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Journal

Is That Traffic Coating Necessary?

Surface Treatments and Parking Structure Protection

Lawrence E. Keenan, PE, AIA and Robert A. Marsoli, Jr., EIT

Elastomeric traffic-bearing membranes are showing up on garages old and new, and their popularity has soared in the past decade. A beautiful coating that locks out harmful moisture and chlorides must be a reasonable long-term investment, right? Not only is this not necessarily true, in some cases, applying such coatings can be a costly mistake. It is true that parking decks must be cared for to ensure that they will be here after we are not, but there is a growing preconception that installing a traffic-bearing membrane is a one-way ticket to the garage equivalent of immortality. While a traffic-bearing membrane may, in fact, be the best solution for many situations, this is a big-ticket item, and thorough consideration is necessary to determine if this costly investment is the correct solution for your garage's needs.

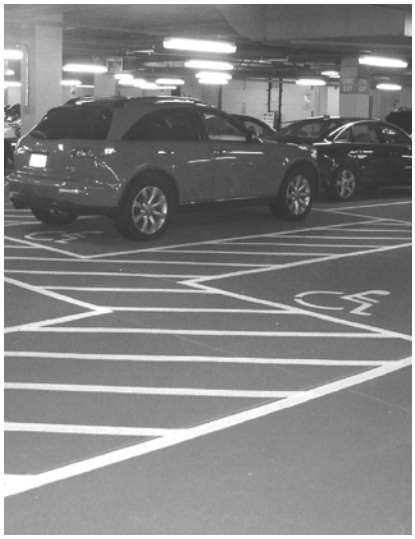
Traffic-bearing membranes are not perfect. In order to withstand the punishing abrasion which a parking deck must endure, the membrane must be hard and durable; however, the membrane must, at the same time, be soft and flexible to bridge over moving cracks and joints without failure. Since very hard membranes are generally inflexible, and more pliable membranes don't hold up well to abrasion, choosing the right membrane is a balancing act. In addition, there are locations where no membrane performs well, such as those areas requiring a flexible membrane that are subject to snow plows.

So…what is the best solution? It's helpful to begin by looking at the reasons why deck protection is necessary.

The Problem

In northern climates, parking decks are subjected to extreme corrosive and deteriorating environments. Moisture, laden with chlorides from deicing chemicals, tracks into garages or hitches a ride as ice formations behind the wheels of vehicles (tenderly referred to as "fenderbergs" by those in the repair industry) and ultimately soaks into the concrete surface. The dissolved chlorides then migrate to embedded steel reinforcement through the pores in the concrete or take the highway and penetrate through cracks. Once they reach the steel, the salts cause expansive corrosion, ultimately resulting in unsightly, destructive, and costly deterioration of the structure.

Moisture's ability to transport corrosive chlorides is not its only damaging property. Coupled with cold weather, water can damage concrete decks as it expands and contracts during freeze/thaw cycles. Air entrainment, the deliberate incorporation of microscopic



Traffic-bearing membranes look appealing. But are they worth the price?

As Director, Engineering with Hoffmann Architects, Inc., Lawrence E. Keenan, PE, AIA has extensive experience in parking structure rehabilitation, including investigation, repair, and surface treatment consultation. Project Coordinator Robert A. Marsoli, Jr., EIT is involved in a number of garage remediation projects, from design through administration.

Cracks are routed and sealed before application of a penetrating sealer.

air bubbles in concrete, releases the internal pressure created by freezing water by permitting moisture to flow from bubble to bubble. Still, although this solution to freeze/thaw degradation has been known for years, garages continue to be constructed with insufficient air entrainment, leading to premature breakdown of the concrete as freezing water destroys it from the inside out.

Water is at the heart of most parking deck deterioration. Moisture can facilitate reactions between certain aggregates and alkali hydroxides in the concrete, creating a cycle of expansion, cracking, and further moisture intrusion. This alkali-silica reaction, or ASR, is very difficult to stop once it has begun. Other minerals, notably sulfates and ettringite, migrate via penetrating moisture and can crystallize and lead to spalling, cracking, delamination, and even loss of integrity of the concrete.

Because parking structures are exposed to the elements inside and out, they are more susceptible than other building types to deterioration due to moisture, temperature cycles, and contaminants. Even the best designed and constructed garages need some help to survive this onslaught of corrosive forces.

