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Below Grade Roofing

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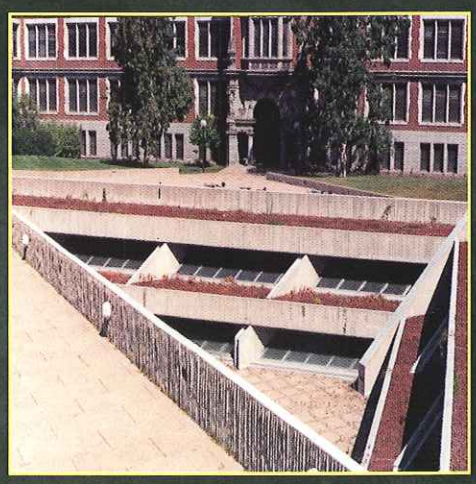
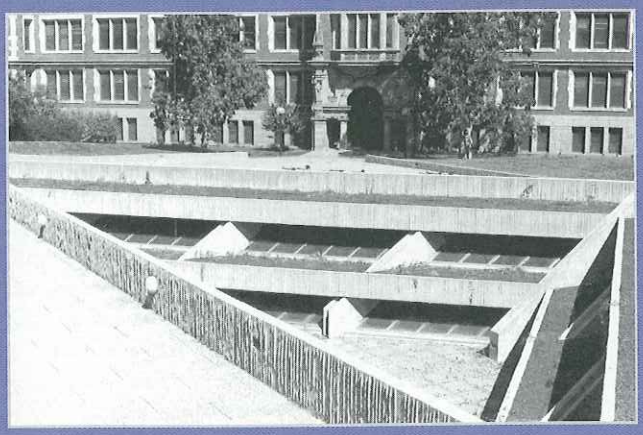


THE INVESTIGATION OF PLAZA WATER Infiltration

By David Campbell, AIA

ABSTRACT



It is not uncommon for a waterproofed plaza to develop water infiltration at some point during its life. Before a cost-effective and long lasting repair or replacement can be designed, however, certain information must first be obtained by means of a water infiltration investigation. This paper will discuss one procedure for conducting such an investigation that will result in thorough and accurate findings, while being cost effective for the owner.

Figure 1 — Roof plaza (grade-related).

Plaza construction has been part of the building landscape for quite a few years. Real estate can be used more efficiently when pedestrians and vehicles are allowed to utilize the "roof" area of a below-ground habitable space.

This convenience, however, creates an interesting challenge for the design professional—specifically, how to keep this habitable space dry over a long period of time in the presence of hydrostatic pressure, while accommodating the abuse and dynamic loading associated with foot and vehicular traffic. The unfortunate reality is that most plazas experience some degree of water infiltration at some point during the service life.

The term "Plaza" is used to describe several different types of outdoor horizontal areas constructed for human use. Most fall under one of the following three categories:

- Ground Plaza: A wearing surface built directly on-grade with no constructed spaces beneath. Infiltration is obviously not an issue with this type of plaza.
- Roof Plaza: The roof or terrace of a building that is one or more stories above grade and has a wearing surface suitable for foot traffic.
- Roof Plaza (grade-related): The roof of a below-ground structure that is either accessible from or closely related to finish grade and has a wearing surface suitable for foot traffic and sometimes vehicular traffic.

The scope of this paper will be limited to grade-related roof plazas, which will hereafter be referred to simply as "plazas" (see *Figures 1* and 2).

When a conventional roof develops a leak, locating and repairing the failure is normally a straightforward process, since most materials are exposed to view and accessible and standing water can be easily swept or drained away. Plaza waterproofing materials, on the other hand, are usually covered and hidden by many other materials, and the waterproofing failure is typically in a hydrostatic environment. This makes locating, evaluating, and repairing the leak more difficult, thereby requiring the additional step of conducting a leak investigation.

Since the cost and facility disruption associated with the

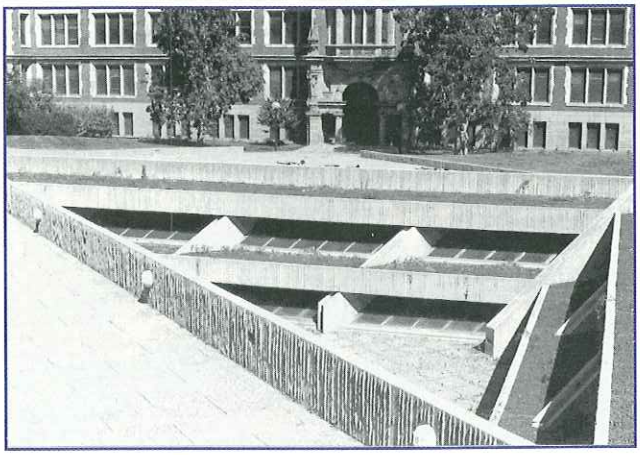


Figure 2 — Roof plaza (grade-related).

repair of such plaza leaks can be considerable, the leak investigation report must identify the failure(s), assess the situation, and provide the owner with the information necessary to select the most cost-effective course of action.

A thorough leak investigation report can be formatted in many ways, but should contain at least the following basic components:

- Context information
- Documentation of the infiltration
- Documentation of existing conditions
- Evaluation and conclusions
- Recommendations
- Cost estimating

The scope of a professional leak investigation should respond to the owner's needs and site conditions, while at the same time show respect for his pocketbook. Consequently, there is no "one size fits all" leak investigation formula; however, there are six basic procedural steps that, if followed, can help assure that all of the owner's needs are met. The balance of this paper will elaborate on those six procedural steps, which are as follows:

A. Initial site visit.
B. Office preparation.
C. Fieldwork.
D. Evaluations and conclusions.
E. Developing recommendations.
F. Estimating project costs.

A. INITIAL SITE VISIT

The initial site visit usually takes place prior to submitting a proposal to the owner. The purpose is to collect enough basic information so that reasonable assumptions can be made about the extent of service required and whether consultants will be needed, both of which will affect the scope and the fee. The following is a typical list of information obtained as part of the initial site visit.

1. Obtain Existing Construction Documents

Obtain a copy of all pertinent construction documents of the existing structure. Determine that these are the most current design documents of the structure and of any adjacent projects that may have modified the original plaza design.

It is not unusual for the installed waterproofing system to bear no resemblance to the original bid documents as the result of either "value engineering" or last minute changes due to cost overruns. This is why special attention should be given to any addenda, construction change directives, change orders, or as-built drawings that may have been issued.

The structural drawings are often more reliable than the architectural drawings for such things as expansion joint widths and structural deck construction thickness, slopes, and tapers.

Mechanical and electrical drawings can be helpful in regard to pipe and conduit penetrations through the plaza deck.

