

Study Shows Maintenance Key To Garage Success

A smart maintenance program adds years to deck's life, according to a study of 200 structures

A national survey of the performance and durability features of precast prestressed parking structures has unearthed a potpourri of construction and maintenance data that was predictable in some areas and eye-opening in others. Sealants in particular showed better performance capabilities than expected, and the value of good maintenance was reinforced.

The study, which centered on characteristics of precast prestressed parking structures in service for at least four years, centered on four major objectives:

1. Recording the durability and performance characteristics of precast parking structures in service.
2. Evaluating owners' perceptions of their parking facilities.
3. Identifying the nature of maintenance and repair practices that are common to these structures.
4. Pinpointing areas of interest for future study.

Three Phases Included

The survey was divided into three phases: a visual survey of the conditions of the precast parking decks from four to 25 years of age; an interview with owners to determine how satisfied they were with the decks; and the nature and cost of deck repairs through interviews with consultants engaged in repairing and maintaining parking decks.

The final survey count totaled 230 precast projects located in 26 states and provinces of Canada. The sample also represented 42 metropolitan areas across

North America. Only conventional precast prestressed structures were included in the study.

Owner's representatives were interviewed on 75 of the projects, while additional information from the parking consultants' group was based on projects unrelated to the initial study but considered pertinent to the project's overall intent.

Since there were many ways to group the data, a summary was adopted for what was considered the most important relationships to be studied. Four vari-

Decks topped at the factory stood up to time and traffic better than those decks topped in the field.

ables of comparison were developed: the age of the structure, sun-exposed versus sun-protected conditions, deck surfaces that were field-topped versus those that were factory-topped, and the severity of climate exposure, which was categorized by the location's geographic durability zone. These zones, three of which cover the United States, are based on the amount of chloride exposure to the structure.

Experts on the construction and durability features of precast parking structures were assigned to the visual survey phase of the survey. Each facility was rated on a scale of 0 to 10 concerning

the conditions of the deck surface, sealants, expansion joints, and sealers, coatings, or membranes. These ratings were accompanied by descriptive phrases to indicate the condition of the specific components examined: "extensive," "common," "occasional," "infrequent," and "negligible."

Sealers Are Nonexistent

Early in the study, the authors say, it became apparent that visual evaluation of the effectiveness of sealers would be meaningless because often there was no visual evidence that sealers were present. So the category was dropped.

Any apparent surface scaling, random cracking, and surface delaminations on the structure were counted against its overall durability rating. Scores were averaged for an overall durability rating for each deck surveyed. The results were compiled and compared in terms of durability zones, sun exposure, age of structure, and type of structure. The results:

- The overall durability characteristics of precast structures is superior. Ratings in all cases fell within the "negligible" or "infrequent" categories as descriptive of the number of problems found.
- Performance was consistent across all durability zones; sun-protected areas fared slightly better than sun-exposed areas.
- Conditions appeared to improve slightly in structures more than 10 years old, because repairs are often



Primary design consideration focused on the deck serving as the background for present and future building sites. Photo: Joann Sieburg Baker

undertaken from eight to 15 years after construction.

- Factory-topped structures had better durability characteristics than field-topped structures.

Surface Scaling Is Rare

It was found that surface scaling on pretopped tees is rare. The reason for this, says PCI's parking committee, is the lower water-to-cement ratio that can be achieved with precast concrete as compared to cast-in-place methods. This combines with quality-control techniques that can be achieved in the factory but are difficult to match on-site. As a result of these conditions, a pretopped structure is more resistant to scaling.

While scaling sometimes is seen on toppings and pour strips, it's generally confined to top-deck exposures or where ponded water is subject to freezing and thawing. These conditions typically are limited in area and are easy to maintain at relative small cost.

In rare instances with toppings and pour strips, conditions showed general joint deterioration, wide-spread leakage, and other corrosion-related problems. The problems were severe and related repairs were expensive to some of the owners.

As with scaling random cracking was found to be an infrequent problem with precast structures. It was noted that the use of strategically-placed control joints is a universal practice in most decks and

is extremely effective in crack control.

During inspections, cracks were seldom seen in the surface of pretopped double tees. When random cracks were seen, they usually related to restraint of movement, a misplaced control joint, or plastic shrinkage. During close inspection, the survey teams noted that warping of tees to create drainage patterns resulted in pattern cracks in some cases. These random cracks typically were repaired by routing and sealing with a urethane sealant. Although effective, the cracks were "unsightly," the inspectors said.