The Objective

Ultimately, the goal of all deck protection is to stop water from getting into the deck. Perhaps this is an over-simplification, but not by much. No water, no deterioration. The tricky part is that water comes in more than one form. Liquid water is an obvious villain, as is the expansive force of ice and snow, but water vapor can be just as damaging.

For example, a chloride-laden deck can actually draw moisture from the air and continue to deteriorate even after your best efforts to keep it dry. In fact, calcium chloride, the most popular and effective of all deicing chemicals, is commonly used on construction sites for dust control. It is sprinkled onto the dry earth and wets the surface by pulling moisture from the air. Unfortunately, it works equally well at saturating your parking deck.

Remediating the effects of chloride ion attack, freeze/thaw damage, or moisture-driven chemical reactions is both difficult and costly, so preventing water infiltration—whether liquid, solid, or vapor—is top priority. While keeping your garage perfectly dry is an impossible task, through thoughtful product selection, you can limit the degree to which moisture can penetrate the parking deck. As such, there are a variety of products on the market that showcase the best protection chemistry can currently achieve.

The Options

Technological advances in the chemical industry in the past 30 years have brought concrete sealers a long way from the boiled linseed oil that was previously used. Today, an industry dedicated solely to concrete protection offers a dizzying array of products to treat concrete before, during, and after production, both inside and out. For existing parking structures, a number of waterproofing agents are available that can be applied to the surface of the deck; the following is a look at some of these product types and their properties.

Penetrating Sealers

These liquid-applied treatments, which include silane, siloxane, and silicates, stop water entry by penetrating deep into concrete and forming a barrier that prevents liquid water from entering, limiting chloride ion migration and freeze-thaw damage. These treatments are also vapor permeable, allowing them to be used at locations where other coatings may not be appropriate, such as slabs on grade. Because they are inexpensive and quickly applied, with little or no down-time, penetrating sealers offer a good first line of defense for a parking structure that is in good overall repair. As invisible penetrants working below the surface of the concrete, these sealers do not affect deck line striping, saving on project duration and cost.

However, these coatings can be short-lived solutions, requiring reapplication every five years or less. They also do not bridge cracks, so they only limit moisture and chloride penetration in intact concrete. Because cracking can be an ongoing process, the ability to bridge new cracks as they form may be important in parking decks that already have evidence of concrete distress.

Methacrylate and Epoxy Healer/Sealers

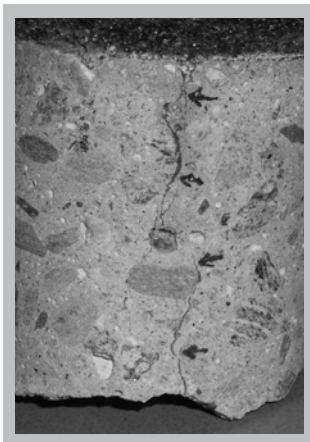
As the name implies, these coatings both repair cracks and seal pores, so they can be used to restore a deck that has already undergone some de-

terioration. Like the penetrating sealers, low-viscosity methacrylates and epoxies fill the pores in concrete to create a barrier to liquid-water-driven chloride intrusion. They can also be injected or gravity-fed into cracks to structurally heal them. Where desirable, the healer/sealers can also limit vapor transmission, although care must be taken not to lock moisture within the deck. With a moderate price tag, this class of surface treatments offers a good solution for parking structures that are starting to show some signs of distress, both to treat deterioration that has already occurred and to prevent continued water-related damage.

Where methacrylate and epoxy healer/sealers fall short is in wet or soiled fractures, to which the materials won't adhere, and in moving cracks, which are likely to re-fracture. On parking decks exposed to continuous sunlight, epoxies can degrade quickly under UV radiation, so consider methacrylates for these areas. For enclosed parking structures or other areas where fumes might be a problem, offensive odors from methacrylates might prove prohibitive. Unlike the penetrating sealers, healer/sealers aren't just coat-and-go; surface preparation necessitates shot blasting, which means increased down time and cost. Also, pavement markings must be reapplied.

