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# Journal

## How Safe Is Your Sidewalk Vault?

Lawrence E. Keenan, AIA, PE and Tai Mahmuti, B. Eng., LEED Green Associate

“It’s probably the last thing you think about while strolling your neighborhood,” begins a report by Nexstar Broadcasting on the collapse of a Springfield, Missouri sidewalk vault, which trapped children on their way to school. “I saw people walking, and

all of a sudden, two boys just disappeared,” reported a distressed bystander who helped rescue the children. Similar accidents have led to fatalities in other cities, leading *The New York Times*, reporting on a midtown sidewalk collapse that plummeted two construction workers 10 feet underground, to bemoan, “More crumbling infrastructure?” This spring, similar incidents in Scranton, Pennsylvania and Prince George’s County, Maryland made headlines, with the Maryland collapse

upending a fire truck and injuring two volunteer firefighters.

*The New York Post* adopted a more sensational stance in its January 13, 2013 cover story, “Saved by the Belly”: “Girth kept 400 lb. woman alive in

sidewalk plunge,” asserted the *Post*, which, while exploiting the grotesquery of the incident, raises questions about responsibility. “The Department of Buildings fined the building’s owner,” reported the *Post*, “for failing to maintain the vault.”

Most people ambling along city sidewalks don’t realize that what they’re walking on is not solid ground, but likely the roof of an underground vault. Like all building components, below-grade spaces require periodic maintenance to resist the ravages of time and the elements, but because sidewalk vaults tend to be used as mechanical rooms or storage space, they garner less attention than those parts of the building people actually see. Moreover, much of the deterioration may not be visually evident, since it is often concealed behind masonry or fireproofing that appears intact.

As these news headlines show, neglecting the space below city sidewalks can spell disaster for building owners and the public should the structure collapse. What’s more, in overcrowded cities where every inch of usable space has income potential, sidewalk vaults can be valuable real estate.

### Why Do Vaults Exist?

Extending the building basement beneath the city-owned sidewalk,



▲ Discovering and remediating sidewalk vault deterioration is crucial to preventing a dangerous collapse.

Lawrence E. Keenan, AIA, PE, Vice President and Director, Engineering, directs project teams in the evaluation and treatment of structural distress. Tai Mahmuti, B. Eng., LEED Green Associate, Senior Project Coordinator, brings a background in building science to the engineering challenges of vault rehabilitation.



▲ At street level (*top left*), the sidewalk appears to be in good condition. In the vault below (*bottom left*), masonry arches show their age but seem structurally stable. Masonry removal, however, shows how badly deteriorated the embedded steel really can be (*above*).

creating a “vault,” was common in many metropolitan areas, especially in industrial neighborhoods. Vaults permitted delivery, particularly of coal, and access to utilities without disturbing building operations. For use of the vaults, cities like New York taxed building owners, who were expected to properly maintain the structural and weather integrity of the below-grade spaces, as well as the sidewalk surface. As the use of coal phased out, many building owners elected to stop using the vaults to avoid paying the vault tax, and, thus, the maintenance of vaults was forgotten.

In New York City, the vault tax was repealed in 1998 (see *Rules of the City of New York*, Title 19, Chapter 2 and *New York City Administrative Code*, Title 11, Chapter 27), which prompted many building owners to reconsider sidewalk vaults as bonus real estate. While most vaults still house generators, boilers, and electrical equipment or are simply used as storage, some have been converted into profitable retail space, dining areas, art galleries, and other commercial venues.

### Common Problems with Sidewalk Vaults

Heavily salted in winter and exposed to weather, sidewalk vaults tend to exhibit extensive water infiltration, which often results in significant damage to the vault’s structural framing. Particularly in historic districts where sidewalks have been around for many decades, waterproofing protection often is inadequate or missing entirely, allowing water to enter the vault below. The resulting corrosion of structural steel and deterioration of masonry arches compromises the vault’s bearing capacity, which can result in the types of sudden collapses that have recently made headlines.

In historic areas where streets are narrow, such as SoHo in New York City, delivery vehicles commonly park on the sidewalk, placing excessive loading onto vaults, many of which were not designed for vehicle traffic and also are likely to have succumbed to deterioration due to age and neglect. Even intact vaults as originally constructed may not meet today’s load requirements.

### Invisible Damage

With steel beams and columns concealed within masonry, concrete, or fireproofing, it can be easy to miss even advanced deterioration of vault structural framing. Until the surface material is removed to reveal embedded structural elements, it may be difficult to distinguish between a stable structure and one that has been compromised. Masonry or fireproofing that appears in good condition may mask steel beams reduced to brittle, tissue-thin scraps by years of corrosion.