Aggregate pop outs—potholes—on topped decks don't seem to be a problem. But most importantly, they're almost never seen on pretopped structures, according to the survey team. Again, this is a result of the stringent quality-control procedures that can be achieved in the factory with pretopped systems, according to PCI.

Delaminations Studied Closely

Inspectors studied deck surface delaminations. The highlights of this close-up procedure showed that surface delaminations related to corrosion of reinforcement was a rare occurrence in both topped and pretopped decks.

Most delaminations either were active, were under repair, or had been previously repaired. Causes included:

- Metal conduit buried in toppings.
- Conventionally reinforced cast-in-place sections such as entry ramps.

- Larger diameter reinforcement used in pour strips or as inserts into columns or spandrels.
- Flange-weld hardware, particularly in conjunction with sealant joints that had failed and had not been maintained over a long period.

Standard mesh with a proper cover performed satisfactorily in all instances, the report said, without showing any significant problems in either topped or pretopped structures. In a few instances, it was noted that epoxy-covered mesh, which is more costly, might enhance durability.

The study group also found that resistance of pretopped tees to corrosion-related deterioration was not a factor; there was no instance of active delaminations. The use of epoxy-covered strand, epoxy-covered mesh, or micro silica in these components to improve durability did not seem to warrant the additional

Later Than Sooner

A typical deck repair, the survey shows, is made when the facility is from 10 to 15 years of age regardless of the type of deck involved. This figure is based on more than 2,500 repair projects undertaken collectively.

Precast structures represent about 15 to 20 percent of the total number of projects undertaken, the study says, but only five to 10 percent of the total repair dollars spent.

expense. Performance levels already were exceptional.

Joint-edge Spalls Common

It was not uncommon to see small edge spalls along a joint, the inspection teams noted. This was especially true where snowplows were used, but the problems also were traced to normal wheel traffic. The likeliness of spall increases as concrete quality decreases, the survey determined. Pretopped decks that are not plowed have minimal exposure to spalls, probably because of greater strength of plant-produced concrete, the team said.

Differential-camber tolerance control on pretopped decks is an important variable in controlling spalling problems under snow plow exposure. It's noted that controlling differential camber within 1/4-

inch tolerances is commonly achieved.

These are minor problems, the experts pointed out, but they can lead to leakage

The use of special added components, such as epoxy-covered mesh, usually doesn't contribute enough to justify the cost of the material.

and sealant deterioration if not properly maintained.

Spot deterioration at welds that results in leakage are often due to spalls behind

flange welds on untopped structures, the report noted. This is caused by weld details that don't allow for upward expansion of the plate during welding. The expansion results in micro cracks that later turn to spalls under traffic. It was noted that this problem is worse in sun-exposed areas.

The experts said that flange-weld spalls were not seen on most projects studied. When they were seen, they often were widespread, resulting in leakage and general, overall deterioration. This situation most often occurs on older structures, which were built before more modern quality-control construction techniques were widely known.

Maintenance Is Key

Where maintenance has been neglected, connection damage and exposed-plate deterioration was found. The exposed plates frequently are used for spandrel-to-column connections.

Corrosion control, say the experts, can be provided by coating the metal or providing galvanized hardware. Of the two, the galvanized plates with cadmium bolts performed better on the older decks inspected. It was rare to see a plate that had been repainted as it began to show corrosion. The galvanized plates, however, were typically okay.

The team found that an alternative way to provide connections is in a pocket, which then is grouted. These pockets invariably crack, however, the experts said, although the connections were not necessarily deteriorating because of this.

