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DIGITAL CONSTRUCTION SAFETY CONFERENCE

DETERIORATION OF CONSTRUCTION MATERIALS IN NYC

PRESENTED BY

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NYC Buildings

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2021 DIGITAL CONSTRUCTION SAFETY CONFERENCE

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PRESENTATION OVERVIEW

This presentation will provide a historical perspective of construction material deterioration caused by climate conditions and design practices in New York City. The presentation includes an overview of basic material science, Code-related requirements, along with an explanation of conditions that led to the deterioration of stone, wood, brick concrete and steel and historic methods of protection.

ORGANIZATION

- Durability
- Climate specific to NYC
- Buildings
- Systems
- Materials

CLEOPATRA'S NEEDLE

FROM 1880 CENSUS: STONE INDUSTRY

credit Central Park Conservancy and NYC Parks.

We have transported another obelisk **Cleopatra's Needle**, from Egypt, and. In defiance of the still greater dangers incidents to our sever climate, have erected it, covered with delicate carvings, upon a bullock In Central park, exposed to the blazing sun, pelting rain, and biting frost, often successively within 24 hours – a monument to the public ignorance in regard to the protection of even our prized possessions – that indifference of our community to the PRACTICAL VALUE OF SCIENCE. – *report by A. Julien*

SERVICE LIFE PLANNING ISO 15686

Service life of a system that is known to be expected under a referenced set of in use conditions and which may form the basis of estimating the service life under other in use conditions

The factor method is used to modify the reference service life while considering the difference between the project specific and the reference in use conditions

ESL= RSL x Factor A x Factor B x... x... x ...x

FACTORS IN MATERIAL DURABILITY FORMULA

Factor classes of the Factor method	
Factor class	**Designation**
A	quality of components
B	design level
C	work execution level
D	indoor environment
E	outdoor environment
F	usage conditions
G	maintenance level

QUALITY STONE AND WORKMANSHIP

DESIGN LIFE BUILDINGS (BS7543)

Table 1 - Categories of Design Life for Buildings (from BS 7543:1992)			
Category	**Description**	**Building Life**	**Examples**
1	Temporary	Up to 10 yrs	Site huts; temporary exhibition buildings
2	Short life	Min. 10 yrs	Temporary classrooms; warehouses
3	Medium Life	Min. 30 yrs	Industrial buildings; housing refurbishment
4	Normal life	Min. 60 yrs	Health, housing and educational buildings
5	Long life	Min. 120 yrs	Civic and high quality buildings

DESIGN CONSIDERATIONS

- Are the materials selected compatible with each other?
- Has the manufacturer provided adequate data on durability?
- Can the required service life be assured with normal maintenance?

DESIGN LIFE COMPONENTS: ISO 2000

Design life of building	Components			Building services
	Inaccessible or structural	Replacement is expensive or difficult*	Major replaceable	
Unlimited	Unlimited	100	40	25
150	150	100	40	25
100	100	100	40	25
60	60	60	40	25
25	25	25	25	25
15	15	15	15	15
10	10	10	10	10

DURABILITY vs STRUCTURAL DESIGN

Durability – Time Component

1. Cosmetics
2. Serviceability limit state - reached when not maintained
3. Codes relate durability to serviceability
4. Safety Limit State - deterioration advances be directly associated with an ultimate limit state.

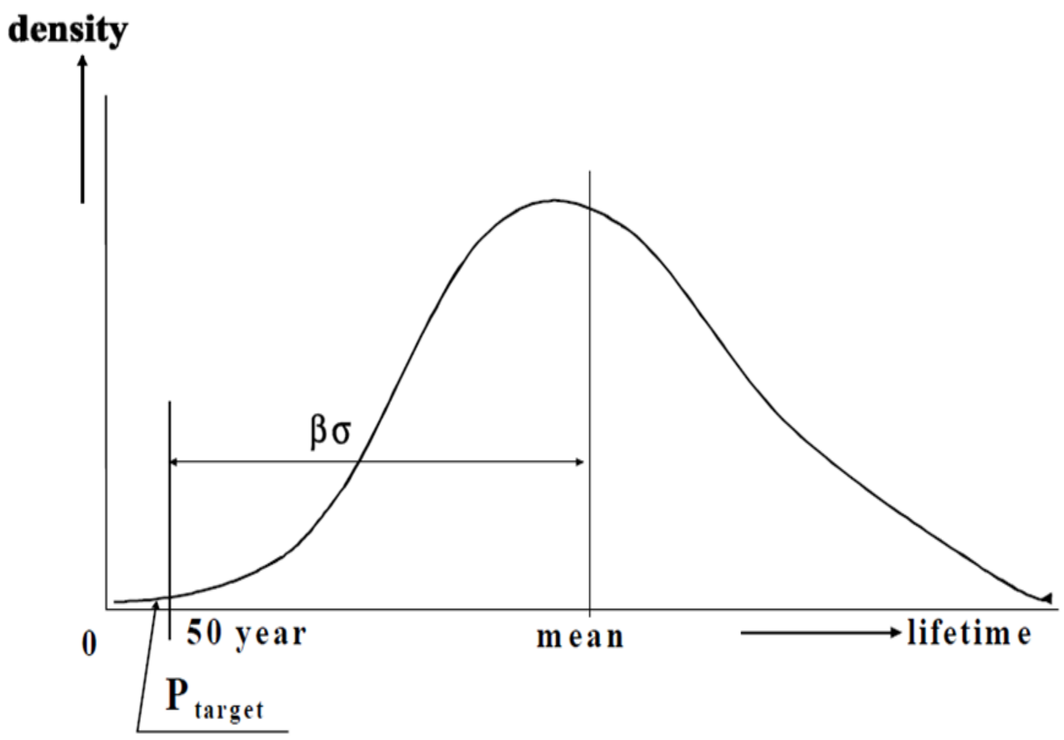
ANCHORAGE

Structural

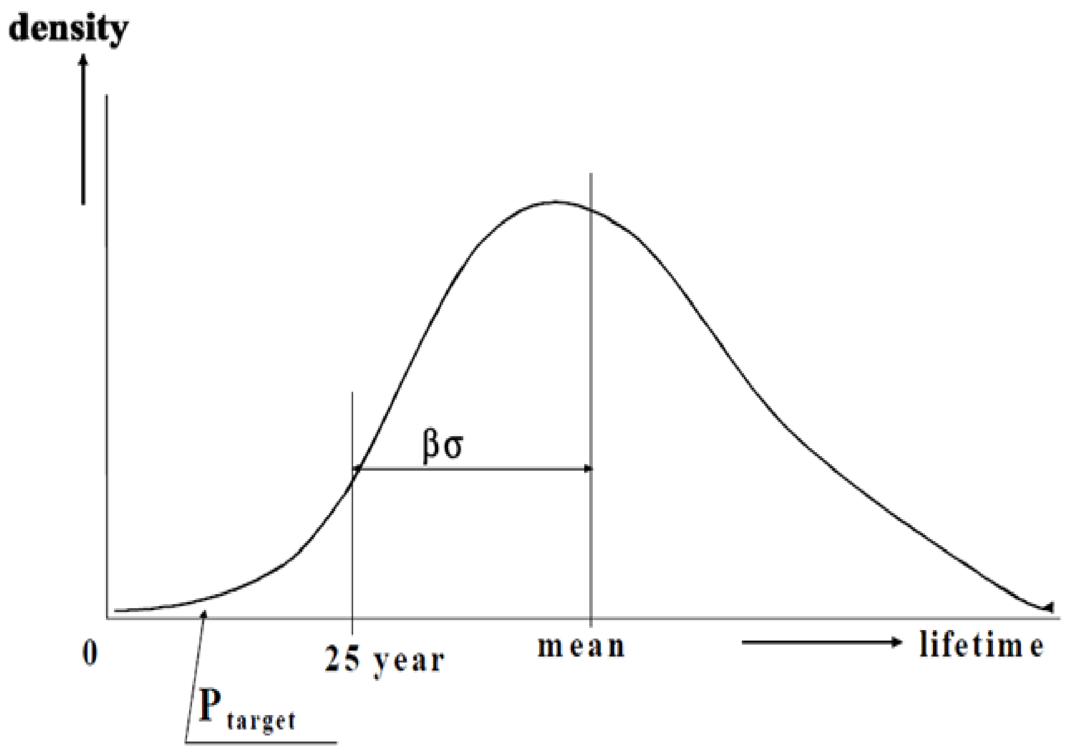
In the performance based structural design both the resistance and the load are considered to be time independent.

EXAMPLE: DESIGN RELIABILITY

Ultimate Limit State for Structure



Serviceability Limit State – Materials



MATERIAL LIFE AS EXPECTED IN 1880

Material in Building.	Frame dwelling. Average life, years.	Frame dwelling. Per cent. of depreciation per annum.	Brick dwelling shingle roof. Average life, years.	Brick dwelling shingle roof. Per cent. of depreciation per annum.	Brick store, shingle roof. Average life, years.	Brick store, shingle roof. Per cent. of depreciation per annum.
Brick	..	..	75	1⅓	66	1½
Plastering	20	5	30	3⅓	30	3⅓
Painting, outside....	5	20	7	14	6	16
Painting, inside.....	7	14	7	14	6	16
Shingle	16	6	16	6	16	6
Cornice	40	2½	40	2½	40	2½
Weather boarding...	30	3⅓	..	..	..	..
Sheathing	50	2	50	2	50	2
Flooring	20	5	20	5	13	8
Doors, complete.....	30	3⅓	30	3⅓	30	3⅓
Windows, complete..	30	3⅓	30	3⅓	30	3⅓

From Kidder Architects' handbook on 1879 Fire Underwriters publication

Based on Empirical Observations of materials as they were manufactured at that time

- Frame Dwelling
- Brick Dwellling (shingle roof) -75 years
- Frame Store
- Brick Store - 66 years
  - AVERAGE LIFE
  - DEPRECIATION

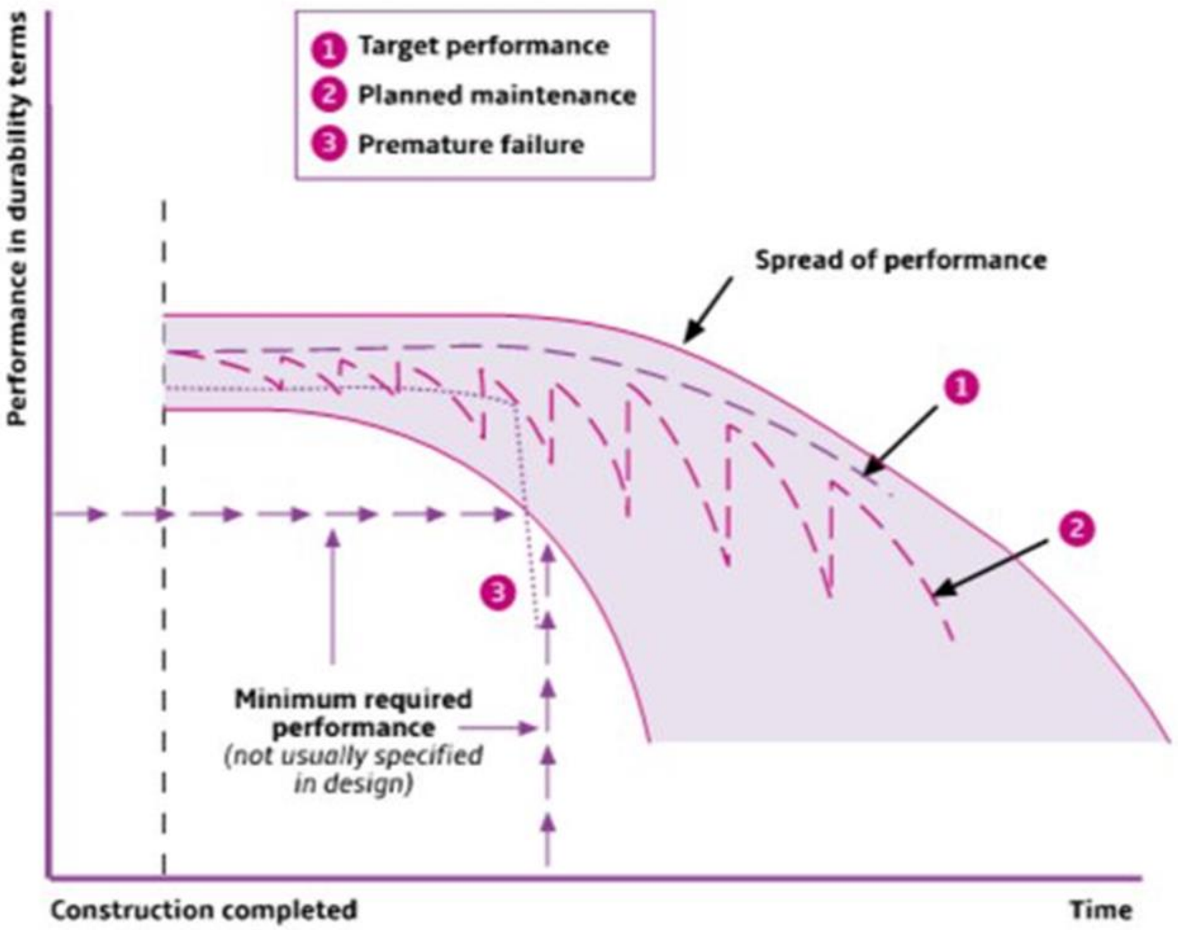
BUILDING LIFE AS EXPECTED 1914

Class of Building.	Structural. Life in years.	Structural. Per cent. of average annual depreciation.	Commercial. Life in years.	Commercial. Per cent. of average annual depreciation.
Cheap detached frame residences	30-40	2.90	25	4.
Good detached frame residences	40-60	2.10	35	2.90
Ordinary brick residences.	50-75	1.65	40	2.50
Good brick and stone residences	100-150	.83	45 or more	2.20
Frame tenements.........	25-35	3.50	27½	3.17
Brick tenements and flats.	40-50	2.25	35	2.90
Good class apartment houses	50-75	1.66	45	2.20
High class fireproof apartment houses	75-100	1.16	45 or more	2.20
Cheap brick shops and dwellings	40-50	2.25	40	2.50
Ordinary brick shops and dwellings	50-75	1.66	45	2.20
Good brick and stone stores and offices	75-100	1.16	45	2.20
High class offices & stores of brick, stone, terra cotta and iron or steel construction	150	.83	50 to unknown	2.

