Vision 2020
A Vision for the Concrete Repair Protection and Strengthening Industry

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SDC

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FOREWORD

The Strategic Development Council (SDC), an inter-industry development group dedicated to supporting the concrete industry's strategic needs, has facilitated Vision 2020 at the request of the concrete repair and protection industry.

The purpose of Vision 2020 is to establish a set of goals to improve the efficiency, safety and quality of concrete repair and protection activities. By focusing on the most important industry goals, it is hoped that we will achieve these goals faster than if we let the industry evolve on its own. The focus on goals for repair is also related to the major issue of sustainability, because extending the useful life of existing installations is a key factor in producing a sustainable environment. Over 100 industry leaders including contractors, engineers, material manufacturers, researchers, educators, researchers, owners and industry association executives participated in focused workshops to define the most important industry issues and needs used to establish the goals in Vision 2020.

As part of the Visioning process, each goal will be road-mapped to establish strategies and action plans. This component is not part of this document, but will be completed and documented to form a companion to this report in the near future. A major part of the road mapping task will be critically examining the suggested dates by which completion of strategies related to the goals can be reasonably expected, and then constructing a timetable of goals. The timetable is needed because many goals are dependent on achieving other goals; thus the timetable will help to define the order in which goals must be achieved.

Industry leadership teams will use the Vision 2020 documents (Goals and Roadmaps) to guide industry activities by prioritizing efforts and resources to the established goals and action plans. Research and materials organizations will use the established needs to prioritize research and development projects. Contractors and engineers will use this document to better understand the current state of the concrete repair industry and develop ideas for implementation of industry envisioned improvements. Owners will understand that we take our industry very seriously and will use these tools to help them understand their structures and continued investments in repair and protection

We thank all those who have participated and contributed to Vision 2020 and look forward to focused efforts in accomplishing the goals. Please direct any comments on this report to Peter Emmons, co-chair of the SDC, (pemmons@structural.net) and copy douglas.sordyl@concrete.org.

THE CONCRETE REPAIR, PROTECTION AND STRENGTHENING INDUSTRY

INTRODUCTION

The concrete repair, protection and strengthening industry is driven by deterioration of, damage to, and defects in concrete structures. More than 500 million cubic yards of concrete are placed every year in the U.S. Much of the concrete is custom made for almost every job, using local materials of varying quality, some designs that are not standard, and accelerated construction processes that sometimes sacrifice quality in the interest of meeting a schedule. It is no wonder that repairs are needed. The annual cost to owners for repair, protection and strengthening is estimated between $18 billion and $21 billion in the U.S. alone. The result is a repair industry that supports engineers, architects, equipment suppliers, material manufacturers, researchers, educators, testing companies, contractors, and lawyers. The recent explosive growth of the industry in the past 25 years has resulted in the need for many improvements in materials, design practice, installation procedures, contracting processes, QA/QC procedures, education, and more. These improvements are needed to improve service life, reduce costs and reduce conflicts. The following section details what the industry provides, who provides it, and the market for repair, strengthening and protection of concrete.

WHY CONCRETE NEEDS REPAIR, PROTECTION, AND STRENGTHENING

Deterioration

Concrete deteriorates when subjected to many environments. Saturated concrete exposed to freeze-thaw cycles may experience disintegration. Chloride penetration from deicing salts or sea water, carbonation of the concrete, and inadequate concrete cover depths result in reinforcement corrosion. The resulting expansion due to corrosion byproducts can cause cracking and delamination of the concrete. (Fig. 1.1).

Fig. 1.1

Damage

Damage caused by fire, earthquakes, chemical spills, overloading, impact or foundation settlement many times results in immediate spalling, disintegration, cracking, or complete failure of the concrete element or structure (Fig. 1.2).

Fig. 1.2

Defects

Defects caused by improper detailing or design, construction practices or faulty materials may result in inadequate structural capacity, premature deterioration or aesthetic issues (Fig. 1.3).

Fig. 1.3

Change in Use, Code Upgrades

Loads change when structures are adapted for new uses, requiring assessment and structural modifications to accommodate the changes. In some cases, building code changes become more stringent and may require existing structures to be strengthened. Seismic upgrades also are a common reason for strengthening concrete structures.

