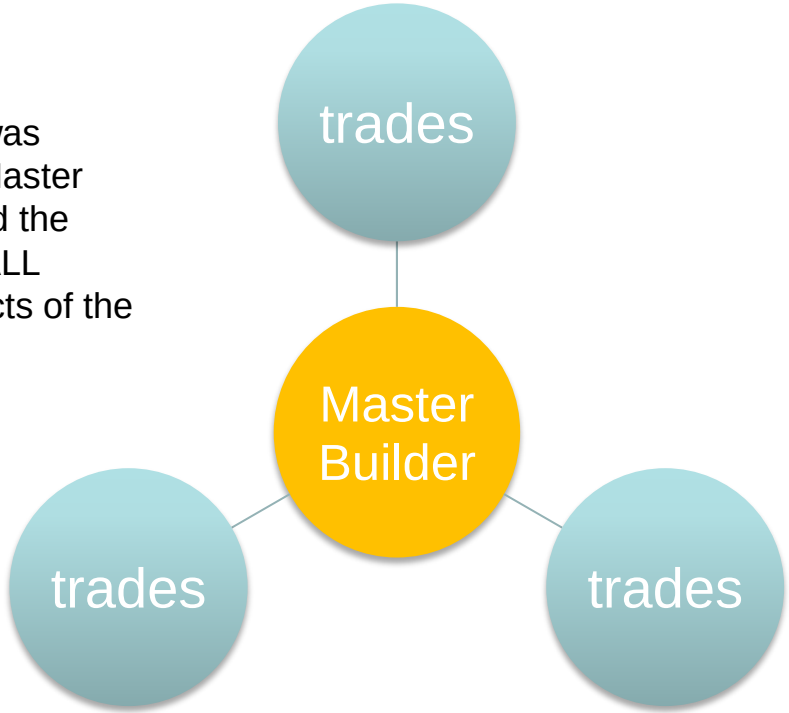
Making and Designing Buildings: The Impact of Regulatory Frameworks on the Form of our Environment

Law Code of Hammurabai
1750 BCE

If a builder build a house for a man and do not
make its construction firm,
and the house which he has built collapse
and cause the death of the owner of the house,
that builder shall be put to death.
If it cause the death of a son of the owner of the house,
they shall put to death a son of that builder.

Pre-Industrial Era Design Process:

The Architect was considered a Master Builder and had the knowledge of ALL technical aspects of the project.



As buildings became more complex and large
… early 1800s to 1900 …
The work was often divided into design decisions
made by an Architect and an Engineer

Towns were developed near rivers for water and eventually power

Sewage, fecal matter, etc. was directed into the nearby rivers

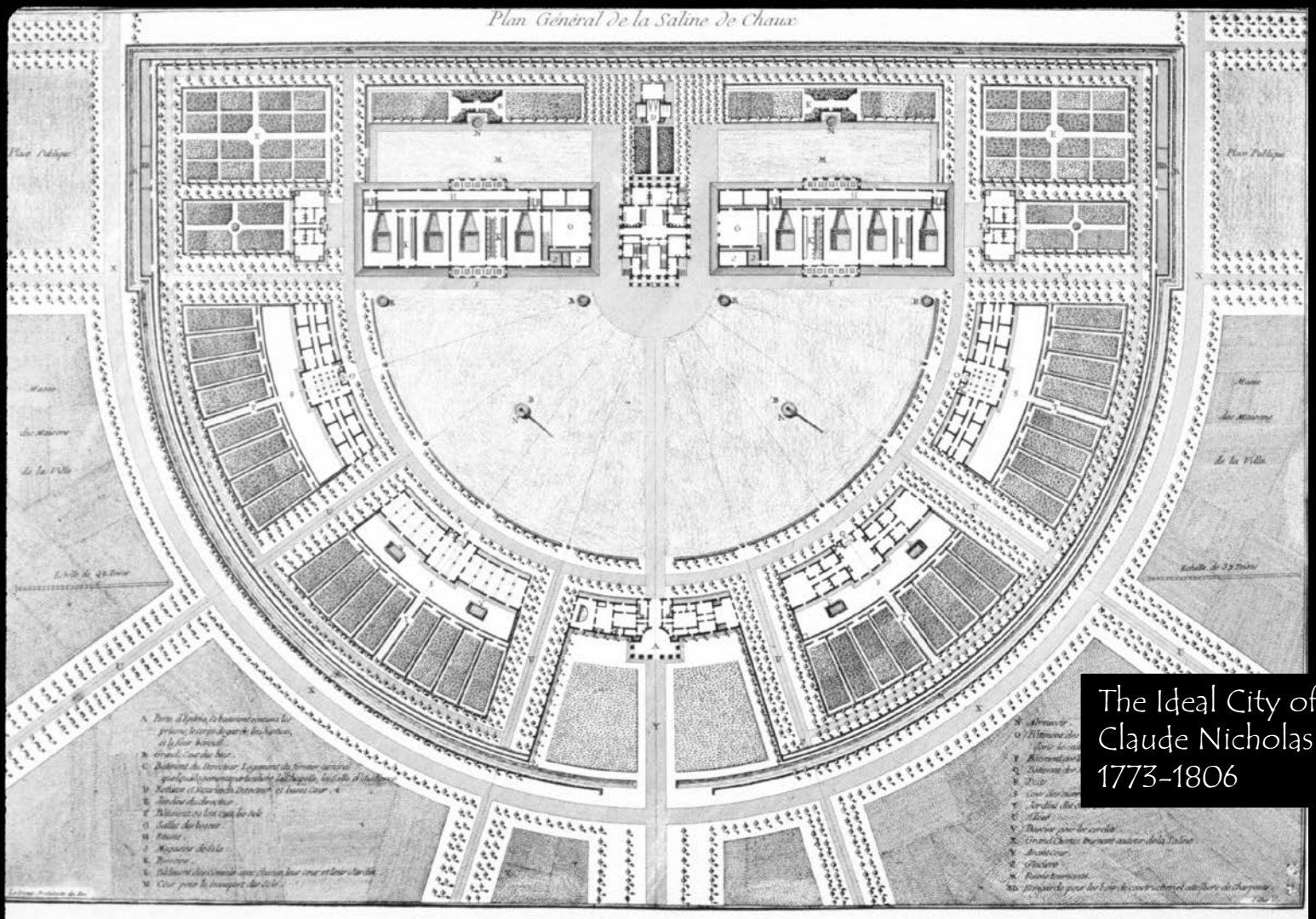
People drew their drinking water from the same river assuming the waste was diluted


CITY
BICYCLE
SCHOOL
SINGER'S
SEWING
MACHINES

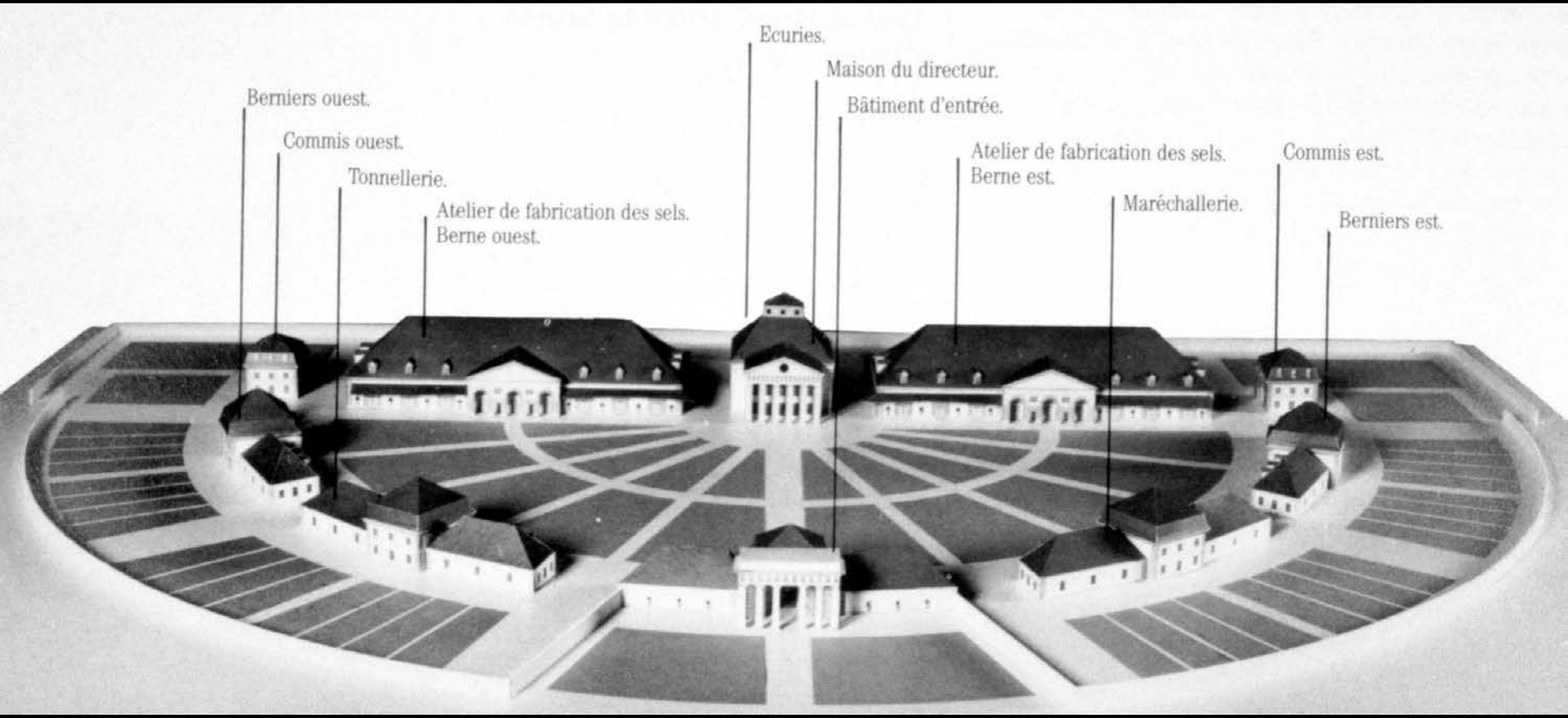
Industrialized cities were abhorrent places

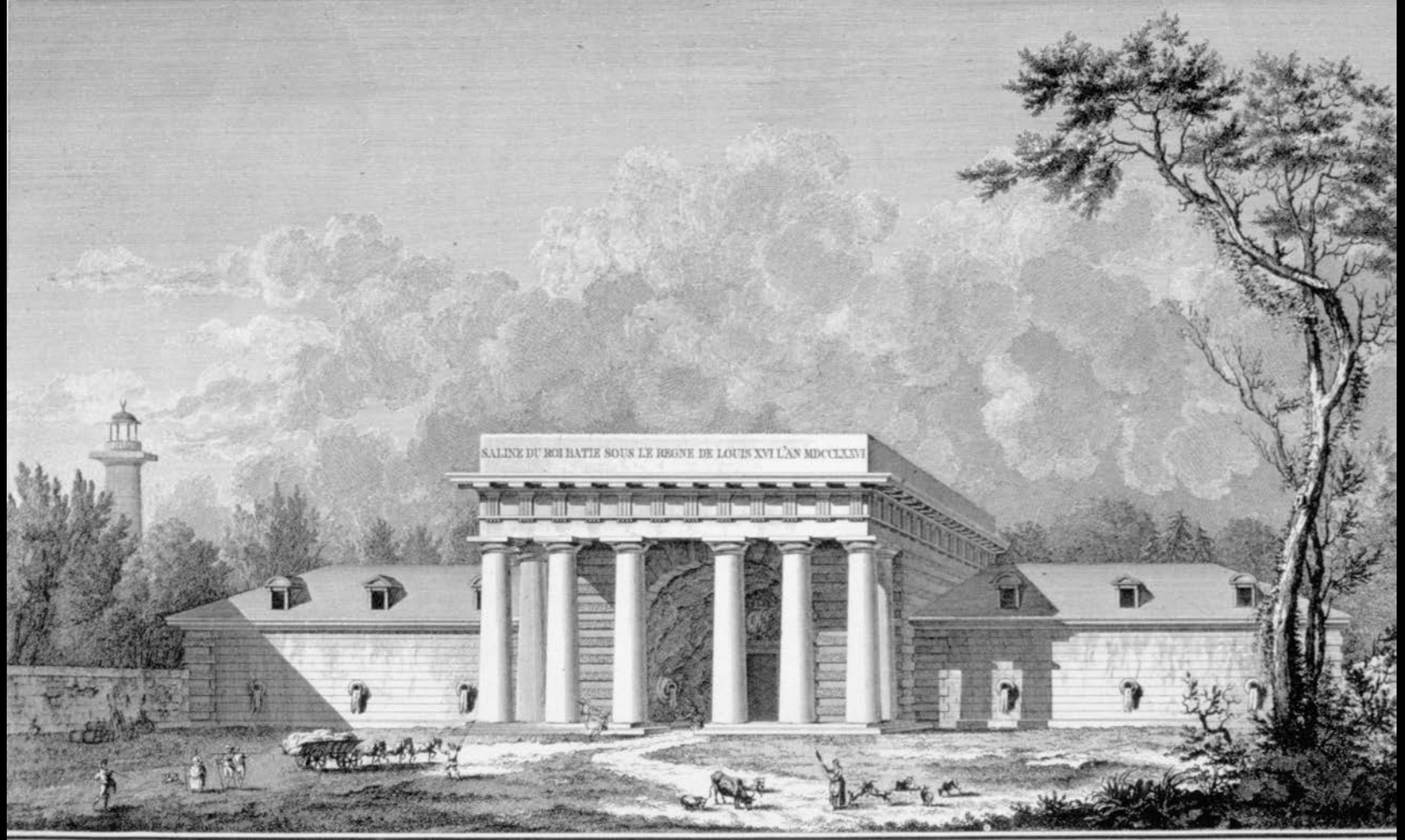
Coal fired equipment spewed waste into the air

People needed to live nearby their work as there was no public transportation

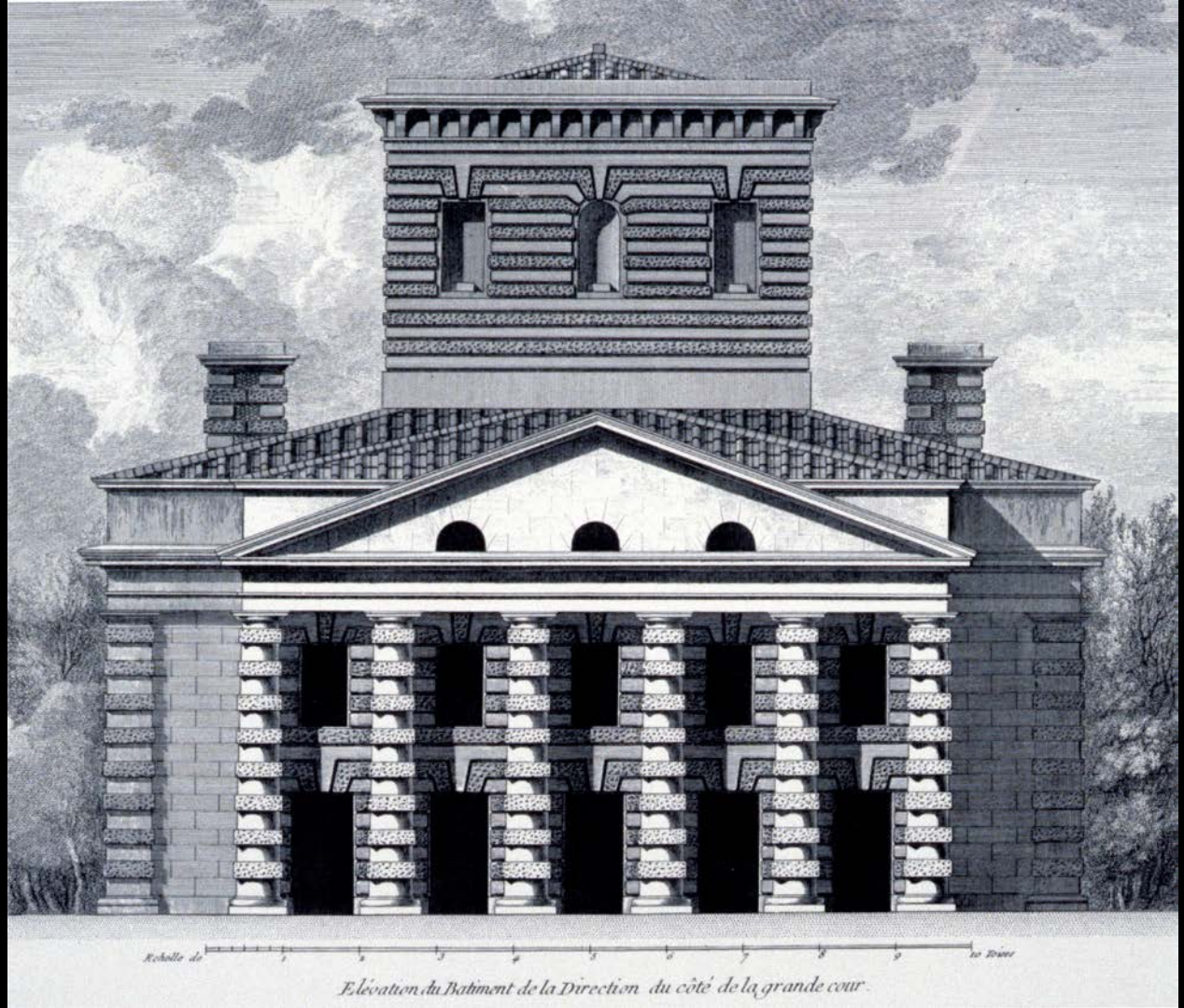


The Ideal City of Chaux, France
Claude Nicholas Ledoux
1773-1806

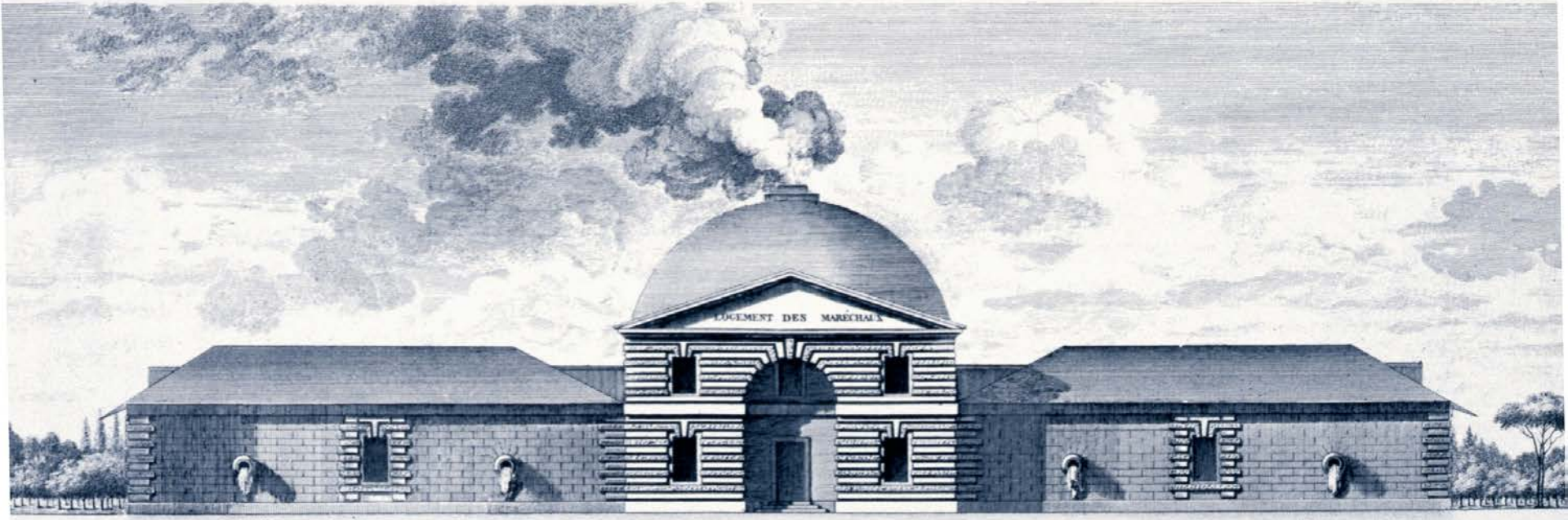

Ecuries.
Maison du directeur.
Bâtiment d'entrée.
Berniers ouest.
Commis ouest.
Tonnellerie.
Atelier de fabrication des sels.
Berne ouest.
Atelier de fabrication des sels.
Berne est.
Maréchallerie.
Commis est.
Berniers est.



PORTE DE LA SALINE DE CHAUX.



Elévation du Batiment de la Direction du côté de la grande cour.

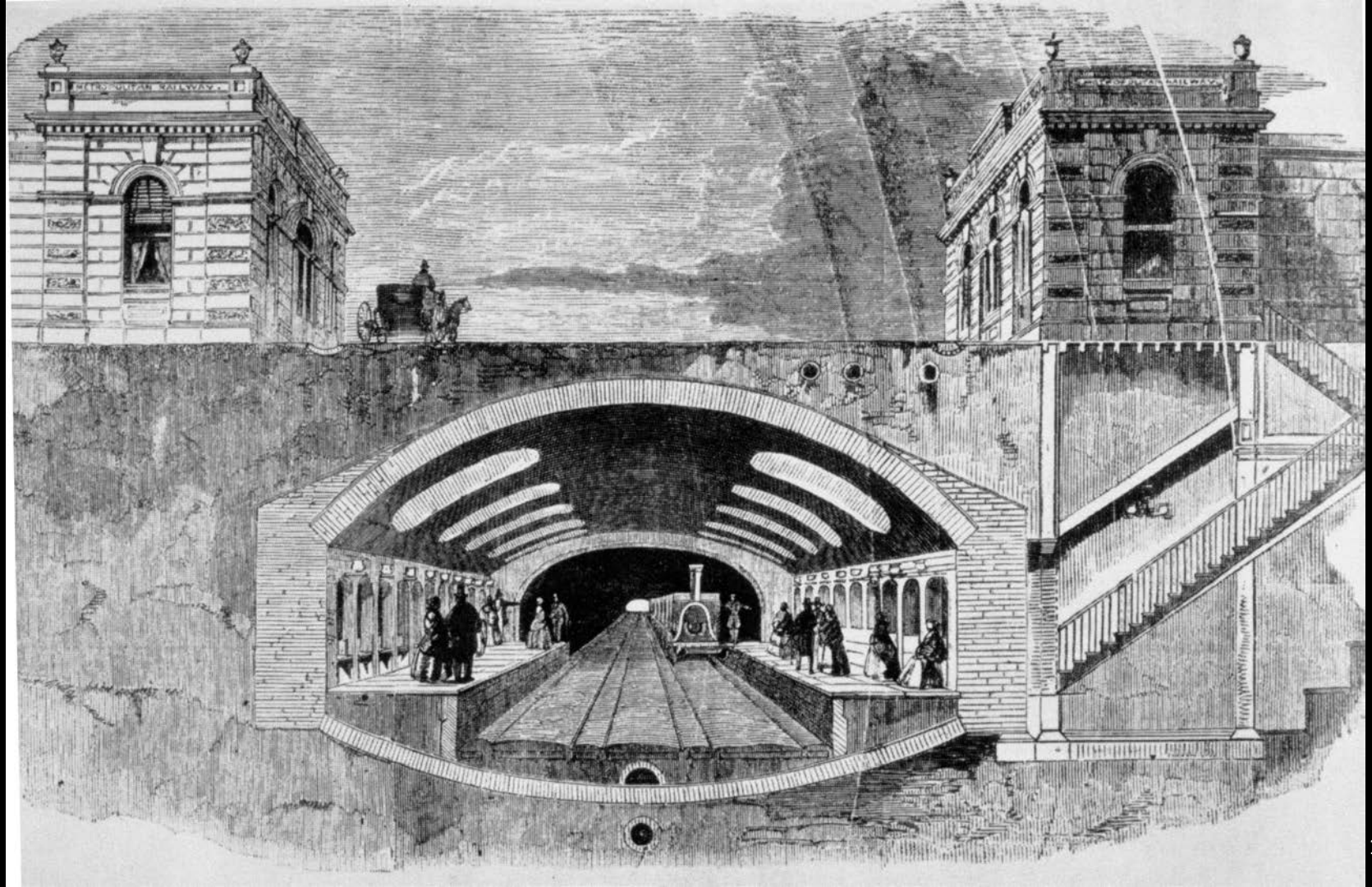


Élévation d'un des Bâtimens d'Ouvriers qui forment l'enceinte de la grande Cour.

Echelle de 1 2 3 4 5 *de Toises*

Doue Architecte du Roi

Gravé par Sen



BUILDING AND FURNITURE

FOR AN

INDUSTRY-HOUSE ESTABLISHMENT,

FOR 2000 PERSONS, OF ALL AGES.

ON THE

PANOPTICON OR CENTRAL-INSPECTION PRINCIPLE.

☞ For the Explanation of the several Figures of this PLATE, see "Outline of a Work, entitled PAUPER MANAGEMENT IMPROVED;" Bentham's Works, vol. viii., p. 369 to p. 439.

The Ranges of Bed-Stages and Cribs are respectively supposed to run from End to End of the *radial* Walls, as exhibited in the GROUND PLAN: they are here represented as cut through by a Line parallel to the Side of the Polygon: in the Bed-Stages, what is represented as *one* in the Draught, is proposed to be in *two* in the Description.

FIG. I.—ELEVATION.

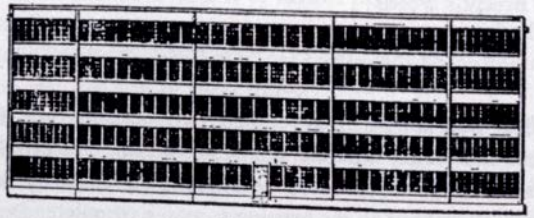


Figure 25a

19 (A and B) Bentham's Panopticon.