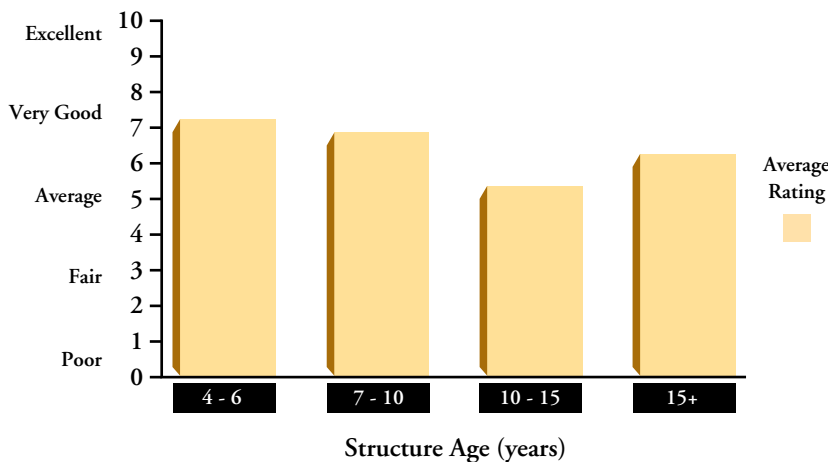
Elastomeric pads, a requirement in precast garage construction to support precast structural members at their bearing points, achieved uniformly excellent results, inspectors reported.

Poor maintenance practices—or no maintenance at all—were cited by the survey team as a common problem. The lack of consistent, timely maintenance was a frequent cause of deteriorating conditions in parking structures, the experts said.

Throughout the survey, results of general good housekeeping practices were only average. The practices tended to decline with the age of the parking deck structure.

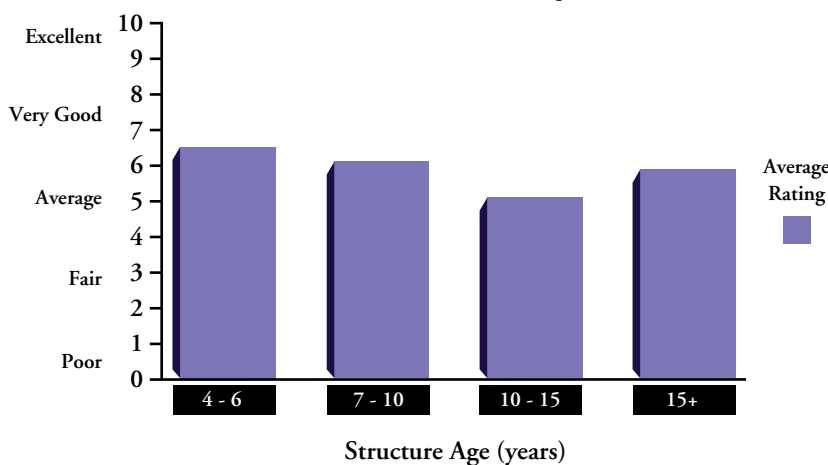
Parking-deck owners use sealants extensively, the survey noted, and both the performance of the deck and the owners' perception of the performance of the deck is dependent on the success of sealants used.

General Housekeeping



General housekeeping on parking structures tends to fall off only when the facilities are 10 to 15 years old.

Maintenance and Repair



Maintenance and repairs rates lower than general housekeeping, and again is worst for those structures 10 to 15 years old.

The Buck's Spent Here

Typical repair costs on precast structures are in a range of \$3 to \$10 psf. Post-tensioned structure repairs run from \$5 to \$25 psf. Repairs on conventionally reinforced cast-in-place concrete decks run from \$7 to \$25 psf.

Fix Now Or Pay Later

Leaks usually are related to a minor sealant and/or concrete edge failure, the survey reports. Both could be repaired simply and inexpensively. Yet owners are lax about making the repairs.

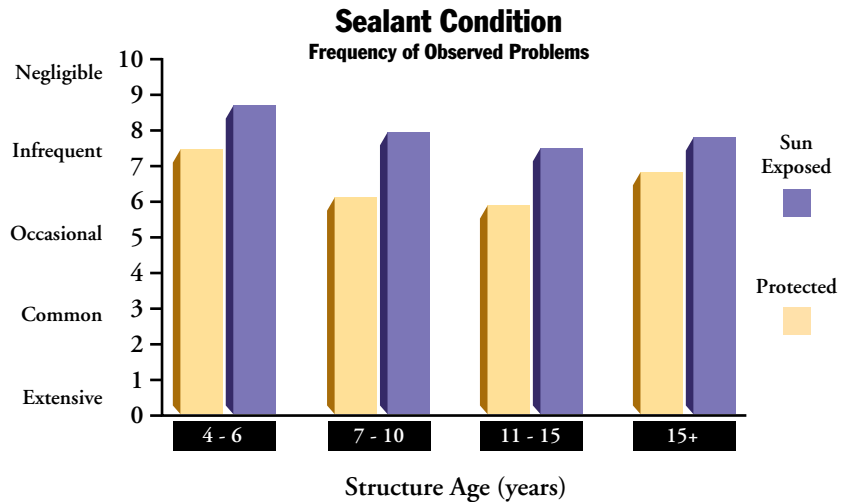
By simply maintaining sealants on a regular basis, the survey contends, the level of waterproofing performance would rise.