2. Document the Water Infiltration

Document all historical information about all infiltration, including location, severity, frequency of occurrence, time of occurrence, related weather conditions, age of the infiltration, and the effectiveness of any previous repairs. Solicit the help of site personnel, if necessary. This type of information can be very helpful. For example, if the infiltration occurs most all the time and does not get worse after a hard rain, the source of water may be a broken utility line.

3. Demolition of Interior Finish Materials

If the point of water entry on the structure interior is hidden from view by finish materials, ask the owner if the investigation should include selected demolition and repair of the finishes or will this be taken care of by the owner's facilities staff? This will obviously impact the proposal and fee.

4. Determine Structural Conditions

If there are obvious signs of structural degradation, the scope of the investigation should include a structural condition survey. Obviously, it would be a disservice to the owner to design a new waterproofing system for an existing structure that has lost its load-carrying capacity and needs to be replaced. Even if there are no obvious signs of degradation during the initial site visit, such degradation may still be revealed later during fieldwork when the interior finish materials are removed and the destructive test openings (DTOs) have been made.

5. Observe Access to the Plaza

Check the vehicular access to the plaza. Will equipment have to be carried long distances?

6. Is the Waterproofing Warranty in Effect?

If the existing waterproofing membrane is still under warranty, the membrane can be cut and patched only by a contractor who is a certified installer of that membrane. Otherwise, there is the risk of voiding the owner's current warranty.

7. Water and Electricity Availability

Ask the owner if water and electricity will be available during the fieldwork. If electricity will not be available, then prepare the owner for the noise from either gasoline-powered saws, gasoline-powered generators, or both. This can be a major issue if this fieldwork will be occurring near hospital rooms or classrooms.

8. Noise Restrictions

Ask the owner when the best times are to schedule the noisy

DTO work so as to minimize disturbing the building users.

9. Special Clearances Required

Have the owner issue the appropriate site security clearances or parking permits prior to the fieldwork, if any are required.

B. OFFICE PREPARATION

Office preparation includes a review of the existing documents, submitting a proposal to the owner, and preparing for the fieldwork.

1. Review of Existing Documents

A thorough review of the existing construction documents can yield insight as to what needs further site verification and what does not. Close scrutiny of the documents can help assure that the fieldwork is more of a surgical strike than a shotgun approach. For example, there may be an expansion joint in the structural deck that does not extend up to or is not visible on the plaza surface.

2. Preparing the Proposal

The Leak Investigation Proposal should clearly describe the project context, the scope of services, a proposed schedule, and the compensation. Sometimes an owner will be in such a hurry to stop a leak, he will forget that the purpose of the investigation service is not to design the repair, but to investigate the problem. Therefore, under the scope of services, it should be made clear that neither design nor construction document services are included.

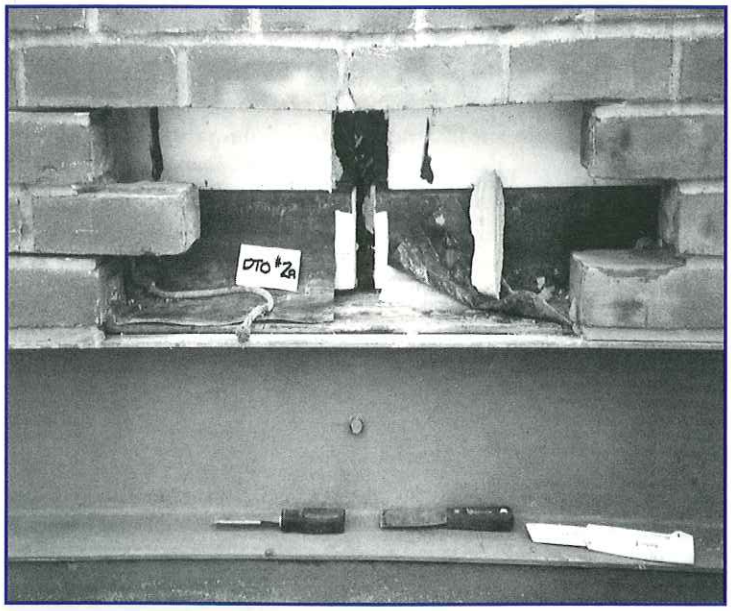


Figure 4 — Destructive test opening (DTO) through a wall feature.

3. Fieldwork Preparation

Since the fieldwork represents the largest single portion of the fee, it is important to anticipate and prepare for every contingency so that time at the site is spent efficiently and return visits are unnecessary.

Figure 3 — Destructive test opening (DTO) through a plaza deck.

a. Destructive Test Openings (DTOs)

Original documents, or even as-builts, should not be the only source of information when documenting existing conditions. These documents can be very helpful; however, *there is no substitute for DTOs* and the high degree of accuracy that is obtained by observing first hand the installed materials. See *Figures* 3 and 4.

When planning the locations and quantity of DTOs, it is important to remember to collect *as much information as possible without being excessive* and wasting the owner's money. For example, if a DTO needs to be dug at a drain and at an expansion joint and the expansion joint comes within a couple of feet of the drain, make the expansion joint DTO oversized and locate it between the two, so that one DTO exposes both the joint and the drain. As another example, assume that the base flashing of both a parapet and a building wall must be exposed. If the parapet and the wall eventually intersect, avoid two DTOs by locating a single larger one at the juncture.

The investigator's level of confidence in the accuracy of the existing documents will impact *the location and quantity of the DTOs.*

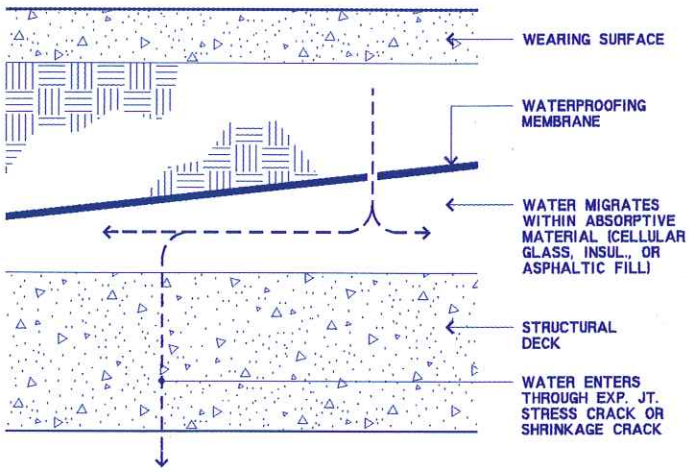


Figure 5 — Water migration within absorptive topping

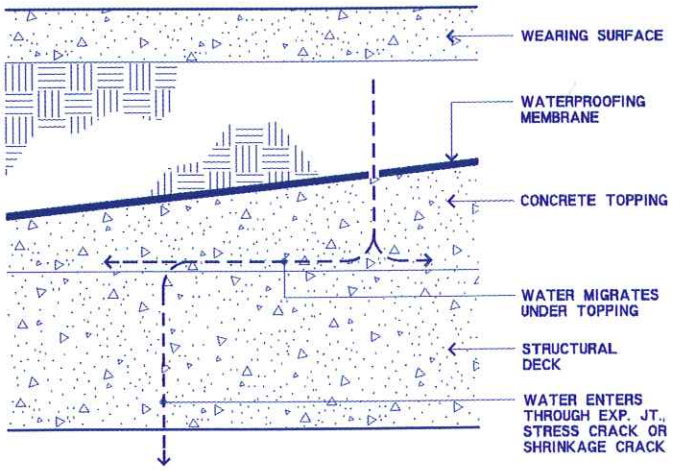


Figure 6 — Water migration under concrete topping.