Traffic-Bearing Membranes (Elastomeric)

In parking structures with dynamic cracking, shrinkage, or more advanced damage, a traffic-bearing membrane may be the only option to address the ongoing deterioration. Unlike the sealers, these do not penetrate the concrete, but remain on the surface to create a barrier that locks out moisture and chlorides. Most elastomeric membranes have two layers: a base coat that provides the waterproofing protection, and a top coat, which protects the base membrane and provides skid resistance. Together, these yield an attractive, easy-to-clean surface that can give a "face lift" to older, crack-riddled parking decks.



> *At right*: Gravity-feeding an epoxy healer/sealer into cracks on a concrete deck.

^ *Above*: Test core showing epoxy penetration to the bottom of a crack.

However, a traffic-bearing membrane's assets are also its downsides. Flexible varieties offer superior crack-bridging, even for moving cracks, but they don't hold up well to abrasion because they are soft and yielding. More rigid varieties, designed to better withstand abrasive forces of heavy traffic, are too stiff to bridge these moving cracks. So while traffic-bearing membranes, as a class of surface treatments, may seem to have all the right stuff, no one membrane, in practice, actually does. Before opting for one of these very expensive coatings, consider, too, that they require lengthy down-time (preparation and application takes several days) and considerable ongoing maintenance (re-coating, or at least top-coating, every five to ten years) for the life of the garage. Once a traffic-bearing membrane has been installed, it's nearly impossible to return to an uncoated surface in the future.

Super-Rigid Elasto-Epoxythane Traffic-Resisting Armor

This surface treatment combines the best of all of the above. Although abrasion defiant, it is flexible enough to bridge moving cracks, locking out all moisture and chlorides. It is environmentally friendly, low odor, and available in a wide variety of colors to match any decor. Unfortunately, it also, as yet, does not exist.

The Criteria

Until such time as the super-rigid elasto-epoxythane traffic-resisting armor is developed, we will have to settle for the solution of selecting the best of the available surface treatments for the parking structure's characteristics, condition, and situation. To that end, there are a number of criteria we can use to determine which products would offer the best-performing option for the cost, in terms of both initial investment and long-term maintenance expense.

Deck Type. Over the years, many different types of parking decks have been developed. For the purpose of

investigating surface treatment options, however, deck types can be simplified into two basic categories: cast-in-place and pre-cast concrete.

Cast-in-place decks. Usually composed of a single, contiguous, reinforced slab of concrete spanning a concrete or steel frame, cast-in-place decks are constructed onsite. Due to its nature, concrete shrinks as it cures, which, coupled with the external restraint stress from the structure to which it's attached, can lead to crack formation. Cracks, as we've seen, are water-borne chlorides' direct route to reinforcing steel. Once established, these cracks form natural expansion joints that open and close with changing temperature and humidity.

Consequently, protective techniques tend to focus on these moving cracks. If cracks are few and the deck is chloride-free, then routing and sealing cracks and applying a low-cost sealer may be appropriate. If the deck is riddled with cracks that can't be adequately sealed, then elastomeric membranes begin to look like a good option.

Applying a low-cost sealer to a concrete deck can be a quick, effective, low-maintenance option.

Pre-cast decks. Cast off-site under controlled conditions, pre-cast decks are lifted and welded into place after they have cured and, to some extent, dried out. Because the concrete used for this type of construction is typically high-strength and more dense than its cast-in-place counterpart, pre-cast decks should rarely experience cracking. However, this manner of construction is favored for fast-track projects, and the end result is rarely defect-free.

Because they are factory-made and must be lifted into place, pre-cast units do not create a single, contiguous, monolithic structure. Instead, the individual members meet at sealant joints. Extending around each pre-cast unit, these joints add up to miles of sealant that must be maintained and periodically replaced. Even if cracking isn't an issue, water migration through failed joints can be just as damaging.

Aside from routine sealant maintenance, surface protection requirements are typically minimal and usually can be addressed with simple low-cost penetrating sealers. Heavily cracked decks may be routed and sealed or treated with rigid epoxies or healer/sealers, since these cracks are typically non-moving. However, the irregular surface of the pre-cast deck does not readily lend itself to flexible membrane-type coatings. The leading edge of each panel quickly becomes a wear point, bumping against automobile tires or catching the tip of a snow plow. Protection techniques that that soak into the deck and keep the concrete as the wearing surface are preferred.

