LIFE SAFETY REPORT

FOR

“XYZ OFFICE”

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For

FPE 596 Culminating Project

Spring 2013

Outline

- Overview of building
- Code Analysis
 - The facility is currently being upgraded to meet the 2009 ICC codes. As such the analysis will be based on these codes and their referenced standards.
- Occupant load
- Egress
- Passive Fire Protection
 - Building construction type
 - Fire resistance
- Active Fire Protection Systems
 - Fire Alarm & Detection
 - Automatic Sprinkler protection
- Performance Based Analysis
- Results
- Summary

Overview —

Ariel view

Overview —

Front view

Overview —

Major features

- XYZ is an office building with an atypically high amount of accessory areas including the stereotypical conference and storage areas.
- The building was constructed in the early '90's with some areas apparently being used for manufacturing.
- No architectural drawings of the initial construction exist.
- Minor tenant improvements (discounting a change of use) have occurred throughout the buildings history without apparent significant change to the structure.
- Although not a code requirement as a "B" occupancy, it is nonetheless fully sprinklered.
- The building is being assessed as a Type IIB construction meeting the requirements of the 2009 IBC.

Overview —

Major features

- The building is a two story structure with the 2nd floor being considerably smaller than the 1st.
- Two sets of stairs communicate between the 2nd and 1st floors.
- One major rated corridor runs North - South.
- Due to security concerns there are no interior pictures available and only publicly available exterior pictures.
- Roof access is available within the shipping and receiving area.

Overall Floor plan — Primary features

First floor will be shown as North and South section for clarity

North Area

South Area

- 1 Hour Rated Enclosure
- Design Fire Area
- Stairway

Code Analysis

- Major relevant codes and standards applied to this analysis;
 - 2009 International Building & Fire Codes
 - 2010 NFPA 13 Standard for the Installation of Sprinkler Systems
 - 2010 NFPA 72 National Fire Alarm and Signaling Code
 - 2008 NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems
- The owner is choosing to use the most current NFPA standards despite the referenced editions in the ICC codes.

Code Analysis

Code Analysis		
Parameter		2009 IBC Reference
Construction Type	IIB	§602
Allowable base area/floor	23,000 ft ²	Table 503
Allowable area increase size	86,250 ft ²	§506
Actual size -	57,948 ft ²	
Accessory use areas 1st floor	23%	§508.2
Accessory use areas 2nd floor	10%	§508.3
Corridor rating	0 hour	Table 1018.1
Building elements fire resistance rating	0 hour	Table 601
Exterior fire resistance rating	0 hour	Table 602
Interior finish -		
Exit Enclosure -	B	Table 803.9
Corridor, rooms, enclosed spaces -	C	Table 803.10
Fire Separation -		
Business/Assembly -	1 hour	Table 508.4
Exit Access Travel distance allowed -	300 feet	Table 1016.1
Actual Exit Access Travel distance -	150 feet	
Common Path of Egress Travel allowed -	100 feet	§1014.3
Actual Common Path of Egress Travel -	20 Feet	
Design occupant load	877 persons	§1004
Egress capacity of 1st floor exits	2,340 persons	§1005.1
Automatic Fire Sprinkler System	NFPA 13	2010 Compliant
Addressable Fire Alarm System	NFPA 72	Central Station monitored – 2010 Compliant
FE-13 Special Hazard system in computer room	NFPA 2001	2008 Compliant

Building Height and area

TABLE 503
ALLOWABLE BUILDING HEIGHTS AND AREAS^a

Building height limitations shown in feet above grade plane. Story limitations shown as stories above grade plane.
Building area limitations shown in square feet, as determined by the definition of "Area, building," per story

GROUP		TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
		UL	160	65	55	65	55	65	50	40
HEIGHT (feet)		STORIES (S) AREA (A)								
A-1	S A	UL UL	5 UL	3 15,500	2 8,500	3 14,000	2 8,500	3 15,000	2 11,500	1 5,500
A-2	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-3	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-4	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-5	S A	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL
B	S A	UL UL	11 UL	5 37,500	3 23,000	5 28,500	3 19,000	5 36,000	3 18,000	2 9,000

Allowable increases

$$A_a = \{A_t + [A_t \times I_f] + [A_t \times I_s]\} \quad \text{(Equation 5-1)}$$

where:

A_a = Allowable *building area* per *story* (square feet).

A_t = Tabular *building area* per *story* in accordance with Table 503 (square feet).

