Fire Protection Analysis Cotchett Education Building

Building 002

Cal Poly, San Luis Obispo

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Cotchett Education Building Building 002

Built in the 1940s

Extensively remodeled when the adjoining **Business Building** was built in approximately 1989.

The central, open stairway was added at this time

the clock tower is not considered occupiable space.

Unsprinklered

Since this is an existing building, with various modifications made during the life of the building, it will be analyzed as an existing building. *NFPA 101, Life Safety Code, 2012 edition* (LSC) contains requirements for existing buildings, and will be the primary code used in this analysis. Other codes used in analysis will be referenced in each section.

CAL POLY

Fire Protection Engineering

N

LEGEND

Assembly

Business

Storage

Mechanical Rooms

Electrical Rooms

Rest Rooms

Elevator

Exit Corridors

Exit Stairs

To Business Building
Not considered in egress calculations

Second Floor

Classrooms and lecture halls
Mechanical and electrical

Structural Fire Protection Analysis

The building was added to, and remodeled to the *Uniform Building Code*, 1985 edition, and designed as Type II FR construction.

This is the equivalent to **IBC Construction Type IB**

This Structural Code Analysis is based on *The International Building Code*, 2009 edition (IBC) requirements for new construction.

Analyzing the building under this standard allows comparison to current expected levels of safety, even though it was designed to earlier standards.

Occupancy

304.1 Business Group B. Business Group B occupancy includes, among others, the use of a building or structure, or a portion thereof, for office, professional or service-type transactions, including storage of records and accounts. Business occupancies shall include, but not be limited to, the following:

Educational occupancies for students above the 12th grade.

There are also **offices**, also classified as Business Occupancy. (IBC, section 304.1)

Minor storage rooms, lecture rooms and electrical and mechanical rooms are considered as accessory to the predominate Business Occupancy. (IBC, section 508.3.1) No separations between occupancies are required per table 508.3.3.

Unsprinklered Building

	Max. Height Above Grade	Maximum Stories Above Grade	Maximum Tabular Area (A_t)	Maximum Allowable Area per Floor (A_a)	Maximum Allowable Total Building Area
Source	From Table 503	From Table 503	From Table 503	$A_t \times 1.25$ Per Section 506.1	$A_a \times 3$ Per Section 506.4.1
Units	(ft)		(sf)	(sf)	(sf)
Minimum Required for This Building	61.5	3	N/A	45,932	132,478
Construction Type					
IA	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited
IB	160	11	Unlimited	Unlimited	Unlimited
IIA	65	5	37,500	46,875	140,625
IIB	55	3	23,000	28,750	86,250
IIIA	65	5	28,500	35,625	106,875
IIIB	55	3	19,000	23,750	71,250
IV	65	5	36,000	45,000	113,500
VA	50	3	18,000	22,500	67,500
VB	40	2	9,000	11,250	33,750

Note: Table entries in **red** are insufficient and these construction types are not allowable for this building if unsprinklered.

Table entries in **green** are for actually used construction type IB

IBC Fire Resistance Requirements

The IBC would allow unsprinklered construction types IA, 1B and IIA for this building.

The building was actually constructed to the *Uniform Building Code, 1985 edition*, Type II FR construction. This has very similar fire resistance requirements to IBC Type IB. Because of this, this analysis will be based on IBC Type IB construction, which is acceptable for this building.

Building Element	Required by Table 601, IBC, 2009 Edition, Type IB	Required by Uniform Building Code, 1985 edition, Type II FR
Primary Structural Frame	2 hr	2 hr
Nonbearing Walls and Partitions	0 hr	0 hr
Floor Construction and Secondary Members	2 hr	2 hr
Roof Construction and Secondary Members	1 hr	1 hr

Exiting and Code Analysis

Based on *NFPA 101, Life Safety Code, 2012 edition* (LSC) requirements for existing construction

The building is primarily college classrooms. College and university instructional buildings, classrooms under 50 persons, and instructional laboratories are classified as Business Occupancy

There are also offices, also classified as **Business Occupancy**. Minor storage rooms and electrical and mechanical rooms are considered as incidental to the predominate **Business Occupancy**.