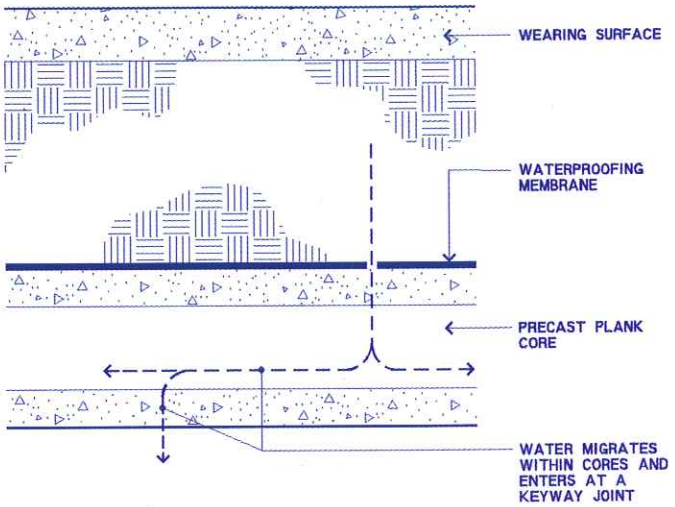


Figure 7 — Water migration within cores of precast concrete planks.

Generally, however, DTOs should be located at existing plaza drains, high spots, low spot expansion joints, parapets, walls, penetrations, areas of newer or older construction, areas of different wearing surfaces, and of course, above each different type of leak. Locating DTOs above the leak only will rarely yield adequate information. If there is any way that the design might allow water to migrate between the waterproofing membrane and the interior surface of the structure, then the membrane failure could be some distance away from the interior infiltration, thereby requiring additional DTOs at other key locations of the plaza. See *Figures 5, 6* and *7*.

This type of water migration can also occur in expansion joints. If there is an absorptive compressible material within the joint, water can penetrate the membrane failure at the top of the joint and migrate some distance within this absorptive material before it finds a sealant failure at the bottom of the joint. See *Figure 8*.

b. Scheduling

Depending on the project, there can be as many as seven other people whose participation during the fieldwork must be coordinated.

Obviously, **the owner** and his facilities people have to be made aware of the date and time of the fieldwork, since parking, pedestrian traffic, deliveries, etc. might be affected. Also, if the DTOs will be dug in the spring or fall, make arrangements to turn off any electric snow melting systems the day of the fieldwork.

If the existing membrane is still under warranty, schedule the services of a **certified contractor** to cut and patch the membrane, so as not to void the warranty.

Since DTOs usually involve concrete or masonry cutting and/or extensive earth excavation, it usually makes sense to retain a **local contractor** for assistance. If the contractor is kept informed as to what minimum equipment he will need and what minimum skill level his laborers should have, then he can keep his costs down which will reduce reimbursables to the owner.

If the presence of asbestos is suspected (either because of the specified materials or because of the age of the building) and the state requires **special certification for the sampling of asbestos**, then such an individual will have to be hired and scheduled accordingly.

Interior air quality has become a major issue. If the owner wants air testing results included in the report, schedule an **air quality testing service**.

The services of a **surveyor** to shoot some spot elevations may also be required if the consultant doesn't have the capability in-house. For instance, by reconciling the depths of the DTOs with their corresponding surface elevations, one can determine whether there is a slope or taper to the structural deck.

Finally, a **utility marking service** should be scheduled to visit the site and mark all buried electrical, cable, and gas lines one day before the DTOs are dug.

C. FIELDWORK

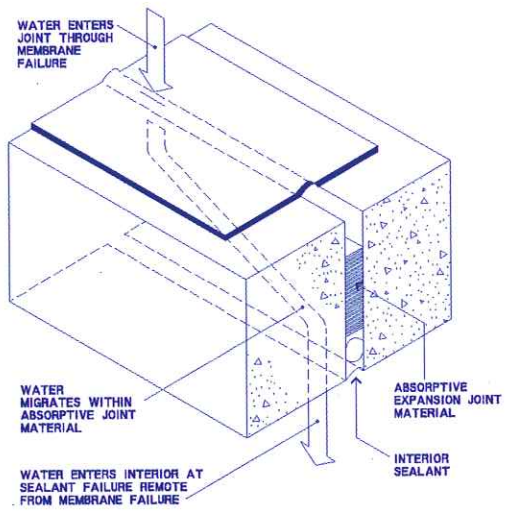


Figure 8 — Water migration within expansion joint.

The reliability of a consultant's conclusions and the effectiveness of his or her recommendations depend greatly on the thoroughness and accuracy of the fieldwork performed.

For example, an owner may decide to proceed with a recommendation to completely replace the plaza system, based on the consultant's cost estimate. However, if the consultant failed to field verify the code compliance of the extensive guardrails and it turns out that the required upgrade would add 30% to the project cost, the owners may decide otherwise and put up with the water buckets for another year.

To further illustrate, let's say that the existing built-up asphaltic membrane has been sampled, but the consultant has neglected to have the felts tested for asbestos. Then, let's further assume that when the asbestos was finally detected during demolition, the time-consuming abatement caused the project to exceed the scheduled completion date and interfered with a long since scheduled graduation exercise.

Fieldwork is basically the documentation of existing conditions associated with the water infiltration, the exposed plaza area, and the DTOs.