### The Dangers of Neglecting Signs of Trouble

As the water and dissolved salts from deicing compounds migrate from the sidewalk surface into the vault, degradation of steel beams and girders destabilizes the structural integrity of the system, priming the structure for potential collapse. Since much of the damage may be invisible from the surface, periodic evaluation and maintenance may entail isolated removals to expose embedded structural elements.

In addition, the constant presence of moisture can foster mold growth and lead to poor indoor air quality, causing health issues for those who access the vaults, and contaminating adjacent interior spaces. Sidewalk vaults are often “out of sight, out of mind.” But the health, safety, and structural consequences of prolonged deterioration endanger the public and put building owners at risk, should they fail to adequately maintain these below-grade spaces.

### Sidewalk Violations

Most cities require property owners to install, restore, reconstruct, repair, and repave sidewalks adjacent to their buildings, at their own expense. Building owners can be held liable for personal injuries that result from failure to maintain safe sidewalks (in New York City, Section 7-210 of the *Administrative Code* stipulates as much), leaving the property owner, and not the city, liable for injury or death resulting from negligent failure to maintain safe conditions.

Poor water management in the area directly below sidewalk finishes can lead to trapped moisture between the structural deck and the wearing surface. Without a drainage membrane or similar material to channel water away

from the sidewalk system, pavers (or “flags”) can heave, shift, crack, or retain water and ice. Unless the underlying problem is resolved, replacing the sidewalk surfacing to mask underlying conditions will not provide a long-term solution.

If a property owner receives a violation for a defective sidewalk and does not remedy the problem, the Department of Transportation or other local authority may have the right to perform the work and then bill the property owner later (see, for example, Section 19-152 of the *New York Administrative Code* or Section 27-104 of the *New Haven, Connecticut Code of Ordinances*). Better to solve the problem on your own terms than to have the city dictate the timing, price, and design of the repairs, with a “fix” that may be neither cost-effective nor aesthetically desirable.

### Investigation of Sidewalk Vault Conditions

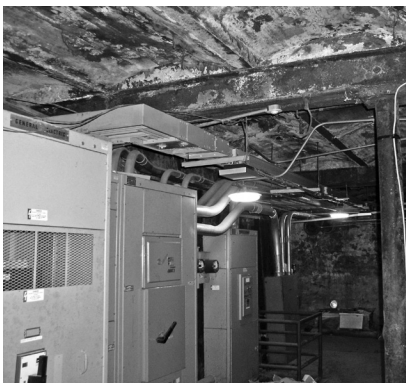
To address the problem of deterioration and health risks at sidewalk vaults, building owners and managers should undertake an investigation that details the nature and extent of the problem, so that appropriate solutions can be implemented. An architect or engineer typically begins with an initial visual

observation, above and below street level, to evaluate general conditions and identify sites for further testing. Photographs of problem areas document existing materials and can be helpful in locating sources of water infiltration. The design professional will also review existing building drawings, if available.

Since most structural elements are concealed within masonry or concrete, invasive probes are often essential to uncover concealed deterioration, particularly of structural steel. Partial removal of masonry arches is typically necessary in historic vaults to access overhead beams. Exploratory probes are also useful in determining whether a waterproofing membrane is present and, if so, its condition.

Once concealed systems have been exposed, samples are often gathered for laboratory analysis to provide more detailed evaluation of material conditions and composition, including the strength of the structural steel framing. Testing can also be used to identify and document the presence of hazardous materials, such as asbestos.

To determine the load capacity of the vault and evaluate structural integrity, the design professional performs tests and analysis that assess the ability of the structure to provide the requisite



▲ Originally used for coal, sidewalk vaults may house mechanical/electrical equipment.



▲ Delivery trucks on sidewalks may add weight beyond what historic vaults can bear.



▲ Replacing or reinforcing structural steel may be necessary for today's traffic loads.

support. Often, evaluation of severe deterioration finds that corrosion of beams is so advanced that the vault can scarcely support itself, let alone the applied load of pedestrian or, worse, vehicular traffic. In such cases, the risk of imminent collapse demands prompt remedial action.

**Codes, Standards, and Review Boards**

Before determining a sidewalk vault rehabilitation strategy, the design team must consider applicable codes for street/sidewalk loads. Because sidewalk vaults occupy the no-mans-land between the building and the street, they are often subject to an overlapping tangle of regulatory authorities, each requiring a separate permitting and approval process. Likely parties include the Department of Buildings, the Department of Transportation (not only are these city sidewalks, but their

rehabilitation often requires street lane closures), and, if the property is a landmark or part of a historic district, the local authority having jurisdiction over historic buildings.