College and university classrooms, 50 persons and over are classified as **Assembly Occupancy**

The Business and Assembly occupancies will be treated as Mixed Occupancies, needing to meet the more restrictive of the two occupancies

Occupant Loads

Area	Occupancy	LSC section per LSC table 7.3.1.2	Occupant Load Factor
Classrooms 50 or over Occupants (Less concentrated use, without fixed seating)	Assembly	6.1.2.1	15 Net
Classrooms under 50 Occupants (Educational use, classrooms)	Business	6.1.11.1	20
Offices, other Business Uses	Business	6.1.11.1	100
Storage, other than storage and mercantile	Storage	6.1.13.1	500

Because the building is primarily **Business Occupancy**, and **Business Occupancy** is based on gross square footage, areas such as corridors and mechanical and electrical rooms will be analyzed at the Business Occupancy load of 100 ft² per person.

Basement exiting capacity

Location	Door Width	Door Capacity	Stair Width	Stair Capacity	Governing Capacity
Corridor C05	36"	180	56" (exterior)	201	180
Corridor C01	64"	320	66" (exterior)	247	247
Corridor C02	64"	320	2@48" (exterior)	330	320
Stair 2	42"	210	56"	201	201
Room 10	36"	180	56" (exterior)	201	180
Total Basement Exit Capacity					948
Basement occupant load					183

Total available exiting capacity of **948** persons greatly exceeds occupant load of **183**.

Second Floor exiting capacity

Location	Door Width	Door Capacity	Stair Width	Stair Capacity	Governing Capacity
Stair 2	42"	210	56"	201	201
Stair 3	N/A	N/A	56"	201	201
Stair 4	N/A	N/A	56"	201	201
Total Second Floor Exit Capacity					603
Second Floor occupant load					405

Total available exiting capacity of **603** persons exceeds occupant load of **405**.

First Floor exiting capacity

Location	Door Width	Door Capacity	Stair Width	Stair Capacity	Governing Capacity
Corridor C15	64"	320	N/A	N/A	320
Corridor C11	64"	320	84" (interior)	330	320
Corridor C12	3@ 72"	1080	N/A	N/A	1080
Stair 2	42"	210	56"	201	201
Total First Floor Exit Capacity					1921
First Floor occupant load					405

Total available exiting capacity of **1921** persons greatly exceeds occupant load of **405**.

Stairways

Stair 1

Serves Floors: Basement and First

Provides Exiting for: Basement,
Not considered in egress analysis.

Discharges to: First Floor
(Corridor)

LSC Code Section: 8.6.9
Convenience Openings.

This stairway is only separated from the first floor and cannot serve as a required means of egress.

Stairways

Stair 2

Serves Floors: Basement,
First and Second

Provides Exiting for:

Basement, First and
Second

Discharges to: Outside
(between the basement
and first floor)

LSC Code Section: 8.6.5
Required Fire Resistance
Rating

This is a conventional
egress stairway,
connecting all three
floors and is required to
have a 1- hour fire
separation.

Stairways

Stair 3

Serves Floors: First and Second

Provides Exiting for: Second
Discharges to: First Floor
(Corridor)

LSC Code Section: 8.6.6
Communicating Space.

This is an open stairway that discharges at the first floor corridor C01. Rated separations enclose the combined first floor corridor C11, second floor corridor C21 (north end) and stair, creating a Communicating Space. The first floor corridor C11 discharges to outdoors.

Stairways

Stair 4

Serves Floors: First and Second

Provides Exiting for: Second

Discharges to: First Floor (Lobby)

LSC Code Section: 8.6.6 Communicating Space.

This is an open stairway that discharges at the first floor lobby. Rated separations enclose the combined first floor lobby, second floor lobby and stair, creating a Communicating Space. The lobby discharges to both outdoors and the Business 03 building.

Communicating Spaces

Stairs 3 and 4 are communicating spaces, and comply with the LSC requirements at the right.

However, (5) requires either:

Approved automatic sprinkler system

(No sprinkler system)

Or

Only low hazard contents, of such low combustibility that no self-propagating fire therein can occur.

