

Egress Elements

- Explain the purpose of the means of egress
- Distinguish between the three elements of the means of egress



Historic Fire

- Happy Land Social Club



Means of Egress

- Chapter 7 of NFPA101
 - Chapter 10 of IBC
 - Fundamental to life safety

1. nfpa 101 and IBC are not identical .but the concepts and principles that underly everything are the same in the two codes
2. most content for nfpa 101 and for PE
3. we should be familiar with



Means of Egress Requirements

- Level
 - Not more than $\frac{1}{4}$ in
 - More than $\frac{1}{2}$ in change in level
 - Clearance
 - 7 ft 6 in
 - 6 ft 8 in
 - Slip resistant
 - No obstructions
1. Make sure everyone can use all these means of egress avoid pump(碰撞) and one person goes down and people end up being stacked up on top of each other and they can not get out
2. we want to do something to avoid slip trips and falls



Egress Elements

- **Exit**
 - Meaning
 - Examples



Egress Elements

- **Exit Access**
 - The portion of a means of egress that leads to an exit.
- **Exit**
 - The portion of a means of egress that is separated from all other spaces of the building or structure by construction, location, or equipment as required to provide a protected way of travel to the exit discharge.
- **Exit Discharge**
 - The portion of a means of egress between the termination of an exit and a public way.



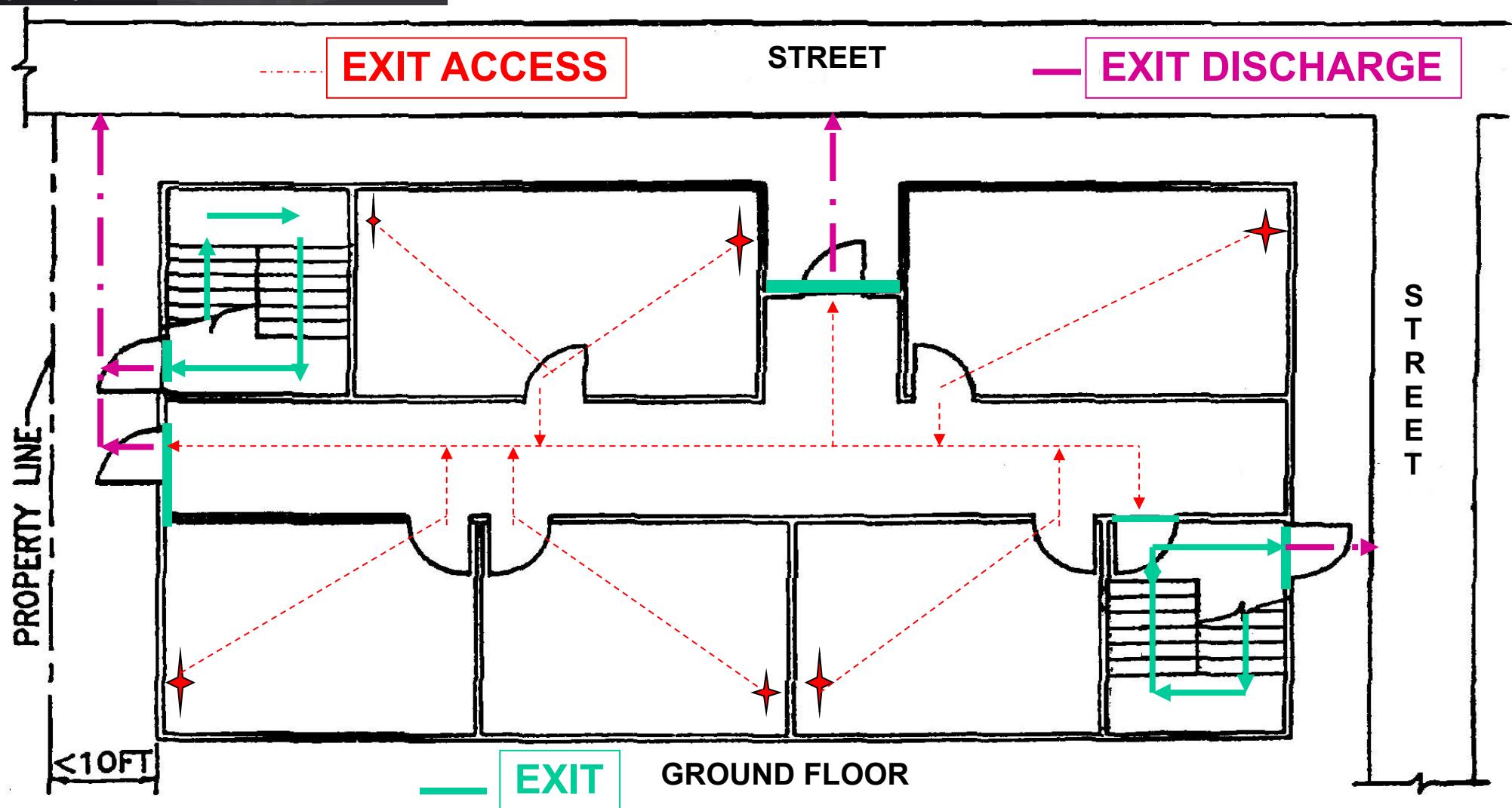
Egress Elements

- **Public Way**
 - A street, alley, or other similar parcel of land essentially open to the outside air deeded, dedicated, or otherwise permanently appropriated to the public for public use and having a clear width and height of not less than 10 ft.
 - The code intends a situation where occupants egressing from a building ultimately reach a point where they can move away from the building unimpeded and no longer need the protection of the Code.



Egress Elements

... you see a door leading out well a few doors leading out to an area that's less than 10 feet to the property line so another building could be built there so that cannot be the public way



Decreasing Hazard

- From corridor to a room
- From one room to another room
- Through kitchens
- Through mechanical rooms
- Exit to exit access
- Exit to lobby
- Stairs directly to outside





door leaning to the
unrated corridor that's
not quite seen here also
exit access



exit access



rated corridor
and I lead people
outside
discharging
directly this is
rare now





exit, not because signs but when fire happened it activate the magnet on those door providing a fire barrier. we will see this in a lot of institutional space like hospital. so this is horizontal exit give protection





exit, inside
rated enclosure.
most stair you're
going to see in
the building are
exit stairs

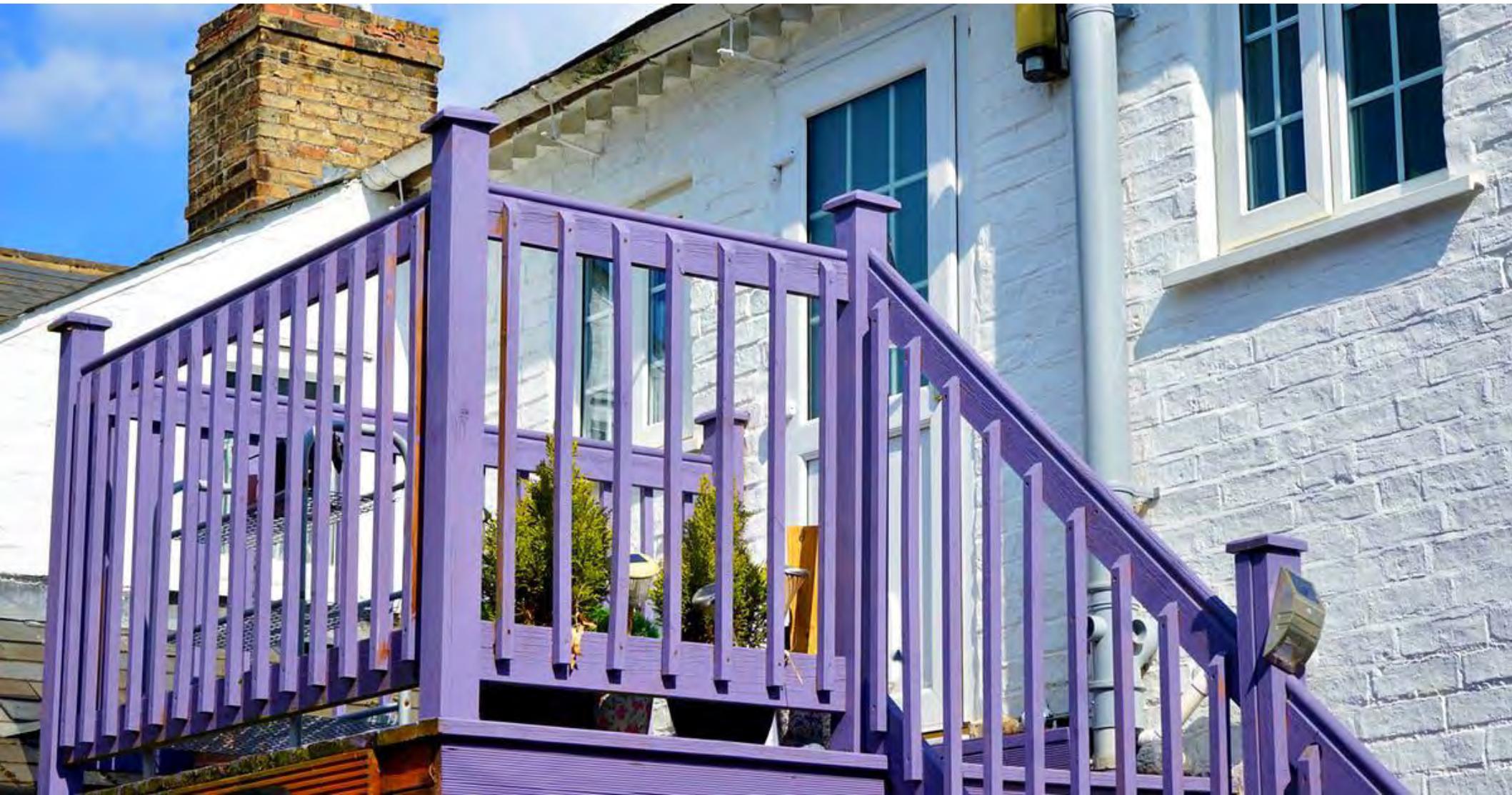


exit lead to
outside



one way exit





exit discharge





exit discharge





Exits

- Calculate the number of exits required
- Explain how the exit should not be used

You should be dependent on a single safeguard

In general rule you should have at least two exits because if a fire blocks one exit you still have a way out of building



Historic Fire

- Rhythm Nightclub



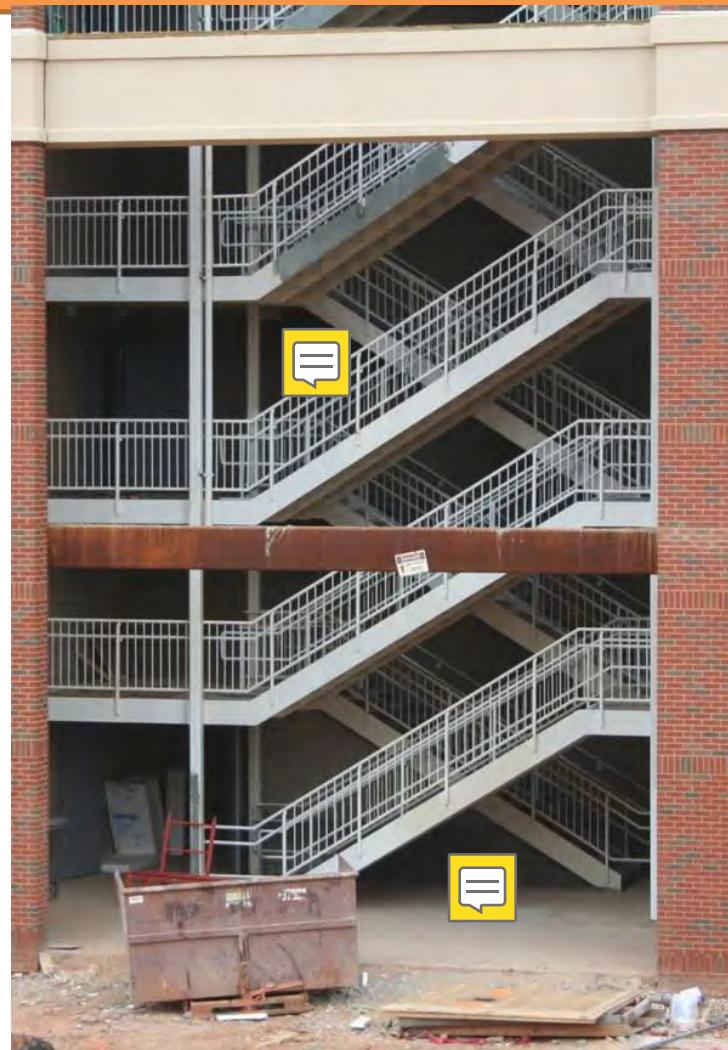
Number of Exits

- Based on the number of people
 - Not dependent on type of occupancy
- Assume single exit could be blocked
 - 50 %

The calculation method is to determine the gross floor area, and then find the occupant load factor of the corresponding occupancy in the table 1004.1.2.

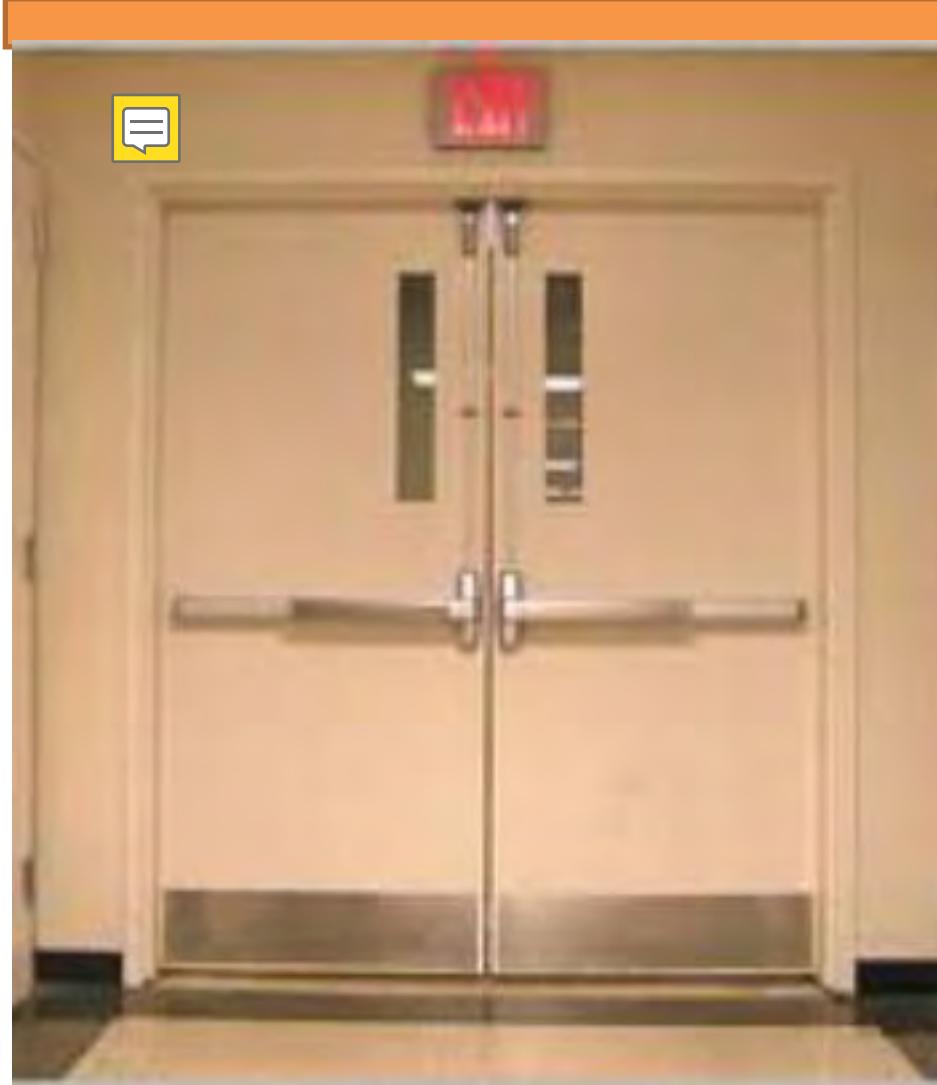
Secondly, through the number of occupants, I can determine the design number of exits: (1) 50 to 500 occupants: two exits. (2) 501 to 1000: Three or more exits. (3) More than 1000 occupants: Four exits. Thirdly, I learned to design the width of the stair, the width of the corridor and the width of the door through the number of people.

the general rule is two is a minimum. So no answer below too on the exam will be correct. Example 499=2 exits, 501=3 exits





Horizontal Exit



Exit Usage

- Fire protection systems only





Maintenance of Exits



Enclosures





Doors and Corridors

- Calculate the minimum size of doors and corridors
- Identify the features of doors and corridors



Historic Fire

- Hartford Hospital



Minimum Widths

- NFPA rules
- IBC rules



Minimums

- Access: 36 in
- Doors:
 - Clear width
 - 28 in
 - 32 in
- Cannot decrease in direction of travel





1/2W
MIN.
7 INCHES
MAX.

7 INCHES
MAX.

(1)

REQUIRED
WIDT_H
W

EXIT ACCESS
CORRIDOR

7 INCH
MAX.

90°

(2)



7 INCH
MAX.

90°

ALCOVE

Doors

- Direction
- Hardware
- Locks
 - Delays
- Forces
- Labels



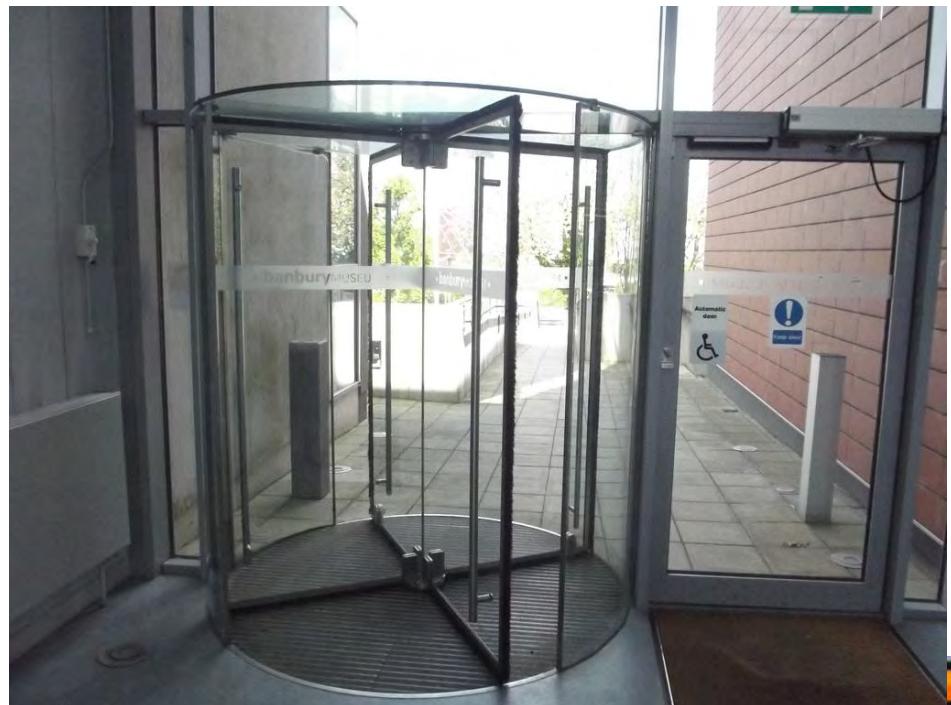
Doors

- Automatic-closing
- Self-closing
- Level
 - Width of leaf on either side
- Egress side
- Ingress side



Revolving Doors

- Typically not included in means of egress
- Must have regular doors adjacent
- Doors must break-away in direction of travel
- Rules on speeds



Doors

- Single action
 - No special knowledge
 - No special tools
- Lock side based on security



Other Components

- Identify other elements that can be part of the means of egress
- Determine when other components are appropriate to use



Historic Fire

- MGM Grand



Others

- Areas of Refuge
 - Area to wait
 - Connected to means of egress
 - 2 way communication
- Smoke Proof Enclosure
 - Outside building
 - Protected shaft

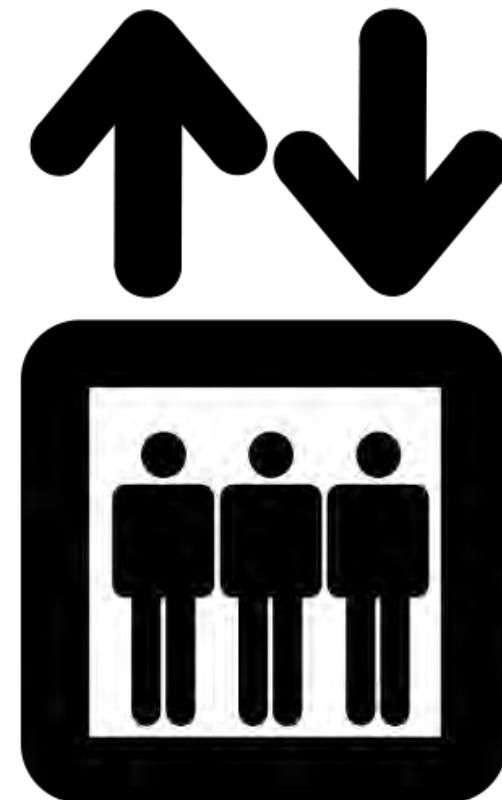


Others



Others

- Before Phase I
- Stair replacement?
- Shaft with stair
- Signage
- FFCP
 - 2 way communication
- Building must have
 - Voice alarm
 - Sprinklers

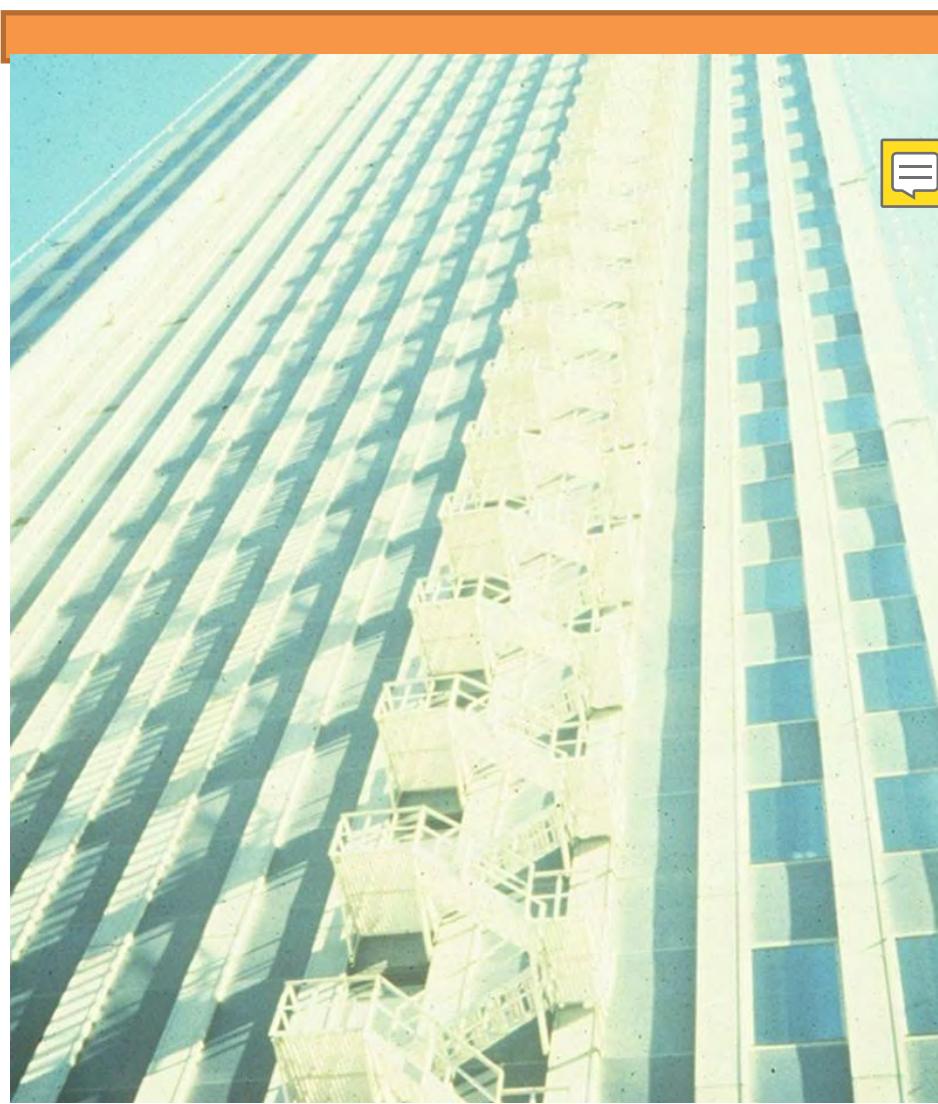


Others



1. training on that
2. limit number of people

Others



Supplementary Escape Devices



Stairs

- Calculate the **minimum size of stairs**
- Identify the **features of stairs**



Historic Fire

- Grenfell Tower



Stairs are Simple

<https://themindcircle.com/30-epic-stair-design-fails/>



Stair Widths

- **Exit lanes**

- Not used by NFPA101 or IBC

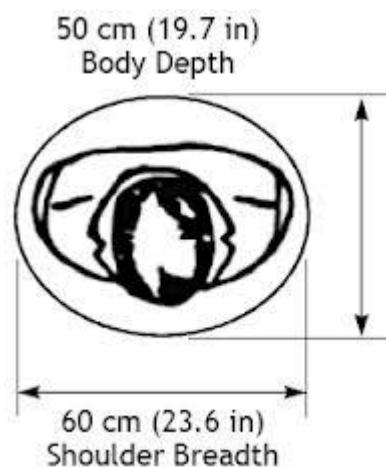
- **Width calculations**

- **NFPA**
- **IBC**

$$C = 146.7 + \left(\frac{Wn - 44}{0.218} \right)$$

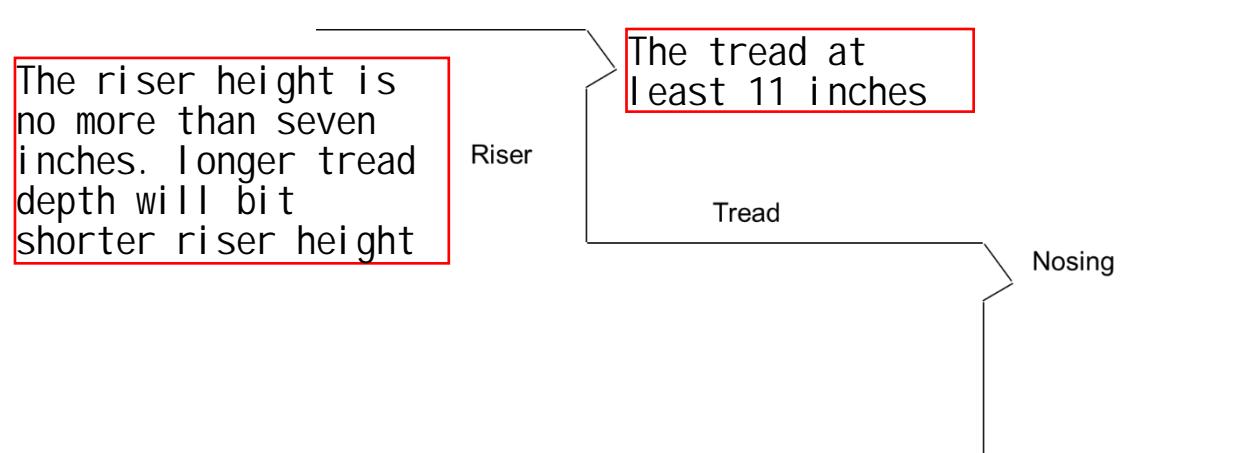
146

Width<44 in, use 0.3
Width>44 in, use 0.218



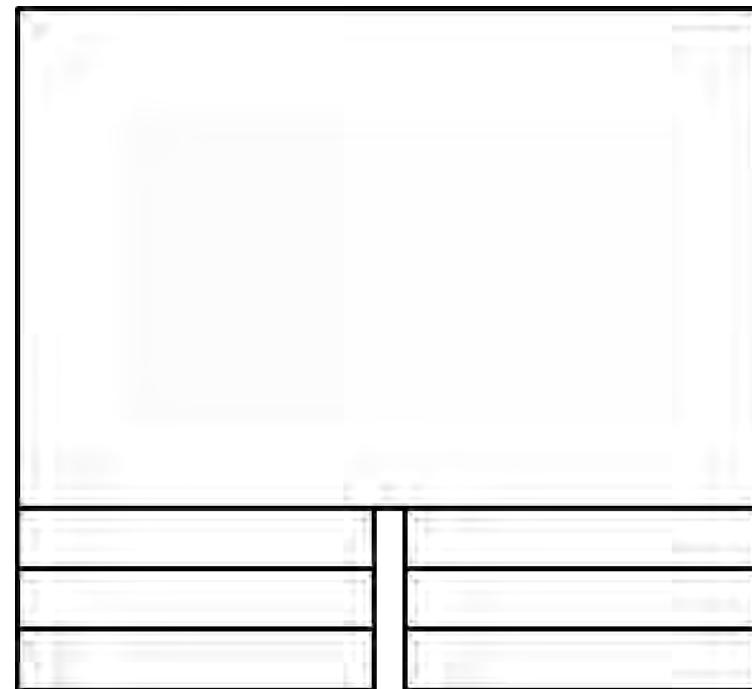
Stairs

- Size
- Usage
- Slip resistant
- Marked
- Changes in size
 - 3/16 in
 - 3/8 in

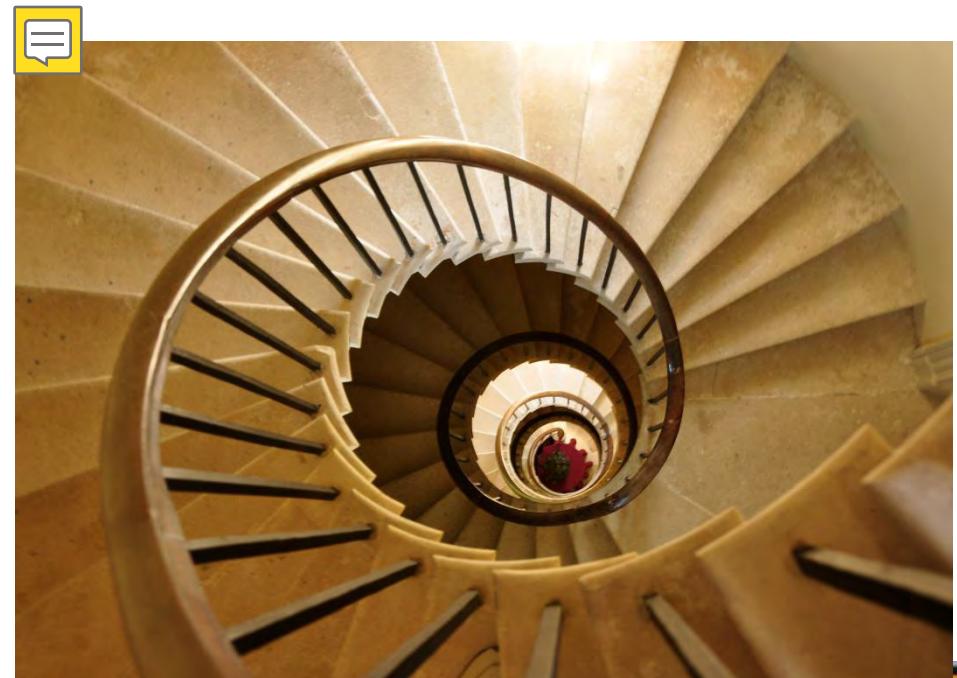
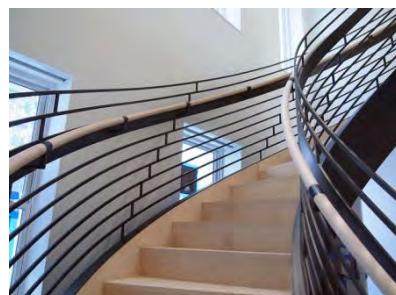


Stair Terminology

- Flight
- Landing
- Dog-leg
 - Sinistral 左旋的
 - Dextral 右旋的
- Straight
- Curved
- Spiral



Curved and Spiral Stairs



Minimums

- 44 in
 - Exception 36 in
- 56 in
- Cannot decrease in direction of travel
- Projections
- Fire alarm



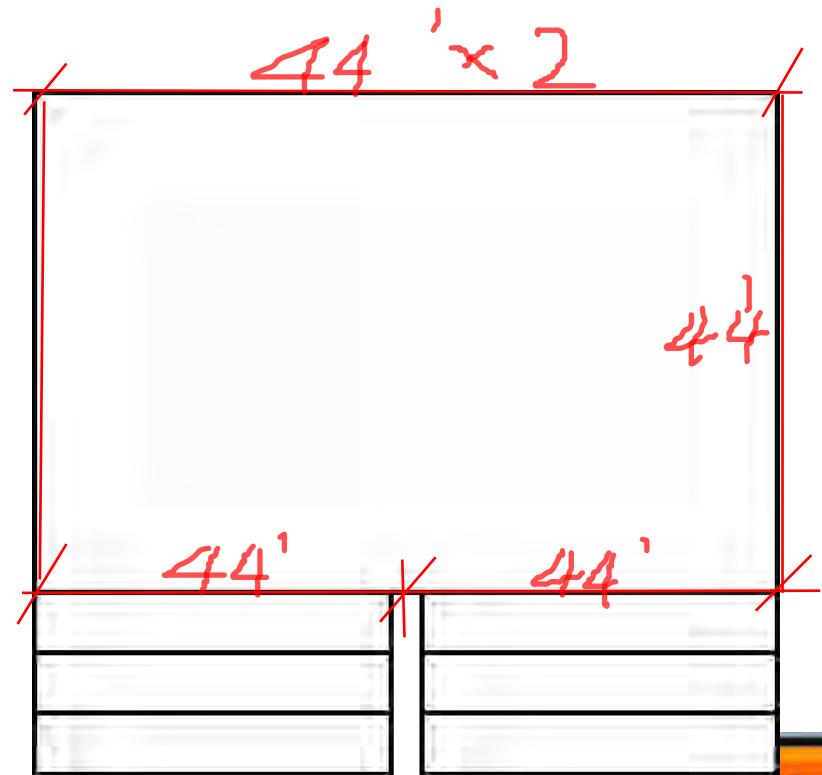
Handrails and Guards

- Shape
- Location



Landings

- No decrease in width
- Length equal to width of stairs
 - 48 in
- At doors



Convenience Stairs

- Uses
 - Atriums
 - Grand stairs
- Connecting multiple levels
- General
- With sprinklered vertical openings

中庭
大樓梯



Occupant Loads

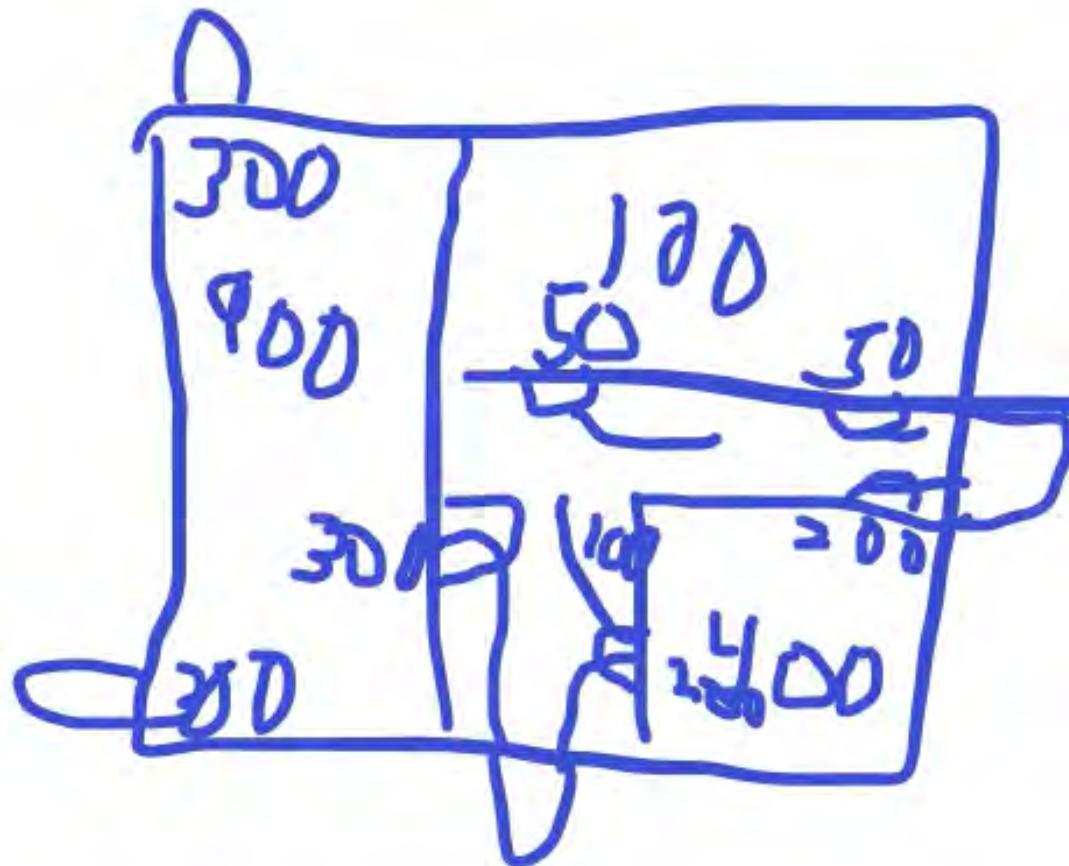
- Select the appropriate number of people per exit
- Determine the capacity of areas with merging flows

选择每个出口的适当人数
确定合并流区域的容量



Historic Fire

- Dusseldorf Airport





Assigning Exits

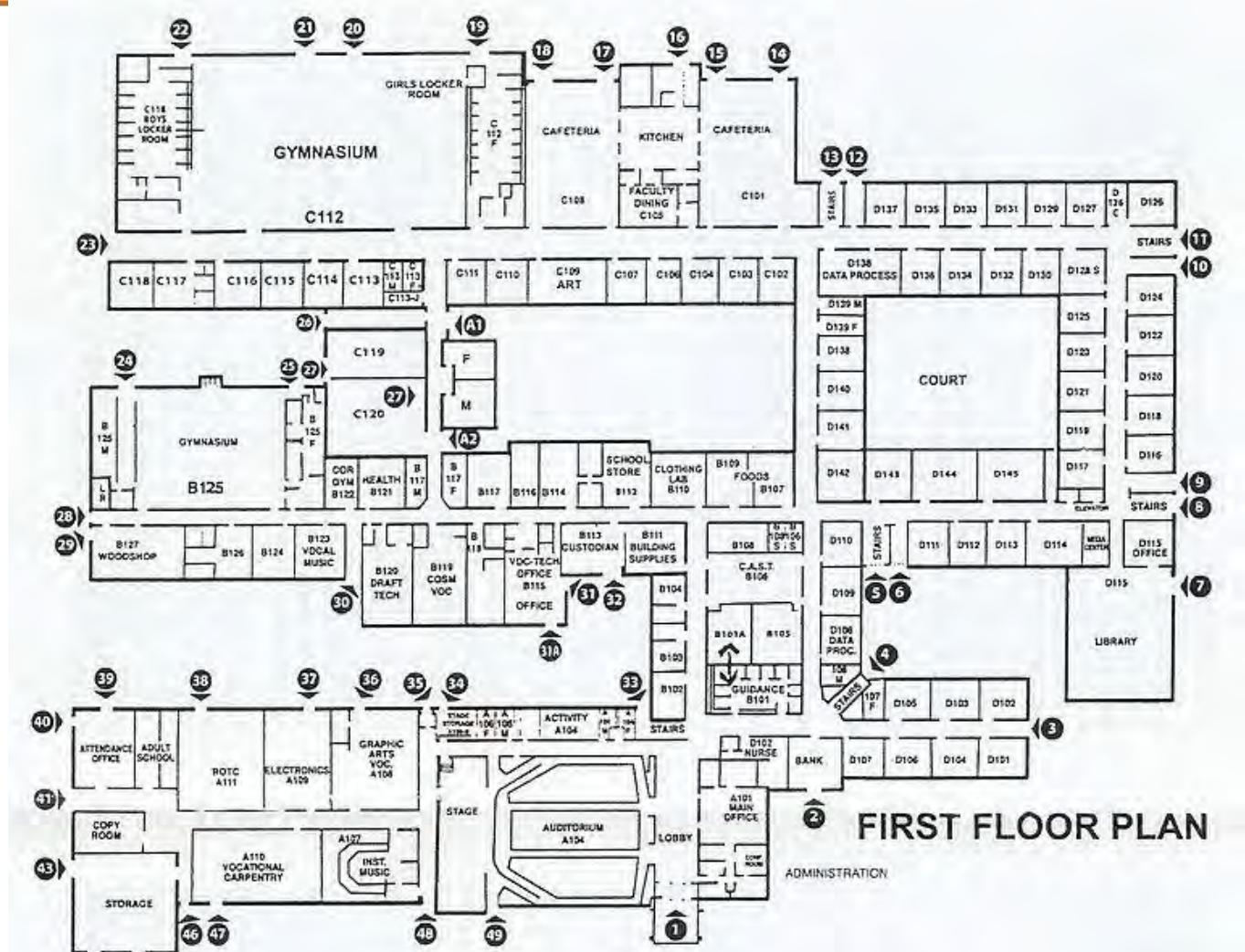
Department store: 20,000

Skating rink: 5,000

Restaurant: 11,000



Simultaneous Occupancy



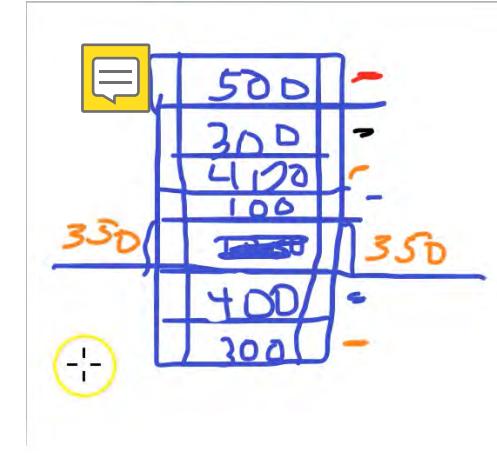
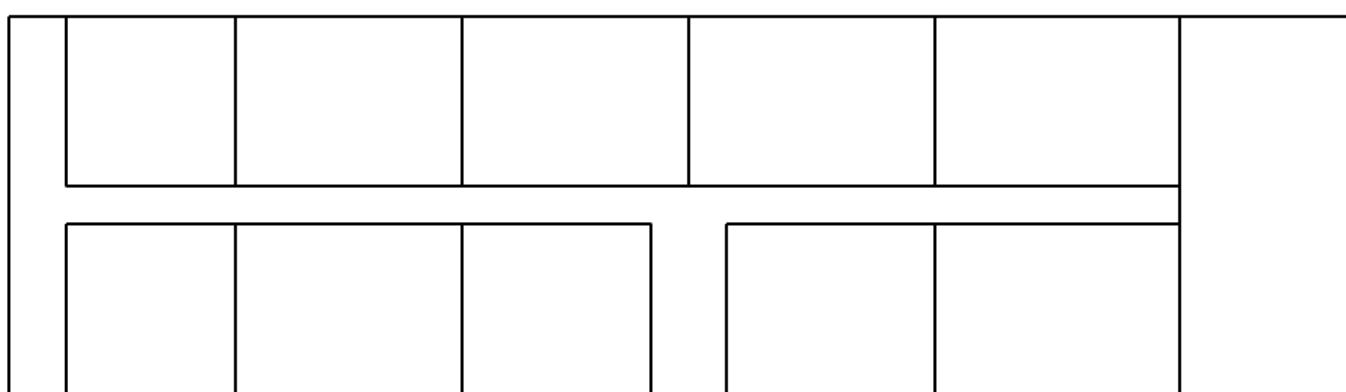
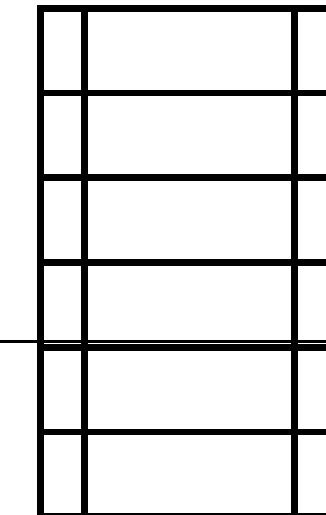
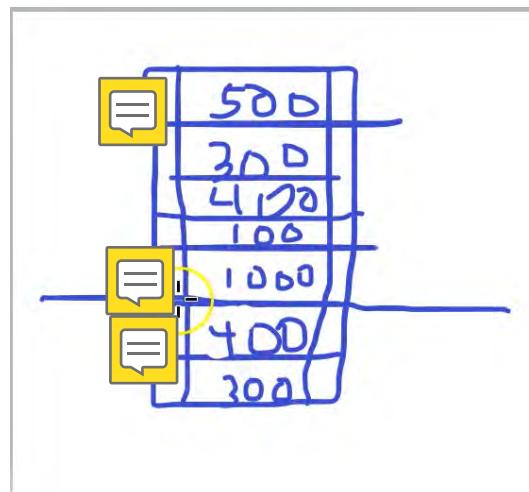
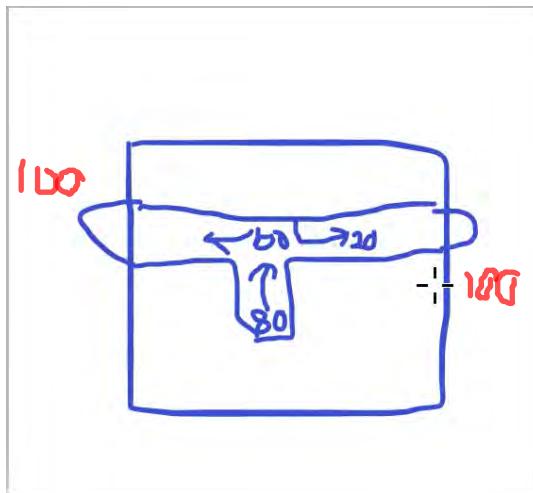
Evacuation Elevators

