

140 Broadway

George Wheeler

**Higgins Quasebarth
& Partners, LLC**

NV5 Companies

**WJE Engineers
& Architects, P.C.**



Technical Review of Stone Selection

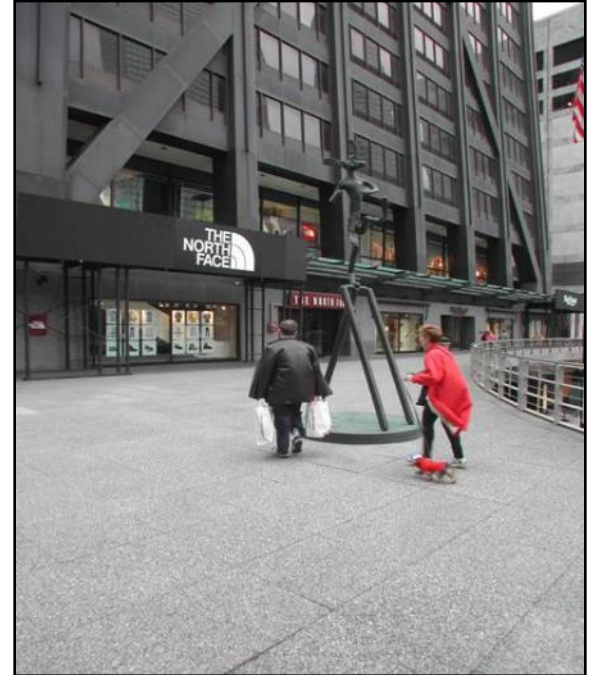
Typical Stone Paving Selections

- Granite
- Marble
- Limestone
- Sandstone
- Travertine



Stone Paving Selections

- Material Characteristics
 - Variability
 - Strength Loss due to Weathering
 - Durability
 - Sealant Stain Resistance
 - Material Properties
 - Erosion
 - Discoloration



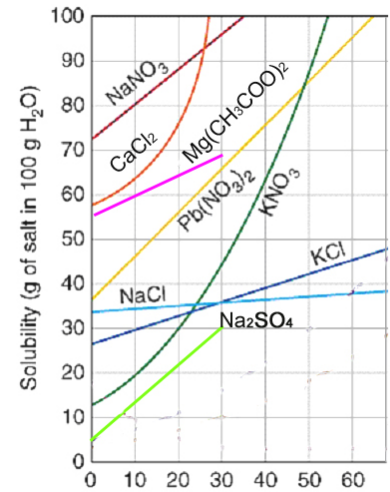
Stone Durability

- Material Characteristics (Voids, Veining)
- Density
- Absorption
- Abrasion Resistance
- Compressive Strength
- Freeze-thaw Resistance



Stone Durability

- Salt Crystallization Resistance



Travertine

- History of poor performance in Northeast United States
 - Exterior Cladding
 - Exterior Paving
 - IMI warning
 - ASTM warning



Abrasion Resistance of Travertine

- Due to low abrasion resistance travertine will become more polished and slip resistance will be decreased.
- More traffic = Less slip resistance



Absorption of Travertine

- Travertine is naturally more absorptive than granite.
- Greater absorption can be an indication of more freeze-thaw distress.
- Greater absorption leads to more of a chance for salt crystallization within the pores of the stone, further weakening the outside surface of the travertine.
- International Marble Institute does not recommend Travertine for exterior paving applications where de-icing salts are used.
- Cannot control de-icing salts entering site from adjacent roadways; pedestrians and vehicles at loading docks will bring in de-icing salts from other sources.

Freeze-thaw Durability of Setting Bed

- Cracks and full depth veins through travertine allow moisture into the setting bed, thereby increasing the likelihood of freeze-thaw deterioration of the mortar setting bed.

Flexural Strength of Travertine

- As underlying mortar setting bed deteriorates, the stone has to span over loose areas of setting bed and flexural strength becomes critical.