“Very few occupancies qualify as having low hazard contents.”

“Pig iron ingots stored underwater.”

(Strict administrative controls would be required)

This will be addressed in Recommendations.

Communicating Spaces :

Unless prohibited by Chapters 11 through 43, unenclosed floor openings forming a communicating space between floor levels shall be permitted, provided that the following conditions are met:

- (1) The communicating space does not connect more than three contiguous stories. *(Complies, connects two stories)*
- (2) The lowest or next-to-lowest story within the communicating space is a street floor. *(Lowest floor discharges at street level)*
- (3) The entire floor area of the communicating space is open and unobstructed, such that a fire in any part of the space will be readily obvious to the occupants of the space prior to the time it becomes an occupant hazard. *(Complies)*
- (4) The communicating space is separated from the remainder of the building by fire barriers with not less than a 1-hour fire resistance rating. *(Complies)*
- (5) **The communicating space has ordinary hazard contents protected throughout by an approved automatic sprinkler system in accordance with Section 9.7 (No sprinkler system) or has only low hazard contents (Strict administrative controls would be required) . (See 6.2.2.) (See recommendations)**
- (6) Egress capacity is sufficient to allow all the occupants of all levels within the communicating space to simultaneously egress the communicating space by considering it as a single floor area in determining the required egress capacity. *(Complies, egress capacity of 1080 is sufficient for entire building.)*
- (7)* Each occupant within the communicating space has access to not less than one exit without having to traverse another story within the communicating space. *(Complies)*
- (8) Each occupant not in the communicating space has access to not less than one exit without having to enter the communicating space. *(Complies)*

Communicating Spaces

Stairs 3 and 4 were part of the analysis and remodeling done in the late 1980s, and this arrangement was acceptable under the UBC of the time:

*Sec. 3309.(a) **General.** Interior stairways, ramps or escalators shall be enclosed as specified in this section.*

EXCEPTIONS: *1. In other than Groups H and I Occupancies, an enclosure need not be provided for a stairway, ramp or escalator serving only one adjacent floor and not connected with corridors or stairways serving other floors.*

This does not comply with the details of current LSC requirements for existing buildings.

Communicating Spaces – Stair 3 :

(3) The entire floor area of the communicating space is open and unobstructed, such that a **fire in any part of the space will be readily obvious** to the occupants of the space prior to the time it becomes an occupant hazard.

(Does not comply, communicating space is mazelike.)

(8) Each occupant not in the communicating space has **access to not less than one exit without having to enter the communicating space**. *(Does not comply, communicating space has rooms whose only egress is through the communication space.)*

Building Evacuation Time

Based on unimpeded exiting.

Calculations do not include horizontal exiting to Business Building.

	Hand Calculation	Pathfinder
Pre-Movement Time	60 s	60 s
Movement time	306 s	160 s
Total Travel Time	366 s	220 s

Pathfinder Model

Floor 0.00 Floor 3.66

Floor 7.32

Exited: 426 / 993

Fire Alarm System Analysis

NFPA 101, Life Safety Code, 2012 edition (LSC) contains requirements for existing buildings, including fire alarm system requirements.

The fire alarm system must be installed in conformance with section 9.6 of the LSC and NFPA 72®, *National Fire Alarm and Signaling Code*, 2010 edition.

A fire alarm system is required by section 39.3.4.1 of the LSC which states:

39.3.4.1 General. A fire alarm system in accordance with

Section 9.6 shall be provided in all business occupancies

where any one of the following conditions exists:

(1) The building is three or more stories in height.

(2) The occupancy is subject to 100 or more occupants above or below the level of exit discharge.

(3) The occupancy is subject to 1000 or more total occupants

Initiation

39.3.4.2 Initiation. Initiation of the required fire alarm system shall be by one of the following means:

(1) Manual means in accordance with 9.6.2.1(1)

(2) Means of an approved automatic fire detection system that complies with 9.6.2.1(2) and provides protection throughout the building

(3) Means of an approved automatic sprinkler system that complies with 9.6.2.1(3) and provides protection throughout the building

9.6.2.3 A manual fire alarm box shall be provided as follows, unless modified by another section of this Code:

(2) For existing alarm system installations, the manual fire alarm box either shall be provided in the natural exit access path near each required exit or within 60 in. (1525 mm) of exit doorways.