MEANS AND METHODS FOR REPAIRING, PROTECTING, AND STRENGTHENING

There are many different organizations involved with this industry. Professional service companies, including architects and engineers, provide forensic evaluation of existing structures. Testing companies provide field and laboratory services to analyze materials. Structural engineers calculate load capacities and produce design details. Inspection companies ensure that installed systems comply with specifications.

Surface Repair

Repairing the damaged surfaces of concrete can restore the structural function, protect the surface itself or the underlying concrete and reinforcement from aggressive environments, or restore any lost performance requirements including drainage and abrasive resistance. All repairs require initial surface preparation, which might include abrasive or hydro blasting, chipping, milling, sanding or chemical treatments. Systems for repairing surfaces include overlayment, resurfacing, formed repairs, hand-troweled mortars, cast-in-place repairs, shotcrete and, in some cases, full section replacement (Fig. 1.4).

Fig. 1.4

Protection

Protection techniques are designed to extend the life of the structure by protecting it from the attack of an aggressive environment (Fig. 1.5). Systems are available in the form of coatings, sealers, membranes, liners, cathodic protection and overlays (Fig. 1.6).

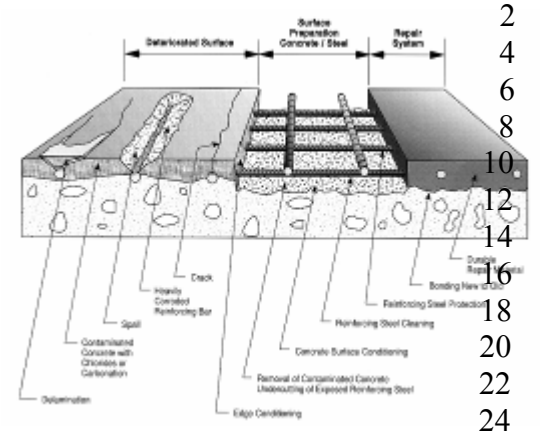


Fig. 1.5

Fig. 1.6

Waterproofing

Waterproofing techniques prevent water from entering or exiting structures through cracks, joints or failed waterstops (Fig. 1.7). Systems include replacement joints and sealants, waterproofing membranes and crack grouting (Fig. 1.8-1.11).

Fig. 1.8

Fig. 1.9

Fig. 1.10

Fig. 1.11

Strengthening

Strengthening is the process of adding or restoring capacity to a member or structure (Fig. 1.12). Techniques include the addition of steel, FRP composite systems, concrete or other special materials to existing members providing for additional strength and capacity of the structure (Fig. 1.13).

Fig. 1.12

Fig. 1.13

Repair and Protection Materials

Material manufacturers design, manufacture, package, and distribute all types of repair and protection materials including:

TABLE 1.1 – REPAIR AND PROTECTION MATERIALS	
Cementitious Prepackaged Surface Repair Systems	
Ready Mix Concrete	
Coatings, Membranes, Liners, Grouts, Sealants	

FRP Carbon, Steel & Glass Fiber	
Reinforcing Steels	
Pile Jackets	
Cathodic Protection Systems and Components	
Expansion Joints Seals, Bearings and Sealants	

Field Installation

Field installation is provided by contractors' and owners' maintenance staffs (Fig. 1.13). Many repairs are serviced by specialty contractors/installers. A sample of the major categories of contractors is listed below:

- General Contractors
- Contractor specialties
  - Membranes, Sealants, Coatings
  - Surface Preparation – Hydro/Shotblast
  - Grouting/Crack Injection
  - Foundation Underpinning
  - Vertical (High Rise) Repair
  - Shotcrete
  - Underwater Repair
  - Waterproofing
  - General Concrete Repair
  - Concrete Placement
  - Formwork
  - Steel Placement
  - Post-tensioning
  - Cathodic Protection
  - Industrial Floor Repairs

Fig. 1.13

Equipment

Equipment is always necessary for preparing, mixing, placing and testing materials. Many jobs require equipment that allows for specialized access. Dust collection equipment, safety gear and environmental protection are also important elements in installation. Some typical examples are shown below (Table 1.2):