- 25 % population + 2 % wheelchairs



Merging Flows

- Corridors
- Stairs



Occupant Loads

- Select the appropriate choice between gross and net area
- Calculate the occupant load



Historic Fire

- Ghost Ship



Occupant Load Factors

- Gross
- Net
- Mixed use

Table 7.3.1.2



Occupant Load Factors

- Minimum design value
 - Are more people acceptable?
- Origin of load factors
- Meaning of words
 - Based on use
- Rounding rules



Seating Arrangements

- Concentrated
- Less concentrated
- Fixed
- Bench
- Waiting spaces



Malls

- Load factor varies with size of mall



Exits

- Determine the remoteness of exits
- Calculate the capacity of exits



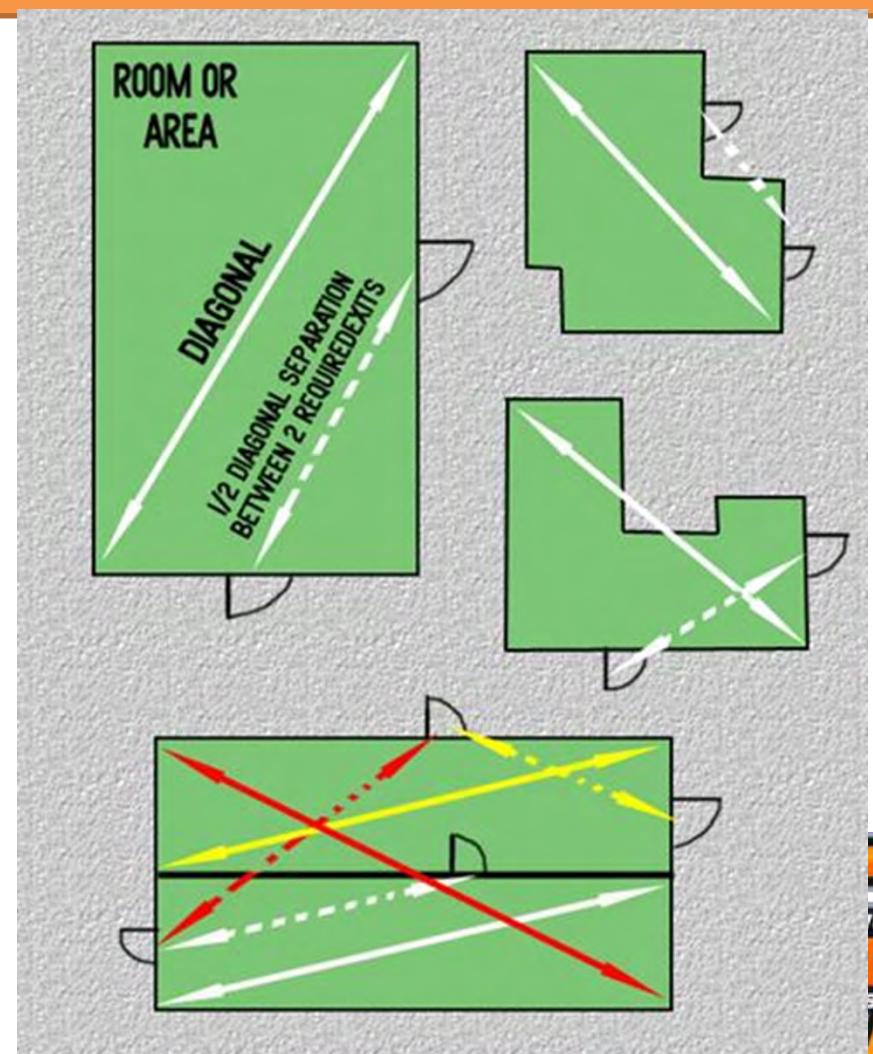
Historic Fire

- Katie Jane Memorial Home



Remote

- Rules for two exits
 - Additional exits as far apart as is practical
- Sprinkler trade-off
- No familiarity requirements



Requirements

- Openings from normally occupied spaces
- Rating depends on building height
 - 1 hr for 3 stories or less
 - 2 hr for 4 stories or more



Discharge

- Remote
- All outside
 - 50 % in some instances
- Barrier



Capacity

- Typically for existing buildings
 - Change of use
 - Reconstruction on floor
- Look for limiting component
 - More to consider than just the first component
- Rounding



Distances

- Determine where distance calculations are required
- Calculate distances
- Explain the limits on dead end corridors and common path of travel



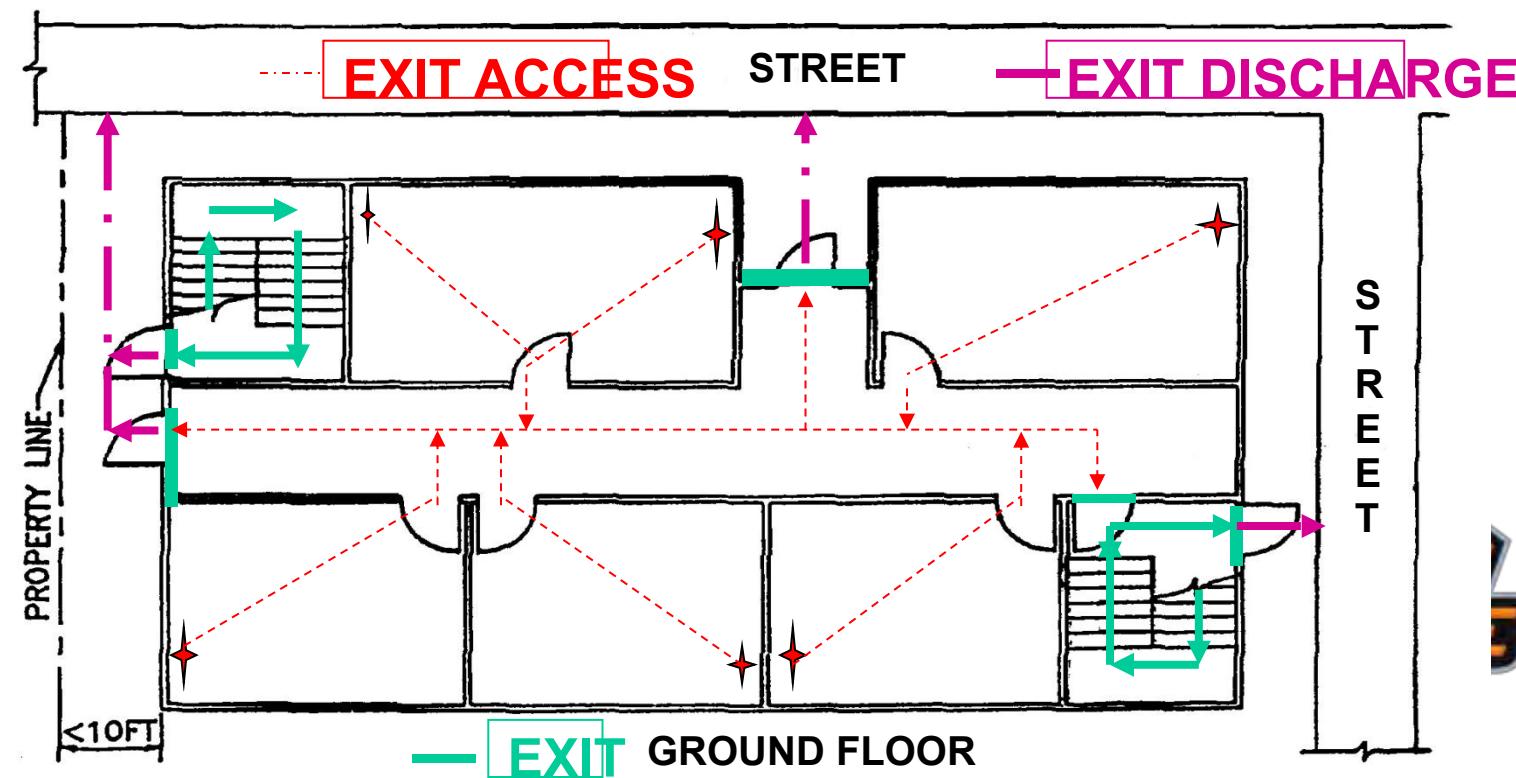
Historic Fire

- Beverly Hills Supper Club



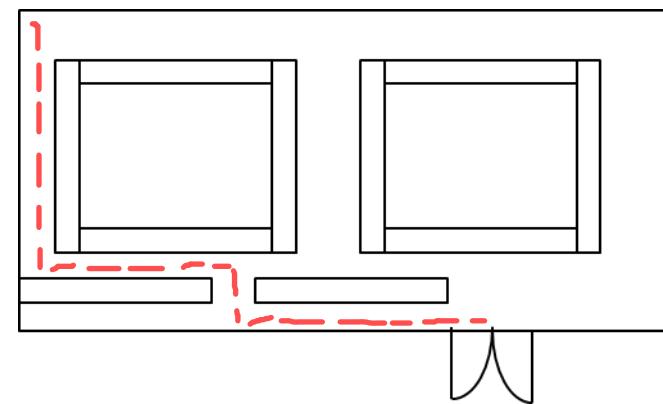
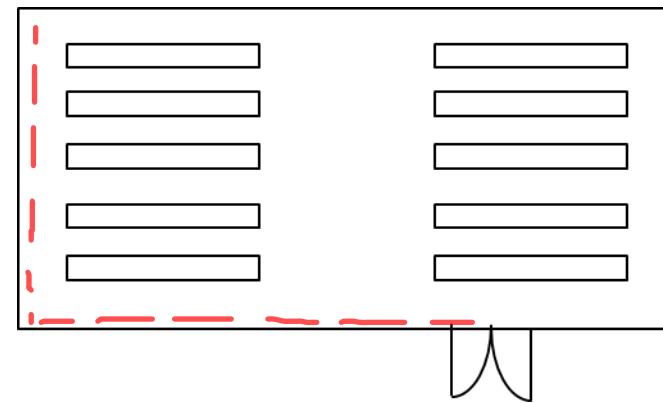
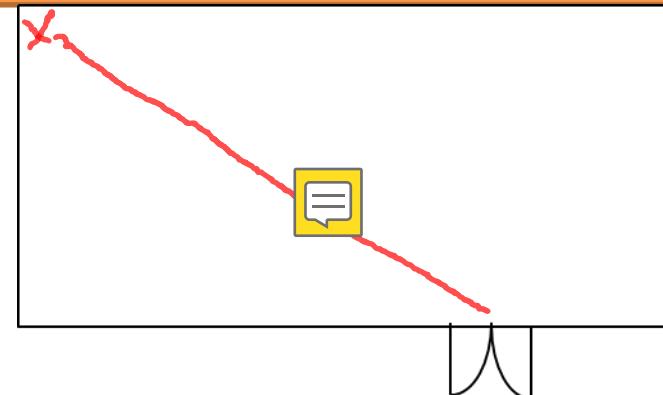
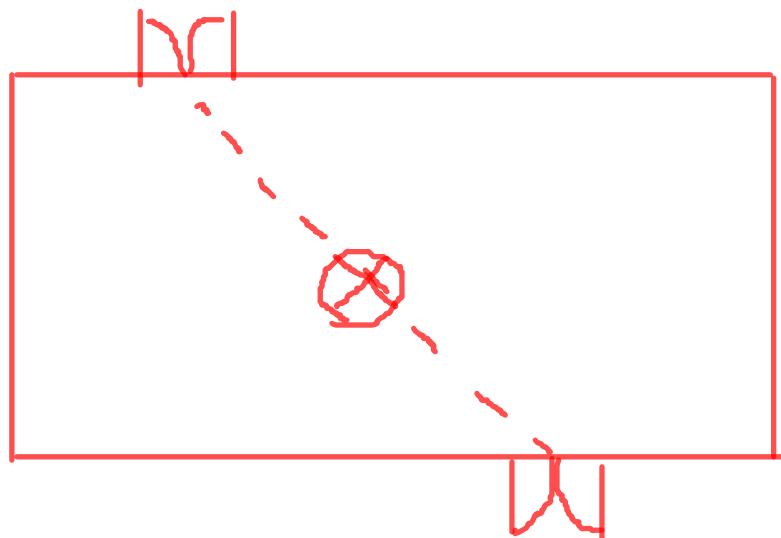
Travel Distance

- When to measure
- Two paths



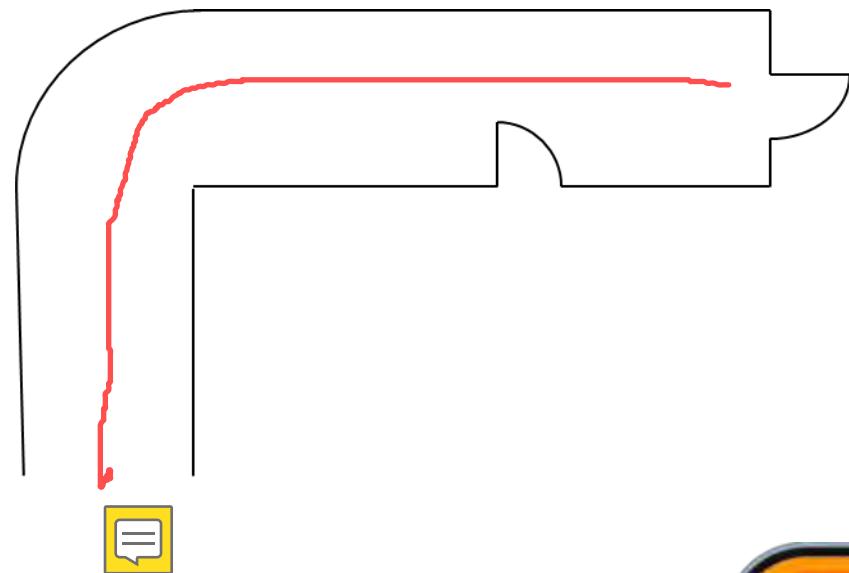
Rooms

- How to measure



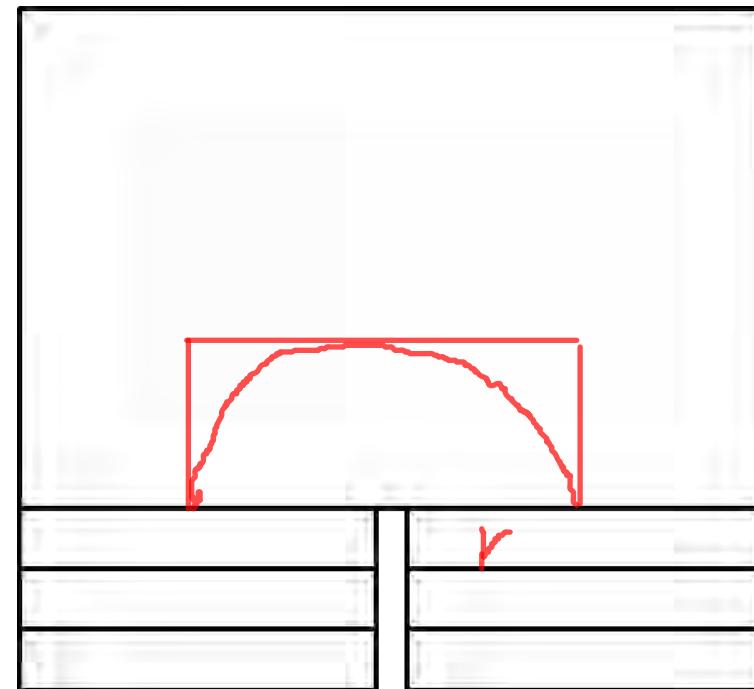
Corridors

- Natural path
- Minimum 12 in clearance around curves/obstructions
- To exit
 - Door



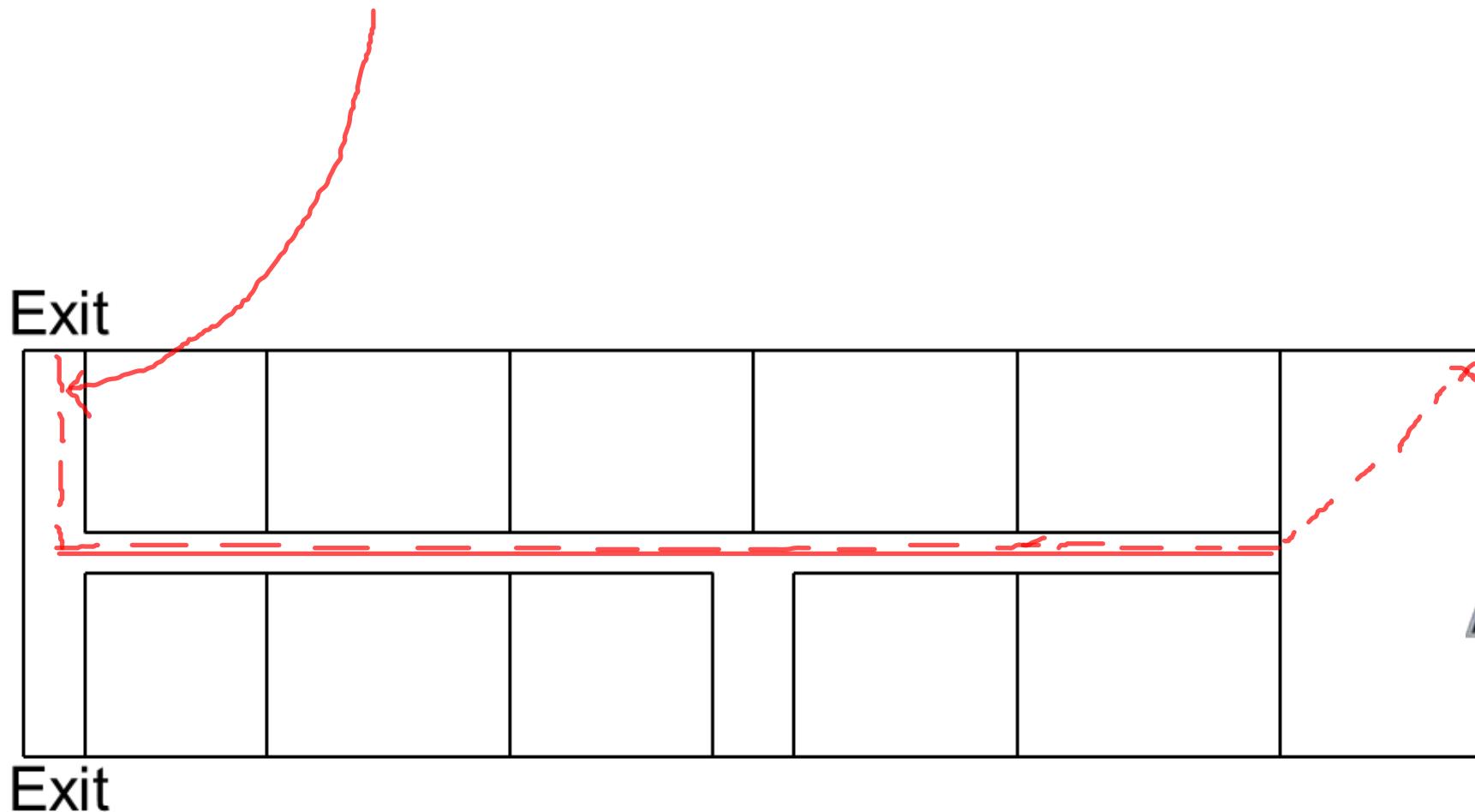
Stairs

- On treads
- On landing



Areas of Concern

- Dead End Corridors
- Common Path of Travel



Life Safety Code

- Explain the difference between building codes and the Life Safety Code
- Describe the general layout of NFPA 101
- Select the appropriate chapter for finding general information



Historic Fire

- Iroquois Theater



The NFPA Manual of Style

- First chapter: administrative information
- Second chapter: referenced publications
- Third chapter: definitions
- Appendix A: explanatory material

说明材料



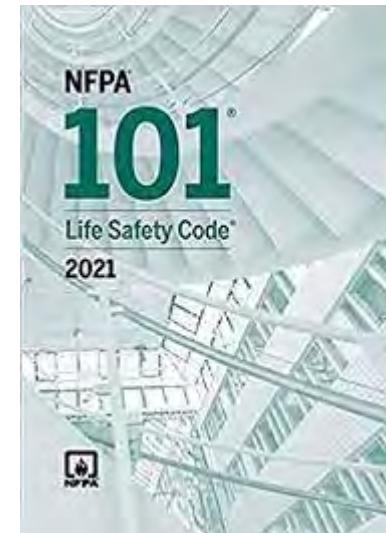
Also

- A vertical line in the margin indicates a change in the standard before 2015
 - Shaded text in 2018- N, Δ, text
- An asterisk * in front of a section indicates additional info in Annex A
- A bullet indicates something was deleted (not 2015)
- First numeral of a section number indicates the chapter



Codes

- Minimum requirements
 - Can exceed
- Not a limit on what can be done 对可以做的事
情没有限制
- Based on consensus 基于共识
 - Best practices



Chapter 1

Administration

- Minimize danger to life from fire
 - Construction protection and occupancy features
 - Egress facilities from building or to safe area
 - Protective systems, building services, operating and maintenance features
- Not a building code or fire prevention code
- Will not provide protection from acts of negligence
- Preserving property not an objective
- Intended for fire
 - Might be beneficial in similar situations



保护财产不
是目的



NFPA101 and IBC

- Both have Life Safety requirements
- IBC also has structural requirements
- Many differences
 - Terminology
 - Gray areas
 - Some requirements
- Adoption
 - Federal
 - State

术语
灰色地带
一些要求



Chapter 1

- Application
 - New and existing buildings
 - Vehicles and vessels immobile and used for human occupancy
- Equivalency
 - Not intended to prevent systems equal or superior alternatives
 - Technical documentation required
 - AHJ approves alternate approaches in compliance with code



不打算阻止系统采用同等或更优的替代方案



Chapter 2

Mandatory References

强制性参考

- Documents referenced by LSC as mandatory requirements and considered part of the code
- Impractical to continually upgrade existing buildings 不断升级现有建筑是不切实际的
- Existing buildings that do not comply shall be permitted to continue service
 - If nonconformity does not present a serious hazard to occupants

如果不合格不会对乘员造成严重危害



Chapter 3

- Contains **important definitions** used in the industry and throughout this course
 - Learn the NFPA definitions (you need them for all codes)
 - Others learn as they are used
 - Never assume standard dictionary definition



Chapter 4

General

- Goals
- Reasonable safety from fire and similar emergencies
- Protection of occupants not intimate with initial fire
- Improve survivability of occupants intimate with fire
- Reasonably safe emergency/nonemergency crowd movement



保护未接触
初始火灾的
人员



Chapter 4

- **Objectives**

- Protect occupants not intimate with fire for time necessary to evacuate, relocate, or defend in place
- Structural integrity maintained for time necessary to evacuate, relocate, or defend in place
- Systems shall be designed and maintained to meet goals

- Assumptions

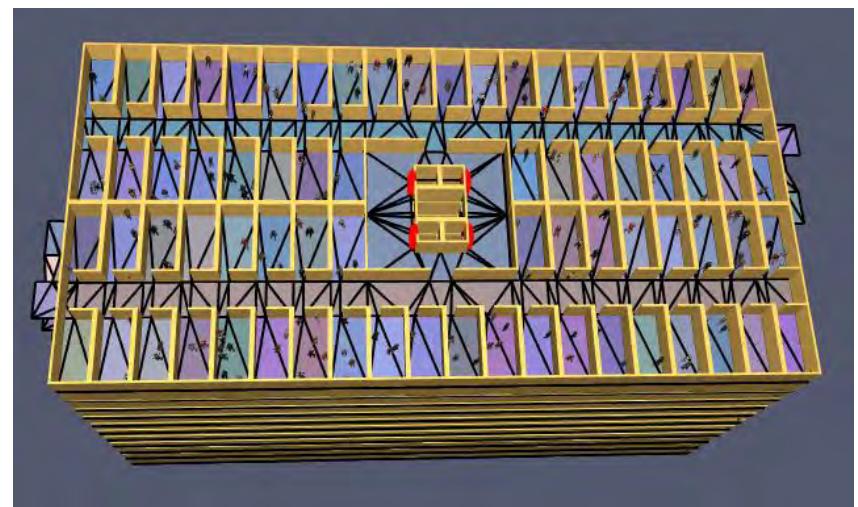
- Single fire



Chapter 4

Compliance options

- Prescriptive Based Option
 - General chapters (1-4, 6-11, 43)
 - Occupancy chapters
 - AHJ has final determination
- Performance-based option
 - Chapter 5



Chapter 4

- Must have multiple safeguards
 - Cannot rely on single safeguard
- Appropriateness of safeguards
 - Character of occupancy
 - Capabilities of occupants
 - Number of occupants
 - Fire protection provided
 - Capabilities of response personnel
 - Height and type of construction
 - Other factors providing safety

占用性质
居住者的能力
居住人数
提供消防设施
应急人员的能力
建筑高度和类型
其他安全因素



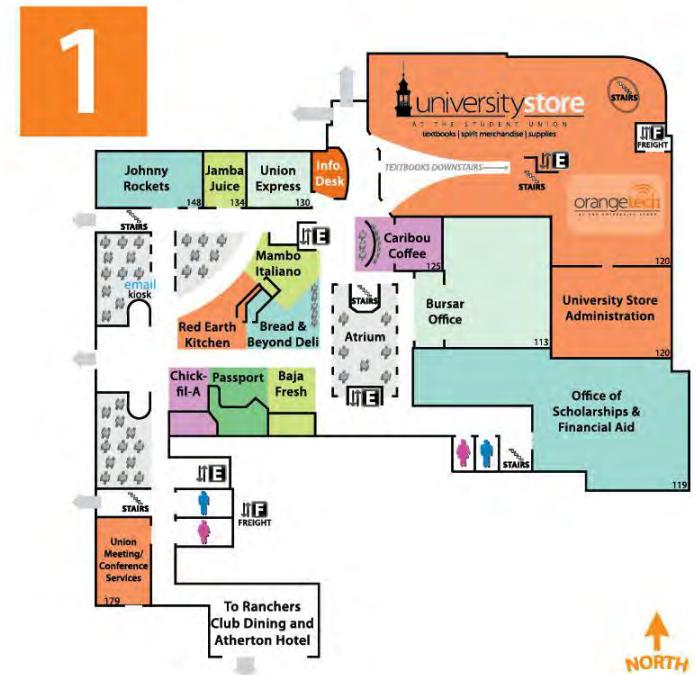
Chapter 6

- Final determination by AHJ
- Can be for entire building or portion of building
- Specific minimum number of people or activities
- Classifications (examples):
 - Assembly: special amusement or 50+ gathering
 - Very common
 - Education: through 12th grade
 - Residential: provides sleeping
 - Mercantile: stores



Chapter 6

- Mixed
 - Exit access combined
 - Use most restrictive criteria
- Separated
 - Rated wall assembly between
 - Reduced requirements with automatic sprinklers
- Incidental use
 - Limited
 - Can use predominant



Chapter 6

- Hazards based on fire, smoke, and explosion threat to people
- AHJ has final say
- Use most restrictive in building unless separated
- Classifications
 - Low: No self-propagation
 - Ordinary: Moderate burning, lots of smoke
 - High: Rapid burning or explosion



General Requirements

- Chapter 7: Means of Egress
- Chapter 8: Features of Fire Protection
- Chapter 9: Building Services and Fire Protection Equipment
- Chapter 10: Interior Finish, Contents, and Furnishings
- Chapter 11: Special Structures and High-Rise Buildings



Occupancy Chapter Layout

- X.1 General Requirements
 - Similar information to chapters 1 to 4
- X.2 Means of Egress Requirements
 - Similar information to chapter 7
- X.3 Protection
 - Similar information to chapters 8, 10, and part of 9
- X.4 or X.6 Special Provisions
 - Something unique to that type of building
- X.5 Building Services
 - Similar information to part of chapter 9
- X.7 Operating Features
- Reserved sections



NFPA 170

- Chapter 4
- Chapter 6



Features of Fire Protection

- Identify requirements for penetrations of fire walls and barriers
- Explain how fire stopping assemblies work
- Discuss the limitations on vertical openings in buildings



Historic Fire

- Baghdad Hospital



Construction

- Applies to existing and new construction
- References NFPA 220 construction types
- Requirements of least resistive construction
 - 2-hr rated fire wall



Passive Fire Protection

被动防火

- The concepts from the first lecture codified
 - Compartmentation
 - Fire barriers
 - Fire doors
 - Vertical openings
 - Smoke barriers
 - etc.

分隔
防火屏障
防火门
垂直开口
烟幕



Fire Resistance

- Typically using assemblies from standard tests
 - ASTM E 119 or ANSI/UL 263
- Can do performance-based design
 - Need to use standard methods or approval
- Permanently identified in concealed space
 - Within 15 ft of end
 - Every 30 ft

可以进行基于
性能的设计



Fire Barriers and Walls

- Fire barriers must go from wall to wall
 - 3-hour, 2-hour, 1-hour, or 0.5-hr
 - Limitations on width openings do not apply
- Fire walls
 - ASTM E 119 or ANSI/UL 263
 - Non-symmetrical evaluated from both sides

从两侧评估非对称性

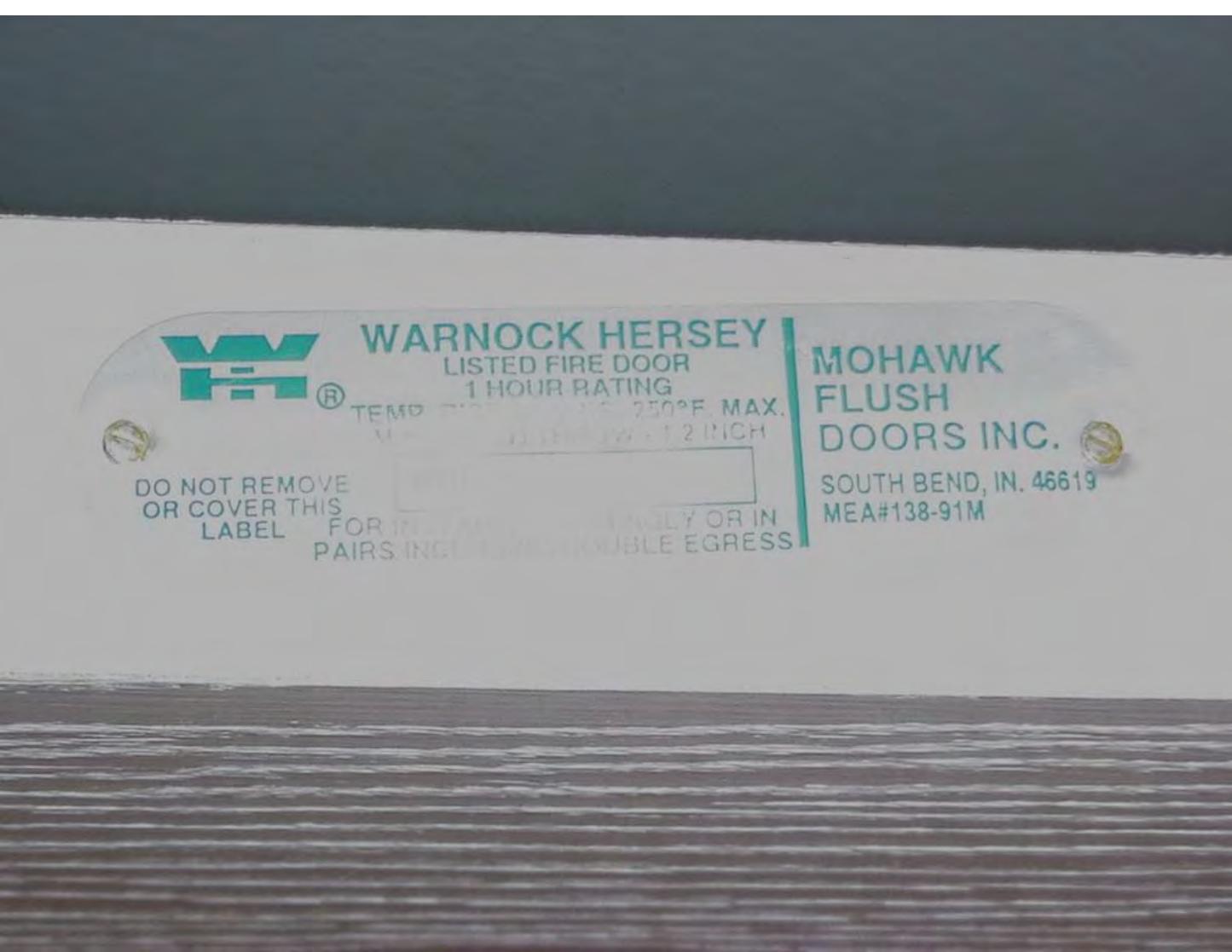


Doors

- All components listed, labeled
- Maximum leakage 3 cfm/ft²
 - Tested at 0.10 inH₂O
- Minimum ratings
 - Standard tests
- Self-closing or automatic-closing
- $\frac{3}{4}$ -hour doors can be used in existing buildings where 1 hr is required
 - Other requirements differ for existing buildings



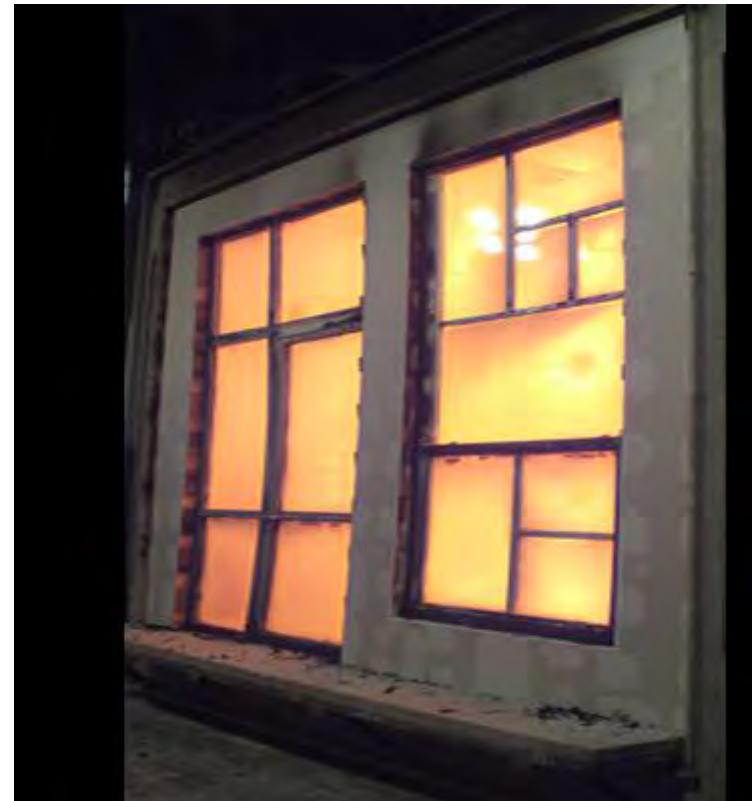
Labeled Doors



Windows

- Allowed in fire doors
 - Existing installation
 - Wired glass
 - 0.25 in
 - New installation
 - Listed, labeled

8.3.3.6.11 Existing installations of wired glass of $\frac{1}{4}$ in. (6.3 mm) thickness and labeled for fire protection purposes shall be permitted to be used in approved opening protectives, provided that the maximum size specified by the listing is not exceeded.



Glazings

玻璃窗

- Allowed in walls, windows, and doors
 - Asymmetrical tested on both sides
- Must meet requirements of standard tests
- Typically limited to 25%

8.3.3.6.10 The total combined area of glazing in fire-rated window assemblies and fire-rated door assemblies used in fire barriers shall not exceed 25 percent of the area of the fire barrier that is common with any room, unless the installation meets one of the following criteria:

Table 8.3.3.12 Marking Fire-Rated Glazing Assemblies

Fire Test Standard	Marking	Definition of Marking
ASTM E119, or ANSI/UL 263 ^a NFPA 257	W	Meets wall assembly criteria
	OH	Meets fire window assembly criteria, including the hose stream test
NFPA 252	D	Meets fire door assembly criteria
	H	Meets fire door assembly hose stream test
	T	Meets 450° F (232°C) temperature rise criteria for 30 minutes
	XXX	The time, in minutes, of fire resistance or fire protection rating of the glazing assembly

^aASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials* and ANSI/UL 263, *Standard for Fire Tests of Building Construction and Materials*.



Openings in Fire Rated Assemblies

- Protect other side from smoke and fire

Table 8.3.4.2 Minimum Fire Protection Ratings for Opening Protectives in Fire Resistance-Rated Assemblies and Fire-Rated Glazing Markings

Component	Walls and Partitions (hr)	Fire Door Assemblies (hr)	Door Vision Panel Maximum Size (in ²) ^a	Minimum Side Light/Transom Assembly Rating (hr)		Fire-Rated Glazing Marking Side Light/Transom Panel		Fire Window Assemblies ^{b,c}	
				Fire Protection Resistance		Fire Protection Resistance			
				Door Vision Panel	Fire Protection Resistance	Door Vision Panel	Fire Protection Resistance		
Elevator hoistways	2	1½	155 in. ² ^d	D-H-90 or D-H-W-90	NP	2	NP D-H-W-120	NP W-120	
	1	1	155 in. ² ^d	D-H-60 or D-H-W-60	NP	1	NP D-H-W-60	NP W-60	
	½	½	85 in. ² ^e	D-20 or D-W-20	½	½	D-H-20 D-W-20	NP W-30	
Elevator lobby (per 7.2.13.4)	1	1	100 in. ² ^b	≤100 in ² , D-H-T-60 or D-H-W-60 ^f	NP	1	NP D-H-W-60	NP W-60	
				>100 in ² , D-H-W-60 ^f					
Vertical shafts, including stairways, exits, and refuse chutes	2	1½	Maximum size tested	D-H-90 or D-H-W-90	NP	2	NP D-H-W-120	NP W-120	
	1	1	Maximum size tested	D-H-60 or D-H-W-60	NP	1	NP D-H-W-60	NP W-60	
Replacement panels in existing vertical shafts	½	½	Maximum size tested	D-20 or D-W-20	½	½	D-H-20 D-W-20	NP W-30	

(continues)

Table 8.3.4.2 *Continued*

Component	Walls and Partitions (hr)	Fire Door Assemblies (hr)	Door Vision Panel Maximum Size (in ²) ^a	Fire-Rated Glazing Marking Side Light/Transom Assembly Rating (hr)		Fire-Rated Glazing Marking Side Light/Transom Panel		Fire Window Assemblies ^{b,c}
				Door Vision Panel	Fire Protection Resistance	Door Vision Panel	Fire Protection Resistance	
Fire barriers	3	3	100 in. ² ^b	≤100 in ² , D-H-180 or D-H-W-180 ^h	NP	3	NP D-H-W-180	NP W-180
				>100 in ² , D-H-W-180 ^h				
	2	1½	Maximum size tested	D-H-90 or D-H-W-90	NP	2	NP D-H-W-120	NP W-120
Horizontal exits	1	¾	Maximum size tested ^f	D-H-45 or D-H-W-45	¾ ^f	¾ ^f	D-H-45 D-H-W-45	¾ OH-45 or W-60
	½	½	Maximum size tested	D-20 or D-W-20	½	½	D-H-20 D-W-20	½ OH-20 or W-30
	2	1½	Maximum size tested	D-H-90 or D-H-W-90	NP	2	NP D-H-W-120	NP W-120
Horizontal exits served by bridges between buildings	2	¾	Maximum size tested ^f	D-H-45 or D-H-W-45	¾ ^f	¾ ^f	D-H-45 D-H-W-45	¾ OH-45 or W-120
	1	½	Maximum size tested	D-20 or D-W-20	¾	¾	D-H-45 D-H-W-20	¾ OH-45 or W-60
Exit access corridors ^g	½	½	Maximum size tested	D-20 or D-W-20	½	½	D-H-20 D-H-W-20	½ OH-20 or W-30
	1	½	Maximum size tested	D-20 or D-W-20	¾	¾	D-H-45 D-H-W-20	¾ OH-45 or W-60
Smoke barriers ^h	1	½	Maximum size tested	D-20 or D-W-20	¾	¾	D-H-45 D-H-W-20	¾ OH-45 or W-60
	½	½	Maximum size tested	D-20 or D-W-20	½	½	D-H-20 D-H-W-20	½ OH-20 or W-30

NP: Not permitted.

^aNote: 1 in² = .00064516 m².

^bFire resistance-rated glazing tested to ASTM E 119, *Standard Test Method for Fire Tests of Building Construction and Materials*, or ANSI/UL 208, *Standard for Fire Tests of Building Construction and Materials*, shall be permitted in the maximum size tested. (See 8.3.3.7.)

^cFire-rated glazing in exterior windows shall be marked in accordance with Table 8.3.3.12.

^dSee ASME A17.1, *Safety Code for Elevators and Escalators*, for additional information.

^eSee ASTM A17.3, *Safety Code for Existing Elevators and Escalators*, for additional information.

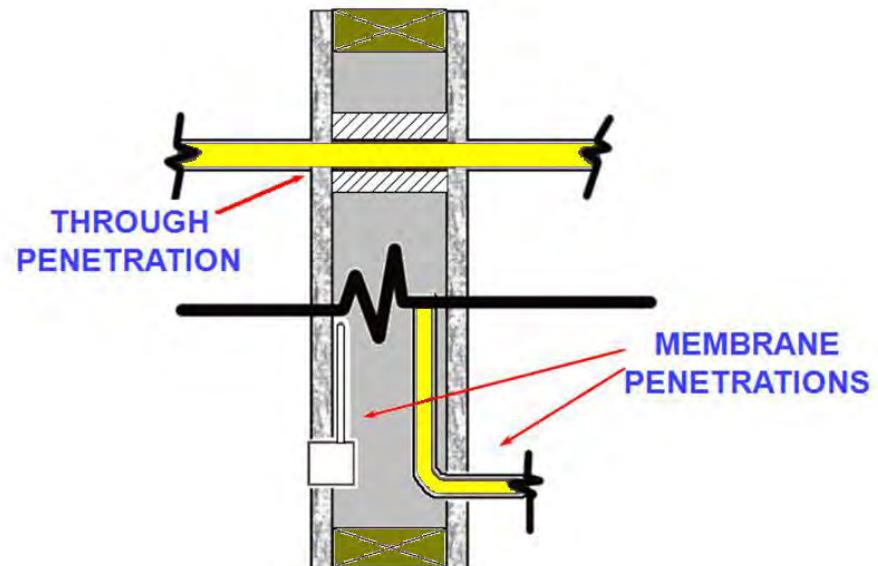
^fMaximum area of individual exposed lights shall be 1296 in.² (0.84 m²) with no dimension exceeding 54 in. (1.37 m) unless otherwise tested. [80: Table 4.4.5, Note b, and 80.4.4.5.1]

^gFire doors are not required to have a hose stream test per NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*; ASTM E 2074, *Standard Test Method for Fire Tests of Door Assemblies, Including Positive Pressure Testing of Side-Hinged and Pivoted Swinging Door Assemblies*; ANSI/UL 10B, *Standard for Fire Tests of Door Assemblies*; or ANSI/UL 10C, *Standard for Positive Pressure Fire Tests of Door Assemblies*.

