Regulatory Frames… Egress

Egress

- Promoter P.T. Barnum is said to have charged people 25 cents to enter a darkened room and "See the Egress."
- Once in the darkened room, the people could only see a dim light over a door with a sign on it saying "This way to the Egress."
- Upon opening the door and walking through they found themselves on the street!
- Egress is the term applied to the various means (corridors, stair enclosures, stairs) *to be used as a means of escape in the event of a fire or other disaster in the building*.

Some key IBC Definitions

- Area of Refuge: Area where persons unable to use stairways can remain temporarily to await instructions or assistance during emergencies
- Corridor: An enclosed exit access component that defines and provides a path of egress travel to an exit.
- Exit: That portion of a means of egress system which is separated from other interior spaces of a building by fire resistance rated construction and opening protectives as required to provide a protected path of egress travel between the exit access to the exit discharge including exit doors, exit enclosures, exit passageways

How Many People?

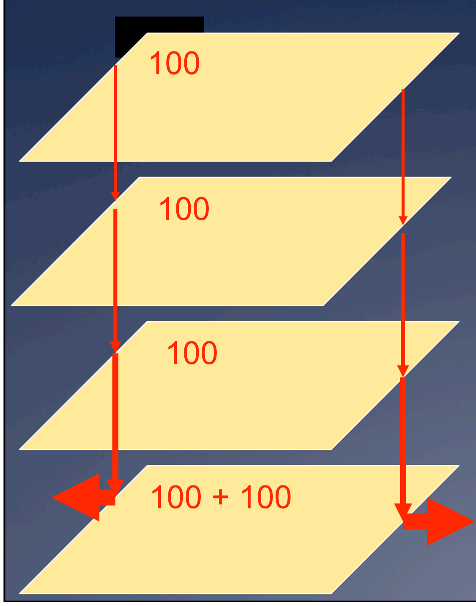
- The IBC offers the choice of two processes for determining the number of people *(occupants)* in the building.
  - The first method is to determine the actual number of people in the space.
  - This is easier to do in a building with fixed seating (auditorium) than in say an open office space where, the density varies over time.
  - The second method is to refer to the Maximum Floor Area per Occupant table, find your use type, divide the number of gross square feet per occupant in the table into your project's gross square footage to arrive at the number of occupants in the building, or per floor.

Occupant load table ...excerpted

Occupancy	Floor Area in Square Feet per occupant
Assembly without fixed seats	
Concentrated (chairs)	7 net
Standing space	5 net
Unconcentrated (tables and chairs)	15 net
Business Areas	100 gross
Dormitories	50 gross
Educational	
Classroom Area	20 net
Vocational Areas (shops)	50 net
Library	
Reading Area	50 net
Stack Area	100 gross

So our Business Occupancy would take the program area (40,000 s.f.) and divide it by 100 s.f. to determine we have 400 occupants

Egress convergence

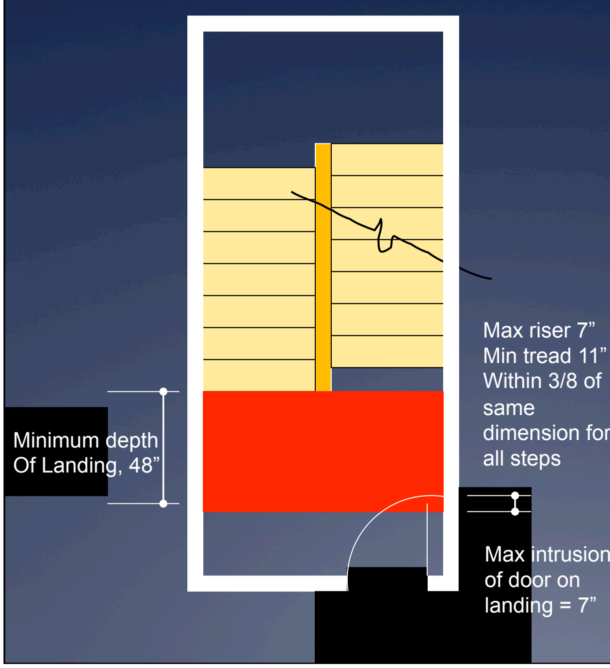


- As the occupants from a floor above exit through lower floors, they don't impact the exit size for the floor the pass through, but the exit size cannot get smaller.
- But when exits converge at a floor, like the ground floor where they leave the building, the occupant load for the ground floor must take into account the occupant load of the floor immediately above.
- First floor, 10,000 s.f. = 100 occ + 100 from second, 200 occupants

How wide does that make the exit?