FIG. II.—SECTION

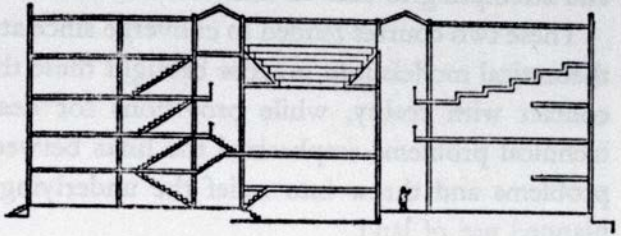


FIG. III.—GROUND PLAN.

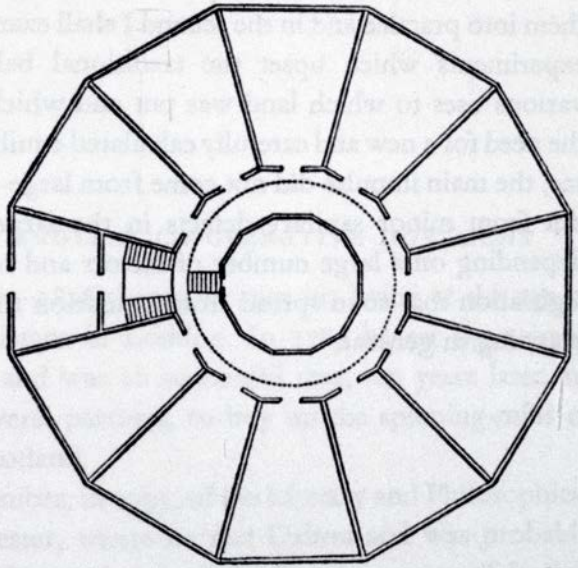
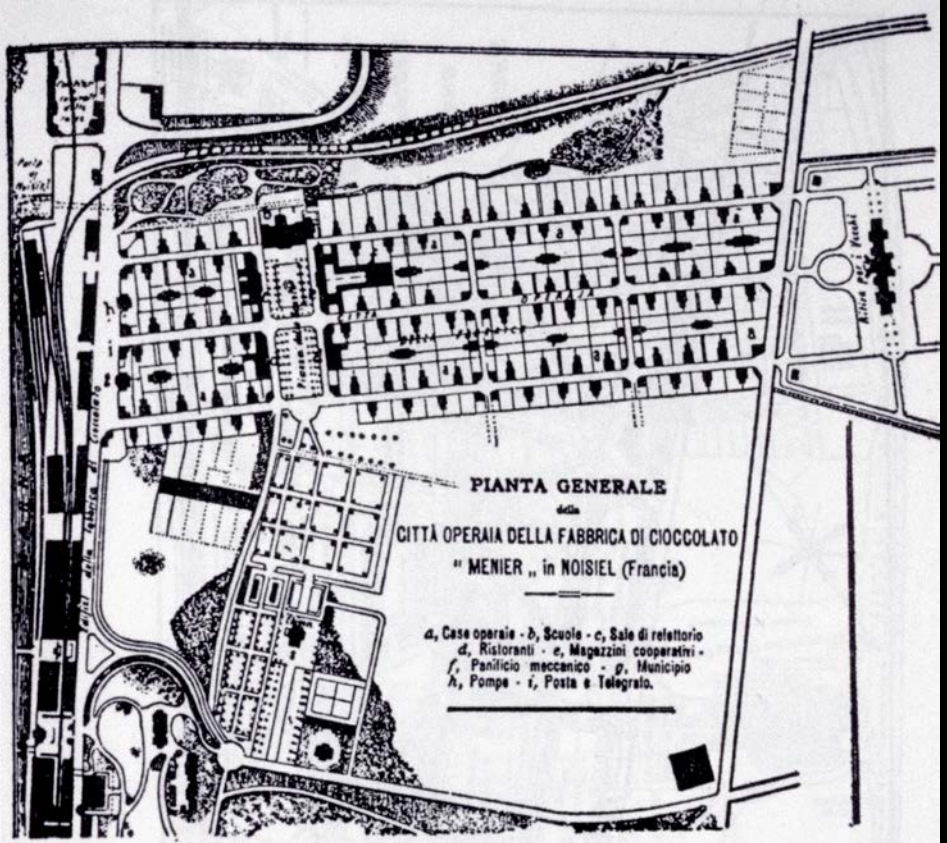


Figure 25b

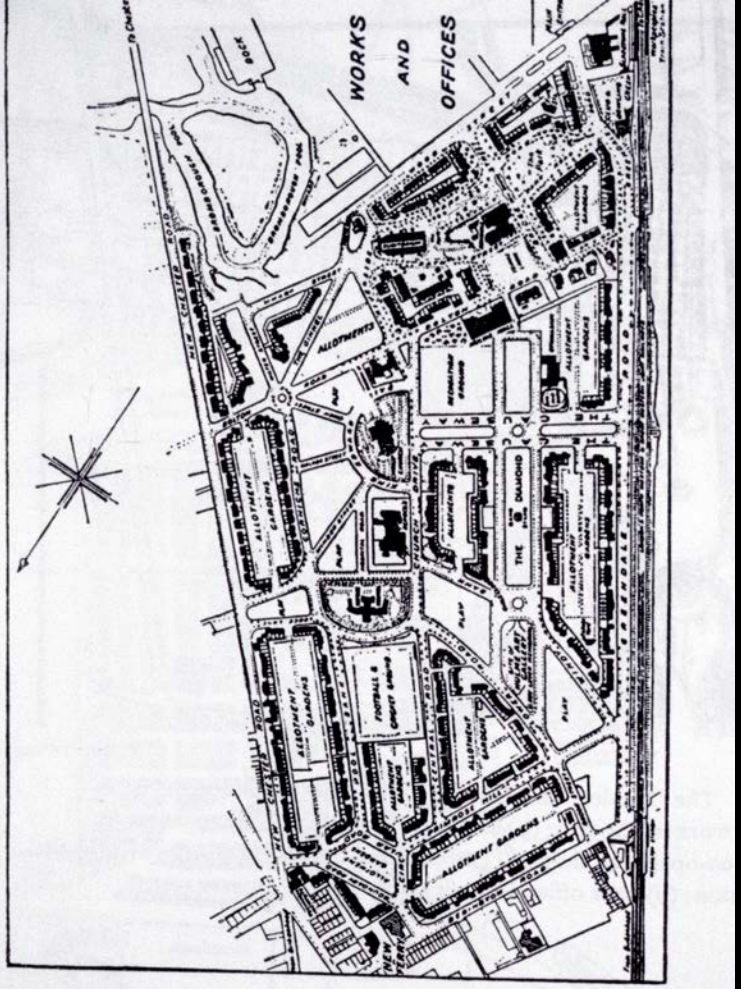
IDEAL TOWNS:
With the advent of industry some owners asked architects to design complete towns for them to keep the workers housed nearby

20 Drawing of Robert Owen's ideal Village.



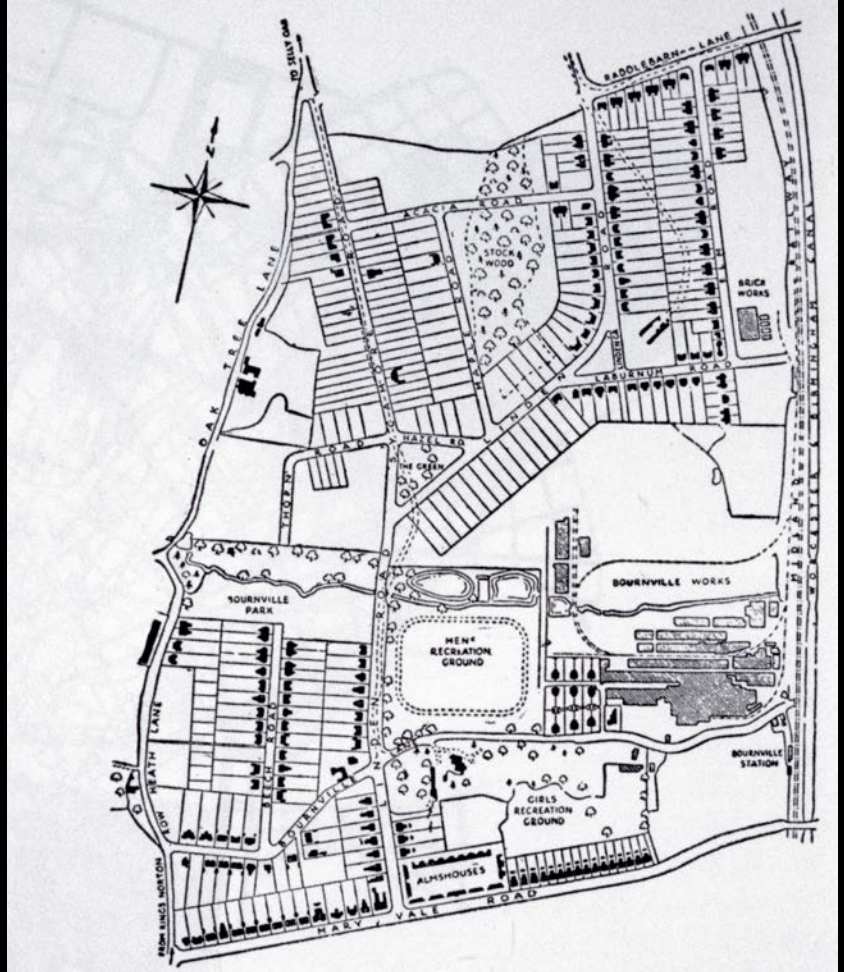
39 The 'Menier' Cité Ouvrière at Noisiel sur Marne (1864): (a) workers' houses; (b) schools; (c) refectory; (d) restaurants; (e) co-operative shops; (f) mechanised bakery; (g) town-hall; (h) fire station; (o) post office and telegraph.

Plan of Menier City, France
1864



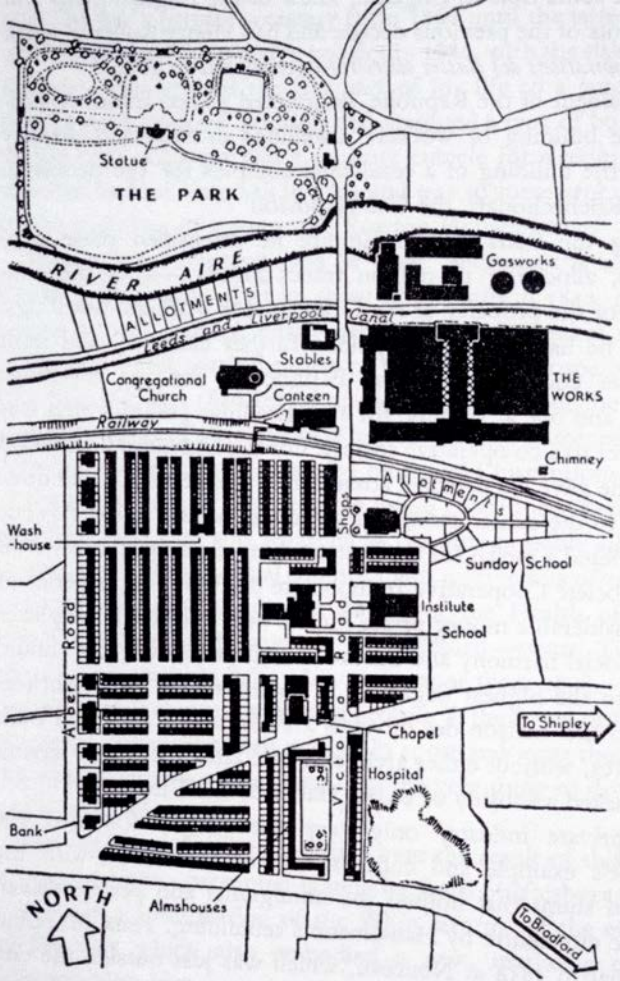
40 Plan of Port Sunlight, founded by W. H. Lever in 1887 (from A. Whittick, *Modern Architecture*).

Plan of Port Sunlight, UK
(Lever Brothers)
1867



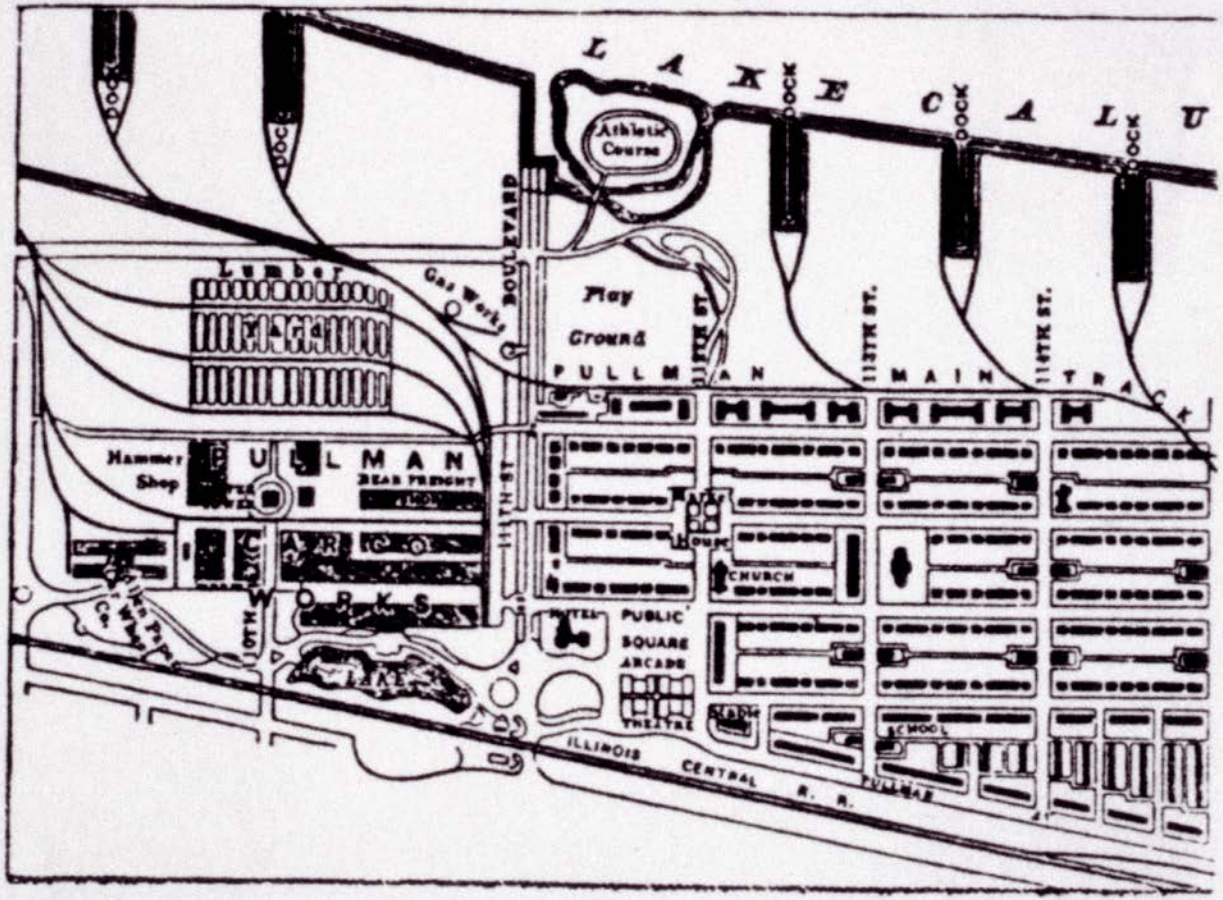
41 Plan of Bournville, founded by G. Cadbury in 1895 (from P. L. Giordani, *L'Idea della citta-giardino*).

Plan of Bourneville (Cadbury) 1895



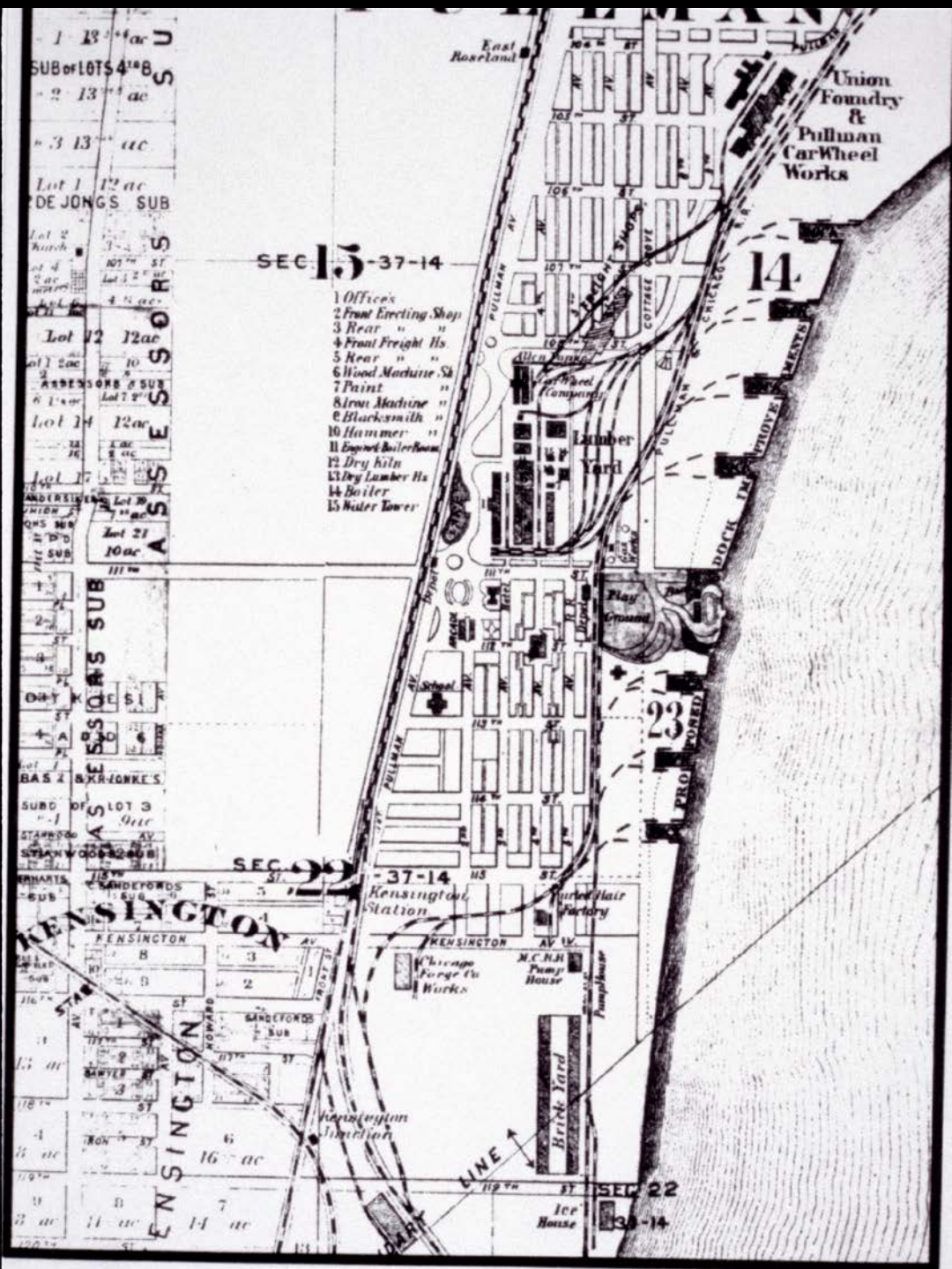
38 Plan of Saltaire, founded by T. Salt in 1851 (from C. Stewart, *A Prospect of Cities*).

Plan of Saltaire
1851



S.S. Beman, factory (left) and town of Pullman, Chicago, illustrated in 1885.

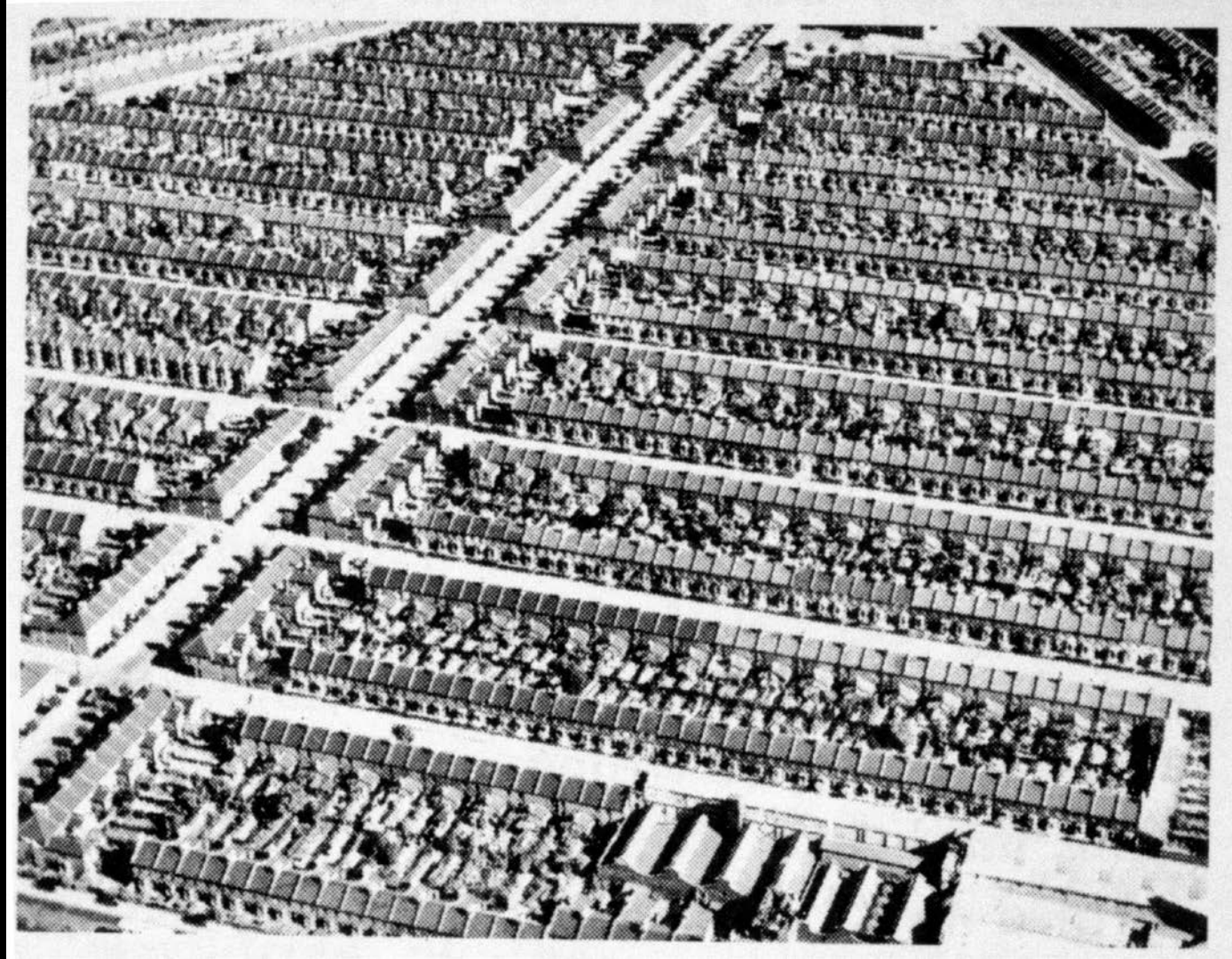
Plan of Pullman near Chicago
(Pullman Rail cars)
1885