From Evers

PLANNED MAINTENANCE

- Planned maintenance requires budgeting funds.
- More expensive over time
- Expressed in depreciation

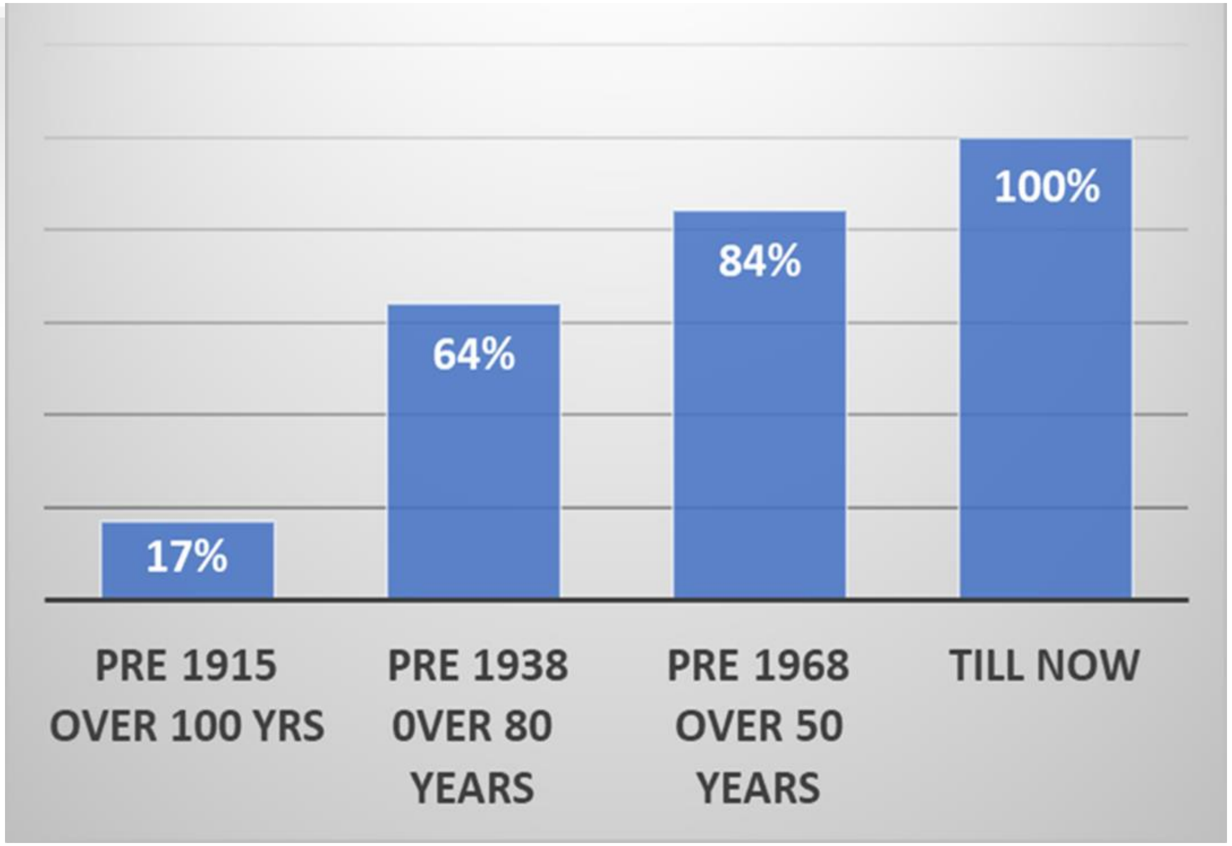


Loss of durability with time

COST OF REPAIRS SCHEDULE 1914

Class of Building.	Per cent of cost of building.	Per cent. of gross rental.
Cheap detached frame residences........	1½ to 2¼	10 to 15
Good detached frame residences.........	¾ to 1¼	6 to 10
Ordinary brick residences...............	¾ to 1¼	6 to 10
Good brick and stone residences........	½ to 1	5 to 8
Frame tenements	1¾ to 2¾	10 to 15
Brick tenements and flats..............	1¼ to 2	9 to 13
Good class apartment houses............	1¼ to 2	8 to 12
High class fireproof apartment houses..	1½ to 2½	8 to 12
Cheap brick shops and dwellings.......	1¼ to 2	10 to 15
Ordinary brick shops and dwellings....	1¼ to 1¾.	8 to 12
Good brick and stone stores and offices.	¾ to 1¼	6 to 10
High class offices and stores of brick, stone, terra cotta and iron construction	½ to ¾	4 to 6

AGE BUILDINGS NYC

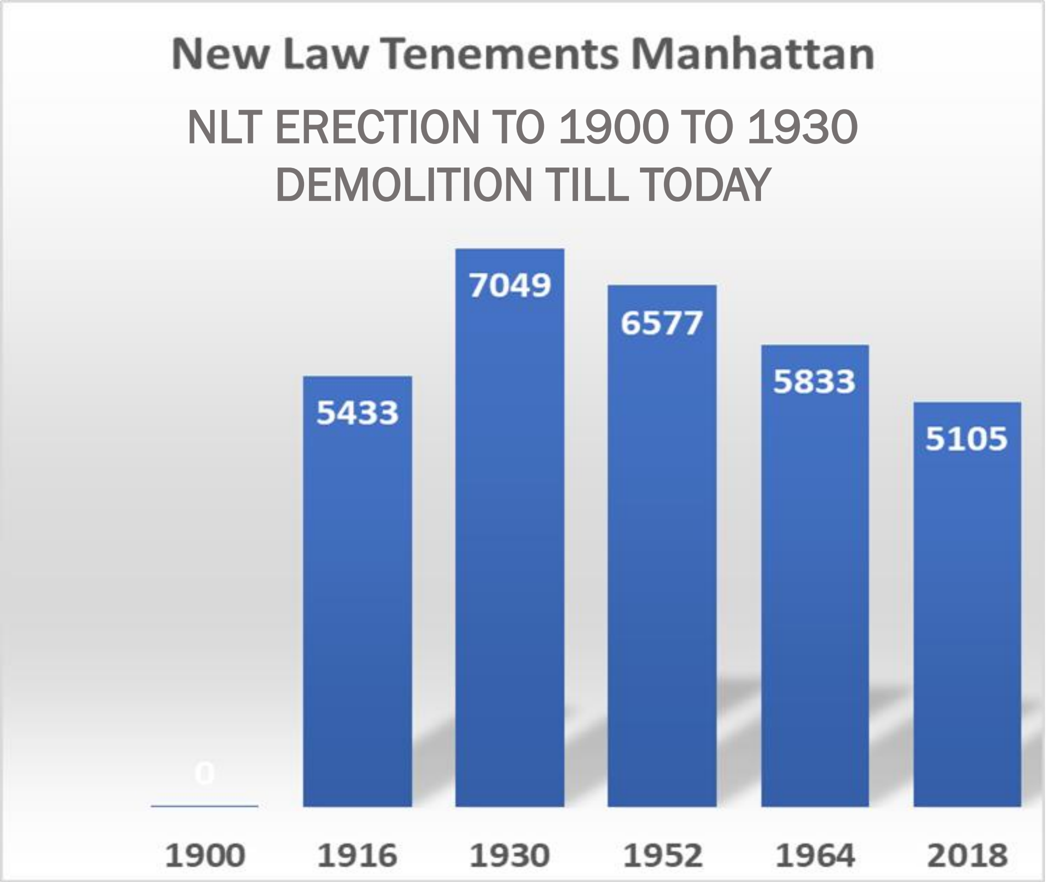


National Register of Historic Places condition to list

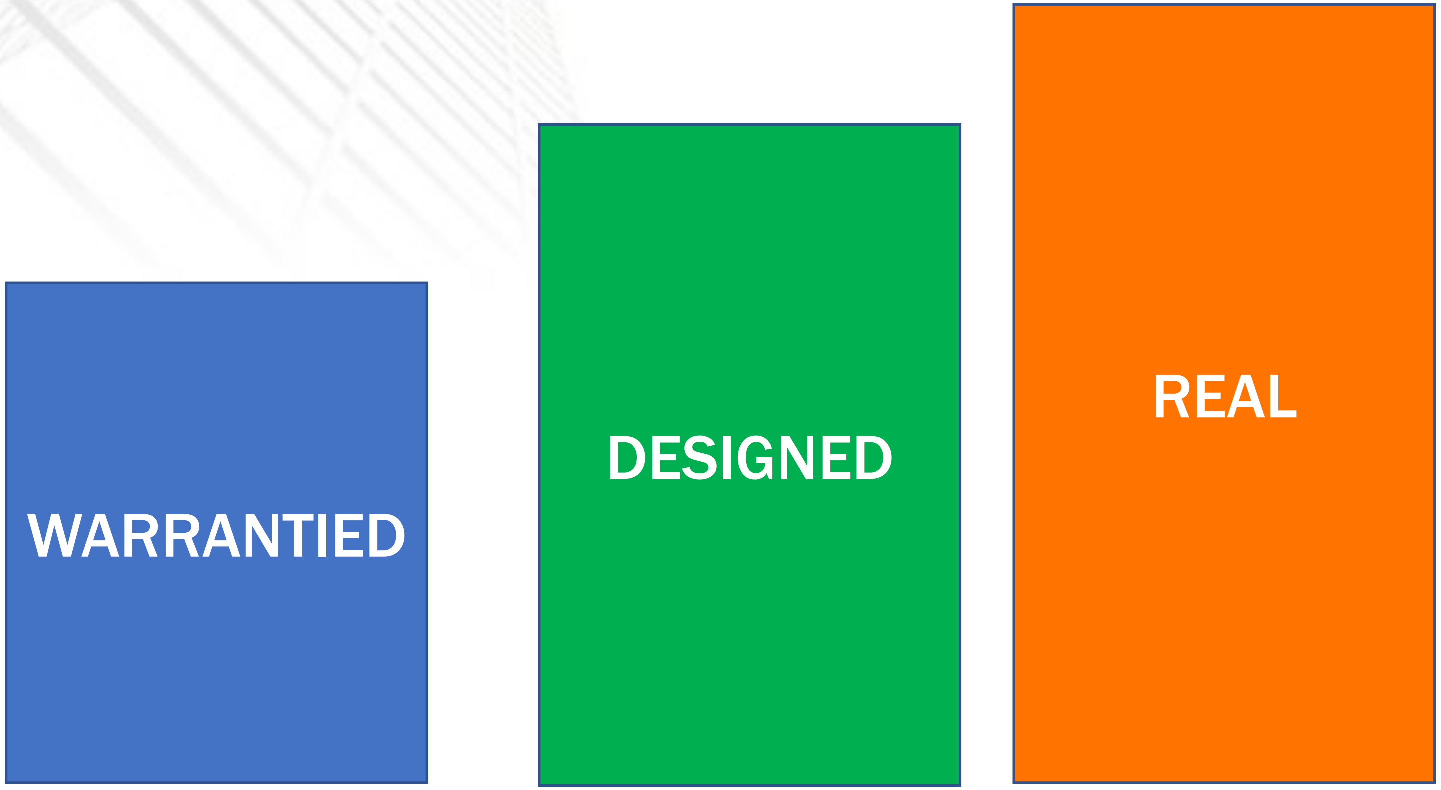
- **Age and Integrity:** Is the property old enough to be considered historic? (generally **at least 50 years old)**