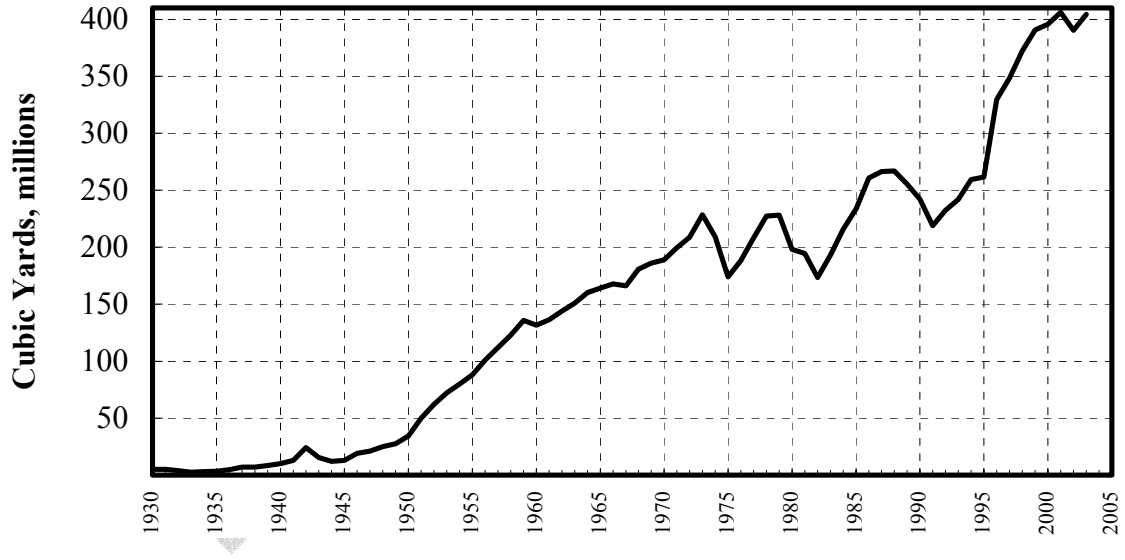
TABLE 1.2 – EQUIPMENT	
Hydro demolition	
Removal tools	
Cleaning systems	
Testing equipment	
Specialized small tools	
Mortar and Concrete Pumps	
Shotcrete Machines	
Epoxy Injection Pumps	

Cost of Repair, Protection and Strengthening of Concrete in the U.S

In the U.S., we consume over 100 million metric tons of cement, with a large portion being used for the production of concrete. It is estimated that over 500,000,000 cubic yards (cy)[1] of concrete (almost 2 cy/per person) are installed each year to support the U.S. infrastructure (Fig. 1.14). The volume of in-place concrete is estimated at 9 billion cy[2] (32 cy/person). Most of this concrete is older than 20 years. Concrete, even if exposed to freeze-thaw cycles, carbonation, chlorides, and other aggressive chemicals, can have a useful life of 30 or more years. More recent developments in the use of low permeability concrete mixes, proper use of air-entrainment, epoxy-coated reinforcement, protective coatings, and corrosion-reducing admixtures have greatly increased the service life of concrete structures beyond 30 years. But some concrete structures being built today may require repairs after as few as five years of service because of several factors. Emphasizing low first cost or improperly using repair materials are some of the reasons for the short service life of structures. More efficient designs may have a lower tolerances for workmanship and design errors, and fast-track construction methods may make it more difficult to incorporate the quality needed for a long service life. As a result, some new structures, in spite of durability enhancements, undergo early-age deterioration and require repair (Table 1.3).

Historical U.S. Ready Mixed Concrete Production

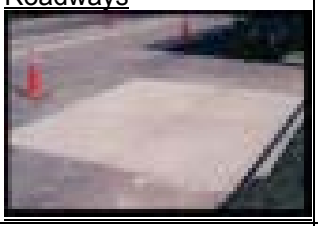
Fig. 1.14



It is estimated that the total cost for repair, rehabilitation, strengthening and protection (including waterproofing) of the concrete structures in the U.S. is $18-21 billion/year(See Table 1.3). Assuming there are 9 billion cy of concrete in these structures, concrete, the annual cost is between $2.00 and $2.33 per cy of in-place concrete.

[1] PCA reports 75% of concrete is ready-mixed concrete

[2] PCA reports cement and concrete usage from 1930. This is the basis for estimating that 15 billion cy were placed since then. The 9 billion cy estimate is based on an assumption that 60% is still in place.