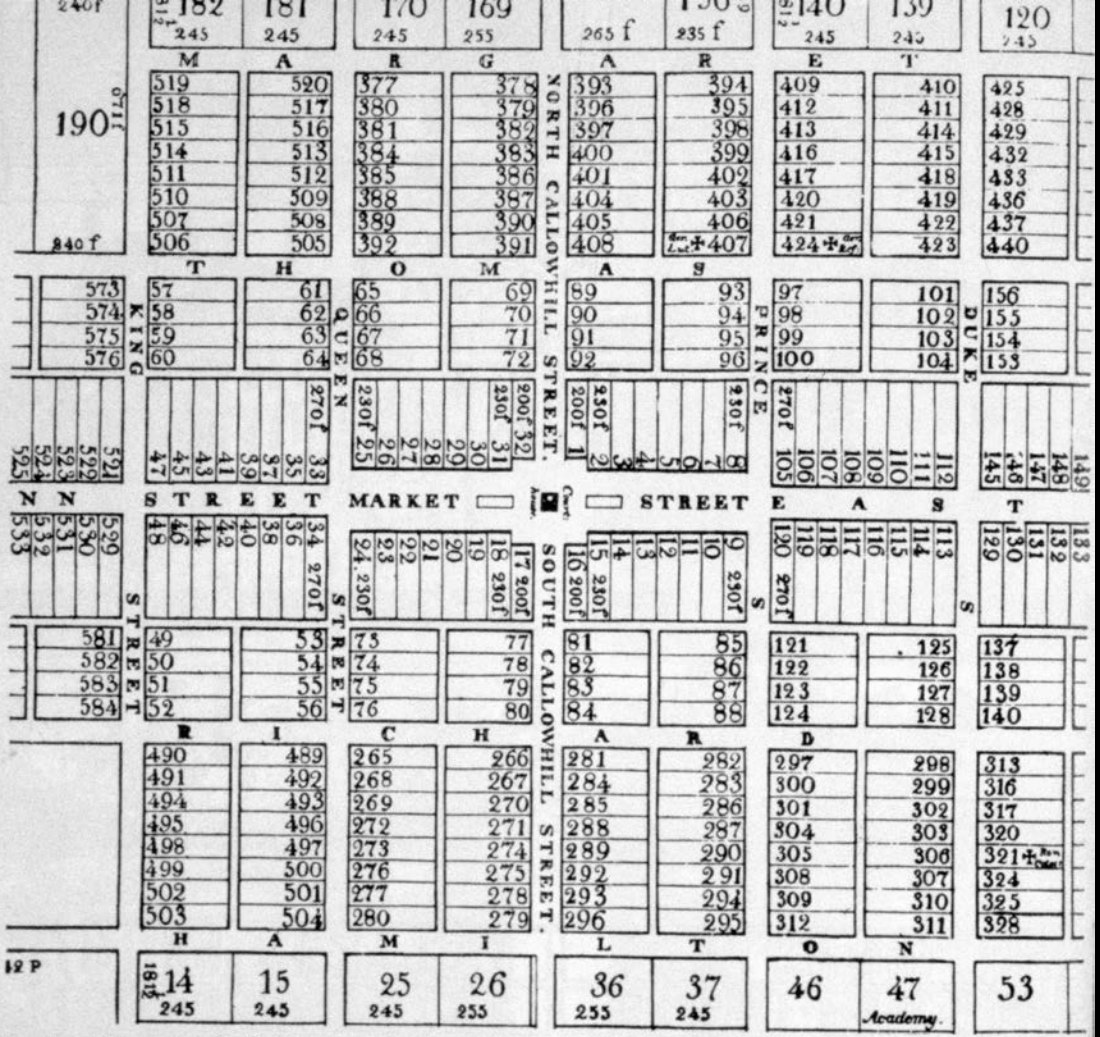


Chicago Historical Society

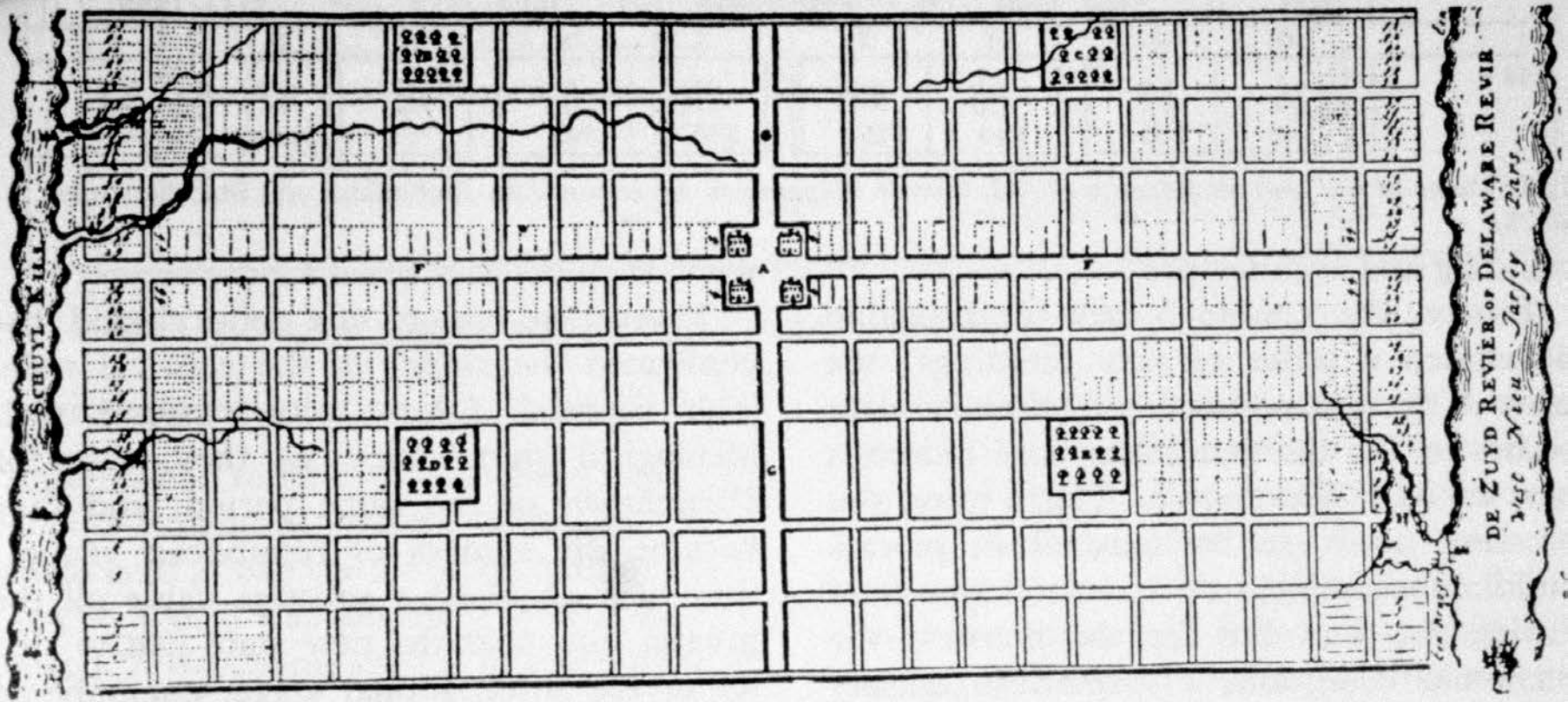
MAP OF PULLMAN


Piaz. Colonna
PIAZZA NAVONA
Piazza di Monte Cavallo
Palazzo Panfilj
Palazzo 173 Rospigliosi
PALAZZO 281 COLONNA
Pal. di Venezia
ISOLA

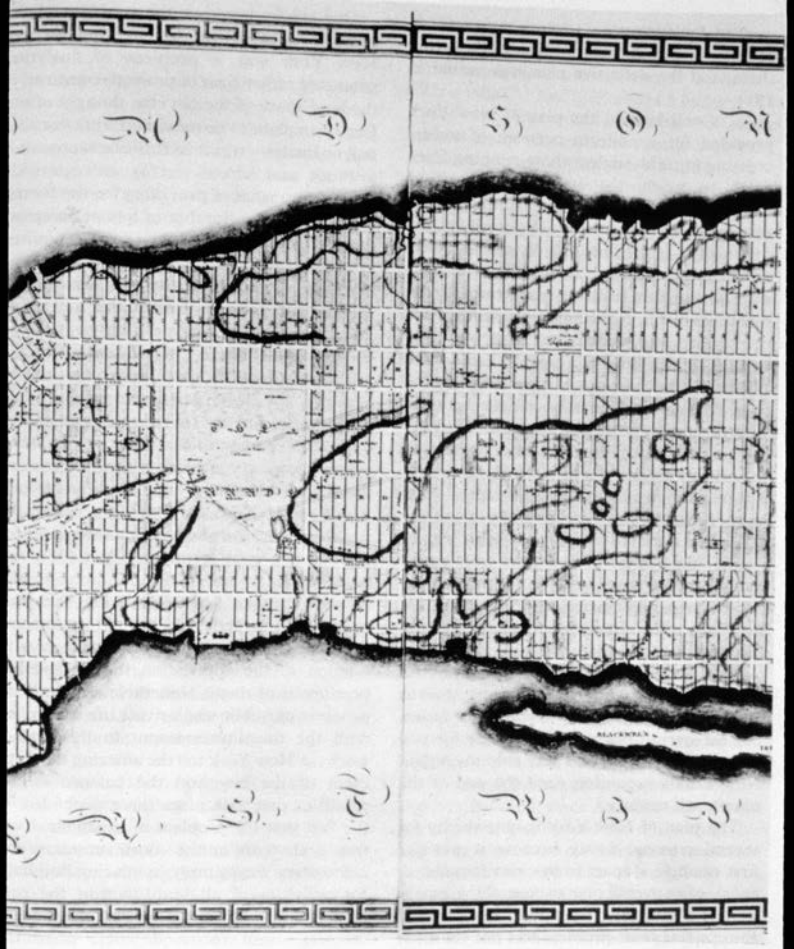




198 *Detail of the plan for Reading (1748, from H. Hegemann,* Amerikanische Architektur und Stadtbaukunst, *1925)*

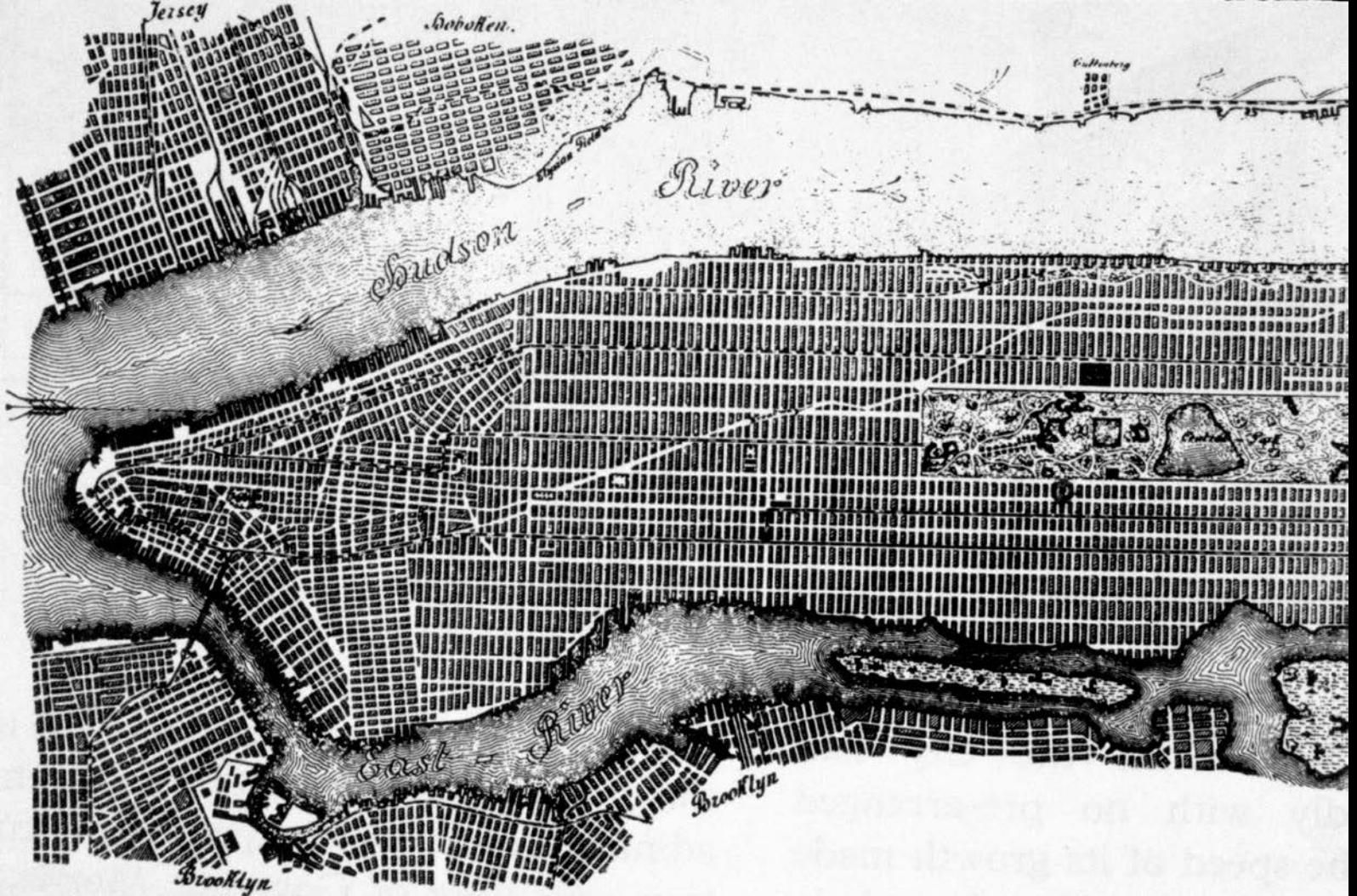


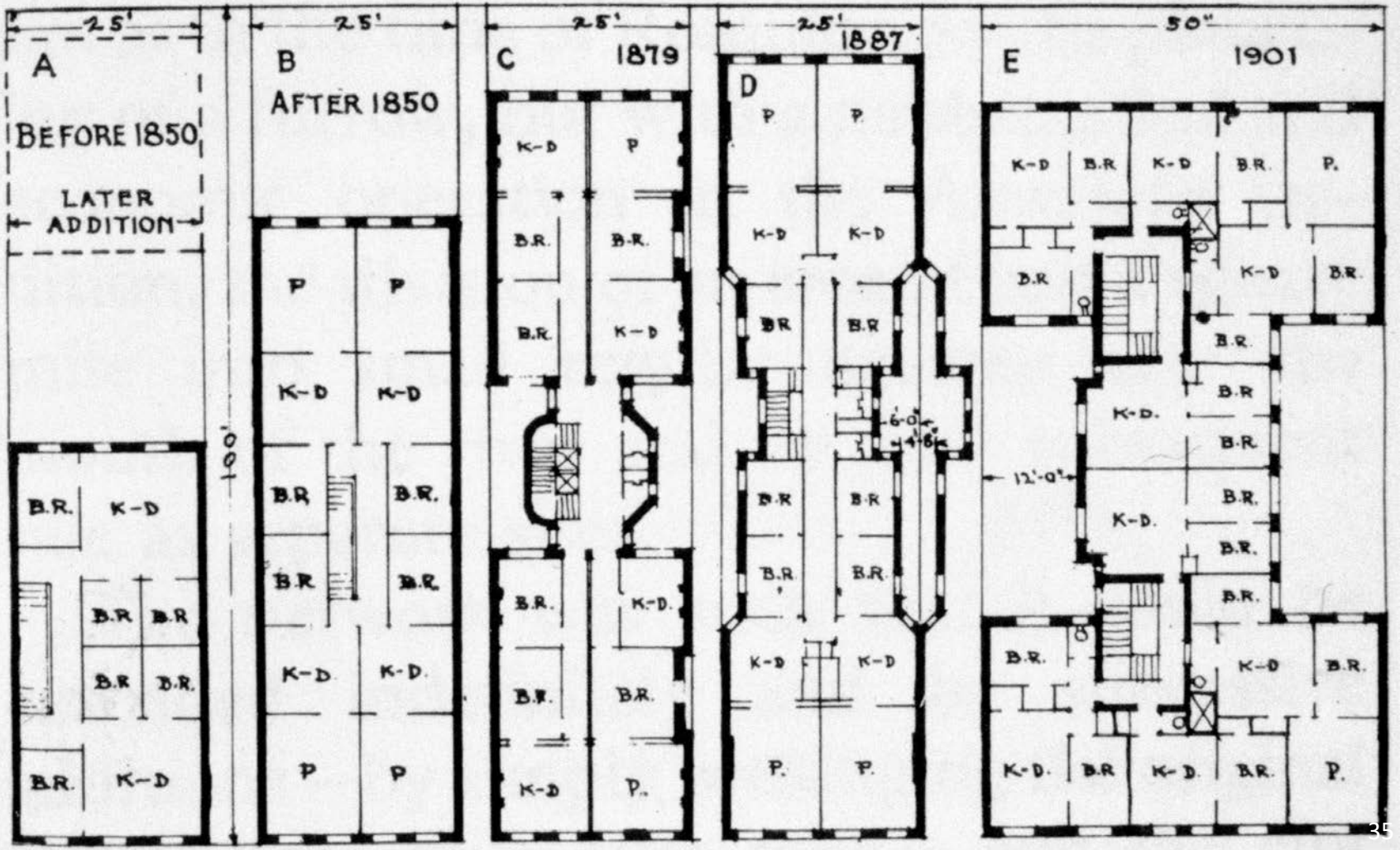
196 *American public building was still inspired by European models. Here are some buildings in Cambridge, Mass., of 1699 (from L.C. Tuthill,* History of Architecture, *Philadelphia, 1848)*
197 *Penn's plan for Philadelphia (1682)*

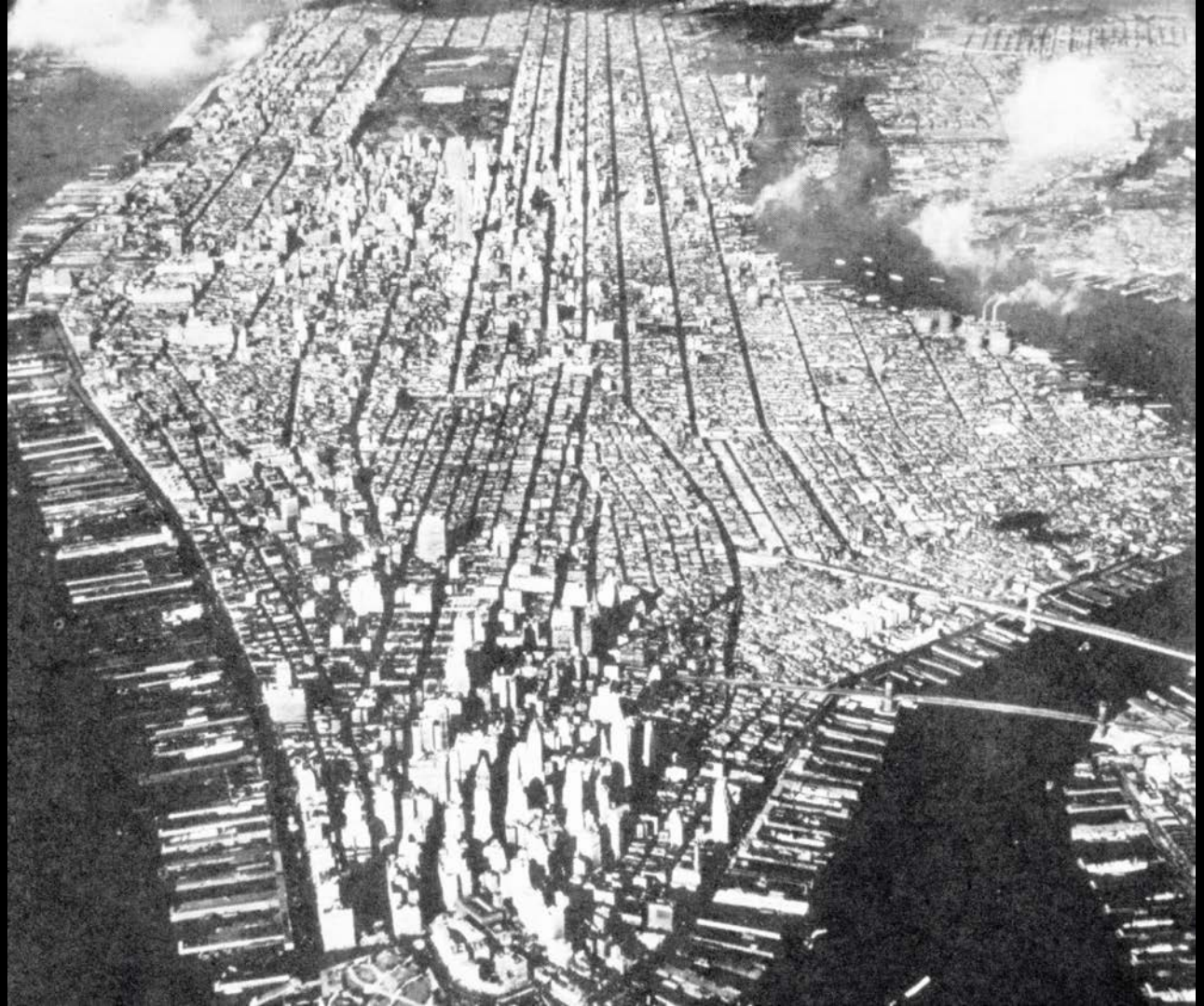


16 *A portion of the 1811 plan for New York; the chess-board was imposed on the projections and unevenness of Manhattan without losing its uniformity (from the original preserved in the public library)*


BATTERY.
CITY OF NEW YORK.


Jersey
Hoboken.
Guttenberg
River
Hudson
East River
Brooklyn
Brooklyn


25'
A
BEFORE 1850
LATER ADDITION
100'
B.R.
K-D
25'
B
AFTER 1850
P
K-D
25'
C
1879
B.R.
K-D.
25'
1887
D
P
K-D
6'-0"
4'-8"
50'
E
1901
12'-0"
P.



Up until the mid 1800s there was virtually nothing in place to determine where and what could be built

No laws to protect the public
No rules governing structural safety
No codes

Nothing

Basically, the Wild West

When do I need an Engineer or Architect?

Only buildings:
MORE THAN 3 ½ storeys
Over 600 m2

Need to be signed off by a person holding a Peng or Architect's Certificate of Practice

Meaning most houses and small buildings can be designed by almost anyone.

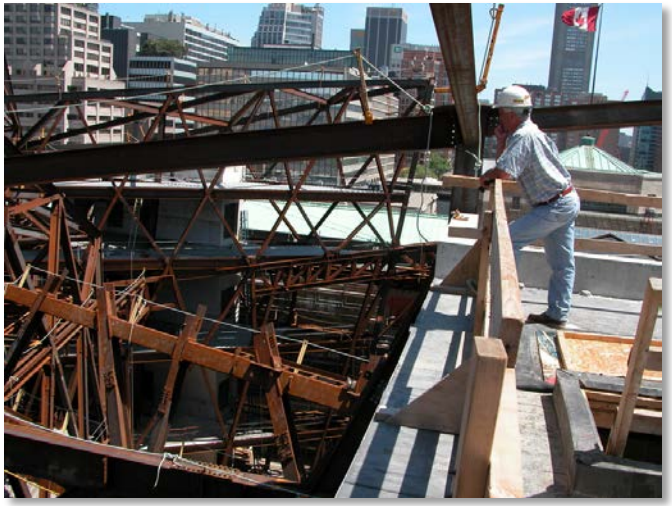
What does an **A**rchitect do?

- Potentially a wide variety of activities as a function of the economy
- Design buildings
- Build buildings
- Green building consultation
- Create larger “developments”
- Master planning
- Interior design

Daniel Libeskind, Design Architect of the ROM

What are the “tasks”?

- Conducting background research
- Verify that the project adheres to “the rules”
- Creating design sketches
- Creating formal design drawings
- Rendering of perspectives and views, model making
- Creation of contract drawings (for construction)
- Writing of specifications
- Attend meetings
- Construction review



The Parts of an Architectural Project:

- Initial feasibility study (not always)
- Preliminary design (sketch phase)
  - Check Official Plan
  - Check Zoning By-law
  - Check Building Code
  - Check climate data for area
- Design development (detailed development of proposal – more material and dimensionally specific)

…Parts of an Architectural Project

- Contract documents
  - Construction drawings (these include materials, dimensions, notes to allow someone to build the building); including plans, sections, elevations, enlarged details
  - Specifications (these are the written supplement to the drawings and are very specific with respect to performance of materials)

…Parts of an Architectural Project

- Bid or Tender Process (getting prices for the job)
- Award of the Contract
- Construction/Contract Administration
  - This will include regular meetings and on site review of the progress of the project
  - Modifications and change orders
  - A lot of paperwork
  - Final review of the project before occupancy

How is the fee divided?

- Pre-Design (approx. 10%)
- Design Development (approx. 25%)
- Contract Drawings (approx. 40%)
- Construction Administration (approx. 25%)

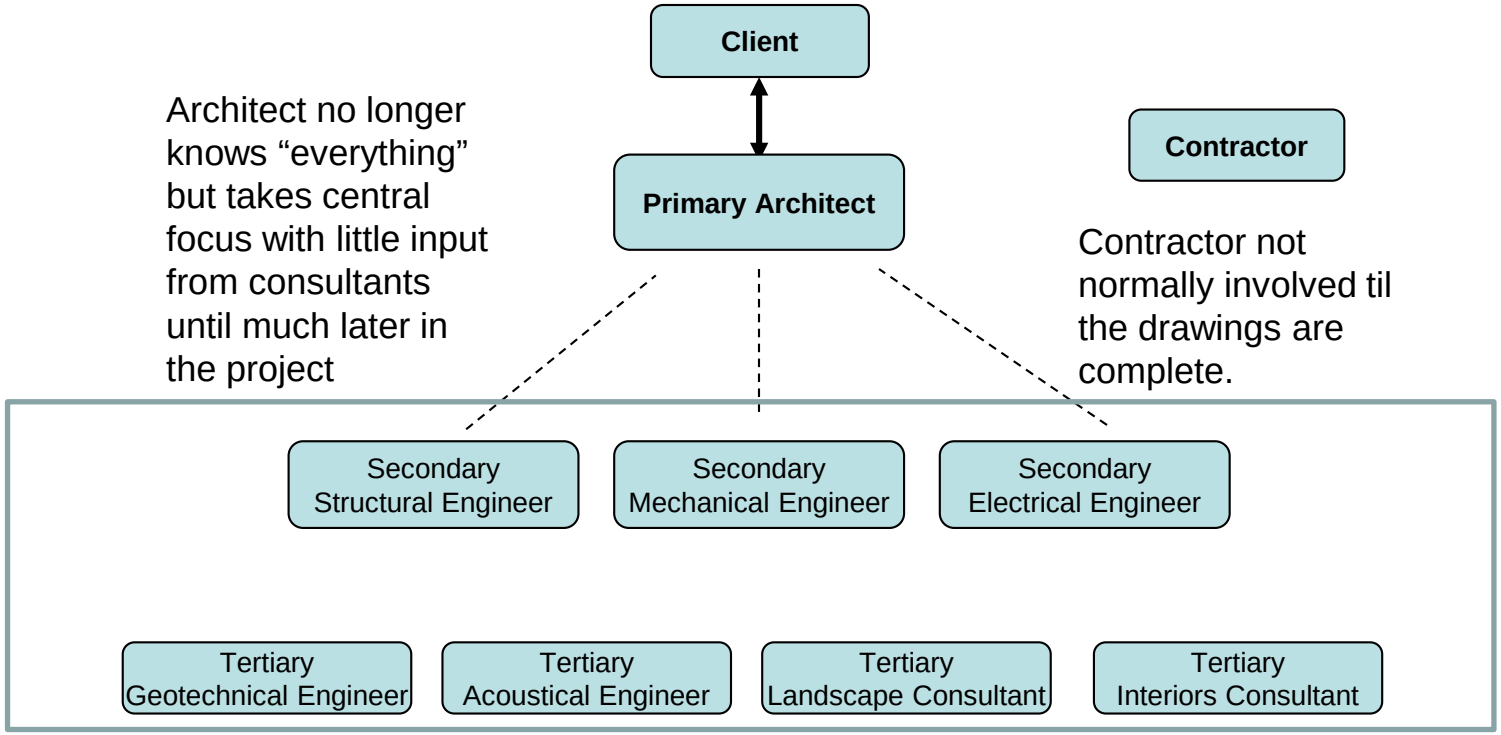
A portion of this is allocated to paying the Engineering consultants

- This would be considered “ideal” – most projects use more than the allotted 25% in the “Design” phase
- The fee must pay the Architect and all involved in the creation of the contract documents for the building
- Normally a percentage of the cost of construction

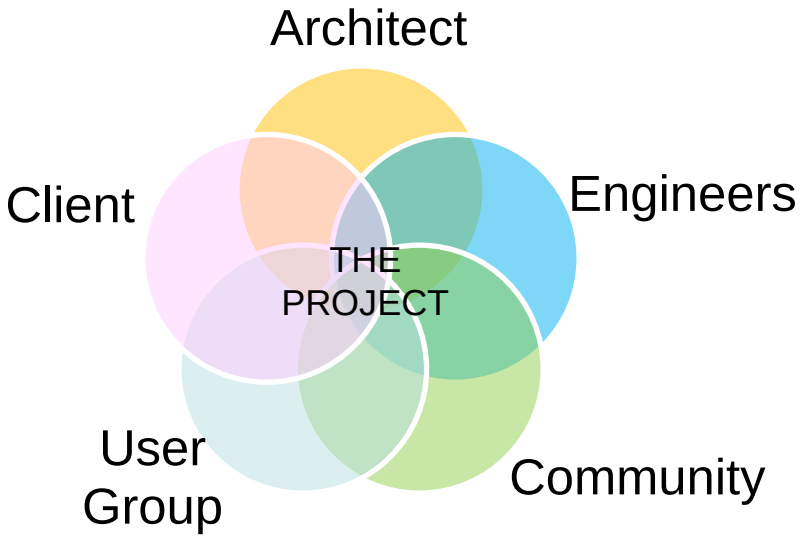
What does the Engineer do?