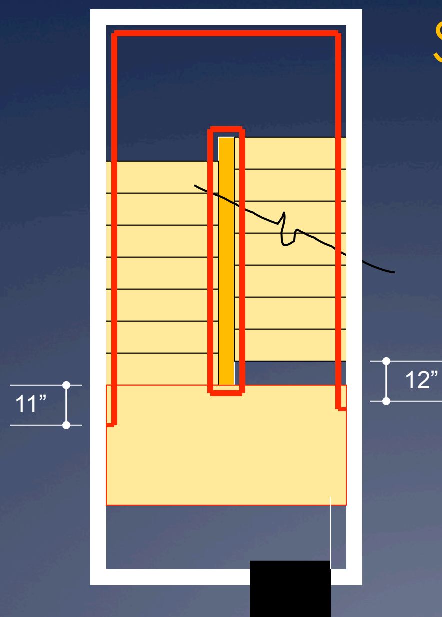
- The IBC reads "The total width of the means of egress in inches shall not be less than the total occupant load served multiplied by"
  - .3 for stairs in unsprinkled buildings
  - .2 for corridors, other egress components in unsprinkled buildings
  - .2 for stairs in sprinkled buildings
  - .15 for other components in sprinkled buildings
- So our top floor stair in our unsprinkled example could be no less than 100 x .3 or 30 inches…not nearly wide enough to meet minimums of the IBC or ADA
- So the code continues to read "nor less than specified elsewhere in this code" so it let's itself out of an apparent contradiction

Stairways



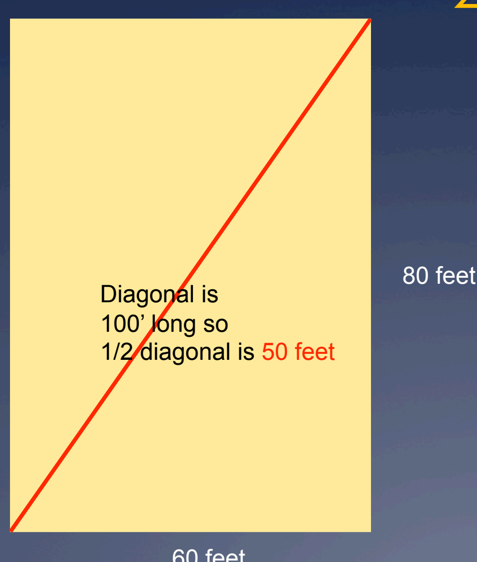
- Two required
- Fully enclosed with 2 hour fire rated construction
- Minimum stair width 48"
- Max stair width without intermediate railing = 5'
  Minimum headroom 80" from nosing line
- Max height between landings = 12'-0"

Stairways...cont'd



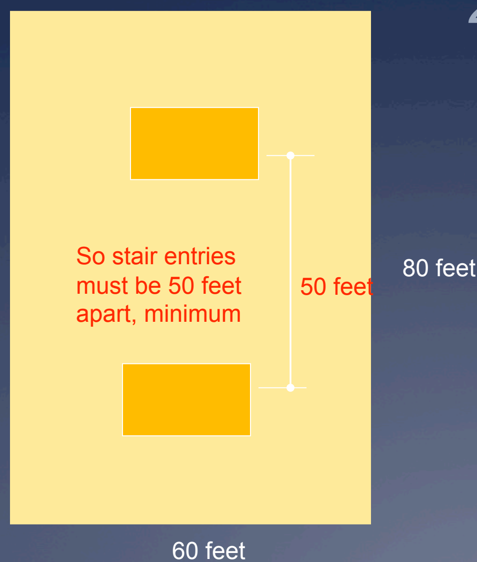
- Handrail height 34" - 38"
- Handrails required both sides. 1-1/4 to 2" dia, 1-1/2" from wall (clear)
- Handrails must extend 12" beyond top riser, and one tread (11"min) beyond bottom tread