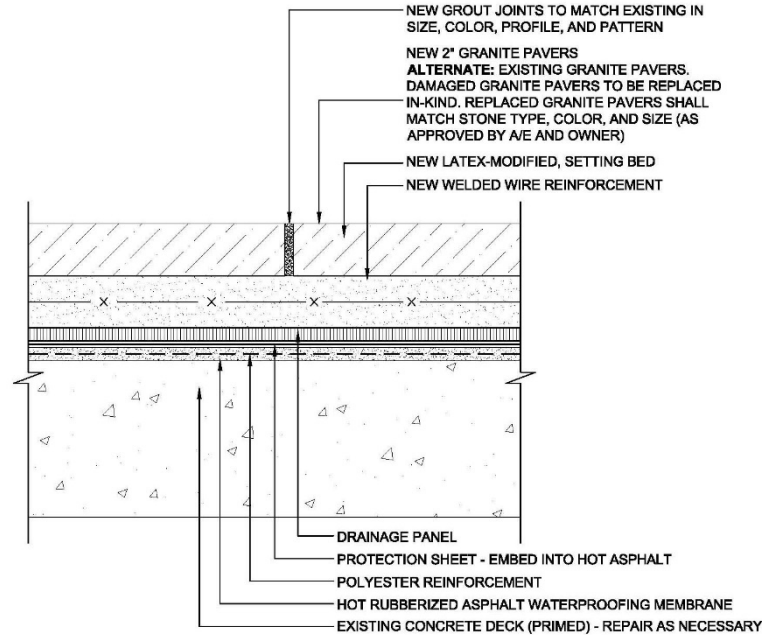


Stone Flooring and Paving Selection

- Recommended Industry Standard Safety Factors based on the natural variability of the stone:

<u>Stone Type</u>	<u>Flexural Strength Safety Factor</u>
Granite (NBGQA)	3
Limestone (ILI)	8
Marble (MIA)	5
Travertine (MIA)	8
Sandstone (MIA)	8
Slate (MIA)	5

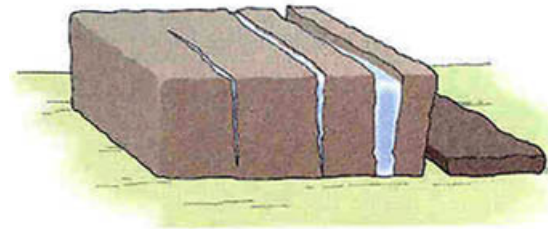
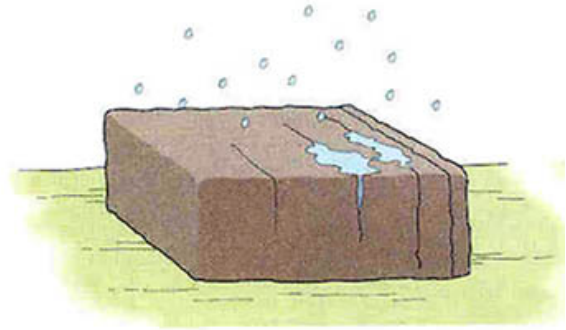
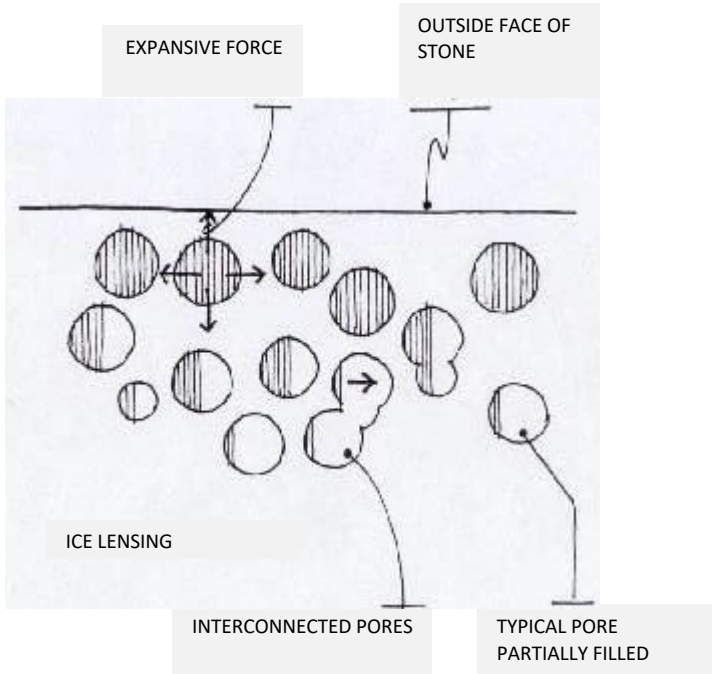
Proposed Section Through Plaza



1 NEW WATERPROOFING ASSEMBLY WITH GRANITE PAVERS

in 1 2 4 6 9 3" = 1'-0"