- Depends on type of engineer!
- Structural will work on the design and sizing of the structural system
- Mechanical works on mechanical systems
- Depending on the firm you may be involved in enclosure design
- If working on site for the contractor, site review
- Consulting engineers do site visits and work a lot with the architect

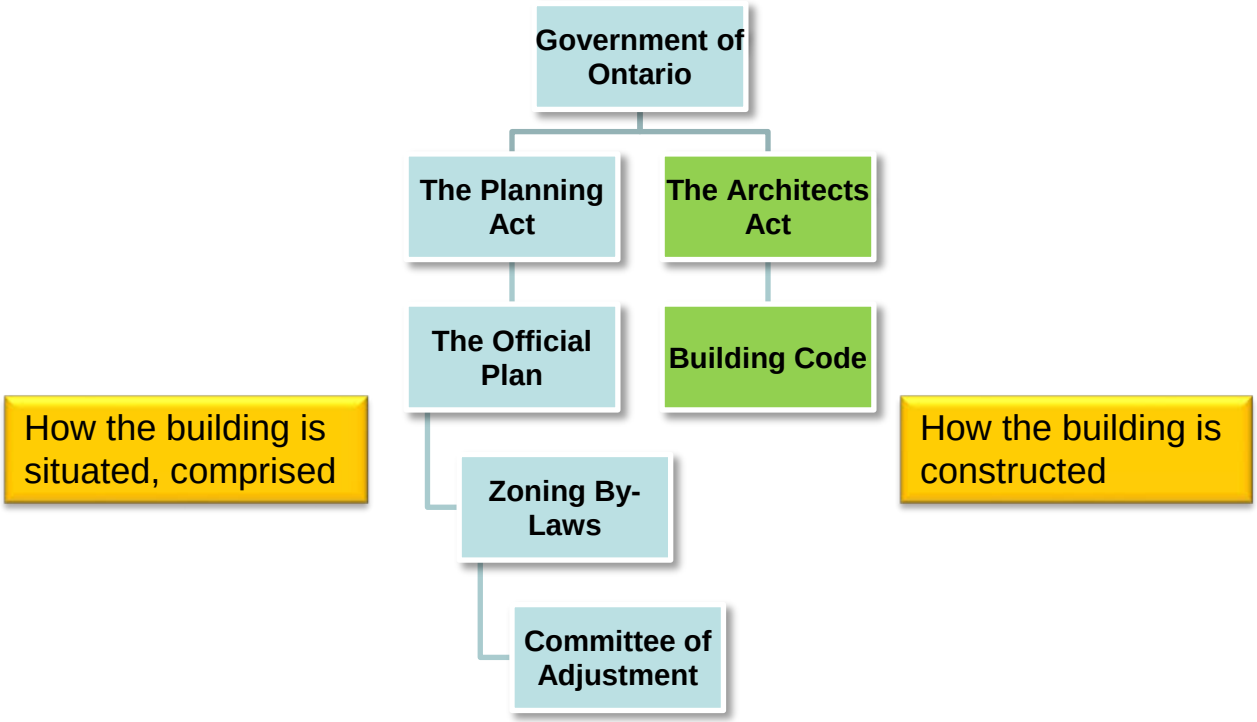
Traditional Modern Design Process:



Integrated Design Process Structure:



What laws govern our **buildings**?



Ontario Building Code:

- This legal document primarily addresses life safety, structural safety issues and energy
- It is a set of MINIMUM standards for building performance
- No variations are permitted
- Looks at materials, exiting, energy efficiency, occupancy, space/room standards, ventilation, insulation

TYPOLOGY STUDY

Effect of Unprotected Openings Limitations on Facades

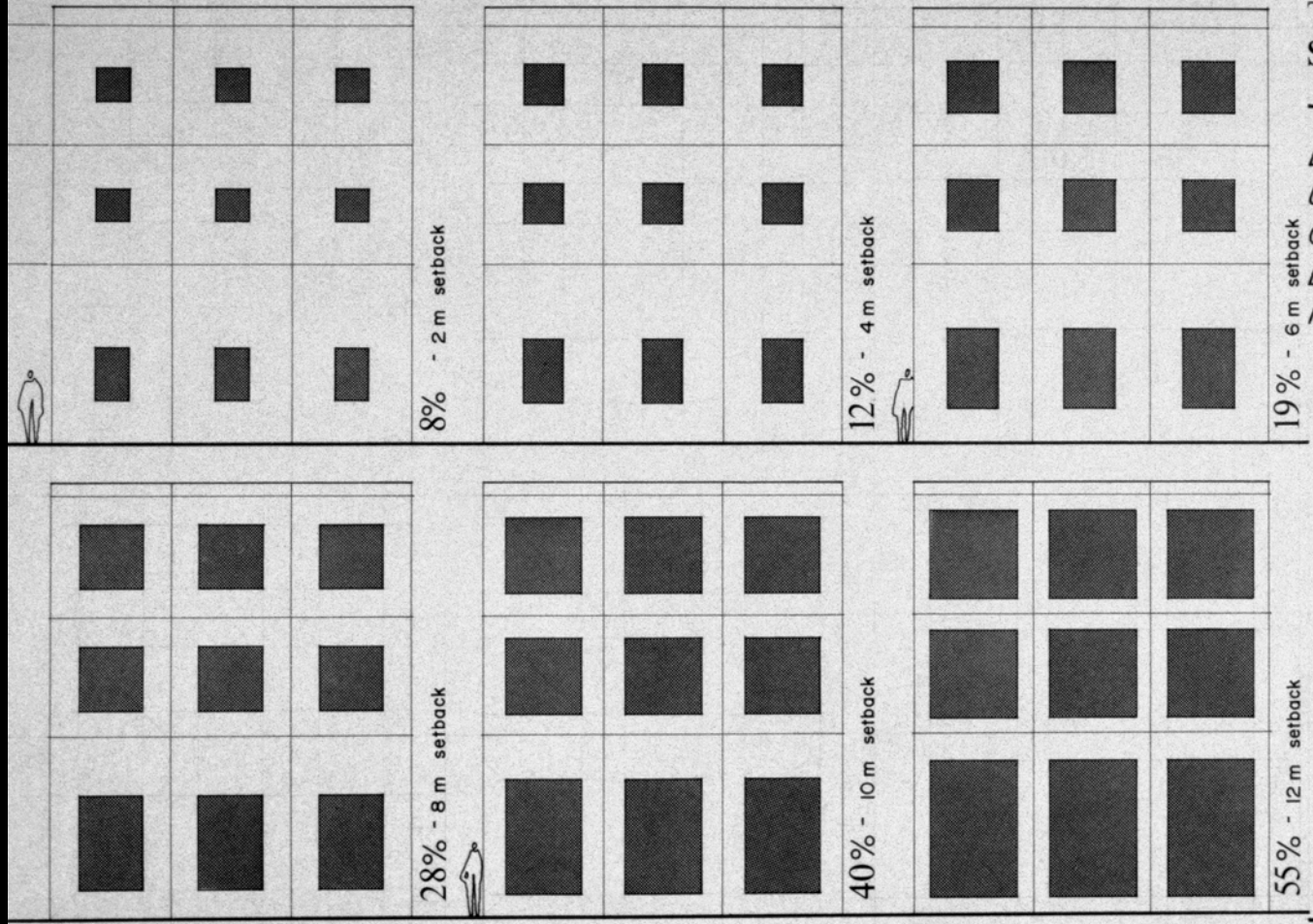


Plate 53

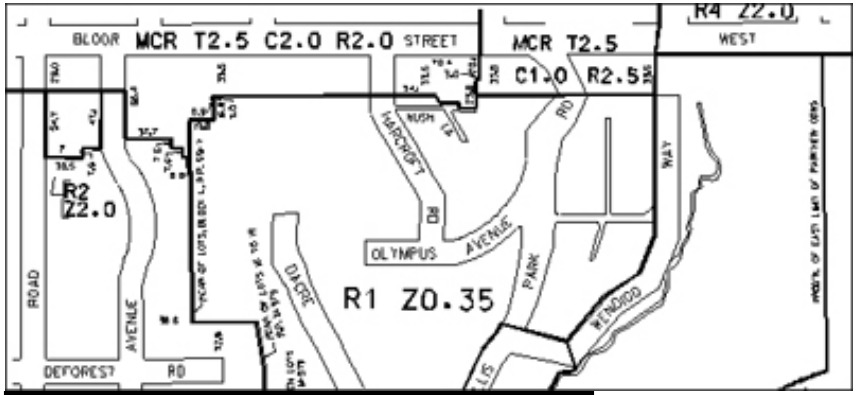
The Official Plan:

- This document sets out high level ideals of what the city should “be”
- Defines areas of use and relationships
- Dedicates certain zones of the city for parks, ravines, recreation, business or residential use
- Comprised of texts, maps and pictures
- “overrules” the Zoning By-law

The Zoning By-Law

- Takes the general issues as set out by the Official Plan and gives them more specifically
- A zoning bylaw contains provisions that regulate the
  - use,
  - size,
  - height,
  - density and
  - location of buildings on properties within the City.

The basic purpose of a zoning bylaw is to regulate what you can build and how big the building can be on a property. A typical zoning bylaw maps out the zones which show how the property can be used. That is, the property can be used for various land uses that range from residential to commercial to industrial and a whole host of other land uses.



This typical zoning map shows the zoning for property. The zone with symbols R1 Z0.35, indicate that the property is zoned Residential District (R1) at a density ratio of Z0.35 (floor area divided by lot area)

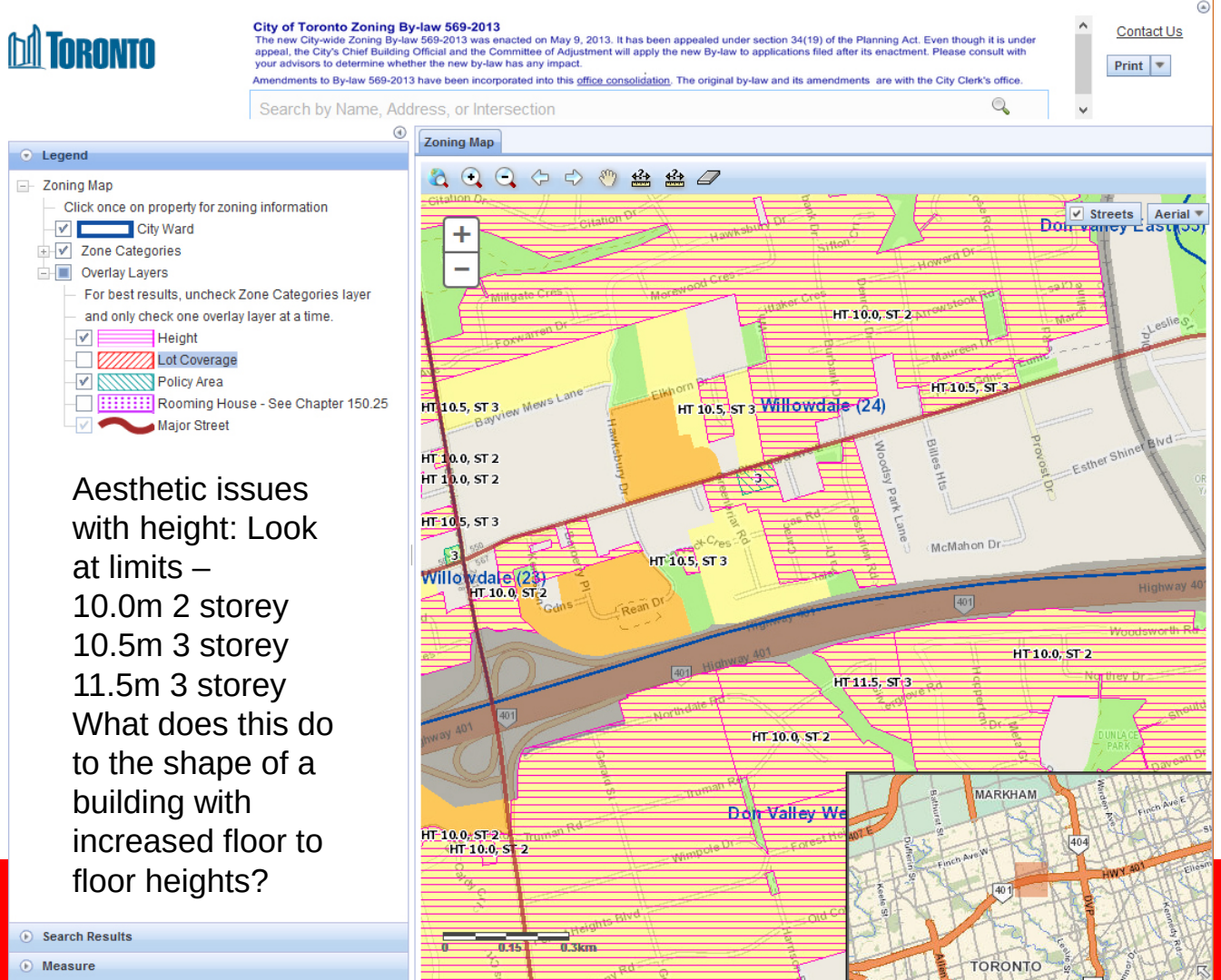
Zoning By-Law Details:

Zoning bylaws have 3 basic components:

- **maps:** number of storeys or metres are the most common feature of any zoning bylaw since they indicate where particular standards apply

- **words:** which form a kind of "language" unique to each bylaw

- **numbers:** can establish;
  - the size of a building, often expressed in floor area or density ratio such as the Floor Space Index
  - the height of the building in storeys or metres
  - the setbacks determine how far back the building must be from the front, side and back of the property line
  - the amount of parking spaces or landscaped space to be provided

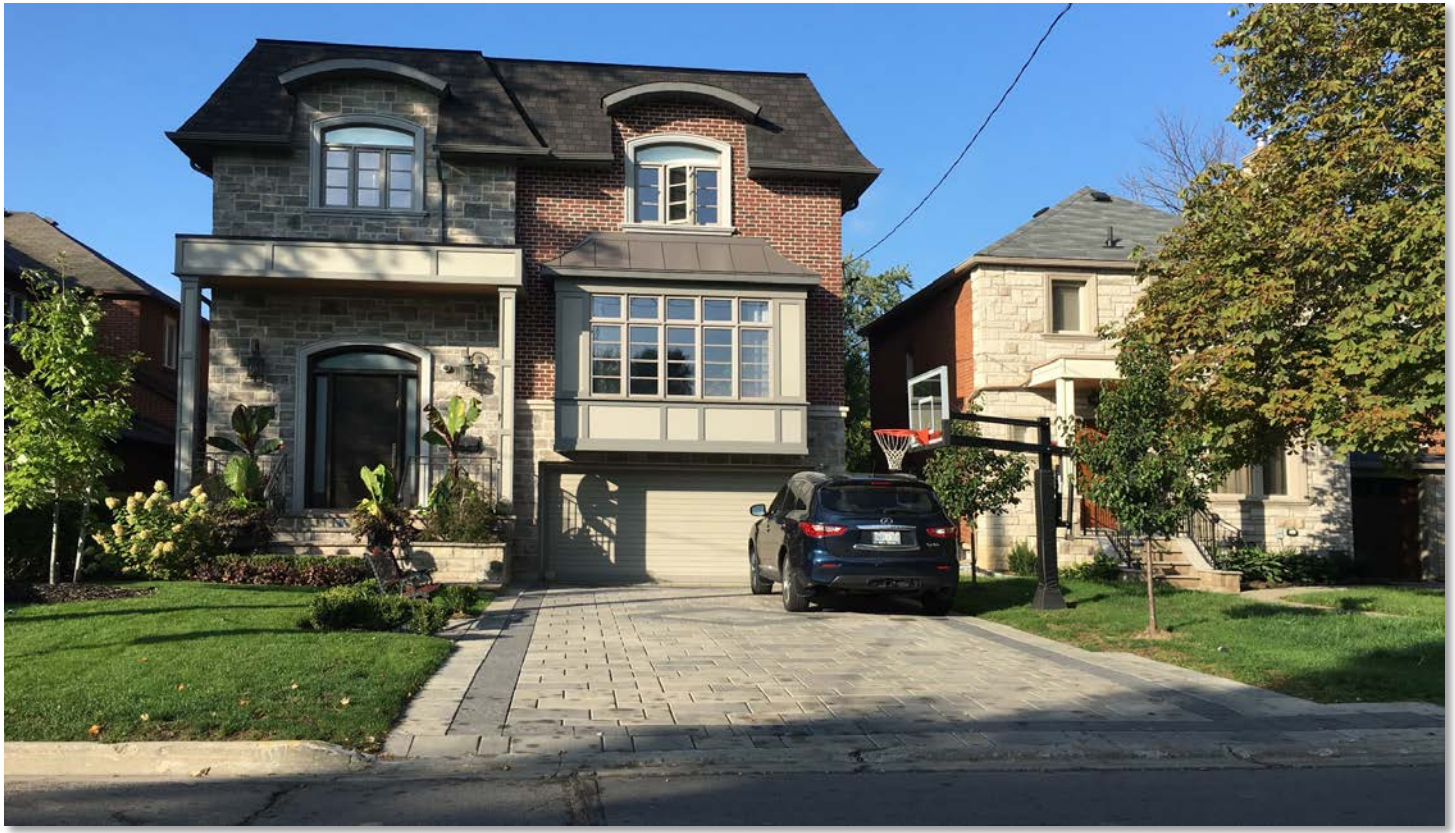


Aesthetic issues with height: Look at limits –
10.0m 2 storey
10.5m 3 storey
11.5m 3 storey
What does this do to the shape of a building with increased floor to floor heights?

The unintended consequences of zoning regulations

New house with taller floor to floor heights

Older house with less pretentious floor to floor heights



Square watermelon house results when floor to floor heights push to the limit of the legal height allowed by old laws that have not adapted to new desires.

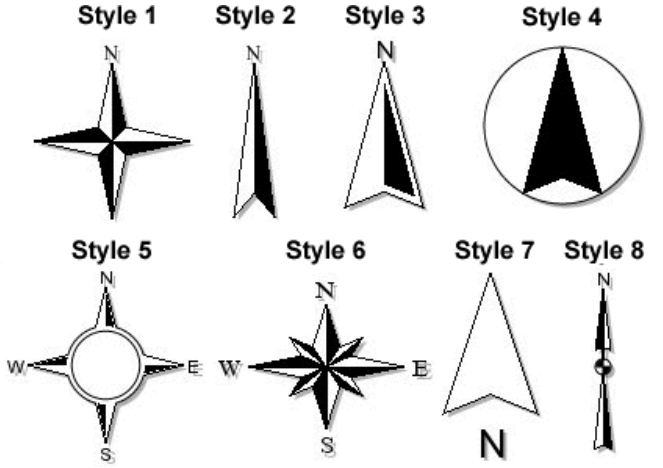
Making and Designing Buildings: Methods of Communication AKA Drawings and Models

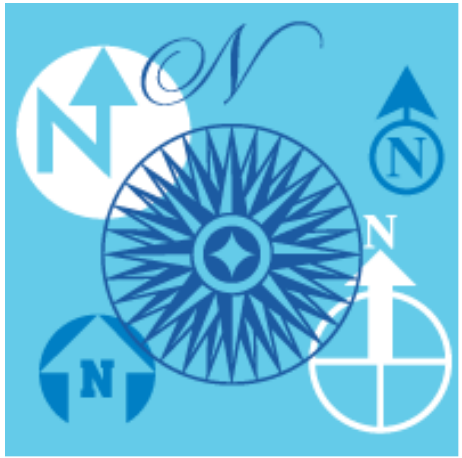
Drawings: Sketches

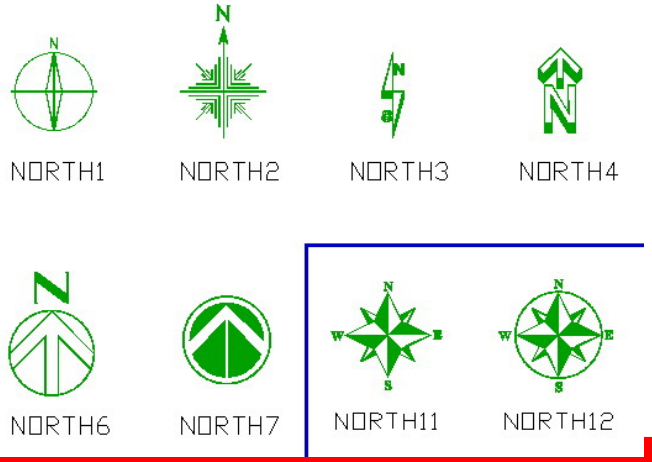
Sketches are quick hand drawings to convey the “concept”.

Roughly to scale.

Daniel Libeskind’s *classic* Napkin Sketch for the Addition to the Royal Ontario Museum in Toronto.

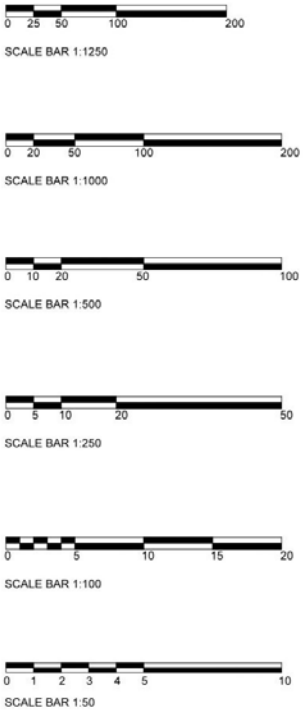


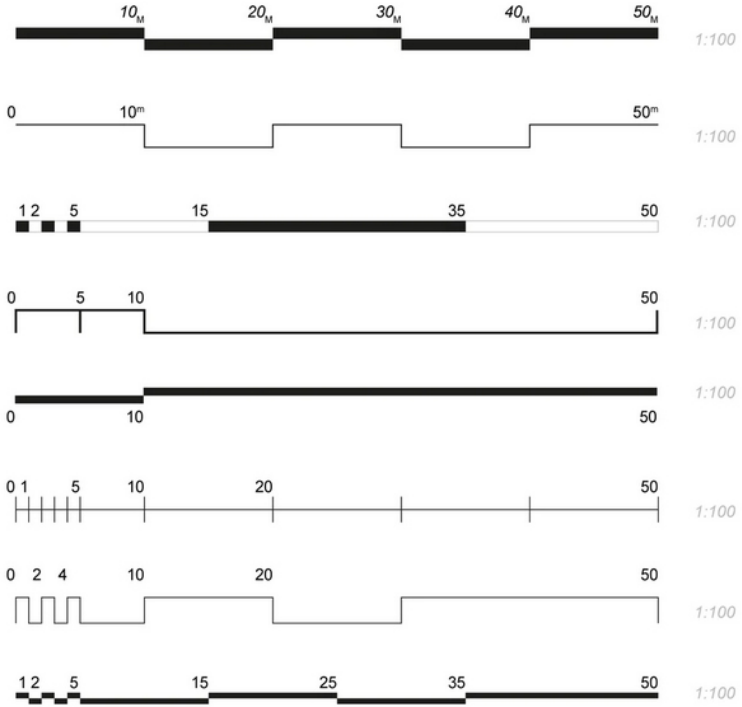


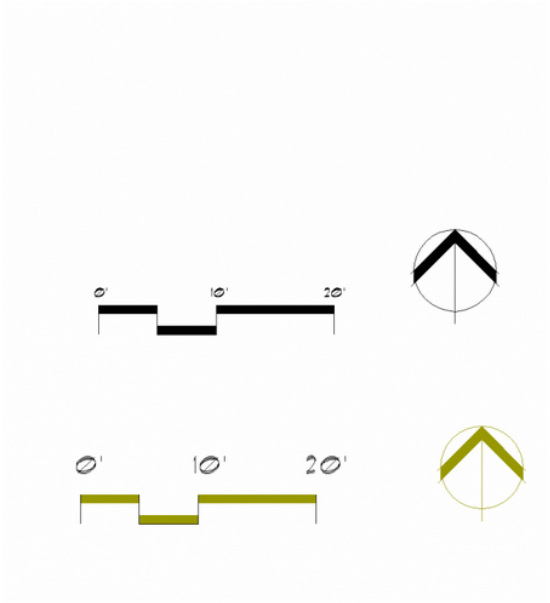


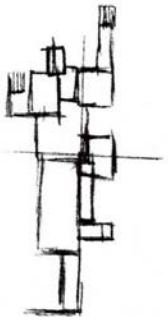
Designing for solar conditions requires that you are aware of the orientation of the site. If you don't have one of these on your plan *from the beginning*, then, *you are not aware.*

It is a nice touch to personalize your design for these!