FIRE & ABANDONMENT

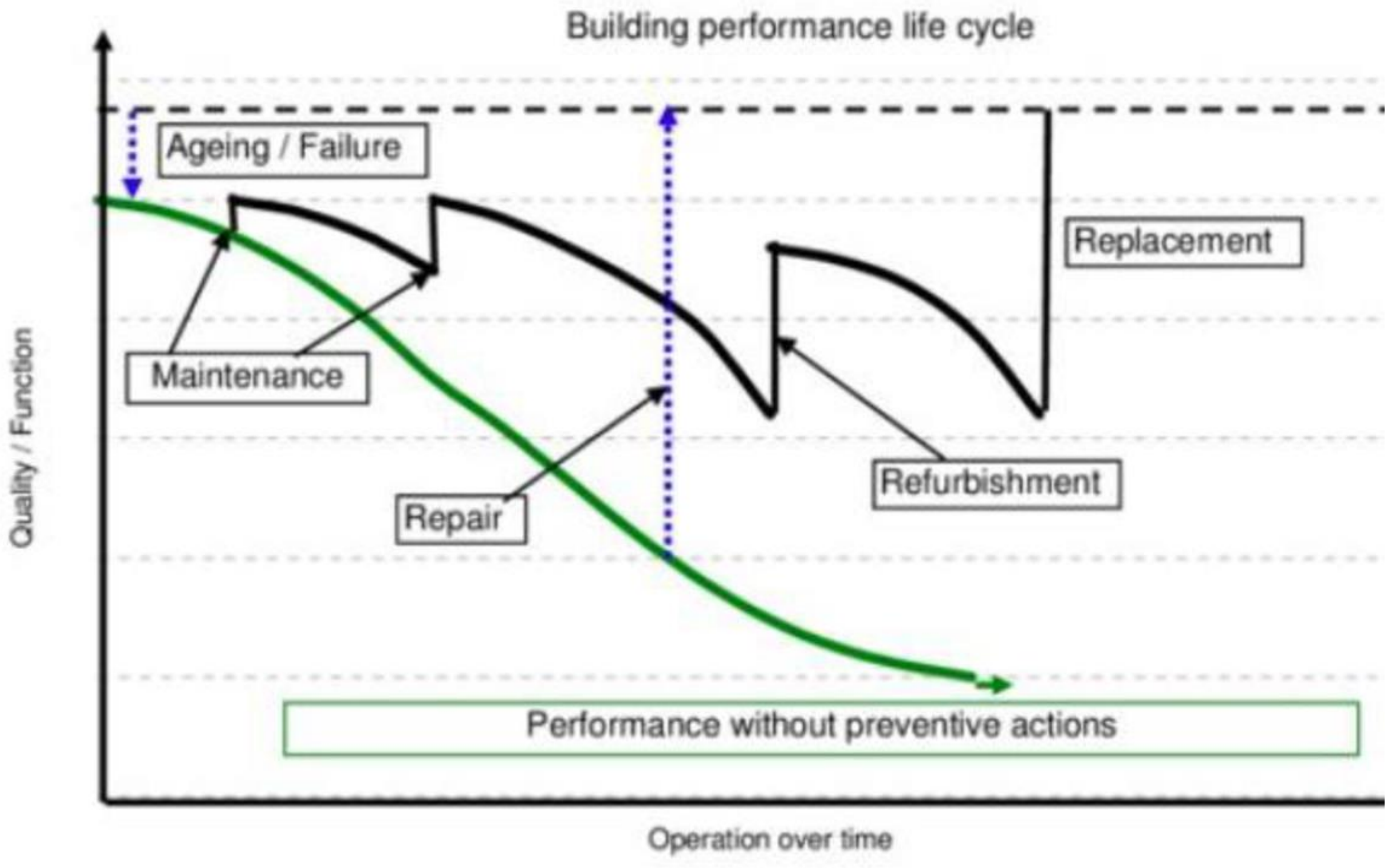
SURVIVAL OF NEW LAW TENEMENTS MANHATTAN



LIFETIME



BUILDING PERFORMANCE LIFE CYCLE



REPAIR PRACTICE IN NYC?

PRESSED METAL SHEET DETERIORATION

REPLACEMENT SOLUTIONS

PRESSED METAL CORNICE PRESENT		97	10 deficient
Cornice Removed	STUCCO COVERED	40	4 stucco cracked
	ORIGINAL OR NEW BRICK EXPOSED	20	
Original parapet or cornice (not metal)		14	
TOTAL		171	

TIME TO FIRST REPAIR: BIA Tech Note 46

Estimated Time for Repair

Material	Application	Estimated Time to Repair (Years)
Brick	Walls	100–150+
Sealant	Joints	5–20
Metal	Coping/flashing	20–75
Metal	Anchors & ties	15+
Mortar	Walls	50+
Plastic	Flashing	5–25
Paint	Finishes	3–5
Water Repellents	Walls	5–10
Stucco	Finishes	5–10

DEGRADATION FACTORS AFFECTING LIFECYCLE BUILDING MATERIALS: after RILEM

- Radiation
  - Solar
  - Thermal
- Temperature
  - Elevated
  - Low
- Water
  - Solid (snow , ice)
  - Liquid(rain, condensate)
  - Vapor (high relative humidity)
- Normal air
  - Oxygen
  - Carbon Dioxide
- Air contaminants
  - Gases)oxides nitrogen, sulphurs
  - Mists (salts, alkali dissolved in water)
- Freeze-thaw
- Wind
- Micro organisms
  - Fungi
  - Bacteria
- Stresses, movement, etc.

FOR MATERIALS IN EXISTING BUILDINGS

- Age
- What was the original expectation
- What measures of protections were used
- History of climate/atmospheric changes
- Discuss observed deterioration to verify against other scientific data
- Failure of buildings
- Failure of systems
- Failure of materials

VISUAL OBSERVATIONS

- Water/Moisture Damage
- Material Cracking/Spalling
- Deteriorated Mortar
- Settlement/Expansion/Contraction
- Efflorescence/Staining
- Disintegration/Erosion/Chipping
- Corrosion/Abrasion/Indentations/Punctures
- Warping/Swelling/Rotting/Insect Infestation
- Mold/Fungus Growth
- Deteriorated Sealants/flashings
- Failed Moisture/Vapor/Thermal barriers

CLIMATIC FACTORS

ELEMENTS

- Rainfall
- Relative Humidity
- Temperature
- Orientation/Exposure to Sunlight
- Local Wind Patterns
- Pollution of Air & Water

CITY VS. BUILDING SPECIFIC

- NYC Macroclimatic Effects
- Microclimatic Effects (siting building within City, adjoining neighborhood)
- External Environment Influences (traffic, nearby industries, ocean)
- Internal – activities within building

MACRO, MESO & MICRO CLIMATE

- Macroclimate gross meteorological conditions described in terms like polar climate, subtropical climate and tropical climate. Based on measurement of meteorological agents such as air temperature, precipitation etc.

- Meso climate, the effects of the terrain and of the built environment are taken into account. Based on the standard meteorological measurements.

- Microclimate describes the meteorological variables in the absolute proximity of a material surface. Variables describing microclimate include relative humidity, surface moisture, surface temperature, irradiation and deposition of air pollutants.

LOCATION

INTERIOR

- Floors
- Ceilings
- Walls
- Both Interior & Exterior

ELEVATION AT EXTERIOR

METEOROLOGICAL DATA OF NYC

- average 121 days of precipitations bringing a 1.2m (46.23 in.) rain water
- 50 freeze thaw days
- 15 freezing periods
- The weathering index 540 calculated per ASTM C216 19 Standard Specification for Facing Brick severe conditions.
- In 1994 the rain had a Ph between 4 to 4.5 about five to ten times higher than the pH of **normal** rain. Improved since.

FREEZE/FROST PROBABILITY OCURENCE

State And Station Name	Threshold (F)	Spring (Date) Probability Level (1)			Fall (Date) Probability Level (2)			Freeze Free Period (Days) Probability Level (3)			Probability Level (4)
New York		90	50	10	10	50	90	10	50	90	
NEW YORK AVE V BROOKLYN	36	Apr01	Apr11	Apr21	Oct21	Nov05	Nov21	227	207	187	28
	32	Mar21	Apr01	Apr13	Nov02	Nov18	Dec03	253	229	206	19
	28	Mar10	Mar24	Apr07	Nov14	Nov29	Dec13	271	249	226	14
NEW YORK CITY CENTRAL PK	36	Apr04	Apr14	Apr24	Oct21	Nov02	Nov13	215	201	187	28
	32	Mar20	Apr01	Apr13	Oct29	Nov15	Dec02	251	227	203	20
	28	Mar11	Mar25	Apr09	Nov14	Nov28	Dec13	269	247	226	14
NEW YORK JFK INTL AP	36	Apr03	Apr11	Apr19	Oct21	Nov02	Nov13	216	204	191	28
	32	Mar19	Mar31	Apr11	Oct31	Nov17	Dec04	252	230	209	20
	28	Mar09	Mar23	Apr06	Nov13	Nov27	Dec10	267	248	228	14
NEW YORK LA GUARDIA AP	36	Mar31	Apr10	Apr20	Oct21	Nov06	Nov22	230	210	189	27
	32	Mar20	Apr01	Apr12	Nov06	Nov20	Dec04	252	233	213	19
	28	Mar09	Mar21	Apr03	Nov16	Nov30	Dec15	272	254	235	13

INCREASE IN POLLUTION: ACIDITY

- The acidity of precipitation in the Northeastern United has increased in the past, probably as a result of anthropogenic emissions.

- The increase in New England and New York occurred primarily before the mid-1950's. Since the mid-1960's there has been no significant change in the acidity of precipitation in this region; however, sulfate concentrations have decreased and nitrate concentrations may have increased.

- The acidification generally has been attributable to localized sources and the time of initial acidification is undefined.

SMOG 1966

From NYTimes

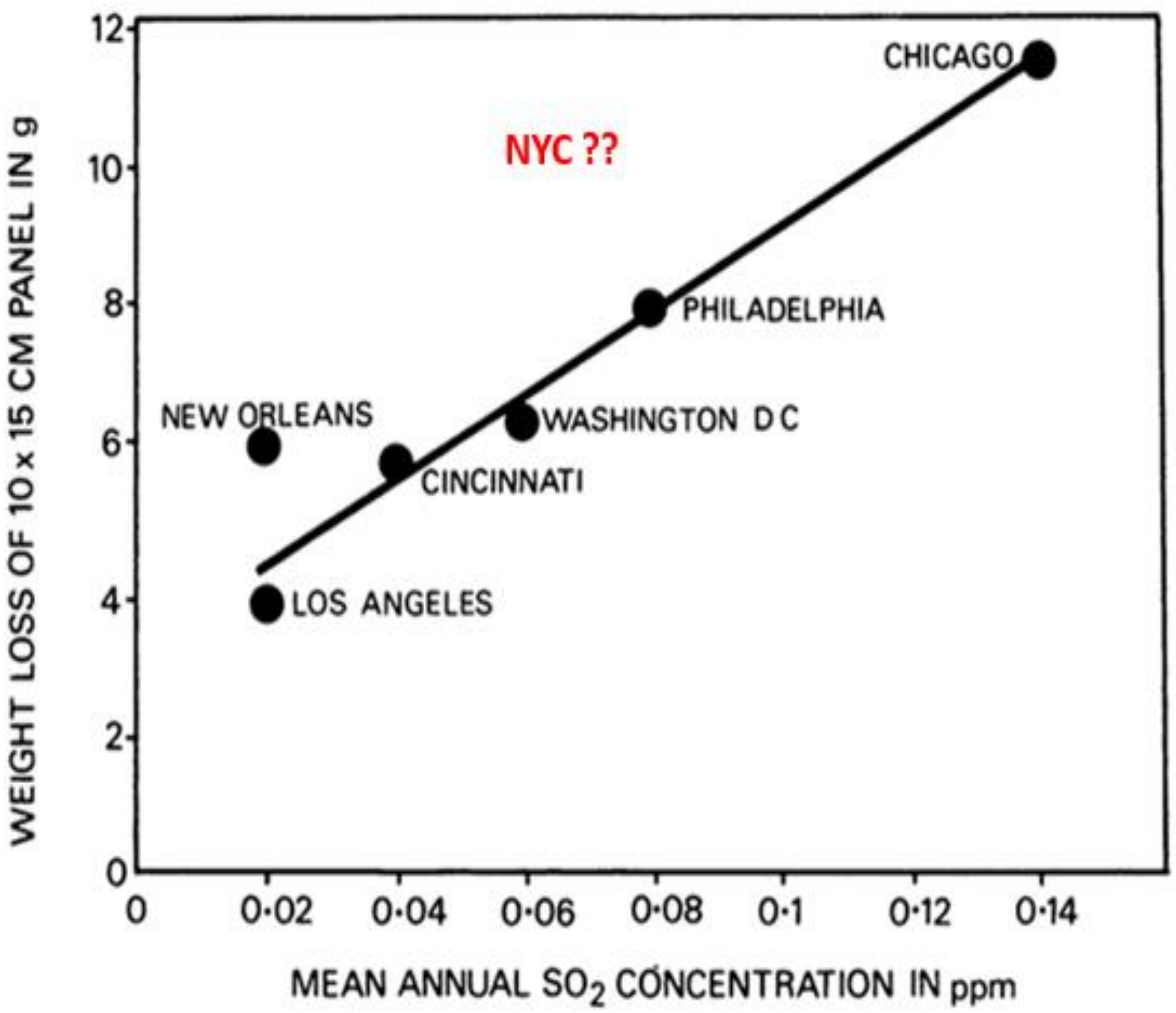
AIR POLLUTANT STUDIES

- Reconstruction of emission of SO2 was performed measuring marble deterioration in NYC marble tombstones over 200 years
- From 1958 -1972 sulfur concentration was studied
- Fuel consumption
- Estimate consumption of anthracite, bituminous coal, residual fuel oil