Freeze-Thaw Distress



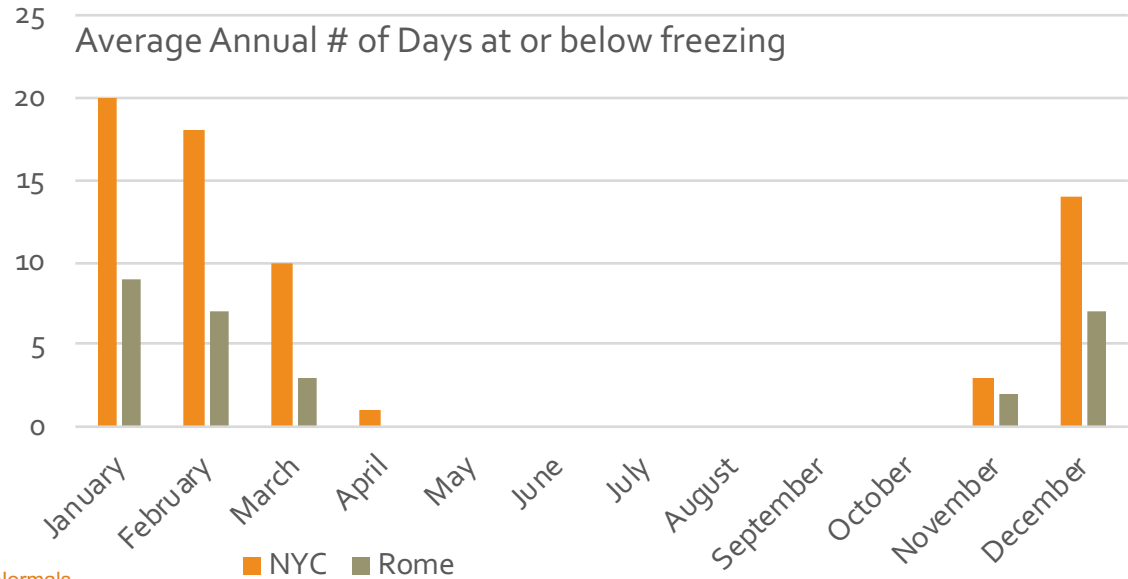
Credit: Superstructures

Climate Comparison



Average Annual # Freezing days in NYC vs. Rome

- In **NYC**, low temperatures drop to freezing or below, on average, **66** days out of the year.
- By contrast, In **Rome**, low temperatures drop to freezing or below, on average, **28** days out of the year.



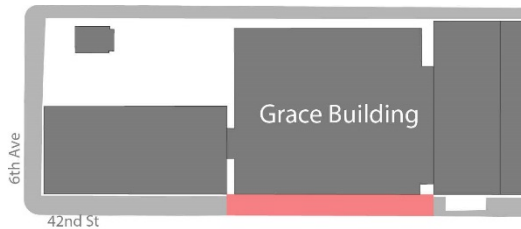
National Climatic Data Center. [NOAA's 1981-2010 Climate Normals.](#)

Avg Annual Freeze-Thaw Cycles - NYC vs. Rome

- Based on a study of meteorological data collected at JFK Airport between 1973 and 1996, the average annual number of freeze-thaw cycles in **NYC** was **39**. ftp://ftp.ncdc.noaa.gov/pub/data/EngineeringWeatherData_CDROM/engwx/new_york_jfk_ny.pdf
- By contrast, based on analysis of data collected by the Italian Meteorological Service between 1951 to 1996 at the Ciampino Airport (13 km SE of the centre of Rome), the average annual number of freeze-thaw cycles in **Rome** was **21**. <https://www.int-res.com/articles/cr/16/c016p145.pdf>

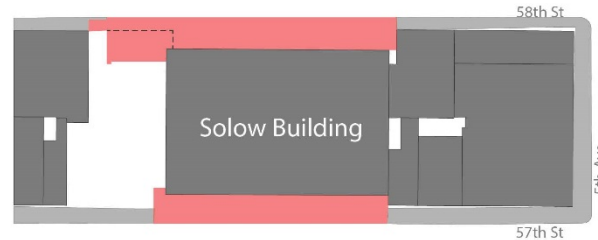
Travertine-Paved Plaza/Sidewalk with Trench Drain

Grace Building



Travertine Pavers – Exposed Area
approximately 5,300 sq. ft.