^hFor residential hoist and cars, see 33.2.3.1 and 33.2.3.1.

Penetrations 贯穿件

- Must be firestopped
 - ASTM E 814 or ANSI/UL 1479
 - Tested under pressure
 - 1 hr F and T ratings minimum
 - Otherwise equal to assembly penetrated
- Same basic rules for fire rated assemblies and membranes



N 8.3.4.2.3 F Ratings. Firestop systems and devices shall have an F rating of not less than 1 hour, and not less than the required fire resistance rating of the fire barrier penetrated.

8.3.4.2.4 T Ratings.

N 8.3.4.2.4.1 Penetrations in fire resistance-rated horizontal assemblies shall have a T rating of not less than 1 hour, and not less than the fire resistance rating of the horizontal assembly.



Joints

- Must be protected from smoke spread
- Testing to be representative of installation
- If on fire barrier must protect against flames
- ASTM E 1966 or ANSI/UL 2079
 - Under pressure
- Curtain walls
 - ASTM E 2307
 - F rating equal to floor assembly



Smoke Partitions

防烟隔板

- Full height
- Doors
 - Cannot contain louvers
 - Self-closing or automatic-closing
- Penetrations protected
- Joints to have limited smoke spread
- Dampers
 - ANSI/UL 555S
 - Class II, 250 °F
 - Close upon smoke alarm



Smoke Barriers

- Full height and width
- Can also be a fire barrier
- Doors
 - Similar requirements to smoke partitions
 - Maximum $\frac{3}{4}$ in clearance on bottom
 - Latching hardware required
- Dampers
 - Similar requirements to smoke partitions
 - Access for testing and inspection
- Penetrations and joints



Vertical Openings

- Every floor must be smoke barrier
- Openings through floors should be enclosed
- Shafts can end in a room associated with use
 - e.g. elevator machine room
- 4 or more stories connected = 2 hr
- Less than 4 stories = 1 hr
- Existing buildings = $\frac{1}{2}$ hr
- Communicating spaces allowed with many restrictions

竖井可以在
与使用相关
的房间中结
束



Atriums

中庭

- Fire barrier of 1 hr
 - Glass walls can sometimes be used
- Low or ordinary hazard contents
- Entire building protected by automatic sprinklers
- Engineered design to keep smoke above occupants



Convenience Stairs

- Can only connect two floors
- Separated from other openings, corridors, and fire and smoke compartments
- Cannot serve as a means of egress
- Entire building protected by automatic sprinklers



Elevators and Escalators

电梯和升降机

- Hoistways shall be enclosed
 - Three or fewer cars in building = can share hoistway
 - Four or more cars in building = at least two hoistways
 - No more than four in one hoistway
- Escalators used as means of egress enclosed like stairs
- Otherwise openings still typically protected

8.6.9.4除现有建筑物中的现有井道外，位于建筑物内的电梯轿厢应按照以下要求封闭：

跟随：

- (1) 如果建筑物内有三个或三个以下的电梯轿厢，则应允许它们位于同一井道外壳内。
- (2) 如果建筑物内有四个电梯轿厢，则电梯轿厢的划分方式应确保至少提供两个独立的井道外壳。
- (3) 如果建筑物内有四个以上的电梯轿厢，则位于单个井道外壳内的电梯轿厢数量不得超过四个



Mezzanines

- Must be less than 1/3 of area
- All portions open and unobstructed



Special Hazards

- Protection
 - Separation
 - Sprinklers
 - Both
- Explosion protection
- Hazardous materials
- Alcohol-based hand-rub dispensers
 - Size limitations
 - Limited locations
 - Discharge limitations



Interior Finish, Contents, and Furnishings

- Select appropriate interior finish, contents, and furnishings

室内饰面、内容物和家具



Historic Fire

- The Station



Why to Consider Interior Finishes

- People do not want to live in concrete boxes
- Can lead to fire spread
- Add to fuel load
- Combustion products
 - Toxicity
 - Visibility



Interior Finish

- Includes

- Fixed/movable walls/partitions

固定/活动墙/隔墙

镶板

墙垫

防撞垫

易燃材料储物柜

- Paneling

- Wall pads

- Crash pads

- Lockers of combustible materials

- Applied as

- Structure/decoration

结构/装饰

声学的

绝缘

- Acoustical

- Insulation



Testing

- Under conditions simulating actual installations
- Up to 1/28 in, exempt
 - Class A
 - Existing
- Class A, B, or C as specified
 - Can use better class
 - Sprinklers reduce level by one class



Product

FS

SD

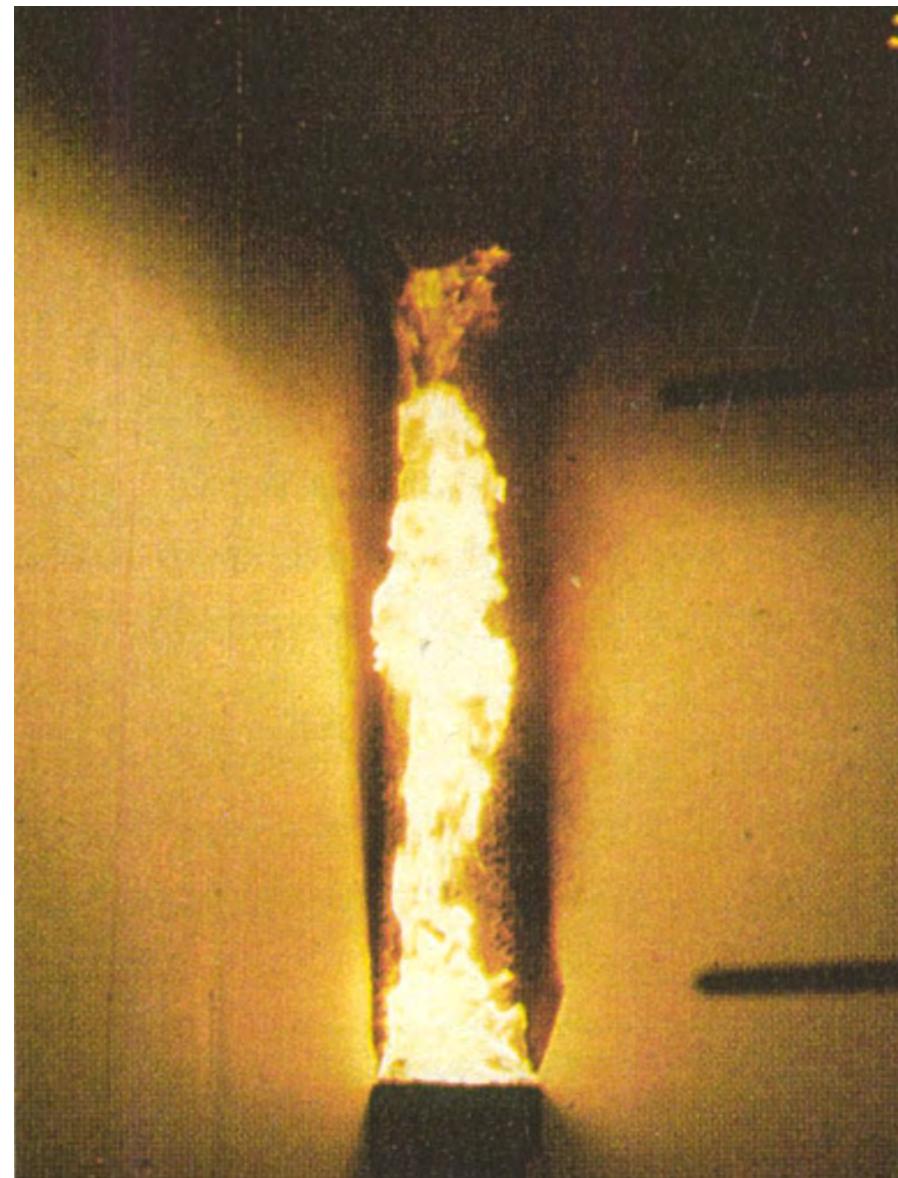
Cement Mineral Board	0	0
Gypsum Board	15	0
Protected Metal	35	80
Mineral Ceiling Tile	10	10
Wood Fiber Ceiling Tile	160	105
Treated Wood Fiber Ceiling Tile	20	0
Painted Glass Fiber Ceiling Tile	10	10
Untreated Fir Plywood	138	60
Fire Retardant Treated Plywood	15	0
Fiberboard	300	55
PVC Plastic Panels	25	Over 500
Glass Fiber Reinforced Plastic Pnls	25	Over 500
Red Oak	100	100

Refer to specific Listings and Classifications in Manufacturer's Literature,
or Building Materials Directory



Room Corner Test

- More realistic assessment of hazard
- 8 ft high, 8 ft wide, 12 ft long, single opening
 - Larger tests as well
- Simulated ceiling
- Diffusion burner
- Heat release and smoke release
- Visual observation of flame spread



Specific Materials

- Textiles

纺织品

- Limitations

- Vinyl

乙烯基

- Limitations

- Plastics

- Most not to be used without large-scale tests

- Limitations when used as trim

用作装饰时的限制

N 10.2.4.4* Textile Wall Coverings. Where used as interior wall finish materials, textile materials shall be tested in the manner intended for use, using the product mounting system, including adhesive, and shall comply with the requirements of either 10.2.3.1, 10.2.4.4.1, or 10.2.4.4.3.
N 10.2.4.4.1* Products tested in accordance with NFPA 265 shall comply with the criteria of 10.2.4.4.2.
N 10.2.4.4.2* The interior finish shall comply with all of the following when tested using method B of the test protocol of NFPA 265.
(1) During the 40 kW exposure, flames shall not spread to the ceiling.
(2) The flame shall not spread to the outer extremities of the samples on the 8 ft x 12 ft (2440 mm x 3660 mm) walls.
(3) Flashover, as described in NFPA 265, shall not occur.
(4) For new installations, the total smoke released through-out the test shall not exceed 1000 m².

× N 10.2.4.4*织物墙面覆面物。当用作内墙饰面材料时，应使用产品安装系统（包括粘合剂）以预期使用的方式对纺织材料进行测试，并应符合10.2.3.1、10.2.4.4.1或10.2.4.4.3的要求。

N 10.2.4.4.1*根据NFPA 265测试的产品应符合10.2.4.4.2的标准。

N 10.2.4.4.2*当使用NFPA 265测试协议的方法B进行测试时，内部饰面应符合以下所有要求：

- (1) 在40 kW暴露期间，火焰不得蔓延至天花板。
- (2) 火焰不得蔓延至8 ft x 12 ft (2440 mm x 3660 mm) 墙壁上样品的外端。
- (3) 不得发生NFPA 265中所述的闪燃。
- (4) 对于新装置，通过试验释放的总烟雾不得超过1000 m²。



Trim and Incidental Finish

- Less than 10%
 - Bulletin boards, etc. 20%
- Can be Class C
- Wall base 6 in



Flooring

- Class I: 0.45 W/cm^2
- Class II: 0.22 W/cm^2
- Critical radiant flux 0.1 W/cm^2
- Can use higher class
 - Automatic sprinklers reduce by one class



10.2.7.4.1 Class I Interior Floor Finish. Class I interior floor finish shall have a critical radiant flux of not less than 0.45 W/cm^2 , as determined by the test described in 10.2.7.3.

10.2.7.4.2 Class II Interior Floor Finish. Class II interior floor finish shall have a critical radiant flux of not less than 0.22 W/cm^2 , but less than 0.45 W/cm^2 , as determined by the test described in 10.2.7.3.



Contents and Furnishings

- Draperies, curtains 窗帘
- Upholstered furniture and mattresses 软垫家具和床垫
 - Resist cigarette ignition
 - Limited char length
 - Differences if sprinklered
- Explosive or highly flammable not allowed
- Combustible decorative vegetation 可燃装饰植物
 - Electrical equipment
 - Open flames
- Outdoor furniture
 - 2 ft



Building Service and Fire Protection Equipment

- Identify the appropriate building service and fire protection equipment
- Explain the commissioning process and integrated testing



Historic Fire

- One Meridian Plaza



Chapter Design

- Requirements for systems used in building
- Most requirements are to other codes
 - Those codes are then part of NFPA 101



Utilities 公用事业

- Emergency power
 - Will be required elsewhere in code
 - NFPA 110
 - Generator running, fault, not in automatic



Air Movement

- HVAC and other ventilation
 - Other codes
- Smoke control
 - Automatic activation
 - Engineer of record certifies intent and method
 - Special inspector

自动激活

记录工程师证明意图和方法
特别检查员



Elevators

- Unless in accordance with 7.2.13 only exit access
- Specific signage in non evacuation elevator lobbies 非疏散电梯大厅中的特定标志
- Available for fire fighter emergency operations
 - Elevator machine room limits



Elevators

- Cannot open to an exit enclosure



Chutes

滑槽

- Connect multiple levels
- Must be in designated room



Detection and Alarm Systems

- NFPA 70 and NFPA 72
- Alarm out of service > 4 hr = notify AHJ
 - Evacuation
 - Fire watch
- Smoke detection to protect system
- Must notify fire department



Detection and Alarm Systems

- **Initiation**

- **Pull station**

- Within 60 in of doorways
 - Within 200 ft of all locations
 - Occupancy chapters might only require one in building



- **Smoke/heat detector**

- Sleeping areas
 - Interconnected
 - Local



- **Suppression system**

- Equal or greater than single sprinkler



Detection and Alarm Systems

- **Notification**

- Audible and visual
 - Must be heard above ambient, distinct, take precedence
 - Must be synchronized
- Detection away from occupied = no notification
- Delay to “trained” staff
- Notification to entire evacuation zone
- Private operating mode allowed
- 520 Hz in sleeping areas



Detection and Alarm Systems

- Alarm zones
 - Each floor
 - Maximum 22,500 ft²
 - 300 ft in one direction
 - Can align with sprinkler system zones
- CO detection
- Risk analysis
 - Where required
 - MNS not explicitly required
- Two-way radio enhancement



Detection and Alarm Systems

- Voice Alarms
 - Intelligibility and audibility
 - Vulnerable populations
 - More information
 - Less confusion
 - Required in some buildings
- Mass Notification
 - Relatively new in the codes
 - Wide range of applications
 - Not required



Detection and Alarm Systems

- Relation to other systems

- Hold-opens
- Pressurization
- Smoke management/control
- Door locks
- Elevator recall
- HVAC



Suppression Systems

- Where required
- Accordance with NFPA installation standards



Commissioning and Integrated Testing

调试和综合
测试

- People involved
 - Owner
 - AHJ
 - System designer
 - General contractor
 - Subcontractor
 - Fire protection engineering consultants
 - Test and balancing technicians
- Integrated testing

所有者
AHJ
系统设计师
总承包商
分包商
消防工程顾问
测试和平衡技术人员



Commissioning

委托

- Approved plan
- Sequence of operations
- Inspection of components
- Design parameters
- Testing of system operation
 - Emergency, normal, and change of power status
 - Performance criteria
 - Test all related systems



Special Inspector

- Must check all performance criteria
- Special training and equipment
- Iterative process



Institutional Occupancies

- Determine what differentiates this type of occupancy from others
- Identify the key provisions that are different from the general chapters



Historic Fire

- Ohio State Penitentiary



People

- Types of people present
 - Familiarity
 - Abilities
 - Activities



Occupancy Classifications- Institutional



- I-2 Medical care
 - 24-hour care
 - More than 5 people
 - 1-5 people: R-3
- **Condition 1:** Nursing and medical, no emergency, surgery, obstetrics, **psychiatric/ detoxification**
- **Condition 2:** Could provide all medical services
- **NFPA101 > 3 occupants**



Evacuation Strategy

- Minimize the need for evacuation
- Consider occupants
- Compartmentation
- Horizontal exits 

 - Wide corridors
 - Wide doors without mullion

- Fewer restrictions on passing through spaces 



Suites

- Hospitals generally divided into suites
- Separated
- Move towards less hazard
- Directly to corridor or horizontal exit (100 ft)
- Smoke detection
- Limitations on decorations
- Limitations on heaters



Related Issues

- Life support equipment
 - Emergency power requirements
- Cooking
 - Limitations on size, type, and control
- Alcohol-based hand-rub dispensers
 - Limitations on size and locations
- HVAC
 - Limitations on types and locations
- Rehabilitation of nonsprinklered smoke compartments
- Sprinklers without exceptions
- Locking of doors



Drills and Fire Alarm

- Must have emergency evacuation plan
- Staff must be informed of duties
- Quarterly drills for each shift
 - Do not have to evacuate patients
- Code phrases 
- Alarms can be visible only in critical care
- Pull station at nurse's station



Ambulatory Health Care

门诊保健

- Outpatient care
 - 4 or more
 - Similar requirements
 - More flexibility



Occupancy Classifications- Institutional

- I-1 Supervised living
 - 16+ people, excluding staff
 - 6-16 people: R-4
 - 1-5 people: R-3
 - 24-hour care
 - Condition 1: Can self-evacuate
 - Condition 2: Limited assistance



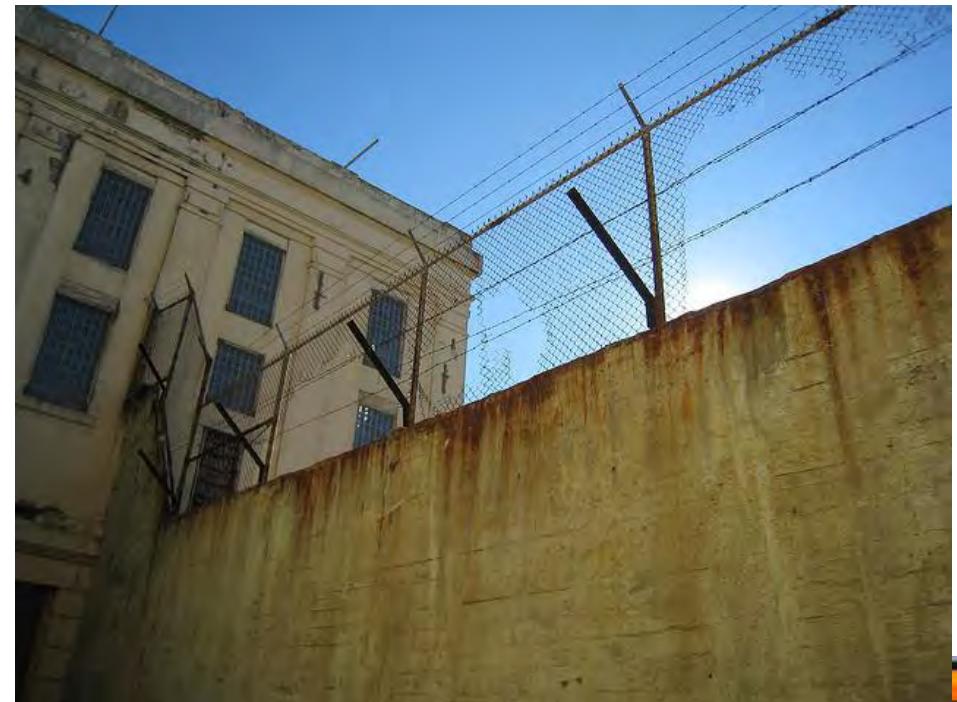
Occupancy Classifications- Institutional

- I-3 Restrained
 - More than 5 people
 - Condition 1: Can freely evacuate to exterior
 - Condition 2: Can freely move to another smoke compartment
 - Condition 3: Can freely move within smoke compartment
 - Condition 4: No free movement, remote-controlled release
 - Condition 5: No free movement, manual release



Egress

- **Doors**
 - Sliding
 - Remote controlled
 - 50 lb force
- **Compartments**
- **Enclosed areas**
- **Staff actions**
- **Sprinklers**



Educational Occupancies

- Determine what differentiates this type of occupancy from others
- Identify the key provisions that are different from the general chapters

确定此类入住与其他类型入住的区别
确定与一般章节不同的关键条款



Historic Fire

- Our Lady of Angels



People

- Types of people present
 - Familiarity
 - Abilities
 - Activities



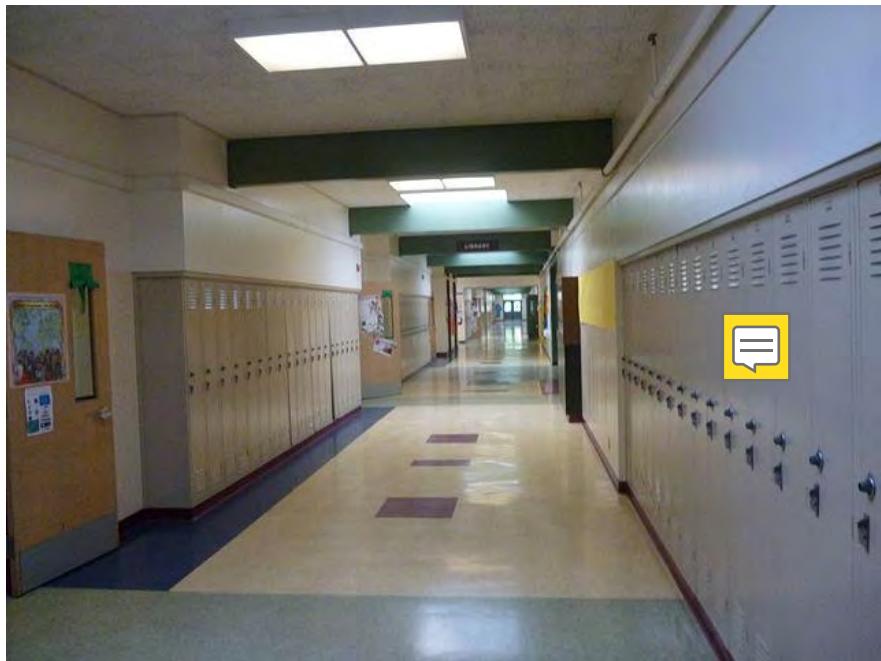
Educational

- Not every class
 - Grade
 - Number of students
 - Hours/day
 - Total hours
 - Incidental
- Limitations on room locations



Means of Egress

- Wider corridors
- Shorter distances
- Daily inspections
- Lockers and bulletin boards
- Classroom door locking
- Windows for rescue
 - Sprinklers
 - Exit door from room
 - 4+ stories



Fire Protection

- Monthly drills
 - Exceptions
 - All participate
- Fire alarm bells
- Sprinklered
- CO detection
- Risk analysis
- Limits on art work
- Open flames (labs)



Day Care

- Day Care
- Day care homes
- Adult
- Children



Day Care

- I-4 Day care
 - More than 5 people in IBC
 - 1-5 people: Primary occupancy
 - < 24 hour care
 - Adult
 - Child
- Oklahoma
 - 7 children
 - 8-12 Residential with sprinklers
- LSC
 - More than 3 people



Assembly Occupancies

- Determine what differentiates this type of occupancy from others
- Identify the key provisions that are different from the general chapters



Historic Fire

- King's Cross Station



People

- Types of people present
 - Familiarity
 - Abilities
 - Activities

熟悉度
能力



Occupancy Classifications- Assembly

- A-1 Theaters with fixed seating
- A-2 Food and drink
- A-3 Worship, recreation, amusement, and general
- A-4 Indoor sporting events
- A-5 Outdoor sporting events



for the exam. I do expect you to know the difference between them and be able to apply them correctly. remember 123 is important



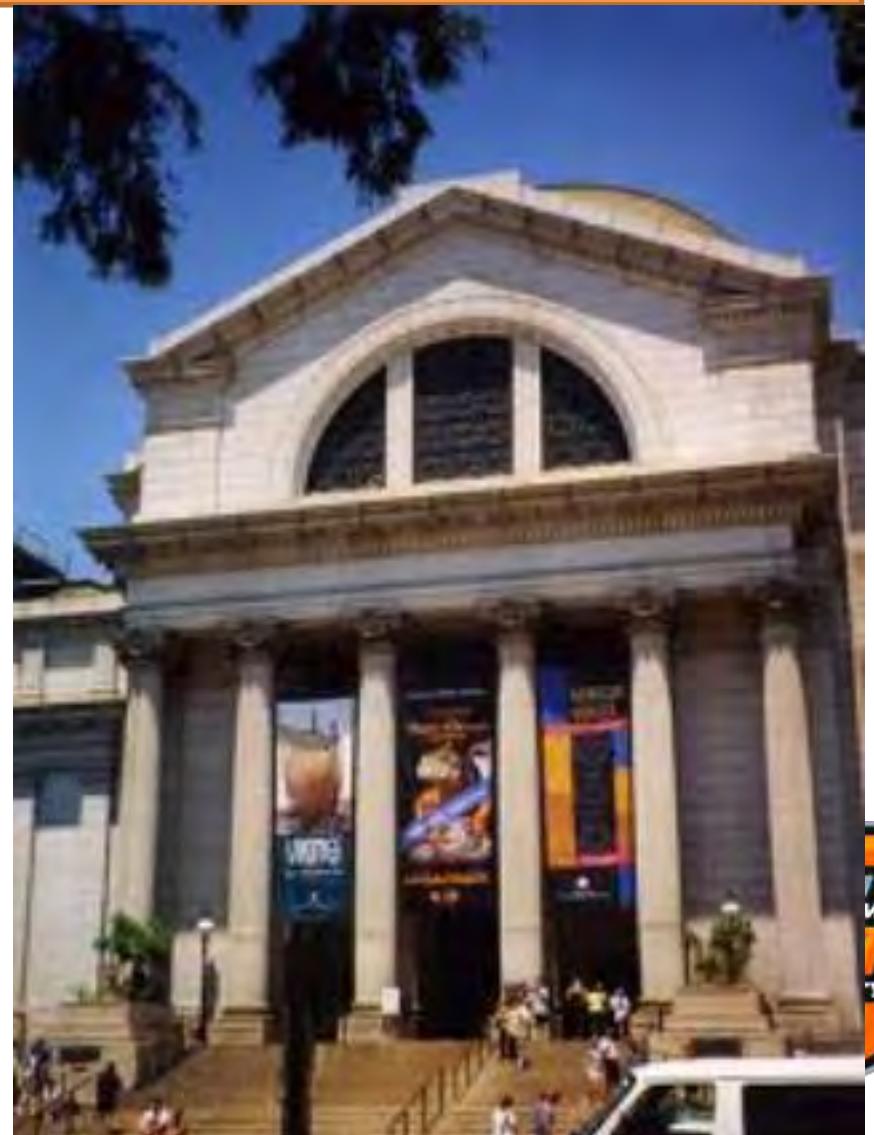
Life Safety Evaluation

- Occupant load exceeds 6000 persons
- AHJ must approve of plan
 - Annual review of written report
- 10 criteria:
 - Nature of event
 - Medical emergencies
 - Structural systems
 - Earthquakes
 - Haz mat incidences
 - Access and egress
 - Fire hazards
 - Severe weather
 - Civil disturbances
 - Stakeholder relations



Main Entrance/Exit

- Required consideration of assembly occupancies
- At level of discharge
 - Stair down is fine
- Accommodate 50% of the population in most buildings
 - 67% in dance halls, discotheques, nightclubs, occupancies with festival seating
- Other exits 50%
 - As far away as practical



Construction Type

- Will depend on height

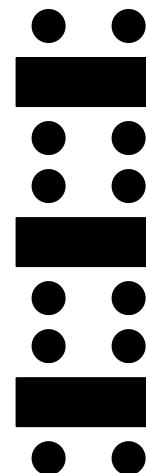
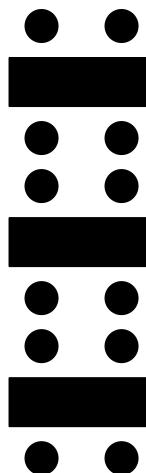
Table 12.1.6 Construction Type Limitations

Construction Type	Sprinklered ^a	Stories Below	Stories in Height ^b				
			1	2	3	4	≥5
I (442) ^{c, d, e}	Yes	X	X	X	X	X	X
	No	NP	X4	X4	X4	X4	X4
I (332) ^{c, d, e}	Yes	X	X	X	X	X	X
	No	NP	X4	X4	X4	X4	X4
II (222) ^{c, d, e}	Yes	X	X	X	X	X	X
	No	NP	X4	X4	X4	X4	X4
II (111) ^{c, d, e}	Yes	X1	X	X	X	X3	NP
	No	NP	X4	X4	X4	NP	NP
II (000)	Yes	X2	X	X4	NP	NP	NP
	No	NP	X4	NP	NP	NP	NP
III (211) ^d	Yes	X1	X	X	X	X3	NP
	No	NP	X4	X4	X4	NP	NP
III (200)	Yes	X2	X3	X4	NP	NP	NP
	No	NP	X4	NP	NP	NP	NP
IV (2HH)	Yes	X1	X	X	X	X3	NP
	No	NP	X4	X4	X4	NP	NP
V (111)	Yes	X1	X	X	X	X3	NP
	No	NP	X4	X4	X4	NP	NP
V (000)	Yes	X2	X3	X4	NP	NP	NP
	No	NP	X4	NP	NP	NP	NP



Means of Egress

- Typically Chapter 7
- No turnstiles in means of egress
 - Most often in places of assembly
 - Options:
 - Gate
 - Fold recessed
 - 44 in wide corridors if >50 people
- Seating at tables
 - Aisle
 - Aisle access
- Approval of layouts



Theater Seating

- Stairs: $0.3 \times A \times B$ in/seat
 - If riser height > 7in:
 $A=1+(R-7)/5$
 - If handrail > 30 in away:
 $B=1.25$
- Passageways, doors, ramps: $0.22 \times C$ in/seat
 - If ramp slope > 1 in 10:
 $C=1.10$
- Aisle access width between seats: 12 in to 22 in
- 100 seats/row



Auditoriums and Arenas

- Seating
- Floor area
 - 50 % not exit through seating
- Festival seating
 - 250 people
 - Maintained egress routes
- Waiting spaces



Management and Systems

- Crowd managers
 - Mass movement of people
 - Staff assigned just to keep order
 - 1 for every 250 people
- Drills
 - Must be held to train
 - Employees taught to use extinguishers
- Rules typically based on size
 - 300 persons
 - Alarms
 - Constantly monitored
 - Visual and audible
 - Voice
 - CO detection
 - Sprinklers
 - Risk analysis



Special Provisions

- **Smoke-protected seating**
 - Smaller egress components for large populations
- **Limited access or underground buildings**
 - Smoke
- **Stages and platforms**
 - Fire load
- **Projection rooms**
 - Fire load
- **Special amusement buildings**
 - Life safety
- **Grandstands**
 - Fire load
 - Life safety
- **Folding and telescopic seating**
- **Airport loading walkways**
 - From planes



Open Flames

- **Cooking**
 - Open flames
- **Pyrotechnics**
 - Typically not allowed



Residential Occupancies

- Determine what differentiates this type of occupancy from others
- Identify the key provisions that are different from the general chapters



Historic Fire

- Winecoff Hotel



People

- Types of people present
 - Familiarity
 - Abilities
 - Activities

The key thing here to remember that we're dealing with people that are asleep and the complications with that of need to get them keeping them safe as we saw in the case of the wine cock hotel. It took them longer and so we needed to keep them longer time safe inside their areas and somewhat more passive protection requirements for that reason



Occupancy Classifications- Residential

Sleeping

R-1: Transient people 流动人口

R-2: Permanent people

More than two units

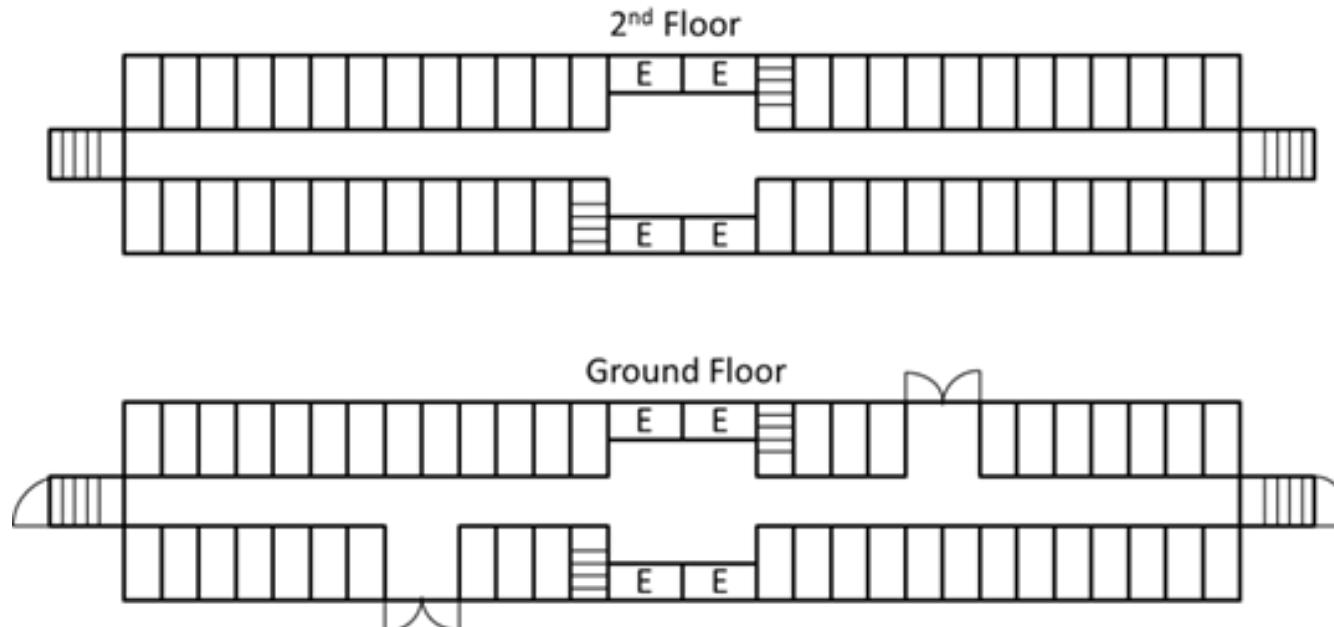


Hotels and Dormitories

NFPA 101



- Means of escape
- Remoteness rules do not apply
- No common path outside of rooms
- Internal discharge
- Travel distance and common path requirements



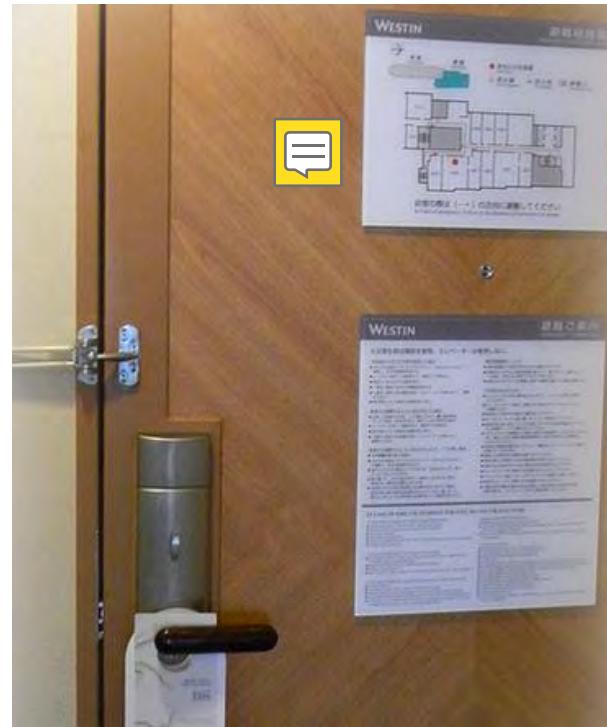
Detection and Suppression

- Corridor smoke detection
- Local smoke alarms in rooms
- CO detection
- Voice alarms can be required
- Some guest rooms with strobes
- Generally, sprinkler systems
 - All rooms exit to outside
 - Portable fire extinguishers
- Grab bars



Drills and Emergency Plans

- Emergency plans provided
- Hotels: Employees drilled quarterly on duties
 - Must start annunciation
 - Must notify fire department
- Dormitories: Drills frequently enough, at times of peak occupant load 1 year
 - Risk analysis for dorms



Apartments

- Means of egress similar to Hotels
- Less fire alarm requirements
- Annual instructions to each dwelling unit



Homes

- R-3
- Single family
 - Three outsiders
- Means of escape
- Lesser requirements
 - 28" doors
 - 36" stairs
 - 7' ceiling height
- Unlock bathroom doors from outside 从外面打开浴室门
- Grab bars
- Smoke alarms
- CO detection
- Sprinklers
- Existing chapter reserved



Lodging or Rooming Houses

宿舍出租公寓住房

- 16 or fewer people
- R-2
- Similar requirements as homes
- Additional fire and smoke spread limitations
- Interior finish requirements
- Fire alarm
 - Strobes
- Existing chapter reserved



Occupancy Classifications- Residential IBC

R-4: Custodial care 监护

6-16 people

Condition 1: **Can self-evacuate**

Condition 2: **Any person needs limited assistance**



Residential Board and Care

NFPA 101

住宿委员会和护理

Small Facilities

- R-4: Custodial care
 - 6-16 people
 - Condition 1: Can self-evacuate
 - Condition 2: Any person needs limited assistance

Large Facilities

- I-1 Supervised living
 - 16+ people, excluding staff
 - 24-hour care
 - Condition 1: Can self-evacuate
 - Condition 2: Limited assistance



Chapter Structure

- 32.1 General Requirements
- 32.2 Small Facilities
- 32.3 Large Facilities
- 32.4 Suitability of Apartment Buildings
- 32.7 Operating Features



Places of Work Occupancies

- Determine what differentiates this type of occupancy from others
- Identify the key provisions that are different from the general chapters



Historic Fire

- World Trade Center 2001



People

- Types of people present
 - Familiarity
 - Abilities
 - Activities

employees : both that are adults They're awake, able to they have moved. They can effectively move throughout the building. Some people maybe in wheel chair especially in the office space, but they'll be elevators. They're already the refuge for them. anyone under the implicit drugs and alcohol We're gonna assume no.

restriction so we get to industrial and storage . It's even less. Why is that because an industrial storage? They have on appropriate PPE So we'll talk about things like we cannot put graded stairs in a business, but you want to put great stairs(大楼梯) in a factory. That's perfect.



Occupancy Classifications- Business

- Office, professional, or service transactions
- Occupancies that do not quite meet definitions



Changes to Occupant Load Factor

- 2012: 100 ft²/person
- 2015: Concentrated Business 50 ft²/person
- 2018: 150 ft²/person, collaborative rooms



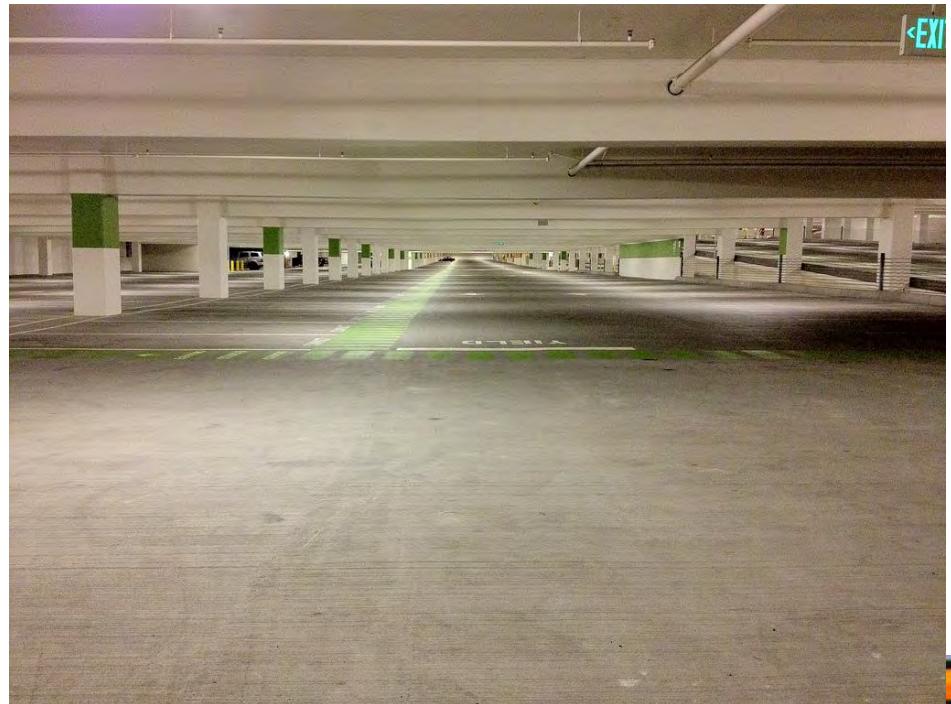
Comparisons to Other Occupancies

- Means of egress
 - Less restrictive than most other occupancies
- Fire protection systems
 - Less restrictive
- Risk Analysis
 - Colleges and universities
- Suppression
 - Extinguishers
- Drills
 - Not required if <500 persons or <100 persons above/below street floor
 - Conducted periodically



Combined Parking Structures

- 2 hr Fire barrier
- Openings do not need protection
 - Openings <25 %
 - Public entrance
 - Sprinklered business
 - Means preventing spilled fuel from accumulating
 - Vehicles always >10 ft away
 - Smoke partition



Factory

- Industrial buildings for assembling, disassembling, fabricating, finishing, manufacturing, packaging, repairing, or processing
 - F-1 moderate-hazard
 - F-2 low-hazard



Industrial Occupancies

- No existing building chapter
- Occupant load calculation gross
 - Exclude spaces not subject to occupancy due to machinery or equipment 不包括因机械或设备而受占用的空间
- Fire alarm typically required
 - Occupant notification
 - Audible and visual in constantly attended location
- Reduced requirements for furniture, mattresses, and soiled linen/trash receptacles
减少对家具、床垫和脏亚麻布/垃圾桶的需求



Subclassifications

子分类

- General
 - Ordinary or low hazards, conventional design
 - Multistory, potentially different tenants (different processes)
- Special purpose
 - Ordinary or low hazard, only suitable for certain operations
 - Low population density
- High hazard
 - Can be incidental and not basis for design 可以是偶然的，而不是设计的基础



Means of Egress

- Typically Chapter 7
- Can have noncombustible grated stairs 
- Fixed industrial stairs for fire escape ladders
- Slides can account for 100% of capacity
 - Must be regularly used in drills
- Dead-end corridors: typically 50 ft
- Common path of travel: typically 100 ft or 50 ft
- Travel distance: varies up to 400 ft

可以有不燃的格栅楼梯



Aircraft Hangars

飞机库

- Industrial?
- Storage?
- 150 ft exit spacing along exterior
- 100 ft horizontal exit spacing



Occupancy Classifications- Storage

S-1 Moderate-hazard

Not classified as S-2

S-2 Low-hazard

Noncombustible materials
with negligible plastic



Storage

- No existing occupancy chapter
- Limited fire alarm requirements
- No extinguishment requirements
- Parking garages
 - Dead ends 50 ft
 - Travel distance up to 400 ft



Occupancy Classifications- High Hazard

H-1爆炸危险

- Physical or health hazard
 - Minimum quantities
 - Manufacturing, processing, generation, or storage
- IFC/NFPA 1 typically referenced
- Multiple hazards
 - Meet each
- H-1 Detonation hazard
爆燃危险或加速燃烧
- H-2 Deflagration hazard or accelerated burning
- H-3 Materials that readily support combustion or pose a physical hazard
- H-4 Health hazards
- H-5 Semiconductor fabrication

半导体制造



Building Rehabilitation

- Explain why there are different requirements for new and existing buildings
- Distinguish between repair, renovation, modification, reconstruction, addition, and change in occupancy
- Determine when chapter 43 applies



Historic Fire

- First Interstate Bank



Existing Buildings

- Once approved buildings stays approved
 - Rare cases of retroactive requirements 追溯要求的罕见案例
 - Odd chapters
 - Work done to building
 - Change of occupancy
- Not always practical to meet all requirements



Types of Rehabilitation Work

康复工作类别

- Repair
- Renovation
- Modification
- Reconstruction
- Change of use or occupancy classification
- Addition

修理
翻新
修改
重建
使用或占用
分类的变更
附加



Chapter 4

- Existing buildings
 - Time for compliance: limited but reasonable, expenditure, disruption, degree of hazard
 - Additions same as new construction
 - Renovations as nearly as practical to new construction
翻新与新建工程尽可能接近
- Conditions for occupancy
 - Plan of correction
 - Occupancy classification does not change
 - No serious life safety hazard



Chapter 4

- Construction, repair, and improvement operations
 - Must have egress routes
- Changes of occupancy
- Maintenance and testing
 - Responsible persons
 - Applicable standards



Reconstruction

- Typically, 50% of building reconstructed = upgrade everywhere 通常，50%的建筑改建=到处升级
- Illumination and emergency lighting at level of new construction
- Supply smoke alarms in residential areas
- Sprinklers and standpipes throughout in some cases





Change of Occupancy

Hazard Category	Occupancy Classification
1 (highest hazard)	Industrial or storage occupancies with high hazard contents
2	Health care, detention and correctional, residential board and care
3	Assembly, educational, day care, ambulatory health care, residential, mercantile, business, general and special-purpose industrial, ordinary hazard storage
4 (lowest hazard)	Industrial or storage occupancies with



规范承认建筑物与其他建筑物不同

Historic Buildings

- Code recognize that buildings are unlike others
- Will usually require PBD
- Can fix with like
- Can leave means of egress with AHJ consent

经AHJ同意，可以离开出口通道



4.6.4.2* The provisions of this *Code* shall be permitted to be modified by the authority having jurisdiction for buildings or structures identified and classified as historic buildings or structures where it is evident that a reasonable degree of safety is provided.

