cutting of the embedded reinforcement can cause additional problems and the need for additional repairs in the form of supplemental reinforcement. Although the intent at the time of construction was to provide a minimum of 1 to 1½ inches of concrete cover, deficiencies in cover have in many instances initiated the problems being observed. Therefore, spot checks on the depth of reinforcement are critical if this procedure is adopted. If the cover to the reinforcement is predominantly less than ¾ inches, then the EOR will have to be satisfied with a perimeter cut of less depth than specified.

All floor demolition is different, and production can vary significantly depending on the type of equipment utilized, the strength of the existing concrete and the density of embedded reinforcement. Generally the restriction for demolition of suspended floor slabs is 30 pound hammers. Different types of chisels for the pneumatic equipment will also be utilized to determine best results. The EOR also needs to evaluate the existing reinforcing for loss of section to determine whether supplemental bars are required or, alternatively, whether any of the existing damaged reinforcement is redundant and can be removed without replacement.

Hydro-demolition of concrete has found a place in the industry but, like many other means and methods, it is suited to certain projects and is constrained in many instances because of logistical issues. There is no doubt that hydro-demolition produces a better surface profile and cleans the bars of contaminants. However, water containment, treatment, clean up and protection of fixtures, along with price, can make it uneconomical unless large areas are available at one time.

Horizontal Deck Repairs

Once the repair areas have been demolished and fine chipped, the process for final preparation in advance of placement can begin. The approach to this can vary significantly depending upon the area being repaired. This is where the EOR may have to vary their thought process and look at what produces the best repair considering constructability and site conditions.

In the instance of small horizontal repairs, the process of surface preparation by water blasting, mechanical grinding or sand blasting is straightforward. The bars are primed soon afterward and the area subsequently patched with either a modified bag mix, or ready mix depending upon the economics of the situation.

Where large areas are being prepared, and particularly where there are large amounts of reinforcement, a different approach, at times, needs to be considered. Cleaning of rust from the bars followed by washing of repair areas can lead to rusting of the reinforcement before the opportunity exists to prime the bars – a process specified by many engineers. The requirement to prime bars with a zinc rich or epoxy primer, where the manufacturer requires the removal of all oxidation, is not at all times feasible on a construction site given that moisture in the environment or a final cleaning with water will immediately start the rusting process. Priming of bars that have started the corrosion process will lead to rust bleed or spotting.

An evaluation by an inspector following ACI 301 *Specifications for Structural Concrete* will in many instances result in a failed inspection, as the guideline states that "When concrete is placed, all reinforcement shall be free of materials deleterious to bond." In a paper distributed by the Aberdeen Group, titled *How Clean Must Rebar Be?*, it was found that contaminants such as rust form release agents. Even motor oil, applied to reinforcing, had little effect on bond strength. Therefore, more consideration is being given to providing a more protective long term environment for the reinforcement in the form of sacrificial anodes or the addition of a corrosion inhibitor to the mix in lieu of bar priming.

With any concrete placement, adhering to the contractor's pre-inspection list and procedures is essential to ensure that the placement is performed correctly. Large placements can appear somewhat chaotic, but there are certain items that require particular attention in order to achieve a successful end product.

In the case of a ready mix placement, trucks must be scheduled at correct intervals. Each load must be checked for both air and slump to ensure compliance with the mix design. Areas must be pre-wetted to a saturated-surface-dry (SSD) condition and a bonding agent or a slurry coat applied to the substrate in advance of the placement.

Vibration and compaction is often achieved through the use of a vibrating screed, as conventional vibrators in a shallow patch area can often result in segregation. Hand finishing of the edges is also critical as this is traditionally a weak point in the repairs and, even with the greatest care, hairline cracking at this interface is likely to occur. In many cases, the EOR calls for these perimeters to be routed and sealed with a urethane sealant, irrespective of whether a topical coating is being applied to the finished surface. Wet cure requirements are often substituted by the use of a curing compound. However, wet curing is more advantageous when the repair area is subject to sunlight and heat.

Overhead and Vertical Repairs

Traditionally, hand applied repair mortars have been used for vertical and overhead repairs. There are many inherent problems with achieving a good durable repair using this method. Generally, application is limited to 2-inch lifts. Proper substrate preparation is critical and scratching of the surface between lifts without disturbing the material at the bond line is difficult, unless performed by an experienced mechanic with the proper tools. Also, a congested reinforcing configuration makes full compaction and encapsulation of the reinforcing difficult.

Recently, and particularly on large extensive repair areas, shotcrete, either wet or dry, has become very popular. However, successful application is heavily dependent upon the material selected, equipment being used and, of prime importance, the experience of the nozzle person. To introduce and maintain quality control, the nozzle person must obtain separate certifications for overhead and vertical application processes.

Form and pump has become common in recent years, particularly with the advent of materials extended with pea stone that have low shrinkage and high slump characteristics. This is certainly the desired process as a monolithic repair is obtained. With form and pump, critical items to be aware and vigilant of include pre-wetting prior to placement, durable formwork capable of withstanding the required pressure, and vibration of the forms to ensure compaction without causing segregation. With enclosed forms, care needs to be exercised to remove trapped air – otherwise voids will occur and can significantly impact the integrity of the repair.

Future

The future of the concrete repair industry will see a more mechanized approach for demolition and material placements. A greater emphasis will be placed on how to provide long term protection for embedded reinforcement, as corrosion is the primary cause for concrete deterioration.▪