Solow Building



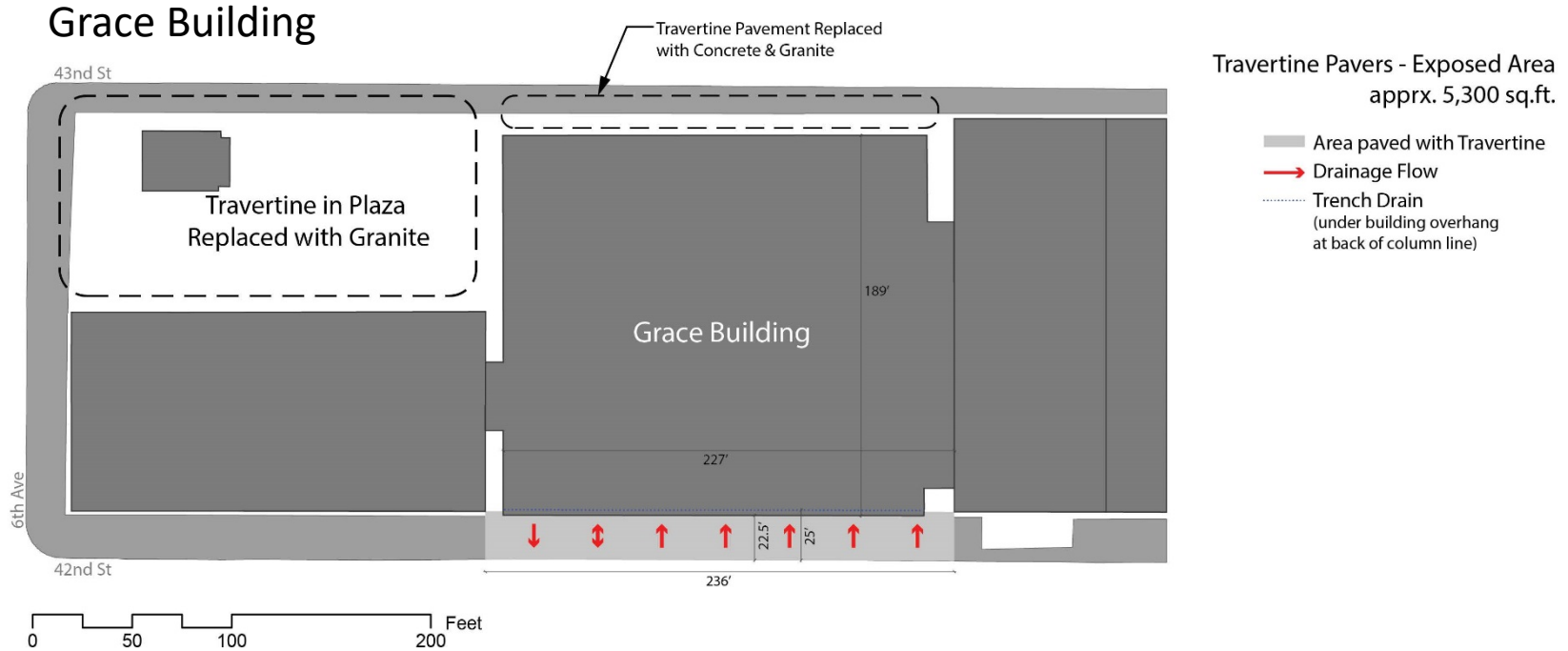
Travertine Pavers – Exposed Area
approximately 21,000 sq. ft.