Special Structures

- Identify special structures
- Describe the requirements for atriums
- Explain the requirements for high-rise buildings

识别特殊结构
描述中庭的要求
解释高层建筑的要求



Historic Fire

- Hartford Circus



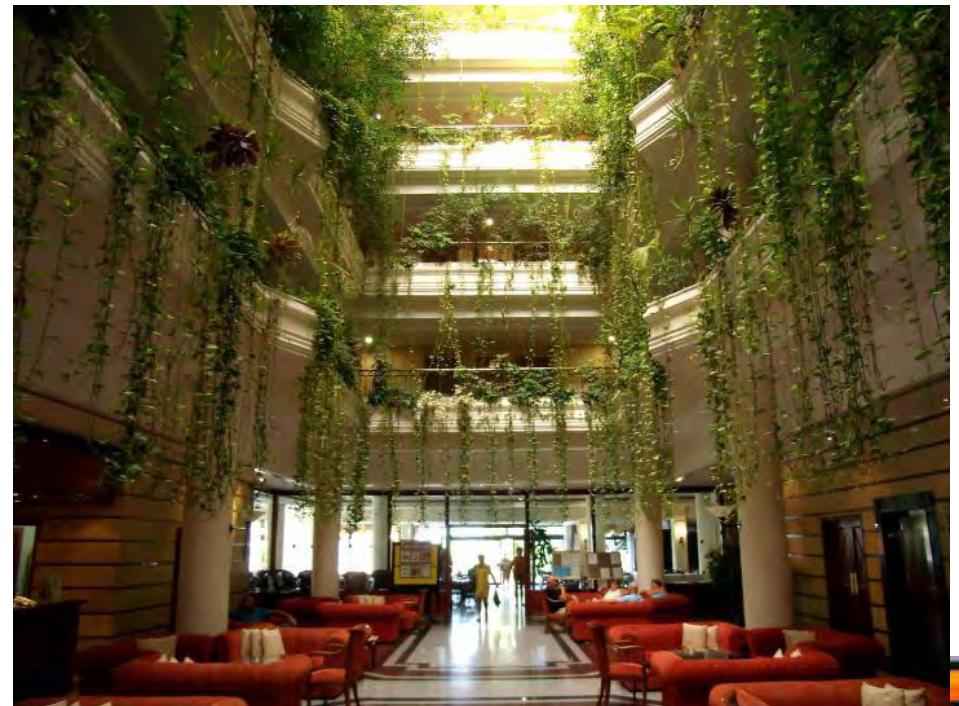
Special Structures

- Multiple occupancies
- Open structures
- Towers
- Water-surrounded structures
- Piers 码头
- Vehicles and vessels 车船
- Underground structures
- Permanent membrane structures 永久膜结构
- Temporary membrane structures
- Tents 帐篷



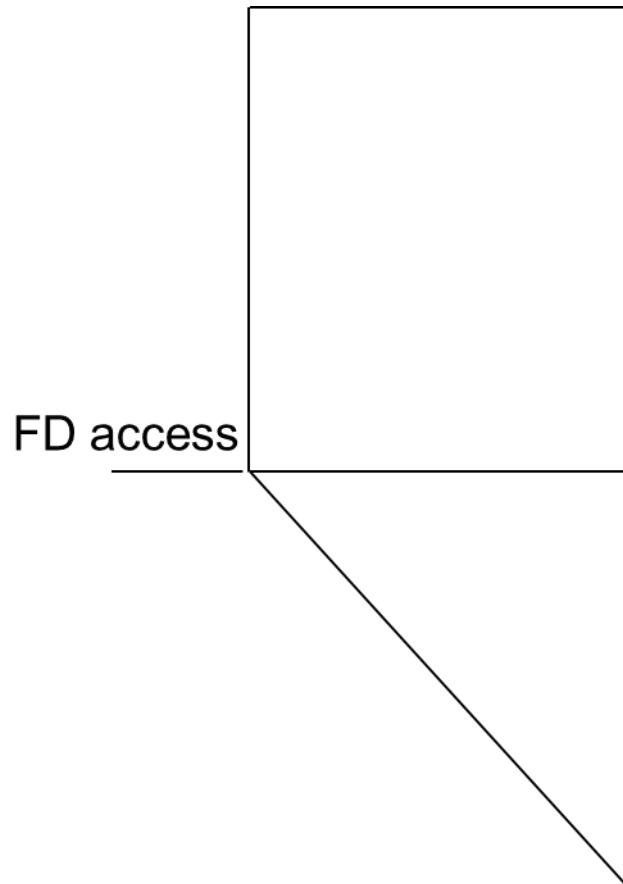
Atriums

- Separated
- Sprinklered throughout
- Smoke layer
 - Engineered design



High-Rise Buildings

- >75 ft above lowest level of fire department access
- Sprinklers and standpipes
- Voice alarm
- Two-way telephone for fire department use
- Additional emergency power requirements
- Emergency action plan
- Risk analysis



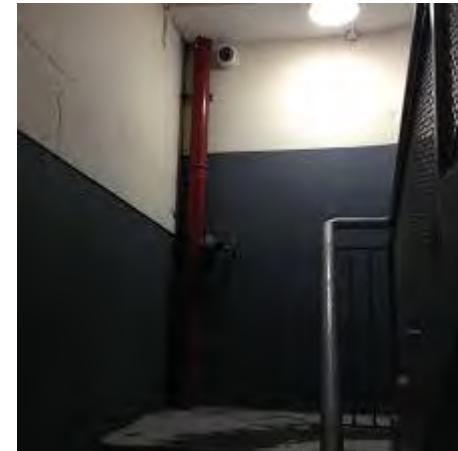
High-Rise Buildings

- Emergency command center
 - Status of fire protection systems
 - Elevator status 电梯状态
 - Emergency power status and control
 - Able to use voice alarm system
 - Two-way communication
 - Stairway video monitoring equipment



High-Rise in NFPA101

- Every 5th floor unlocked from ingress side 每五层从入口侧解锁一次
 - Minimum two re-entry doors 至少两个返回门
 - One door within top two stories 顶层两层内有一扇门
- Stairway video monitoring equipment
- Integrated testing
 - Initial
 - Every 10 years





High-Rise in IBC

- Remoteness of stairs
 - $\frac{1}{4}$ diagonal
 - 30 ft
- Additional stair
 - 420 ft
- 2-way communication every 5th floor if doors locked



International Building Code

- <https://codes.iccsafe.org/content/IBC2021P1>
- Describe the difference between a building code and the Life Safety Code
- Identify construction classifications
- Determine the separation requirement between different occupancies



Historic Fire

- Cardington



International Building Code

- Non structural
 - Identify the occupancy classification
 - Determine if sprinklered
 - Determine construction type
 - Building height
 - Building area
 - Locate building on site
 - Determine special occupancy
 - Calculate occupant load
 - Compliance with means of egress



International Building Code

- Non structural
 - Identify rated components
 - Identify interior finishes
 - Identify building systems
 - Identify special features
 - Identify roof covering
 - Determine location of glazings
 - Determine accessibility

Pretty much like we look at before



International Building Code

- Structural
 - Determine material
 - Concrete
 - Aluminum
 - Masonry
 - Steel
 - Wood
 - Determine design loads
 - Live
 - Dead
 - Environmental



Organization

- First digit indicates the chapter
- First section of chapter is designated by "01"
 - The first section of chapter 3 is section 301
- Subsections paragraphs and subparagraphs are indicated by decimal points
 - For example, 302.1.1
- Heavy vertical lines in the margin is change
- Arrow in the margin is deletion
- Italicized terms are defined in Chapter 2

斜体字术语



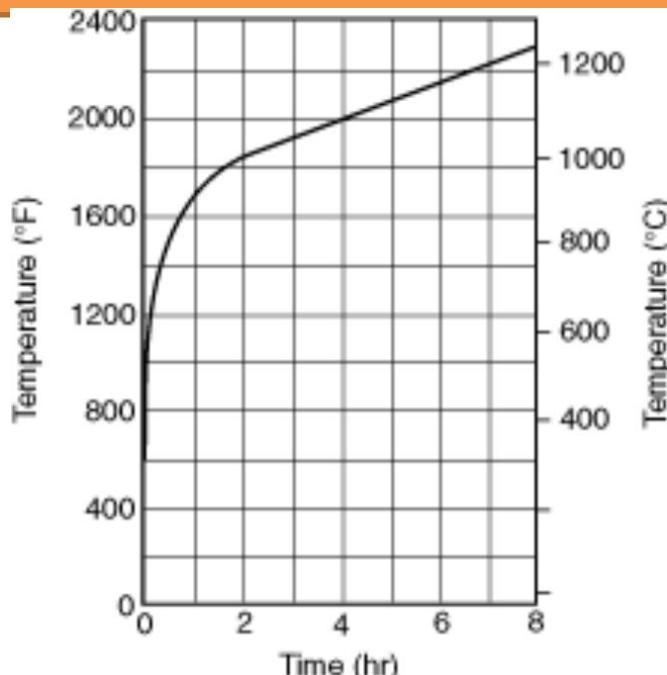
Chapters

- Chapter 1
 - Basically Chapters 1 and 4 in NFPA 101
- Chapter 2
 - Basically Chapter 3 in NFPA 101
- Chapter 3
 - Basically Chapter 6 in NFPA 101
- Chapter 4
 - Basically Chapters 11-42 in NFPA 101
- Chapter 7
 - Basically Chapter 8 in NFPA 101 with additional design information
- Chapter 8
 - Basically Chapter 10 in NFPA 101
- Chapter 9
 - Basically Chapter 9 in NFPA 101
- Chapter 10
 - Basically Chapter 7 in NFPA 101



Fire Resistance Ratings

- Typically given in units of hours
 - Determined by nationally recognized testing laboratories
 - Example: Underwriters Laboratories
 - Standard time vs. temperature fire exposure



Note: The following are the points that determine the curve.

1000°F (538°C)	at 5 minutes
1300°F (704°C)	at 10 minutes
1550°F (843°C)	at 30 minutes
1700°F (927°C)	at 1 hour
1850°F (1010°C)	at 2 hours
2000°F (1093°C)	at 4 hours
2300°F (1260°C)	at 8 hours or over



Fire Resistance Requirements

Find information on the code

- Fire walls typically 3 hour rated
- Fire barriers typically 2 hour rated
- Required fire resistance ratings for openings
 - Tables
 - In text



Comparison of Codes

NFPA	IBC
I (443) 	
I (332)	I-A A is one hour rated, B is unrated
II (222)	II-B
II (111)	II-A
II (000)	II-B
III (211)	III-A
III (200) 	III-B
	IV-A
	IV-B
	IV-C
IV (2HH)	IV-HT
V (111)	V-A
V (000)	V-B



New Construction Classifications

- Type IV has been redefined in the 2021 edition of the codes
 - Based on the results of testing
 - Allows for taller wood buildings
 - Fire resistance ratings required
 - New types
 - IV-A (fully protected by non combustible material)
 - IV-B (limited exposed interior members)
 - IV-C (increases for lower hazard occupancies)
 - NFPA 5000 no new categories, but allowed to follow Type II rules when having equivalent fire resistance and meeting other requirements



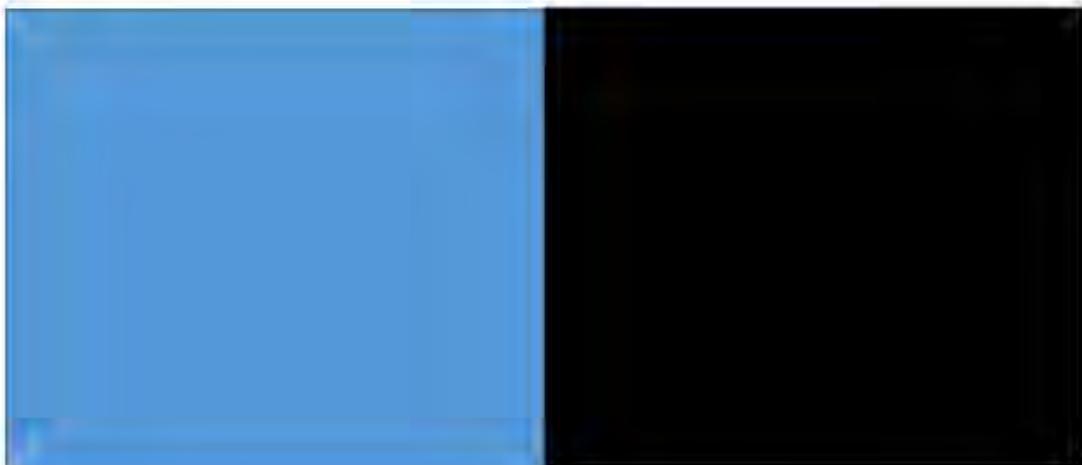
Separation

- For incidental accessory occupancy
 - (509 and Table 509) 附带附属设施占用
- Mixed occupancies 
 - Accessary (508.2)
 - Nonseparated (508.3) 
 - Separated (508.4 and Table 508.4)



Incidental Use

- Table 509



Half restaurant and half business
508.4, 2 hr rated wall between them
Area: 50% assembly allowed area plus 50% business allowed area

$$0.5 * 9500 + 0.5 * 23000 = 4750 + 11500 = 16250 \text{ ft}^2$$

$$\frac{5000}{9500} + \frac{5000}{23000} < 1 \quad \checkmark$$

$$\frac{5000}{9500} + \frac{12000}{23000} > 1 \quad \times$$



Separated

- Table 508.4
- As of 2021 filling in both sides of the table
- Must use Table 506.2
- Options
 - No wall required
 - Use most restrictive
 - Rated wall required
 - Not allowed



International Building Code

- Apply the rules for height and areas of buildings
- Perform calculations related to adjustment factors



Historic Fire

- Cook County Office Building

TABLE 504.3 ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE^a

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A, B, E, F, M, S, U	NS ^b	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
H-1, H-2, H-3, H-5	NS ^{c, d}	UL	160	65	55	65	55	65	50	40
	S		180	85	75	85	75	85	70	60
H-4	NS ^{c, d}	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 1, I-3	NS ^{d, e}	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 2, I-2	NS ^{d, e, f}	UL	160	65	55	65	55	65	50	40
	S	UL	180	85		75	85	75	70	60
I-4	NS ^{d, g}	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
R ^h	NS ^d	UL	160	65	55	65	55	65	50	40
	S13D	60	60	60	60	60	60	60	50	40
	S13R	60	60	60	60	60	60	60	60	60
	S	UL	180	85	75	85	75	85	70	60



Height and Area

- Sections 504 and 506
 - Sprinklers generally increase by 20 ft and 1 story for height
 - Sprinklers add 2 or 3 times original area

https://codes.iccsafe.org/content/IBC2018/chapter-5-general-building-heights-and-areas#IBC2018_Ch05_Sec504



Modifications of Area Limits

All the A_t and I_s use non-sprinkler value

$$A_a = A_t + [A_t * I_f] + [A_t * I_s]$$

or

Both will have the same answer

Use 2 values on table

$$A_a = A_t + [NS * I_f]$$

Where:

A_a = Allowable area per floor

A_t = Allowable area from Table

I_f = Area factor increase due to frontage 建筑前面的空地面积

I_s = Area factor increase due to sprinklers



Area factor for sprinklers

- $I_s=3$ for buildings one story above ground
- $I_s=2$ for buildings more than one story above ground



Area Factor for Frontage

If not more than 0.75

$$I_f = \left[\frac{F}{P} - 0.25 \right] \frac{W}{30}$$

Where:

I_f = Area factor increase due to frontage

F= Building perimeter with frontage (ft)

P= Total building perimeter (ft) 建筑总周长

W= Width of the frontage (ft)

Note: W/30 not permitted to exceed 1.0

W must be at least 20 ft



Area Factor for Frontage

- New table values in 2021

% of Perimeter	Open Space <20 ft	Open Space 20 to <25 ft	Open Space 25 to <30 ft	Open Space 30 ft or more
<25	0	0	0	0
25 to <50	0	0.17	0.21	0.25
50 to <75	0	0.33	0.42	0.50
75 or greater	0	0.50	0.63	0.75

- New values are at the lower end of each range
- **Interpolation allowed**
 - Client will want you to use linear interpolation
 - Old equation was linear interpolation
 - All values are still the same



Example 1

- What are the height and area limitations for a Group M occupancy in a building of Type III B construction?
- Solution: 2 Stories, 12,500 ft² per floor.

	SM	UL	181,500	79,500	39,000	70,500	39,000	229,500	153,000	76,500
M	NS	UL	UL	21,500	12,500	18,500	12,500	61,500	41,000	26,625
	S1	UL	UL	86,000	50,000	74,000	50,000	246,000	164,000	102,500
	SM	UL	UL	64,500	37,500	55,500	37,500	184,500	123,000	76,875
	NS ^d									

	S	UL	6	4	3	4	3	9	6	4	4	2	2
M	NS	UL	11	4	2	4	2	4	4	4	4	3	1
	S	UL	12	5	3	5	3	12	8	6	5	4	2



Example 2

- What are the height and area limitations for a library in an unprotected steel building without sprinklers?
- Solution: 2 Stories, 9,500 ft² per floor

A-1	NS	UL	5	3	2	3	2	3	3	3	3	2	1
	S	UL	6	4	3	4	3	9	6	4	4	3	2
A-2	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-3	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2

		A	B	A	B	A	B	A	B	C
A-1	NS	UL	UL	15,500	8,500	14,000	8,500	45,000	30,000	18,750
	S1	UL	UL	62,000	34,000	56,000	34,000	180,000	120,000	75,000
	SM	UL	UL	46,500	25,500	42,000	25,500	135,000	90,000	56,250
A-2	NS	UL	UL	15,500	9,500	14,000	9,500	45,000	30,000	18,750
	S1	UL	UL	62,000	38,000	56,000	38,000	180,000	120,000	75,000
	SM	UL	UL	46,500	28,500	42,000	28,500	135,000	90,000	56,250
A-3	NS	UL	UL	15,500	9,500	14,000	9,500	45,000	30,000	18,750
	S1	UL	UL	62,000	38,000	56,000	38,000	180,000	120,000	75,000



Example 3

- Are the height and area of the building acceptable?
 - Building is unsprinklered
 - Frontage on two adjacent sides **25 feet wide**
两个相邻侧面的正面25英尺宽
 - 2 Stories
 - 110 ft x 100 ft
 - Type V-B Construction
 - Group B occupancy



Example 3

- Need 11,000 ft², 2 stories
- 9,000 ft², 2 stories
- Allowance for frontage:

$$I_f = \left[\frac{210}{420} - 0.25 \right] \frac{25}{30} = 0.208$$

- Total area allowed:

$$A_a = 9,000 + [9,000 * 0.208] + [9,000 * 0] = 10,875 \text{ ft}^2$$

<11000 not allowed



Example 3

- Options
 - Just tell the owner no
 - Ask the owner to make their building smaller
 - Relocate building on site to increase frontage
 - Change to different construction type
 - Protect structural elements
 - Change material
 - Add sprinklers



Example 4

- Are the area and height acceptable if frontage 30 ft wide exists on all sides?
 - Sprinklered
 - 3 Stories
 - 130 ft x 360 ft
 - Group E Occupancy
 - Type II B Construction



Example 4

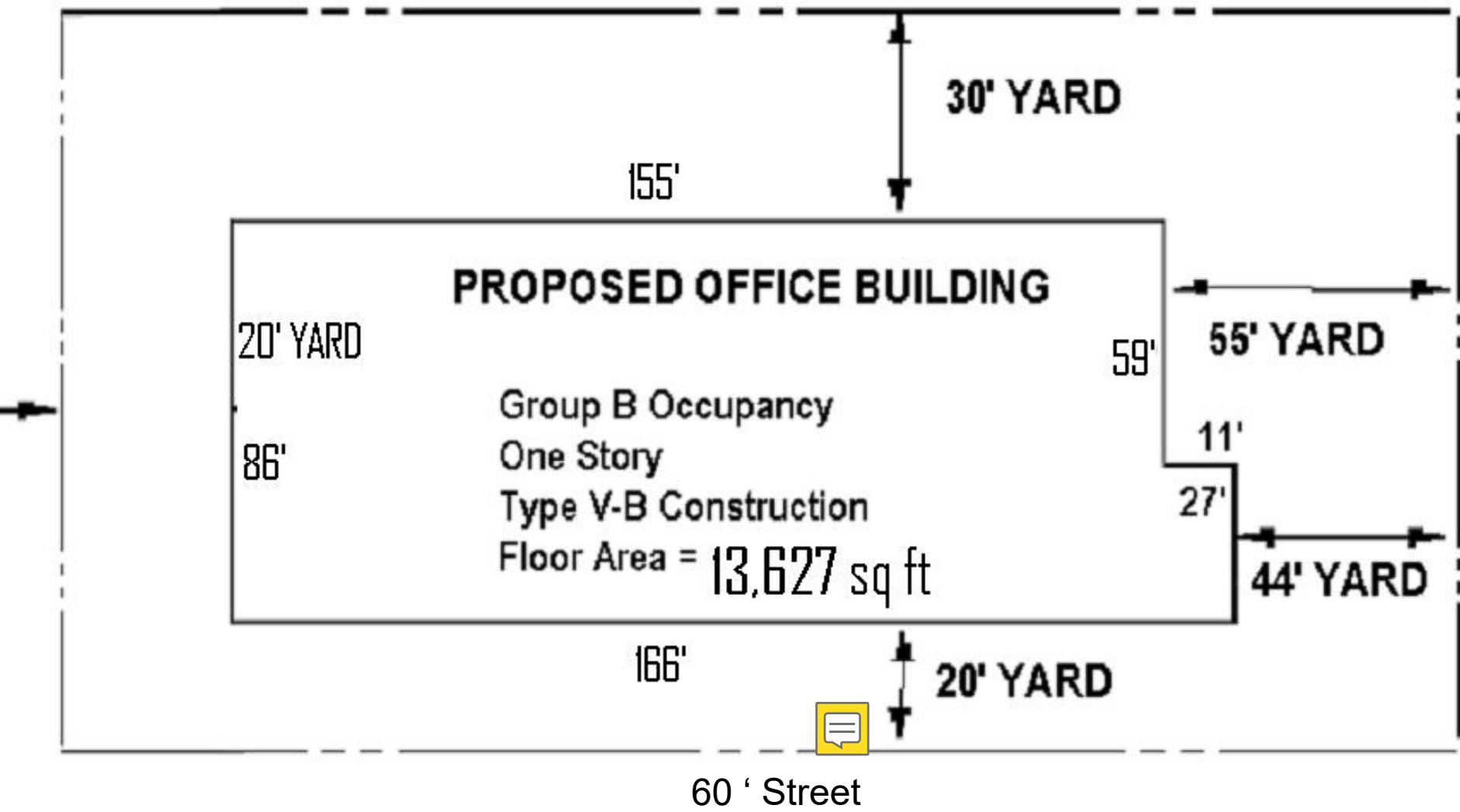
- Need 46,800 ft², 3 stories
- Nonsprinklered: 14,500 ft², 2 stories
- Sprinklers can increase to 3 stories
- Allowance for frontage:

$$I_f = \left[\frac{980}{980} - 0.25 \right] \frac{30}{30} = 0.75$$

- Total area allowed:

$$\begin{aligned} A_a &= 14,500 + [14,500 * 0.75] + [14,500 * 2] = 54,375 \text{ ft}^2 \\ &= 43,500 + [14,500 * 0.75] = 54,375 \text{ ft}^2 \end{aligned}$$





Using the information given, determine if the building may be of Type V-B Construction as proposed

Example 5

- Group B Occupancy, Type V-B: 9000 ft²
- Varying frontage = check multiple configurations
 - Option 1: 20 ft frontage on all sides

$$I_f = \left[\frac{504}{504} - 0.25 \right] \frac{20}{30} = 0.5$$

- Option 2: 30 ft frontage on 83%

$$I_f = \left[\frac{418}{504} - 0.25 \right] \frac{30}{30} = 0.579$$

- Use Option 2
- Total area allowed:
- $A_a = 9,000 + [9,000 * 0.579] + [9,000 * 0] = 14,211 \text{ ft}^2$



Building Evacuations

- Select the appropriate evacuation strategy for a building
- Determine when elevator evacuations are appropriate
- Identify the requirements for fire drills and emergency plans

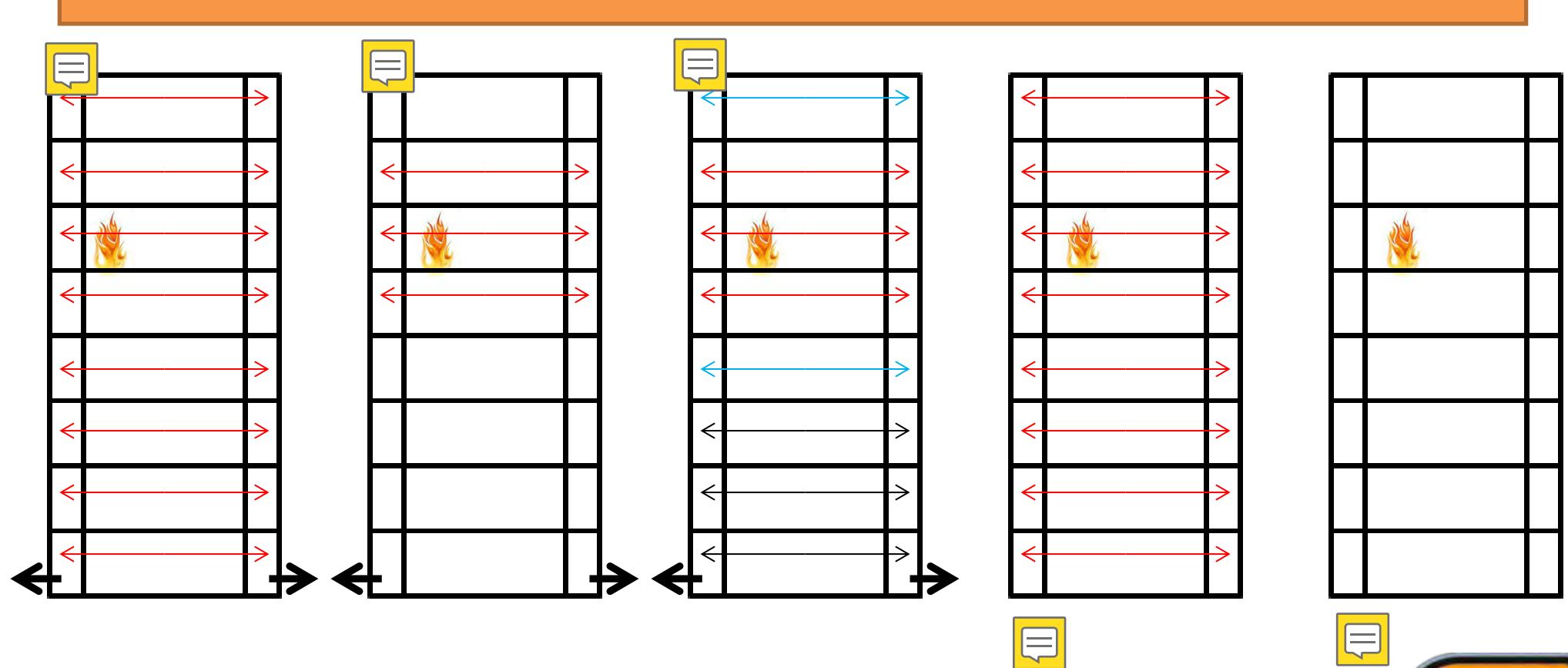


Historic Fire

- 1993 World Trade Center



Evacuation Strategies



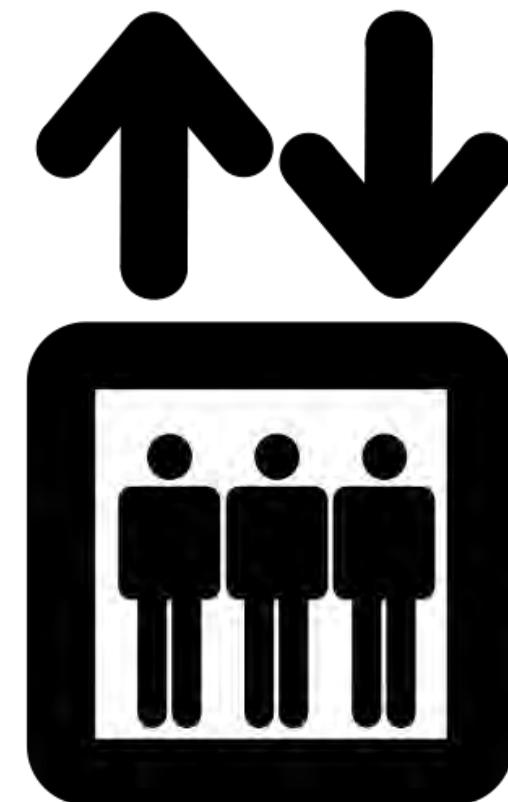
Hazardous Areas

- **High-hazard**
 - 75 ft
 - Means of egress from other codes
- **Mechanical rooms**
 - 50 ft (longer with sprinklers and other conditions)
- **Normally unoccupied spaces**
 - Less stringent requirements



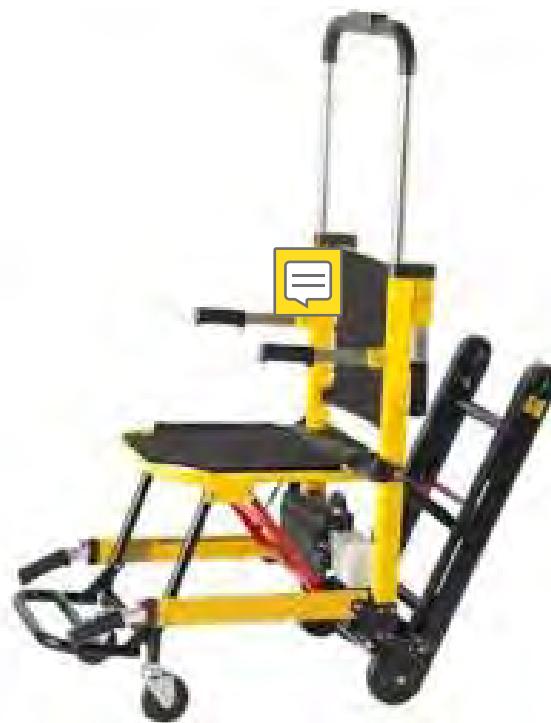
Elevator Evacuation

- Advantages
- Problems
- Messages
 - Content
 - Templates



Emergency Stair Travel Devices

- Not required
- New installations to meet relevant standard



Fire Drills

- As required by chapters 11 through 42
- Announced or not
- Sufficient frequency
 - Familiarity
 - Identify problems
- All persons shall participate
 - Training
- Availability of exits
- Competent persons shall be responsible
- Order and discipline -- not speed
- Relocate to predetermined location
- Cry-wolf
- Lost productivity



Emergency Plan

- Procedures for reporting of emergencies
- Occupant and staff response to emergencies
- Evacuation procedures
- Appropriateness of the use of elevators
- Design and conduct of fire drills
- Type and coverage of fire protection systems
- Other items required by AHJ
- Shall be submitted to AHJ for review
 - AHJ sets frequency



Construction

- Explain the hazards during construction
- Discuss how to effectively utilize site planning
- Determine the separation required between buildings



Historic Fire

- Notre Dame



Construction

- Greater fire risk than at other times
 - Incomplete or missing fire barriers
 - Limited water supplies
 - Extraordinary combustible sources 特殊可燃源
 - Limited ingress and egress routes
 - Extraordinary ignition sources
 - Extraordinary security conditions
- Earlier installation of fire protection systems could be beneficial



Construction

- Limited notification
- Human activities
 - Smoking
 - Housekeeping
 - Open flames
 - Intentional fires by unauthorized people



Construction

- **Life safety**
 - Stairway (temporary or permanent) required when construction exceeds 40 ft above lowest level of fire department access
 - Within one floor of the highest point of construction having secured decking or flooring
 - Means of egress must be maintained at all times

If the fire marshal happens to show up on site and see that mean of egress are being blocked. They're gonna shut down operations



Why Talk About Site Planning?

- Important issues affect:
 - Value and usability to the owner
 - Life safety of occupants
 - Cost
 - Effects upon neighboring properties
对邻近财产的影响



Site Planning



Interior Layout

- Relative use of doors, walls and other elements of compartmentation
- Relative complexity
 - Circulation patterns are important in emergency evacuation
- Building height
 - Ladder trucks only reach about 7 floors
 - Interior evacuation above the 7th floor
- Security features



Transportation

- How accessible is the building?
- Time is vital for fire department
 - How quickly can the fire department arrive
 - What traffic issues could delay arrival



Accessibility for Fire Department Operations

- Access to the building
 - Fire lanes
 - Windowless areas
 - Concealed spaces
 - Interior access

消防车道
无窗区域
隐蔽空间
内部通道



Water Supply

- Critical issues
 - Residual pressure
 - Volume
 - Reliability
- High-rise pressure requirements
- Number of sprinklers that might activate
- Location of hydrants



Exposure Protection

- Fire in another building a threat
 - Radiation
 - Flame impingement
 - Flying debris
- Requirements in IBC



Exposure Protection

$$A/a + A_a/a_a \leq 1.0$$



Where:

Three examples



A=Area of protected openings

a=Allowable area of protected openings

A_a=Area of unprotected openings

a_a=Allowable area of unprotected openings

Separation Distance (ft)

	< 3	3 to <5	5 to <10	10 to <15	15 to <20	20 to <25	25 to <30	30+
UPNS	NP	NP	10 %	15 %	25 %	45 %	70 %	UL
UPS	NP	15 %	25 %	45%	75 %	UL	UL	UL
P	NP	15 %	25 %	45 %	75 %	UL	UL	UL

Exposure Protection

$$A_e = A + (A_f * F_{eo})$$



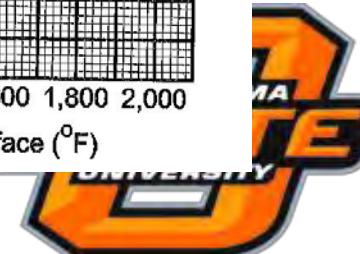
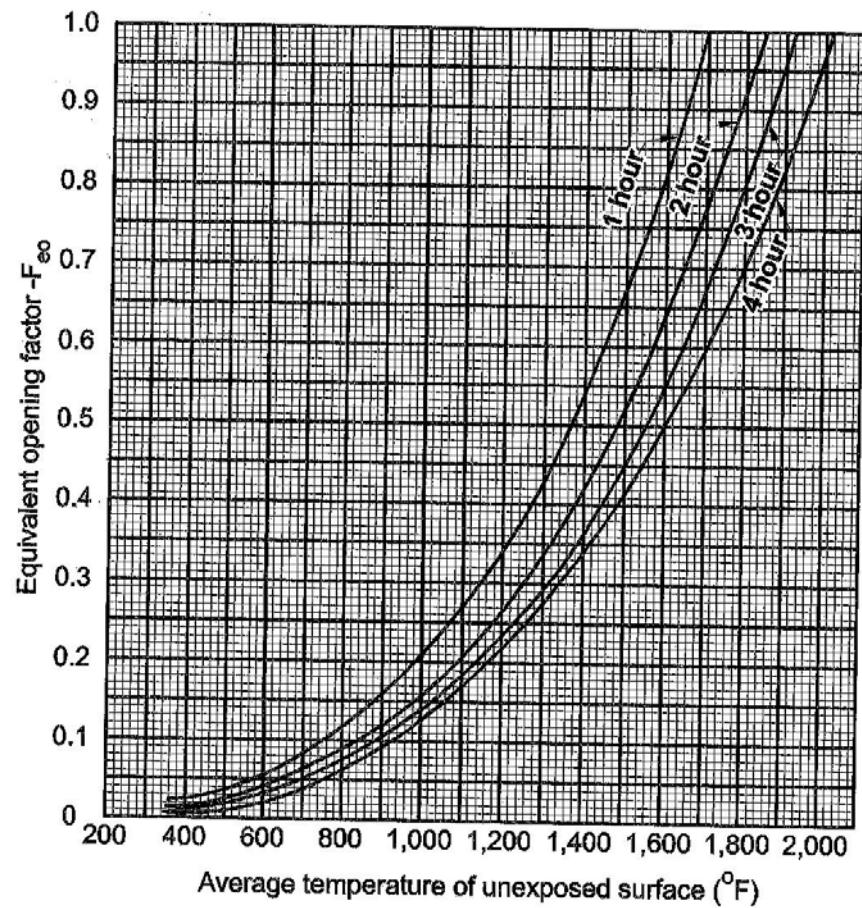
Where:

A_e =Equivalent area

A =Area of protected openings

A_f =Area of wall surface
excluding openings

F_{eo} =Equivalent opening factor



Design of the Building

- Compartmentation
- Detection, alarms, and communications
- Automatic fire suppression
- Egress systems
- Ventilation systems



Occupant Behavioral Scenarios

- Explain the PBD process
- Select appropriate evacuation scenarios
- Identify appropriate fire scenarios



Historic Fire

- Cocoanut Grove

There was one room particular fire started fake palm trees and lots of other things to make it look like it was a floral tropical type of place but the fire started because well within all that insulation. Obviously they have lights and other things and in a back corner. Apparently there was one guess to was with his. girlfriend at the time. Wanted a little bit more dark in that corner of the room for whatever reason and so went and unscrewed the light bulb there to make it dark in that back corner. First boy later on was told to go back there and fix the light So we went there but because it's dark. you see the lighter so he could see what he was doing and the process of the hot material from light bulb or his lighter caught some of that foam plastic into your finish on fire which then led to very rapid fire spread

有一个房间是由假棕榈树和其他很多东西引起的，使它看起来像是一个热带花卉类型的地方，但火灾是在所有的隔热层内发生的。很明显，他们有灯光和其他东西，在后面的角落里。显然有一个猜测是关于他的。当时的女朋友。不管什么原因，她想在房间的那个角落再暗一点，于是去拧下那个角落的灯泡，让后面的那个角落变暗。第一个男孩后来被告知回到那里修理灯，所以我们去了那里，但因为天很黑。你看到打火机，这样他就可以看到他在做什么，从灯泡或他的打火机的高温材料的过程中，一些泡沫塑料在你的饰面上着火，然后导致火势迅速蔓延



Performance Based Option

- Chapter 5 of NFPA101
- No rules
 - Goals and objectives
 - Some prescriptive rules stay
- All stakeholders
 - Assumptions
 - Agreement
- Establish performance criteria



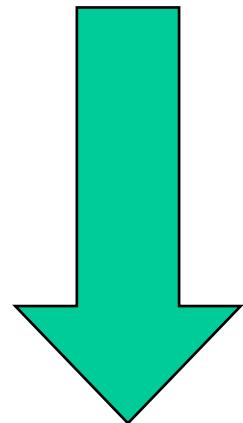
Safety Assessment

Performance based design

Required Safe
Escape Time
(RSET)

<

Available Safe
Escape Time
(ASET)



Safe



Occupant Scenarios

- Characteristics
 - Physical
 - Cognitive
- Number
 - High density
 - Low density
- Location
- Activities
 - Actions
 - Decisions
- Trained staff
- Building life cycle
- Off-site conditions



Prescribed Occupant Scenarios

so you can't really go to chapter 5 NFPA 101 for this one you're gonna have to consider different variables. What's important to that space? Why is it important you come up with the scenarios accordingly?