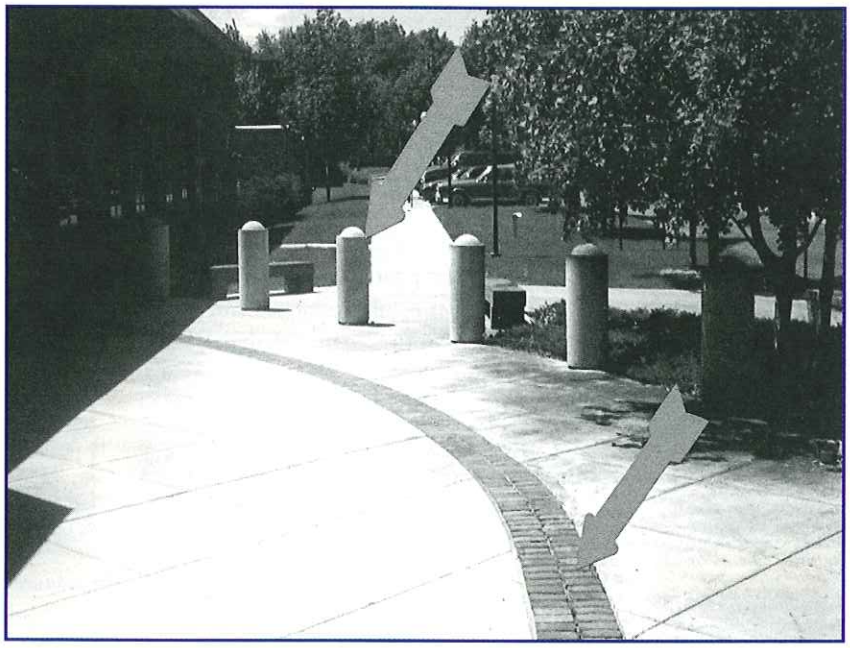


Figure 9 — Plaza site features.

1. Interior Infiltration

When documenting water infiltration, it is essential to identify where the water is entering the building through the structure, even if this means the selected demolition of various finish materials.

To illustrate the importance of this, a watermark on the underside of an acoustical ceiling tile could be caused by infiltration through a structural crack directly above the mark. On the other hand, it could be caused by water leaking through the clamp ring of a plaza drain ten feet away and following the underside of the sloped leader until it encounters a fitting, drips, and stains the tile.

To further illustrate the importance of this, one might mistake numerous watermarks on the underside of a plaster and lathe ceiling as a badly failing waterproofing membrane. In reality, the marks may be the result of condensation forming on the underside of the structure due to a combination of high room humidity and a low R-value in the plaza assembly. Condensation can be called the "fools gold" of water infiltration.

Figure 10 — Core drilled test opening.

2. The Exposed Plaza Area

Verify the code compliance of such things as guardrails, handrails, stairs, ramps, signage, striping, and lighting levels. Record any evidence of ponding or water evidence on the plaza surface or adjacent building wall. Document all other site features and plaza characteristics including, but not limited to, planters, retaining walls, parapets, curbs, outdoor furniture, light standards, overhead utilities, building exits, plaza drains, scuppers, expansion joints, bollards, control joint patterns, aesthetic feature strips, and plaza surface color and texture. See *Figure 9*. Also of value would be the location of any special water sources such as roof downspouts, landscape irrigation, decorative ponds, and fountains.

3. Destructive Test Openings (DTOs)

The following are six sequential steps that one could follow when making DTOs:

- Make the DTO so as to reveal all materials down to the structural deck. The size of a DTO should be largest at the surface and get progressively smaller as different material layers are uncovered. This better enables the camera to pick up the sequence of materials and facilitates the patching of the cut waterproofing membrane. The problem with using a core drill is that the cut waterproofing membrane is exactly the same size as the hole. This makes resealing the membrane difficult, if not impossible. See *Figure 10*.
- Take samples of all materials, especially the waterproofing membrane. If the membrane level is flooded, use a wet vacuum to remove the water long enough to take a sample and reseal the membrane. If the membrane or flash-

ings are suspected of containing asbestos, they should be sampled and patched by someone who is so certified.
- Photograph the DTO and all exposed materials.
- Sketch the complete composition of the plaza noting all materials and their condition.
- Reseal the waterproofing membrane, keeping in mind that it might have to last a couple of years or more if the owner experiences "sticker shock" after seeing the estimated construction costs. If the membrane is still under warranty, have the certified contractor sample and reseal the membrane so that the warranty is not voided. The contractor will need to document the DTOs to send to the manufacturer for future reference.
- Finally, fill in and flush out the DTO to match the surrounding surfaces as closely as possible.

D. EVALUATION AND CONCLUSIONS

There are many characteristics of a plaza assembly that, when properly evaluated, will reveal the deficiencies and lead one to the proper conclusions. The following is a partial list of such characteristics:

1. The Waterproofing Membrane

There are many waterproofing products that have been specified for plaza application over the years. See *Figure 11*.

When evaluating the membrane itself, the following characteristics should be evaluated:

NATURAL CLAY TYPES
- Spray bentonite (2-part, one part)
- Bentonite mats (bentonite contained within cardboard)
- Bentonite composite sheets (bentonite adhered to HDPE)
- Bentonite panels (bentonite contained within cardboard)

LOOSE LAID SHEET SYSTEMS
- Thermoplastics (PVC, CPE, HDPE, Polyolefins and Hypalon)
- Vulcanized rubbers (EPDM, Butyl, and Neoprene)

FULLY ADHERED SHEET SYSTEMS
- Thermoplastics (PVC, CPE, HDPE, Polyolefins and Hypalon)
- Vulcanized rubbers (EPDM, Butyl, and Neoprene)
- Rubberized asphalt with polyethylene cover ("peel-N-sticks")
- Impregnated asphalt composites
- Thermoplastic/asphalt composites

PREHEATED LIQUID APPLIED SYSTEMS
- Hot rubberized asphalt (reinforced and non-reinforced)
- Hot mopped asphalts/coal tar (built-up)

COLD LIQUID APPLIED SYSTEMS
- Cold rubberized asphalt
- Cold polyurethane based

Figure 11 - Most common plaza waterproofing products

a. Has it retained its original elastic properties? This is especially important if there are numerous expansion joints or if the pre-cast deck has no concrete topping.
b. Are the seams still well adhered? A tensiometer can be used to determine this if there is any doubt. See *Figure 12*. Are the seams still watertight? Keep in mind that some membranes have various accessory products within their seams which do not necessarily last as long as the membrane itself. See *Figure 13*.
c. If it's an adhered membrane, is it still well bonded to the substrate?
d. Is there any evidence of shrinkage? Look for stress tears or bridging at plane changes.
e. Are there any blisters or fishmouths? See *Figures 14* and *15*.

Figure 12 — A tensiometer for evaluating peel strength of membrane seams..

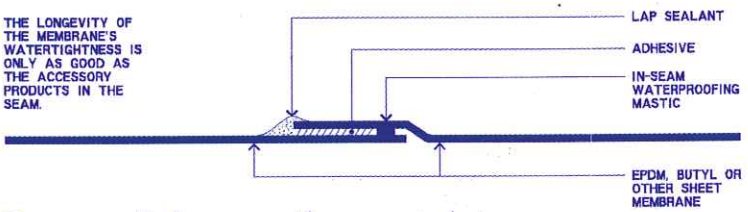


Figure 13 — Membrane seam with accessory products.