TABLE 1.3		
STRUCTURE	**COST**	**DESCRIPTION**
Bridges 	$8 B (Source Cost of Corrosion Study NACE)	Decks, Superstructure Components, Substructure Components There are 235,000 conventionally reinforced concrete and 108,000 prestessed concrete bridges. Corrosion and other related deterioration mechanisms make 15% of these bridges structurally deficient. Seismic retrofit may also be required because of changes in code requirements. Repair methods include surface repair systems, removal and replacement, protective coatings, membranes, pile jacketing, cathodic protection systems, strengthening systems, and crack repair.
Roadways 	$4+B	Slab on Grade, curb and gutter, sidewalks Freeze thaw deterioration, alkali silica reaction attack, D-cracking, and abrasion are someof the deterioration mechanisms. Repair methods include remove and replace, slab subsealing, doweling, partial-depth repairs, overlays, and use of joint and crack sealants
Piers and Wharfs  *Fig. 1.14*	$0.2B	Piles, bents, decks Exposure to chlorides and vessel impact are primary distress mechanisms. Repairs include cathodic protection, surface repair systems, jacketing, and protective coatings
Buildings 	$2B	Facades, Balconies, Plaza Decks, Exposed concrete Airborne chlorides, freeze-thaw cycles, and carbonation are some of the distress mechanisms that may be related to design and construction errors. Waterproofing failures are also common, and seismic retrofits may be needed. Repair methods include foundation waterproofing, plaza deck waterproofing, and replacement or repair of balconies.
Parking Structures 	$0.5-1B 18,000 structures in the U.S.	Precast, Post-tensioned, Cast in place, Composite Water leakage through cracks and joints, chloride ingress, and freeze-thaw cycles are common mechanisms that cause reinforcement corrosion, spalling, and other distress. Repair methods include waterproofing membranes, joint sealants to control water intrusion, strengthening systems to correct design and construction errors, surface repair systems for spalling damage, and slab replacement
Locks and Dams 	$0.2B	Locks and dam structures Freeze-thaw cycles, abrasion /erosion, structural modifications, and leakage are some causes of distress. Repair systems include overlayments, grouting, spall repair, component replacement, and strengthening with anchors.

Residential 	$0.3 B	Sidewalks, driveways, patios, foundations Freeze-thaw cycles, deicing agents, and soil settlement, are some of the distress mechanisms. Basement leakage is also a problem. These may be accentuated by poor quality materials or construction methods. Repair methods include remove and replace, slab jacking, overlays, surface repairs, waterproofing, and crack sealing.
Industrial Facilities 	$0.3B	Foundations, slabs, structural frames, containments, vessels, tanks Deterioration mechanisms include chemical attack and structural overloads that produce spalling, cracking, and disintegration, Repair methods include surface patching, coatings, liners, membranes, and strengthening systems.
Water Treatment 	$0.5B	Tanks, Deterioration mechanisms include chemical attack, leaching, freeze-thaw cycles, and soil settlement that can cause cracking, leakage, spalling, and disintegration. Repairs may include surface patching, concrete replacement, crack injection, coatings, liners and membranes
Pipelines 	$1B	Sewer Pipes, Pressure Pipes, Aqueducts, Canals, Tunnels Deterioration mechanisms include chemical attack, erosion, abrasion, and soil settlement that can cause cracking or spalling, Repairs may include use of liners, coatings and membranes, overlays, spall repair, or specialized trenchless pipe rehab technology
Misc Structures 	$1B	Stadiums, Runways, Chimneys, Towers and more Freeze-thaw damage, thermal degradation, and aggressive chemicals are some of the deterioration mechanisms. Repairs can include remove and replace, patch, and apply surface treatments.

Industry Involvement

Repair contractors, materials manufacturers, equipment suppliers, engineers, and architects have been heavily involved in the repair industry for many years. Although some owners and universities have made contributions to advancements in the industry, more cooperation is needed from education and research establishments that include:

- Government agencies
- Universities
- Private research institutes

Trade associations and technical institutes have also advanced the repair industry by developing codes, specifications and other standards, plus guides and state-of-the-art reports for condition evaluations, testing, and use of repair materials and methods. A more integrated effort is needed, however, because while some or all of these groups have similar objectives, they can produce standards with conflicting requirements. Organizations such as the following need to work more closely to harmonize the standards that are produced.