0 25 50 100 200
SCALE BAR 1:1250
0 20 50 100 200
SCALE BAR 1:1000
0 10 20 50 100
SCALE BAR 1:500
0 5 10 20 50
SCALE BAR 1:250
0 5 10 15 20
SCALE BAR 1:100
0 1 2 3 4 5 10
SCALE BAR 1:50


10M 20M 30M 40M 50M
1:100
0 10m 50m
1:100
1 2 5 15 35 50
1:100
0 5 10 50
1:100
0 10 50
1:100
0 1 5 10 20 50
1:100
0 2 4 10 20 50
1:100
1 2 5 15 25 35 50
1:100

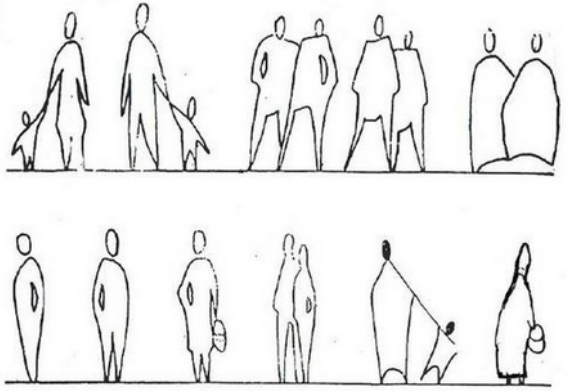

0' 10' 20'
0' 10' 20'

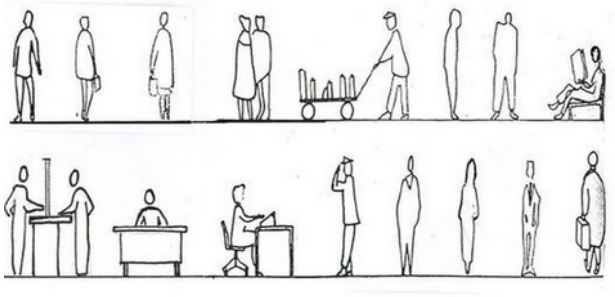


Theo van Doesburg

Le Corbusier

Steven Holl

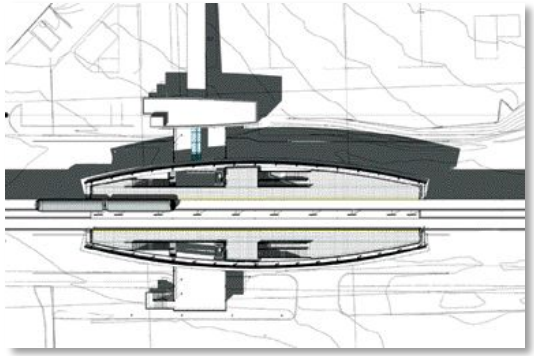


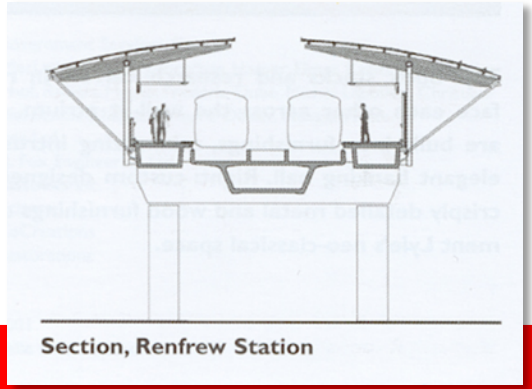


Design Drawings

Design drawings show the building in more detail, with accurate sizes, but with minimal technical information.

They usually have a sense of materiality and reflect the actual scale and physical location of the project.

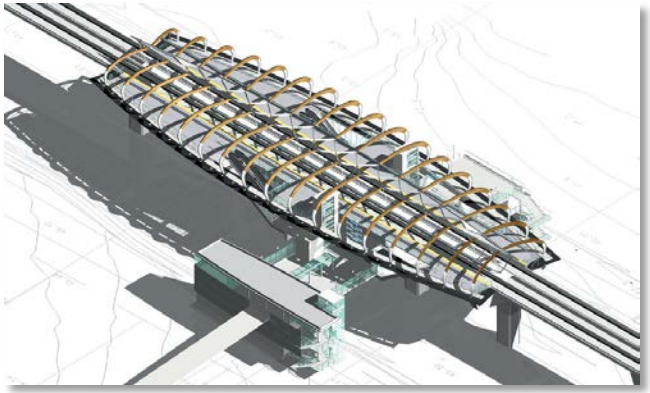




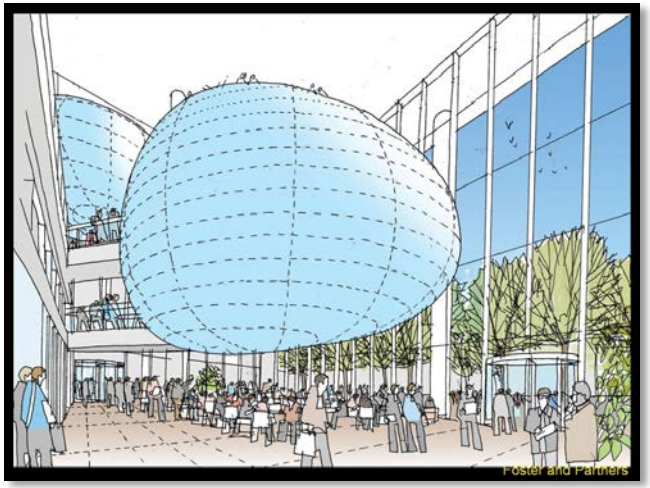
Section, Renfrew Station

Renderings:

Renderings whether done by computer or by hand give us a 3-D feel of the finished building.



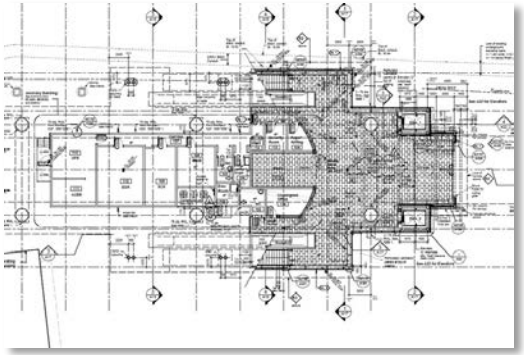
Brentwood Skytrain Station: Busby

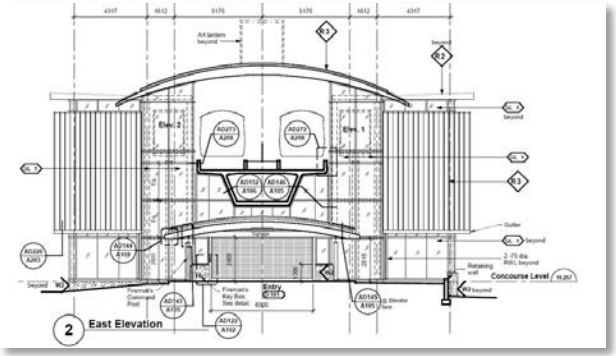


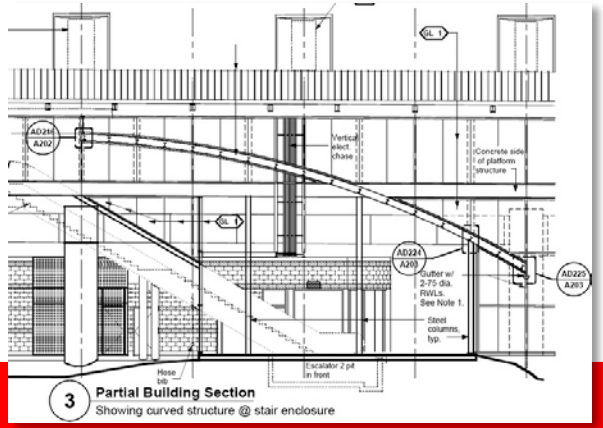
Leslie Dan Pharmacy Building: Foster

Contract Drawings:

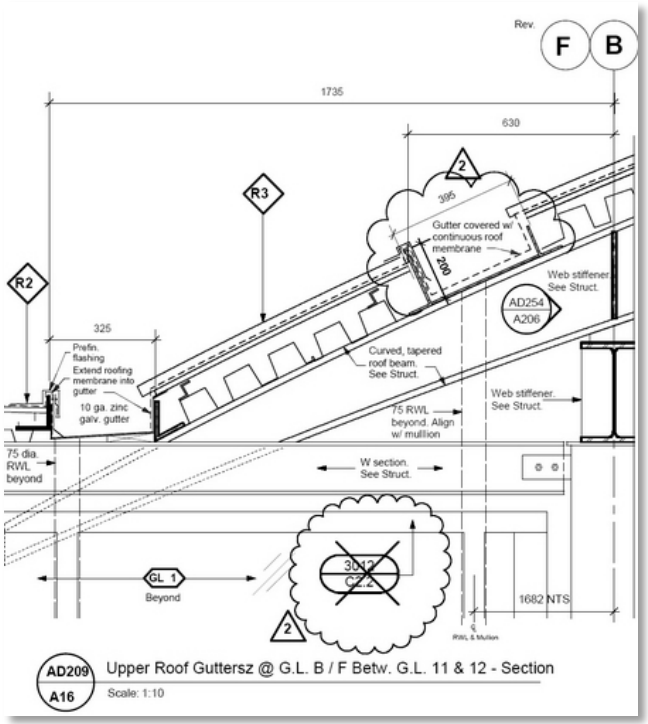
As these form the legal agreement to construct, they are loaded with technical information.

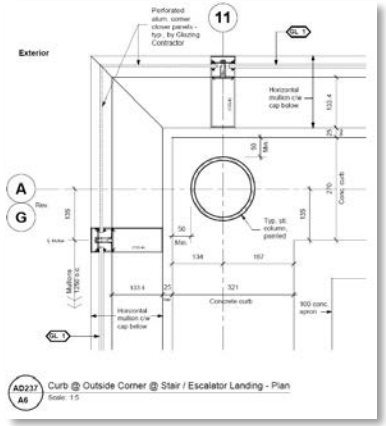


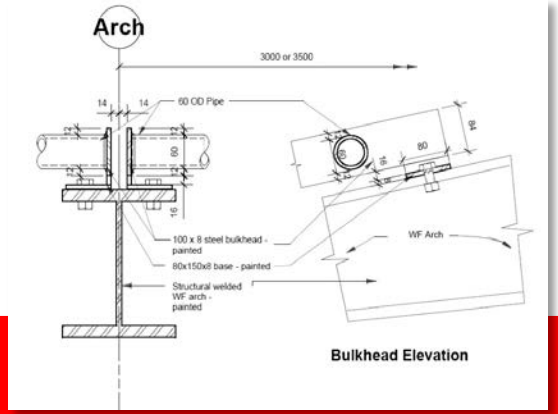




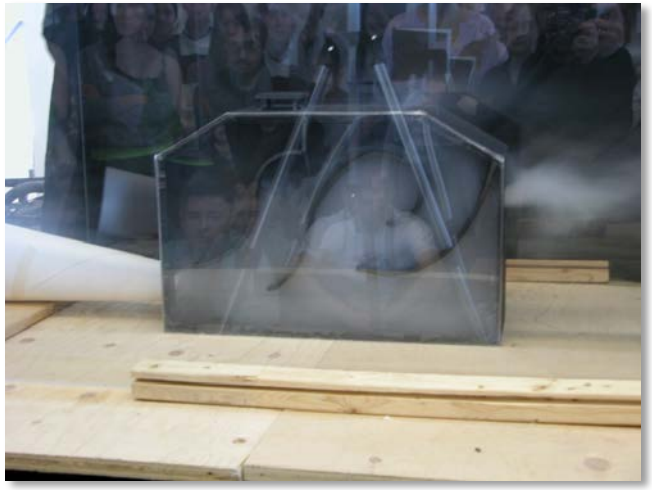
Construction Details:







Rough / test models:



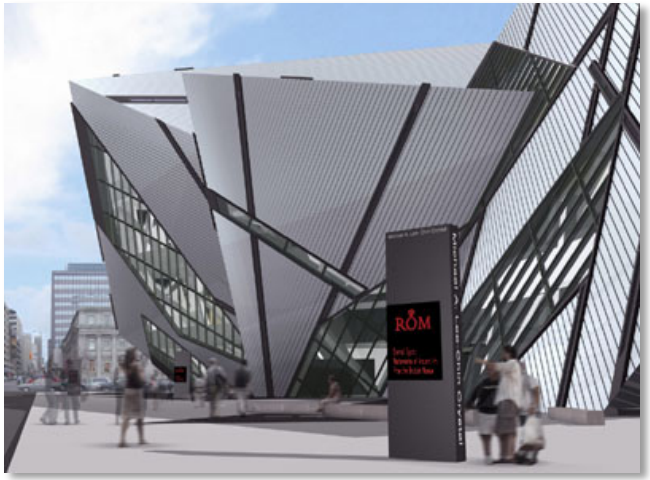
We can make models to understand how a building works for wind and sunlight, or simply to establish “massing”.

Massing Models:

These models are used to see how the general shape of the building works; orientation, sun access, relationships

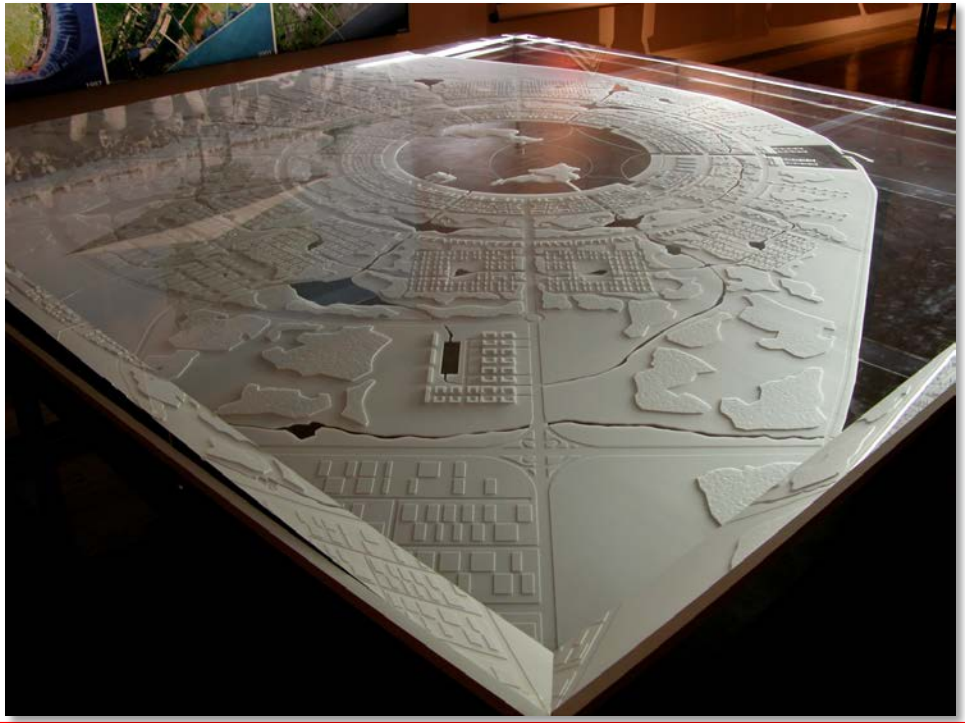
Massing model of the ROM showing its relationship to the original building

Detailed models

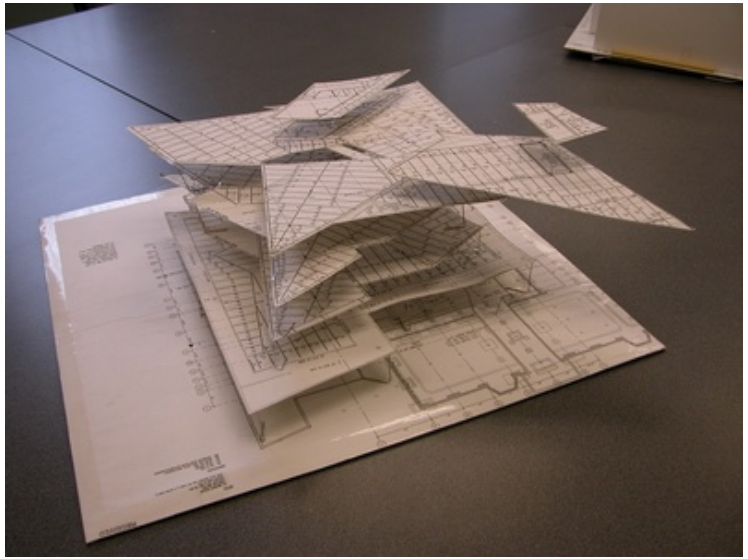


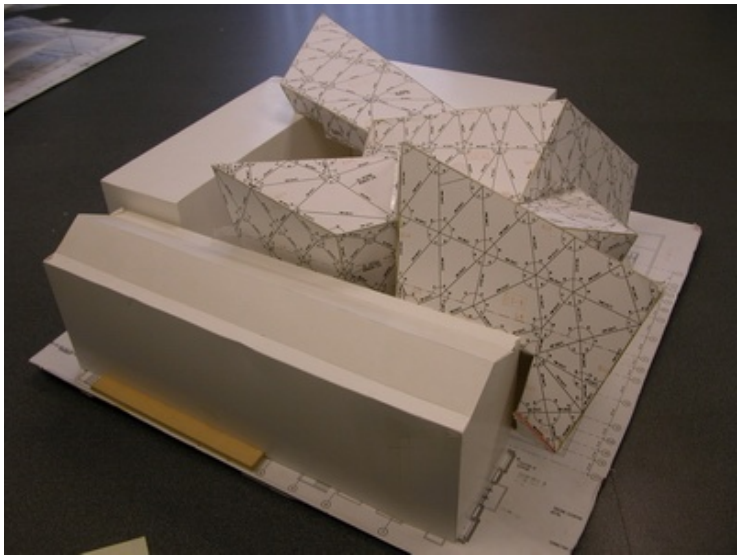
The architect might also supply detailed models that can give the client or user group a better feel for the finished building. These can be physical or computer created.

Urban scale model:



Structural Models:

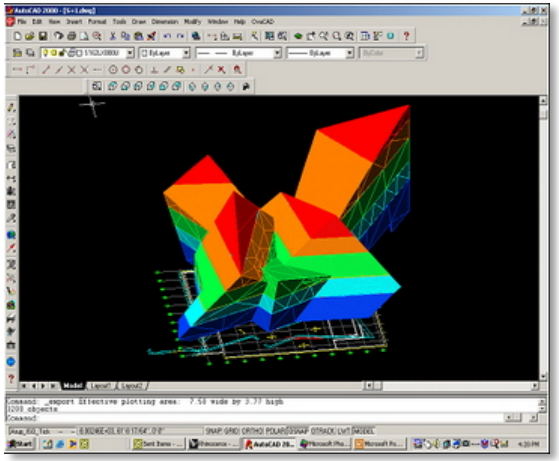


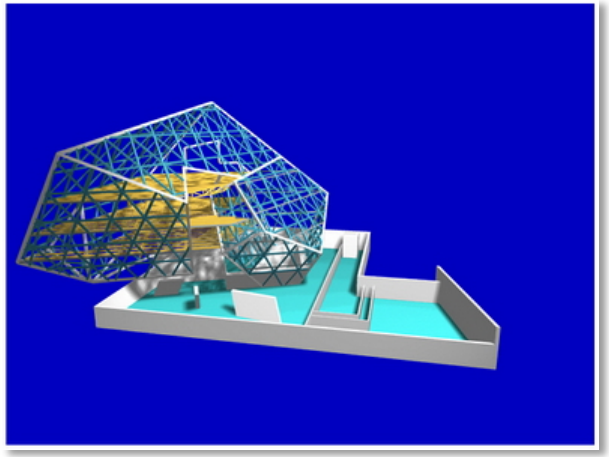


The engineers and fabricators might also make rough models to see how things like the framing are working. The steel diagrid used in the ROM required many different ways to understand its 3-D nature and construction detailing.

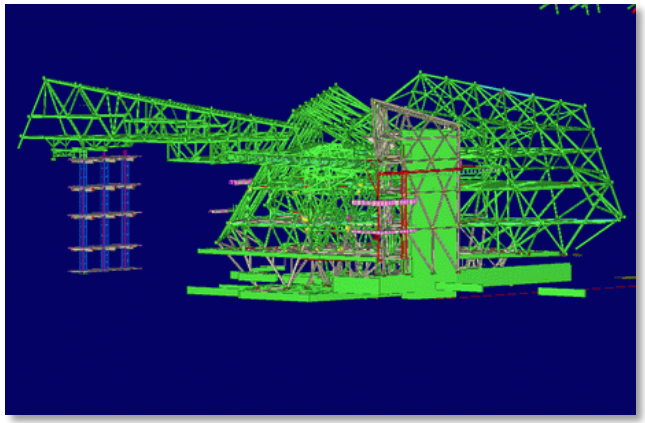
Structural computer models

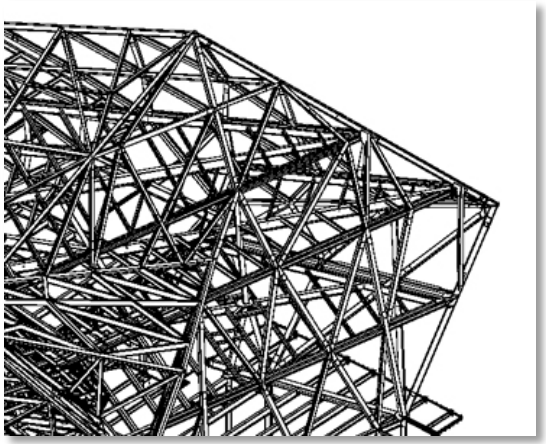
These were done by the structural engineers to look at the relationships of the ROM crystals.



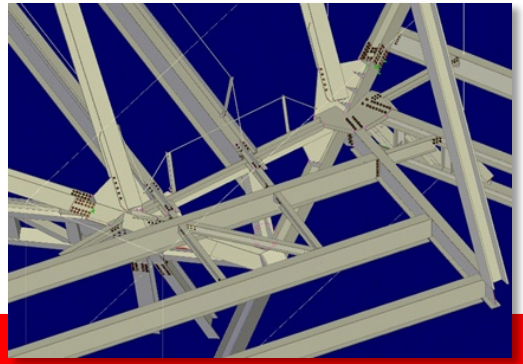


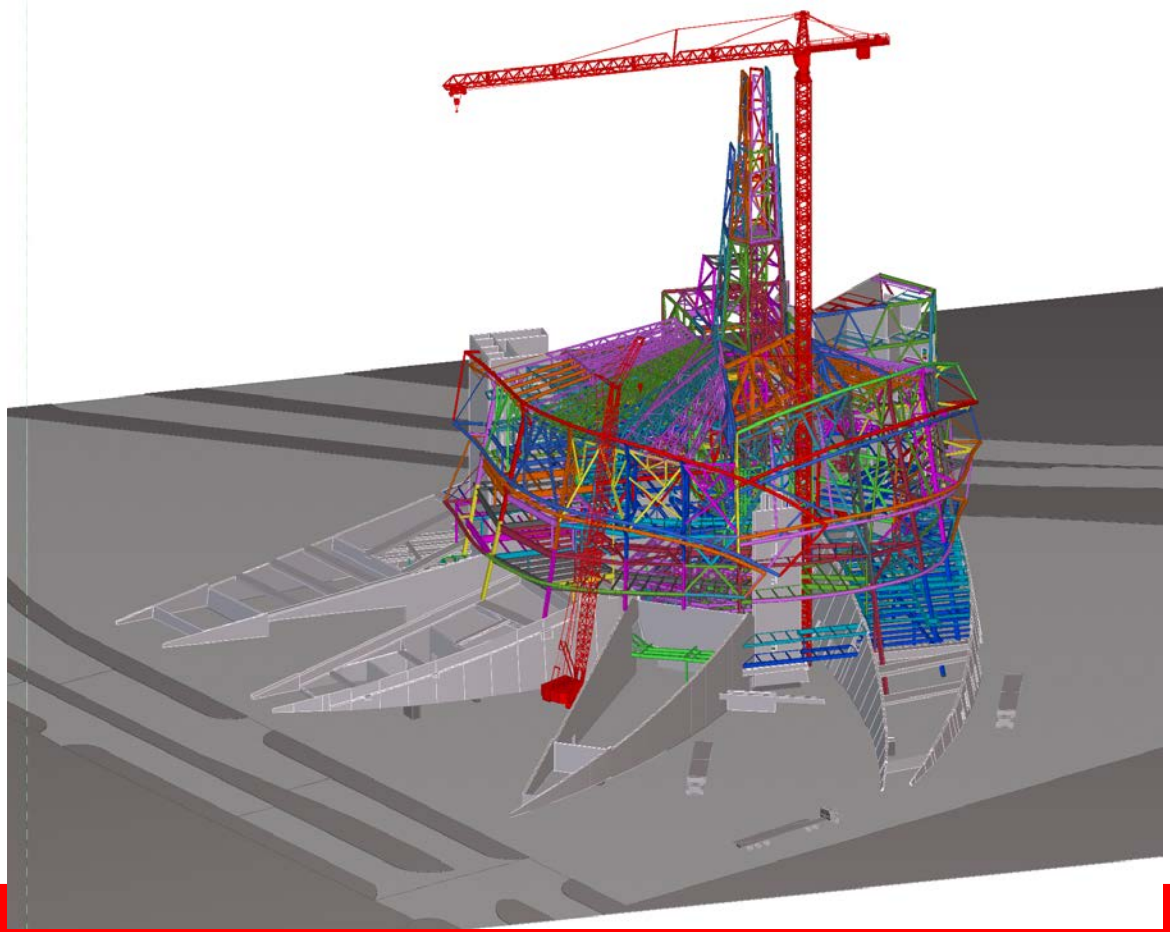
Fabrication modelling:





If the project has a complex structure, the fabricators of various components might also need to be more involved in the design and detailing process.