Concrete Quality. Knowing the quality of the concrete offers insight into the type of deterioration to which it would be most susceptible. This is most often achieved by ordering a petrographic analysis of a test sample. A petrographic analysis is an extraordinarily useful tool in determining what is wrong with concrete or predicting what will be wrong with concrete in the future. This analysis can detect most durability issues, such that the most appropriate level of protection can be selected.

Chloride Content. Chlorides are detected by removing concrete samples from varying depths and analyzing them in a laboratory. If chlorides are moving through the concrete quickly, the deck protection system must be aggressively enhanced to stop further migration. If the chlorides have reached the level of the reinforcement, chances are deterioration has already begun. Low-cost sealers are no longer an option. Deck protection that retards water vapor intrusion or effectively inhibits corrosion is now necessary.

Age and Deterioration. While there is nothing inherently wrong with old concrete, the life of a deck does tend to follow a natural progression. Unless design or installation defects are at issue, a new deck can be effectively treated with low-cost sealers that limit the intrusion of chlorides through the concrete.

Further in the life of the deck, a more positive barrier, such as a moderately-priced epoxy sealer, may be necessary to retard moisture entry.

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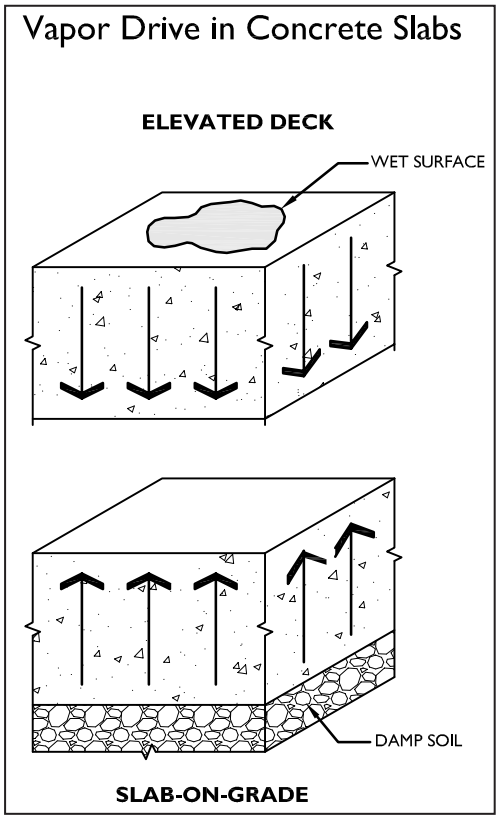
When Coatings Go Bad



A coating applied successfully to an elevated deck may have disastrous effects in the same garage when applied to a slab-on-grade. Why?

As water levels and humidity change, ground moisture seeps up into the concrete slab. Vapor barriers, often installed under slabs-on-grade, are designed to block this moisture from entering the slab, but, in reality, breaches in that barrier or cracks in the slab can still permit water entry. If an impermeable coating is applied to the top surface of the deck, that moisture becomes trapped between two impenetrable surfaces. Unable to escape, the water sits in the slab, leading to chloride and freeze-thaw degradation. Even with no vapor barrier present, moisture in the ground rises within the slab and becomes trapped within the deck. Therefore, leaving the slab-on-grade uncoated is the best course of action.

On an elevated deck, that permeability gradient is reversed. Moisture enters the deck from above and migrates through the slab to the underside, where it evaporates. Even with a waterproofing membrane protecting the top surface, the deck is still susceptible to water entering at cracks, joints, and failed coating sections. Coating the bottom of the deck with an impermeable coating invariably leads to trapped moisture and accelerated deterioration. For this reason, the underside of an elevated deck should be treated similarly to a slab-on-grade: leave it uncoated.

One often-overlooked fact is that paint is also a coating. Many of the concrete paints on the market are epoxy-based and relatively impervious to moisture. Even if a vapor-permeable paint is used, successive reapplications increase the coating thickness and so decrease its permeability. Over time, what was once a high-permeability surface can become surprisingly resistant to moisture migration. With the eventuality of peeling paint, spalls, rust, and cracks taken into account, a deck underside that's been painted for appearances' sake begins to lose its appeal, as compared with a simple, uncoated one that's still intact.