2. The Termination

a. Does the termination method used meet or exceed the membrane manufacturer's recommendations?
b. Does the termination occur below the plaza surface? If so, it could be subjected to hydrostatic pressure.
c. In what condition is the termination? For example, if a termination bar was used, have the anchors withdrawn or has the bar corroded?

3. Subsurface Water Management

Subsurface water management is any technique, device, product, or combination thereof that provides a way for water above the membrane to be discharged, thereby reducing hydrostatic pressure. Such things as "drain tile" composite drainage sheets (CDS), bi-level plaza drains, channeled insulation, and aggregates would fall in this category.

a. Are there provisions for such water management?
b. Is the water management system clogged or closed off? Sometimes the vacuum-formed dimples of a CDS can be

"driven" up into the insulation above it if the compressive strength of the insulation is inadequate for the weight of the overburden and the superimposed loads on the plaza. Generally, 40 to 60 psi insulation compressive strength is recommended.

c. If there is a CDS or something similar, are the plaza drains bi-level so that the water can discharge? Are the lower level openings of the drain clogged?

4. Water Migration Under the Membrane

When moisture is allowed to migrate below the waterproofing, then the location relationship between the membrane failure and the interior infiltration is severed, making it almost impossible to locate the failure.

a. If the original design intent was to fully adhere the membrane, is it still well bonded? If the membrane is well bonded, the leak should be localized.

b. Some membranes are designed to be loose laid, but with a "containment grid" underneath that limits the distance water can migrate if it should penetrate the membrane. The DTO should be dug above a grid line.

c. If there are absorptive materials of any kind between the waterproofing and the structural deck (such as rigid insulation, asphaltic fill, lightweight concrete topping, etc.), and if there is moisture present in these materials, then an isolated repair would be of little benefit since the moisture is free to travel to all parts of the plaza around the repaired area. See *Figures 16* and *17*.

Figure 14 — Disbonding blisters of a fluid-applied membrane.

Figure 15 — Disbonding blisters on existing fluid-applied membranes.

5. The Structure

a. If moisture has been held against the structural deck for a considerable length of time, there may be some serious structural degradation (i.e., spalling, reinforcement corrosion). See *Figures 18* and *19*. This alone may make it necessary to replace the entire membrane rather than just repair it, since all materials must be removed to expose the structure, anyway.

b. If the structural deck is pre-cast plank and there is no concrete topping on the plank, then a case for complete waterproofing replacement would be strengthened. Grout key joints alone do not do an adequate job of tying the entire pre-cast system together. Resultant joint movement places stress on the waterproofing membrane.

c. If there is no pitch to the top surface of the structure

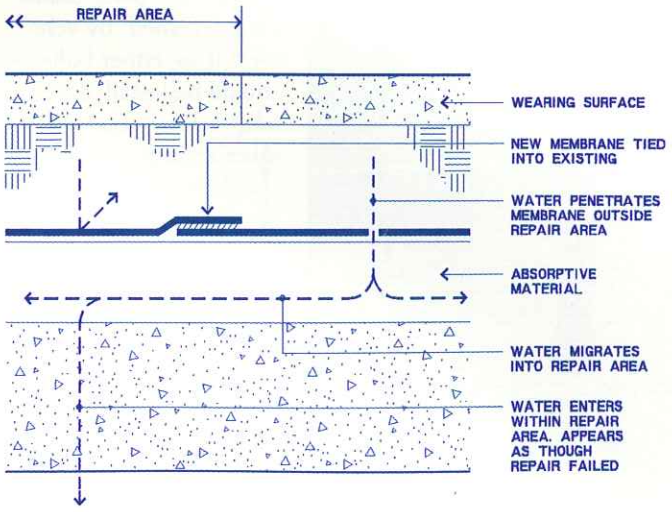


Figure 16 — Repair area not isolated.

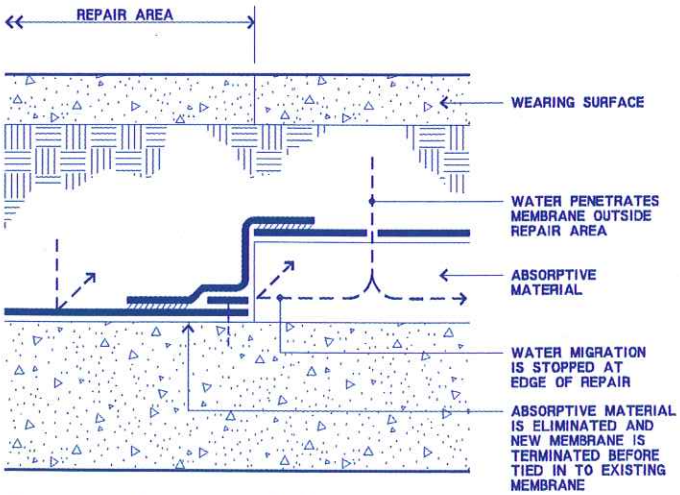


Figure 17 — Repair area isolated.

Figure 18 — Structural deck degradation.

from absence of either taper or slope to the structural deck, then this would also strengthen a case to completely replace the plaza system. There is no way to introduce subsurface water management without pitching the waterproofing.

6. Bentonite Waterproofing

By swelling or hydrating in the presence of moisture, bentonite can function not only as a very effective waterproofing barrier but also to prevent water migration under another primary membrane. Bentonite does not absorb water by capillary action. If containment pressure is applied to bentonite to restrict its hydration, an internal pressure is created, and water molecules cannot pass through.

a. If the existing bentonite is observed to be hydrated, then all hydrated areas will have to be replaced with dry product, even if the original was functioning properly. This is because all containment pressure against the bentonite has been removed as the result of excavating the DTO, thereby allowing the unrestricted bentonite to "free swell" and lose its waterproofing characteristics. This may impact the decision of whether or not to repair or replace the plaza assembly.

7. Tie-Ins

a. If the tie-in between two different waterproofing systems is failing, perhaps all that is needed is a new, properly-designed repair at that tie-in location. However, if the tie-in is not currently failing but the two materials are incompatible over a long period of time, then consider changing the entire membrane on one side to a more compatible one. One example of incompatible materials would be PVC and pitch.

8. Surface Water Management

a. If the current wearing surface is so badly damaged and permeable that significant amounts of water are accumulating at the waterproofing level, then perhaps a repair approach is inappropriate, particularly if there is no subsurface water management system. Most liability-conscious owners will want to eliminate trip hazards anyway. See *Figure* 20.

b. If the wearing slab concrete has been allowed to ooze down between the butt joints of the rigid insulation, thereby forming thin concrete "knives," then complete system replacement may be appropriate.