In addition, for cities with subways, the transit authority may impose additional requirements. In New York City, the Metropolitan Transit Authority (MTA) requires that, for vaults within 200 feet of a subway line, the design professional visit the MTA archives, locate the original drawings for that location, and incorporate them into the rehabilitation documents, demonstrating that vault rehabilitation will not impact the subway.

**Rehabilitation Solutions for Sidewalk Vaults**

To restore sidewalk vaults to a functional condition demands a multi-part strategy, working from the inside out.

Severely compromised structural elements must be replaced, and those building materials that are salvageable usually need some degree of restoration and repair. The exterior envelope, including the sidewalk and foundation walls, demands integration of water infiltration protection to promote the longevity of below-grade elements.

**Removal and Replacement of Finishes and Waterproofing**

At the sidewalk level, remediation of water-related vault deterioration typically involves removal and replacement of finishes and waterproofing. For newer sidewalks, the wearing surface, usually concrete, may be replaced, but historic construction often demands the temporary removal and reinstallation of existing stone pavement. In some historic districts, notably SoHo in New York, massive granite sidewalk slabs typically bear directly on the structural steel of the vault, a structurally deficient condition that makes rehabilitation a challenge. Other historic construction includes cinder concrete slabs with draped wire mesh, or concrete slabs with glass inserts (vault lights), all of which must be carefully removed, restored, and reinstalled following rehabilitation of the vault.

To prevent further water infiltration, proper waterproofing of the sidewalk is essential. Waterproofing should extend beyond the sidewalk to the face of the building foundation wall to a reasonable depth (depending on existing conditions) on the street side. A typical waterproofing assembly might consist of multi-ply modified bitumen membrane on the new concrete structural slab, with a drainage mat and wearing surface.

If the vault is intended to be habitable, insulation must be incorporated in the assembly. Considering that modern sidewalks are subject to occasional vehicular traffic from delivery trucks and

**CASE STUDY: Sidewalk Replacement**



▲ First, the concrete wearing surface is removed to expose the concrete vault.



▲ After installation of new waterproofing, flood testing confirms water-tightness.



▲ The new concrete sidewalk is poured over the insulation.



▲ The completed sidewalk system protects against water infiltration into the vault below.

## Why Engineers Are Afraid to Walk on Sidewalk Grates (and You Should Be, Too)

To cover access points to underground vaults, many sidewalks incorporate surface grate systems, the familiar metal panels that make a hollow clanging racket as pedestrians race across them. What engineers know, and the rest of us like to ignore, is that many of these grates are ill-maintained and cannot properly bear their intended loads.

In the winter, when heavy machinery is used to clear snow, the problem is even worse. The Occupational Safety and Health Administration (OSHA) cites one example when the weight of a skid steer overloaded a sidewalk grate in the Boston metropolitan area, dropping the loader into the vault and killing the operator (“Hazard of Potential Sidewalk Grate System Failure,” OSHA, 2004). Grate failures kill pedestrians, too: in New York City, a worker clearing snow fell 12 feet into a sidewalk vault when he stepped on the edge of a grate and it suddenly flipped over. Not far away, in Brooklyn, a group of schoolgirls posing for a class picture sustained serious injuries when the grate on which they were standing gave way.

To ensure that sidewalk grates can effectively support pedestrian and heavy machinery loads, OSHA recommends inventorying all grates on a property and performing regular engineering inspections to determine the condition and load allowances of each. An engineer should consult with the property owner on redundant support structures, and design for new grates should include a concrete shelf system on which angle irons can rest, to prevent failure due to corrosion. Routine inspection and maintenance are key to reducing the likelihood of failure, as is communicating to workers the locations and load capacities of grates, along with the weight of any heavy machinery that might access sidewalks.

Although it's true you'd be more likely to be hit by a car than fall into a sidewalk grate, a “better safe than sorry” approach might be prudent, given how commonplace deferred maintenance can be. Just as you wouldn't step in front of a moving car even if you had the right of way, it's probably not a bad idea to avoid traversing flimsy metal mesh over a two-story drop. Our engineers will not walk on these grates. Now that you know what the engineers know, you might want to join them in taking the long way around – just in case. ■



▲ Falling into a faulty grate is a real concern.

emergency vehicles, insulation installed directly below the wearing surface must be designed with an appropriate compressive strength. Depending on the jurisdiction, insulation may not be a code requirement for sidewalk vaults, but it may be beneficial to protect the space below from temperature extremes, condensation, and thermal cycling.