140 Broadway



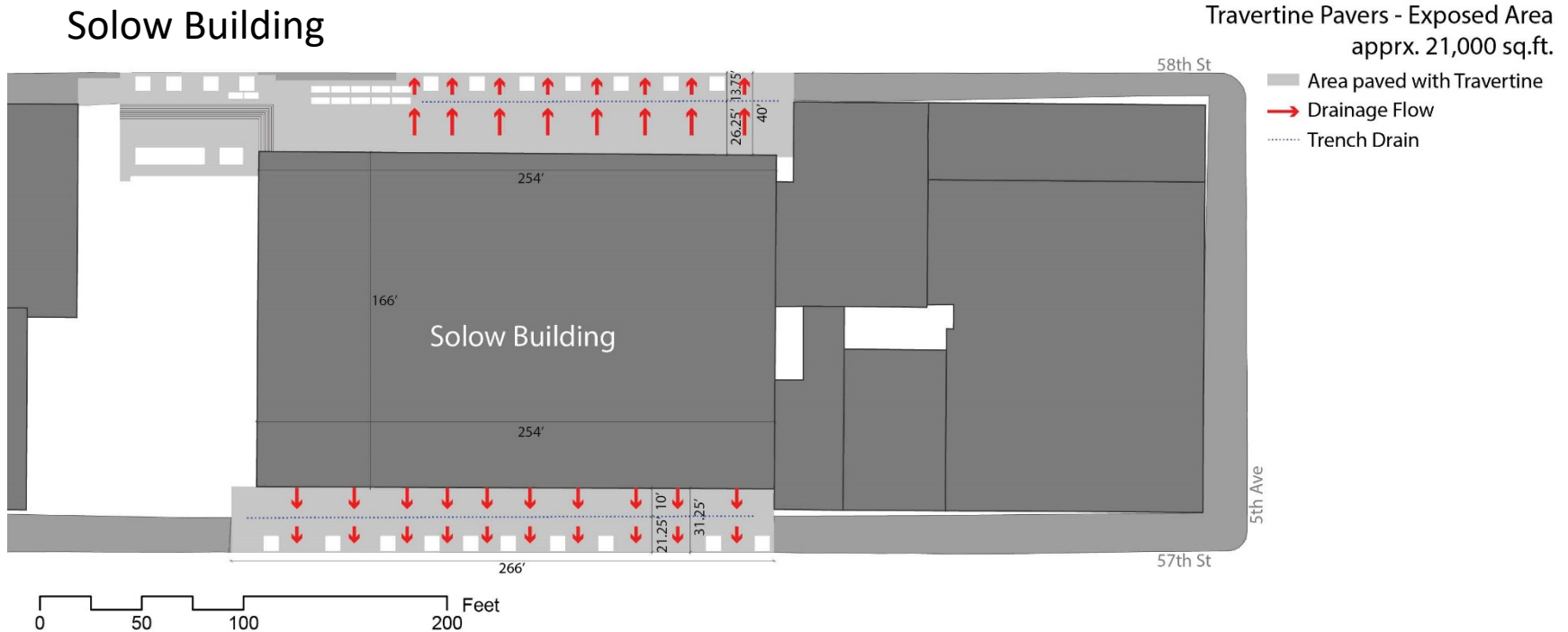
Pavement to be replaced
28,800 sq. ft.

Travertine-Paved Plaza/Sidewalk with Trench Drain



Travertine-Paved Plaza/Sidewalk with Trench Drain

Solow Building

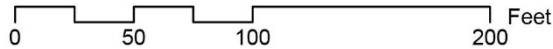
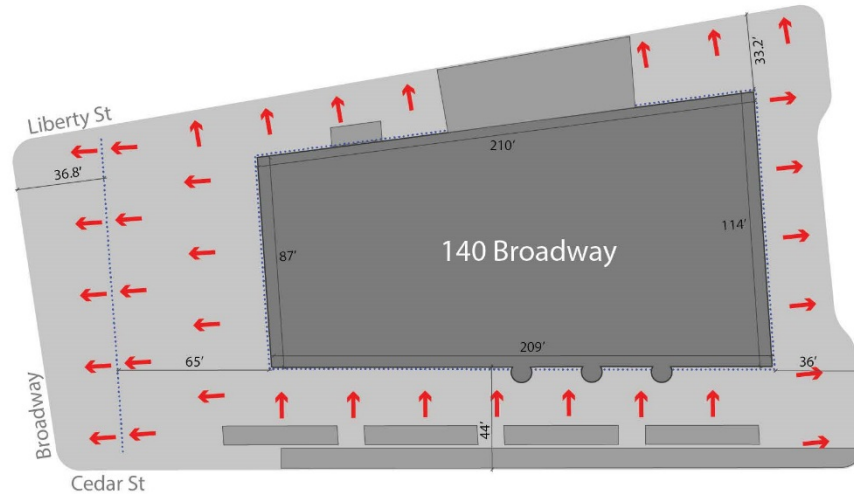


Travertine-Paved Plaza/Sidewalk with Trench Drain

140 Broadway

Pavement to be replaced
28,800 sq.ft.

- Paved area to be replaced
- Drainage Flow
- ⋯ Trench Drain



Conclusions

- Due to its inferior material properties when compared to granite and other stone paving materials, travertine is not recommended for use in an exterior plaza assembly such as 140 Broadway

Appendix

140 Broadway - Conditions



Historical Context

Pedestrians Find 'New' Sidewalks Are Often Slippery: 'New' Sidewalks ...