I_f = Area increase factor due to frontage as calculated in accordance with Section 506.2.

I_s = Area increase factor due to sprinkler protection as calculated in accordance with Section 506.3.

$$I_f = [F/P - 0.25]W/30 \quad \text{(Equation 5-2)}$$

where:

I_f = Area increase due to frontage.

F = Building perimeter that fronts on a *public way* or open space having 20 feet (6096 mm) open minimum width (feet).

P = Perimeter of entire building (feet).

W = Width of *public way* or open space (feet) in accordance with Section 506.2.1.

$$86,250ft^2 = \{23,000ft^2 + [23,000ft^2 \times 0.75] + [23,000ft^2 \times 2]\}$$

$$0.75 = \left[\frac{936ft}{936ft} - 0.25 \right] 30/30$$

Corridor

**TABLE 1018.1
CORRIDOR FIRE-RESISTANCE RATING**

OCCUPANCY	OCCUPANT LOAD SERVED BY CORRIDOR	REQUIRED FIRE-RESISTANCE RATING (hours)	
		Without sprinkler system	With sprinkler system ^c
H-1, H-2, H-3	All	Not Permitted	1
H-4, H-5	Greater than 30	Not Permitted	1
A, B, E, F, M, S, U	Greater than 30	1	0
R	Greater than 10	Not Permitted	0.5
I-2 ^a , I-4	All	Not Permitted	0
I-1, I-3	All	Not Permitted	1 ^b

Occupant Load

Occupancy Classification	Square Footage	Occupant Load Factor	Design Occupant Load
Ambulatory Health Care	1105	100	11
Assembly	5571	15	371
Business	47171	100	471
Exercise Room	850	50	17
Kitchen	150	100	1
Library	132	100	1
Storage	2969	500	5
2 nd Floor			126
1st Floor			751
Total	57948		877

Accessory areas - North

- Building Utilities
- Storage
- Misc use
- Assembly

Accessory areas - South

- Building Utilities
- Storage
- Misc use
- Assembly

Accessory areas – 2nd floor

- Building Utilities
- Storage
- Misc use
- Assembly

Fire Rated Construction

- Building construction fire resistance meets the requirements of the 2009 IBC, Table 601.

GENERAL

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A ^d	B	A ^d	B	HT	A ^d	B
Primary structural frame ^g (see Section 202)	3 ^a	2 ^a	1	0	1	0	HT	1	0
Bearing walls									
Exterior ^{f, g}	3	2	1	0	2	2	2	1	0
Interior	3 ^a	2 ^a	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior ^e	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and secondary members (see Section 202)	1 ^{1/2} ^b 2	1 ^{b,c}	1 ^{b,c}	0 ^c	1 ^{b,c}	0	HT	1 ^{b,c}	0

Interior Finish

**TABLE 803.9
INTERIOR WALL AND CEILING FINISH REQUIREMENTS BY OCCUPANCY^k**

GROUP	SPRINKLERED ^l			NONSPRINKLERED		
	Exit enclosures and exit passageways ^{a, b}	Corridors	Rooms and enclosed spaces ^c	Exit enclosures and exit passageways ^{a, b}	Corridors	Rooms and enclosed spaces ^c
A-1 & A-2	B	B	C	A	A ^d	B ^e
A-3 ^f , A-4, A-5	B	B	C	A	A ^d	C
B, E, M, R-1	B	C	C	A	B	C
R-4	B	C	C	A	B	B
F	C	C	C	B	C	C
H	B	B	C ^g	A	A	B
I-1	B	C	C	A	B	B
I-2	B	B	B ^{h, i}	A	A	B
I-3	A	A ^j	C	A	A	B
I-4	B	B	B ^{h, i}	A	A	B
R-2	C	C	C	B	B	C
R-3	C	C	C	C	C	C
S	C	C	C	B	B	C
U	No restrictions			No restrictions		

- b. In exit enclosures of buildings less than three stories above grade plane of other than Group I-3, Class B interior finish for nonsprinklered buildings and Class C interior finish for sprinklered buildings shall be permitted.