2 exit spacing



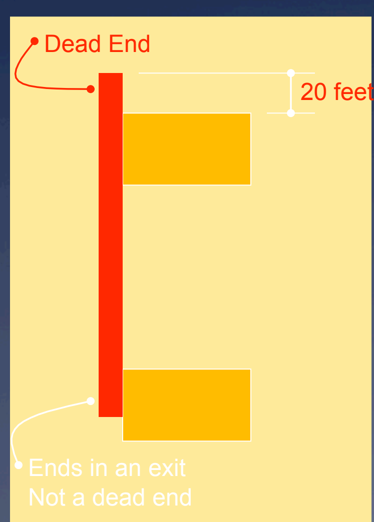
- Exits cannot be closer than 1/2 the maximum diagonal distance of the floor plate

2 exit spacing



- So in this example, the exit stairs could not be placed closer than 50 feet apart
- Maximum travel distances would be for this type 'B' building
  - 200 feet without sprinklers
  - 250 feet with sprinklers
- What would be the maximum stair spacing in a sprinkled type 'B' building?

Dead End Corridors



- A corridor not ending in an exit is considered a *dead end corridor*
- Dead end corridors are limited to 20 feet in length in most occupancies.
- In occupancy group B with a sprinkled building, the dead end can be extended to 50 feet long.

On your way to the exit...

- DO NOT plan the egress path to exit through another tenants space
- DO NOT plan the egress path to exit through storage spaces, kitchens, mechanical rooms…or other high hazard occupancies.
- But exiting through a non hazardous accessory space is acceptable, as long as there is a clear path discernable to the exit.

& in housing

- One egress window per bedroom is required.
- Minimum width is 20 inches
- Minimum height is 24 inches
- Minimum area is 5.7 square feet.
- Maximum height above floor is 44 inches
- (20x24=480 sq. in. or 3.33 s.f.)

Some fine print

- Area allowed in table 503 is area *per floor* so a two story building would double the total allowable area…
- Sometimes this allowable area per floor is not enough given the program area, and site conditions affecting how many floors can be built (example: a zoning height limit)

Increasing area

- Section 506 of the IBC allows modifications to the area values in table 503.
- Increases in the allowable area can be earned through the addition of a fire sprinkler system or by having a large (>25%) proportion of the building perimeter facing an open space (permanently deeded as such and accessed by an approved fire lane or street) or *public way* (usually a street, alley or other publicly deeded right of way)

Formula for increasing area

$$A_a = A_t + \left[\frac{A_t I_f}{100}\right] + \left[\frac{A_t I_s}{100}\right]$$

- A_a — Allowable Area
- A_t — Area listed on table 503
- I_f — Area increase from frontage on public way (506.2)
- I_c — Area increase due to sprinkler protection

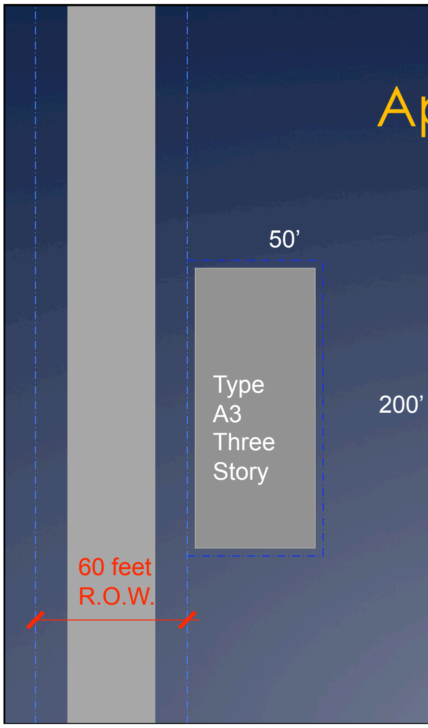
Calculating increase for frontage

$$I_f = 100\left[\frac{F}{P} - 0.25\right]\frac{W}{30}$$

Note: w/30 cannot exceed 1.0 unless qualifications for unlimited area are met

- I_f — Percent Area increase due to frontage
- F — Building perimeter fronting on a public way having 20 feet of minimum width
- P — Perimeter of entire building
- W — Minimum width of public way or open space