COMPARISON WITHIN US RATE OF SO2 CONCENTRATION

Effects of sulfur dioxide and acid precipitation on metals and anti-rust painted steel

Source: Kucera



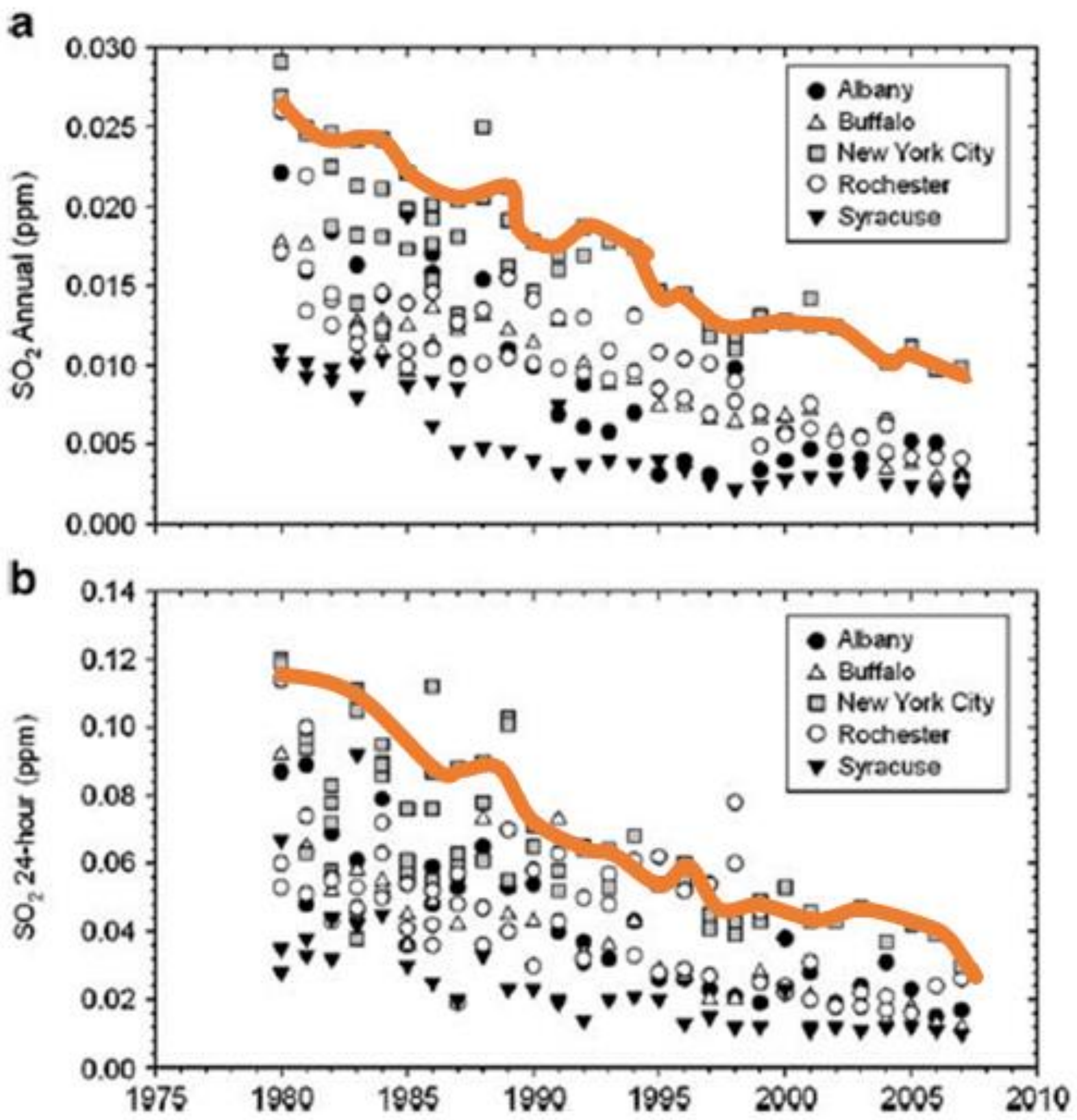
SO2 LEVELS NYS 1980-2007

A – Annual

B – Average 24hrs

New York City

From Buckley improvement of air quality



DETERIORATION BRIDGE ELEMENT NEW YORK

Deck Curb	Granite or stone	CR=7−0.0605424T+0.0001089T2−0.0000001T3
	Steel plate	CR=7−0.0577393T+0.0001956T2−0.0000017T3
	Timber	CR=7−0.0584921T−0.0003144T2+0.0000024T3
	Concrete	CR=7−0.0507576T−0.0002625T2+0.0000019T3
Pier cap top	Concrete	CR=7−0.0475800T−0.0001091T2+0.0000012T3
	Masonry	CR=7−0.0094394T−0.000 7153T2+0.0000038T3
	Steel	CR=7−0.0131302T−0.0007820T2+0.0000049T3
	Timber	CR=7−0.0467232T+0.0001051T2−0.0000013T3

BRIDGE COMPONENT DETERIORATION

Table 2: Shortest Life (L_{i0}) and Weights (w_i) of Bridge Components

Component *i*	Lio [years]	w_i
Bearings	20	6
Backwalls	35	5
Abutments	35	8
Wingwalls	50	5
Bridge Seats		6
Primary Member	30/35[a]	10
Secondary Member	35	5
Curbs	15	1
Sidewalks	15	2
Deck	20/35[a]	8
Wearing Surface	15/20/30/35[a,b]	4
Piers	30	8
Joints	10	4

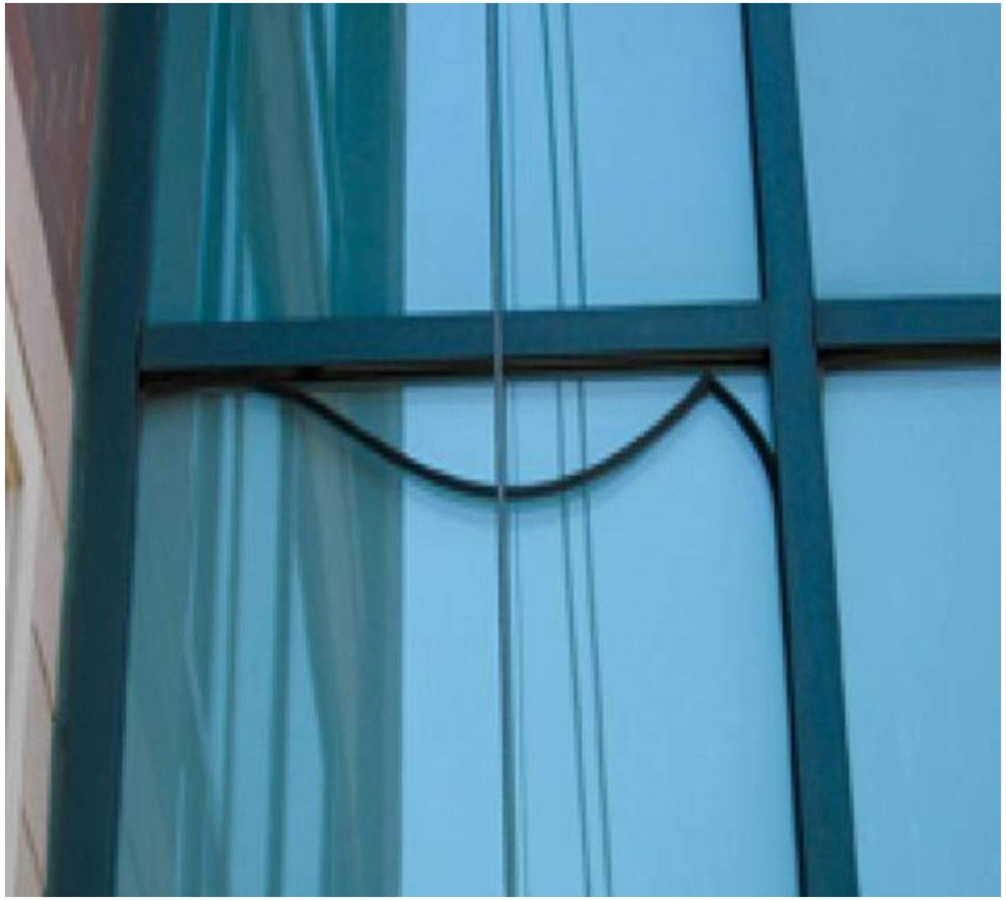
YANEV

ELEMENT TO BE REPAIRED

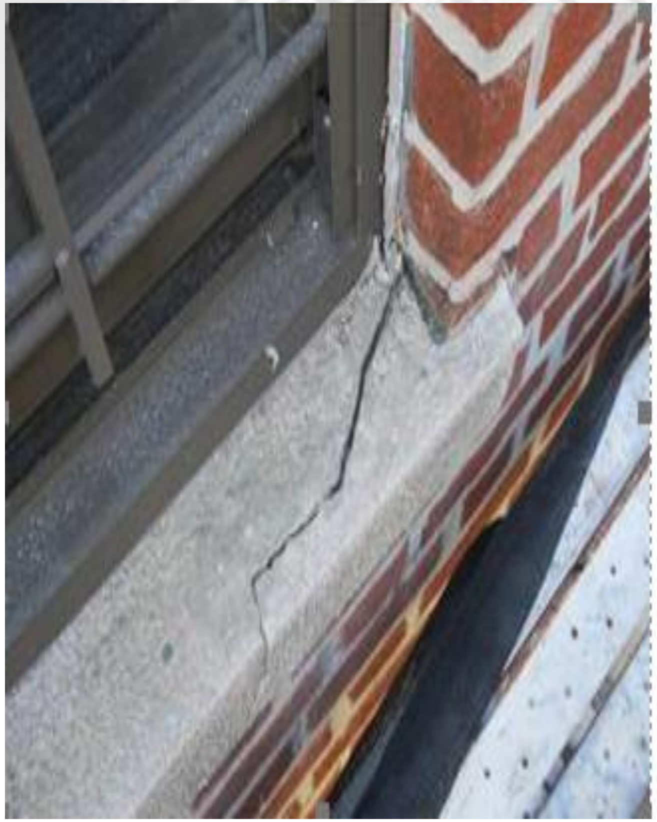
Specified in Applications 2010 - 2019

Element mentioned	NON LL -7367 applications	Loca law 6515 applications
brick	29%	29%
stucco	7%	3%
parapet	46%	26%
terrace	4%	10%
terracotta	3%	6%
balcony	0%	3%
lintel	21%	22%
stone	DE FOR NYC EBC 8%	10%

MAINTENANCE: JOINT TREATMENT



MAINTENANCE: SILLS?