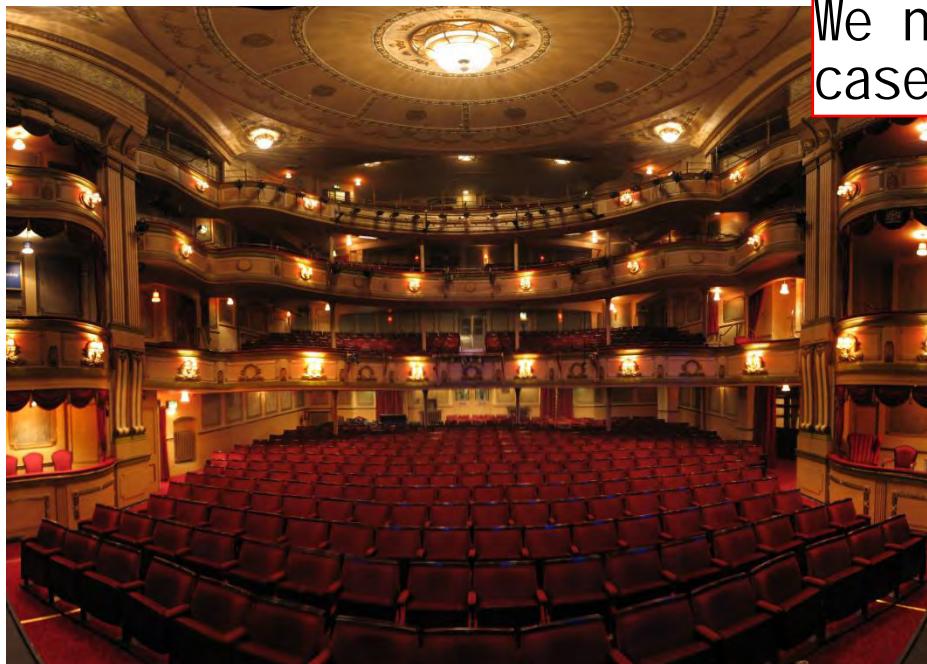
Potential Occupant Scenarios: Characteristics

- Sensibility
- Reactivity
- Mobility
- Susceptibility

敏感性
反应性
流动性
敏感性

- Normal conditions
- Elderly
- Children
- Disabled

正常条件
老年人
儿童
残废



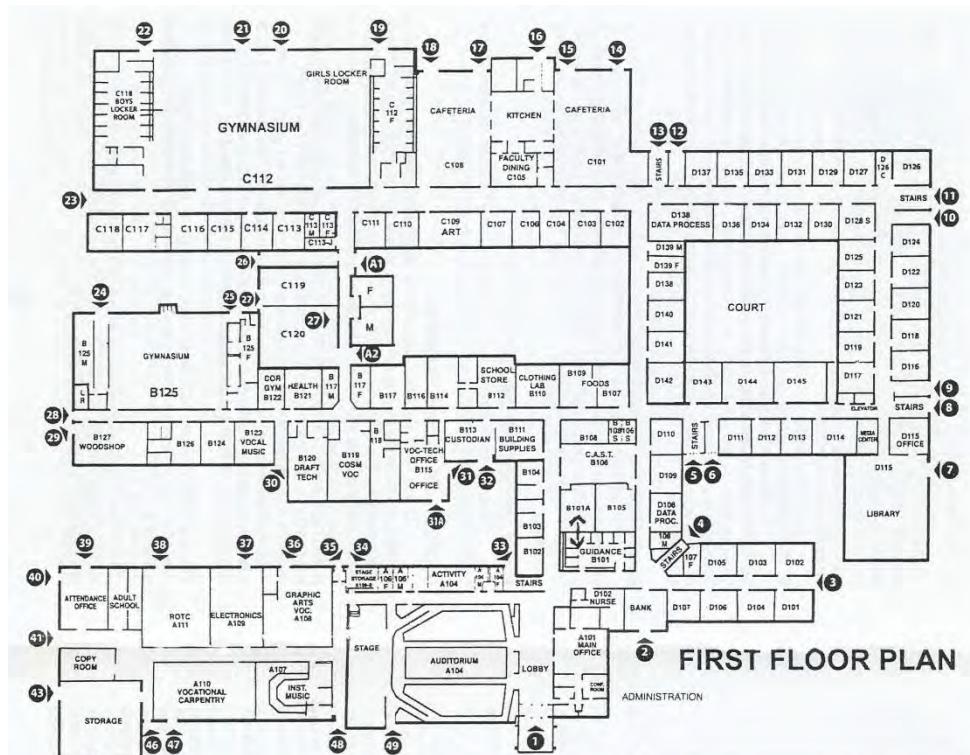
We need to count worst case realistic scenario



Potential Occupant Scenarios: Number and Location



- Normal conditions
 - Maximum occupant load
 - All occupied rooms
 - Average density
 - Special occasion
 - Low occupant load



Potential Occupant Scenarios: Activities and Staff

潜在占用场景：活动和员工

- Normal conditions
- Delays
 - Role
 - Familiarity
 - Actions
 - Decisions
- Staff assistance
- Emergency response personnel



Potential Occupant Scenarios Building and Off-Site Conditions

建筑物和场外条件下的潜在占用场景

- Post-construction
- Off-site



what's happening outside the building can make a big difference.



Fire Scenario Considerations

- Identify the specific fire safety challenges
- Location of the fire
- Type of fire
- Potential complicating hazards leading to other fire scenarios
- Systems and features impacting the fire
- Occupant actions impacting the fire



Prescribed Fire Scenarios

主要出口的
超快火力

- Occupancy specific typical fire 特定占用的典型火灾
- Ultrafast fire in primary means of egress



Prescribed Fire Scenarios

- Starts in normally unoccupied room with large number of people in another area
- Concealed space fire adjacent to a large room

靠近大房间的隐蔽空间火灾

fire starts somewhere where there's not many people because of that people's response is delayed and then the fire gets much larger as people delayed



Prescribed Fire Scenarios

- Slow fire shielded from systems near high occupancy
- Severe fire characteristic of the building



Prescribed Fire Scenarios

- Outside exposure fire
 - Ordinary combustibles fire without passive fire protection system functioning
 - Ordinary combustibles fire without active fire protection system functioning



We don't have to assume the worst case because the worst case is the massive fire, shielded from the system and passive system fails and and and it's just an ordinary combustible part



Scenario Selection

- Must address all potential scenarios
 - Realistic
 - Do not have to model all
 - Results must be documented



Analysis

- Deterministic vs. Probabilistic 确定性与概率性
- Sensitivity analysis 敏感性分析



Wayfinding

- Explain the difference between emergency lighting and means of egress lighting
- Determine how to use signage effectively
- Specify the appropriate guidance for the means of egress



Historic Fire

- Haunted Castle



Illumination

- People need to find ways to exits
 - Lighted means of egress at all times
 - Designated portions of exit access and exit discharge
- Can use natural or artificial light
 - Will the building ever be used after dark?
 - Cannot use batteries 不能使用电池
 - Can use motion sensors 可以使用运动传感器



Lighting

- Normal
 - 10 ft-candle on stairs
 - 1 ft-candle normal
 - 0.2 ft-candle in assembly occupancy during performance
 - 0.2 ft-candle if failure

楼梯上的10英尺烛光

1英尺烛光正常

演出期间，装配占用0.2英尺烛光
如果发生故障，则为0.2英尺烛光



Emergency Power

- Purpose of emergency power
- Systems required to be on emergency power



Means of Egress

- Automatically closing doors fail closed
- Electronic locks fail open



Emergency Lighting

- 10 s max
- 1.5 hr required
- Monthly test (30 s)
- Annual test (1.5 hr)
- 1 ft-candle at any point
- 0.1 ft-candle at floor level
- Cannot drop below 0.6 and 0.06 ft-candle after 1.5 hr
- Maximum-to-minimum no greater than 40 to 1

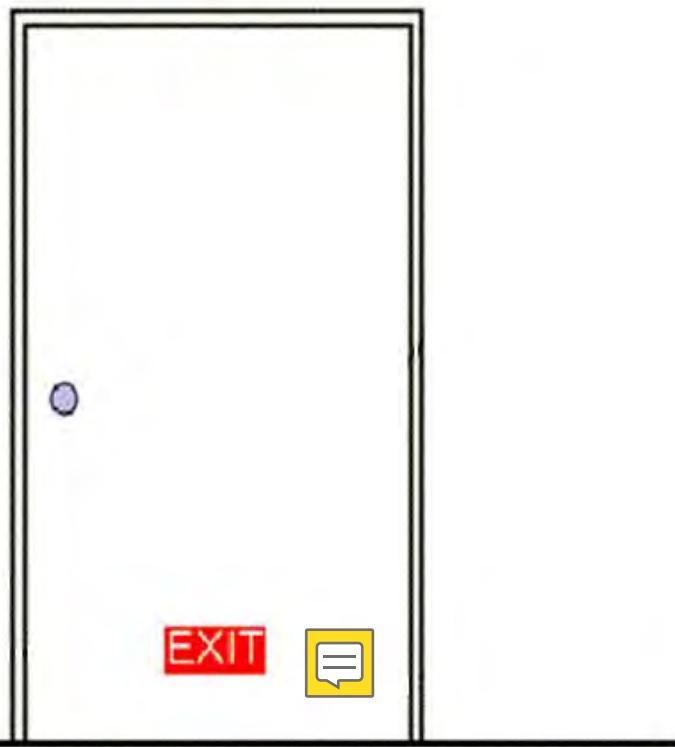


Activation of Emergency Power

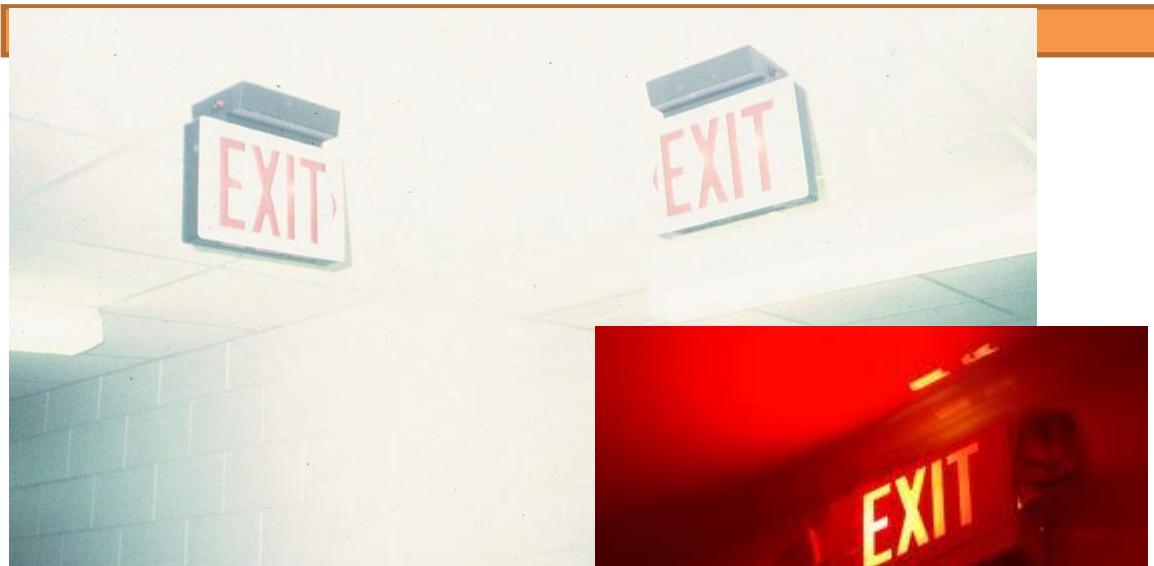
- Failure of public utility 公用事业的失败
- Opening of circuit breaker or fuse 断路器或保险丝断开
- Manual acts
 - Turning off the normal lights



Illumination and Placement of Signage



Signs



SALIDA

CH'É'ÉTIIN



Sign Requirements

- Tactile 触觉的
- 100'
- 5 ft-candles
- Monthly inspections
- Other signs



Not an Exit

- Purpose
- Requirements

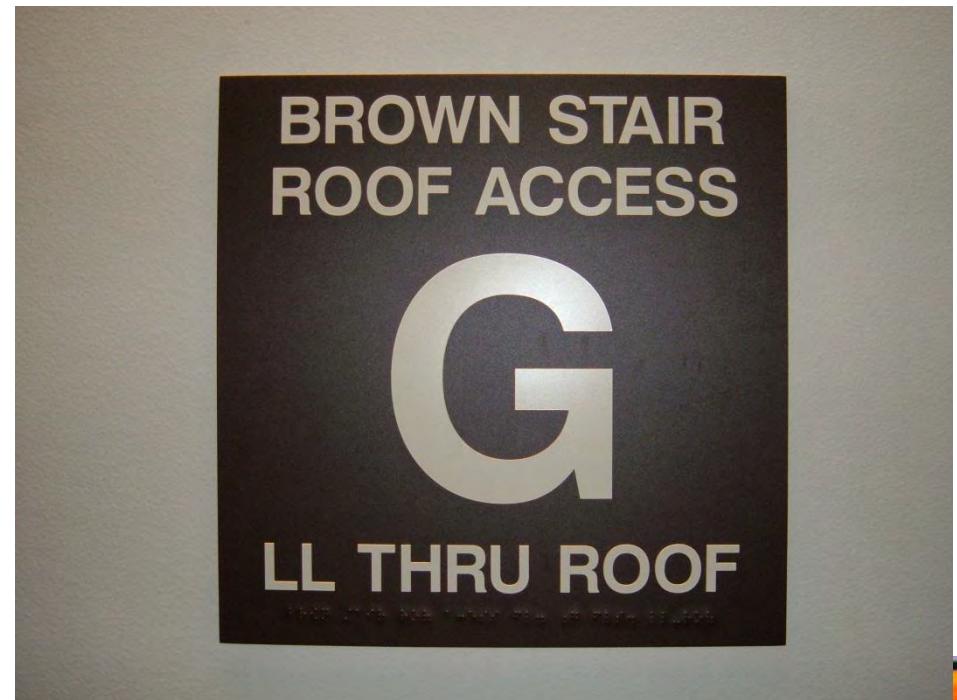


NFPA101 permit



Exit Stair Signage

- Connecting 3 stories
- Requirements
 - Every floor
 - Floor level
 - Top/bottom
 - Stair identification
 - 48 to 84 in above floor
 - Visible when door open
 - Tactile
 - NO ROOF ACCESS
 - Re-entry locations indicated



Occupant Load

- Occupancy specific
- Conspicuous 引人注目的
 - Near main exit/exit access

3.3.170.2 *Occupant Load.* The total number of persons that might occupy a building or portion thereof at any one time.
(SAF-MEA)



Accessibility

- Area of refuge 避难区
 - Two-way communication system
 - Exterior area for assisted rescue
 - IBC



Delayed Egress Doors

- Must have signage
 - Action
 - Alarm
 - Time



Static vs. Dynamic

- Intent to raise situational awareness
- Traditionally static
- Dynamic has advantages
 - Cost
 - Information

提高态势感知的意图



Characteristics of “Good” Alarm System

- Exploit learned/natural expectations 利用学到的/
自然的期望
- 2-stage signal if complex information is being provided
 - 1st: Attention-getting signal
 - 2nd: Information signal: provide distinct information
- Distinguishability from ambient noises & other alarms
- Provide only essential information
- Provide same signal at all times
- Multiple senses



ASET

- Predict time to incapacitation 预测丧失能力的时间
- Calculate the available egress time

NFPA 101 anyone not intimate with ignition shall be kept safe from the fire. So how long do you have to keep them safe



Historic Fire

- DuPont Plaza Hotel 



ASET

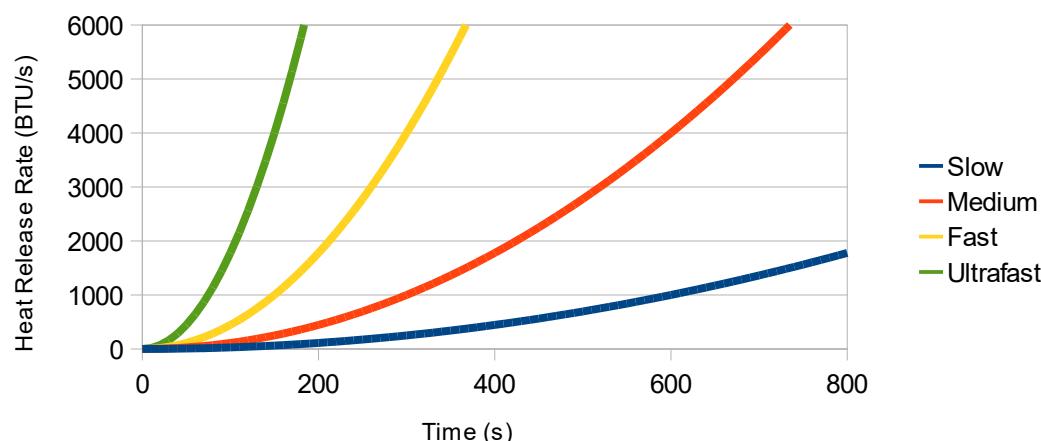
- Meaning of acronym
- Times included 



Fire Growth

- **t²**

- Based on reaching 1000 Btu/s (1055 kW)
 - Slow: 0.28×10^{-2} Btu/s³, $\tau=600$ s
 - Medium: 1.11×10^{-2} Btu/s³, $\tau=300$ s
 - Fast: 4.44×10^{-2} Btu/s³, $\tau=150$ s
 - Ultrafast: 17.78×10^{-2} Btu/s³, $\tau=75$ s



Smoke Plume

$$T_p = \frac{\dot{Q}_c}{\dot{m} \cdot c_p} + T_0$$

Where:

T_p =Smoke plume temperature

\dot{Q}_c =Convective heat release rate

\dot{m} =Mass entrainment rate

C_p =Specific heat

T_0 =Ambient temperature



Smoke Plume

$$\dot{V} = \dot{m} \cdot \frac{(T_p + 273)}{353}$$

Where:

\dot{V} =Volumetric flow rate (m^3/s)

T_p =Smoke plume temperature ($^\circ\text{C}$)

\dot{m} =Mass entrainment rate (kg/sec)



Smoke Production

$$\dot{m} = 0.071 \cdot k^{2/3} \cdot (\dot{Q}_c)^{1/3} \cdot z^{5/3} + 0.0018 \cdot \dot{Q}_c$$

Where:

\dot{m} = Mass flow in plume at height z (kg/s)

k = Wall factor

\dot{Q}_c = Convective heat release rate of fire (kW)

z = Height above top of fuel (m)



Ceiling Jet

$$\Delta T = 5.38 \cdot \frac{\left(\frac{\dot{Q}}{r}\right)^{2/3}}{H}$$

Where:

$r/H > 0.18$

ΔT =Temperature change ($^{\circ}\text{C}$)

\dot{Q} =Total heat release rate (kW)

H=Height (m)

r=Distance from center of plume (m)



Ceiling Jet

$$U_{cj} = 0.195 \cdot \frac{\dot{Q}^{1/3} \cdot H^{1/2}}{\left(\frac{r}{H}\right)^{5/6}}$$

Where:

$$r/H > 0.15$$

U_{cj} =Velocity (m/s)

\dot{Q} =Total heat release rate (kW)

H =Height (m)

r =Distance from center of plume (m)



Activation Times

激活时间

$$T_d = \sum \left(T_{d,i-1} + \frac{(U_{cj})^{1/2} \cdot (T_{cj} - T_{d,i-1})}{RTI \cdot \Delta t} \right)$$

Where:

T_d =Temperature of detector ($^{\circ}\text{C}$)

U_{cj} =Velocity (m/s)

T_{cj} =Temperature of ceiling jet ($^{\circ}\text{C}$)

RTI= Response Time Index ($\text{m}^{0.5} \cdot \text{s}^{0.5}$)

Δt = Time step (s)



Smoke

$$\text{Where: } \%COHb = 3.32 \cdot 10^{-5} \cdot CO^{1.036} \cdot RMV \cdot t$$

Where:

CO=concentration (ppm)

RMV=breathing rate (L/min)

$$FED = \sum \sum \frac{C_i}{Ct_i} \cdot \Delta t$$

Where:

C_i=Concentration at given time

Ct_i=Dose at endpoint

t=1 min, 1000 ppm	Time (min)	CO (ppm)	Dose (ppm-min)	Exposure (ppm-min)
t=2 min, 4000 ppm	1	1000	1000	1000
t=3 min, 9000 ppm	2	4000	4000	5000
t=4 min, 16,000 ppm	3	9000	9000	14,000
t=5 min, 25,000 ppm	4	16000	16000	30,000

Endpoint 35,000 ppm-min
1 min time steps

Tenability

容受度

$$F_{IN} = ((F_{ICO} + F_{ICN} + FLC_{irr}) * VCO_2 + FED_{IO})$$

- See 3-130 or 6-18 in NFPA Handbook for details
刺激物可导致丧失工作能力
- Irritants can cause incapacitation
 - See FEC equation (6-24)



Visibility

- Incapacitation when not able to see exits
 - 2 ft (0.6 m) cannot see own hand
 - 16.4 ft (5 m) visibility where familiar
 - 49 ft (15 m) visibility where unfamiliar
- $Vis = 0.43 \cdot \frac{K}{D}$

Where:

Vis=Visibility distance (m)

K=Constant

D=Optical density (m^{-1})



Heat

- Skin burns 皮肤烧伤
 - Skin temperature 113 °F (44.8 °C)
 - 2.5 kW/m²
 - 392 °F (200 °C)
- Respiratory burns 呼吸道烧伤
 - 140 °F (60 °C)
- Hyperthermia 热疗
 - 248 °F (121 °C)
 - 150 °F (66 °C)



Heat

$$t_{I,rad} = r \cdot (\dot{q}'')^{-1.33}$$

Where:

辐射致残时间(最小)

$t_{I,rad}$ =Time to incapacitation from radiation (min)

r =Radiant heat exposure dose at endpoint (1.33 for pain, 10 for incapacitation from serious injury)

\dot{q}'' =Heat flux (kW/m^2) r=终点辐射热暴露剂量 (疼痛为1.33, 重伤致残为10)

$$t_{I,conv} = 5 \cdot 10^7 \cdot T^{-3.4}$$

Where: 由于对流而丧失行动能力的时间(MJ)

$t_{I,conv}$ =Time to incapacitation from convection (min)

T=Temperature at skin surface ($^{\circ}\text{C}$)



Crowd Management

- Explain crowd response
- Apply FIST to crowd management
- Determine solutions to crowd events



Historic Event

- Who Concert



Crowd Management

- Crowd control
- Crowd management
- Locations



Crowd Characteristics

- Ambulatory: moving in and out of venue
- Disability/movement limited: restrictions in movement
- Cohesive/spectator: watching activities
- Expressive/reveler: emotional release
- Participatory: mass involvement in activity
- Aggressive/hostile: disregarding authority
- Demonstrator: some organization with leader
- Escaping/trampling: attempting to flee
- Dense/suffocating: individual movement lost
- Rushing: purpose to obtain
- Violent: Attacking



Crowd Factors

- Organization: planned or spontaneous
- Leadership: who is in charge
- Cohesiveness: individuals bonds
- Unity of purpose: goals
- Common motives for action: responding to same threat
- Emotional intensity: may not notice external cues
- Volatility: boiling point
- Individuality: how much self control and concern for others



Crowd Response

- Panic
 - Scarce resource
 - Contagion
 - Selfish
 - Irrational behavior
- Collective behavior
 - Emergent norm theory
 - Reorganization during emergency
 - Social affiliation
 - Group size

稀缺资源
传染病
自私的
非理性行为

涌现规范理论
紧急情况下的重组
社会关系
组大小



Risk Factors

- Flight response
- Craze
- Festival seating
- Escalator
- Transportation

飞行反应
狂热
节日座位
自动扶梯
运输

Solution of
this is in
reading



FIST

- F Force information space and time
- I
- S
- T



Solutions

we can do metering where we limit the flow in and out that also encounter things like that bridge going over to the station, so we spread people out in terms of a space type issue there of only giving enough space to handle the crowd More information, more easy to control



RSET

- Calculate the required safe egress time



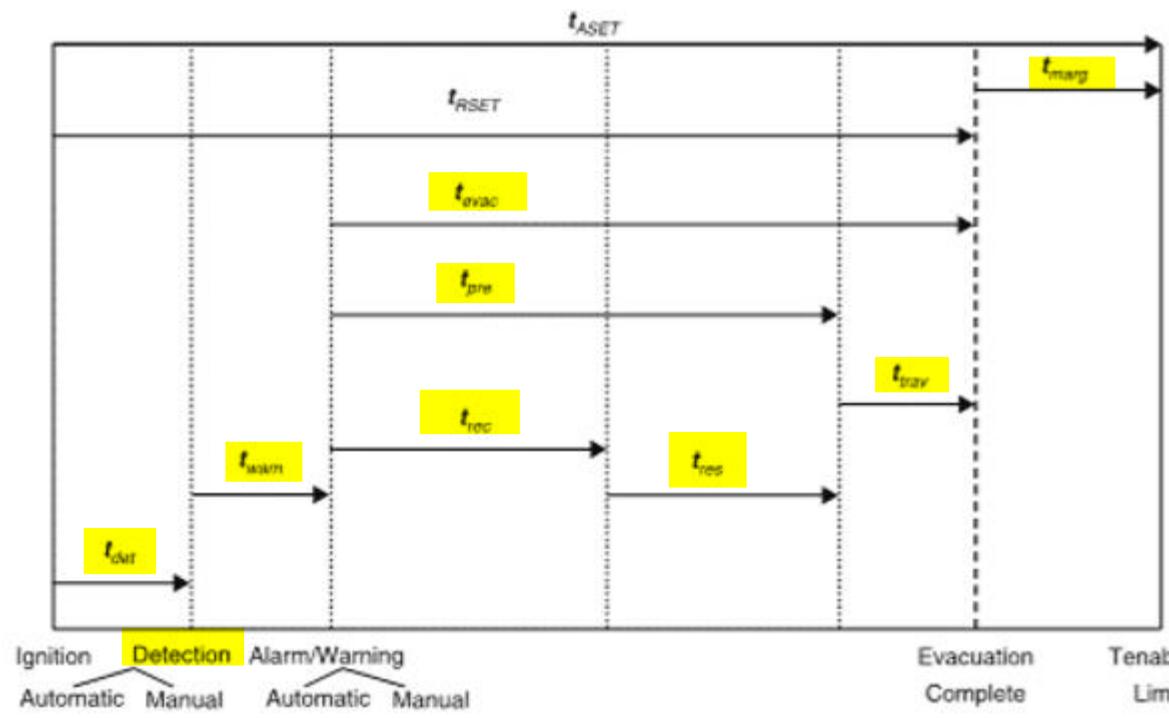
Historic Fire

- Shanghai Apartment



Time

- Detection and notification
- Reaction
- Pre-evacuation
- Travel time



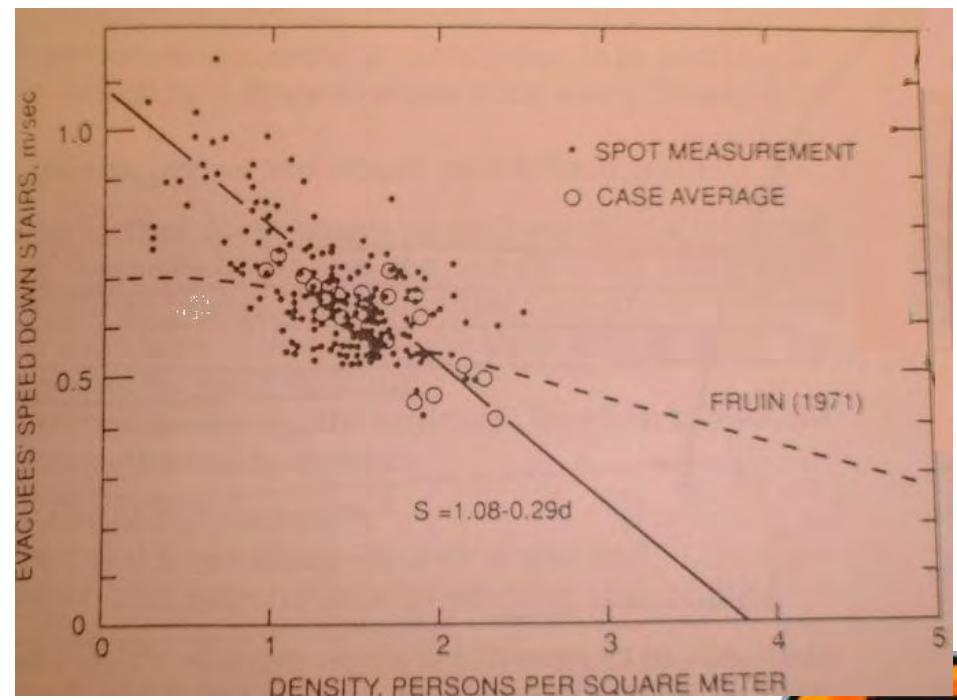
Effective Width

- Boundary layer

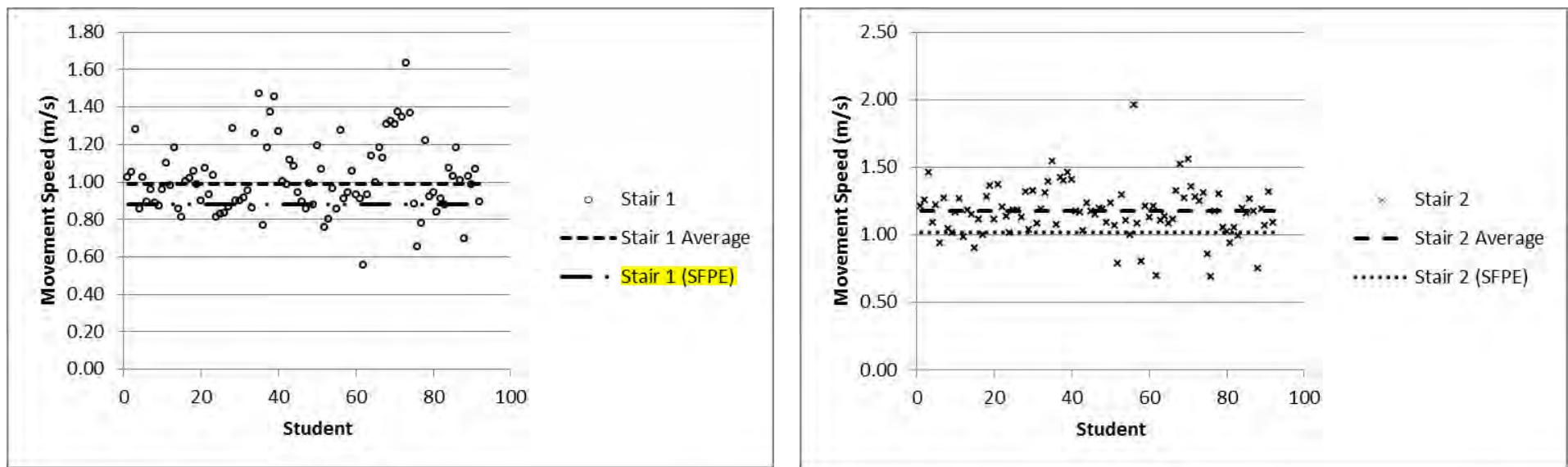


Movement Times

- SFPE equation
 - Pauls, Fruin,
Predtechenskii and
Milinskii
 - Beyond data collected
 - Not internally consistent
 - Age of data
 - Diversity of population
 - Distribution
 - No data to support k



Observed Flows



Movement Times

$$S = k - a \cdot k \cdot D$$

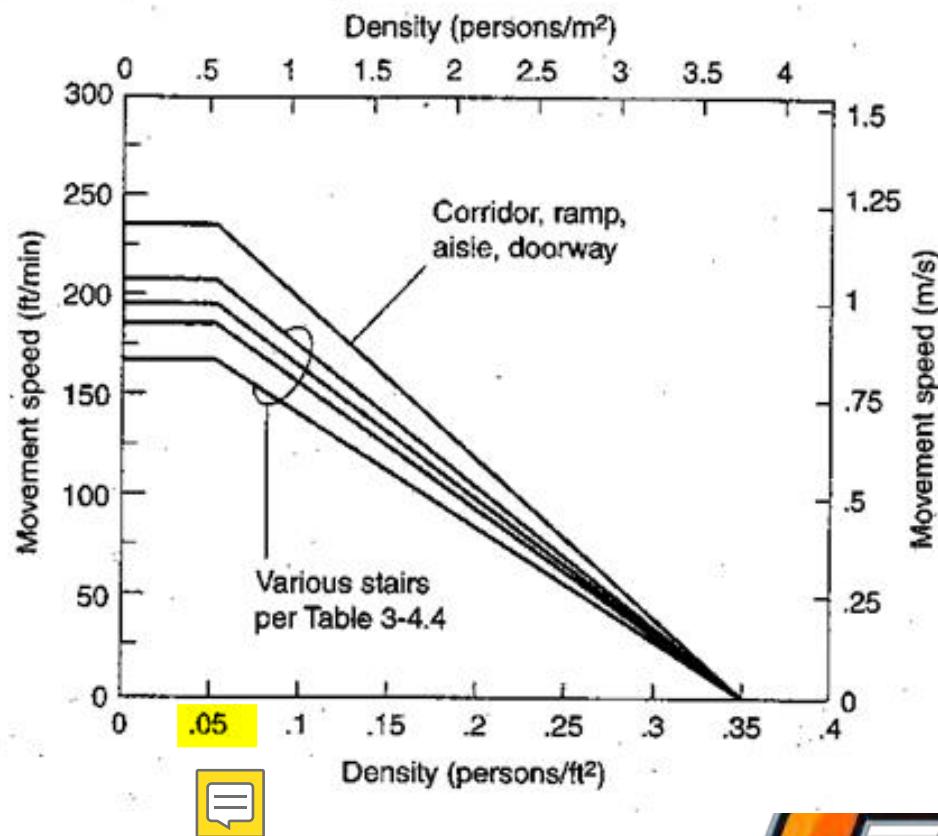
Where:

S=speed (ft/min or m/s)

k=constant (Table 4.2.5)

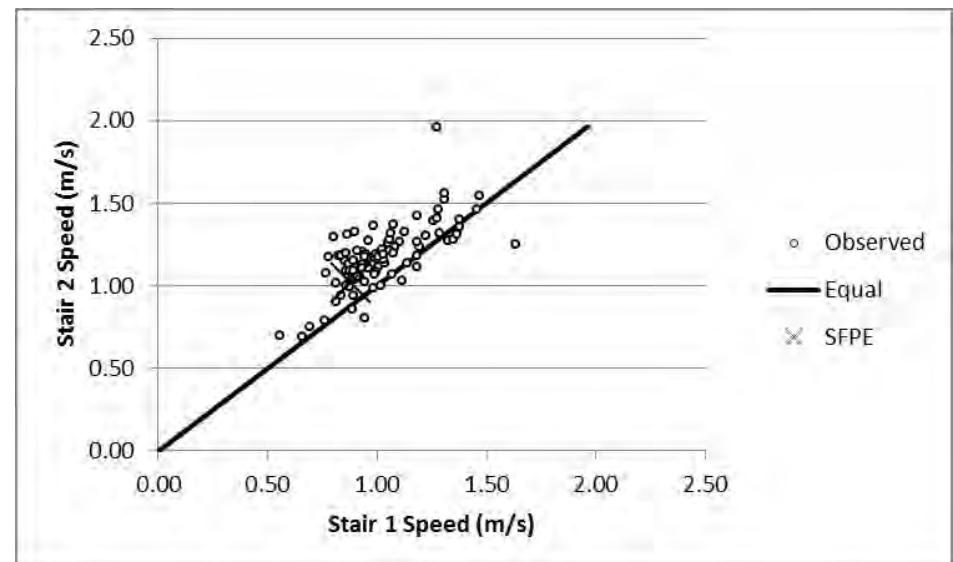
a=constant (2.86 when using ft, 0.266 when using m)

D=density (persons/ft² or persons/m²) 



Justification of k-Factors

Element	k (U.S. units)	k (metric)
Corridor, door, ramp	275	1.40
Stairs		
Riser, Tread (in)		
7.5, 10	196	1.00
7.0, 11	212	1.08
6.5, 12	229	1.16
6.5, 13	242	1.23



Movement Times

$$\begin{aligned} & (F_{s(in,1)} \cdot W_{e(in,1)}) + \dots + (F_{s(in,n)} \cdot W_{e(in,n)}) \\ & = (F_{s(out,1)} \cdot W_{e(out,1)}) + \dots + (F_{s(out,n)} \cdot W_{e(out,n)}) \end{aligned}$$

Where:

F_s = Specific flow (persons/ft-min or persons/m-s)

W_e = Effective width (ft or m)

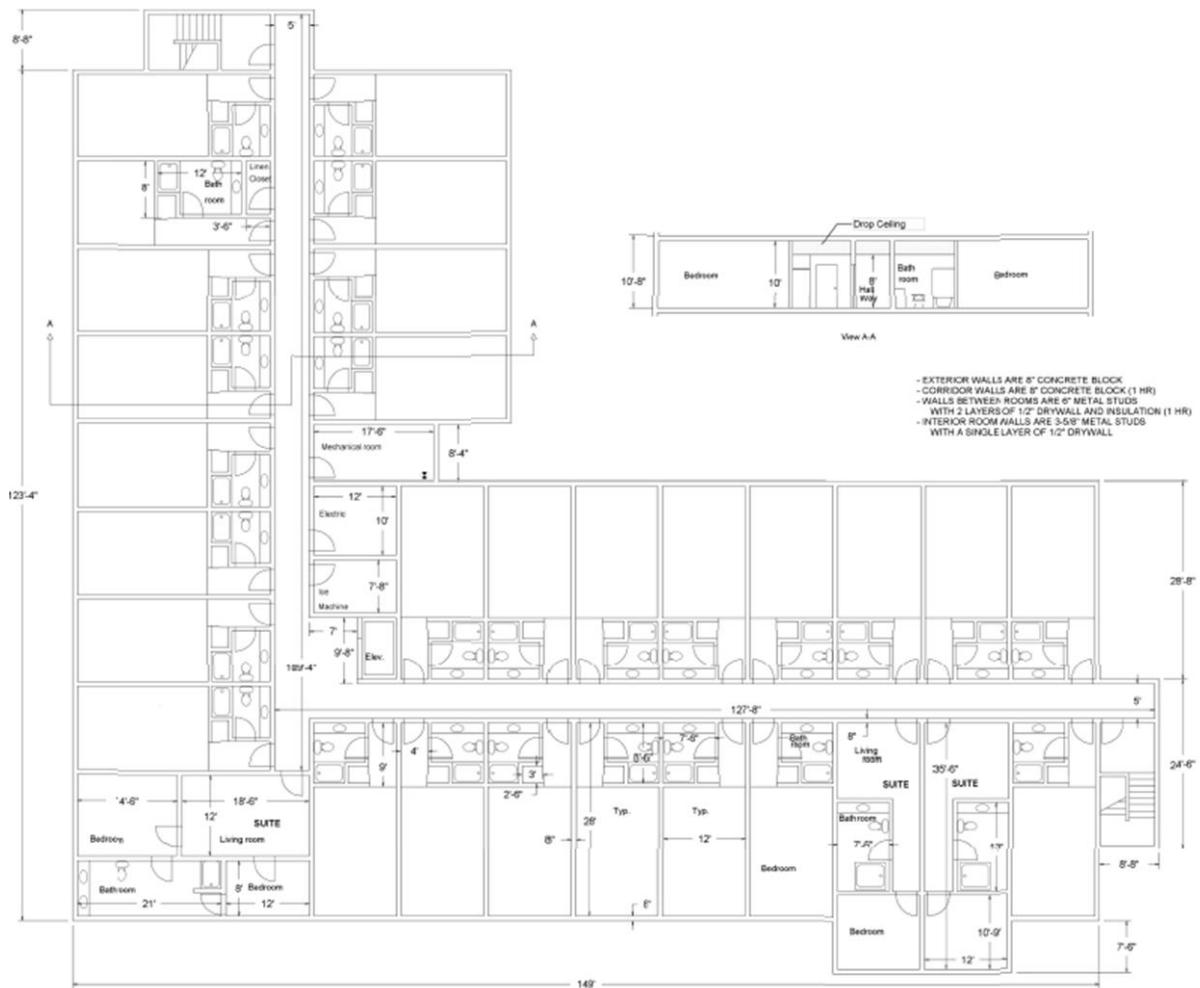
$_{in,out}$ = arriving at, after

Element	Boundary Layer (in)
Stairways	6
Railing, handrails	3.5 
Theater chairs	0
Corridor, ramp	8
Obstacles	4
Wide concourses	< 18
Door	6



Movement Times

- Calculations build
 - See example problem on
4-62 to 4-64 in NFPA Handbook
- Consider limiting component 



Movement Times

- Speed in reduced visibility



$$W = -0.1364 \cdot \ln \alpha_K + 0.643$$

Where:

Speed can change the visibility

W= movement speed (m/s)

α_K = Extinction coefficient (m^{-1})

You should check your result with $S = k - a \times k \times D$,
Because W only give you a lower speed

If $W < S$, we can use W



Flow

• Specific Flow: $F_s = \left(\frac{\text{Persons}}{\text{min} \cdot \text{ft}} \right)$

→ How to get F_s ?

$$\text{Density} = \frac{\text{Person}}{\text{ft}^2}, \quad \text{Speed} = \frac{\text{ft}}{\text{min}}$$

• So $\boxed{F_s = \text{Density} \times \text{Speed}}$

→ Speed = $K - \alpha K D$

$$F_s = (K - \overset{\text{speed}}{\underset{\downarrow}{\alpha K D}}) \times \overset{\text{Density}}{\underset{\downarrow}{D}}$$

↑ We can find maximum F_s because = 1/R 方程

• If give you F_s , let you calculate D . choose the smaller D
= 1/R 方程，两个解选最
小的那个

• Calculated Flow

Calculated Flow: $F_c = F_s \cdot W_e$





Population Variability

- Age
- Fitness
- Gender
- Fatigue



Accessibility

- Identify the vulnerable populations to consider
- Discuss requirements for accessibility and other special needs

识别弱势群体考虑

讨论无障碍要求和其他特殊需求



Historic Fire

- L'Isle Verte



Mobility Impairments

- Must accommodate everyone
- All occupants not intimate with fire shall be kept safe



IBC Chapter 10

- Four or more floors
 - Elevator
 - No exit access stairs
 - Stairs 48" between handrails
 - Normal with sprinklers
 - Area of refuge



IBC Chapter 11

- Not all areas
 - Work areas where change in elevation is essential
 - No elevators
- Not all routes
 - One
 - Site plan
 - 60 % of entrances
- General circulation



IBC Chapter 11

- Parking spaces
- Hospital sleeping rooms
- Hotel rooms
- Apartments
- Assembly seating areas
- Self-service storage
- Bathrooms
- Check-out aisles
- Recreation facilities



International Codes

- https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/441786/BR_PDF_AD_M2_2015.pdf



Vulnerable Populations

弱势群体

- Movement impaired
- Visually impaired
- Hearing impaired
- Cognitive disability
- Elderly
- Children
- Large groups
- Isolation
- Unfamiliar
- Asleep
- Intoxicated
- Non-Native speakers
- Committed to task
- Situationally disabled
- Compounded effects



Code Requirements

- Combination horn/strobe
- 520 Hz smoke alarms
- Voice alarms?
- Area of refuge
- Occupant evacuation elevators
- Assistive listening systems
- Stair markings?
- Signage



Future

- Increased occupant evacuation elevators
- Stairway descent devices
- Multi sensorial wayfinding
- Personalized emergency messaging
- ?



Human Behavior

- Explain how people actually respond compared to the myths of human response
- Describe the decision making process
- Explain what pre-evacuation time is and why it is important



Historic Fire

- Hamlet Chicken Processing Plant



Myths 神话

- Panic 
- Disaster shock
- Immediate
- To exits
- Flocking
- Fluid
- Ignore own senses
 - Will travel through smoke



Awareness

- Environment
 - Fire cues
 - People
- Systems
 - T-3
 - Flashing lights
 - Voice alarm
 - Other
- Latane and Darley



Notification

- Not all people receive message
 - Background noise/images
 - Hard of hearing
 - Limited vision
 - Dedicated to task
- Not all people comprehend message
 - Recognition of alarm
 - Do not speak/read language



Non-Adaptive Behaviors and Interactions

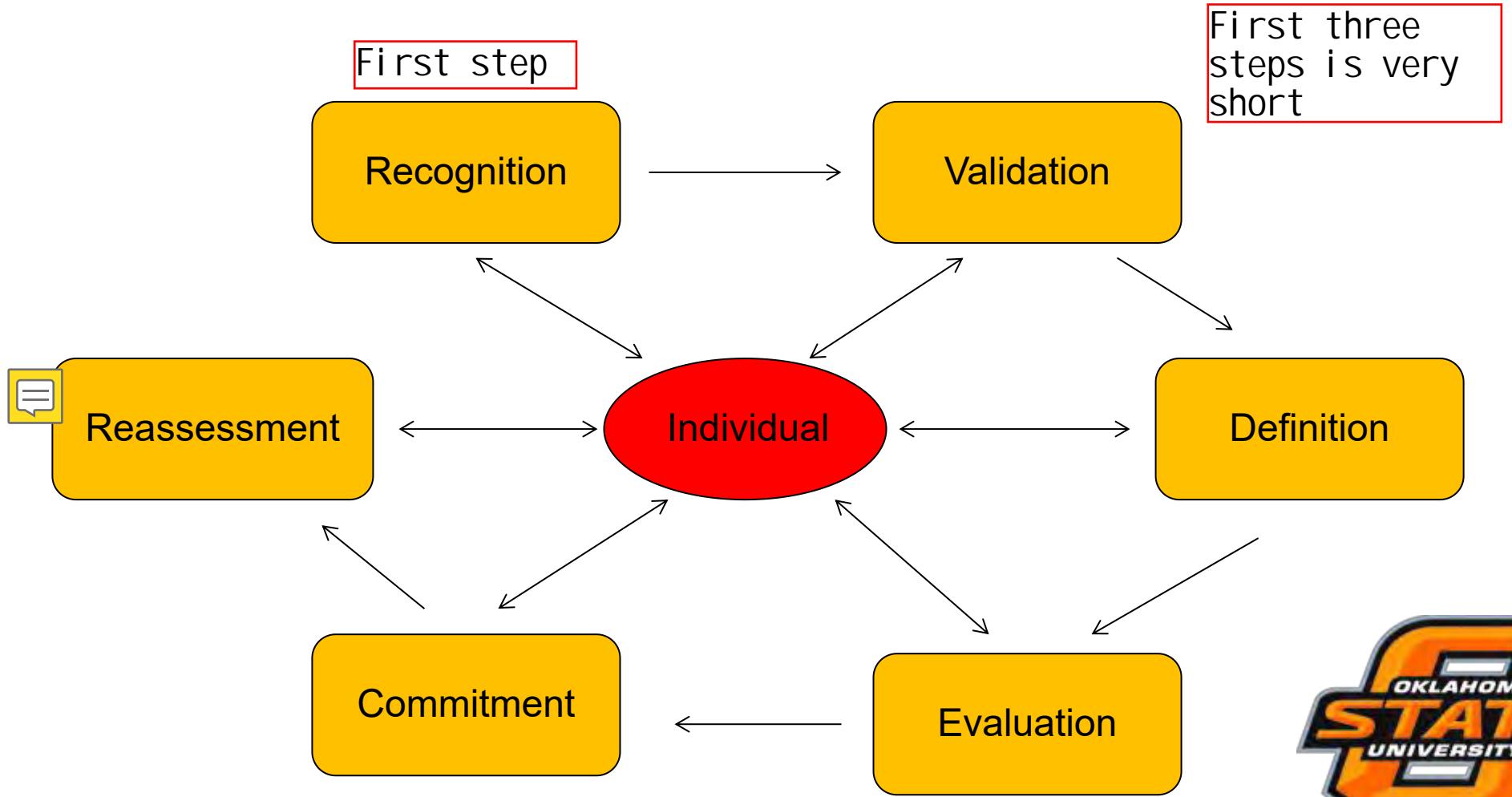
非适应性行为与互动

- Non-Adaptive Behaviors
 - Notification
 - Re-entry
 - Firefighting
 - Crowd crush
- Interactions
 - Milling
 - Convergence clusters
 - Platoons
 - Groups

碾磨
聚合簇
排组



Decision Making Process



Response

- Actions
 - Waking up
 - Gathering more information
 - Dedicated to task
 - Notifying others
 - Preparing
 - Fighting fire



Pre-Evacuation Time

撤离前时间

- Amount of time can be great
- Introduces uncertainty
 - Densities 
 - Exposures
- Messaging is critical
 - Attention
 - Source
 - Event
 - Location
 - Action
 - Time



Expected Times 预期时间

So how much evacuation time should you account for ?