Applied



- This type A3 occupancy building has 500 feet of perimeter
- 200’ feet of perimeter face the street, which is in a 60 foot wide R.O.W.
- The rest of the perimeter faces property lines within a few feet.

Plug it in

$$I_f = 100\left[\frac{200}{500} - 0.25\right]\frac{60}{30}$$

$$I_f = 100\left[.4 - 0.25\right]\ 1$$ (A3 Occupancy doesn't qualify for unlimited area)

$$I_f = 100\left[0.15\right]\ 1$$ (A3 Occupancy doesn't qualify for unlimited area)

$$I_f = 15$$ This works out to a 15% Area increase in this example

Plug in to the Area Increase formula

$$A_a = 15{,}500 + \left[\frac{15{,}500 \times 15}{100}\right] + \left[\frac{A_t I_s}{100}\right]$$

$$A_a = 15{,}500 + \left[\frac{232{,}500}{100}\right] + \left[\frac{A_t I_s}{100}\right]$$

$$A_a = 15{,}500 + \left[2{,}325\right] + \left[\frac{A_t I_s}{100}\right]$$

$$A_a = 17{,}825$$

Frontage effect

- This Area increase allowed by the *frontage* of the building on an open space or public way has increased the allowable area per floor to 17,825 s.f.
- Section 506.3 also allows an area increase for installing an approved automatic sprinkler system. The tabular area can be increased by 200% for multi-story buildings and 300% for single story buildings.

Plug in the Sprinkler Increase formula

$$A_a = 15{,}500 + \left[\frac{15{,}500 \times 15}{100}\right] + \left[\frac{15{,}500 \times 200}{100}\right]$$

$$A_a = 15{,}500 + \left[\frac{232{,}500}{100}\right] + \left[\frac{3{,}100{,}00}{100}\right]$$

$$A_a = 15{,}500 + \left[2{,}325\right] + \left[31{,}000\right]$$

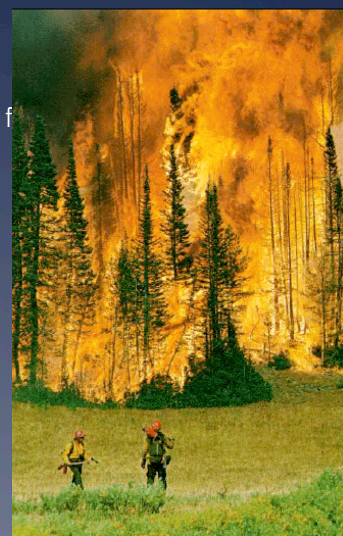
$$A_a = 48{,}825$$

Sprinkler advantage

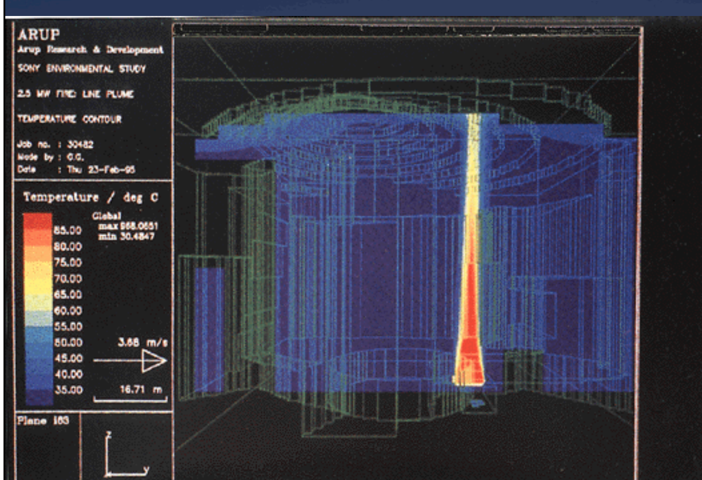
* Now, with the sprinkler area increase, the allowable area per floor is 48,825 square feet. Quite a difference from the initial allowable area of 15,500 s.f.