Fire Separation

TABLE 508.4
REQUIRED SEPARATION OF OCCUPANCIES (hours)

OCCUPANCY	A ^d , E		I-1, I-3, I-4		I-2		R		F-2, S-2 ^b , U		B, F-1, M, S-1		H-1		H-2		H-3, H-4, H-5	
	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS
A ^d , E	N	N	1	2	2	NP	1	2	N	1	1	2	NP	NP	3	4	2	3 ^a
I-1, I-3, I-4	—	—	N	N	2	NP	1	NP	1	2	1	2	NP	NP	3	NP	2	NP
I-2	—	—	—	—	N	N	2	NP	2	NP	2	NP	NP	NP	3	NP	2	NP
R	—	—	—	—	—	—	N	N	1 ^c	2 ^c	1	2	NP	NP	3	NP	2	NP
F-2, S-2 ^b , U	—	—	—	—	—	—	—	—	N	N	1	2	NP	NP	3	4	2	3 ^a
B, F-1, M, S-1	—	—	—	—	—	—	—	—	—	—	N	N	NP	NP	2	3	1	2 ^a
H-1	—	—	—	—	—	—	—	—	—	—	—	—	N	NP	NP	NP	NP	NP
H-2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	N	NP	1	NP
H-3, H-4, H-5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1 ^{e, f}	NP

Fire Separation

- Only one assembly area with an occupant load >50 persons.
- Conference room that is approximately 3000 ft² and has an occupant load of 200.
- Using an occupant load factor for unconcentrated tables and chairs, i.e. 15 ft²/person.

Egress

Stairway B

Stairway A

Egress Capacity

- 1st Floor
 - 2,145 with eight exits
- 2nd Floor
 - 294 with two exits

Egress Lengths

**TABLE 1016.1
EXIT ACCESS TRAVEL DISTANCE^a**

OCCUPANCY	WITHOUT SPRINKLER SYSTEM (feet)	WITH SPRINKLER SYSTEM (feet)
A, E, F-1, M, R, S-1	200	250 ^b
I-1	Not Permitted	250 ^c
B	200	300 ^c
F-2, S-2, U	300	400 ^c
H-1	Not Permitted	75 ^c
H-2	Not Permitted	100 ^c
H-3	Not Permitted	150 ^c
H-4	Not Permitted	175 ^c
H-5	Not Permitted	200 ^c
I-2, I-3, I-4	Not Permitted	200 ^c

2nd floor egress

- The corner office has an approximate 100 ft travel distance to Stairway A and out the 1st floor exit.
- The same office has an approximate 120 ft travel distance to Stairway B.

1st floor egress

- The occupant load with the number of exits provided provides for safe egress with multiple egress choices throughout the building. This results in a **Common Path of Egress Travel** of typically less than 20 feet.
 - §1014.3 Exception 1 of the 2009 IBC allows for 100 feet.
- The greatest **Exit Access Travel Distance** is approximately 130 feet to Exit 3 from one of the centrally located offices.

Fire Protection and Detection

Fire Detection

- The fire alarm system is a conventional system with full NFPA 72 compliant initiating devices and notification appliances.
 - The fire alarm panel meets UL 864 (pre Rev 9)
 - All 58 smoke detectors are the photoelectric type meeting UL 268.
 - All 75 Audio/visual notification appliances meet UL 1971 and/or meet UL 1638.
 - The Fire Alarm system is monitored by a UL 827 listed Central Station however it does not receive Central Station Service as defined by NFPA 72.
 - For all intents and purposes it receives “Remote Station Service” through a bona fide and listed Central Station.

Portable Fire Extinguishers

TABLE 906.3(1)
FIRE EXTINGUISHERS FOR CLASS A FIRE HAZARDS

	LIGHT (Low) HAZARD OCCUPANCY	ORDINARY (Moderate) HAZARD OCCUPANCY	EXTRA (High) HAZARD OCCUPANCY
Minimum Rated Single Extinguisher	2-A ^c	2-A	4-A ^a
Maximum Floor Area Per Unit of A	3,000 square feet	1,500 square feet	1,000 square feet
Maximum Floor Area For Extinguisher ^b	11,250 square feet	11,250 square feet	11,250 square feet
Maximum Travel Distance to Extinguisher	75 feet	75 feet	75 feet

NFPA 10 2013 edition –
*§A.5.4.1.1 Light hazard
occupancies can include
some buildings or rooms
occupied as offices,
classrooms, churches,
assembly halls, guest room
areas of hotels or motels, and
so forth.*

Extinguisher placement

Extinguisher placement

Fire Sprinkler

- The building is fully sprinklered by an NFPA 13 compliant wet-pipe automatic fire sprinkler system.
- The base design of the system is Light hazard with a minimum design density of 0.10 gpm/ft² over a minimum of 1500 ft².

FIGURE 11.2.3.1.1 Density/Area Curves.