By DEBORAH BLUMENTHAL

New York Times (1923-Current file); Jan 4, 1981;

ProQuest Historical Newspapers: The New York Times with Index

pg. R1

Pedestrians Find 'New' Sidewalks Are Often Slippery

By DEBORAH BLUMENTHAL

Jesse Ann Cohen, a former account coordinator with Ted Bate & Company, used to walk past 188 Avenue of the Americas on her way to work from her East Side apartment. But when the streets were wet or icy, she changed her route to avoid that sidewalk.

"I find it slick and if there's ice, forget it—I just don't grip," she said.

Israel Iveson, a 75-year-old part-time messenger, walked in front of 1 Times Square while on the job last winter. It had snowed that morning and the terrazzo sidewalk was icy and slippery.

Mr. Iveson fell and fractured his hip. His lawyer has filed a claim against the city for a million dollars, charging that Mr. Iveson was disabled for life.

In a pending case, Mohamed Ahmed, an accounting clerk, seeks \$2 million in damages for injuries that he says resulted from a fall in 1974, when he was 32, on a terrazzo sidewalk outside 322

Fifth Avenue on a rainy day. Mr. Ahmed says he was permanently disabled, with a loss of sight in one eye and the use of one arm seriously impaired.

Both the property owner — then the first National City Bank — and the city were sued for \$2 million on the claim that terrazzo is dangerous when wet and needs to be covered, at the very least, by a rubber mat.

According to lawyers in negligence suits, such cases are on the rise as a result of the wider use of a variety of materials for sidewalks to obtain a more esthetic effect than concrete provides. Many of the new materials tend to be slippery in snow or rain.

"I saw a variety of 20,000 lawsuits, including hundreds and hundreds of this kind," said Abraham Pushberg, the lawyer for Mr. Iveson. Herman Glaser of Glaser and Dills and Robert L. Conson of Gair, Gair and Conson also have handled such cases.

Although many lawsuits are filed against the city each year for accidents involving snow and ice, there is no breakdown of figures to indicate which of these may have resulted from hazardous sidewalk materials. Without this information, the Highways Department, responsible for approving materials, contends it has no way of knowing whether materials it has deemed safe are, in fact, causing accidents.

There are no safety tests that the department subjects materials to before approving them.

When an accident takes place on a pedestrian walk, the municipality is usually liable since it is that government's responsibility to safeguard the walks.

For all nonconcrete sidewalks, plans of the proposed sidewalk along with samples of the material must be submitted to the engineering section of the Highways Department. Then, according to Henry C. Sison, assistant commissioner of highways, the material is judged according to the engineers' judgment of the product, along with information from manufacturers' brochures, reports from the American Institute of Architects and studies of other uses of the product.

At least in the case of terrazzo, it has been an accepted practice, according to Edward A. Graded of the National Terrazzo and Mosaic Association, for municipalities to rely on safety standards established by the industry-sponsored organization.

Consequently there have been some settlements. Martin Schaefer, an office worker, slipped on a wet, slick terrazzo sidewalk at 110 East 58th Street on her way to work one morning and badly fractured her right femur. Both the property owner and the cleaning company responsible for cleaning the

city street were sued and the case was settled in 1977 for \$2,500.

An architect is not usually involved in such suits. However, the architect too may be liable, according to Harry Lipig, a noted negligence attorney. "If the architect directed a slippery condition for the sidewalk and the jury be-

lieves that a dangerous condition exists — such as slippery tiles on a slippery substance or a dangerous slope — then the architect who designed it can be held liable for his dangerous design," Mr. Lipig said.

Most often it is the property owner who pays, according to Mr. Fuchsberg. "Sometimes I don't even sue the city because it complicates the lawsuit," he said. "I sue the property owner who put up what we call a defective sidewalk. The only time I'd sue the

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'New' Sidewalks Often Found Slippery

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rough the surface to increase traction. Asked about the sandblasting, however, Robert H. Dexter, vice president of Facilities Advisory Services at Citibank, said that it was done for esthetic reasons.

"I put up the building and I didn't like the way the sidewalks looked so I had them sandblasted," he said. "I don't know about any claims."

Employees of the complex remain skeptical of the change. "They pitted it, but I don't know if it will make any difference," said a concessionaire in the complex. "I slipped myself."