Typically, a small section of the roadway (asphalt or cobblestone) must be removed for proper installation of waterproofing and potential replacement of structural framing. Deteriorated setting beds, pavers, and curbs must be replaced. For concrete wearing

surfaces, control joints and expansion joints are required to allow for shrinkage and thermal movement, and to prevent cracking and heaving of the sidewalk. Control joints at one-third the depth of the concrete wearing surface should be provided at a maximum of five feet on center, and full-depth expansion joints at a maximum of twenty feet on center. For granite pavers, a watertight expansion joint system is likewise required.

Within the vault, portions of walls, ceilings, and floors damaged by water must be repaired. If the investigation traced the source of water infiltration to the foundation wall, crack injection

or negative side waterproofing may be recommended, considering that access on the positive side (outside the vault) is probably not feasible. Where spray fireproofing has been used, asbestos-containing materials may be present, requiring remediation. Mold and other health hazards also must be remedied.

### Structural Rehabilitation

Deterioration that has not compromised the structural integrity of beams, columns, and building piers may be addressed through repair of the original materials. Depending on the existing construction and the load capacity requirements dictated by

**CASE STUDY: Historic Sidewalk Vault Rehabilitation**



▲ Massive granite paving slabs typify sidewalk construction in historic SoHo, New York.



▲ Masonry arches with steel beams comprise the sidewalk vault structure.



▲ Historic granite slabs are retained for reinstallation after vault rehabilitation.



▲ Concrete sidewalk and slab are removed to access the vault below.



▲ Removal of masonry arches uncovers severely deteriorated structural steel beams.



▲ Temporary stabilization of brick masonry permits replacement of deteriorated steel.

code, supplemental structural support may be necessary.

Many city sidewalk vaults dating from the turn of the last century were constructed of masonry arches and vaults, often of clay brick. Over time, as structural steel embedded in the masonry began to corrode in the presence of moisture, the oxidized steel expanded, exerting pressure on the surrounding brick and causing it to crack and spall. To treat the damage, masonry must be removed to access and treat corroded steel. The expansive force of the rusting structural steel may have damaged some areas of masonry beyond repair, necessitating replacement. New fireproofing may also be necessary, as per code requirements.

**Replacement of Compromised Structural Systems**

In addition to the deterioration of structural framing, the structural deck

may have sustained enough damage to merit replacement. Even if intact, the deck may need to be reinforced to meet current codes. In some cases, as when historic granite pavers bear directly on structural steel, installation of a new structural deck may be required to provide adequate support, given the rigors of modern traffic loads.

Other structural elements too deteriorated to serve their intended function must be replaced. Rehabilitation affords the opportunity to assess anticipated loads and augment load-bearing elements in accordance with code requirements and projected future use of the vault space.

**Usage Considerations**

As part of any rehabilitation project, continuous operation and access to the building are key considerations. For both weather protection and security, a temporary sidewalk enclosure

typically is erected, with rerouted pathways to building entrances, elevators, and emergency exits. Per fire code, the construction site must also maintain access to building standpipes.

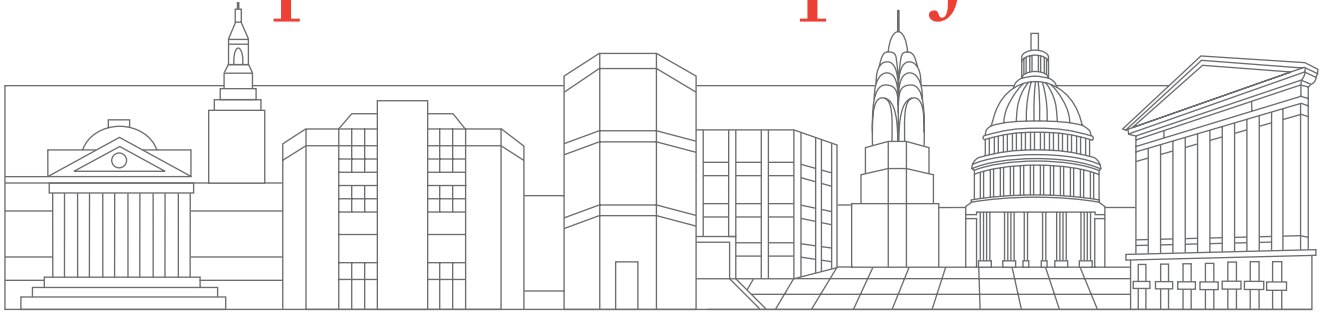
Sidewalk vault repairs often require both footpath and traffic lane closures, and the owner must provide a five-foot pedestrian walkway throughout the construction period. Maintaining smooth and continuous operation while rehabilitating sidewalk vaults can be a challenge in the tight quarters of narrow historic streets, where traffic may already be limited.