YEAR BUILT:
ELEMENT MENTIONED IN INCIDENT DATABASE

	BALCONY/Deck	CHIMNEY	CORNICE	ENTRANCE FIRE ESCAPE	NOT SPECIFIED	FRONT FAÇADE	PARAPET COPING	POCH GATE FENCE	RERAR WALL	ROOF STRUCTURE	ROOFING	SIDE WALL	SIDING	STRUCTURE	WINDOW LINTEL SILL
SINCE 1968	20	1	5	1	11	16	13	6	4	13	8	4	5	5	17
1942-1967	14	15	8	8	25	45	50	14	10	29	9	26	8	7	37
1916-1942	7	26	42	14	79	103	106	17	13	73	19	36	10	28	68
BEFORE 1916	2	33	80	21	88	145	79	20	26	36	18	53	19	25	110

INCIDENTS BY MATERIAL

	MASONRY -BRICK	BRICKS	CMU	CONCRETE	FRAME BLDG	MEP	NA	ROOFING COVER	METAL	STONE	STUCCO	WINDOW GLASS	WOOD	Grand Total
DISREPAIR	11	17		2	2	3	19	12	28	4	3	2	38	141
CRACK LOOSE	86	116	1	3	1	4	46	2	43	18	39	12	18	389
LEAN BULGE BOW	109	75	1	1	4	2	15		6	5	4	2	24	248
FALL MISS COLLAPSE	44	387	13	27	4	11	138	17	103	124	120	40	142	1170
GRAND TOTAL	250	595	15	33	11	20	218	31	180	151	166	56	222	1948

NOTE: Terra Cotta and Stone same column – Inspectors did not distinguish

MDL INCIDENTS & BUILDING AGE

		Pre 1901	1902-16	1917-30	1931-39	1940-69	1970-08	Post 08	TOTAL
ENVELOPE	APPURTENANCE	9	2	5		1	2		19
	FAÇADE	248	71	67	6	31	39	12	474
	FIRE ESCAPE	9		2				1	12
	ROOF CHIMNEY	5	5	8		1	2	1	22
TOTAL ENVELOPE		271	78	82	6	33	43	14	527
INTERIOR Struct & Architect.		89	37	25	2	1	8	4	166
Over 3 story MDLs		13912	3577	3202	433	1074	1664	593	24455
Envelope %		1.9%	2.2%	2.6%	1.4%	3.1%	2.6%	2.4%	2.2%
Interior %		0.6%	1.0%	0.8%	0.5%	0.1%	0.5%	0.7%	0.7%

STONE

STONE DETERIORATION

BROWNSTONE

WOOD

WOOD IS RESISTANT

CLIMATE INDEX MAP FOR WOOD DECAY HAZARD FOR 1971-2000

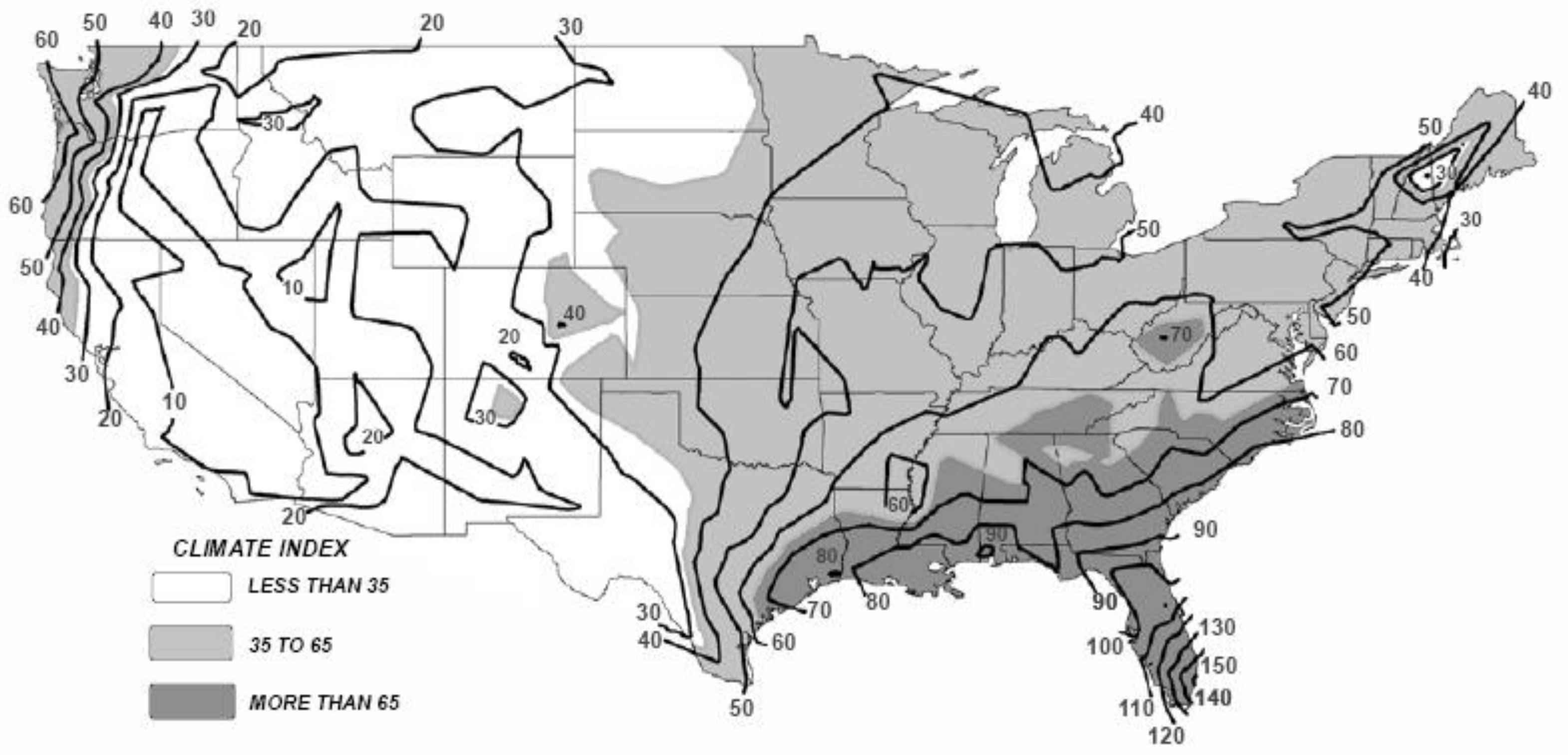


Figure 2. Revised climate index map for decay hazard based on data for the period 1971–2000. Higher index values indicate greater decay hazard.

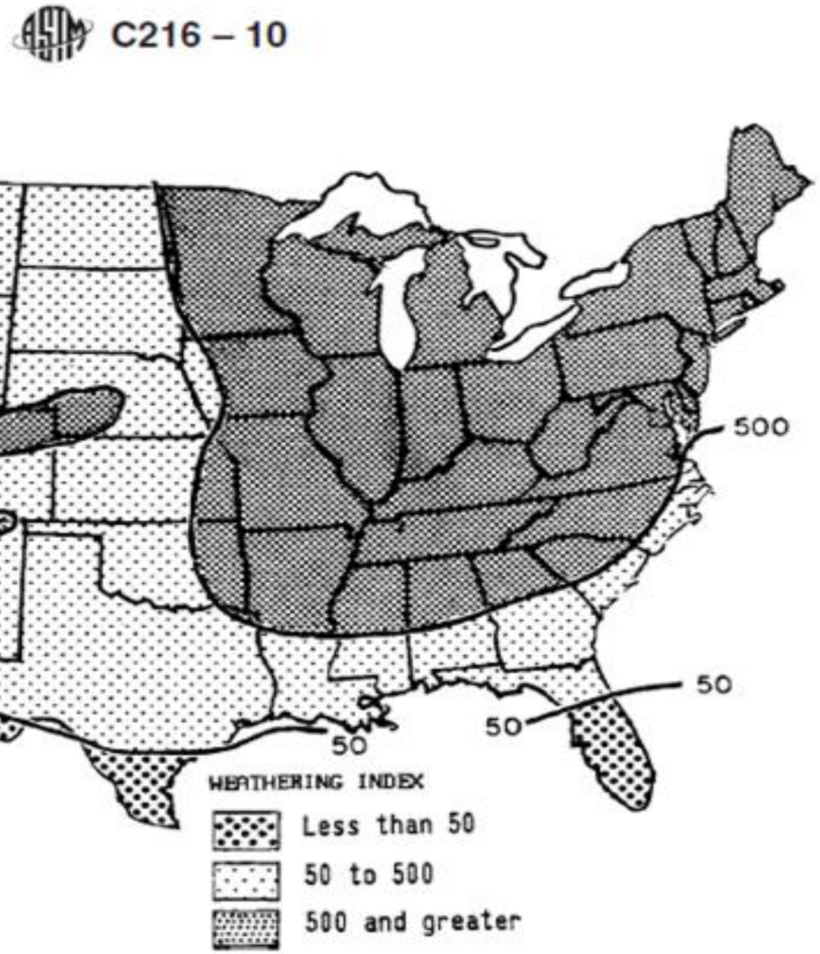
WOOD ROT IN MASONRY POCKETS

ACCIDENT WALTON AVENUE, BRONX

FIRE TREATMENT OF WOOD LED TO COLLAPSE

CERAMICS

CLIMATE FOR MASONRY



BRICK & MORTAR

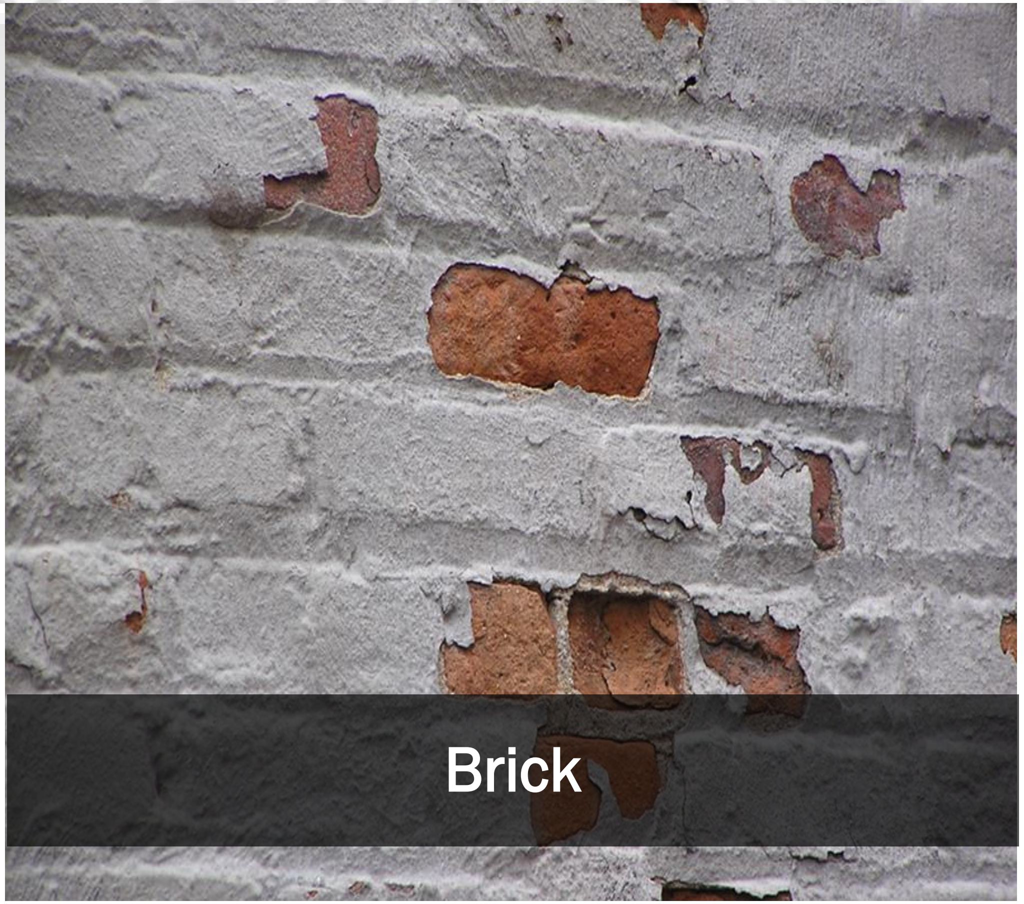
- Soluble salt crystallization main mechanism in the deterioration of brick and mortar. The salt will concentrate where evaporation occurs and crystallization deteriorates material

- Air pollutants act on both materials and <u>interaction</u> between them determines which one will be deteriorated more

- Usually the <u>evaporation will be higher in a more porous material</u>, so that the question which of the materials will be destroyed can only be answered in the context of pairs of bricks and mortars as well the local humidity

- Cold temperatures, and in particular frost formation, can adversely affect the durability of both the brick and mortar components