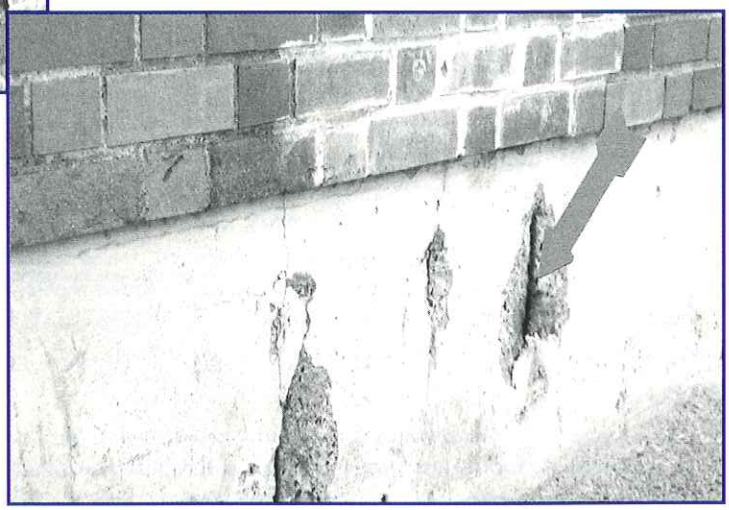


Figure 19 — Plaza wall degradation.

Conceivably, these knives could be driven down into the waterproofing membrane if the super imposed loads were sufficient.

c. The location and number of plaza drains should be able to accommodate a worst-case rainfall event.

d. The drain should be equipped with a clamping ring so the membrane is secured.

e. Have the plaza drains been "crushed" by vehicles? If so, either bollards should be installed to limit vehicle access or more appropriate drains should be installed. See *Figure* 21.

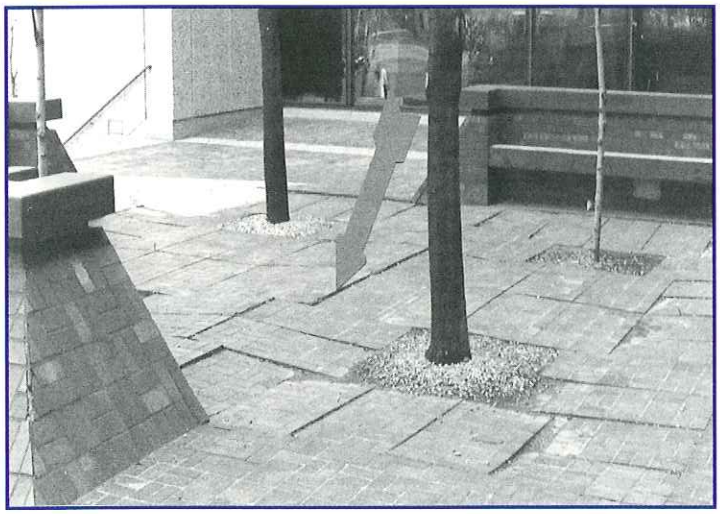


Figure 20 — Frost heaved wearing surface with trip hazards.

9. Interior Air Quality

Depending on the test results and the amount of visual evidence, mold and mildew abatement may be necessary.

10. Adjacent Above-Grade Walls

Sometimes a deficiency

Figure 21 — A crushed plaza drain due to vehicular traffic.

in an adjacent wall can make it appear as though the plaza waterproofing is failing when it is not.

a. If there are open joints, cracks, or other openings in the wall face above the plaza, sometimes the entering water can circumvent the waterproofing and enter the building. See *Figures* 22 and 23.
b. Something similar can occur if a masonry cavity wall has no through-wall flashing or is weeped below the plaza surface. See *Figure* 24.
c. Sometimes the source of water entry into an above plaza wall is quite evident. If window sill flashings are failing badly, either moisture or efflorescence may appear on the brick face. See *Figure* 25.

11. Interior Evidence Can Be Misleading

a. Pre-cast plank with hollow cores can complicate a diagnosis. Water entering a pre-cast core at the location of a membrane failure can travel a great distance before it reaches the bearing end of the plank, where it migrates behind the edge flashing and enters the building interior at the top of a wall, resembling a flashing failure. See *Figure* 26.
b. When a long, consistent watermark on the inside surface of an expansion joint originates at the top of the wall, look closer. It may be originating from dozens of pin-size holes in the expansion joint sealant itself running from the top of the wall down to the floor. See *Figure* 27.

E. DEVELOPING RECOMMENDATIONS

That which distinguishes a "professional" from a "non-professional" (using the terms in their broadest sense) relies in large measure on whose interests really come first—the owner's or the consultant's. Fortunately, because of the nature of most projects, it's not an either/or situation. Usually, the recommendation that best serves the owner also best serves the investigating firm by creating a nice future design project.

However, there are times when these two interests are in conflict. On these occasions, the professional must make rec-

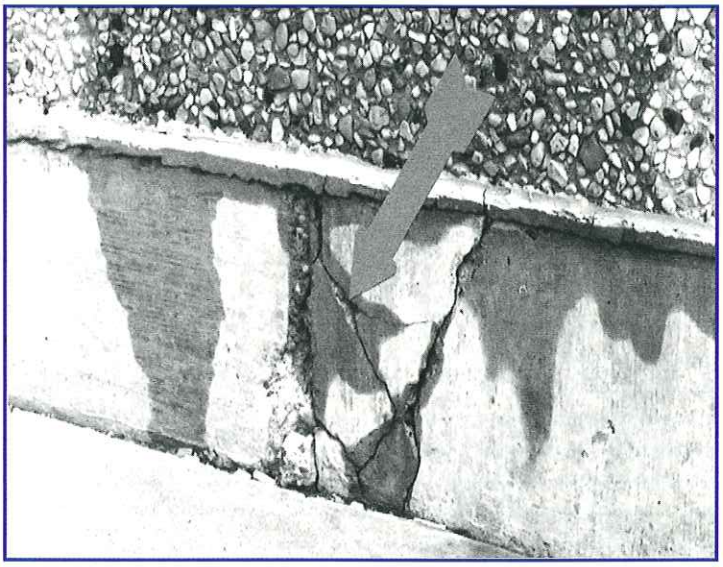


Figure 22 — Cracks in plaza wall.