At 919 Third Avenue, the sidewalks are handsomely covered with travertine, a form of marble found mostly in Italy. Several employees of offices in the building complained that the surface was slippery when wet, and a building attendant who asked for anonymity confided, "I fell outside here myself."

But Charles Quinn, president of Tishman East Realty, the management company for the building, said that the surface did not get slippery and that there had been no safety problems.

"The only problem with travertine is that it cracks and that it's difficult to match," said Mr. Quinn.

However, one industry expert, Thomas E. Leo, vice president of Port Morris Tile and Terrazzo, said that travertine becomes slippery particularly when wet because it "tends to self polish with heavy wear."

Other buildings with travertine sidewalks include 9 West 57th Street, the W. R. Grace building at 114 Avenue of the Americas at 42d Street, and 1166 Avenue of the Americas at 46th Street.

At the Union Carbide building at 270 Park Avenue and 46th Street, at 909 Third Avenue at 54th Street, at 1 Times Square and around Madison Square Garden at 4 Penn Plaza, among numerous other locations, the sidewalks are terrazzo, a material composed of cement and aggregates such as marble or granite.

When terrazzo becomes wet and icy, according to George Lewis, executive director of the New York chapter of the American Institute of Architects, and others, it is the most slippery of all sidewalk materials.

Rustic terrazzo is the most heavily textured and the safest, said Mr. Leo of Port Morris Tile and Terrazzo, because of its pebbly finish. Some of the smoother terrazzos can be a problem.

When the red Verona marble terrazzo sidewalks around the Union Carbide building were first put down, they were so slippery that in a year's time they were etched with acid to roughen their surface. The effects of acid etching are shortlived in heavily walked-upon areas, however, and Union Carbide has had to repeat this treatment, most recently in 1978.

Asked about claims for falls, Thomas Moore, a Union Carbide attorney for more than 20 years, said he could find

no figures. "We have had some slip-and-fall situations and they have as far as I know given rise to claims," he said, "but what the number, volume or magnitude is I have not been able to ascertain."

Similarly in recent years the granite sidewalks around the McGraw-Hill Building, on the Avenue of Americas at 48th Street, and the Exxon Building, at 49th Street, were "flame sprayed" with torches to roughen their surface, according to James Reed, assistant director of public relations for Rockefeller Center Inc.

Among dozens of pedestrians interviewed on a cold and wet day in front of 909 Third Avenue was John Savo, an IBM systems engineer who works in the building. Did he find that sidewalk more slippery than concrete when wet? he was asked. "You better believe it," he replied.

Industry representatives contend that there is nothing amiss. Mr. Grazzini of the National Terrazzo and Mosaic Association insisted that terrazzo was no more hazardous than other materials. "Any surface covered with ice becomes slippery," he said.

Smooth sidewalks are not a disadvantage, to everyone. There is a slick sidewalk on the Avenue of the Americas up the block from the discotheque New York, New York. In the evening, to the music of blaring stereo radios, young people can be seen on this stretch disco roller-skating.



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Stone Paving Selections

- Serviceability
 - Vertical Load Resistance
 - Impact Resistance
 - Weather Resistance
 - Chemical Resistance
 - Repair/Replacement/Maintenance (Attic Stock)
 - Resistance to Soiling/Ease of Cleaning
 - Slip Resistance



Conditions to Avoid

- High Absorption Stone
- Long Spans
- Large Formats
- Irregular Joint Patterns
- Changes in Bearing, Depth
- Improper Mortar Types
- Inadequate System Depth
- Un-accommodated Volume Changes
- Cracks/Discontinuities in Substrates
- Substrate Deflections over $L/600$



Loading Conditions

- Dynamic Loads
 - Pedestrian
 - Vehicular
 - Cleaning Equipment
- Static Loads
 - Planters
 - Bollards
 - Threat Protection Barriers
- Impact Loads