As the adage goes, location is everything. Knowing which surfaces in a parking structure can accept an impermeable coating and which are best left bare is critical to prolonging the life of your garage. ■

(continued from page 4)

Edges of pre-cast concrete units at sealant joints catch snowplow tips, quickly wearing away surface treatments. Here, coating patches were used as a temporary fix.

Unfortunately, this option is often overlooked or skipped.

Ultimately, if not properly protected, a deck may require a traffic-bearing membrane to provide the best defense. However, as these membranes are costly and require maintenance and periodic reapplication, waiting to address signs of trouble until there are no other options is not the best course of action. Remember, once a deck has begun to deteriorate, the coating can only retard further deterioration, not stop it.

Exposure. Whatever the protection system that is employed, it must withstand the rigors of its environment. UV degradation may be a problem for some coatings on a top deck. Epoxies, in particular, have difficulties when exposed to direct sunlight. Soft, flexible membranes may not withstand abrasion in high-traffic garages or on a typical turning radius and will fare poorly against snow plows. A coating that looks like new after many years in an apartment garage may not withstand a year at an airport or shopping mall.

Snow Removal. Do not underestimate the damage that can be inflicted by the average snow plow. Most coating warranties require that snow removal equipment have rubber tips; others do not cover snow plow damage outright. The truth is, most snow plow companies have never heard of rubber snow plow tips, let alone know where to buy one. Unless the garage management operates their own snow removal equipment, it's a given that steel will touch pavement at some point in the life of the garage. Therefore, coatings at exposed decks must be armored against such an onslaught. There are coating systems tough enough to repel the steel tips and let sparks fly, but these super-rigid coatings do not bridge cracks. The best solution, therefore, depends on finding the right compromise between rigidity and flexibility for a specific situation.

Cost. While the saying, "you get what you pay for," can be applied just as well to surface protection as it can to anything else, in terms of quality materials selection and skilled application, it's also true that lower-cost systems are usually lower-maintenance alternatives. Don't overspend. If an inexpensive sealer would suffice, installing a traffic-bearing membrane because it's the high-end option may mean investing in a costly system that doesn't perform any better in that situation—and may even perform worse. Plus, once the membrane is in place, it must be maintained and, eventually, replaced. More moderately priced treatments, such as penetrating sealers and epoxy healer/sealers, will no longer be options. (*See sidebar, "Don't Seal Your Fate," page 8.*)

Aesthetics. While a simple sealer can help prevent water infiltration, it won't change the parking deck's appearance. An elastomeric membrane, on the other hand, will change the look of the garage and provide a uniform, fresh-looking surface that's easily cleaned of dirt and stains. For a crack-riddled older garage, this can be a welcome change. In a newer garage, however, the existing concrete surface probably looks fine as is. Using paint on a deck to improve its appearance can have problematic effects, as paint, too, is a type of coating. (*See sidebar, "When Coatings Go Bad," page 5.*)

The Solution

The preferred protection techniques stop deterioration before it begins. If a parking deck is well maintained from the start, with sealers applied early and cracks promptly addressed, then surface treatment choices can evolve over time as the garage ages and its needs change. If, on the other hand, conditions are such that distress is advanced and progressing rapidly, more immediate and aggressive action must be taken to slow deterioration and minimize its impact.

Should you follow the trend and apply that traffic-bearing membrane? Look first at your parking deck type, concrete age and quality, and level of exposure to traffic and weather. Don't invest in a surface treatment until you've assessed your garage's condition; through investigation, testing, and evaluation, a qualified architect or engineer can help you navigate the array of available coating options. If that means shunning the coating-of-the-moment in favor of a low-cost, low-upkeep alternative, so be it. The right parking structure protection program should not only protect the deck today, but anticipate the maintenance needs of tomorrow. Now that's a bandwagon to jump on. ■

representative projects

Parking Structure Rehabilitation

Hoffmann Architects' exclusive focus on the building exterior makes the firm uniquely suited to resolving distress, failure, and wear in parking structures. Beginning with a review of existing conditions, Hoffmann Architects' design team assesses the type and extent of deterioration. Based on the parking structure's individual characteristics, the project architects and engineers develop a plan to resolve water infiltration and distress before more serious, lasting damage can occur. The firm then prepares detailed documents for competitive bidding. Contract administration services see that the project reaches successful completion.