- There is no single number 没有单一的数字
- There are no general engineering guidelines
 - No rules of thumb
 - No table values
- Need to use engineering judgment
 - Informed



Pathfinder

- Select an egress model to meet the needs of the project
- Use Pathfinder to predict egress times



Historic Fire

- Brown's Ferry

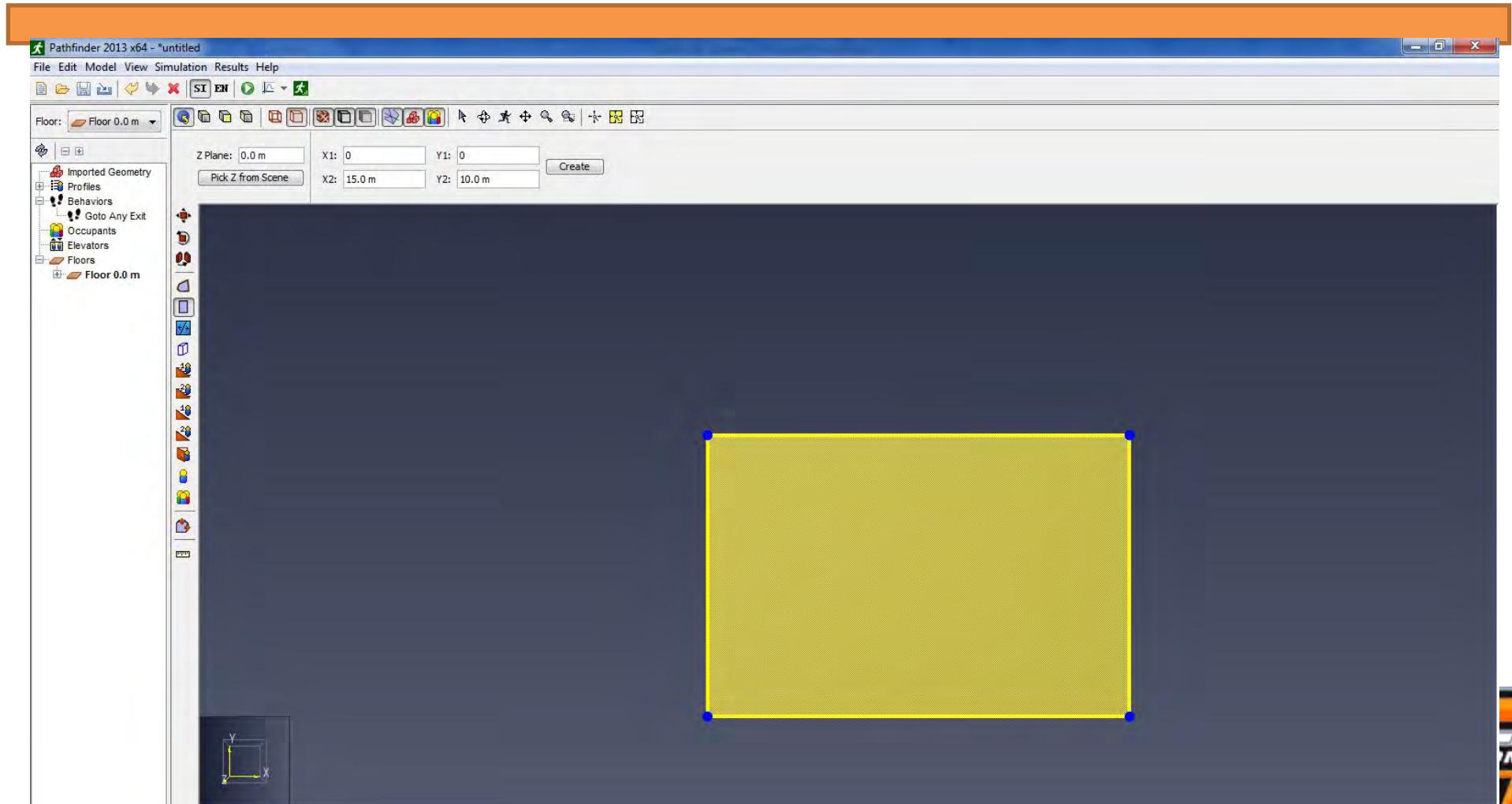


Pathfinder

- <http://www.thunderheadeng.com/pathfinder/download/>
- 60F5 8ED5 5895 7390 6048 94
- Read:
http://www.nist.gov/customcf/get_pdf.cfm?pub_id=906951