- International Concrete Repair Institute (ICRI)
- American Concrete Institute (ACI)
- National Association of Corrosion Engineers (NACE)
- Society for Protective Coatings (SSPC)
- American Society of Concrete Contractors (ASCC)
- Sealant, Waterproofing and Restoration Institute (SWRI)
- American Shotcrete Association (ASA)

Many of these groups have also independently launched certification and education programs that could benefit from an interchange of ideas among the organizations' members when such information products are produced.

A UNIFIED INDUSTRY VISION

Why do we need a vision?

A vision provides a glimpse of the future state of the industry. If most key people in the repair industry believe that no improvements are necessary–and there are no big problems to solve—their vision will result a future state of the industry no different than what we see today. That isn't the case. Repair industry leaders have spoken in the Vision 2020 workshops, and they envision a great need for improvement. These improvements include reducing repair mistakes, miscalculations, and poor workmanship, and finding better repair methodologies that reduce costs while improving quality. This Vision and the goals related to achieving it, are the basis for moving forward and helping industry organizations, research establishments, and educational institutions to accelerate progress in the repair industry.

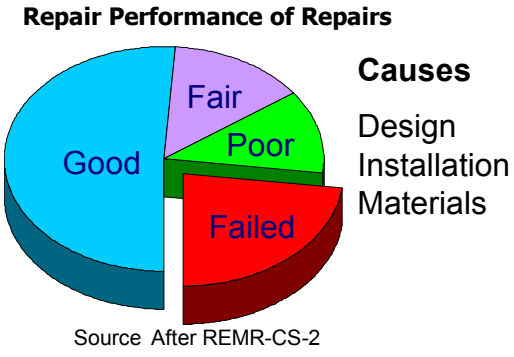


Fig. 2.1

The need to reduce the failure rate of repairs

Concrete repair and protection projects do not always satisfy owner performance objects. The U.S. Army Corps of Engineers maintains a

large number of concrete structures. A little more than 50% of the repairs performed on the Corps structures are performing satisfactorily, which is an unacceptable rate. Failures of repairs are attributable to design or evaluation errors, materials and installation or construction errors. The Corps experience is not unusual (Fig. 2.1).

Examples of areas that need improvement

Figure 2.2 shows the collapse of a parking structure that occurred while the repairs were being completed. Lack of temporary shoring caused the weakened structure to collapse. The supervising engineer and contractor did not have adequate training and guidance to perform the work safely.

Fig. 2.2

Figure 2.3 shows an existing concrete repair that has delaminated and is ready to fall from the building façade. Close examination of the picture reveals insufficient surface preparation around the corroded reinforcing bar. Loose pieces of repair material create a large risk for the building's owner, the public, the repair contractor, and the engineer.

Fig. 2.3

Figure 2.4 shows a failed repair on the side of a water storage tank. What at first appears to be an installation error, poor surface preparation, is actually the result of a design error. The design must take into consideration the water vapor transmission from the tank interior. The water vapor transmission is trapped behind the repair which is very dense and resistant to freeze thaw damage. With a concentration of moisture trapped behind the repair, the original substrate undergoes freeze-thaw disintegration causing the repair to delaminate. The design requires a strategy to mitigate these factors.

Fig. 2.4

Figure 2.5 shows a new repair that has cracked badly and requires removal and reinstallation. The cause of these cracks is the repair material's volume change or drying shrinkage properties. Excessive shrinkage restrained by the repair material's bond to the substrate causes the material to crack. Many prepackaged repair materials shrink more than standard ready-mixed concrete does when drying occurs**.**

Fig. 2.5

Figure 2.7 shows massive deterioration of a repaired structure. The repair included an impressed current cathodic protection system. Faulty installation of the cathodic protection system, which was improperly balanced and acting on discontinuous reinforcing steel caused an accelerated deterioration process**.**

Fig. 2.8

Figure 2.6 shows an elastomeric membrane delaminated from the substrate. Failures like this are a result of many factors, including poor surface preparation, primer installation or high moisture levels in the substrate. These failures can be massive and result in the need to replace the coating systems.

Fig. 2.6

Fig. 2.7

Figure 2.8 shows strengthening systems applied to a newly constructed structure. This costly repair was a result of inadequate reinforcing steel across the top of the pier.