Polyurethane sealants generally are used for a seal between precast elements or to seal crack control joints provided in concrete toppings. They also are used for a cove joint at floor-to-wall junctions.

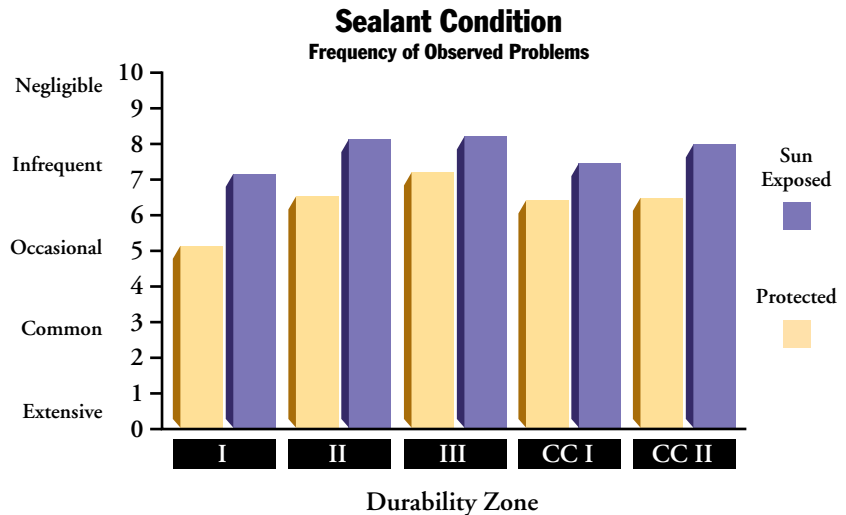
General-sealant ratings declined with the age of structures, and sun-protected sealants fared better than those directly exposed to weather at all ages. Performance was rated high, with only the sun-exposed category in southern states getting an “average” score. There was little difference reported between pre-topped and topped structures across all age categories and durability zones.

The report makes these significant observations:

- The use of joint sealants, also a construction requirement, is extensive and universal on precast structures.
- Urethane-based sealants are used in almost every case. However, performance of all urethane-based sealants is not equal. Some sealants exhibited hardening and weathering deterioration sooner than others.
- In the rare instances where joint failure occurs and produces leaks, it usually has resulted from concrete edge failure of adjacent cracking, rather than because of cohesive, adhesive, or weathering failure of the sealant itself, as might be thought. This edge failure usually results from misuse or extraordinary wear by snow plows or other equipment or vehicles.
- Deck-joint sealants hold up well



Sun-exposed structures showed the most frequent occurrence of sealant deterioration, as might be expected. Since facilities 15 years or more often have been refurbished, the condition of their sealants often is better than those 11 to 15 years old.



Sealant condition was affected only minimally by which geographic durability zone the parking structure was located in.

under traffic—even in widths of 2 inches or more.

- Sun exposure is the most significant variable in the useful life of sealants. Sealants will last longer in northern sun exposures than southern sun exposures. Sealants in sun-protected areas dramatically outperform those in direct sun exposure.
- It is a myth that sealants have to be replaced every five years. Between five and 10 years, sealants exposed to direct sun will show signs of weathering deficiency and may need replacement. This is especially true of surface cove joints at floor-to-wall intersections. Sealants not directly exposed to the sun

show little deterioration at 10 years and have a life expectancy years longer than sun-protected sealants on structures 20 years old.