Hoffmann Architects has developed parking garage rehabilitation and waterproofing solutions for a number of facilities, including:

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Great Cedar Garage and
Grand Pequot Garage
Mashantucket, Connecticut
Condition Investigation and Repairs

Chase Manhattan Centre
Wilmington, Delaware
Garage Survey

M & T Bank Headquarters
Buffalo, New York
Garage and Plaza Investigation and Repairs

Hartford Square North
Hartford, Connecticut
Garage Repairs

West*Park Garages in McLean, VA.
Investigation of Four Garages.

Pfizer, Inc.
New London, Connecticut
Peapack, New Jersey
Basking Ridge, New Jersey
Garage Repairs

One Beacon Street
Boston, Massachusetts
Garage Survey and Slab Repairs
Conversion of a Subgrade Movie Theatre into a Garage

The George Washington University
Ross Hall
Washington, District of Columbia
Garage Investigation and Repairs

Seneca Niagara Hotel and Casino
Niagara Falls, New York
Garage Evaluation

Phoenix Life Insurance Company
Hartford, Connecticut
Garage and Plaza Investigation and Repairs

American Center
Vienna, Virginia
Garage Survey

The Crowne Plaza Times Square
New York, New York
Garage Investigation and Repairs

University of Connecticut Health Center
in Farmington, CT. *Garage Assessment.*

Embassy Suites Hotel Nashville at Vanderbilt
Nashville, Tennessee
Garage Assessment and Repairs

Quinnipiac University
Anthem Campus
North Haven, Connecticut
Garage Evaluation

Legg-Mason Building
Baltimore, Maryland
Building Envelope Survey, including Garage

One Financial Plaza
Hartford, Connecticut
Garage Rehabilitation

Elizabethtown Gas
Union, New Jersey
Garage Survey

Town Center
West Hartford, Connecticut
Garage Investigation and Repairs

Cold Spring Harbor Laboratory
Cold Spring Harbor, New York
Garage Rehabilitation

Archstone Murray Hill
New York, New York
Garage Investigation

Don't Seal Your Fate

Not all surface treatments are compatible. The parking deck protection you choose now may limit your options in the future, so consider both immediate performance goals as well as long-range planning before committing to a coating. Investigate, too, any applications that may already be in place.

For example, if you are looking for a "quick fix" to get you through the winter, a less-restrictive sealer that penetrates the slab—rather than one that coats the surface—might be a good option, because a wide variety of surface treatments can be applied over it in the future. Epoxy healer/sealers can cover such penetrants, and they provide a good base for membrane systems, should you choose to install one down the road. However, once you opt for a traffic-bearing membrane, you must stick with a traffic-bearing membrane, as there is no way to effectively remove it without severely damaging the slab.

To determine which coating types can generally cover an existing application, as well as which options remain following a proposed treatment, check the accompanying table. ■

Compatibility of Existing and Overlaid Garage Surface Treatments

	Future Sealer			
Current Sealer	Migrating Corrosion Inhibitor	Penetrating Sealer	Epoxy Healer/Sealer	Traffic-Bearing Membrane
Migrating Corrosion Inhibitor	●	●	●	●
Penetrating Sealer		●*	●	●
Epoxy Healer Sealer			●	●
Traffic Bearing Membrane				●

** Compatibility of penetrating sealers should be taken into consideration*

JOURNAL is a publication of Hoffmann Architects, Inc., specialists in the rehabilitation of building exteriors. The firm's work includes investigative and rehabilitative architecture and engineering services for the analysis and resolution of problems within roofs, facades, glazing, and structural systems of existing buildings, plazas, terraces and parking garages.

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2321 Whitney Avenue
Hamden, CT 06518
203-239-6660

500 Fifth Avenue, Suite 830
New York, NY 10110
212-789-9915

1001 Connecticut Avenue NW, Suite 825
Washington, DC 20036
202-530-1100

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Editor: Alison Hoffmann
Production: Margaret Bailey

Hoffmann Architects, Inc.
2321 Whitney Avenue
Hamden, CT 06518

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Hoffmann Architects