Sprinkler 1st Floor North

Sprinkler 1st Floor South

Design Area – 2nd Floor

- The hydraulically most demanding area was also the geographically most demanding. This was the distal point of the 2nd floor with a demand of 540.21 gpm at a pressure of 42.96 psi.
 - This includes a hose demand of 250 psi per the owners requirements.

Sprinkler Supply and demand

Note the >3900 gpm available for firefighting at the local fire AHJ's minimum 20 psi requirement.

Fire Protection

(Cont'd)

- The shipping area is calculated as Ordinary Hazard II with a design density of 0.20 gpm/ft² over a minimum of 1500 ft².
- The computer room is protected by a FE-13 Special Hazard system.
 - The system has been calculated for flame extinguishment concentrations.
- Manual fire suppression by trained and duly assigned personnel with hand held fire extinguishers is expected during normal business hours.

Fire Protection

(Cont'd)

- The office area, and most accessory areas, are all protected with standard spray pendent sprinklers with a nominal K-factor of 5.6.
- The shipping and receiving area uses standard spray 8.0 K-factor heads.

Performance-based Scenarios

- 2 scenarios will be modeled.
 - The highest fire hazard area – the shipping area
 - The typical area – an average office
- Both scenarios will juxtapose the available egress time against the required egress time.

ASET

- The Available Safe Egress Time is the time that the occupants have until these design criteria are met.
 - CO level <1200 ppm
 - Temperature <60°
 - Visibility >6m
 - Smoke layer height >2m
- Evaluated by analyzing the results of FDS for the time frames as shown.

Carbon Monoxide criteria for ASET

- The CO RSET goal is to have personnel egressed prior to incapacitation level.
- The chosen ASET criteria 1200 ppm for CO provides an available time of approximately 23 minutes (1380 seconds).

Figure 2-6.5. Relationship between time to incapacitation and carbon monoxide concentration in active monkeys. 1000 ppm $Ct = 26,600$ ppm·min; 2000 ppm $Ct = 28,097$ ppm·min; 4000 ppm $Ct = 26,868$ ppm·min; 8000 ppm $Ct = 26,086$ ppm·min.

Temperature criteria for ASET

- The RSET goal is to have personnel egressed prior to 60°C.
- This provides approximately a 27 minute (1620 seconds) timeframe based on tolerance limits defined in the 3rd edition of SFPE HB.

Figure 2-6.26. *Thermal tolerance for humans at rest, naked skin exposed, with low air movement (less than 30 m/min). Adapted from Blockley.¹¹³ See text and Table 2-6.16 for discussion of data points A to D.^{112,115,116}*

Visibility criteria for ASET

- RSET goal is to have personnel egressed prior to visibility is decreased below 6 m.
- 3rd edition of SFPE has multiple values averaging approximately 9.5 m.
- A 6 m value provides a buffer of roughly 50%.

Table 2-4.2 Allowable Smoke Densities and Visibility That Permits Safe Escape

Degree of Familiarity with Inside Building	Smoke Density (extinction coefficient)	Visibility
Unfamiliar	0.15 1/m	13 m
Familiar	0.5 1/m	4 m

Table 2-4.3 Values of Visibility and/or Allowable Smoke Density for Fire Safe Escape Proposed by Fire Researchers

Proposer	Visibility	Smoke Density (extinction coefficient)
Kawagoe ⁷	20 m	0.1 1/m
Togawa ⁸	—	0.4 1/m
Kingman ⁹	4 ft (1.2 m)	—
Rasbash ¹⁰	15 ft (4.5 m)	—
Los Angeles Fire Department ¹¹	45 ft (13.5 m)	—
Shern ¹²	—	0.2 1/m
Rasbash ¹³	10 m	0.2 1/m

RSET Defined

The Required Safe Egress Time (RSET) is the summation of the time steps involved in the egress of all occupants from an area or building.

RSET

Detection time

FDS provided time for the fire to be detected.

Alarm Time

10 second requirement per NFPA 72. Assumes automatic detection is operational.

Pre-movement Time

30 second timeframe based on literature, includes;

- Recognition

- Response

Travel Time

The travel time will be calculated based on characteristics of the egress components and the occupants. This is the empirically based calculation gleaned from sources such as the SFPE HB or the FPHB.