Some last points about fire

- Fire
- Three elements are necessary f
  - fuel
  - heat
  - oxygen



Learning about fire

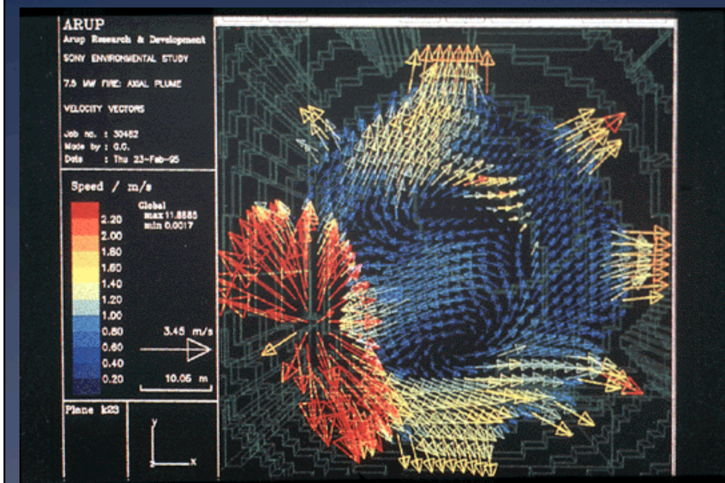


Computational Fluid Dynamic (CFD) modelers are being used to understand the behavior of fire in buildings

This model of an atrium in Berlin has a “virtual fire” burining

The CFD modeler calculates the heat, speed and direction of air movement in the space

Learning about fire



The Building and Fire Research Laboratory (BFRL) at the National Institute of Standards and Technology (NIST) leads research in fire science and fire engineering

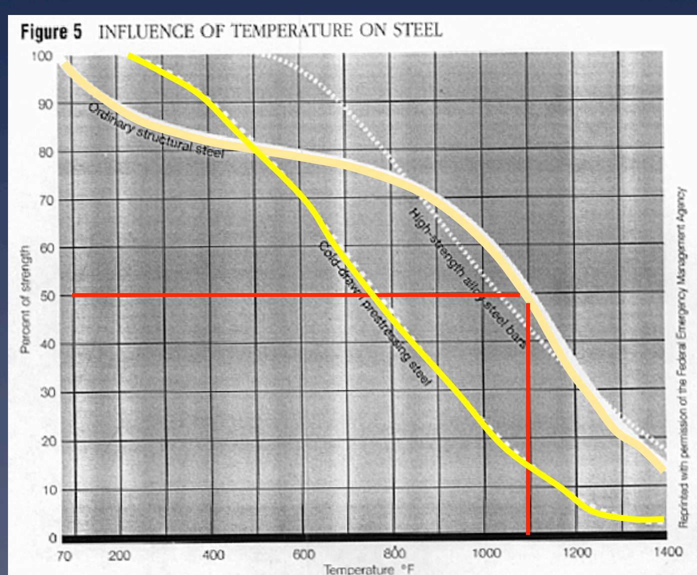
http://www.bfrl.nist.gov/

Fire temperatures

- In a fire, temperatures vary, but 1000 to 2000 degrees Fahrenheit are common.
- A temperature difference of 650 degrees between the ceiling and floor are common. (stay low)
- Around the time when the temperature hits 1500 degrees, the superheated gases given off by materials and furnishings explodes sending out a fireball which moves at over 20 feet per second.
- This fireball event, called flashover by firefighters has sufficient force to blow out most window assemblies, (hence no windows in stairs and corridors)