Unified Vision and Goals

The diverse concrete repair and protection industry recognizes the importance of a unified vision. In developing Vision 2020, leaders throughout the industry have described the desired state of the industry by 2020. They have identified potential breakthroughs in materials, equipment, industry cooperation, research and funding, professional practice, design methodology, environmental impact, workforce supply and owner education. They realize that creating an accurate and attainable vision, establishing goals, and seeing the goals completed will require a strong effort. But they also believe this effort will significantly advance the industry by improving repair quality, reducing repair cost, and enhancing the safety of workers the public. All of these results will encourage increased owner investment in repair and protection of their structures.

Industry leaders have categorized Vision 2020 into 13 key goals, including 45 separate strategies. These are presented here without order of preference.

1. *By the year 2010 the industry will have established mechanisms for industry cooperation to facilitate better and faster worldwide creation of concrete repair and protection technology and dissemination of information about the technology .*

   Advances in the repair industry won't be achieved by just one organization. The advances will require a worldwide effort involving many organizations. Closely coordinating the many organizations' activities will eliminate duplication of effort, improve sharing of resources, coordinate projects to eliminate conflicting recommendations, and improve the education of industry members.

   The repair and protection industry envisions:

   a. Establishing a repair and protection council made up of members from several associations and institutes to monitor and manage Vision 2020 initiatives and the existing Concrete Repair Manual project, and to coordinate assignments of needed documents and educational programs. *(By 2005)*
   b. Developing a Manual of Repair and Protection Practices, which is the next step beyond the current Concrete Repair Manual (second edition)--a joint project of ACI, ICRI, The Concrete Society (CS), and Building Research Establishment (BRE) *(By 2010)*
   c. Identifying and developing more joint industry documents, thus accelerating the rate at which best practices are delivered to the repair industry *(Ongoing)*

2. *Develop and implement means of accelerating the process of document creation and dissemination within industry associations.*

   Under current conditions, the time needed to produce or revise industry documents such as codes, specifications, and guides averages 8 years. Many documents are out of date by the time they are published. Additionally, most industry documents are produced solely by volunteers on a part-time basis. The industry would be well served if more expedient methods were employed to produce and disseminate important industry guidance to the broad user community.

The repair and protection industry envisions:

a. Establishing corporate funding of specific projects and initiatives, possibly coordinating this with the Strategic Development Council's ATA program *(Ongoing)*
b. Establishing portals for the general public to access important industry knowledge, with funding by private sponsorship in lieu of selling specific documents. Fixconcrete.org is an example of this kind of portal *(By 2007)*

3. *Create a repair, rehabilitation, and protection code to establish the most critical elements in evaluation, design, materials, field and inspection practices needed to raise the level of performance of repair and protection systems, establish clear responsibilities and authorities for all participants and provide local building officials a means for issuing permits. (By 2015)*

   Repair and protection practice varies widely based upon individual beliefs, understandings, experiences and motivations. It is very hard to define a current standard practice for many types of repairs. The current ACI 318 Building Code does not deal with repair and protection issues. Practitioners are left to themselves to do the best job they can. When repair and protection projects fail to deliver the intended results, damages, claims, and lawsuits result. Establishing a Code of Practice, especially on projects involving life safety, will give the practitioner proper design, material and construction information. The Code of Practice can also provide a basis for defining standard industry practices. This effort will raise the whole industry to a higher level of performance.

   The repair and protection industry envisions:

   a. Establishing a focused team to create a project plan for a "Repair, Rehabilitation, and Protection Code" *(By 2005)*
   b. Creating a multi-part document that ultimately becomes a complete code. Parts may include:
      - Defining performance requirements for repairs
      - Establishing material performance requirements
      - Defining considerations for structural safety during repair
      - Developing guidelines and standards for inspections of repairs

4. *Develop performance based, guide specifications for specific and generic repair designs to improve specifications. (By 2010 and ongoing)*

   A performance-based specification should detail requirements for the work in accordance with the environment during installation of the repair and during service of the repaired element. Other specific criteria such as shrinkage limits for repair materials may also be identified. Such specifications <u>should not</u> provide instructions to the contractor on how to achieve these requirements. Many repair specifications are incomplete, ambiguous, and may establish a basis for claims, poor quality performance, and increased costs.
   Too many specifications are created from product manufacturer's guide specifications. However, reluctance to embrace performance specifications is based on the fact that there

are still few short-term tests that reliably predict long-term performance.