The shipping area fire

Scenario #1

- The shipping area has frequently the highest fire load in the building.
- Although the fuel package for the area is potentially high, it is reasonably isolated from all other means of egress.
- Common ignition sources include common electrical office equipment and a small propane powered fork lift.
- **In this scenario the sprinklers within the Secured Storage area are disabled.**

1st Scenario - Shipping area fire

- The fire being modeled is based on data gleaned from the 3rd edition of the SFPE handbook with a HRR as shown at right.

Figure 3-1.13. *Storage units.*

1st Scenario – Shipping area fire

Temperature assessment

- The receiving area reaches a temperature of 60°C at the same time the sprinkler heads exterior to the storage room actuate at approximately 260 seconds.

Frame: 217
Time: 260.5

Visibility assessment

-
- A 3D visualization of a simulated environment, likely a water body or a terrain model. The scene is enclosed in a transparent rectangular box. The main area is a light blue surface, possibly representing water, with a dark blue, swirling pattern in the center. A brown, rectangular structure is positioned in the middle of the scene. In the foreground, there is a red, stepped structure resembling a staircase or a set of platforms. A color bar on the right side of the image indicates a scale from 1.50 to 31.5, with a red color at the top and blue at the bottom. The color bar has a red '5.97' label near the bottom.

1st Scenario – Shipping area fire

CO assessment

With the black demarcation set to our criteria of 1200 ppm for Carbon Monoxide concentration, the shipping area is roughly at 497 seconds.

Frame: 414
Time: 496.8

1st Scenario – Shipping area fire

Smoke layer height assessment

115 Second

ASET/RSET- Shipping fire

RSET - Shipping fire

ASET - Shipping fire

The average office fire

Scenario #2

- The average office has occupancy only during daylight hours with several offices having long periods where their occupant is absent for periods of weeks or months.
- The offices have stereotypical office equipment and furniture.
- In this scenario the sprinklers within the Office of origin are disabled.

2nd Scenario – Office fire

The office fire being modeled is based on data from the 3rd edition of the SFPE handbook with a HRR as shown at right.

Figure 3-1.39. Identical workstations with old-style wood furniture tested under open burning and under room fire conditions.

RSET – Office area/Travel time

Corridor Length =	170 feet
Corridor Width = 44 inches	3.67 feet
Corridor Boundary = 8 inches	1.33 feet
Corridor area =	397.8 ft ²
Occupants =	63 Persons
Density =	0.158371041 Persons/ft ²
k_1 =	275
a =	2.86
S =	150.4411765 ft/minute
Farthest occupant egress =	190 feet
Time to egress =	1.26 minutes 76 Seconds

RSET – Office area/Travel time

Door clear width =	2.83 feet
Door boundary = 6 inches	1 feet
Maximum Specific Flow =	24
	Persons/min
Calculated Flow ($F_c W_e$) =	43.92
	ute
Occupants =	63
Time to egress =	1.43 Minutes
	86 Seconds

RSET – Office area/Travel time

Stairway width =	44 inches	3.67 feet
Stairway boundary =	6 inches	1 feet
Stairway density =		0.175 Persons/ft ²
k_1 =		212
a =		2.86
S =		105.894 ft/minute
Floor height =		12 feet
Stair conversion factor =		1.85
Landing(s) =		2 number of
Length of landings =		8 feet
Stair distance =		38.2 feet
Time to egress =		0.36 Minutes 22 Seconds

Total egress time =	3.05 Minutes 184 Seconds
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Common Office fire

- The common office fire assumes a point of ignition intimate with a desk, typically electrical in nature although candles are not uncommon.
- The fuel load is allowed to free burn by assuming sprinkler failure within the room of origin, the sprinklers flow is obstructed or the pipe has an internal obstruction.
- The sprinklers outside of the room are operational.

Common Office fire

Egress requires navigation down either hallway to reach one of two second floor stairways.

2nd Scenario – Office fire

Temperature assessment

The criteria of 60°C is met at approximately 1084 seconds.

2nd Scenario – Office fire

CO assessment

The criteria of
1200 ppm
Carbon
Monoxide was
reached outside
of the room at
approximately
1593 seconds.

Frame: 937
Time: 1592.9

2nd Scenario – Office fire

Visibility assessment

Visibility in the common office area outside of the office, and the hallways, decreases below 6m at around 1200 seconds.

2nd Scenario – Office fire

Smoke layer assessment

211 Second

ASET/ RSET – Office fire

RSET - Office Fire

ASET - Office fire

Summary

- All tenability limits are well within reasonable limits in adequate egress times with the exception of smoke layer height.
- The building construction meets all construction criteria of the 2009 IBC that are able to be readily assessed.
- Questions?