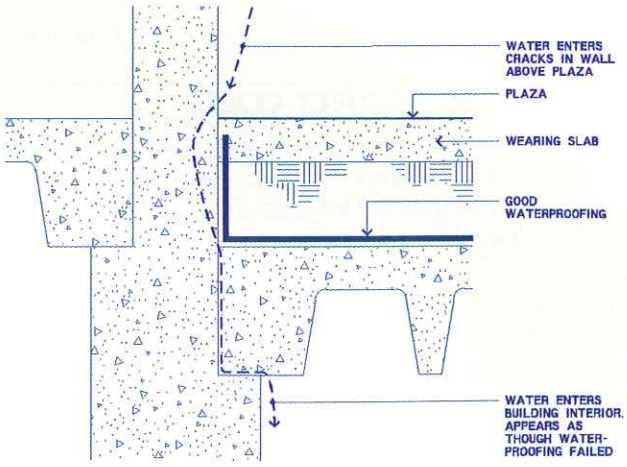


Figure 23 — Wall cracks above plaza surface allow moisture to bypass waterproofing.

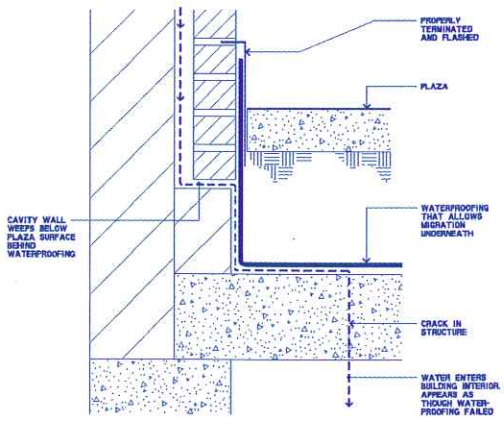


Figure 24 — Cavity wall weeps below plaza surface allowing moisture to bypass waterproofing.

Figure 25 — Water trapped in cavity wall.

ommendations in the owner's best interests. The leak investigation service should stand on its own merit and not become a marketing tool used to create future design projects.

Generally, the recommendation made by the Leak Investigation Report will fall into one of three categories:

- No action.
- Isolated repair(s).
- Complete system replacement.

Below are some examples covering each of these three recommendation categories. Some are case histories, and some are hypothetical.

RECOMMENDATION - NO ACTION

Existing conditions: An elaborate, concrete wearing slab (with decorative feature strips), sand fill, insulation, drainage board, a waterproofing membrane, bentonite, and a tapered asphaltic fill directly applied to the structural deck. The entire plaza was recently constructed and designed by another firm.

Infiltration: A very small amount of water dripping steadily from a new shrinkage crack having no apparent relationship to the weather.

Recommendation: Take no immediate action and monitor. Most likely a small amount of construction or rain water entered the asphaltic fill during construction before the waterproofing was installed and was then trapped between the waterproofing and the structure. Without a vapor retarder below the asphalt, the trapped moisture entered the first available shrinkage crack that developed in the new structure. If the trapped moisture is slight, it may drain away on its own without the owner spending any money on repairs.

RECOMMENDATION - ISOLATED REPAIR(S)

Existing conditions: Wearing slab, sand fill, insulation, protection board, hot fluid-applied rubberized asphalt waterproofing directly adhered to sloped structural deck. Plaza drains are exposed on the underside of the structural roof in a room being used temporarily as a high school student lounge.

Infiltration: Water is dripping from around each plaza drain bowl in the student lounge.

What's happening is that the students in the lounge are occasionally hanging from the exposed drain leaders. This has loosened up the connection and created movement between the drain bowl and the deck, thereby tearing the membrane.

Recommendation: Open up a small area of plaza around each leaking drain and repair the waterproofing failures at the drain clamping ring. Also, tighten the connection between the drain bowl and the structural deck.

RECOMMENDATION - COMPLETE SYSTEM REPLACEMENT

Existing conditions: Concrete wearing slab, sand fill, protection board, built-up pitch waterproofing membrane, tapered cellular glass insulation, structural deck. There are also two planter boxes.

Infiltration: Water is dripping from two pipe penetrations and one expansion joint. The flashing of these three details, however, is not failing.

Apparently, a groundskeeper sometimes drives stakes into the planter areas to support young trees and on one occasion punctured the membrane. The cellular glass insulation below the punctured membrane absorbs the irrigation and rain water, and then the water migrates everywhere until it encounters an opening in the structural deck itself, such as a pipe penetration or an expansion joint. Unfortunately, the only way to assure complete repair is to remove the waterlogged cellular glass which probably has lost most of its thermal properties anyway.

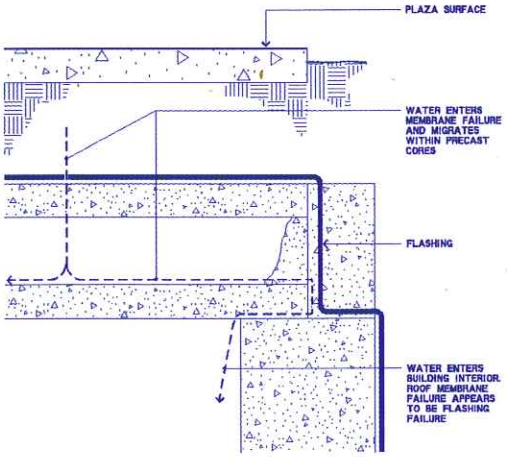


Figure 26 — Membrane failure resembles a flashing failure.

Recommendation: Complete system replacement from wearing slab down to and including the cellular glass insulation. Built-up pitch is an excellent waterproofing membrane, which lasts an extremely long time.

F. ESTIMATING PROJECT COSTS

Everything up to this point has been devoted to revealing to the owner why the water is entering the building and what measures are necessary to fix it. However, this information alone is academic without the costs associated with such a "fix." Estimated cost information is an essential part of a leak investigation report because it enables the owners to make an informed decision about which fix they can afford, when they can best afford it, or whether they can afford it at all. *Figure 28* is an example of how these estimated costs could be formatted in a report.

The following items can impact fees, construction costs, or both and should therefore be taken into consideration when calculating estimated project costs.

- **Prime or Consulting.** Does the owner want the consul-

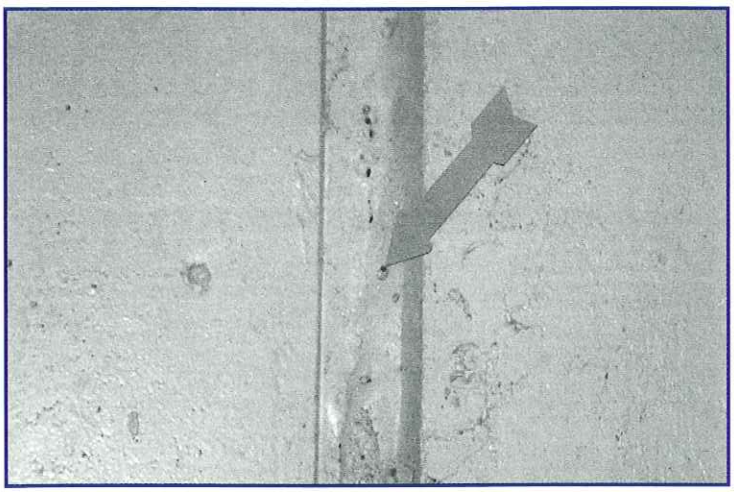


Figure 27 — Expansion joint sealant failures resemble a plaza flashing failure.

tant to provide prime or consulting design services? This will greatly impact the extent of service, especially during the bidding and construction observation phases.