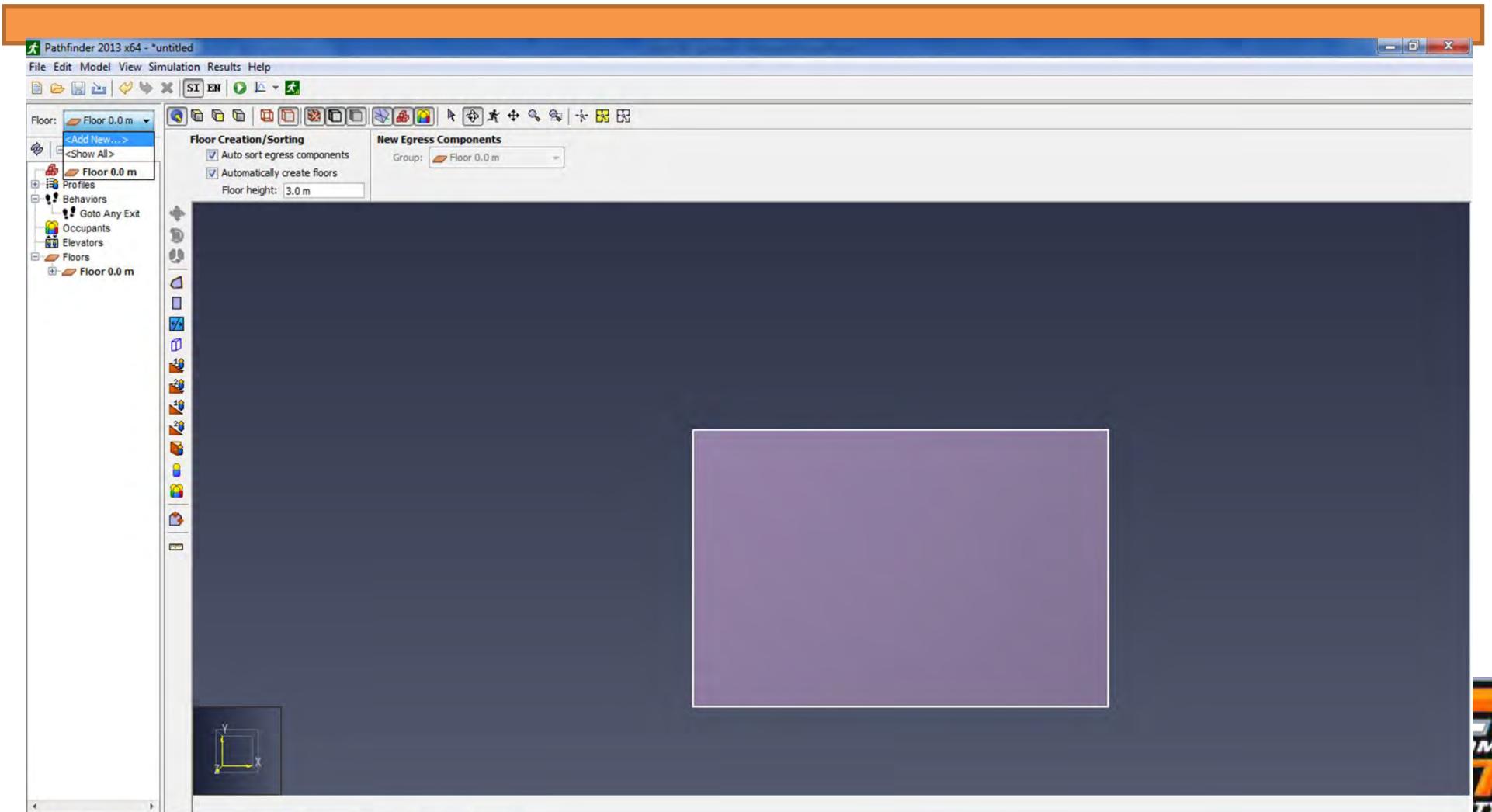
Pathfinder



- Draw Room

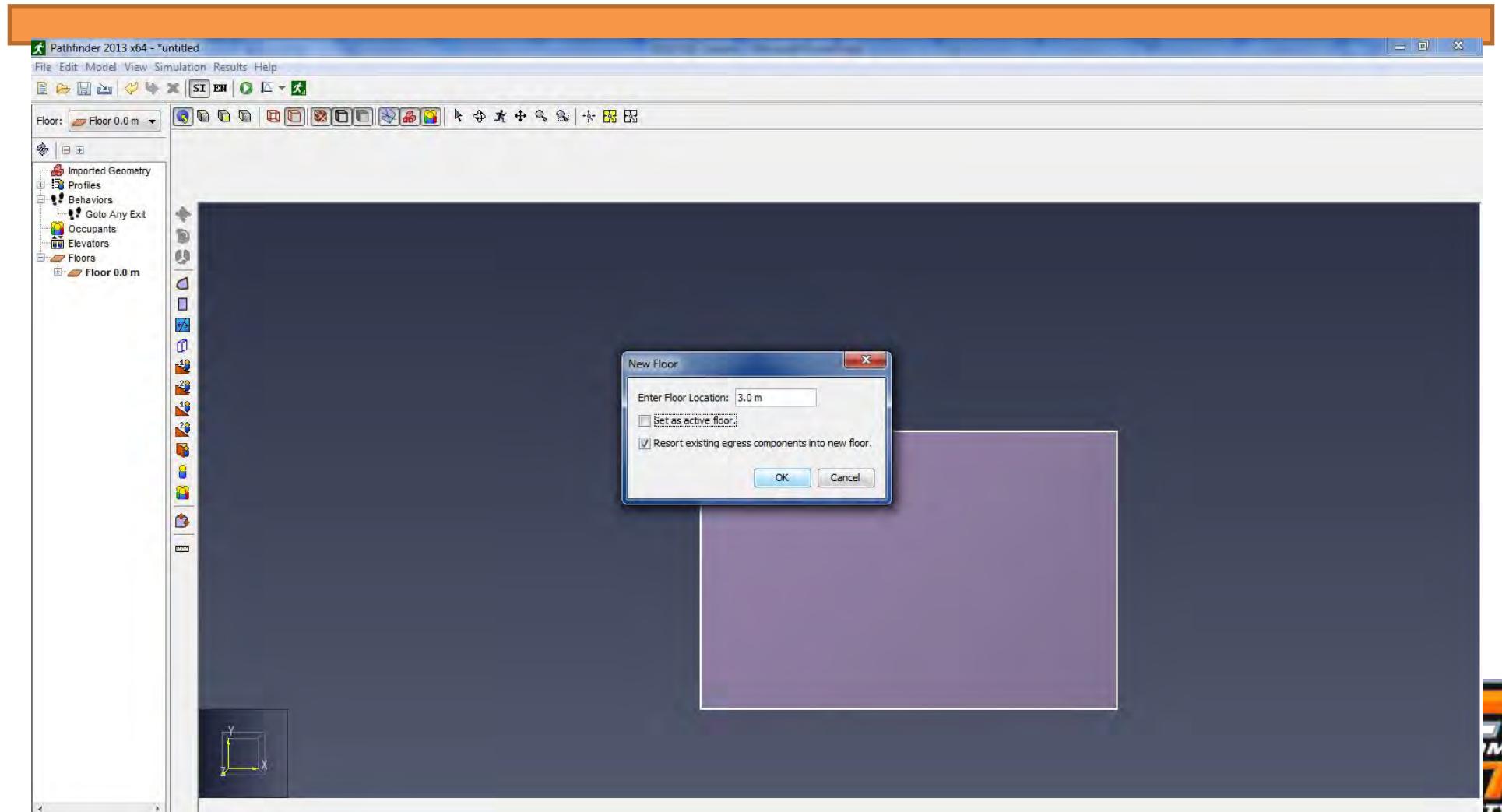


Pathfinder



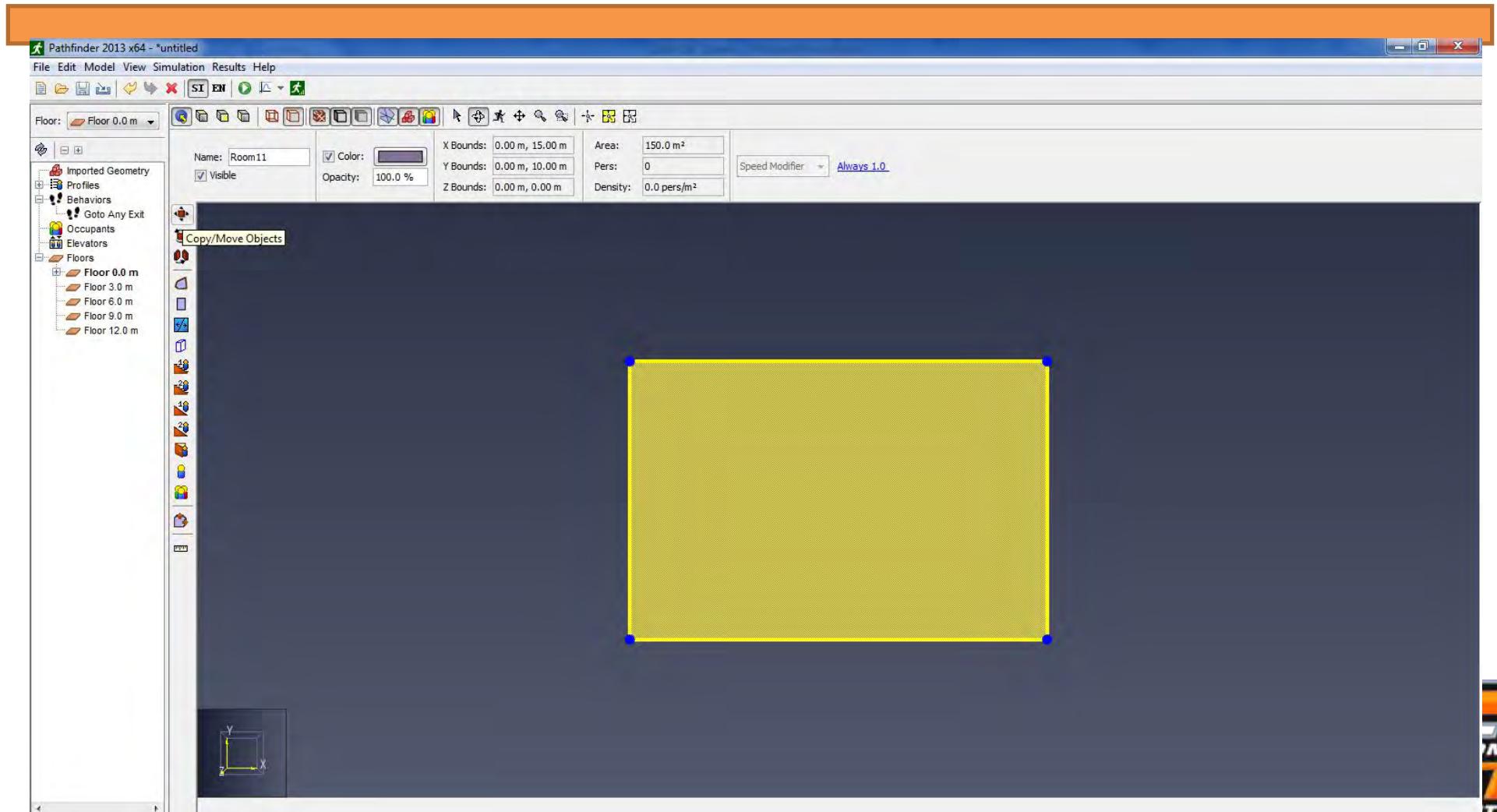
- Add new floors

Pathfinder



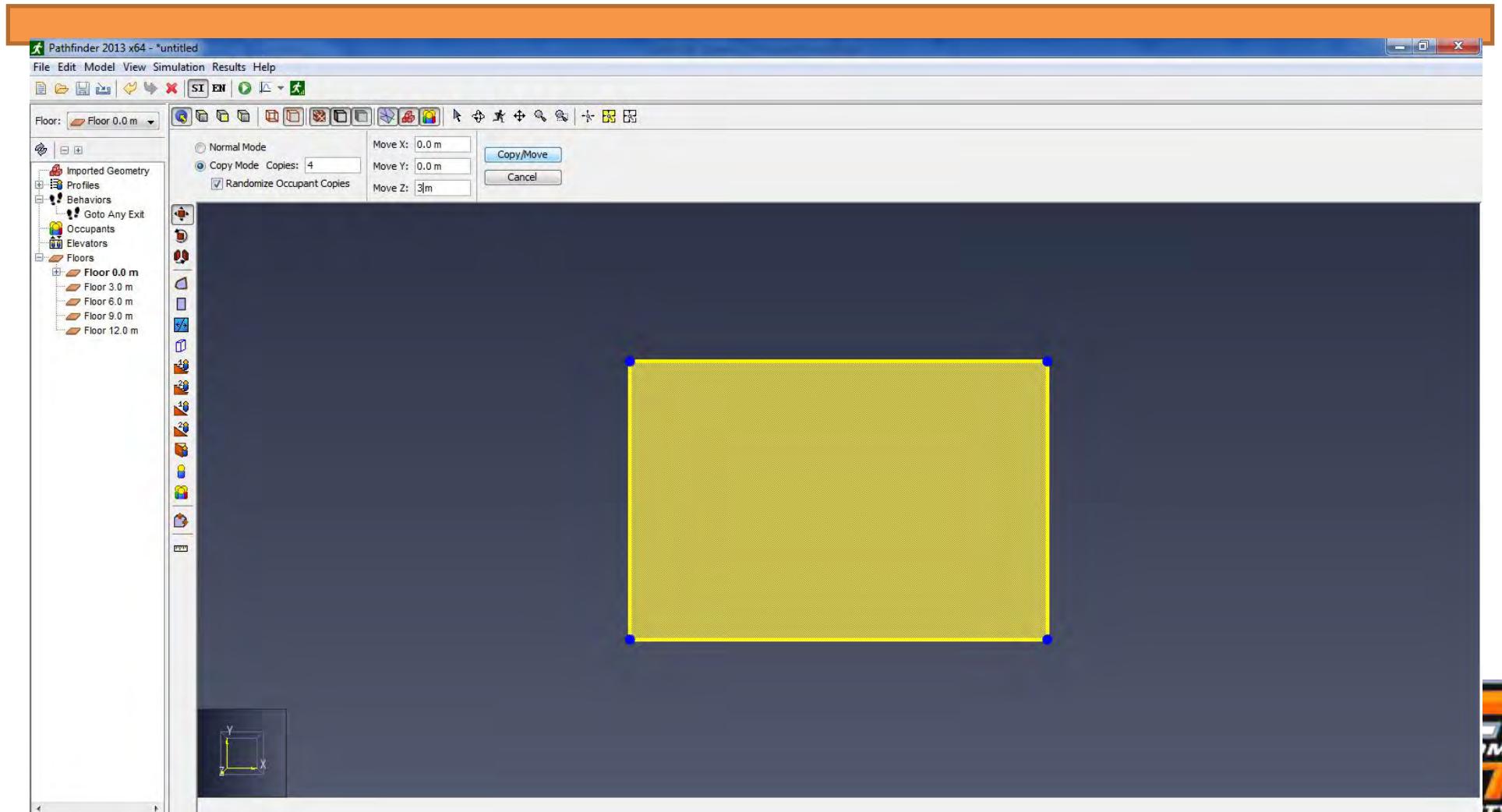
- 3 m between floors

Pathfinder



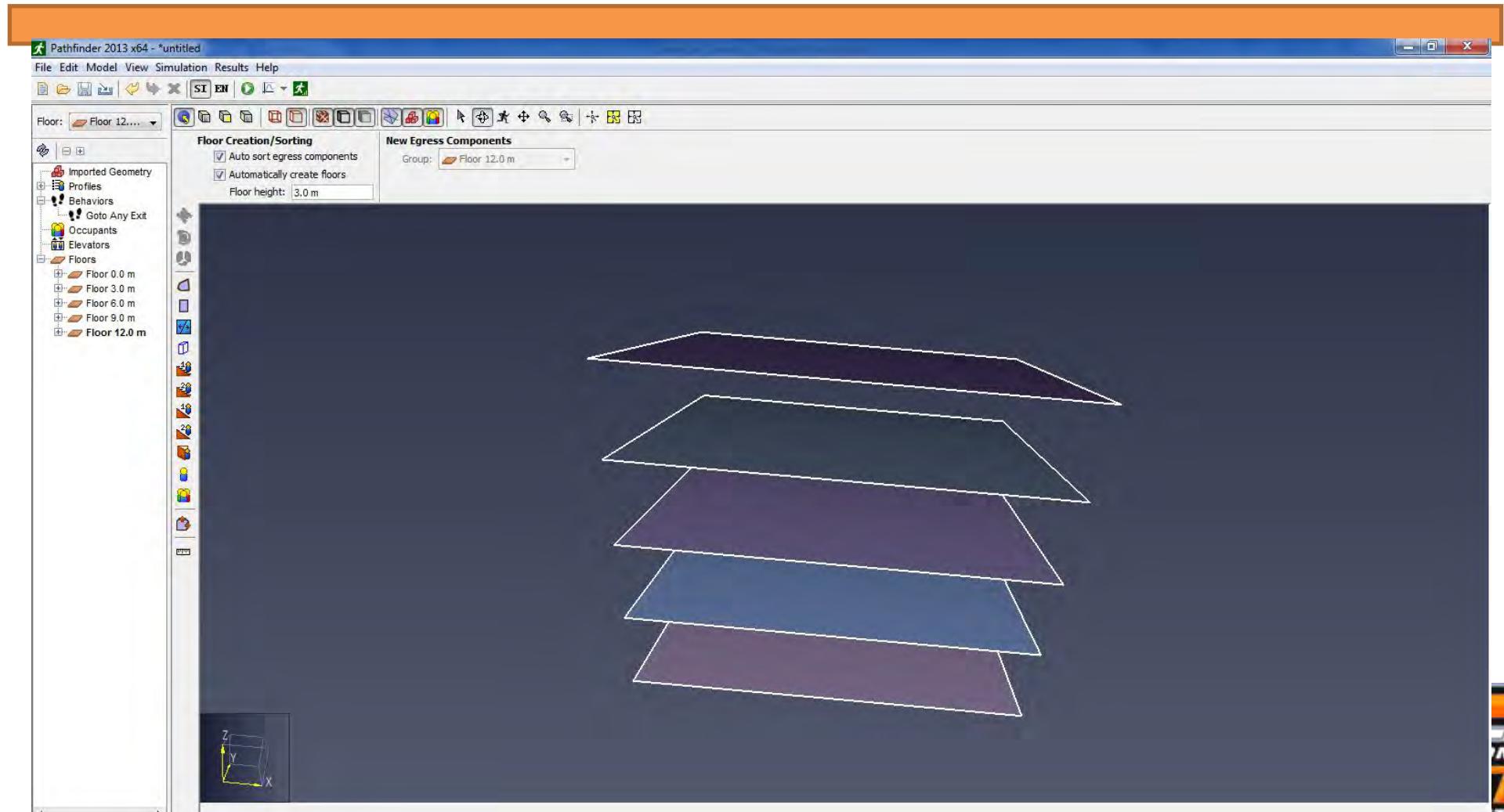
- Copy room to other floors

Pathfinder



- Four new rooms needed

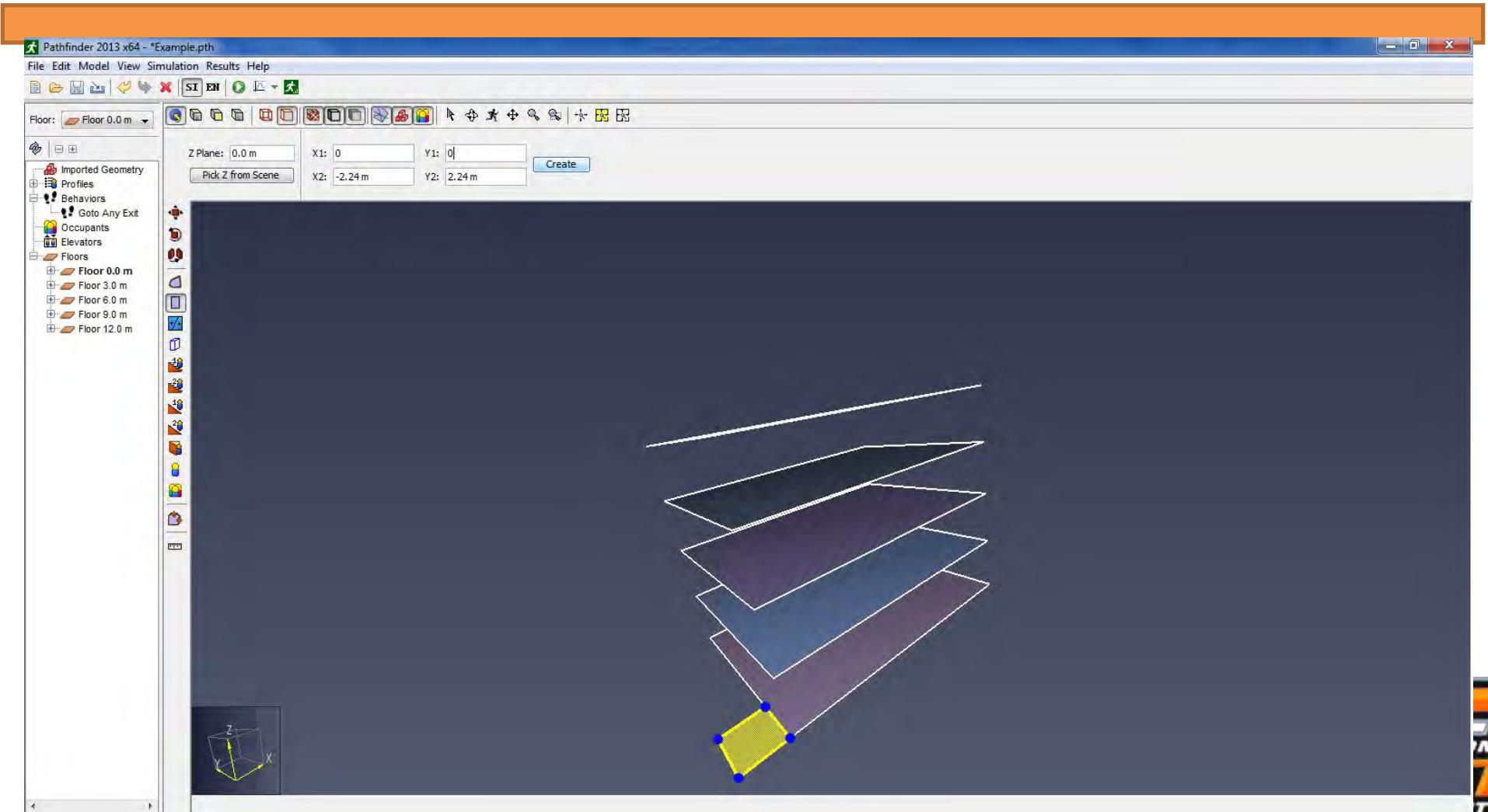
Pathfinder



- Rotate view to see all floors



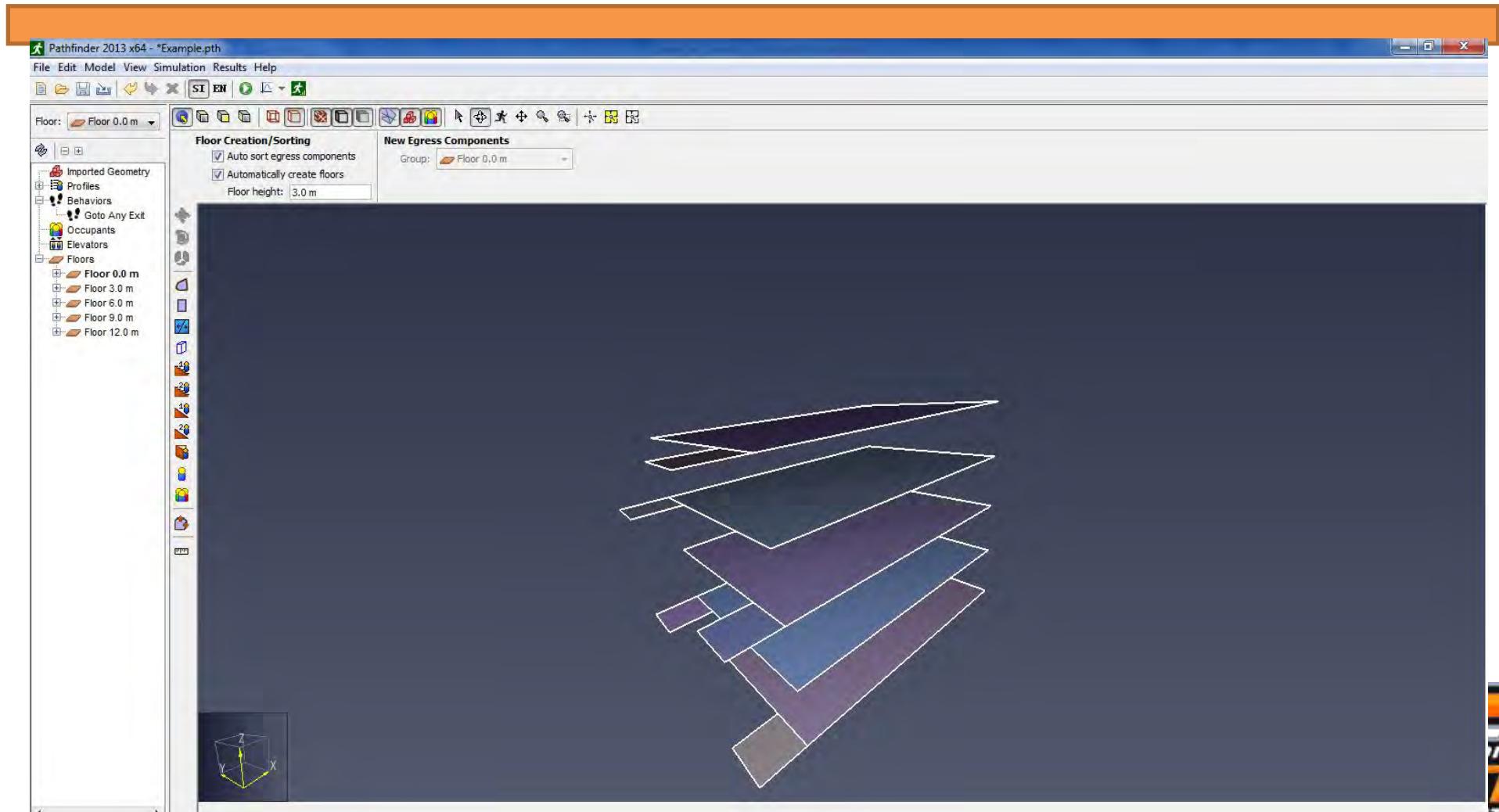
Pathfinder



- Add room for stairs

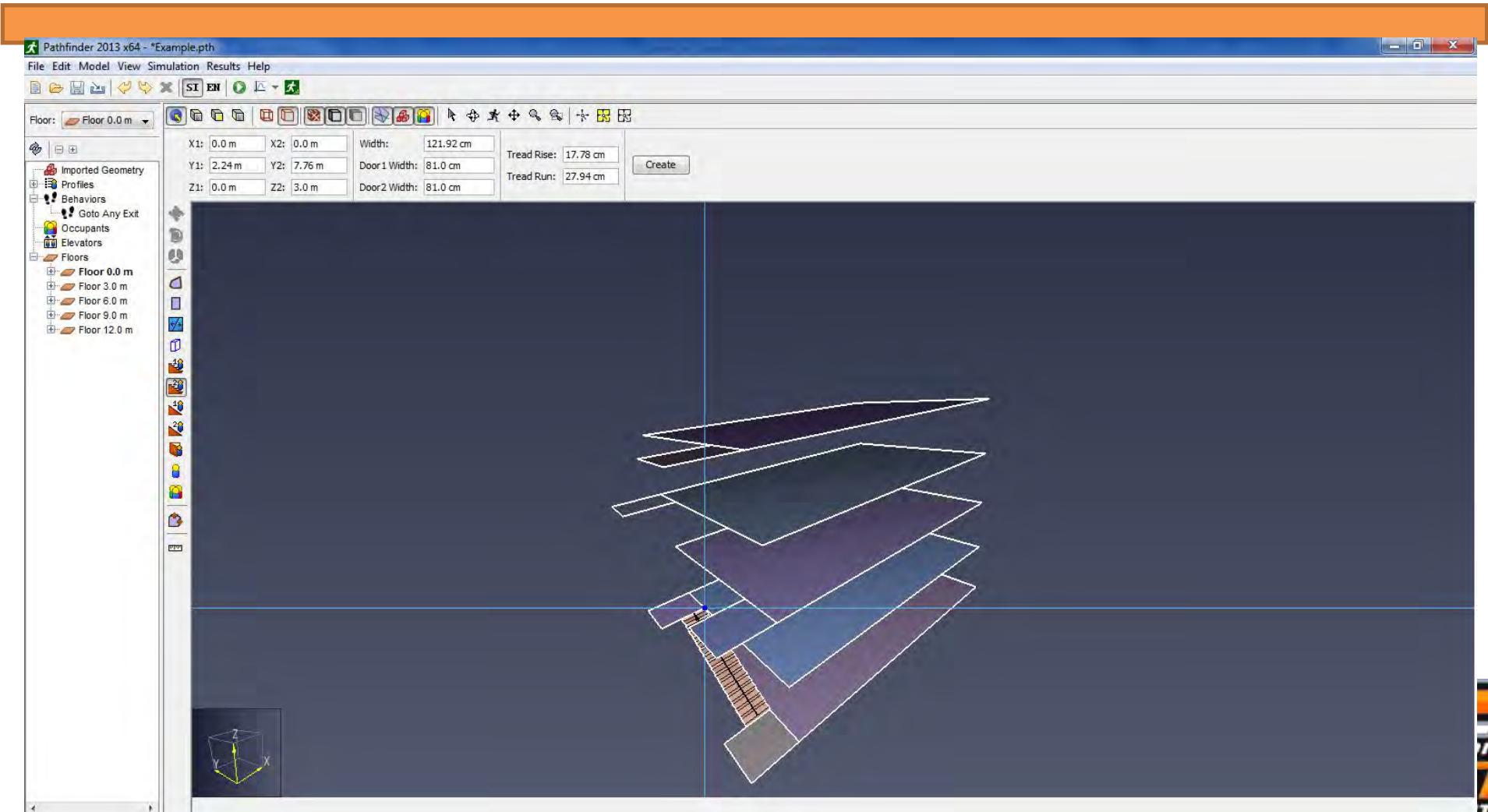


Pathfinder



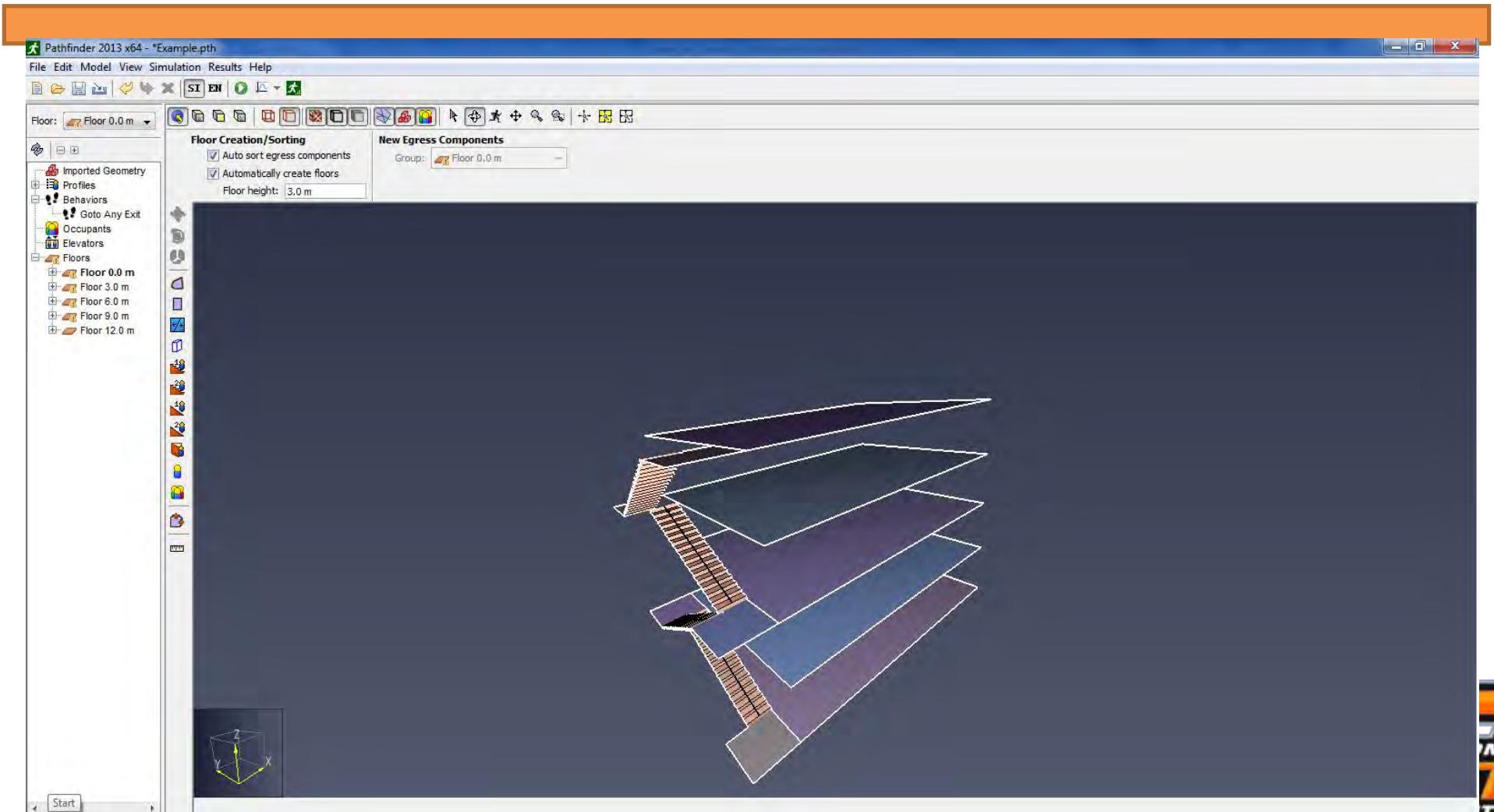
- Copy and move to other levels

Pathfinder



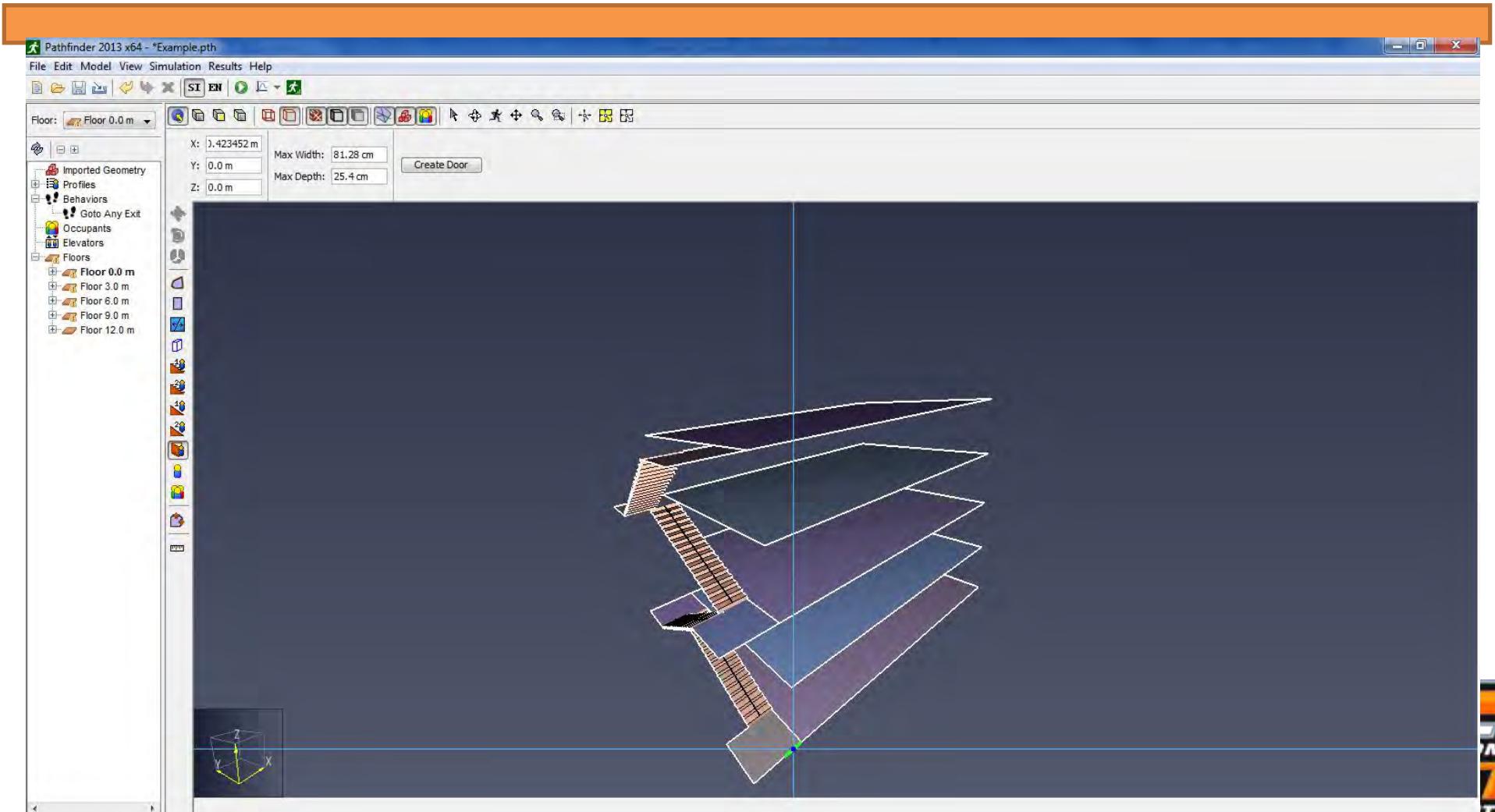
- Add stairs

Pathfinder



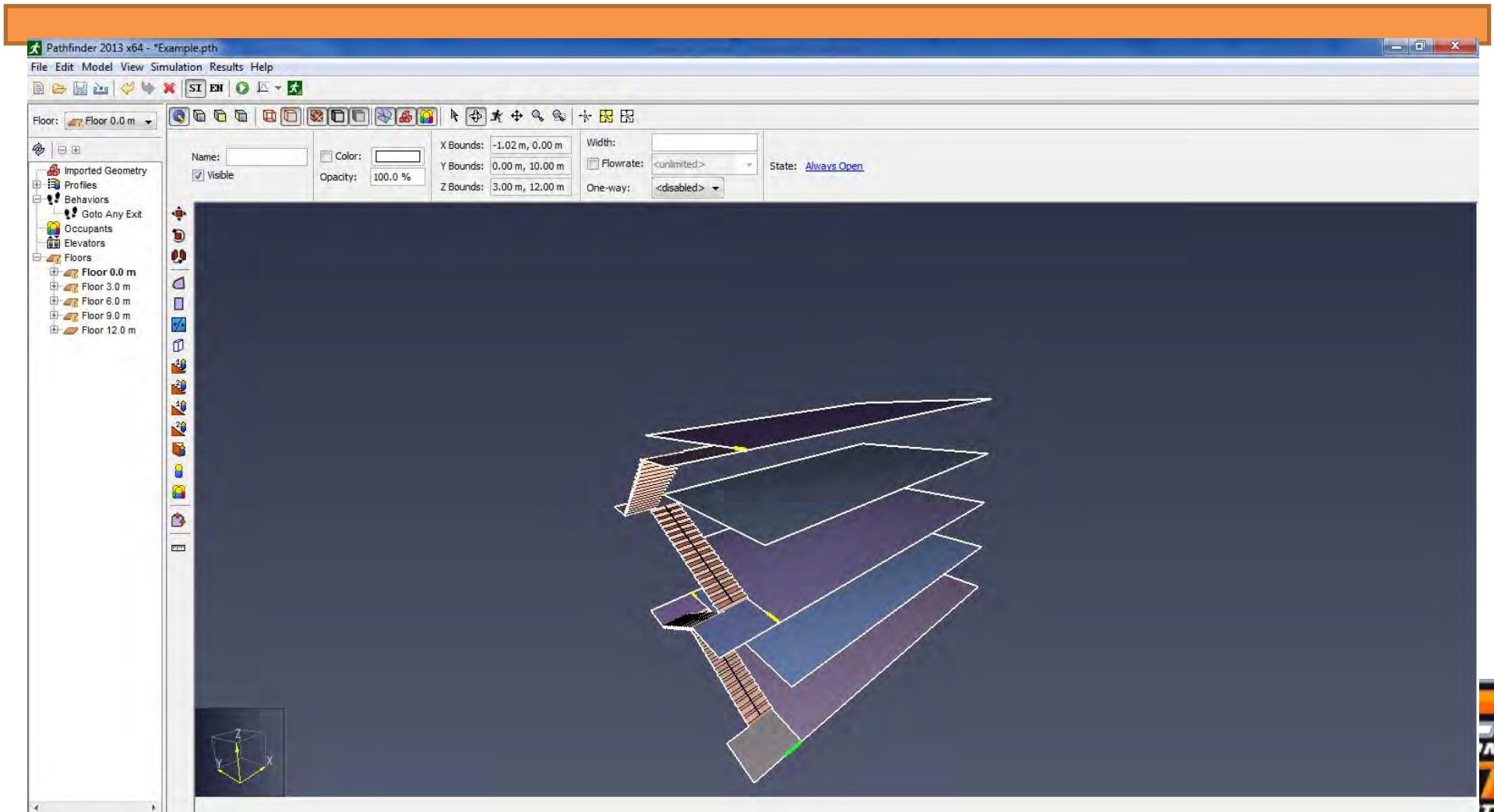
- Stairs connecting all floors

Pathfinder



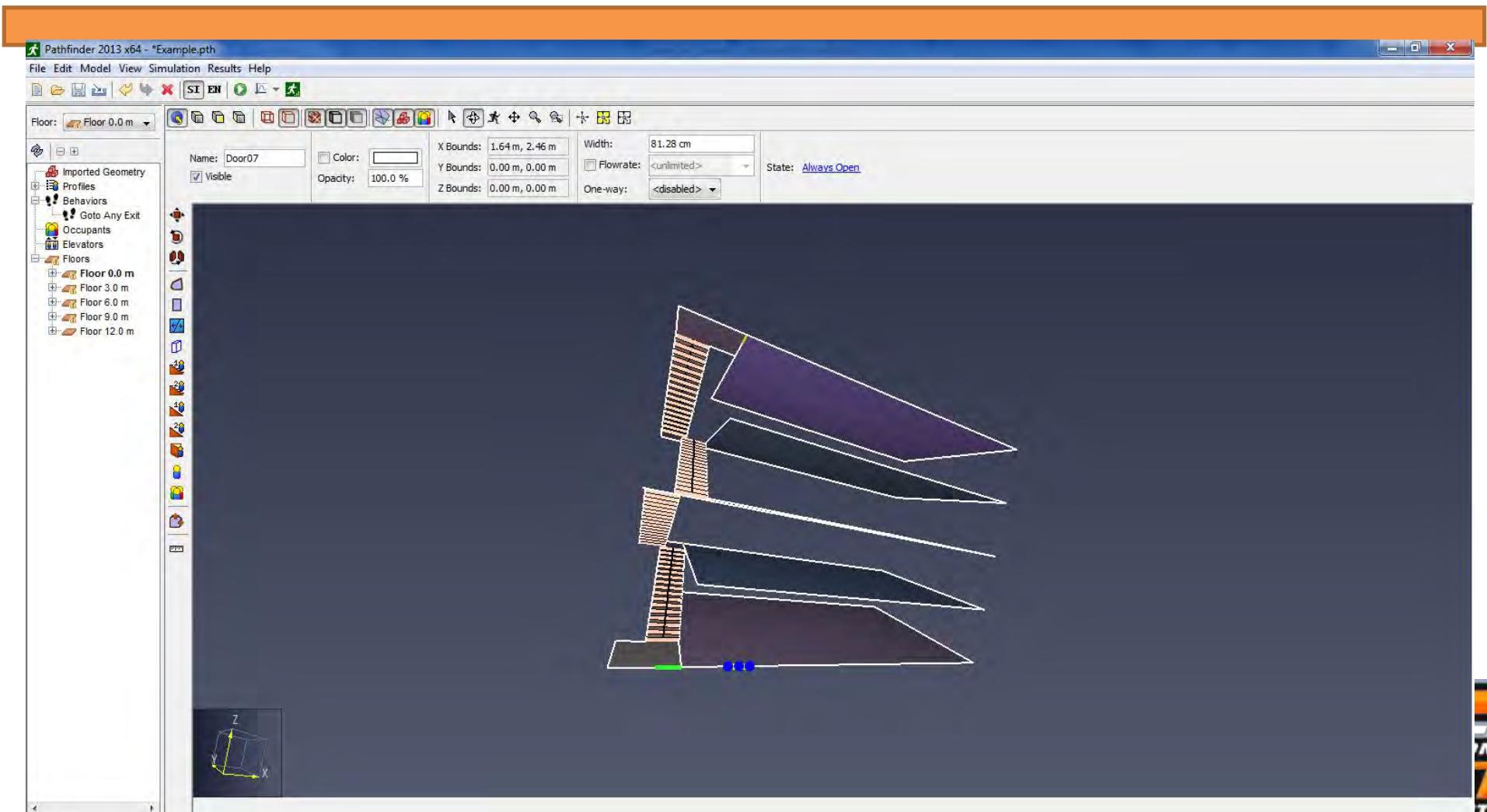
- Add exit door

Pathfinder



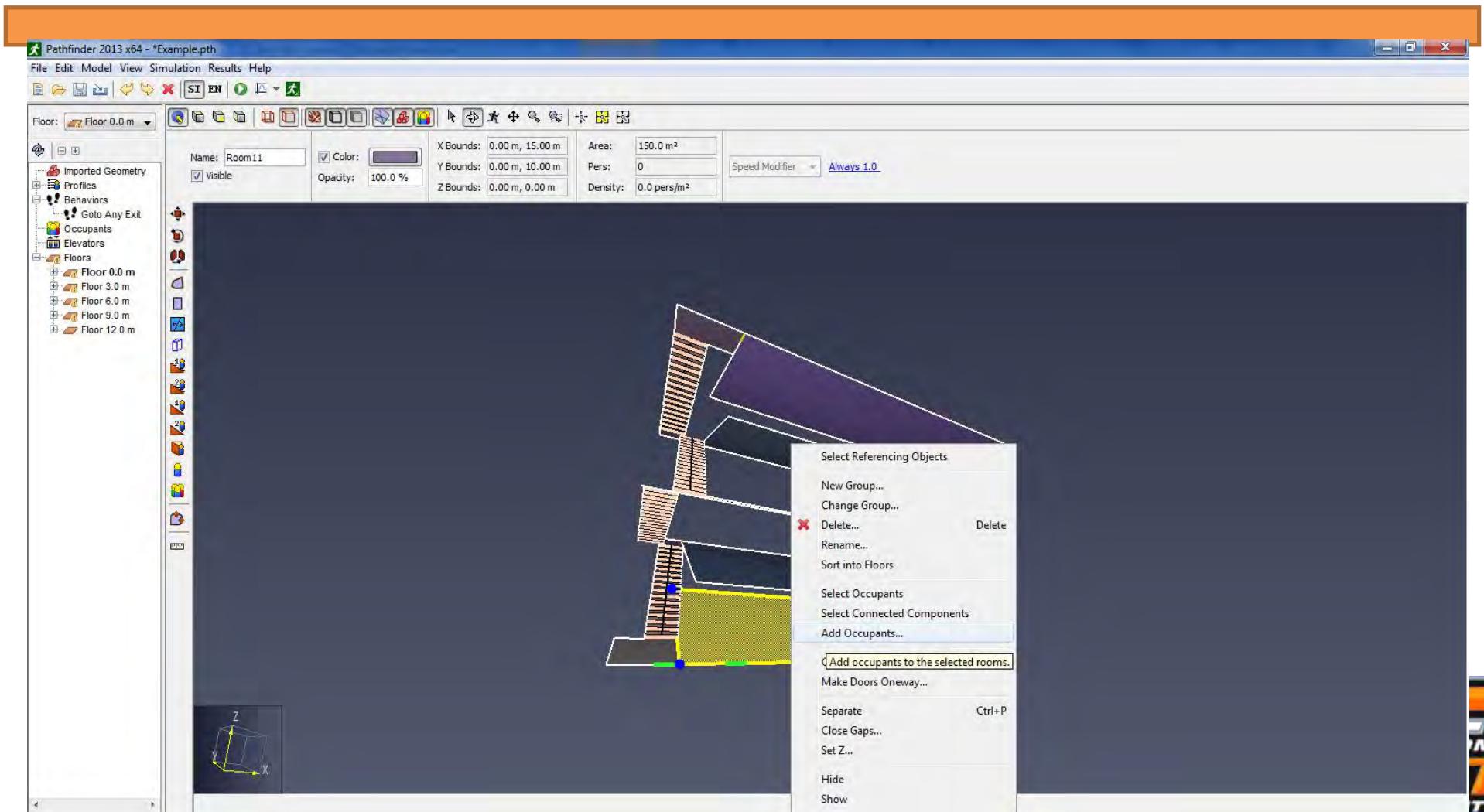
- Stair doors on other floors

Pathfinder



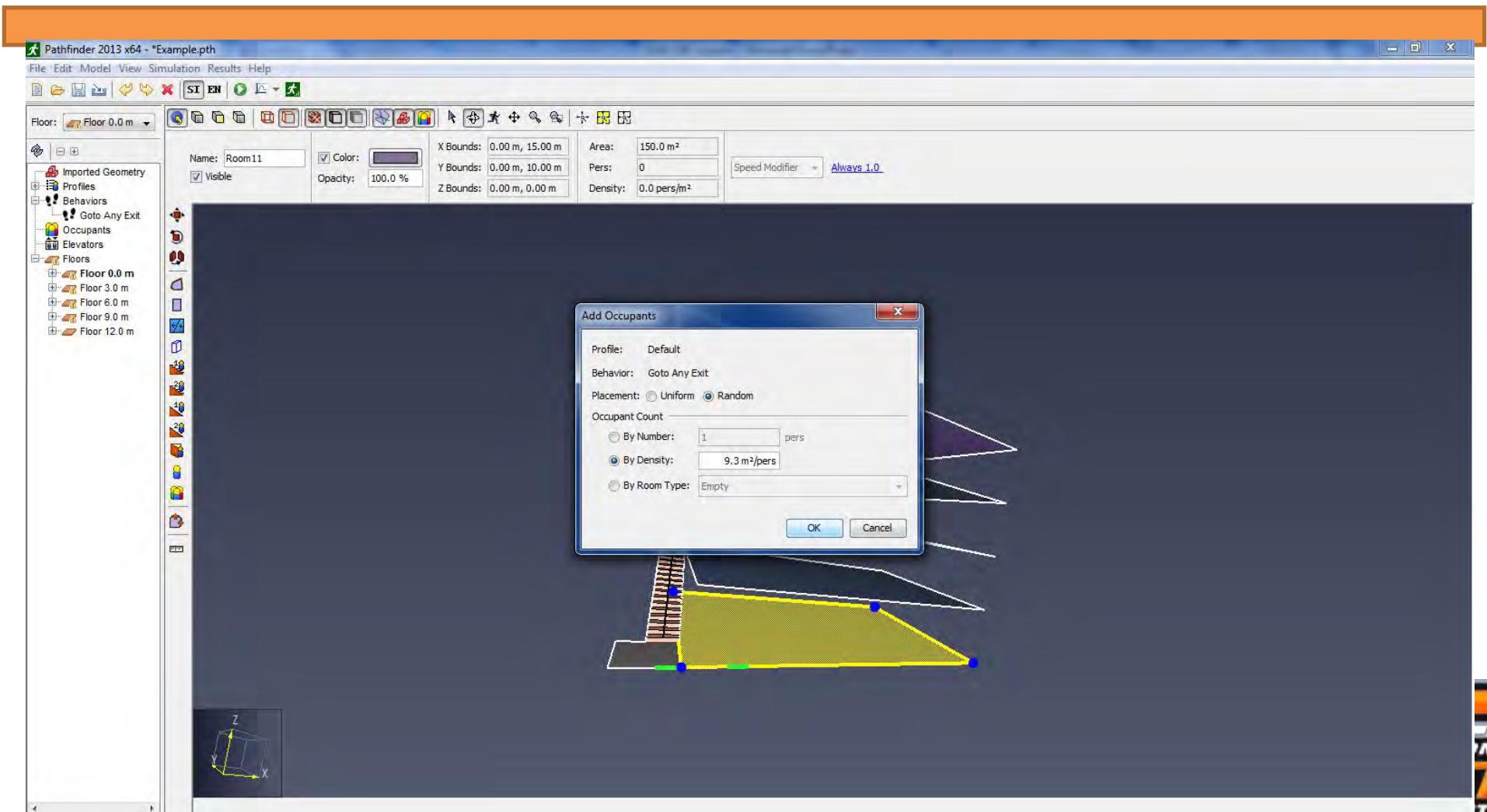
- Add exterior door

Pathfinder



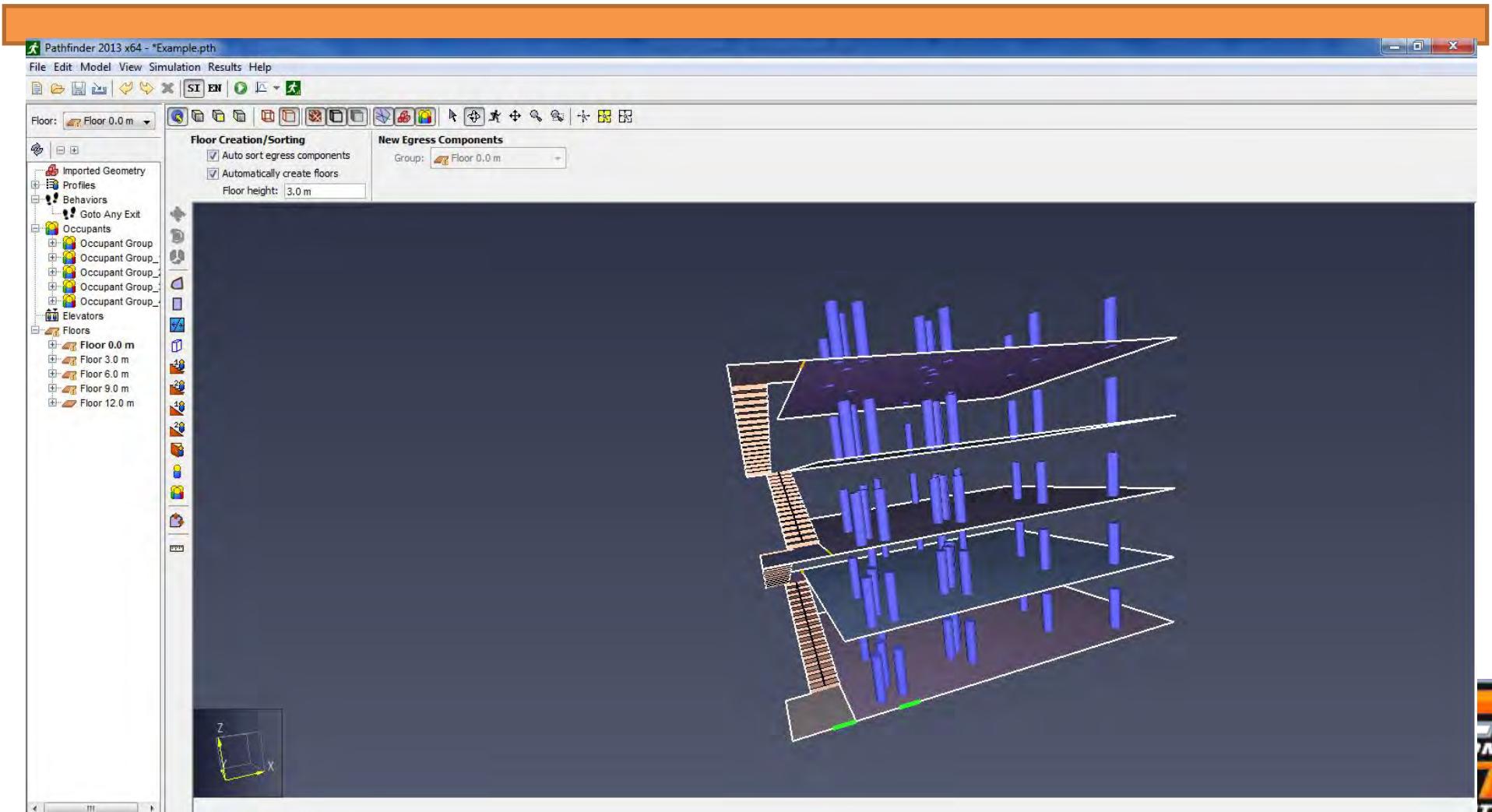
- Add occupants

Pathfinder



- Business

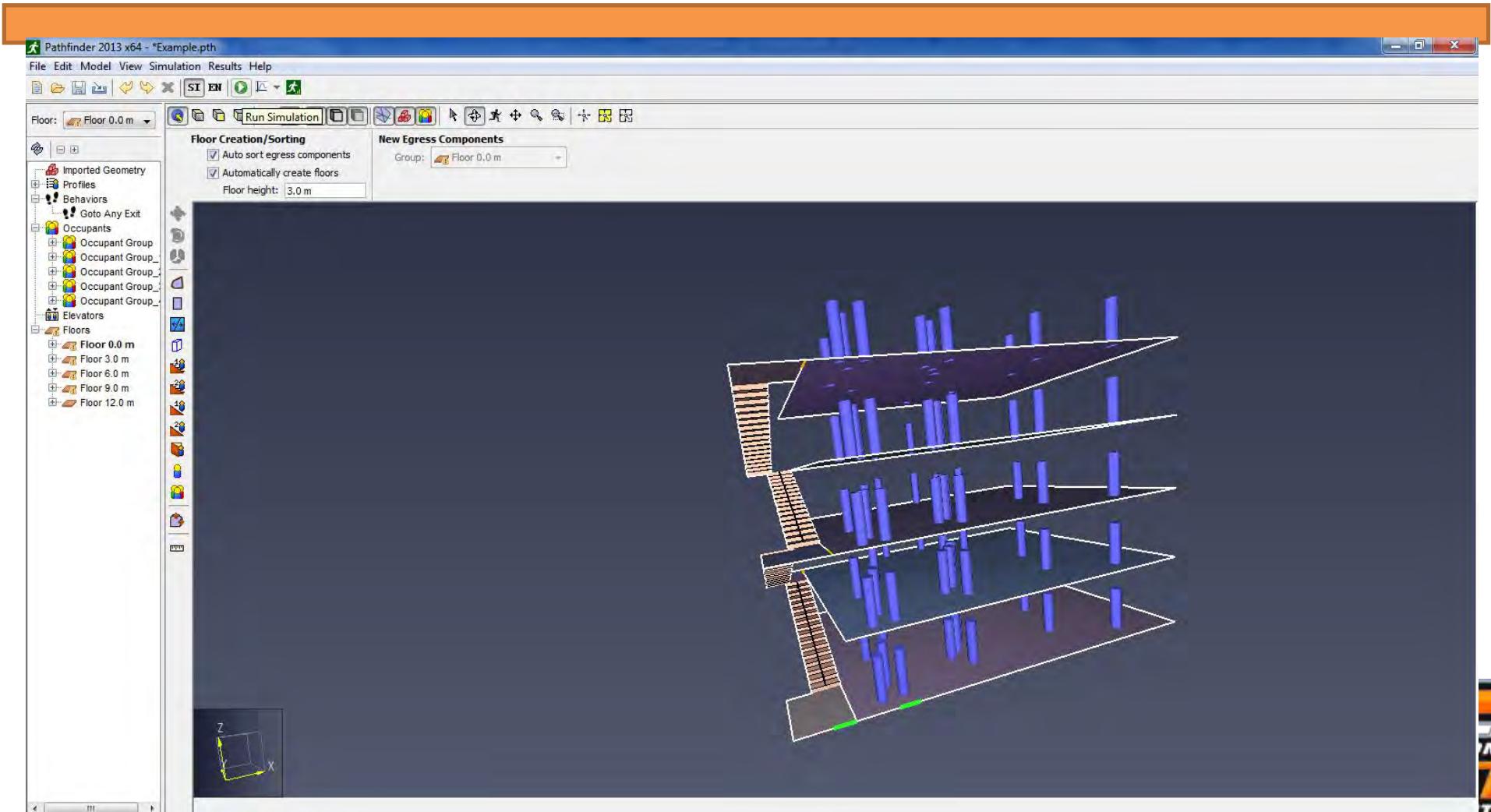
Pathfinder



- Put occupants on all floors



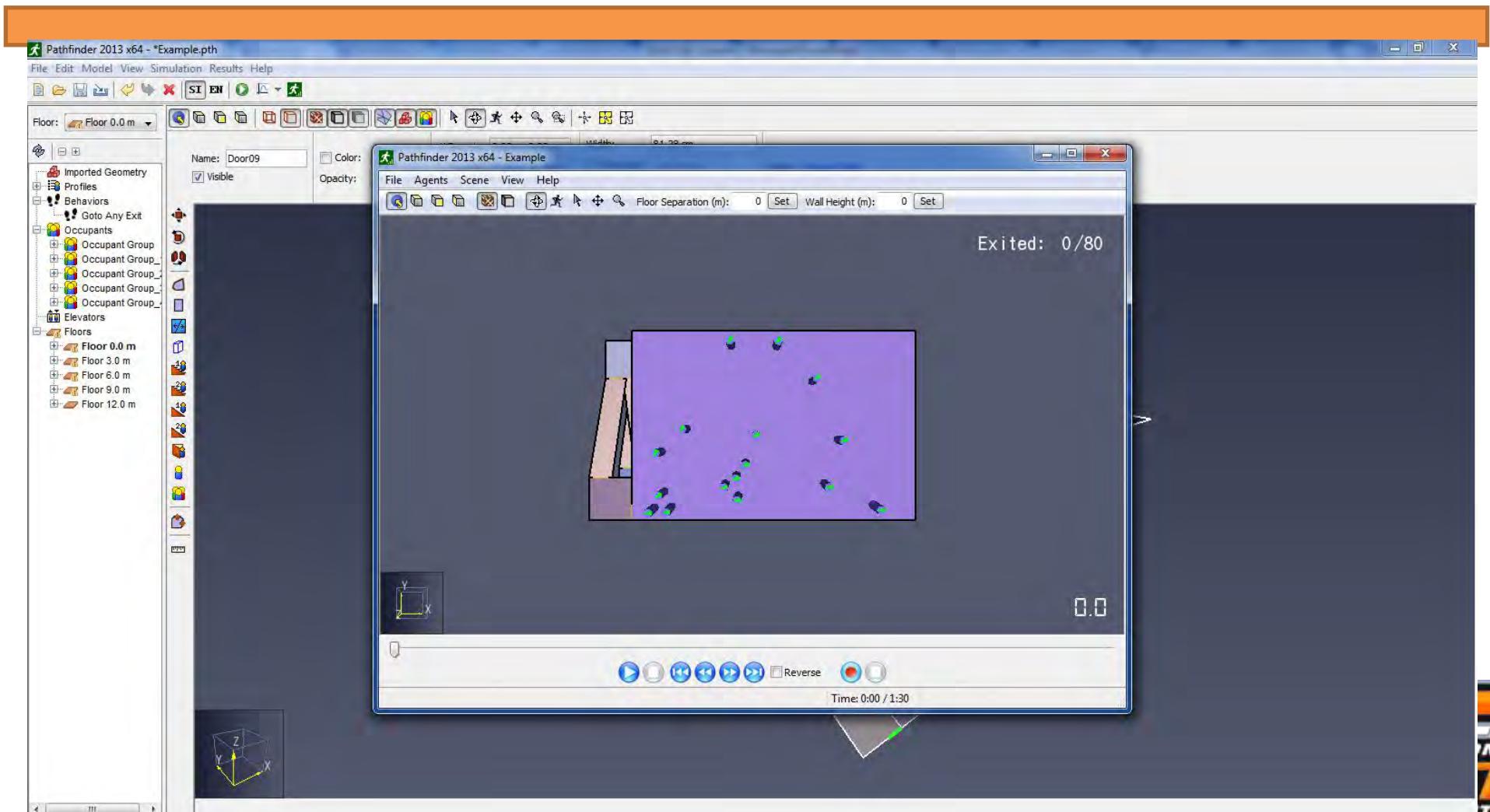
Pathfinder



- Run simulation



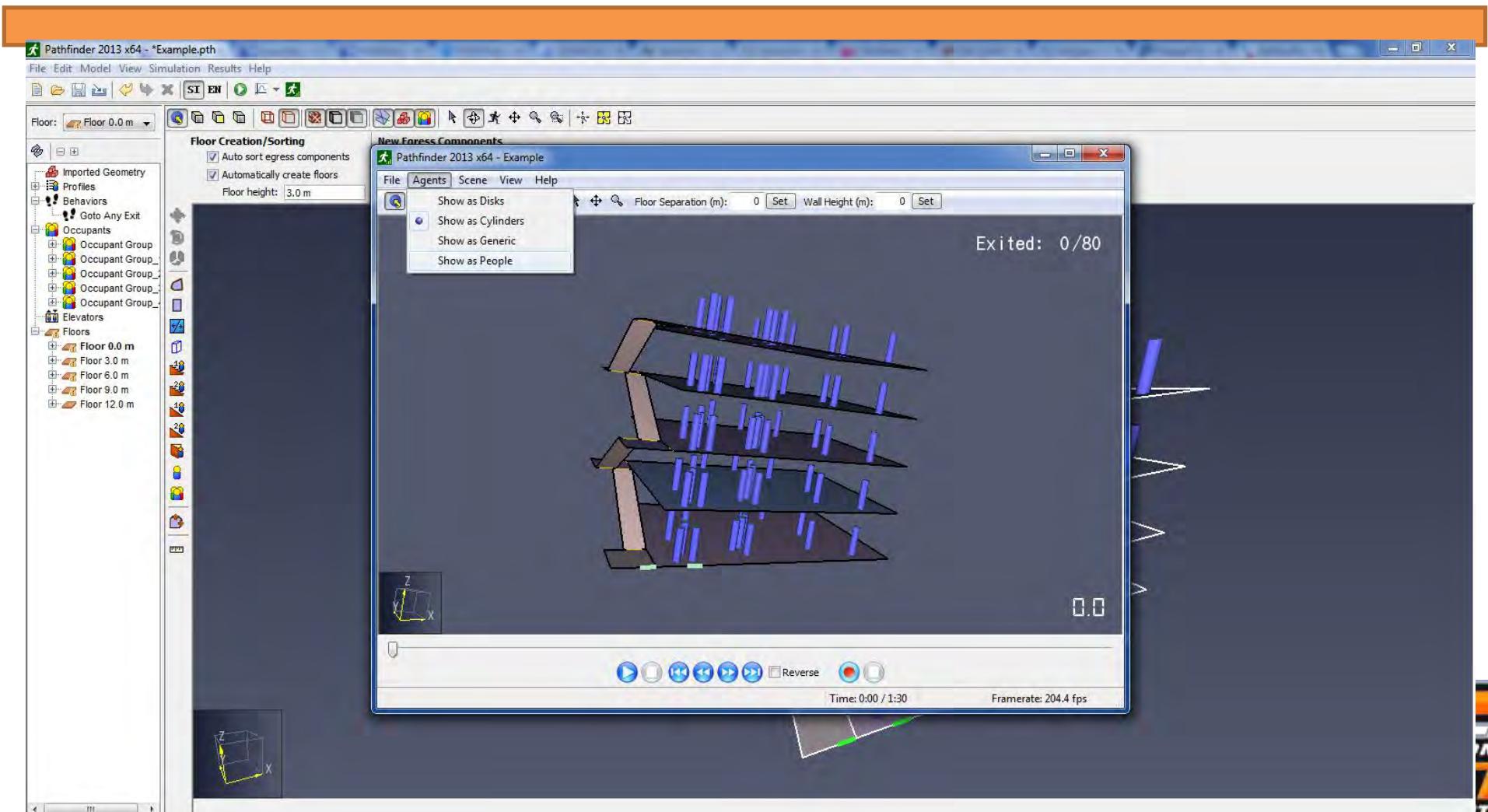
Pathfinder



- After following prompts, simulation runs and movie pops up
- Can rotate view



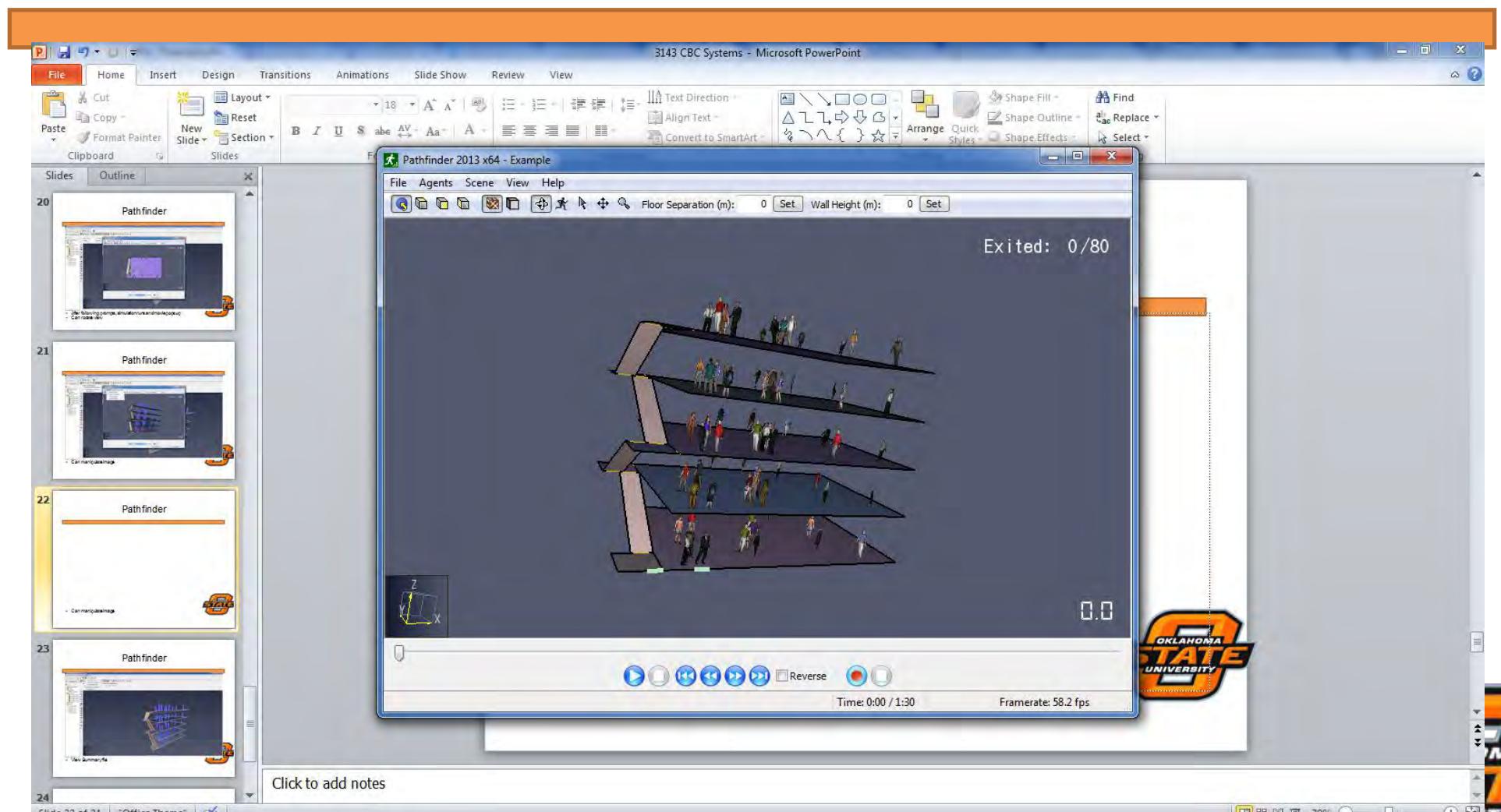
Pathfinder



- Can manipulate image

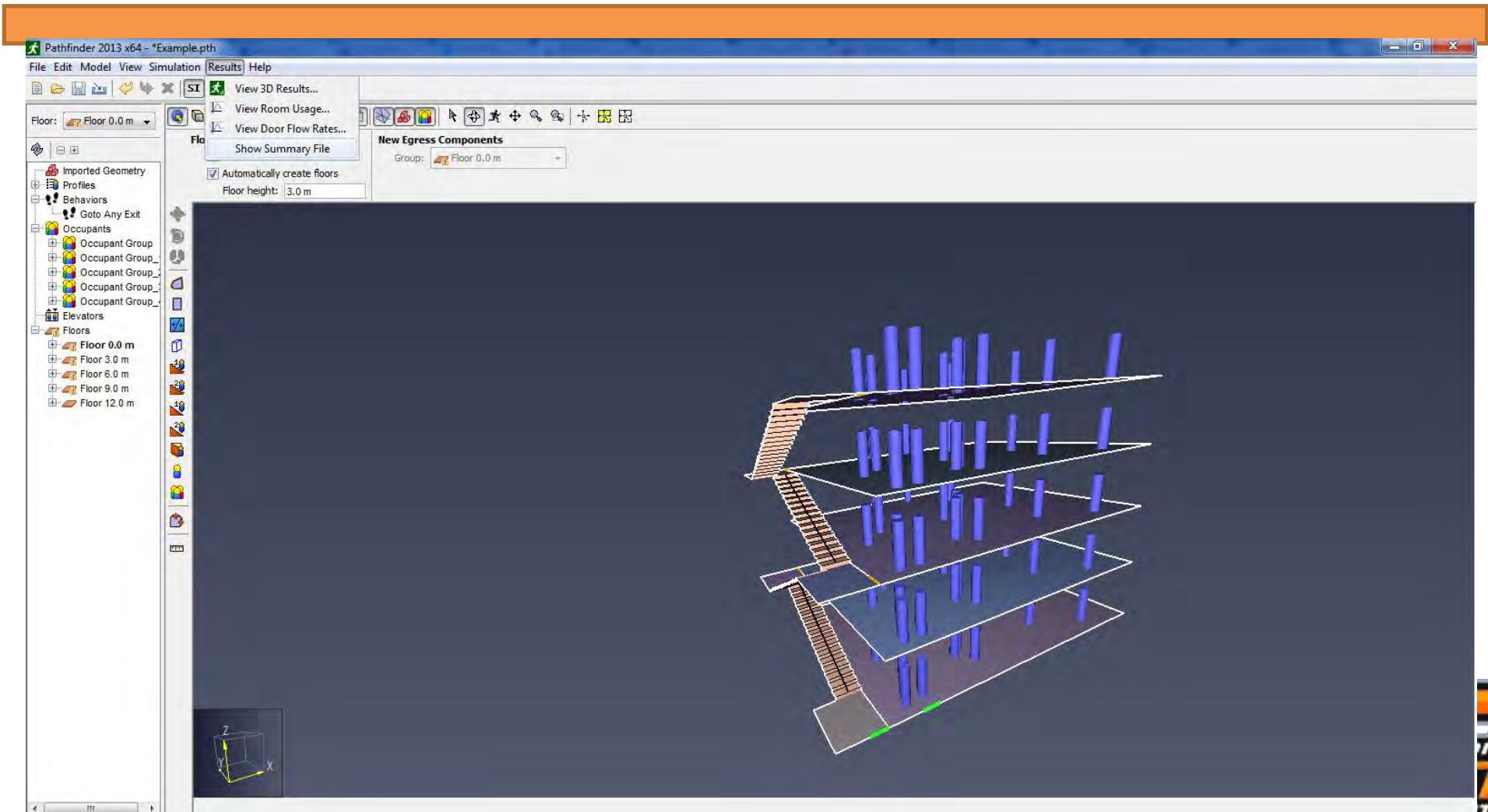


Pathfinder



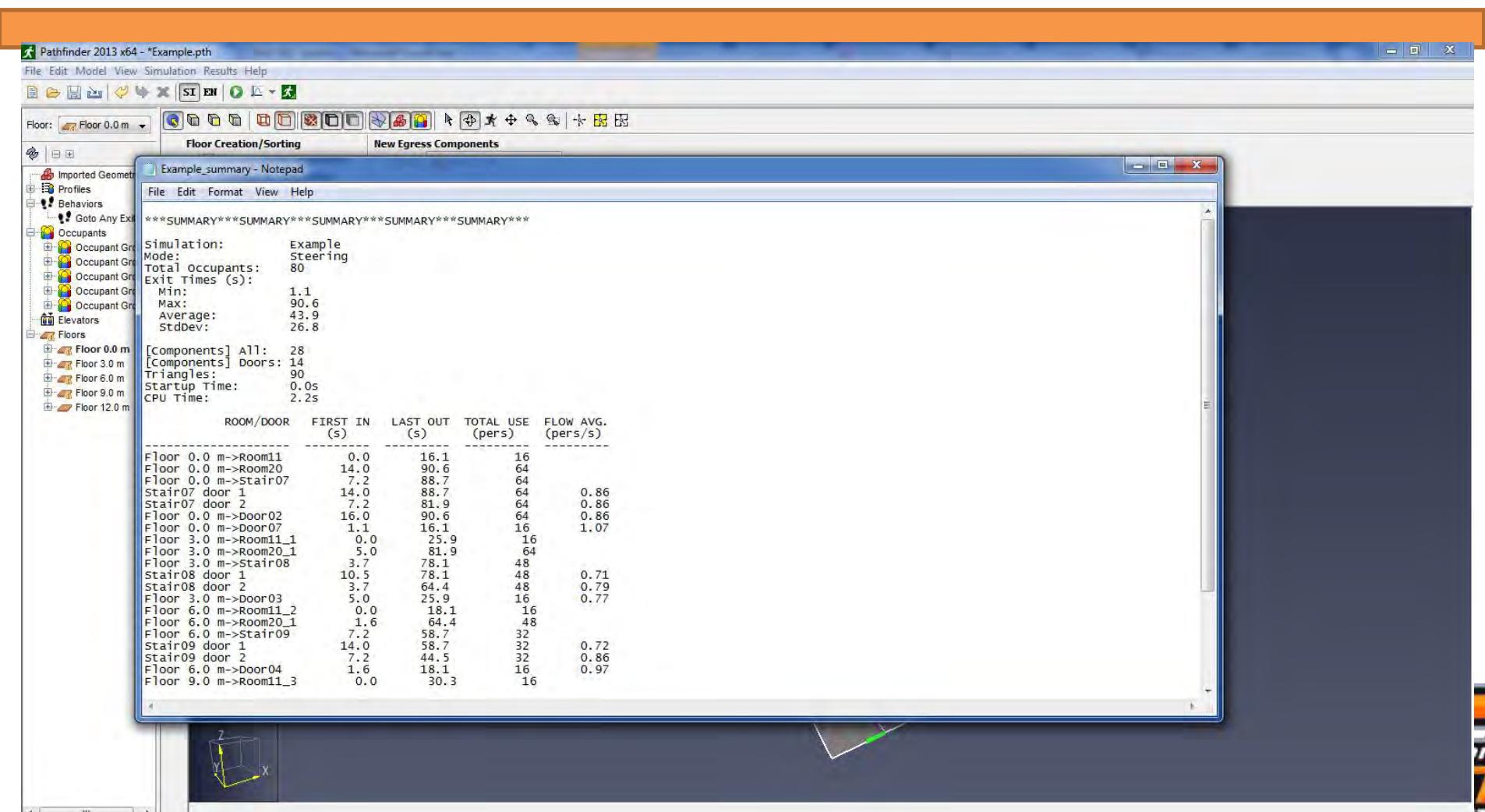
- Can manipulate image

Pathfinder



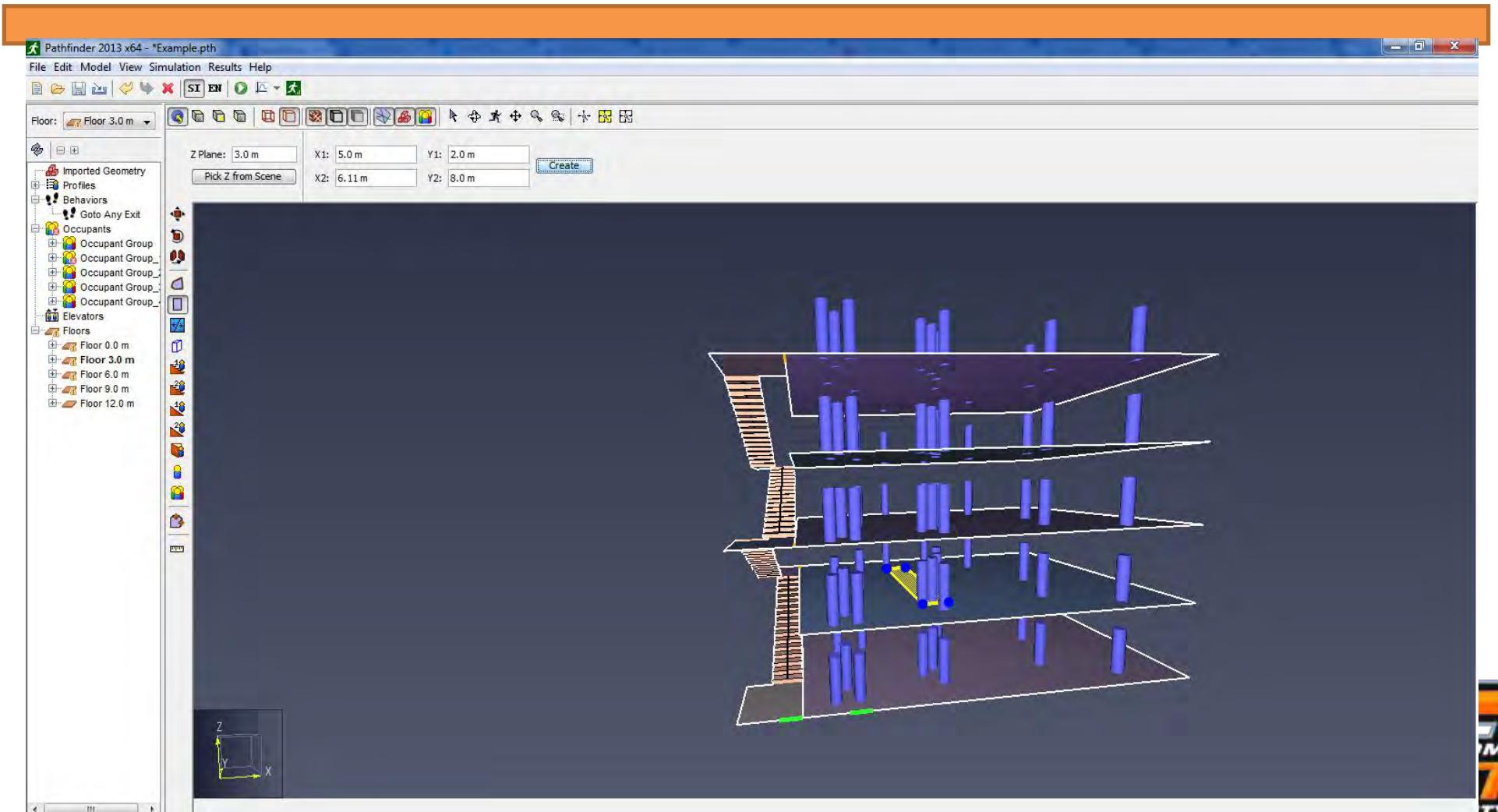
- View Summary file

Pathfinder



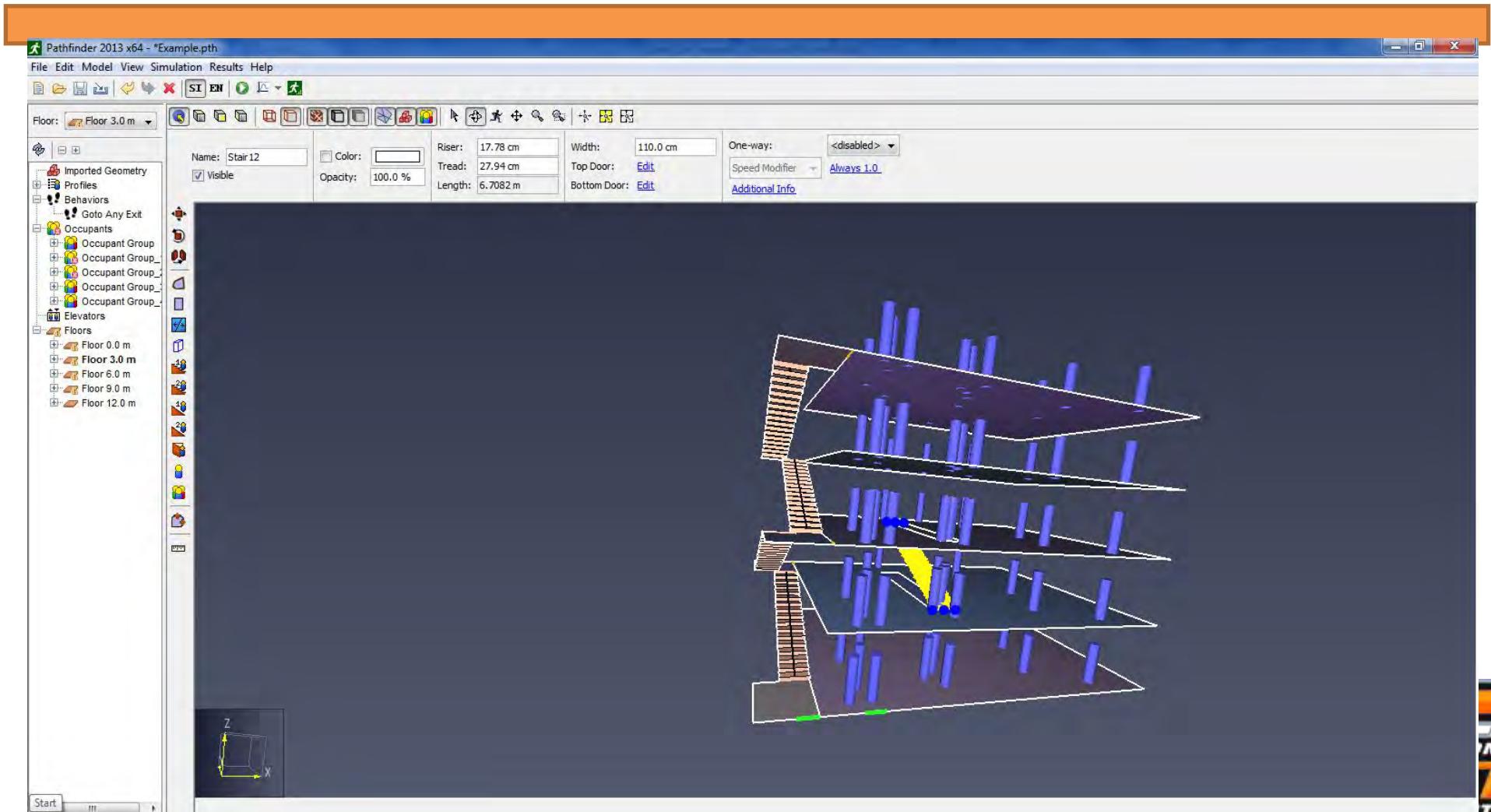
- Summary File

Pathfinder



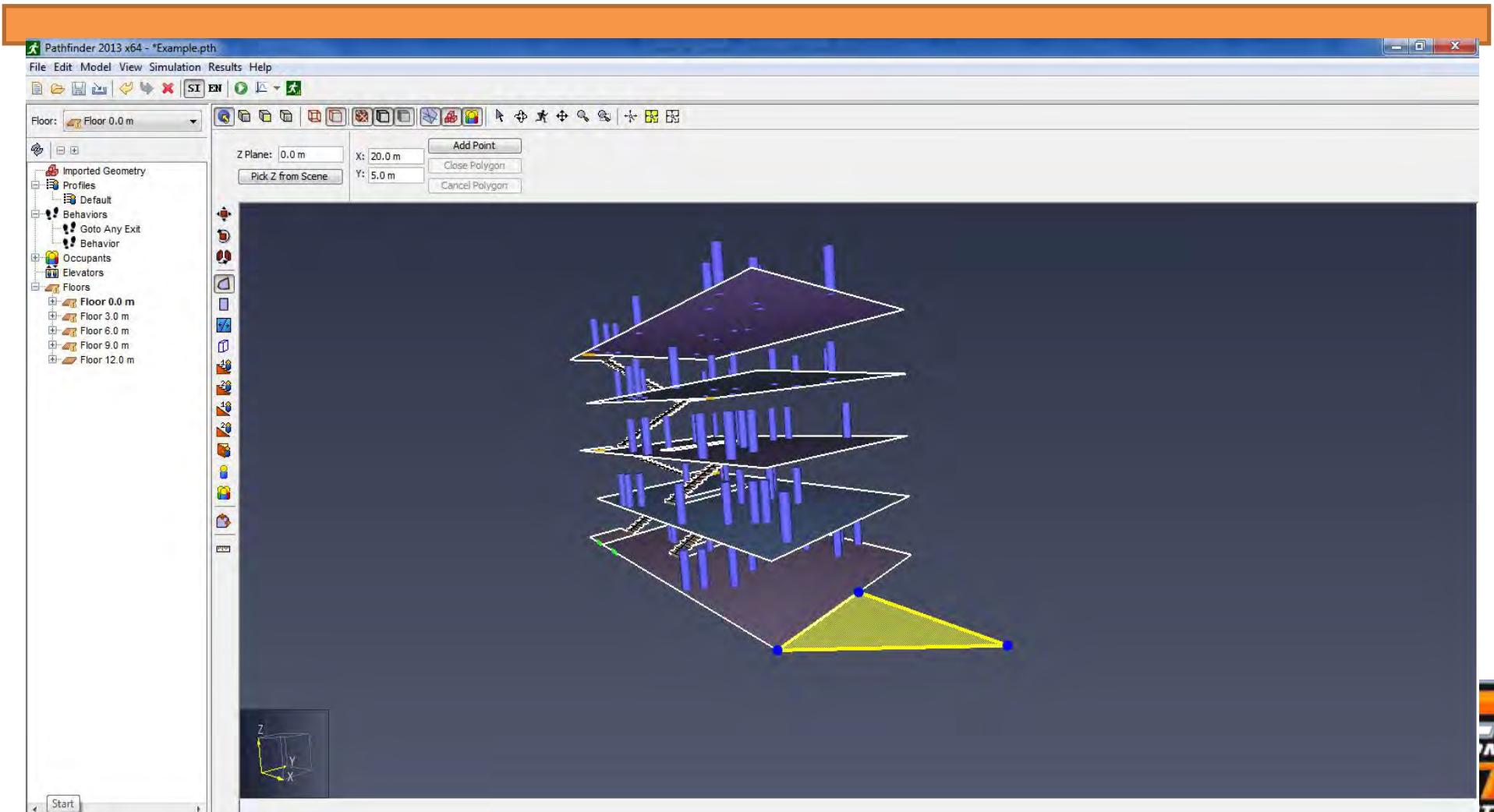
- Create hole by adding new room inside old room
- Copy to floor above
- Delete new rooms

Pathfinder



- Add stair

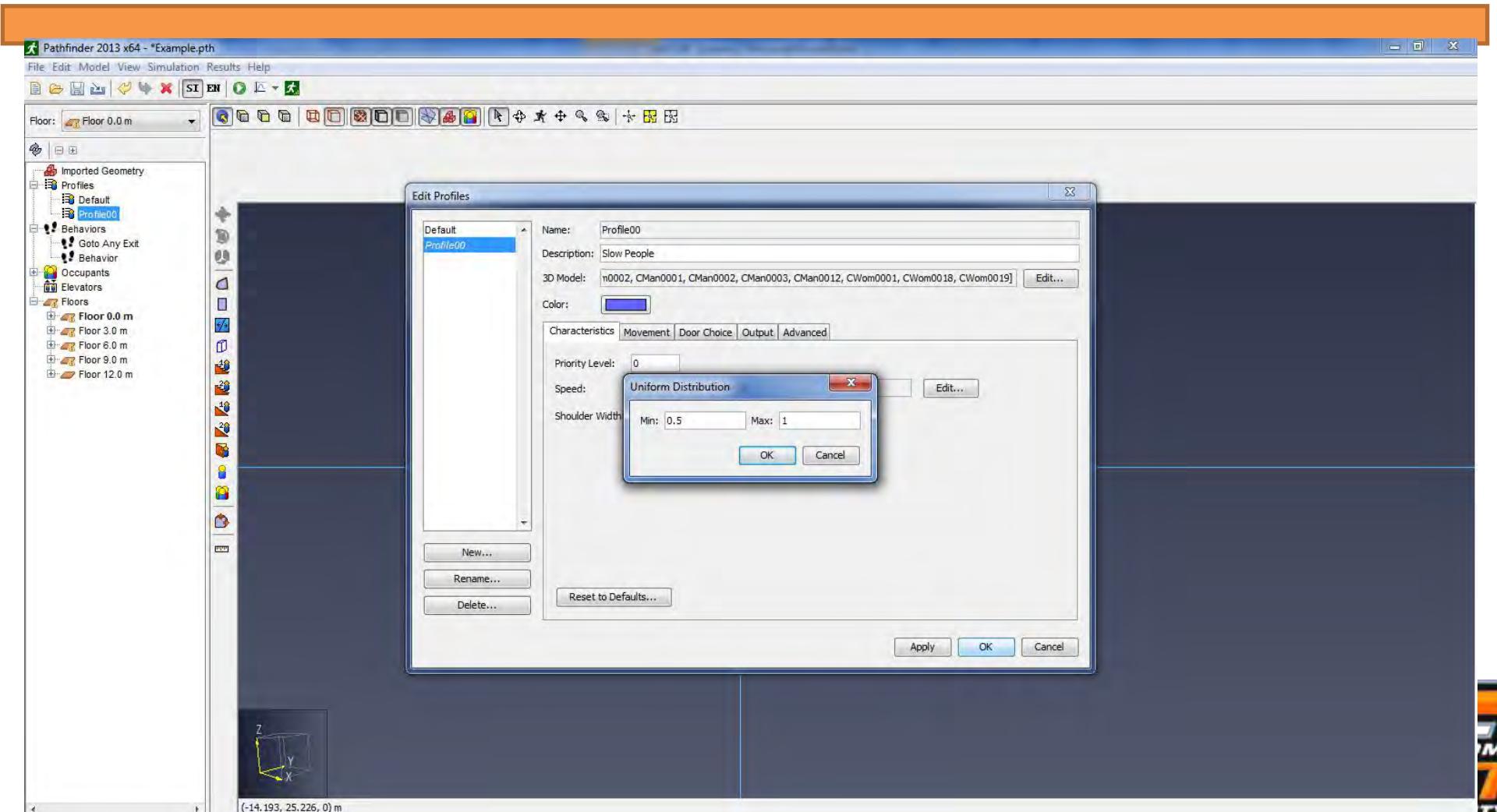
Pathfinder



- Create triangular room
 - 5 m base and height



Pathfinder



- Add in three occupants
- Make one slow moving
- Apply to selected occupants on each floor

Pathfinder

- Modifying occupants
 - Double click on profiles
- Individual occupants
 - Select one occupant
- Exit choice and pre-evacuation time
 - Double click on behaviors



Population Characteristics

- Identify factors that can influence a person's ability to evacuate
- Explain the impact of different population characteristics



Historic Fire

- Arundel Park



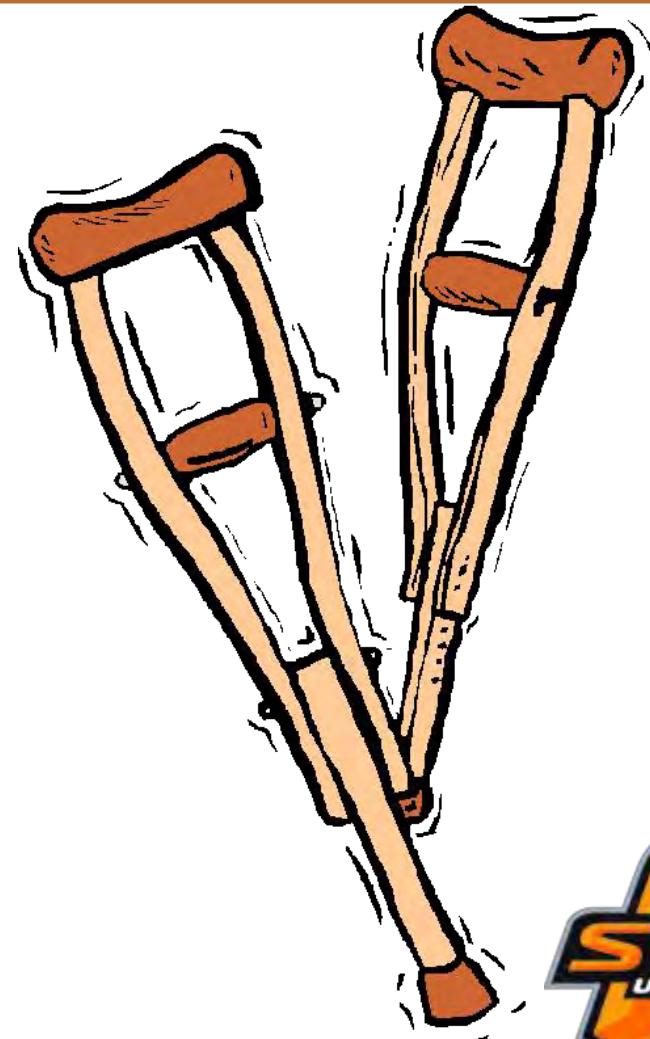
Occupant Characteristics

- Not all people are the same
 - Designs based off of “expected” population
 - Homogeneous? 基于“预期”人口的设计
 - Not always obvious which occupants are most at risk
- Number of people
 - Occupant load factors?
 - Crowded conditions more problematic
 - Locations of people



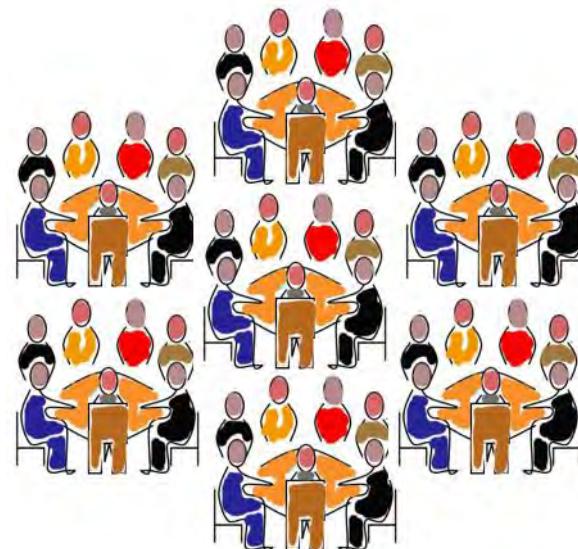
Factors

- Alertness
 - Sleep
 - Drugs/alcohol/medication
- Physical and cognitive ability
 - Poor understanding
 - Temporary condition
 - Permanent condition
 - Different impact of effluent
 - Notification
 - Movement



Factors

- Social affiliation
 - Seek out others
 - Move at speed of slowest member
 - Impact flow
- Role and responsibility
 - Staff
 - Activities other than evacuation
- Previous experience



Factors

- Commitment
 - Inattentional blindness/deafness
 - Refusal to leave task
- Focal point
 - Inattentional blindness/deafness
 - Beneficial use



Factors

- Gender
 - Actions
 - Movement speeds
- Culture
 - Societal
 - Individual
- Age
 - Movement speeds
 - Sensory skills
 - Decision making
 - Impact of effluent



Factors

- Familiarity
- External
 - Weather
 - Egress systems
 - Light
 - Noise



Personal Characteristics

- Age
- Gender
- Pre-evacuation
- Body size
- Perception
- Knowledge
- Experience
- Notification



Mobility

流动性

- Disabilities
- Encumbrances
- Clothing
- Fatigue
- Groups



Position Factors

- Density
- Exit lanes



Interactions

- Merging
- Passing
- Counterflow
- Congestion

合并
经过
逆流
拥塞



Cultural Significance

- Explain how building design should change based on the expected occupants
- Identify code requirements that are culturally dependent



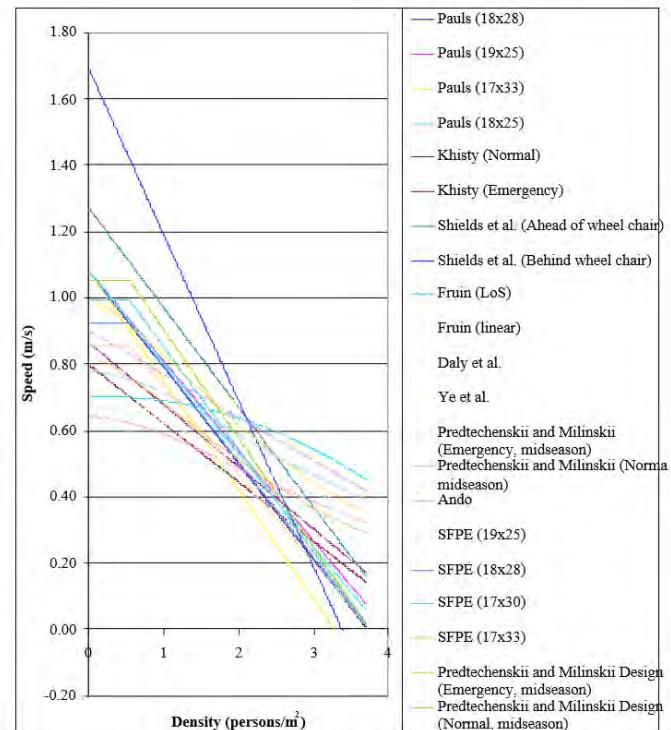
Historic Fire

- Notre Dame



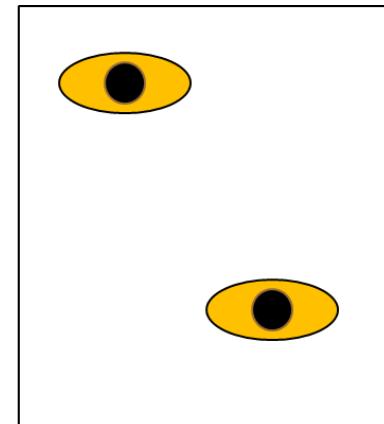
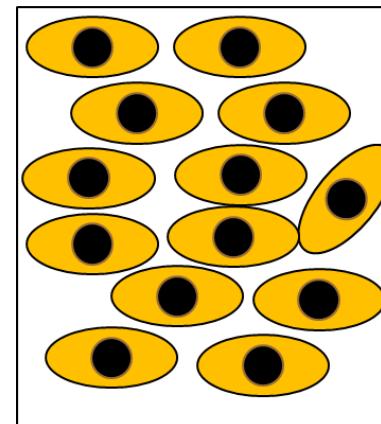
Underlying Assumptions

- Data primarily from relatively few locations
- Significant variation



Underlying Assumptions

- Density drives flow
- At lowest levels people free to choose own speed
- Spacing is culturally dependent



Building Codes

- Use factors
 - Determined based on observations of actual buildings
 - Change with time
- Spiral stairs
 - NFPA 5000: Spiral stairs shall turn such that descending users have the outer handrail on their right side



Societal Norms

- Gender
 - Some studies found differences in movement speeds, others have not
 - Potential correlation to clothing
 - Interpersonal spacing
- Passing and merging
 - Deference behavior
- Exit choice



Fire Experience

- Project BeSeCu
 - Library evacuations from multiple European countries
 - Statistically different results



Fire Experience

- Differences in fire safety training in schools- sometimes within country