The repair and protection industry envisions:

a. Establishing a list of needed specifications *(By 2006)*
b. Creating specifications outlining responsibilities and performances expected and QA and QC methods, and promoting the use of preconstruction mockups and field trials. *(Ongoing after 2006)*
c. Developing short-term tests that reliably predict long-term performance of repairs *(By 2020)*

5. *Improve repair material design and performance to minimize cracking, to improve load-carrying capacity, and to produce setting and curing properties consistent with requirements of the construction process.*

   Surface repairs materials often crack, may sag in vertical or overhead applications, or may set too quickly. Repair materials used in partial depth situations may not be effective in carrying loads because they shrink and can't transfer load to the substrate. Manufacturers are free to develop repair products that don't meet any standards or code requirements for many applications. Some ingredients in repair mortars, such as gypsum-based materials, can cause expansion during use in a wet environment and cause damage to the structure.

   The repair and protection industry envisions:

   a. Developing protocols for selection of materials with defined test methods and commentary
   b. Developing and instituting a standardized data sheet protocol (in process) *(By 2005)*
   c. Developing materials for specific applications, e.g. column-patching materials that will carry loads indefinitely instead of transferring the load to the substrate concrete as they shrink. *(By 2015)*
   d. Identifying material properties and test methods necessary to predict long-term performance *(By 2012)*
   e. Developing better understanding of how material properties are interrelated. *(Ongoing)*
   f. Incorporating basic requirements of repair materials into the Repair Rehabilitation and Protection Code *(Item 3 above)*

6. *Develop environmentally and worker friendly repair methods and materials that will greatly reduce the adverse effects on workers, the public and the earth's eco system.*

   Repair processes produce many byproducts that adversely impact the environment. Almost any tool interacting with existing concrete produces particulate materials (dust) that may become airborne unless they are contained. These airborne particles contain the base ingredients of the concrete and, in the case of sandblasting, the abrasives used in the process. Silica-bearing aggregates are commonly used in concrete. Crystalline silica inhaled over a long period of time may cause respiratory illness. Properly worn safety

gear will eliminate inhaled dust. Concrete removal is currently done by pneumatic, electric, high pressure water and hydraulic removal tools. For most jobs, the tools are hand held resulting in repetitive motion/vibration to the workers body. In addition, the impacting of concrete results in excessive noise generation. Current personal safety gear, properly worn, will reduce both the vibration and noise impact to the body, but will not eliminate it totally.

The repair and protection industry envisions:

a. Establishing new standards (or procedures and equipment) for abrasive blasting, concrete demolition, and disposal that eliminate airborne particulates *(By 2010)*
b. Establishing a means for identifying, tracking, and disseminating environmental concerns *(By 2007)*
c. Developing demolition equipment that is quiet, dust free, and has low impact on the body *(By 2012)*
d. Developing an industry safety manual *(By 2009)*

7. *Develop a means for predicting repair system performance to help ensure the use of proper materials, design details and installation methods based upon predictive models validated by experience.*

Repairs have been performed successfully and unsuccessfully for many years. Within each project lies important feedback for future projects. Learning from what works and what does not work would ultimately eliminate most repair failures. We do not have an effective way to document project's successes and challenges, thus we miss the greatest opportunity to learn and improve. There is no formula in our business that spells out how systems will perform given a particular service environment. Success is either individual wisdom or just luck.

The repair and protection industry envisions:

a. Establishing an infrastructure for collection of information to be used in a database of projects that will detail historical performance. This infrastructure must combine experiences from the North and South America, Europe, and Asia, and must be supported in a way that gives an incentive for repair industry members to participate *(By 2007)*
b. Developing forums to share experiences both successes and challenges. Create a "what went wrong" guide for solutions *(By 2006)*
c. Developing a monitoring (observation) protocol for repaired structures to properly compare project results *(By 2007)*
d. Developing predictive modeling of service life of repairs *(By 2020)*

8. *Establish a clearing house for all research needs and ongoing projects to eliminate duplication and to focus resources on important projects.*

At any one time, research in many areas affecting concrete repair and protection is underway. Hundreds of projects involve thousands of people and millions of dollars in

seeking to accomplish research tasks. Industry leaders view many of the projects as unimportant or not relevant to what the industry needs. Some projects are duplications of current or past work. Most research is conducted in university settings and results may not transfer to field situations. There are no lists that establish what the industry deems to be important.