- **Construction Standards**. Does the owner have formal construction standards above and beyond federal, state, and local codes that must be adhered to during the design phase?
- **Code Upgrades**. Are there any ADA or other code upgrades required such as handrails, guardrails, stairs, ramps, lighting, or energy loss? Code authorities may not require certain code upgrades if the extent of construction is limited (i.e., repair instead of replacement).
- **Special State Programs**. Does the project require conformance to any special state-legislated programs designed to bias contract award to minority or other targeted groups? This could increase construction costs.
- **Liquidated Damages**. Will the owner require a liquidated damages clause in the contract? Such a clause may assure that the contractor will complete the project on time; however, the owner will likely pay for this assurance in higher bids.
- **Project Size**. Will the construction value of the project be large enough to attract competitive bidding, or will contractors look upon it as a small "nuisance" project?
- **Bidding Climate**. Will the project likely be bid at a time of year when bidding is competitive or when it is not?
- **Contractor Base**. Is the local contractor availability good for this type of project? If not, expect the bids and project costs to increase.
- **Access and Staging**. How accessible is the site? Are there potential staging areas next to the site, or will staging be remote?
- **Stockpiling**. Will on-site stockpiling be permitted, or will it have to be remote from the site? This usually does not affect the construction value much unless the quantities are large.
- **Seasonal Road Restrictions**. Will construction take place during a time of year when seasonal road restrictions are in effect?
- **Fire Lanes**. Are any of the access roads immediate to the site designated as fire lanes, which have to remain unobstructed? If so, this may complicate the contractor's negotiation of car, truck, and equipment parking, thereby

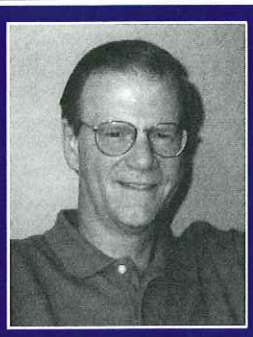
Cost Category	Option A - Repair	Option B - Replacement
a. Architects Design/Construction Observation	$ 18,000	$ 20,000
b. Consultant (surveyor)	NA	$ 2,000
c. Consultant (structural analysis/repair design)	$ 4,000	$ 8,000
d. Consultant (electrical design)	NA	$ 4,000
e. Consultant (mechanical design)	NA	$ 4,000
f. Consultant (landscape design)	NA	$ 4,000
g. Subtotal (sum of a. through f.)	$ 22,000	$ 42,000
h. Estimated Construction Cost	$200,000	$800,000
i. Construction Contingency (5% of h.)	$ 10,000	NA
j. Construction Contingency (15% of h.)	NA	$120,000
Total Estimated Project Cost (g. + h. + i. + j.)	**$232,000**	**$962,000**

Figure 28 — Hypothetical example of estimated project cost breakdown.

increasing the construction cost.

- **Egress/Access Provisions.** Will the contractor have to construct elaborate temporary stairs or ramps in order to maintain egress and access during construction? As necessary as these might be, they will build additional costs.
- **Restrictive Work Hours.** Will the owner require unusual working hours to reduce occupants' exposure to noise, dust, or fumes? Evening and weekend labor will most certainly increase construction costs.
- **Construction Equipment Weight Limit.** Does the existing structural capacity of the deck put unusual restrictions on the size of equipment that will be allowed on the plaza during construction? If so, will the habitable space below accommodate shoring to increase the size restriction, thereby reducing costs?
- **Overhead Obstructions.** Are there any overhead utilities or other forms of overhead construction that would seriously interfere with construction cranes or activities?
- **Adjacent Construction Projects.** Is the owner planning any other construction projects adjacent to this one? Could they be combined to reduce costs, or will they interfere with each other, thereby adding costs?
- **Plaza Drains.** If new or additional plaza drains are necessary, how accessible is the plumbing from the building interior? Are there convenient utilities into which new piping can be joined?
- **Air Intakes.** Will the contract require elaborate temporary measures to close off mechanical air intakes, assuming that supply air can be temporarily rerouted?
- **Contingency Cost.** The size of the recommended contingency should reflect the designer's comfort level with the accuracy of the existing documents and the degree to which he expects "surprises" once things are opened up and existing conditions are revealed. ■

About the Author



David Campbell

David Campbell is a registered architect and manager of the Waterproofing Department of Inspec, Inc. Engineers/Architects. Mr. Campbell received his Bachelor of Architecture and Bachelor of Environmental Design degrees from the University of Minnesota. He is a member of AIA and ASTM. During his career he has been involved in the design of a wide variety of building types, including earth-integrated structures, commercial buildings, and residential structures. He has devoted the last 16 years, however, to the study, investigation, and design of below-ground waterproofing and gives talks on waterproofing to other architectural and engineering firms in the Minneapolis area. He has been involved in over 300 waterproofing projects, including the Minnesota State Capital Terrace, the Boston Subway, the Hyatt Regency Waikaloa Hotel Complex, the Minneapolis/St. Paul International Airport Tunnel, and the University of Minnesota Northrop Plaza.

Industry News

PEOPLE

Engelmeier Installed As FRSA President

Carl Engelmeier, CPRC, was recently installed as the President of the Florida Roofing, Sheet Metal and Air Conditioning Contractors Association (FRSA). FRSA is one of the largest state trade associations.

Cook Named Chairman of generalRoofing

C.E.I. Florida, Inc. President John C. Cook has been named Chairman of the Board of generalRoofing. In 1999, C.E.I., along with 11 other companies, merged to form generalRoofing.

SMACNA Elects Officers

At a recent meeting of the Board of Directors of the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), the following officers were elected: President Ron Rodgers; President-Elect Jack Desmond; Secretary/Treasurer Mark Watson; Immediate Past President Phil Meyers.

Promotions at Koppers

Swen E. Swenson has been appointed Manager, Business Development and Technology for Koppers Industries Inc.'s Commercial Roofing Division. C.R. "Rob" Ardoin has been named Southwest Regional Manager for the Commercial Roofing Division. Howard J. Patrick joins Koppers Roofing's Technology Group as a Technical Service Manager.