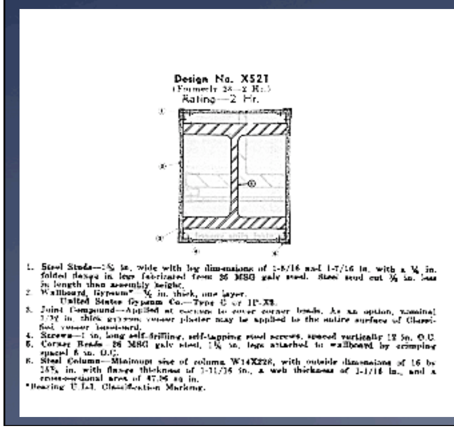
Steel and Fire

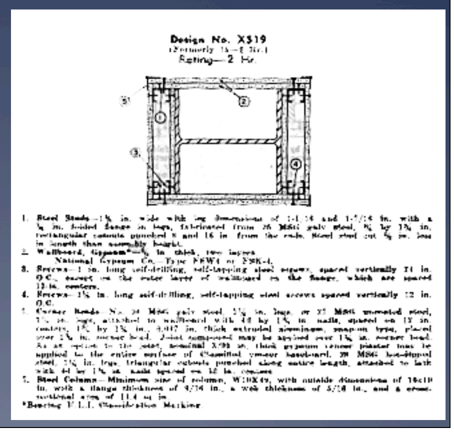
- Steel doesn't burn but will lose 90% of its strength by the time fire hits 1400 degrees.
- But up to 1100 degrees, the steel retains up to 50% of its strength. So as architects, we try to keep steel cool, usually by insulating, but strategies for steel protection will be discussed in the steel chapter.



Steel & Fire

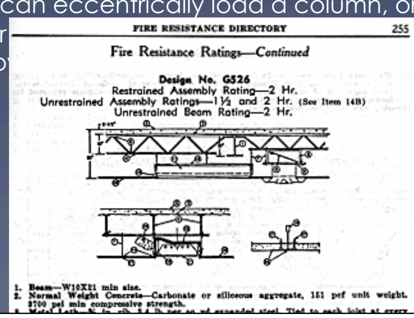
- Thicker steel conducts heat away from the fire source and keeps temperature lower.
- This is why the UL tests for heavier steel sections require less insulation than the thinner sections.





Steel and more fire

- A lightweight steel web joist (bar joist) can collapse within 5 to 15 minutes when exposed to 1100 degree heat.
- Steel will elongate 1 inch for each 10 feet of length at 1000 degrees.
  - This can eccentrically load a column, or literally push over firefighters belo



Wood and Fire

- As wood burns, it produces a layer of charcoal at a rate of approx. 1/40th inch per minute.
- Small members (2x4...) burn through rapidly.
- In larger members (heavy timber) the charcoal layer acts as insulation to protect the interior of the member from fire and allow it to keep much of its structural capacity.
- This is why Type 4 construction allows more height and area then Type 5 and even more than some Type 3 constructions.

Concrete and fire

- Concrete protects the reinforcing steel inside by transferring heat through its mass.
- Moisture in concrete turns to steam in a fire and will spall the surface off, sometimes exposing the reinforcing steel to the fire.
- A minimum of 2 inches of concrete should cover all reinforcing steel.
- Structural precast concrete members usually depend on prestressed steel tendons for strength.
- These tendons are made of a type of steel which loses strength faster than mild steel rebars, and don't recover their strength when the fire is out. Tendons are permanently damaged by temperatures over 800 degrees.

Plastics and smoke

- Plastics are extremely flammable, they are principle contributors to the combustible gases making up a flashover, their melting and dripping flaming drops spreads fire.
- Smoke production by vinyl and urethanes (most furnishings, some thermal insulation) will reduce visibility to less than 6 feet in less than 1 minute.
- Smoke production by wood will reduce visibility to less than 16 feet in less than 1 minute.

People and fire

- People
- comfort zone 60 to 80 degrees
- tolerable for 1 hour 140 to 150 degrees
  (maximum survivable breathing temperature)
- intolerable in 25 minutes 210 to 220 degrees
- intolerable in 15 minutes 240 to 250 degrees
- intolerable in 5 minutes 270 to 280 degrees
- irreversible injury in 30 seconds 350 to 360 degrees
  - Common fire temperatures 1000 to 2000 degrees