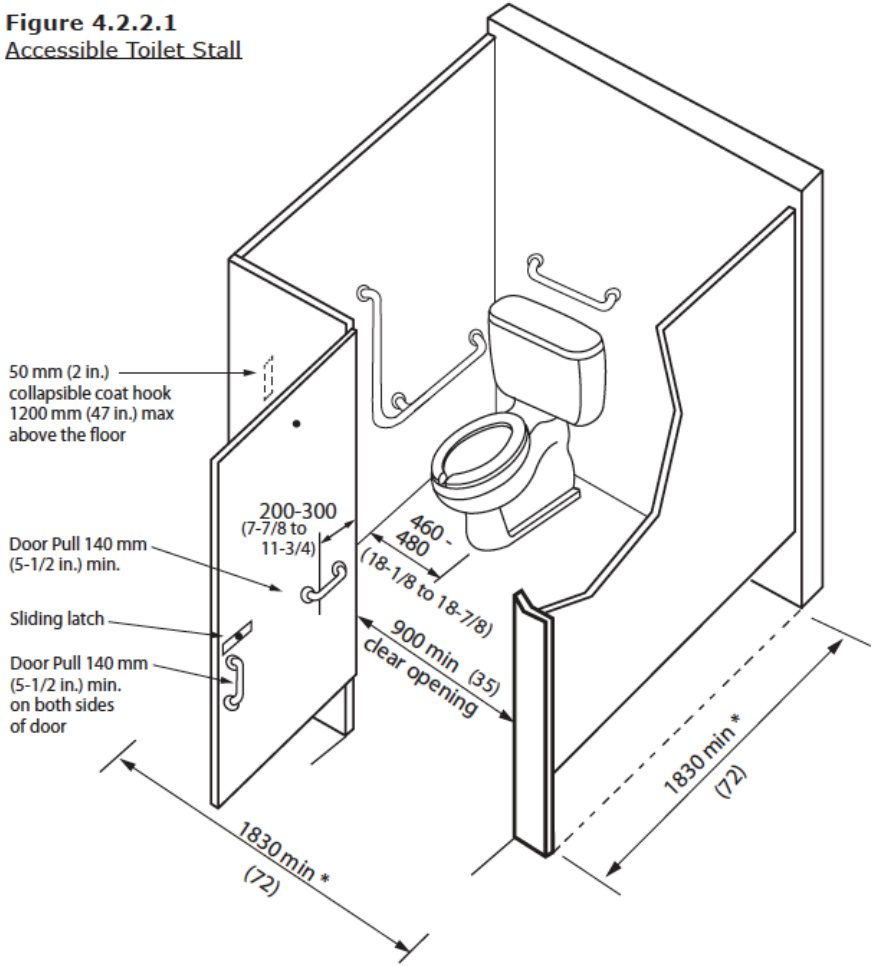


Size and Complexity Matters

- Not all projects are developed to the same level of detail, nor use all types of communication methods.
- The scale / size / scope of the project will greatly affect what methods are used, as will the cost and the amount of fees paid to the design team.
- The region / location / history and local practices of the project will greatly affect the way work is carried out.

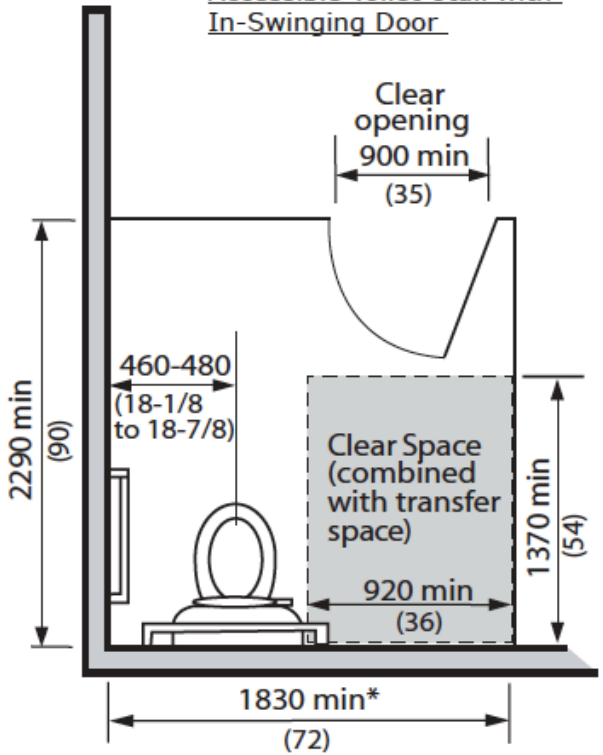
BARRIER
FREE DESIGN
applies to all
public buildings

Figure 4.2.2.1
Accessible Toilet Stall



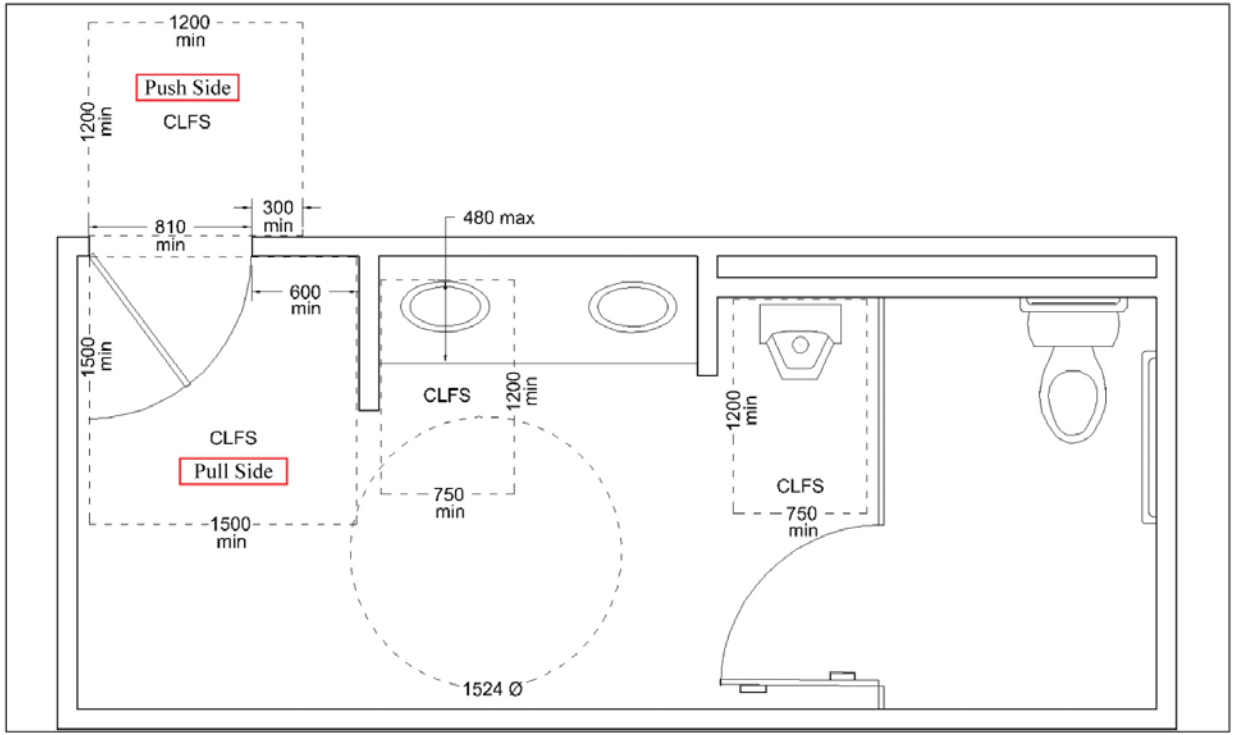
NOTE: In a retrofit situation where it is technically infeasible to provide the required clearances, the dimensions marked with an * may be reduced. Refer to 4.2.2 - Design Requirements.

Figure 4.2.2.2
Accessible Toilet Stall with In-Swinging Door



Note: In a retrofit situation where it is technically infeasible to provide the required clearances, the dimension marked with an * may be reduced to 1525 mm (60 in.) and the clear transfer space may be reduced to 760 mm (30 in.).

Figure 2


1200
min
Push Side
CLFS
1200
min
300
min
810
min
480 max
600
min
1500
min
CLFS
1200
min
CLFS
Pull Side
750
min
1500
min
1200
min
CLFS
750
min
1524 Ø

Access to Washrooms

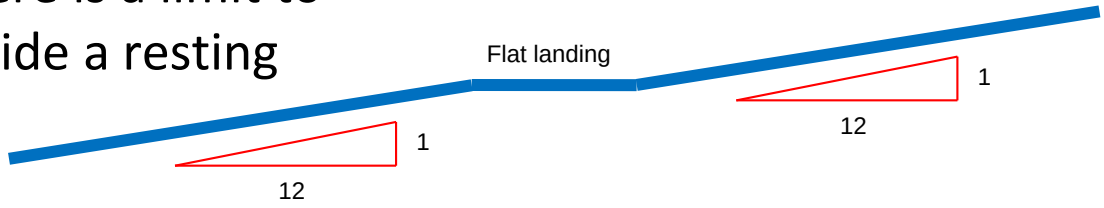
- Make sure to provide adequate washrooms on each floor so that people do not have to go up or down a floor to access the washroom
- Gender Neutral washrooms can and should be provided
- Ensure adequate privacy! Stall partitions should go to the floor or complete separate washrooms provided

Barrier Free Access

- All major entrances and exits must allow access via wheelchairs, walkers, strollers; that means NO STEPS
- Ramps may be used as an alternate to steps as long as they are reasonably close to the entry/exit point
- All areas within public buildings are to be accessible to all people, regardless of mobility (so no putting the cool mezzanines out of reach)

Barrier Free Access

- Elevators can be provided for access between floors, particularly in multi storey buildings where ramps would be impractical
- Elevators should be easy to spot and not far from the entry point
- Ramps should have a slope of no more than 1:12 (less is better) – and there is a limit to the length of the run to provide a resting point



The impact of FIRE on design

THE GREAT CHICAGO FIRE

Conflagration that began on Sunday, October 8, 1871, and burned until early October 10, devastating an expansive swath of the city of Chicago. After the smoke cleared, the extent of the disaster revealed itself: the fire had burned thousands of acres, killing hundreds of people and causing millions of dollars in damage. The city rebuilt quickly, its population increasing from 324,000 in 1871 to 500,000 by 1880.

$200 MILLION IN DAMAGE

300 FATALITIES (estimated)

17,450 BUILDINGS DESTROYED

100,000 PEOPLE LEFT HOMELESS

STARTED BY (THEORIES)

- vandals
- milk thieves
- spontaneous combustion
- drunken neighbor
- the O'Learys' legendary cow

FUELED BY

- months without rain
- strong southwest wind
- congested poor neighborhoods
- wooden buildings, streets, sidewalks
- technical and human errors in alarm system

STOPPED BY

- rainfall
- Lake Michigan
- stretches of unbuilt lots
- gunpowder explosions

The 2nd star from the left on the Chicago flag represents the Great Chicago Fire.

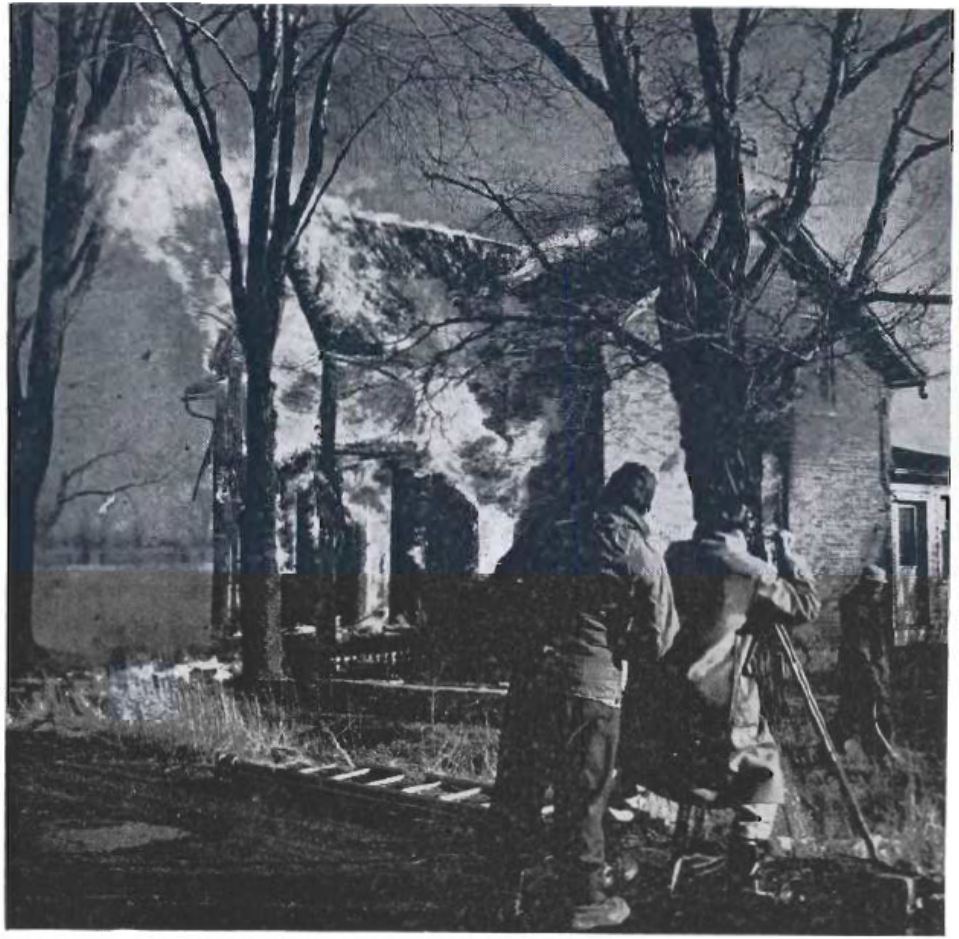
A Where the great fire began: De Koven St. barn of Patrick and Catherine O'Leary. Current location of the Chicago Fire Department training academy.

B Area burned by the October 7 fire, which had exhausted firefighters and damaged equipment.

REBUILT BY

talented architects who were drawn by postfire rebuilding opportunities:

Louis Sullivan · *Dankmar Adler* · *John Wellborn Root* · *Daniel H. Burnham* · *William Holabird* · *William Le Baron Jenney*



Malak, Ottawa

One of the dwelling house "burns" being filmed by the National Film Board.

Primary Motivation in Design for Fire

No. 1: Life Safety

no loss of life

safe evacuation of occupants

No. 2: Protection of Structure

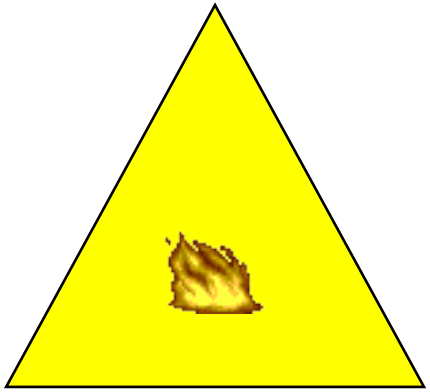
maintaining integrity of building structure

Requirements for Combustion

remove any one of these, and, no fire…

heat

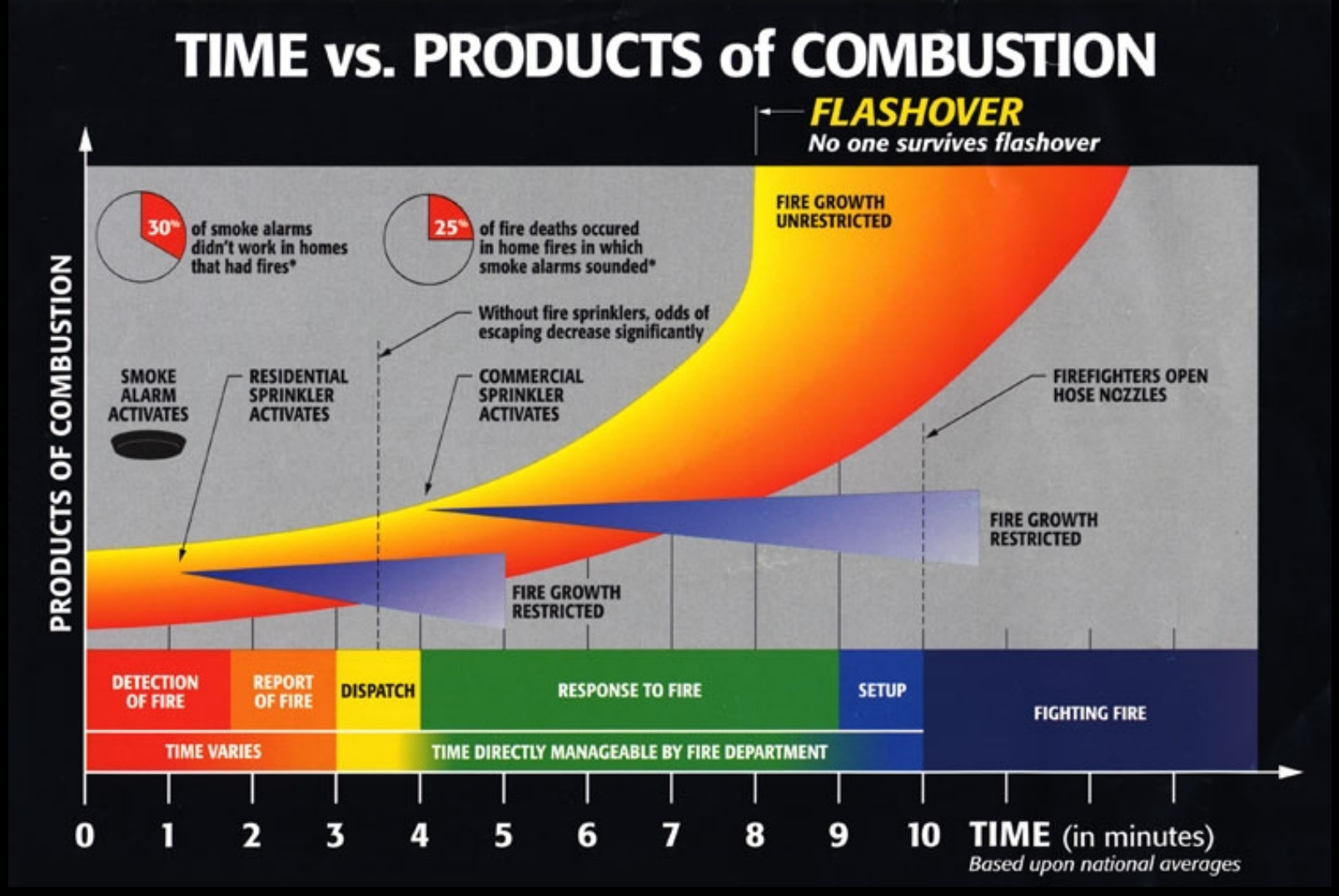
fuel = Building!



oxygen

Main Issues in Fire Design

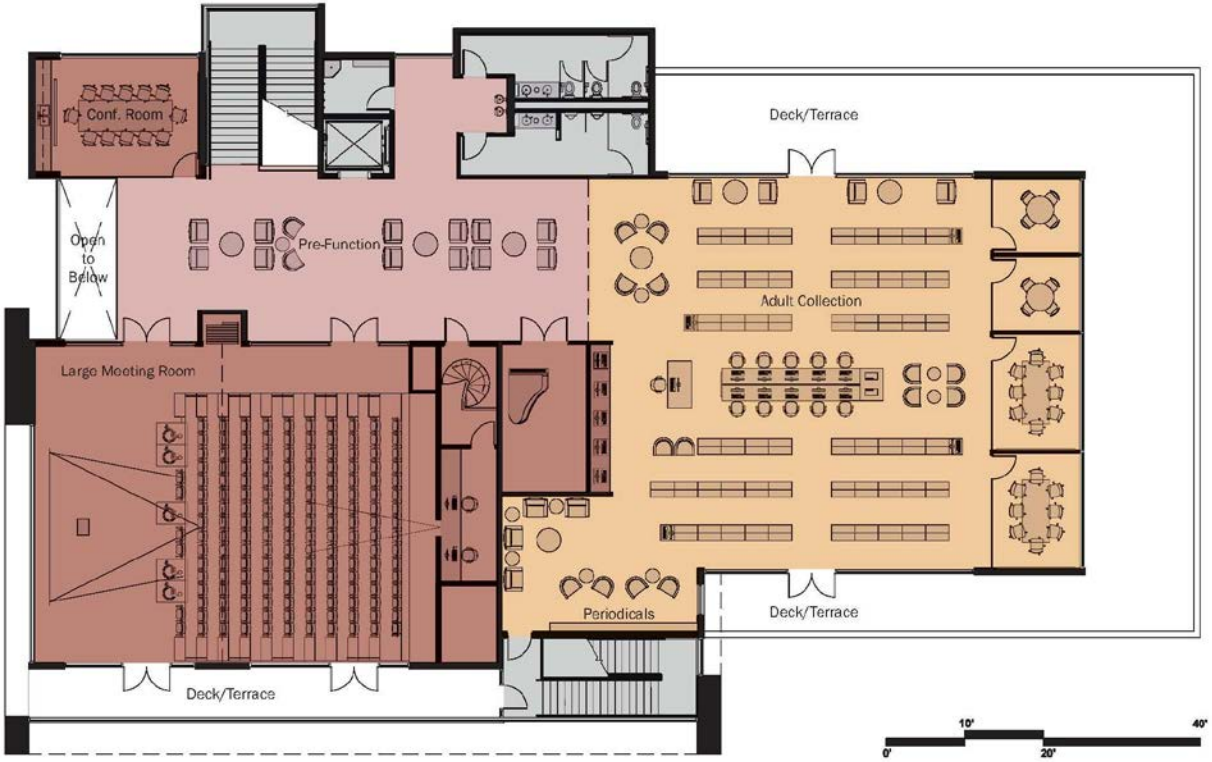
- occupancy type
- occupant load
- building size
- construction type
- exit requirements
- fire resistance ratings
- fire separation


TIME vs. PRODUCTS of COMBUSTION
FLASHOVER
No one survives flashover
PRODUCTS OF COMBUSTION
30% of smoke alarms didn't work in homes that had fires*
25% of fire deaths occured in home fires in which smoke alarms sounded*
FIRE GROWTH UNRESTRICTED
Without fire sprinklers, odds of escaping decrease significantly
SMOKE ALARM ACTIVATES
RESIDENTIAL SPRINKLER ACTIVATES
COMMERCIAL SPRINKLER ACTIVATES
FIREFIGHTERS OPEN HOSE NOZZLES
FIRE GROWTH RESTRICTED
FIRE GROWTH RESTRICTED
DETECTION OF FIRE
REPORT OF FIRE
DISPATCH
RESPONSE TO FIRE
SETUP
FIGHTING FIRE
TIME VARIES
TIME DIRECTLY MANAGEABLE BY FIRE DEPARTMENT
0 1 2 3 4 5 6 7 8 9 10
TIME (in minutes)
Based upon national averages

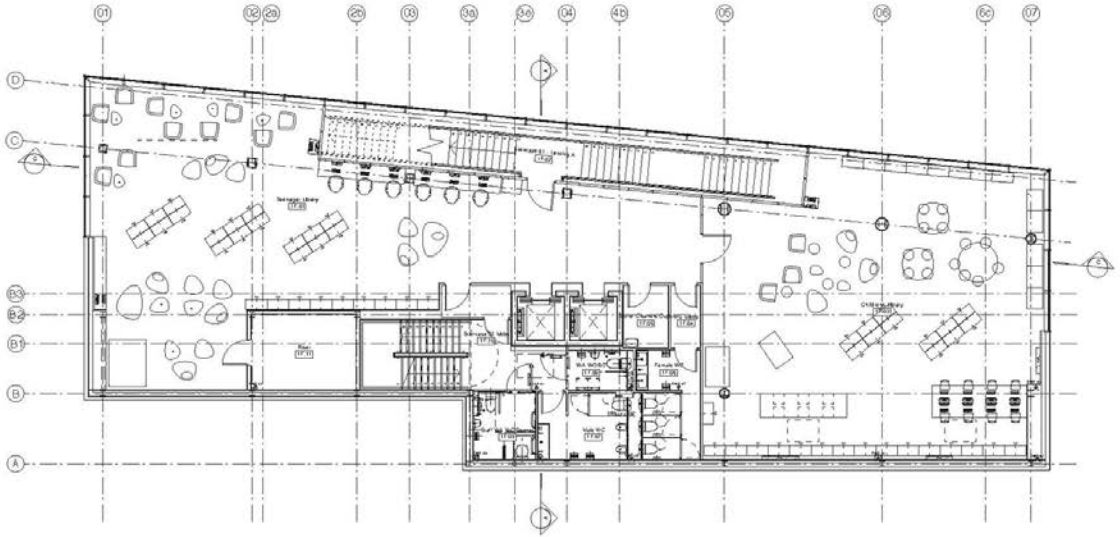
Exit Requirements

- You ALWAYS ALWAYS ALWAYS
- Need at LEAST two means of egress from every floor area
- No dead end corridors
- More exits required for institutional and commercial buildings as they house unrelated occupants

Sample small library: Ground Floor Plan



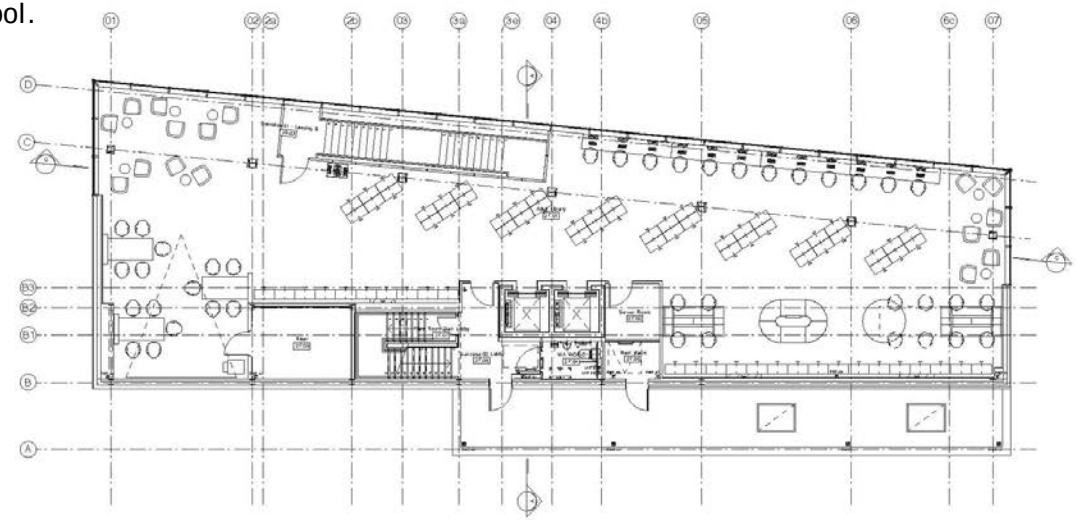
Sample small library: Second Floor Plan



Library with two means of egress – one feature stair and one more conventional one.

bisset adams
Idea Store Watney Market 1st Floor

Note the feature stair is actually enclosed for safety, but still pretty cool.



bisset adams
Idea Store Watney Market 2nd Floor

Occupancy Type:

Group	Division	Description
A	**1**	Production and viewing of performing arts
A	**2**	Not elsewhere classified
A	**3**	Arena type
A	**4**	Open air
B	**1**	Detention occupancies
B	**2**	Care and treatment occupancies
B	**3**	Care Occupancies
C		Residential Occupancies
D		Business and Personal Services
E		Mercantile
F	**1**	High Hazard Industrial
F	**2**	Medium Hazard Industrial
F	**3**	Low Hazard Industrial

Risk factors determine where a use falls as well as which can or cannot be combined in a single building.