DETERIORATION



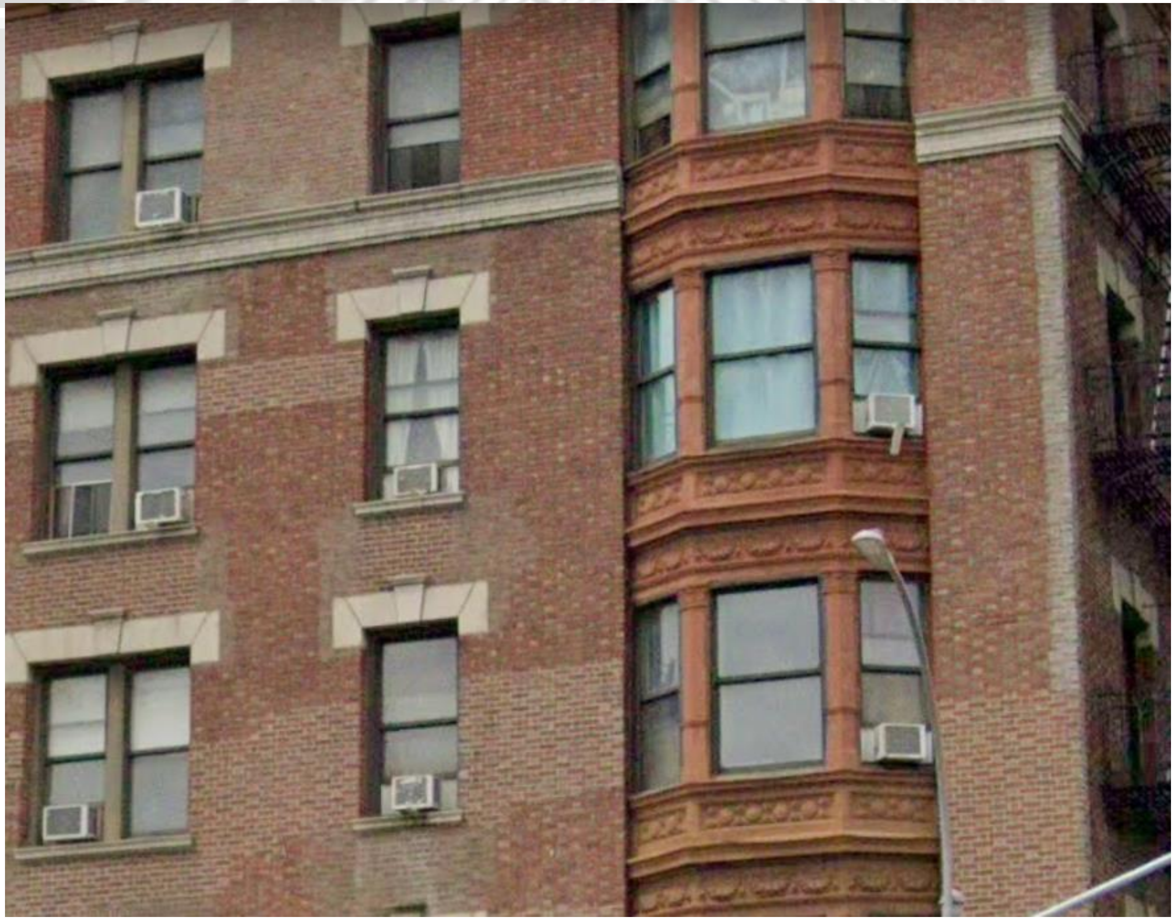
BRICK/JOINT CONDITION

BRICK/JOINT CONDITION 110 YEAR OLD

COURSING	Grand Total	CONDITION MORTAR IN JOINT			BRICKS REPALCED			OPEN CRACKS
		OK	ERODED	RECENT REPOINT	INDIVIDU AL	AREAS REPLACED	NO WORK	STEP CRACK
COMMON	79	78%	6%	15%	14%	24%	62%	4%
FLLEMISH	57	75%	11%	14%	12%	25%	63%	2%
ROMAN	4	75%	0%	25%	0%	50%	50%	0%
RUNNING	29	66%	17%	17%	14%	24%	62%	17%
TOTAL	169	75%	9%	15%	13%	25%	63%	5%

From Eschenasy – Condition Manhattan Apartment Facades

BRICK CONDITION IN 100 YEARS BUILDINGS



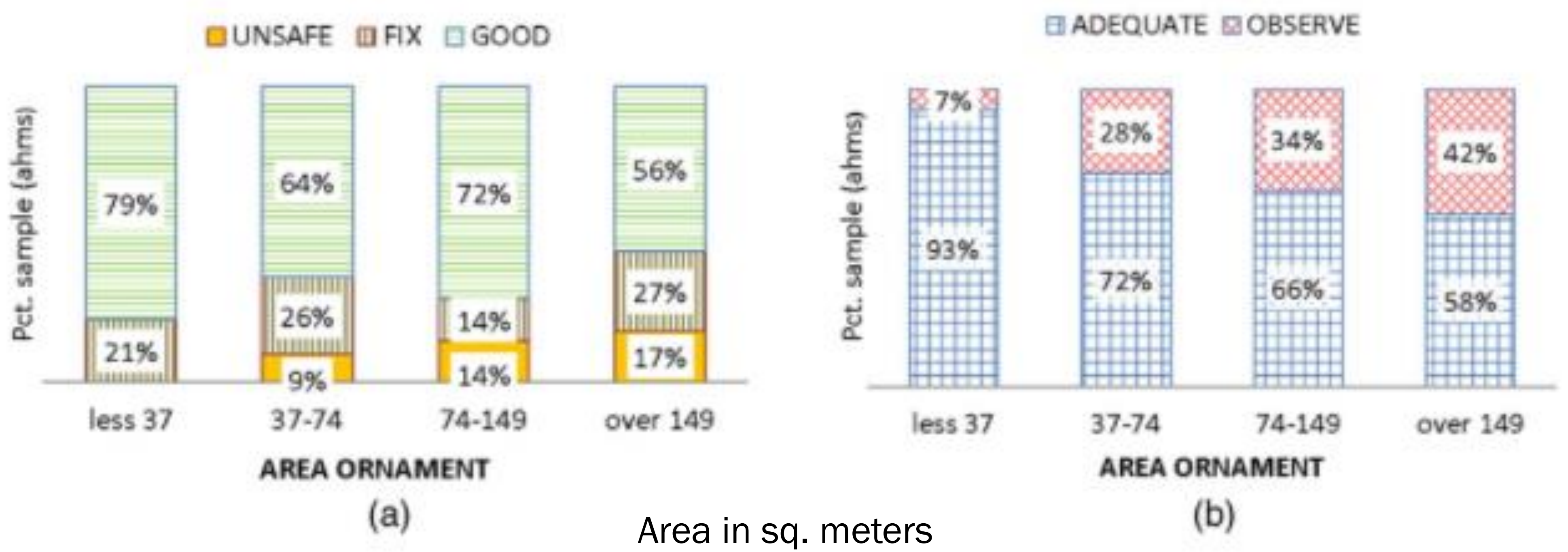
	ALL	LL11	NOLL
Individual at Places	21	16%	9%
No Replacement	104	52%	67%
Area Replaced Brick	38	30%	15%
Total 8-story	171	100%	100%

WATER ABSORPTION & MORTAR IN FACADES

Table 1. Materials Properties of Masonry Considered

Masonry Material	Typical Unit Length	Typical Unit Finish	Water Absorption Rate
Stone[2]	2-4 feet	Various Chiselled or Polished Finishes	Granite – < 1% Limestone – 10-12%
Terra Cotta[3]	18-24 inches	Baked-On Glaze	Glazed – 4.2-6.5%
Clay Brick[4]	6-12 inches	Un-Glazed	Un-Glazed – 15-20%

INFLUENCE PERCENTAGE ORNAMENT



Area in sq. meters

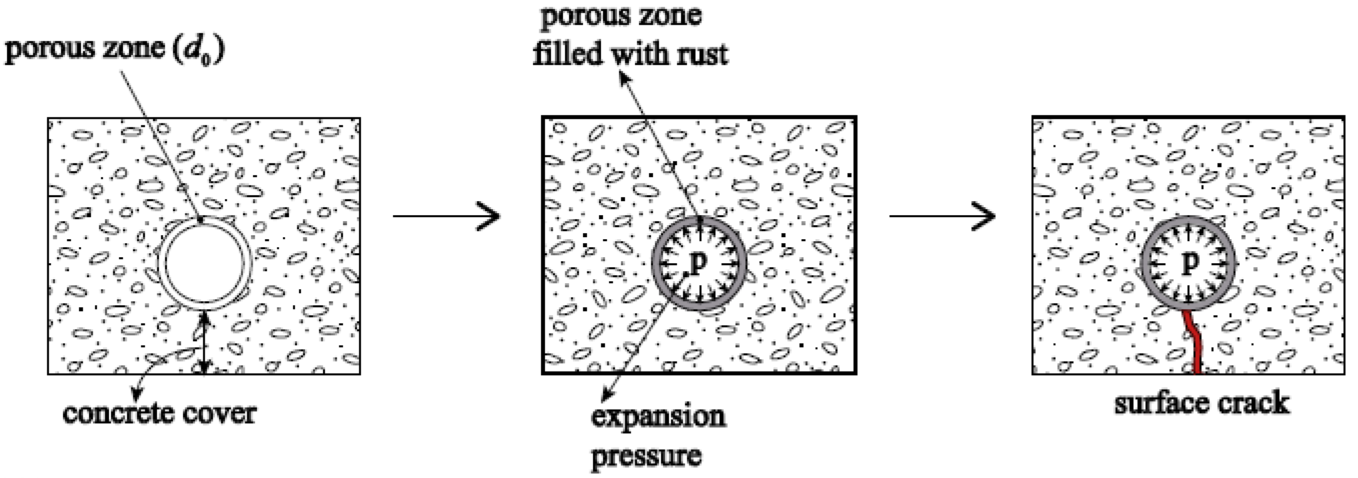
From Eschenasy Facades of Manhattan

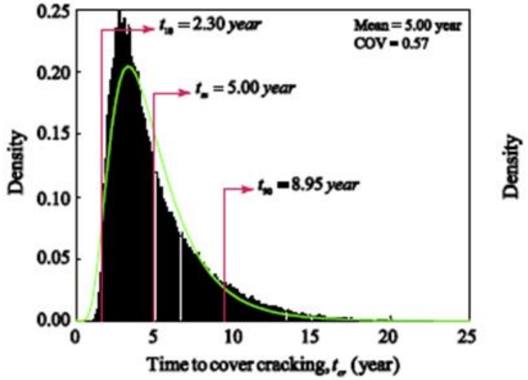
INTERIOR CONCRETE

CARBONATION & CORROSION

Carbon dioxide reacts to form carbonic acid and it is transported into concrete pores, leading CARBONATION. Carbonation starts at the outside and proceeds to the inside of a component. At the same time, the pH of the alkaline pore water decreases. When the carbonation front reaching the steel reinforcement causes the loss of the steel's protective alkaline layers; as a consequence the steel starts rusting. Rust causes a volume increase, so that resulting tension inside the cement paste may lead to cracking, blistering and spalling of the surface.

CRACK OF COVER REINFORCED CONCRETE





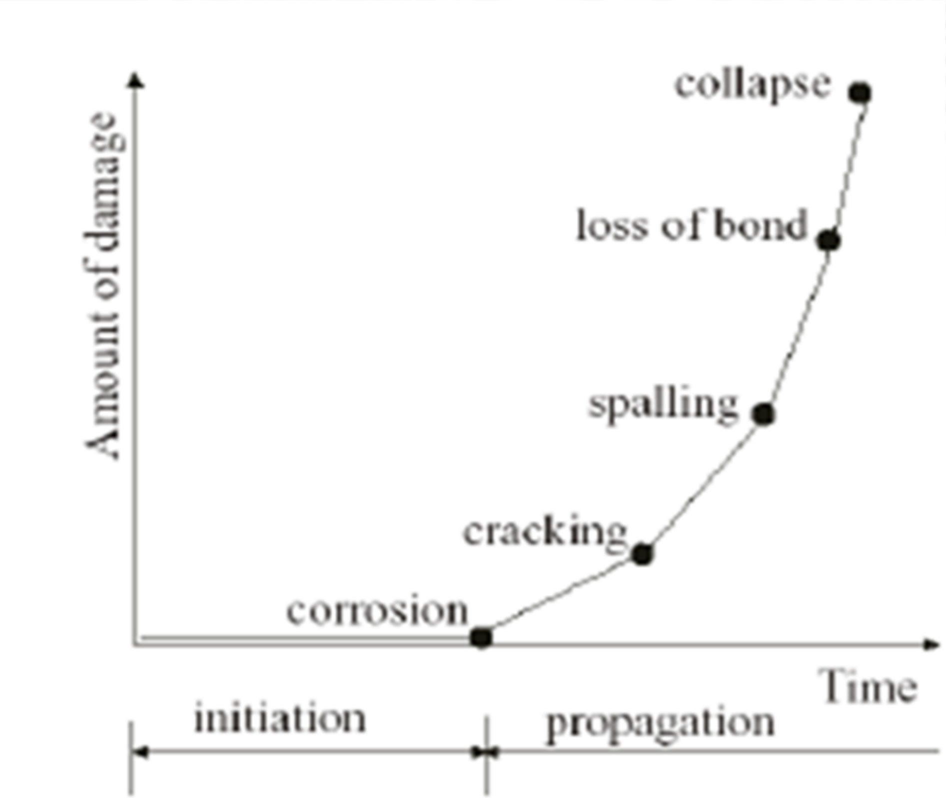
(c) El Maaddawy and Soudki, (2007)