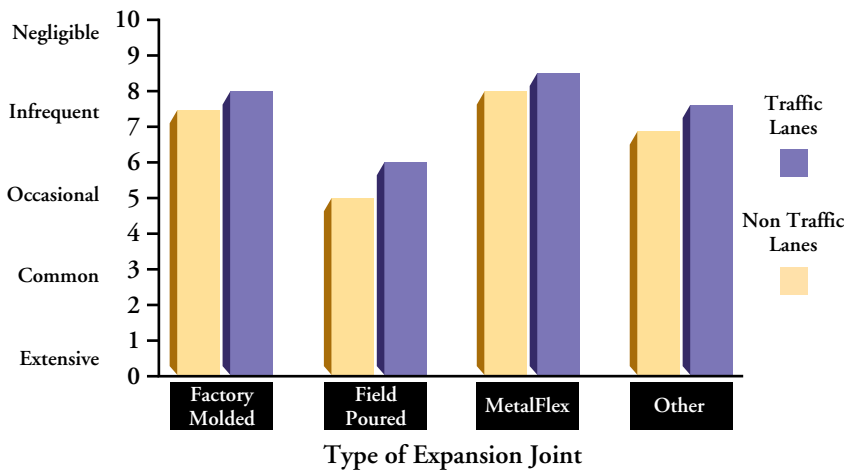
- Sealant procedures for non-sun exposed areas are alive and well and don't need modification, the experts agreed. Upgrading sealants used for sun-exposed conditions to aliphatic urethanes would merit the extra expense involved for the longer term.

In the rare instances where joint failure occurs and produces leaks, it usually has resulted from concrete edge failure of adjacent cracking, rather than because of cohesive, adhesive, or weathering failure of the sealant itself, as might be thought. This edge failure usually results



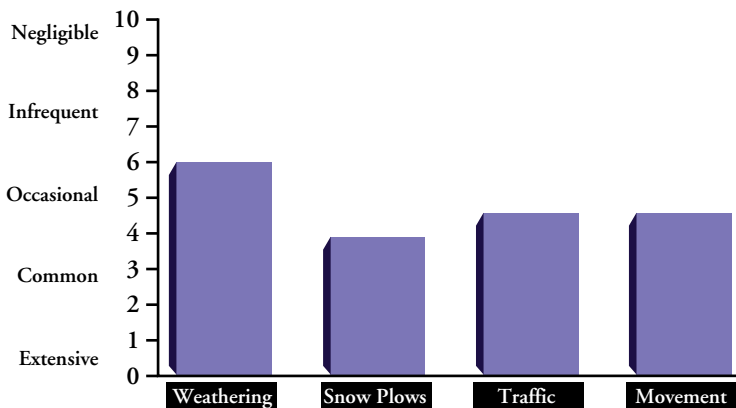
A large complicated parking facility has become a delightful yet durable structure.
 Photo: Gage Brothers Concrete Products Inc.

Expansion Joint Condition



Field-poured expansion joints suffered the most deterioration, particularly in traffic lanes.

Causes of Expansion Joint Seal Deterioration



No noticeable difference was observed between different structural types

Snowplows cause the most damage to expansion joints; operators must be constantly reminded to lift their plow blades slightly.

from misuse or extraordinary wear by snow plows or other equipment or vehicles.

Leaks were particularly common on pretopped structures that have a pour strip along the end of the tees. In these cases, a sealant joint provided between the strip and tee intersects the flange joint of each tee. This joint line frequently coincides with a drainage path, making it susceptible to water penetration. Where this had been successfully corrected, the experts noted, the pour strip was eliminated and replaced with a sloped, thickened section integral to the tee, which eliminated the joint. An elastomeric, traffic-bearing membrane was put over the pour strip and into the drainage path.

Snowplows cause lots of damage to joint edges that results in leakage, the team reported. Owners must be told and then reminded that these structures are not surface lots and care in snow removal is necessary to avoid expensive damage.

When ponded water was found, it usually was the result of not providing proper drainage lines or of misplacing the drain location.

Only 17 percent of the structures surveyed used any type of coating or membrane system. When used, elastomeric coatings and membrane were utilized to enhance waterproofing protections. Precast systems, however, were less likely to incorporate coatings than other types of structures because of inherent durability features.