TABLE 4.1

Classification of buildings

Occupancy	Group	Division	Risk Factors	Examples
Assembly	A		Evacuation of considerable number of people, often from large spaces	
		1	• poor lighting conditions can hinder evacuation	theatres
		2	• good lighting conditions	schools
		3	• well lit • low fire loads • large open spaces where smoke can dissipate	arenas
		4	• open air assembly area • low risk of being trapped	bleachers
Care and Detention	B		Acute evacuation problems because of restricted mobility of occupants	
		1	• occupant movement is restricted by security measures	penitentiaries
		2	• lack of occupant mobility • require safe area to permit two stage evacuation • need to contain fire to area of origin	hospitals

Residential	C		• people may be sleeping when the need for emergency evacuation arises • significant delays in people becoming aware of a fire and evacuating the building • occupants must be protected while preparing to evacuate	apartments hotels
Business	D		• occupants are fully alert • relatively low fire load • no major evacuation problems	offices
Mercantile	E		• high combustible content which can result in severe fire with heavy smoke • occupants are aware • no unusual evacuation problems	department stores
Industrial	F	1	• highly combustible and flammable or explosive substances	distilleries
		2	• medium hazard, no explosive substances	factories
		3	• low hazard, can still have high fire load	warehouses

Occupant Load

- is the number of people is an estimate of the expected maximum use of a building or floor area, for the most hazardous use
- provides a basis to calculate the number of exits required
- can be used as a ‘rule of thumb’ basis for determining floor area requirements when designing

TABLE 1 Occupant Load

Type of Use of Floor Area or Part Thereof	Area per Person (m^2)
Assembly Uses	
space with fixed seats	See Note (1)
space with nonfixed seats	0.75
spaces for theatrical performances	0.75
space with nonfixed seats and tables	0.95
standing space	0.40
stadia and grandstands	0.60
bowling alleys, pool and billiard rooms	9.30
classrooms	1.85
school shops and vocational rooms	9.30
reading or writing rooms or lounges	1.85
dining, beverage and cafeteria space	1.20
laboratories in schools	4.60
Institutional Uses	
treatment and bedroom areas	10.00
detention quarters	11.60
Residential Uses	
dwelling units	See Note (2)
dormatories	4.60
Business and Personal Service Uses	
personal service shops	4.60
offices	9.30

TABLE 1 Occupant Load

Type of Use of Floor Area or Part Thereof	Area per Person (m^2)
Mercantile Uses	
basements and first storeys	3.70
second storeys having a principal entrance from a parking area	3.70
other storeys	5.60
Industrial Uses	
manufacturing or process rooms	4.60
storage garages	46.00
storage spaces (warehouse)	28.00
aircraft hangars	46.00
Other Uses	
cleaning and repair of goods	4.60
kitchens	9.30
storage	46.00
public corridors intended for occupancies in addition to pedestrian travel	3.70

Notes: (1) The occupant load is based on the number of fixed seats provided.
(2) The occupant load for dwelling units is based on 2 persons per bedroom or sleeping area.

Source: National Building Code of Canada

Construction Types

Two Primary types of construction:

COMBUSTIBLE: i.e. materials that burn easily and provide fuel for a fire (wood...)

NON-COMBUSTIBLE: i.e. materials that do not burn or act as fuel (these include steel and concrete)

Construction materials are *supposed* to stop the spread of fire from one house/building to the next.

Combustible Construction:

- typically light wood frame construction or Post and Beam
- only able to be used on buildings less than 6 storeys and usually less than 600 m^2.
- used on buildings which require a fire resistance rating of 3/4 hour or less

Non-Combustible Construction:

- used on all other types of buildings
- used for fire resistance classifications of 3/4 hour or greater
- unprotected steel can only be used for ratings of 3/4 hour
- 1 hour or greater requires the use of concrete structural products or protection on steel products (gypsum, concrete, intumescent coatings or other fireproofing)

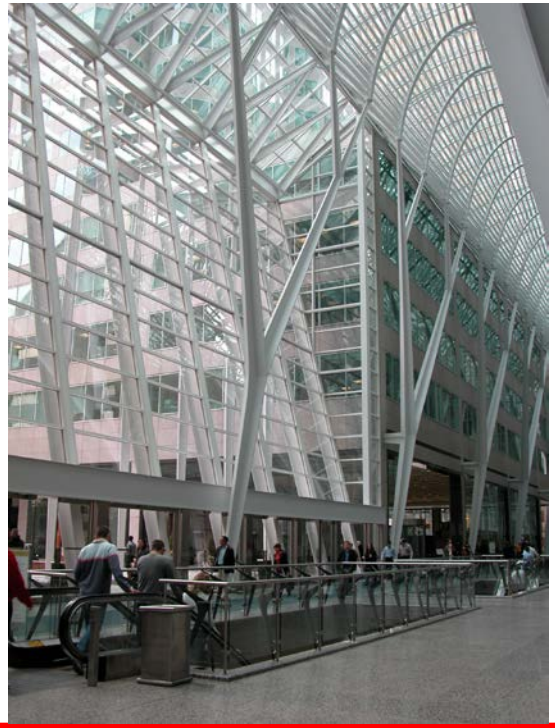
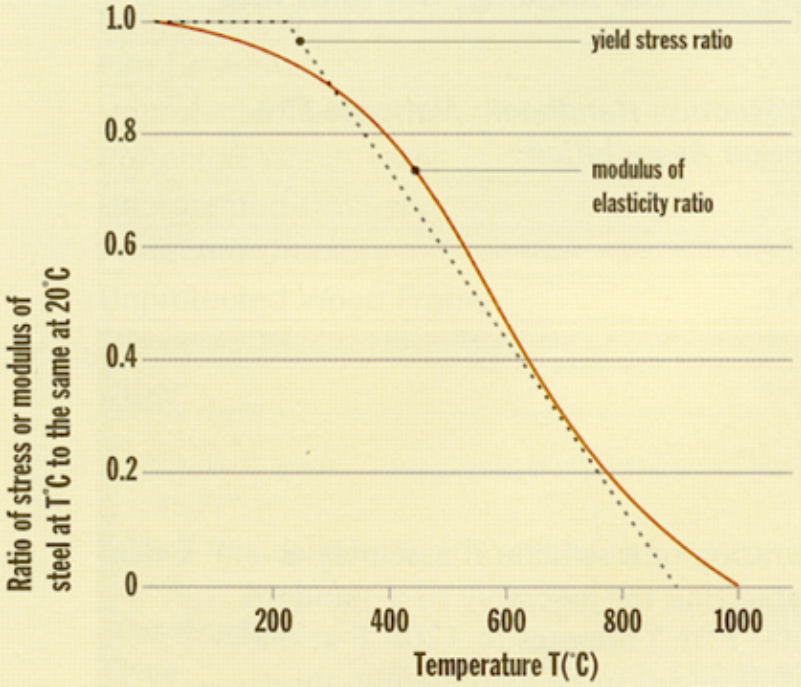


Figure 5 Steel Loses Strength at Elevated Temperatures

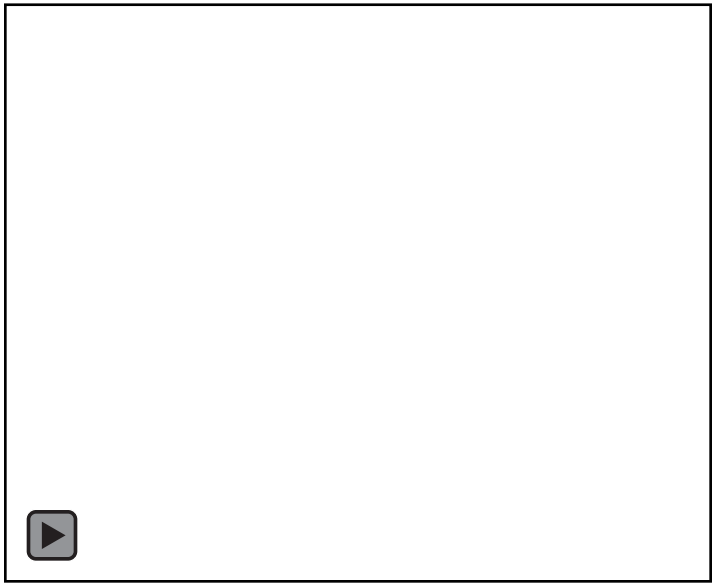


Source: Fire Engineering Design Guide,
University of Canterbury, New Zealand, 1994

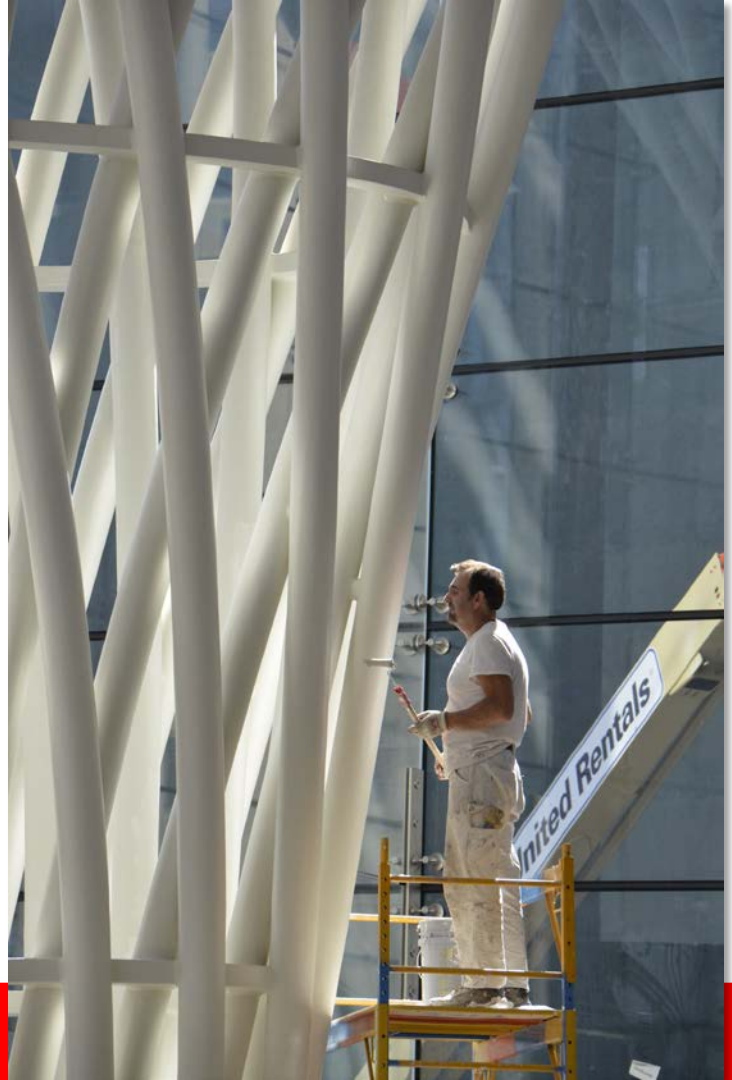
Galpão USP - 2002 - São Paulo – steel beams have melted

Intumescent coatings were used on the exterior “legs” at OCAD and on this truss in the Bloomberg Tower in NYC.

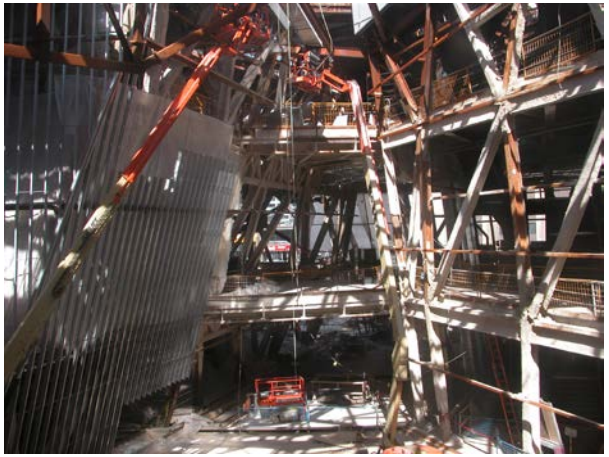
Intumescent coatings



Film of intumescent coating under a fire condition.



The texture of the intumescent coating is akin to an orange peel.



Spray on fireproofing is used in areas where the steel will be concealed from view. It may also be covered with gypsum board, which improves its fire resistance rating.

Building Size

- a limit on the maximum area and number of floors based on:
  - building use (occupancy type, hazard level)
  - construction type (combustible/non)
  - sprinklered or not (sprinklering allows for a doubling of area allowed)
  - access for fire fighting (number of streets the building faces, hydrant location, standpipes…)

Determining Maximum Building Area:

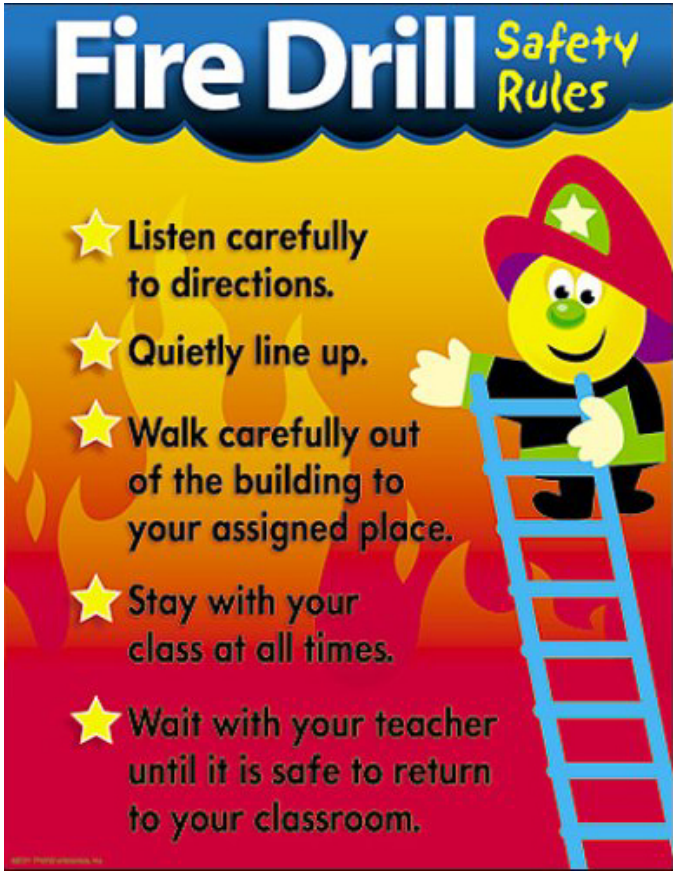
i.e. Maximum Building Area Group C Residential up to 3 Storeys

No. of Storeys	Maximum Area ($m^{2)}$		
	Facing 1 Street	Facing 2 Streets	Facing 3 Streets
1	1,800	2,250	2,700
2	900	1,125	1,350
3	600	750	900

Building Height:

- taller buildings are more difficult to evacuate quickly so have more stringent limitations
- the gross floor area of single storey buildings will be greater than the g.f.a. of a multi storey building for the same use on the same site
- tall buildings require internal fire fighting equipment as trucks and ladders have a limit to the heights they can reach (usually 6 floors)

Schools practice with fire drills so have more lenient construction requirements.

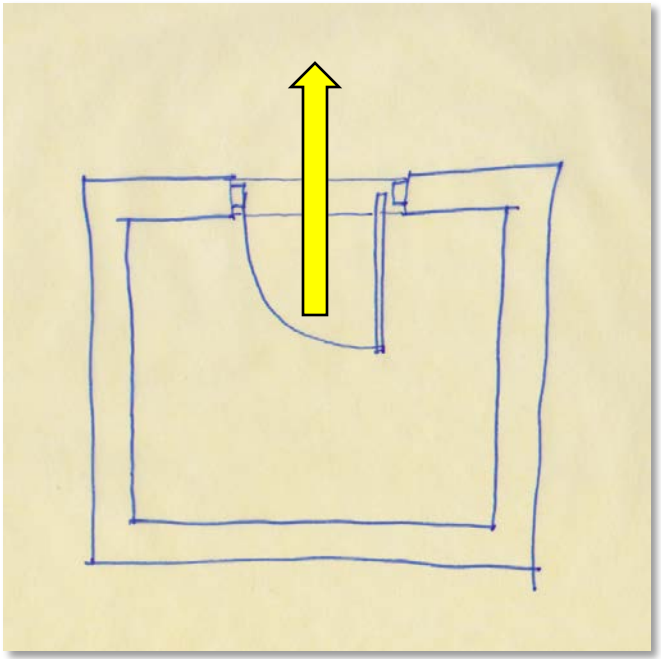


Where IS the fire exit sign???

Exit Requirements

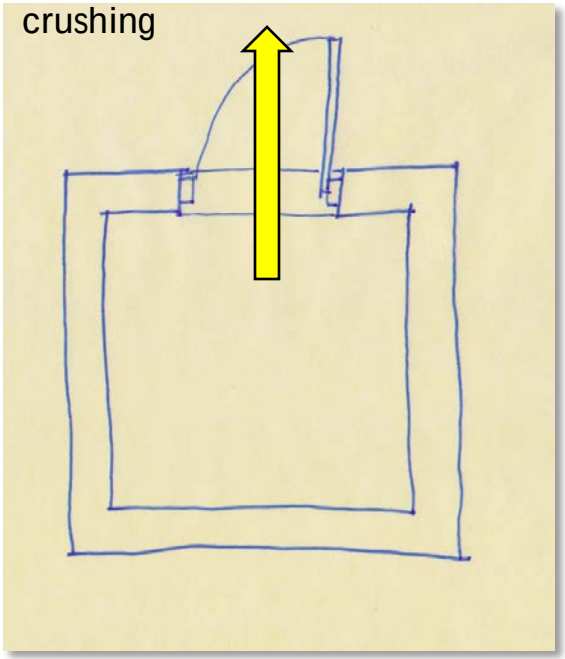
- number and type dependent on occupancy type and load
- i.e. greater risk, more people, more exits
- every floor area must have 2 exits
- travel distance to the exit is limited
- dead end corridors (more than 6m) not permitted
- exits must be fire separated from the rest of the building they are serving

• Low number of people exiting
• Door opens in (in case of obstruction outside)



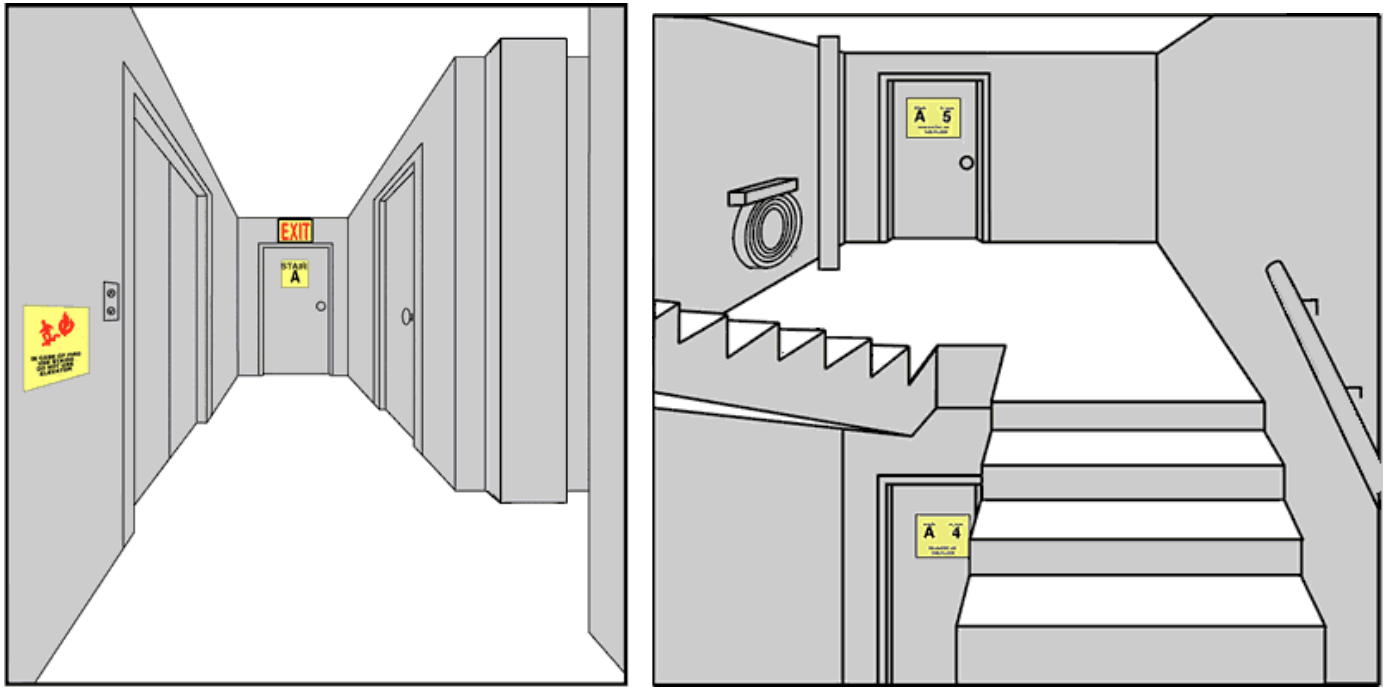
Residential/Single Family

• High number of people exiting (pushing and shoving!)
• Door opens out to prevent crushing



Commercial/Institutional

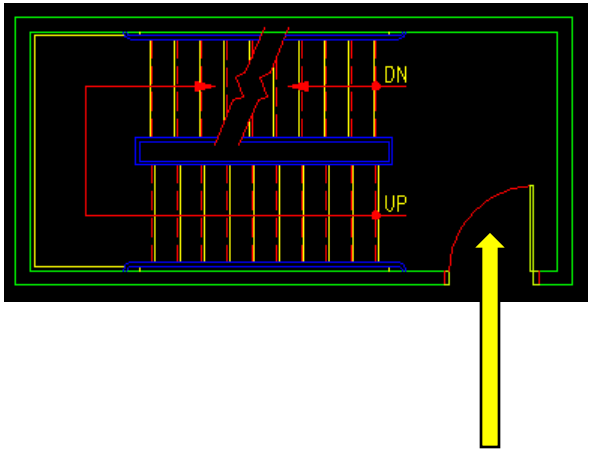
Buffalo snow storm 2014
The reason residential exit doors open inward.



Exits must be clearly marked with “internationally recognized” signage.

Fire Stairs

- Must be a safe route
- Minimal glazing allowed into the building
- Door opens into the stair
- Enough space between door and riser to allow someone to pass by (30cm minimum)



- People exiting into stairwell
- Door opens IN

With rare exceptions (like in stand alone houses), almost all building areas require at least 2 means of egress.

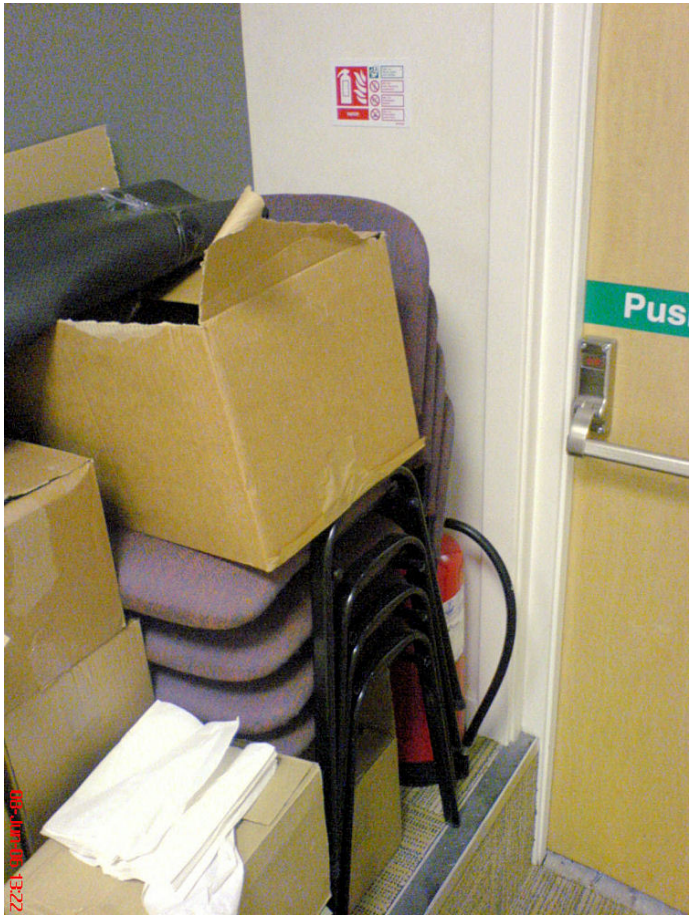
In buildings over one floor in height this normally means at least 2 sets of fire safe stairs.