FROM CHEN /CONSTRUCTOIN AND BUILDING MATERIALS

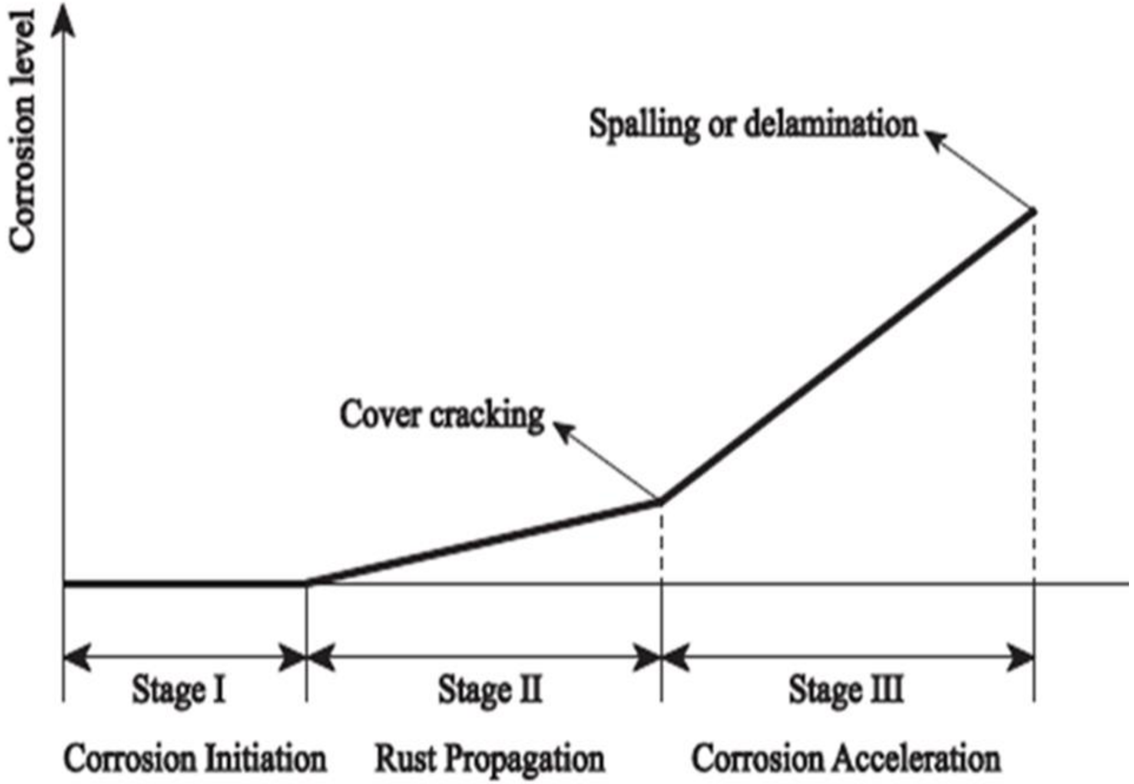
TIME TO COVER CRACKING

MODELS CONCRETE DETERIORATION

2 PHASES



3 PHASES



INTERIOR CONCRETE


Boiler Room


Garage

IRON & STEEL

1883 SCIENTIFIC AMERICAN: CORROSION OF IRON AND STEEL

- It was found that in moist air chromate steels were most rapidly corroded, and tungsten steels less than carbon steel. In similar conditions cast iron oxidized less than steel and soft iron; and white specular iron rusted less than gray cast iron. Thus hard white cast iron is the best for withstanding' damp air-an observation which agrees with common experience. Sea water, on the other hand, attacks cast iron more than steel, and especially the white specular kind.

- Tempered steel stands in sea water better than the same I steel annealed; and soft steel is less attacked than manganese or chromate steel.

- These experiments agree with the results obtained by Mallet in 1843 (..). Wrought iron and steel in such localities are thus seen to be exceptionally liable to decay.

METALS IN NYC AROUND 1900

- In New York City at the turn of the twentieth century, the metals used in the construction of new buildings were primarily steel, cast iron, zinc, and copper and copper alloys. Steel had largely supplanted unornamented cast and wrought iron as a structural material by the late 1890s. With the exception of a few prominent large facades, cast iron was reserved for storefronts, window surrounds, spandrels, gates, grilles, and fencing.
- Copper, lead-coated copper, and galvanized or terne-plated sheet steel were the metals available for roofing and flashing

1910 OBSERVATIONS ON CORROSION OF IRON AND STEEL

Steel has come into wide use simultaneously with a great increase in the sulphureous acid in our city air and of strong electric currents in our city ground it may lead the practical man into inferring that the rapid corrosion of today is certainly be due to sulphureous acid and electrolysis,

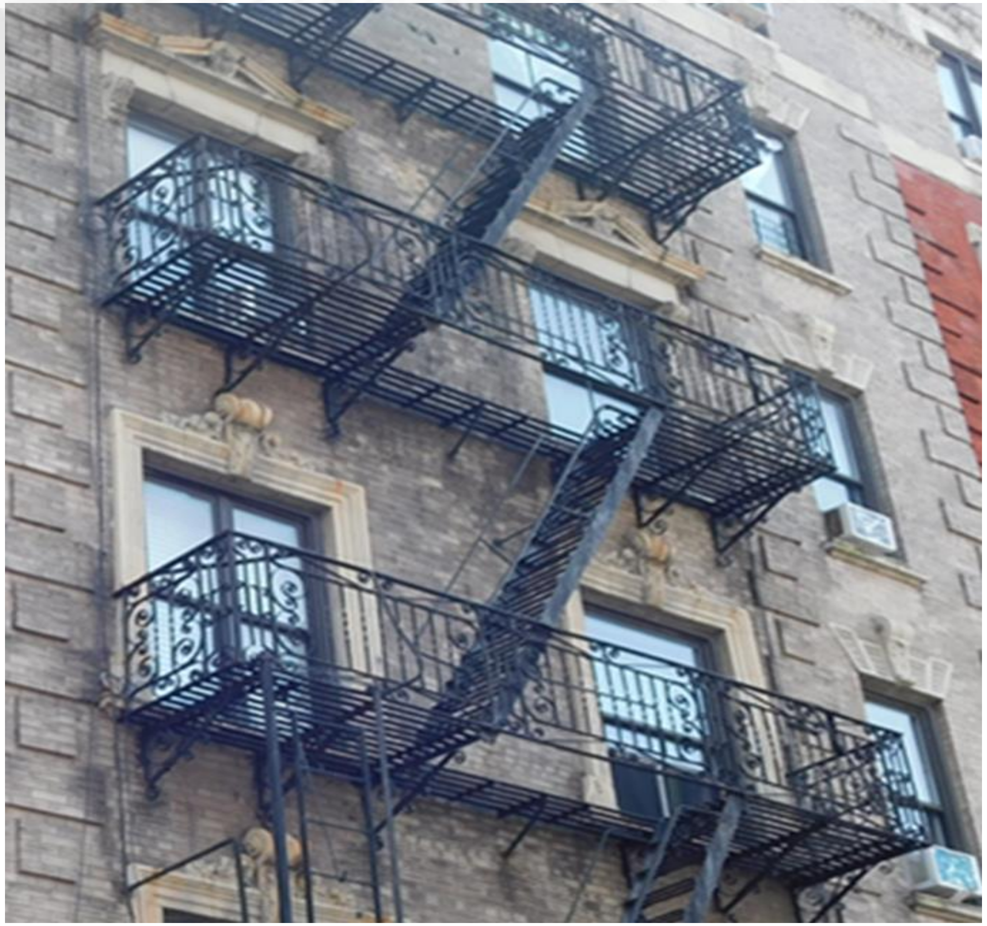
REMOVAL OF IRON FEATURES: LIFE LENGTH

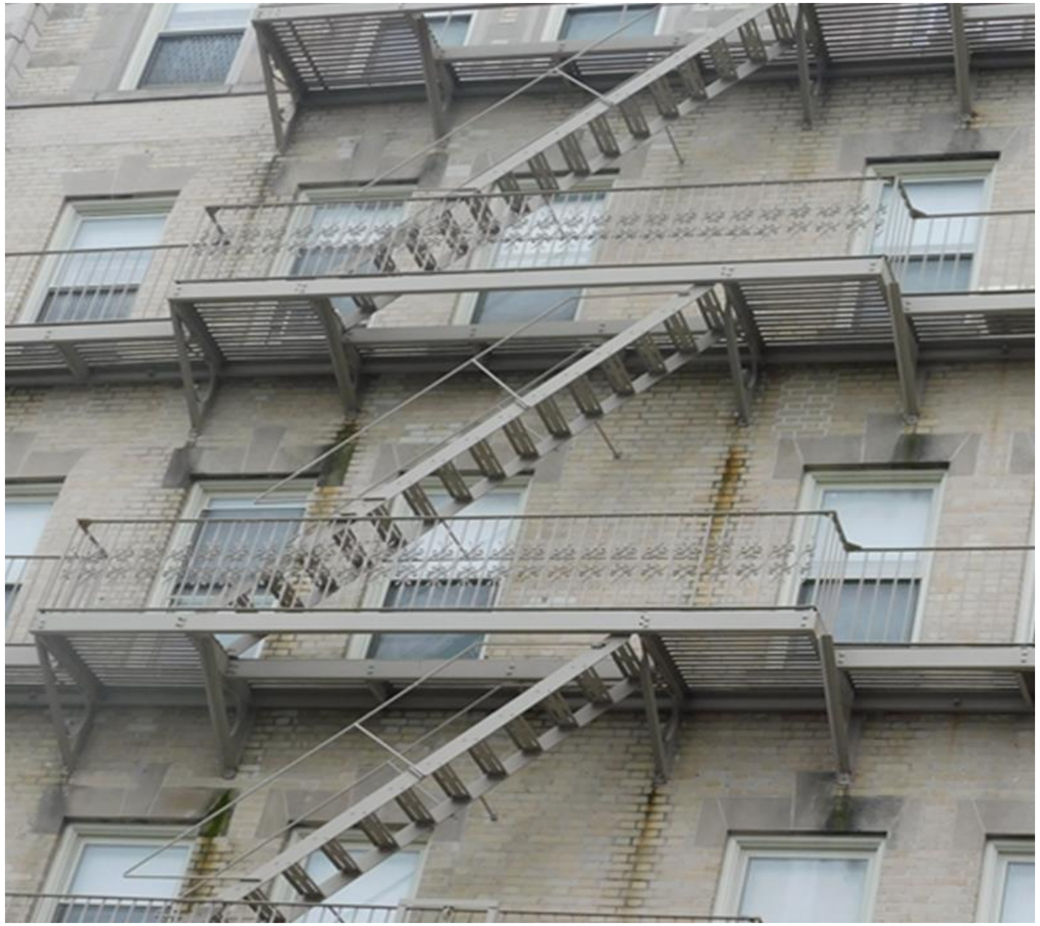
- **Built 1908**

BASICS OF STEEL CORROSION

For iron alloys without special alloying, the most evident source of degradation is rusting. The most common recourse is to coat the material surface with paint or some type of environment-resistant plating, such as zinc galvanizing or a similar electroplated coating. All of these TREATMENTS ARE EFFECTIVE FOR A PERIOD OF TIME BUT EVENTUALLY MUST BE RENEWED, SINCE SOME OF THESE PROTECTIONS ARE THEMSELVES DEGRADABLE OR SACRIFICIAL. Without these coatings, iron-based materials exposed to moisture are consumed as iron oxide develops on the iron surface. The rate of consumption is affected by the presence of elements in the environment, such as salt or chemicals; in all but very dry environments, the process will eventually consume most iron or steel materials. To prevent this corrosion, either special surface protection or additional alloying is necessary.