Traffic-bearing membranes are more commonly used than buried membranes. The most effective use of these

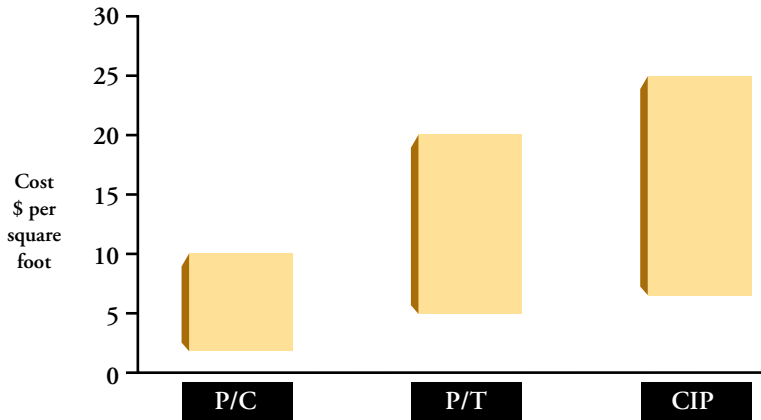
Joints Vs. Snowplows

In the battle between expansion joints and snowplows, the snowplows are almost always the winners.

This is the title fight between the “factory-molded” sealant-type joint, consisting of a wide, flat ribbon of polyurethane sealant molded in the factory and installed over a traffic bearing plate to seal the joint.

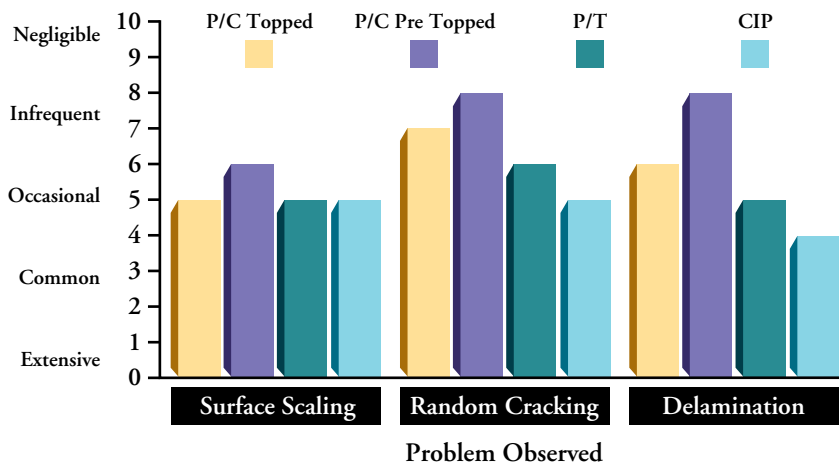
These joints perform super until the snowplows come along. To put these sealant joints in the winning corner more often, the report suggests, snowplow operators have to be educated about the need to raise the plow blade just a tad.

Typical Repair Project Costs



The range of repair costs for precast structures was significantly less than for other types of construction methods.

Deck Durability Characteristics



Precast pre-topped structures tended to offer the best durability of all types of structures, while cast-in-place fared the worst.

Salt And Sealers

Chloride resistance of concrete, tests show, can be enhanced if a sealer is used. Silane and Siloxane sealers are the two most prevalently used today.

Pour Strips

Pour strips at traffic crossovers usually take the form of thickened sections several feet in width. The strips, as might be expected, create traffic bumps as well as funnel water away from beam lines.

In some decks, the strips were made in an even plane and the waterproofing handled with a traffic deck coating for protection.

This made the bumps disappear, making drivers happy while providing the needed protection—which make the owners happy.

Would You Buy Another Precast?

A whopping 92 percent of owners surveyed said they would use precast in another structure, the report says.

Three owners said they wouldn't because the deck caused them expensive maintenance situations. These situations, on investigation, showed that the problems were created by poor initial construction practices.

were found when they were used in three ways: as secondary protection over occupied space; as strip membranes over joints or in gutter lines to correct or prevent joint edge spallings and as a water-

Sealants protected from direct sunlight fair better than those exposed. But sealants get an 'average' rating even in the South.

proofing membrane; and as a surface-repair method for badly scaled areas.

Traffic-bearing membranes that utilize epoxy traffic toppings show extensive reflective cracking over joints and are not as effective as those systems based on urethane polymers.

What It All Means

When the survey pluses and minuses were totaled, it was apparent that conclusions were favorable to precast structures. Key findings include:

- The durability characteristics were very good going across the variables.
- The specially designed parking-structure sealant systems that are universally used on a large scale within precast parking garages generally perform better than first assumed, the inspectors said. They tend to experience fewer problems and offer longer life.
- Sun exposure especially in the South is a significant variable in determining the life of sealants used.
- Life expectancy of sealants is at least from eight to 10 years with sun exposure, and from two to three times longer in protected areas. ■

— Richard V. Nunn