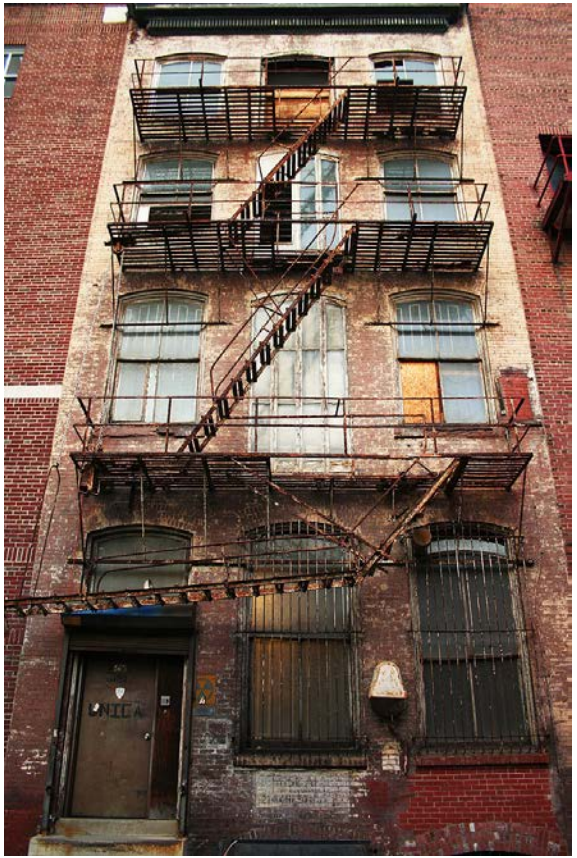
What is a fire safe stair??? One that is enclosed. Very little glass (often only a wee pane in the door). Has doors that open into the stairwell. Is pressurized so that if the door is left open no smoke can enter. Usually provides an exit directly to the exterior of the building.

i.e. It is really boring architecturally speaking -- but SAFE.

Fire exit doors need clear signage, panic hardware and are also fire rated. They may only have a small area of wired glass.

Fire exit doors and extinguishers need to be kept unlocked and unblocked.





Fire escapes are no longer permitted as a means of egress in NEW construction.

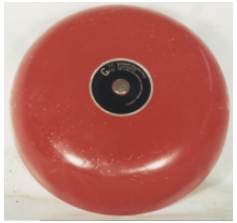
A major part of the risk here is the spread of the fire through the windows out onto people trying to exit on the fire escape.

To make it safe they would have to eliminate the windows, which rather defeats any advantage.

Fire Supression Systems

- Smaller residential buildings require smoke detectors on each floor
- Larger buildings (and all buildings over 6 storeys) must be equipped with fire suppression systems
- Must have sprinkler system
- Must have fire hose cabinets on each floor
- Must have exterior standpipes
- Very tall buildings must have their own water supply located at the top of the building to be able to use gravity feed in case of a fire

Smoke detectors



Fire alarms

Extinguishers and fire fighting equipment

Sprinkler head have a fusible (melting) link that activates the water flow and a rotating device to spray the water.

Spatial Separation

- separation of buildings to isolate them from one another and to control the spread of fire by either:
  - physical space between buildings, including control over openings and finishes
  - physical barrier (wall) between buildings (firewall) or areas within a building (fire separation)

Fire Separation

- is any wall, partition or floor assembly designed and built to prevent the spread of fire by restraining the passage of smoke, heat, gases and flame between compartments within one building
- assigned a fire resistance rating as required by the nature of the adjacent spaces

Fire Walls

- are special fire separations -- continuous walls of masonry or concrete -- that prevent fires from within one structure from spreading to another structure
- must allow building to break away in a fire without destroying the integrity of the firewall
- can be used to divide a large building into smaller building areas
- fewer and more specially designed openings are allowed

FIGURE 15 Exterior Wall—Firewall Junctions

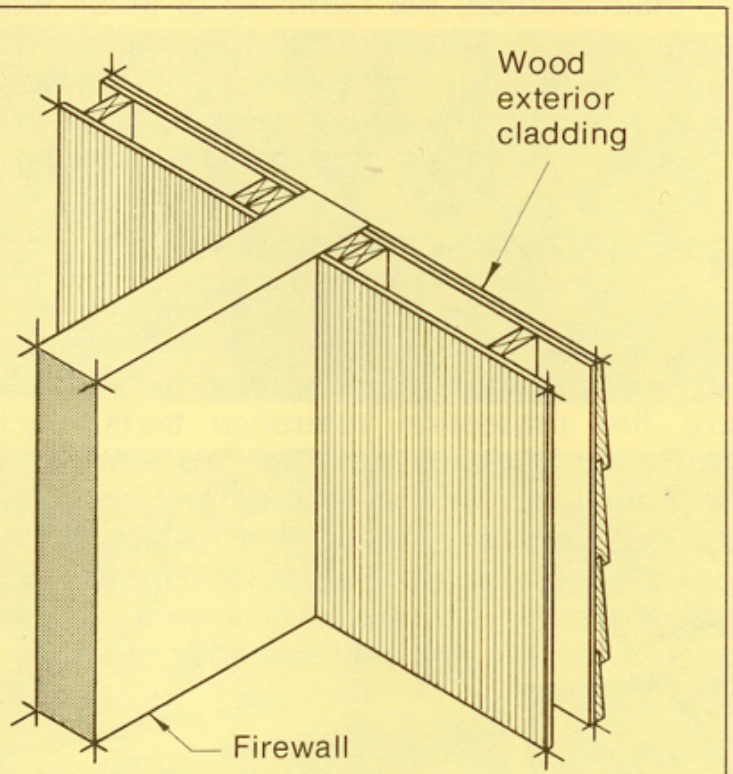
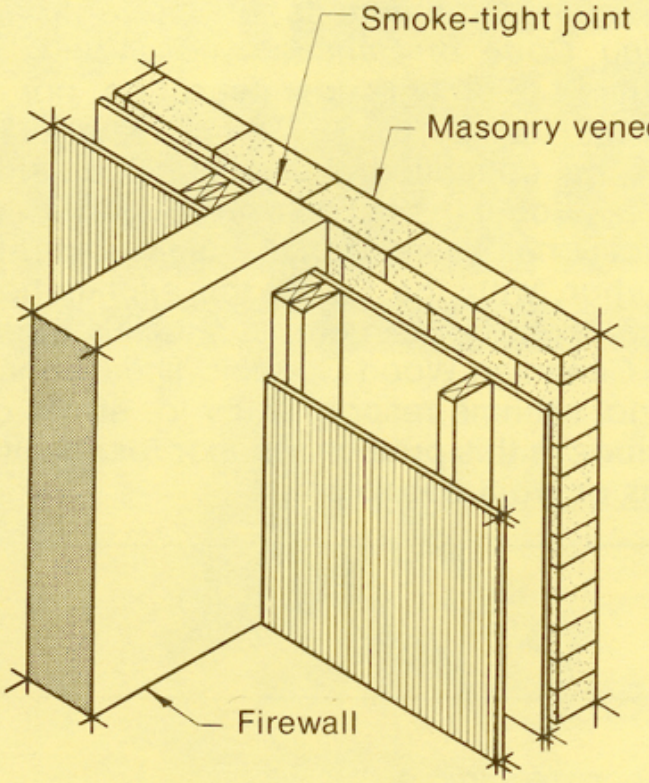


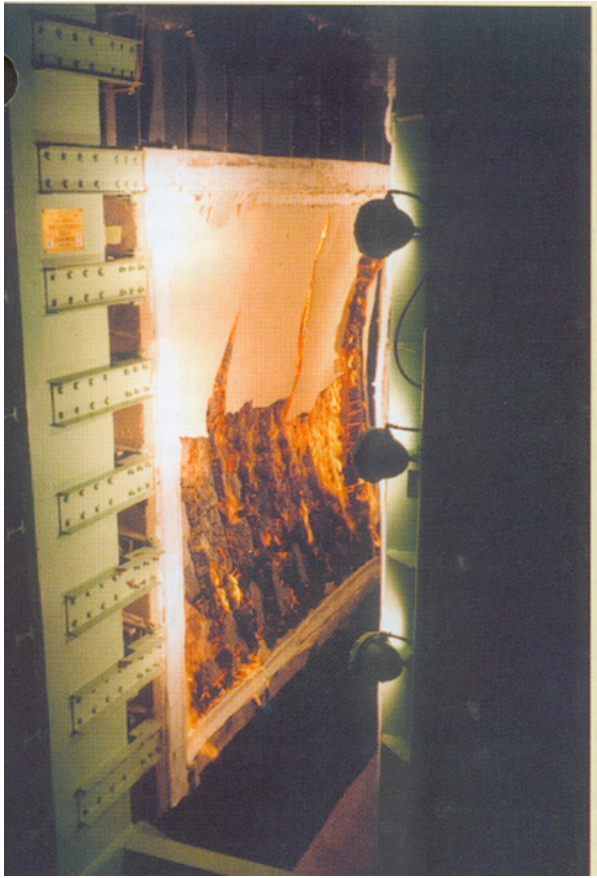
FIGURE 15 Exterior Wall—Firewall Junctions



The concrete block firewall between these units is not long enough to meet the brick veneer and stop the flow of air between the units.

Fire Resistance Rating

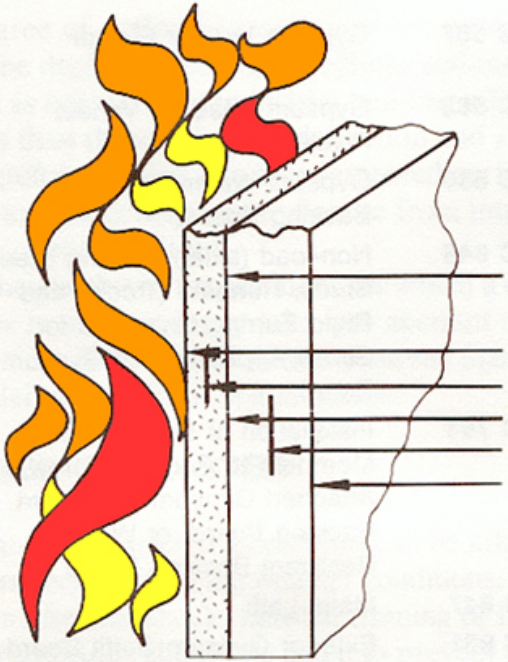
- is the time in hours that an assembly can withstand the passage of flame and heat when exposed to fire under standard test conditions
- is characterized by the ability of an assembly to confine a fire or continue to perform a given structural function, or both, when exposed to fire
- these ratings are established by a government or certified private testing agency after rigorous testing; often assemblies and products will be required to have a ULC Rating (Underwriters Laboratories of Canada)



The fire resistance rating of a structural assembly is determined by subjecting the assembly to a standard fire, ranging from 1000°F at 5 minutes to 1700°F at one hour. The assembly, if designed to be loadbearing, must support the full design load for the duration of the fire test without allowing any flames to pass through.

Fire testing of loadbearing and non-loadbearing wood stud and sheet metal stud wall assemblies protected with gypsum wallboard show that fire rated wood stud wall assemblies prevent fire spread through the wall for as long as, if not longer than, identical walls built with sheet metal studs. [23, 24, 25]

Figure 4 Wood Stud Wall Assembly After 1 hour Test.



HOW GYPSUM RETARDS HEAT TRANSMISSION

AFTER TWO HOUR EXPOSURE TO HEAT FOLLOWING ASTM E 119 TIME-TEMPERATURE CURVE

Vertical line represents plane of calcination at depth of about 2″. Temperature never greatly exceeds 212 F. behind plane of calcination.

Temperature of exposed surface = 1900 F. (1040C)

Temperature 1″ from exposed face = 950 F. (510C)

Temperature 2″ from exposed face = 220 F. (105C)

Temperature 4″ from exposed face = 180 F. (82C)

Temperature 6″ from exposed face (at back surface) = 130 F. (54C)

(Data from Underwriters' Laboratories, Inc.)

Fire Compartment

- an enclosed space within a building that is separated from other parts of the building by surrounding continuous construction built as a rated fire separation
- between row houses or apartments, a one hour fire separation is required
- openings are allowed in the fire separation, but are limited in size and must be able to be closed

FIGURE 1 Fire Compartments

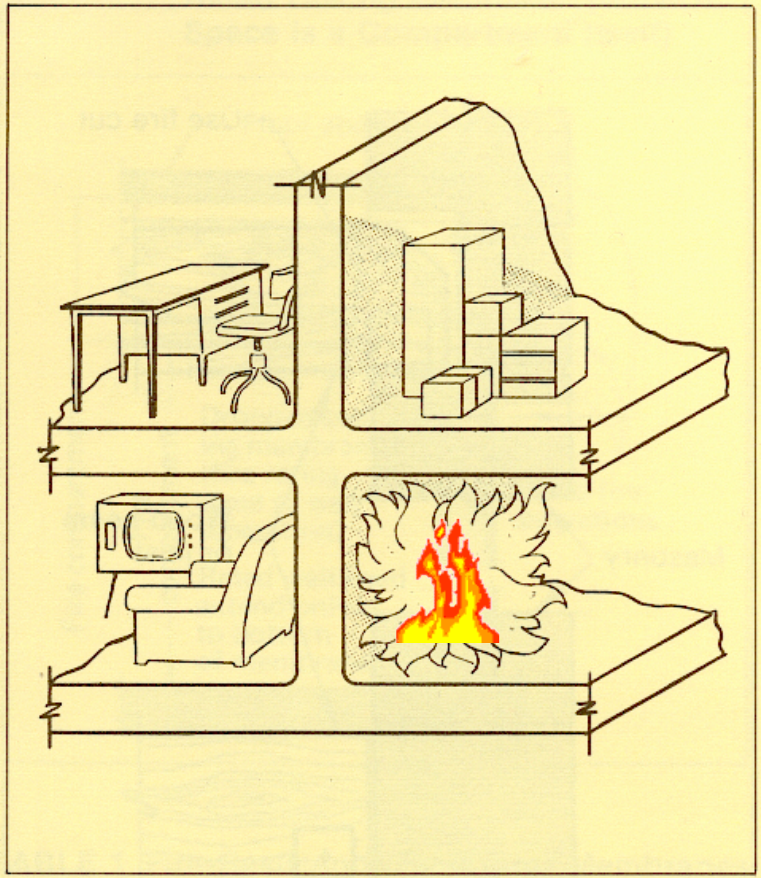
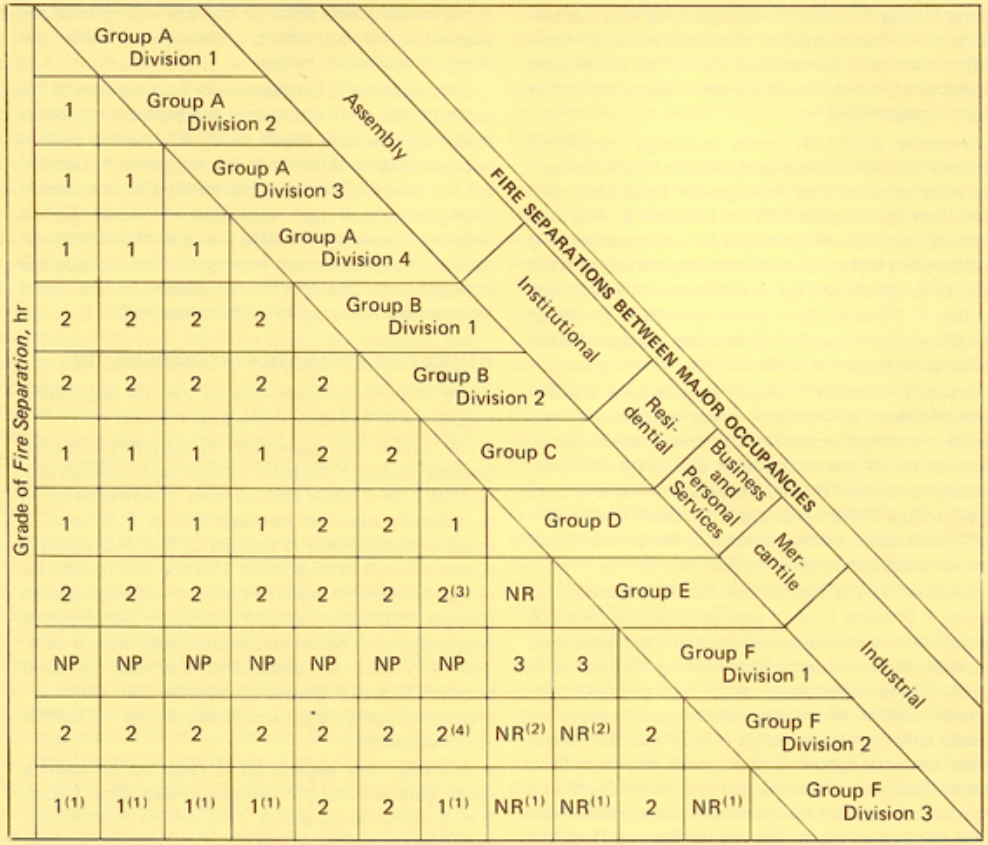


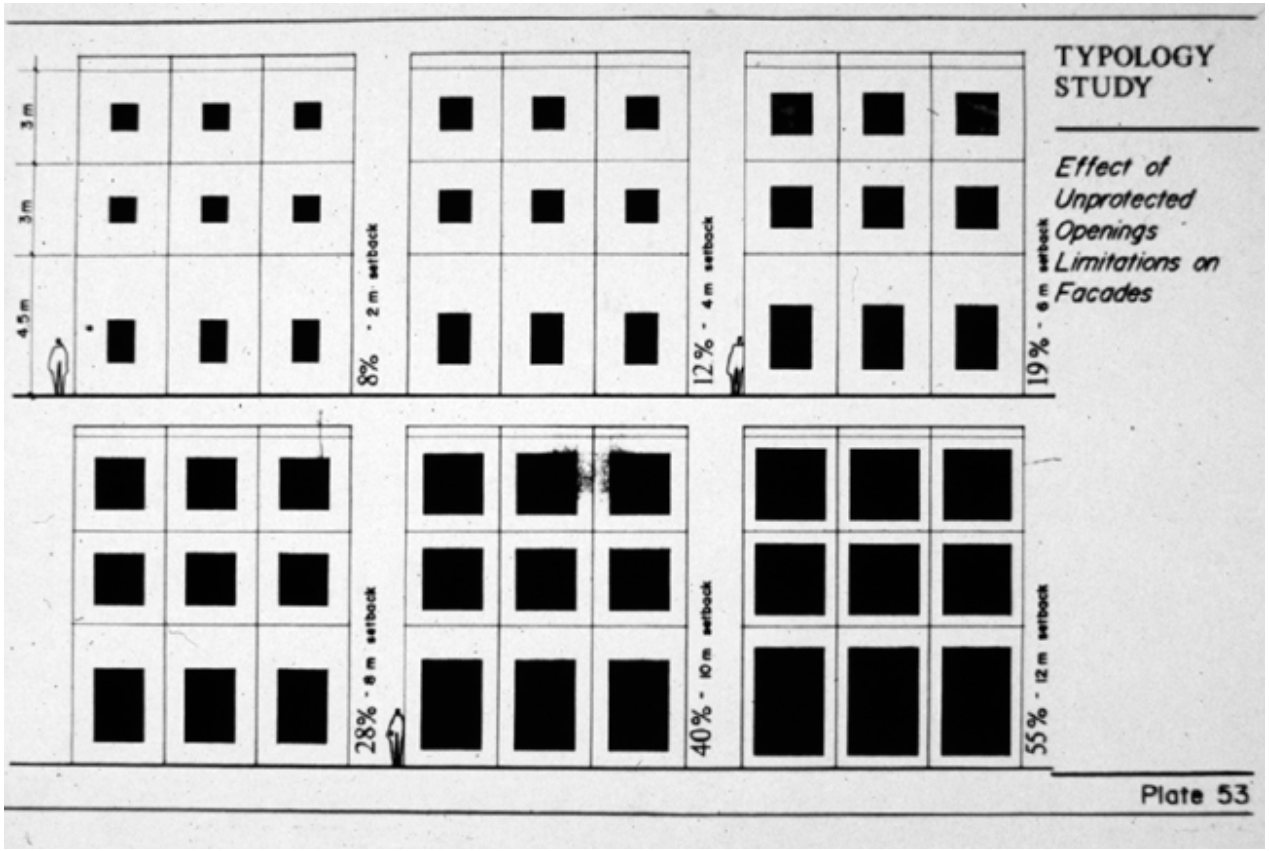
TABLE 3 Grade of Fire Separation Required Between Major Occupancies (Hours)



Notes: (1) A 1½-hour fire separation is required when the Group F Division 3 occupancy is a storage garage. (See Sentence 3.3.7.6.(11).)
(2) A 2-hour fire separation is required when the Group F Division 2 occupancy is a repair garage. (See Sentence 3.3.7.6.(10).)
(3) If the building containing a Group E major occupancy is not over three storeys in height and the Group C major occupancy does not contain more than two dwelling units, only a 1-hour fire separation is required.
(4) Not more than 1 dwelling unit permitted.
NP — Not permitted; prohibited occupancy combination.
NR — Not required.

Unprotected Openings

- any portion of an exterior building face that does not meet the fire resistance rating required for the building face (ie. windows, doors, vent grilles)
- steel window frames, wired glass and glass block allow for a doubling of the OBC maximums
- sprinklering allows for a doubling of areas


TYPOLOGY STUDY
Effect of Unprotected Openings Limitations on Facades
3m
3m
4.5m
8% - 2 m setback
12% - 4 m setback
19% - 6 m setback
28% - 8 m setback
40% - 10 m setback
55% - 12 m setback
Plate 53

Sizing Unprotected Openings

- limits are based on distance from property lines, as a % of the building face area
- ie. for residential (50 s.m. building face):
  - less than 1.2m setback allows 0%
  - 1.2m setback allows 7%
  - 1.5m setback allows 8%
  - 2.0m setback allows for 10%
  - 4.0m setback allows for 28%

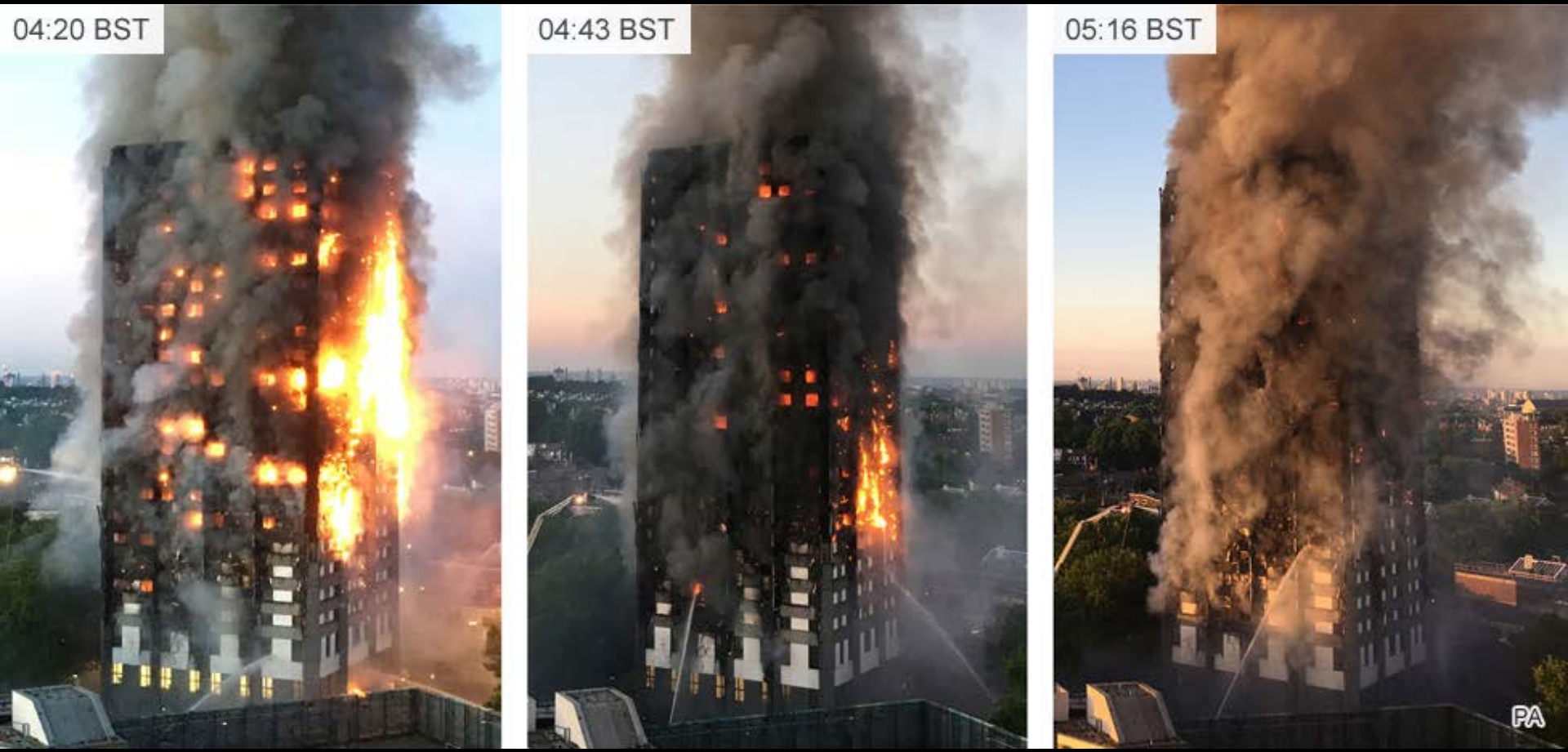
Limiting Distance

- refers to the distance between an exposing building face and the property line or to an imaginary line between two buildings on the same property.
- if the two buildings are the same (area of face and glass) the line will be midway; if they are different, the distance will be proportional

The Role of the Façade and Cladding

- Lots more on this in AE 200 Enclosure Studio in 2A
- Huge variety of choice in our enclosure/cladding materials
- Not all have been adequately tested for fire spread
- Not all rules and applications are the same around the world


Insulation Layer
250mm thick concrete of original tower block
Waterproof membrane
Cladding with flammable plastic core
50mm Air cavity that allowed fire to spread behind it
GRENFELL TOWER PRE-REFURB IN 2011
POST REFURB WITH NEW CLADDING
© PA Wire/PA Images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