The repair and protection industry envisions:

a. Establishing a centralized listing of industry research needs *(By 2006)*
b. Establishing a centralized listing of ongoing research projects *(By 2007)*
c. Establish a centralized listing of completed research findings *(By 2008)*

9. *Increase the number of material-, engineering-, and construction-related professionals interested in and skilled in repair and protection practice to support the growing need for evaluation, design, new materials and construction professionals.*

   Current interest in choosing a career in repair and protection is very low. Very few schools have courses that introduce or prepare the student for the industry. Where courses and interested professors exist, such as the University of Texas at Austin, the University of Illinois, Middle Tennessee State University, Georgia Tech, and the University of Missouri-Rolla, students attending make their way into the industry with excitement and passion.

   The repair and protection industry envisions:

   a. Developing text books specific to the industry *(By 2007)*
   b. Developing curriculum for repair courses *(By 2006)*
   c. Recruitment of schools to offer courses from the current 6 schools to 20 schools *(By 2008)*

10. *Develop selection processes, contractual agreements, procurement methods and relationship arrangements (partnering) that will greatly reduce conflicts, rework, claims and lawsuits resulting from disagreements among contractors, general contractors, engineers and owners.*

    Successful repair and protection projects are a result of the owner, engineer, and contractor establishing and maintaining healthy cooperative relationships, and with realistic expectations that are understood by all parties. The success of all repair projects is the result of the combined experience, attitudes and wisdom of the project team. Selecting the lowest bidder for repair design or construction services often fails to produce the best value because the most qualified bidders aren't chosen. This can cause a claim-oriented process to develop where relationships are tested, corners are cut, and feelings damaged. Many bidding processes initiated by owners or their agents produce one-sided agreements that place most, if not all, risks on the engineer and contractor. These types of arrangements cause relationships to be strained and future opportunities to be lost.

The repair and protection industry envisions:

a. Developing standard warranty and indemnification language that will offer clear motivation to the material supplier and contractor to perform in alignment with owner interests, yet not be excessive. *(By 2007)*
b. Developing an owner guide for design-build procurement bringing both speed and innovation to cost effective solutions *(By 2008)*
c. Developing a guide for project partnering arrangements. *(By 2008)*
d. Developing standard templates for contracts and subcontracts that are fair to all parties in the contract. *(By 2008)*
e. Developing guidelines for prequalifying engineers and contractors to improve repair project performance, cost effectiveness and project safety *(By 2008)*
f. Developing a specific industry certification/training program for contractors, engineers and inspectors *(By 2015)*

11. *Develop facility owner education that will promote awareness of the effects of deterioration and the means to reduce the risks while protecting their investments.*

Many owners do not fully appreciate the structures that support activities within a building. Lack of education and a basic understanding of materials and structures by owners can lead to unpleasant surprises and unforeseen risks of a failure. Examples are changing the use of building and thus increasing live loads, or using aggressive chemicals that can deteriorate even good quality concrete.

The repair and protection industry envisions:

a. Developing guides for owners to support life-cycle cost investments in maintenance which include flow charts and decision trees *(By 2009)*
b. Developing an owner's guide to inspection and maintenance of facilities *(By 2009)*
c. Promoting the new ASTM standard for façade inspection *(By 2005)*

12. *Develop improved means and methods for accurate and thorough condition assessment.*

The success of all repair projects is dependent on the completeness, accuracy, and logic of the condition assessment. Planning for many projects fails to address underlying causes, therefore shortening the repairs' useful life. For many projects, under estimates or over estimates of the quantities of repairs needed, cause cost overruns and contractor claims.

The repair and protection industry envisions:

a. Developing an industry standard for condition assessment and reporting (*By 2008)*
b. Improving scope and quantity estimating to improve accuracy
c. Developing structural health monitoring systems that continuously measure corrosion potential as an aid in predicting when maintenance and/or repairs will be needed (*By 2007)*

d. Developing improved nondestructive diagnostic systems, similar to ultrasound, that can produce 3D imaging of existing concrete including items such as multi-layered reinforcement placement (*By 2006*) and internal defects such as voids and cracks *(2012)*

13. *Develop specific repair system needs for expanded use, efficiency, and failure reductions*.

The repair and protection industry envisions:

a. Developing a heat-resistant adhesive for FRP systems that will provide an adequate fire rating for the installed system.
b. Developing coatings that are less sensitive to minor imperfections in concrete surfaces (such as bugholes) and can thus be used to lower surface preparation costs.

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