WROUGHT IRON vs STEEL WEATHERING





BURIED METALS

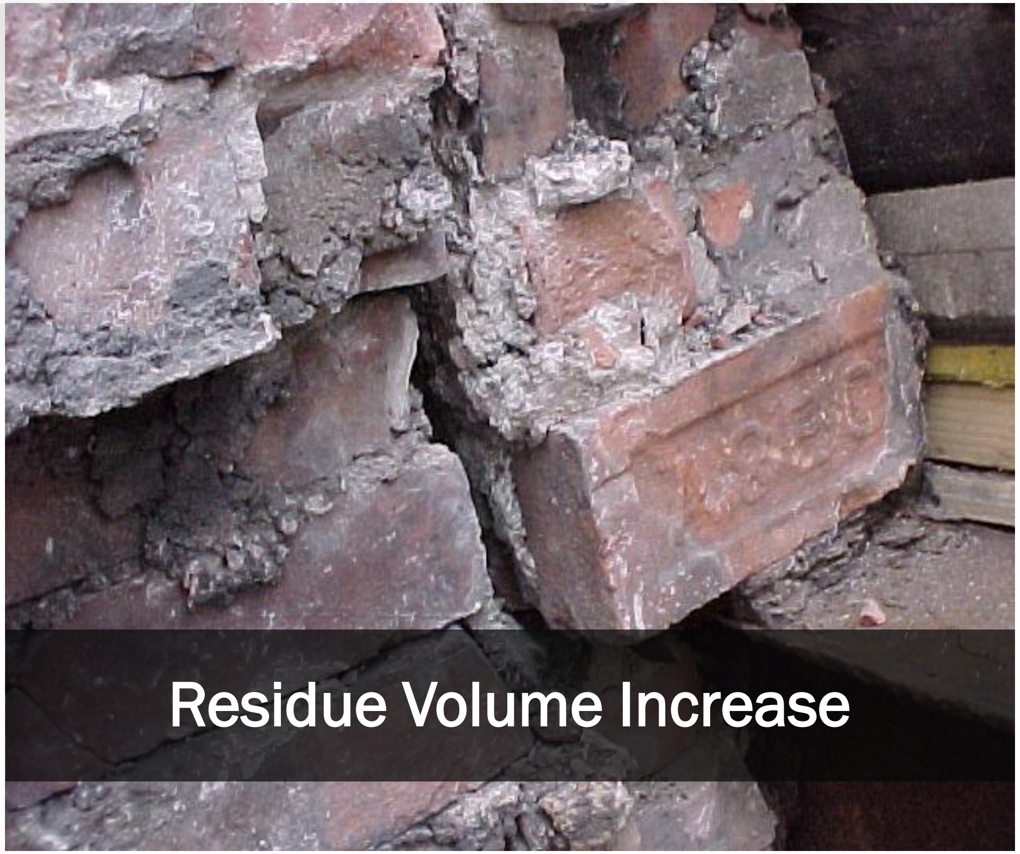
Data from the US NBS study for corrosion of buried objects are employed to show that average annual atmospheric precipitation directly influences corrosion of ferrous objects buried in various soils. The relationship and the amount of corrosion also depend on soil type, a matter not previously considered.

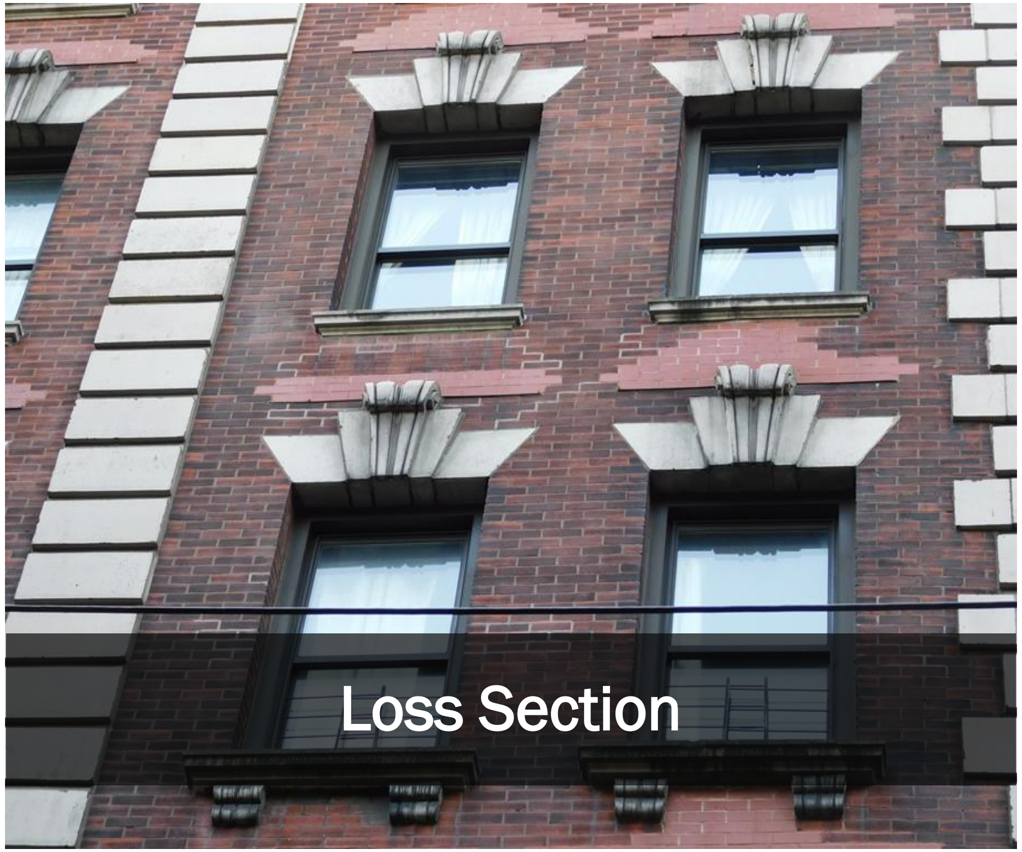
The effect of atmospheric precipitation on the corrosion of ferrous metals buried in soils - Robert E. Melchers

STEEL DETERIORATION INTERIOR

STEEL & MASONRY

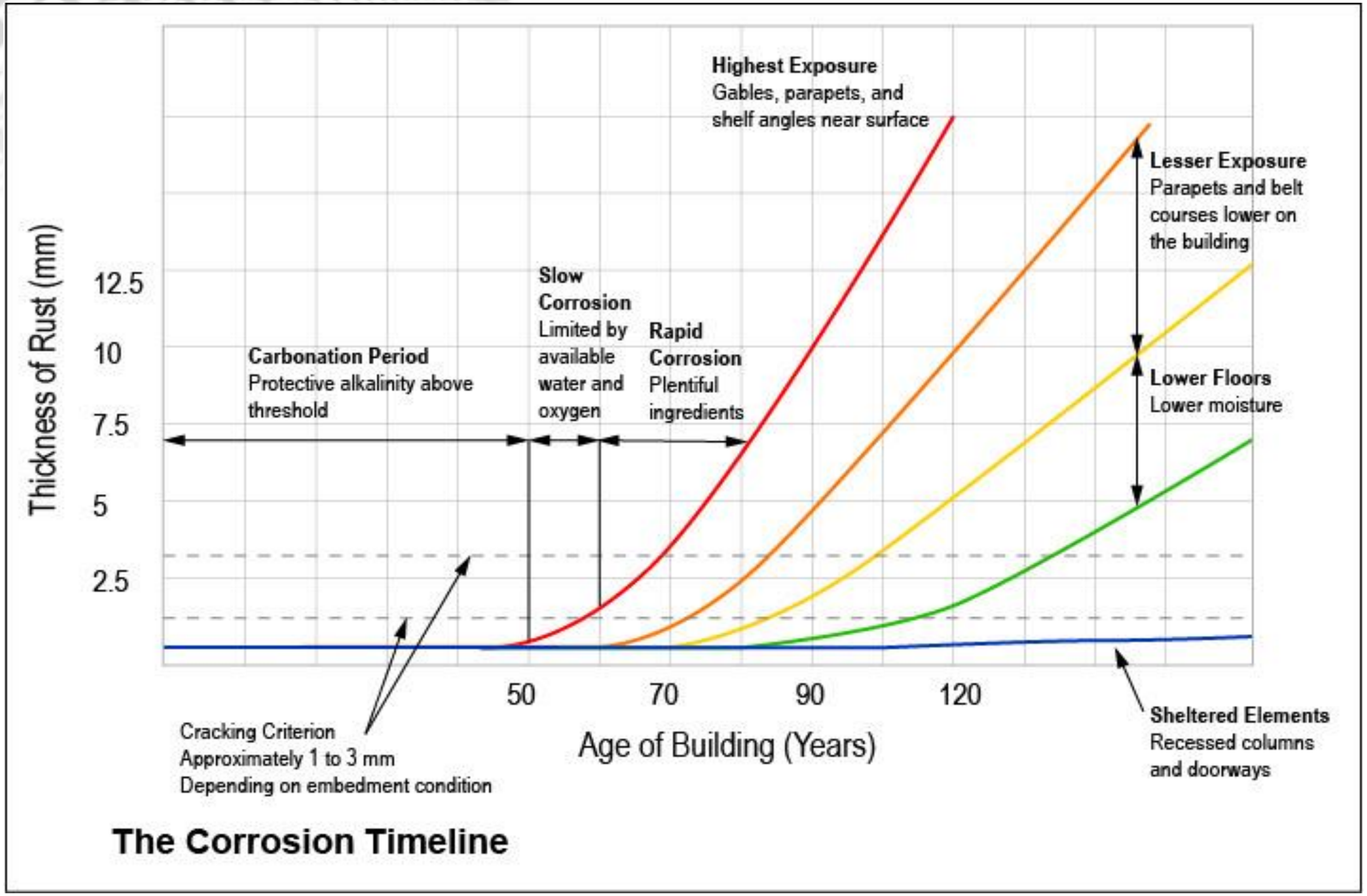
EMBEDDED STEEL CORROSION ACCIDENTS





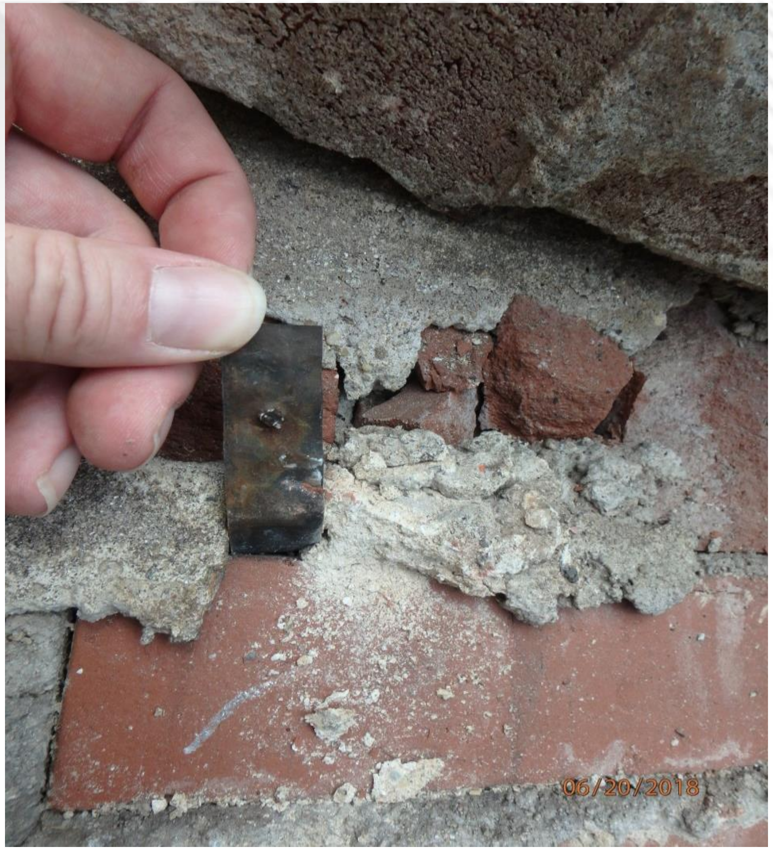
CORROSION

CORROSION TIMELINE



From G. Crevello

TIES



Life Expectancy

- BIA - 6 year for ties and 20-30 anchors
- ACI - 7 years embedded ties and 16 years for not embedded
- Cover PROPERTIES

EVOLUTION SPECIFICATIONS ANCHOR MATERIALS

BRICK VENEER

YEAR	CODE	REQUIREMENT
1899		wire or 1-1/4 in tie galvanized
1938	NYC	one substantial metal tie
1943	NBS	1/4in dia corrosion resistant
1946		corrugated, non corrodible
1966	BIA	22 ga, corrugated metal, corrrsion resitant
1968	NYC	3/16 in dia. corrosion resistant (copper coated or zinc coated, or of metal equivalent to zinc-coated mild steel)
1986	BIA	corrugated metal

TERRA COTTA

YEAR	SOURCE	WHEN	MATERIAL
1899	NYCBC	ashlar?	not specified
1906	Brickbuilder		wrought iron painted or galvanized
1906	Brickbuilder	small pieces	copper wire
1911	Kidder	unbalanced	wrought iron or copper
1914	National Terra Cotta		thoroughly protected with rust preventing pigment
1927	National Terra Cotta	balanced	not less than1/4 x 1/4"or round or square bars or No. 6 gauge galvanized wire

THANK YOU