- Differences in pre-evacuation time
- Differences in actions taken
- Difference in perceived severity



Impact

- Building design
 - Refuge floors
 - Vestibules
 - Numbers in codes
- Speeds
 - Clothing
 - Density
 - Fitness
- Interactions
 - Merging
 - Deference
- Response
 - Pre-evacuation
 - Training
 - Behavioral norms
- Exit choice
 - Exits designated for others
 - Familiarity



Culturally Significant Buildings

- Concerns beyond life safety
- Building more than just a building
- May not be obvious what the significance is to outsiders



Methodologies

- Explain how means of egress rules have been developed
- Identify other methods of determining people movement
- Explain the limitations of existing methodologies



Historic Fire

- Daegu Subway



Origins of Egress Requirements

- Stair width
 - First building code (1905): 20 in
 - NFPA committee (1913): 44 in, handrails protrude 3.5 in
 - Based on people standing in stair (28 per floor)
 - 22 in per person on every other tread (from soldiers standing in line)
 - “Sufficient” to prevent three people from forming arch and blocking traffic
 - Why stairs are based on single floor at a time



Flow Method

- Based on number of people per minute per exit lane
 - Level 60 persons/min
 - Stairs 45 persons/min
 - Stairs later found to be closer to 27 persons/min
- Still used in NFPA 130
- Time based
 - 4 min for platform
 - 6 min to point of safety
- Level
 - 2.08 persons/in-min
 - 124 ft/min
- Stairs
 - 1.41 persons/in-min
 - 48 ft/min (vertical)

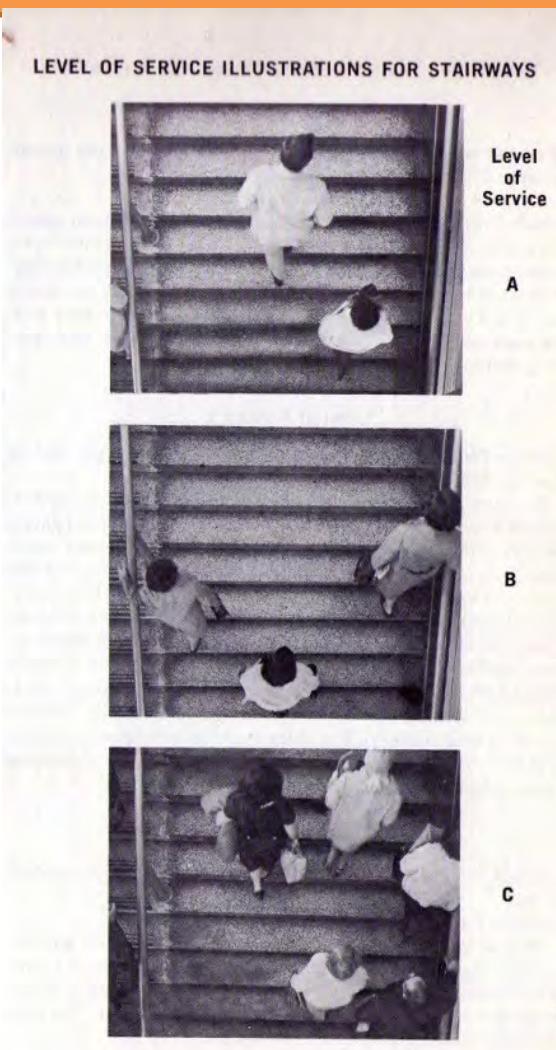


Level of Service

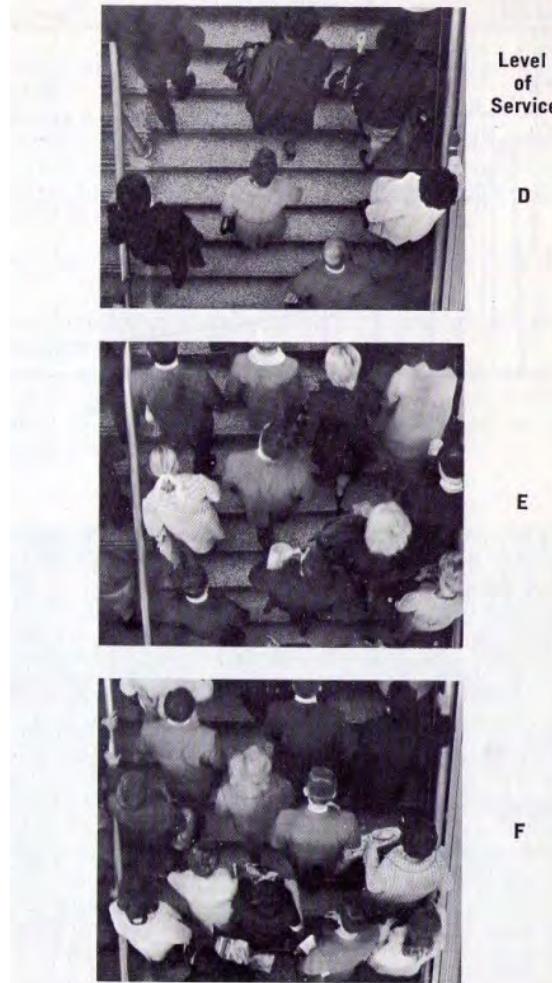
- Concept from transportation
 - Pathfinder allows you to view
 - Ability of people to freely choose their own speed
 - A: Free to choose own speed and pass
 - B: Free to choose own speed and pass, minor conflicts
 - C: Speed and passing restricted, major conflicts
 - D: Cannot pass
 - E: Intermittent stoppages
 - F: Movement to shuffle, not suited for design



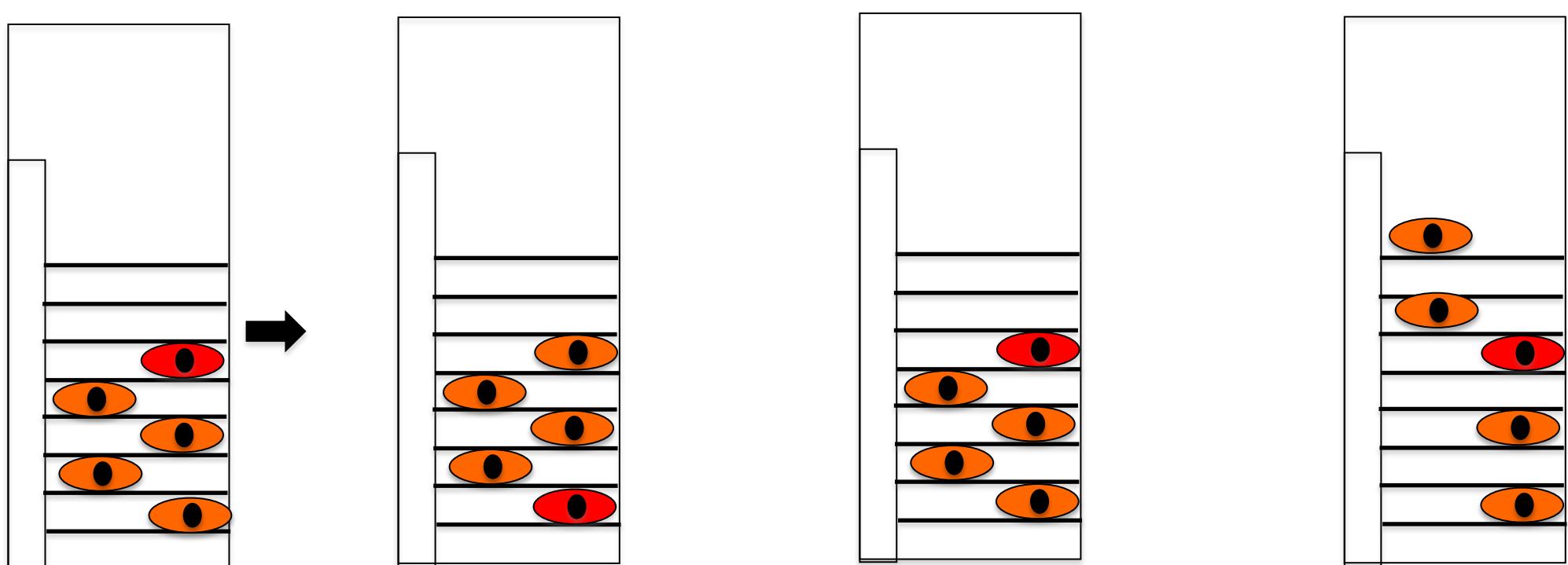
Level of Service



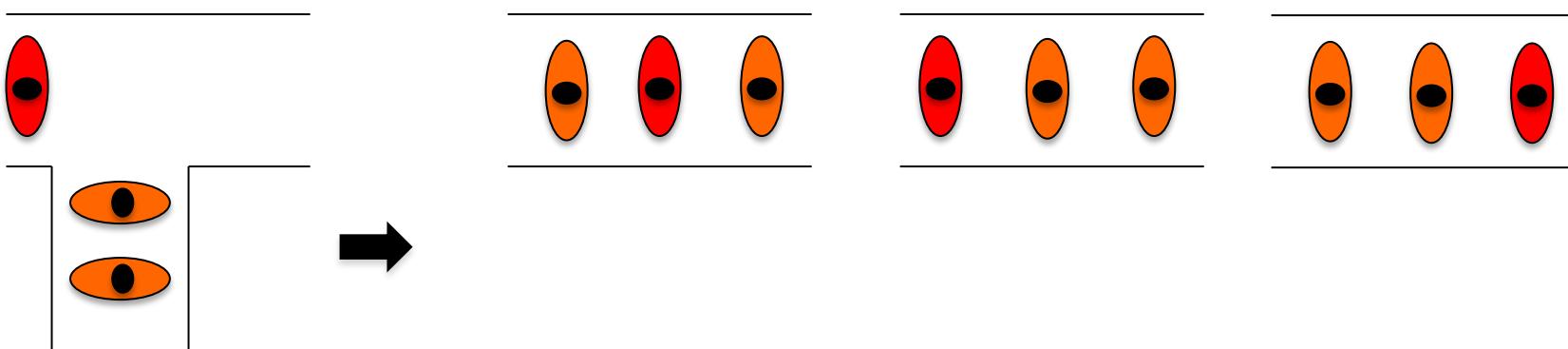
LEVEL OF SERVICE ILLUSTRATIONS FOR STAIRWAYS



Behavior



Behavior



Behavior

- Stairs
 - Preference



Model Selection

- Determine the appropriate type of model to use for a given project
- Explain validation and verification of a model
- Identify appropriate information to include in the documentation of the results of a model



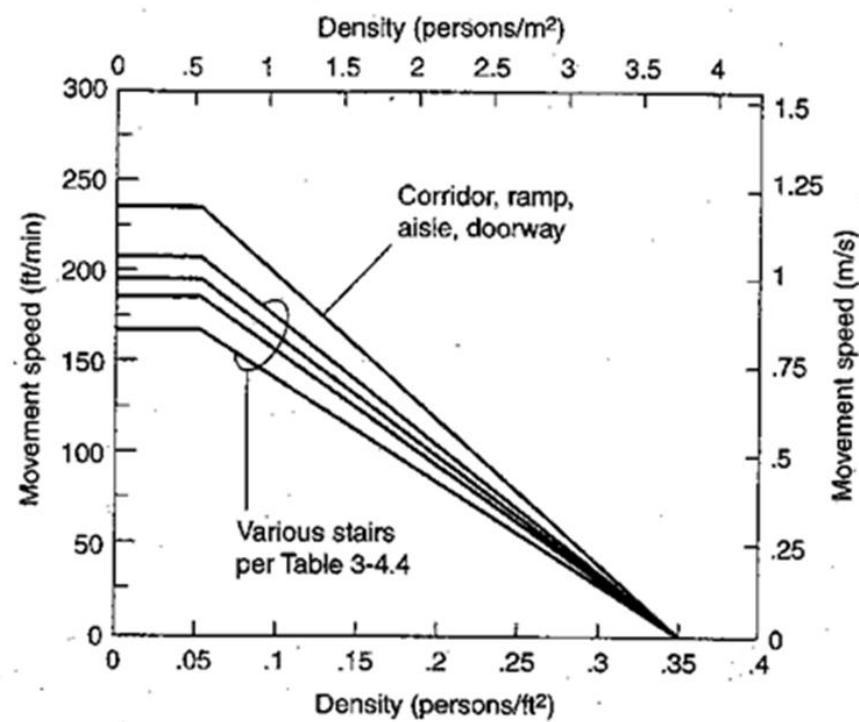
Historic Fire

- General Slocum



Model Selection

- Essential to choose a model that meets the needs of the project
- Models are approximations
 - Each best suited for different applications
- Multiple considerations
 - Skill/knowledge of user
 - Cost
 - Time
 - Desired output



Algebraic Equations vs. Simulation Models

Algebraic Equations

- Simplistic (component) analysis
- Single actions
- Homogeneous population
- Limited knowledge of building
- Less time and funding
- Simplistic output

Simulation Models

- Complicated (system) analysis
- Multiple actions
- Variations within population
- Detailed knowledge of building
- More time and funding
- More advanced output

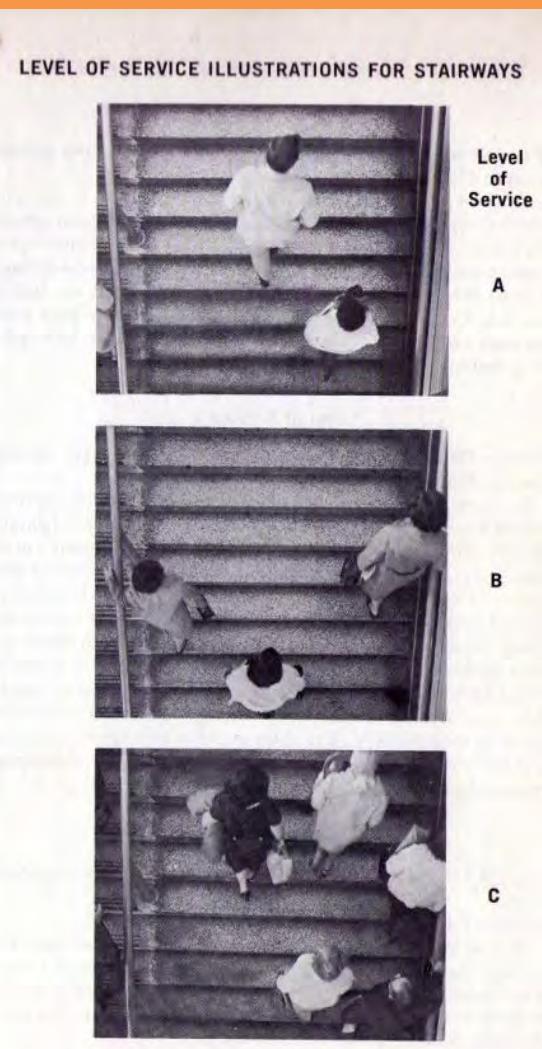


Level of Service

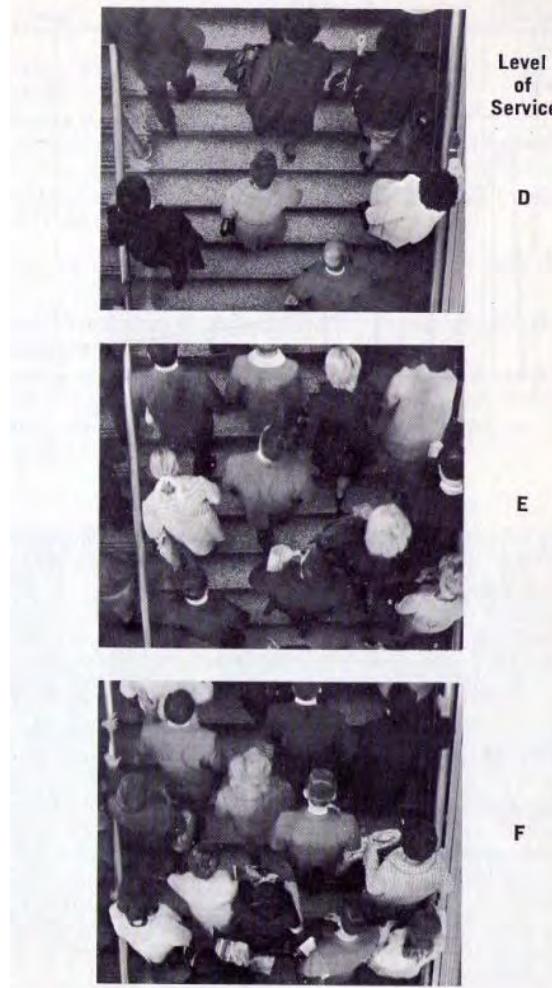
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 - F: Movement to shuffle, not suited for design



Level of Service



LEVEL OF SERVICE ILLUSTRATIONS FOR STAIRWAYS



Types of Models

- Movement
- Partial Behavioral
- Behavioral
- Special applications
 - Vessels
 - Low-rise buildings
 - Stadiums
 - Transportation stations
- Special Features
 - Fire effects
 - Elevator use



Verification and Validation

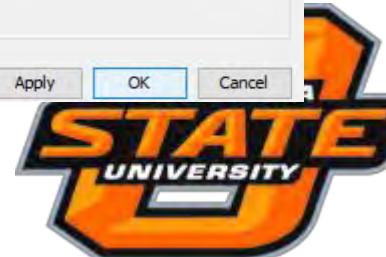
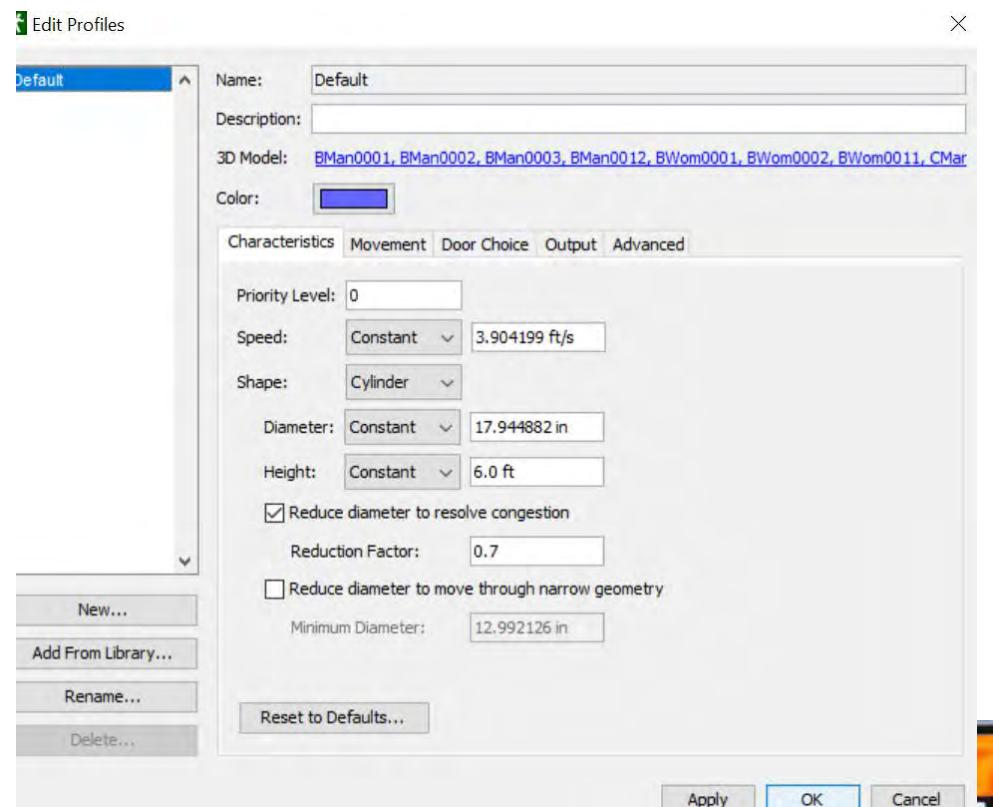
- Verification
- Validation

both a way to see it's a model working correctly



Default Values

- Immediate use
- Underlying assumptions



Output

- Text files
- 2-D graphs
- 3-D animations
- Individual level
- Aggregate level
- Scenario level

文本文件
二维图形
三维动画

个人层面
聚合层面
场景层面



Documentation

- Explain why model was selected
 - Capabilities of model
 - Validity
- Explain selected scenarios
 - Sensitivity
 - Bounding
 - Values used
- Explain results
 - Verification
 - Meaning
 - Values



Emerging Issues

- Identify areas where more information is needed



Historic Fire

- Oakland Hills Fire



Human Behavior (Details)

Data	Technology	Design Tools	Risk/Probabilistic Approaches
<ul style="list-style-type: none">• Demographics<ul style="list-style-type: none">○ Vulnerable populations○ Anthropometry○ Cultural differences• Basis for numbers in codes• Response to notification	<ul style="list-style-type: none">• Smart egress systems<ul style="list-style-type: none">○ Cameras○ Cell phones○ Exit usage○ Other• LED strobos• Occupant evacuation elevators	<ul style="list-style-type: none">• Design egress scenarios• Behavior based models<ul style="list-style-type: none">○ Cultural○ Pre-evacuation time○ Actions other than evacuating• Combined fire and evacuation models	<ul style="list-style-type: none">• Residential buildings• Large populations• Community level• High challenge environments• Quantify level of “life safety” in a building• Effects of fire<ul style="list-style-type: none">○ Visibility○ Gases• Impact of public education on fire risk