Stone Durability

- Natural Defects



Stone Durability

- Stain Resistance

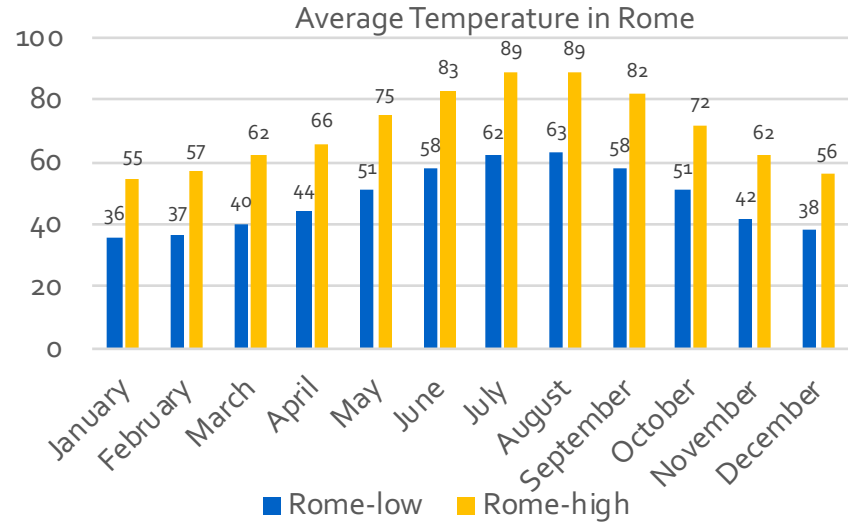
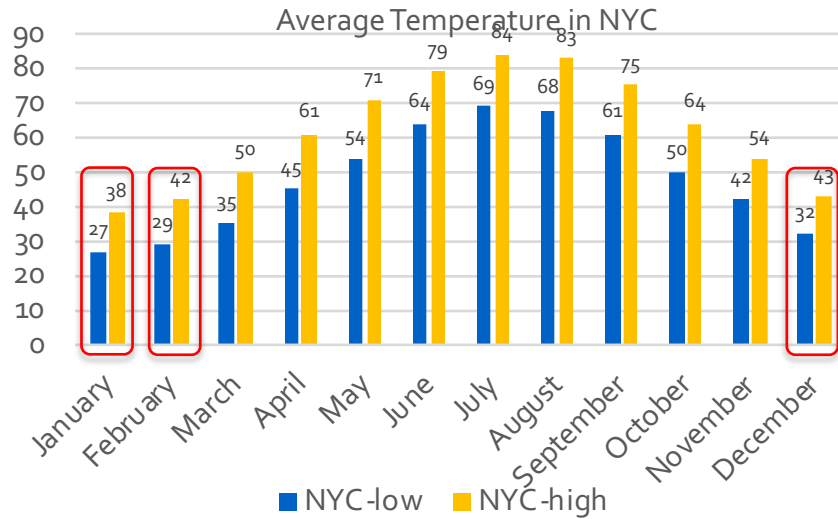


Stone Durability

- Confirm appropriate physical properties.
- Consider orientation and exposure.
- Avoid stones not suitable for a particular use.
- Stones for use in vertical applications may not be appropriate for horizontal applications.



Average Temperature In NYC and Rome



National Climatic Data Center. [NOAA's 1981-2010 Climate Normals.](#)

Additional Information

A public open space and primary pedestrian thoroughfare, 140 Broadway's plaza is subject to variable loads, including intermittent vehicular loading, as well as to climatic extremes and de-icing applications. The plaza also functions as a roof deck to the occupied cellar below.

- **STRENGTH:** Granite has more than twice the strength of travertine, in both compressive and flexural strength, making granite pavers less vulnerable to cracking and breakage than travertine.
- **SLIP RESISTANCE:** Granite, finished for exterior applications, offers greater slip resistance than travertine, and will hold its slip-resistant quality longer than travertine.
- **FREEZE-THAW:** Granite is less absorptive than travertine, and therefore less vulnerable to deterioration caused by freeze-thaw cycles in northern climates. Travertine typically includes veins, voids and inclusions at its surface which must be filled with cement or synthetic materials prior to use as a paving material. Fillers are prone to failure due to the combination of water intrusion and freeze-thaw cycles in northern climates.
- **DE-ICING:** The Marble Institute of America recommends against the use of travertines in exterior locations where de-icing salts or other chemicals are used.
- **STAINING:** Travertine is more porous than granite, and will stain more easily.
- **MAINTENANCE:** Sealants and fillers must be applied frequently to travertine to modify its natural porousness and absorption.

Additional Information

	TRAVERTINE (ASTM C1527-09)	TUDOR GOLD GRANITE
Density	144 lb/cu.ft.	163 lb/cu.ft.
Compressive Strength	7,500 psi	19,800 psi
Flexural Strength	500 psi	1,500 psi
Absorption, by weight	2.5%	0.27%