**Your Vault, Your Responsibility**

Sidewalk vault collapses make headlines in part because many people are shocked to discover that the solid ground they traverse every day is in fact not solid at all. When someone falls into the sidewalk, we must come

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# representative projects



## Below-Grade Vaults

With deterioration often concealed behind seemingly intact surfaces, identifying structural distress in sidewalk vaults usually demands professional evaluation. Hoffmann Architects specializes in uncovering hidden deficiencies that, left untended, can lead to serious, potentially life-threatening, structural failure.

We have provided investigation and rehabilitation design services for vaults beneath sidewalks, plazas, and entrances, housing everything from critical telecommunications equipment to irreplaceable historic books and manuscripts. Our project list includes:

### Scholastic, Inc.

New York, New York  
*Historic Sidewalk Vault Rehabilitation*

### One Thomas Circle

Washington, District of Columbia  
*Water Meter Vault Investigation and Stabilization*

### New York City Public Schools, High School for Health Professions and Human Services

New York, New York  
*Building Envelope Rehabilitation, including Sidewalk Vault*

### Folger Shakespeare Library

Washington, District of Columbia  
*Book Vault Water Infiltration Investigation and Rehabilitation*

### Pfizer World Headquarters

New York, New York  
*Sidewalk Waterproofing*

### The Eli Apartments

New Haven, Connecticut  
*Telecommunications Sidewalk Vault Survey*

### 1166 Avenue of the Americas

New York, New York  
*Steam Vault Investigation*

### Library of Congress, Thomas Jefferson Building

Washington, District of Columbia  
*Book Vault Waterproofing Consultation*

### The Republic and The Broderick Apartment Buildings

Philadelphia, Pennsylvania  
*Sidewalk Vault and Building Envelope Investigations*

### New York Public Library, Mid-Manhattan

New York, New York  
*Sidewalk Condition Survey*

### MetLife Building

New York, New York  
*Electrical Vault Structural Consultation*

### Frontier Communications (formerly Southern New England Telephone), Stamford Central Office

Stamford, Connecticut  
*Cable Vault Waterproofing and Rehabilitation*

### Bank of New York Mellon Corporation,

101 Barclay Street  
New York, New York  
*Sidewalk Replacement and Waterproofing*



▲ One Linden Place, Hartford, Connecticut, *Electrical/Boiler Room Vault Rehabilitation.*



▲ Paramount Plaza, New York, New York, *Pedestrian Tunnel Leak Investigation.*



▲ Open Society Foundations, New York, New York, *Sidewalk Vault Rehabilitation Design.*

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

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to terms with the fact that the urban terrain we all take for granted as sturdy and reliable may well be disconcertingly unstable.

While there may be no obvious outward signs of deterioration, even a seemingly intact vault could be seriously in jeopardy. Years of severe, persistent water infiltration can lead to hazardous deterioration of structural members and thus pose a danger to public safety. Especially in areas where vehicles and heavy machinery regularly access the sidewalk above under-designed, aging vaults, the threat of collapse is a real concern.

Even for those sidewalk vaults in reasonably sound repair, structural capacity may not suffice for the demands of today's live loads, including fire engines and delivery trucks. Sidewalk vaults that are regularly accessed by maintenance workers, including spaces housing electrical, mechanical, and telecommunications equipment, can pose health hazards if water infiltration



**A** An engineer investigates structural slab conditions at a partially deconstructed sidewalk vault.

leads to mildew and mold growth.

While sidewalk vault rehabilitation is not glamorous, having your property wind up on the front page of the New York Post under a sensational headline about collapse and injury could be devastating. What's more, by ignoring the problem below your feet, you could risk a fatal accident for which you will be responsible. Unless you're planning to turn the vault into a gallery or artisanal shop, few will ever even know it's there. But isn't it best to keep it that way? ■

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

1040 Avenue of the Americas, Ste. 14C  
New York, NY 10018  
212-789-9915

2711 Jefferson Davis Highway, Ste. 333  
Arlington, VA 22202  
703-253-9800

[www.hoffarch.com](http://www.hoffarch.com)

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