9.6.2.5* Additional manual fire alarm boxes shall be located so that, on any given floor in any part of the building, no horizontal distance on that floor exceeding 200 ft (61 m) shall need to be traversed to reach a manual fire alarm box.

Notification

Occupant notification means (1), general alarm, is provided in building corridors and two of the larger rooms in the basement, using audio/visual devices.

Other areas will need to be notified by means (2), via a voice communication or public address system.

Section 39.3.4.3 of the *Life Safety Code* has the following requirement for occupant notification in a Business occupancy:

39.3.4.3 Occupant Notification. During all times that the building is occupied (see 7.2.1.1.3), the required fire alarm system, once initiated, shall perform **one of the following** functions:

(1) It shall activate a **general alarm** in accordance with 9.6.3 throughout the building, and both of the following also shall apply:

(a) Positive alarm sequence in accordance with 9.6.3.4 shall be permitted.

(b) A presignal system in accordance with 9.6.3.3 shall be permitted.

(2) Occupant notification shall be permitted to be made via a voice communication or **public address system** in accordance with 9.6.3.9.2.

Basement

Has non-required smoke detectors and duct detectors.

Pull Station Locations are acceptable.

Audible Signaling is acceptable.

Visual Signaling deficiency:

Corridor west of room 25A (no visible device)

First Floor

Pull Station Locations are acceptable.

Audible Signaling is acceptable.

Visual Signaling deficiencies:

North corridor, west of room 118, visual device is over 15 feet from end of corridor.

South end of south corridor, south of rooms 129 and 130 (no visible device)

Second Floor

Pull Station Locations are acceptable.

Audible Signaling is acceptable.

Visual Signaling deficiencies:

North corridor, west of room 201, visual device is over 15 feet from end of corridor.

Corridor south of room 214 (no visible device)

Proposed Fire Sprinkler System

Since the building is **unsprinklered**, a conceptual design for a fire sprinkler system has been developed as part of this project .

Design based on
NFPA 13,
Installation of Fire Sprinkler Systems,
2013 edition

Basement

Primarily Light Hazard
(offices and support facilities)

Some Ordinary Hazard (Group 1)
(storage, electrical rooms and mechanical rooms).

First Floor

Primarily Light Hazard

(offices, classrooms, teaching labs and lecture rooms)

Some Ordinary Hazard (Group 1)

(storage).

Hydraulic Calculations

For

Cotchett Education Building

Building 002

Cal Poly

San Luis Obispo

February 14, 2013

Remote Area: 1

Remote Area Location: Second Floor

Occupancy Classification: Light Hazard

Density: 0.10 gpm/ft²

Area of Application: 900 ft²

Coverage per Sprinkler: 225 ft² max

Type of Sprinklers Calculated: ½" orifice, K= 5.6, Quick Response

Number of Sprinklers Calculated: 8

Hose Stream: 100 gpm

Total Water Required (Including Hose Stream): 238.2 gpm @ 42.8 psi

Type of System: Wet Pipe

Water Supply

Information: Static: 60 psi

Residual: 55 psi

Flow: 914 gpm

Date: 8/19/2011

Location: N. Poly View Drive

Hydraulic Calculations

For

Cotchett Education Building

Building 002

Cal Poly

San Luis Obispo

February 14, 2013

Remote Area: 2

Remote Area Location: Second Floor

Occupancy Classification: Ordinary Hazard (Group 1)

Density: 0.15 gpm/ft²

Area of Application: Entire Room

Coverage per Sprinkler: 130 ft² max

Type of Sprinklers Calculated: ½" orifice, K= 5.6, Quick Response

Number of Sprinklers Calculated: 9

Hose Stream: 250 gpm

Total Water Required (Including Hose Stream): 388.8 gpm @ 37.7 psi

Type of System: Wet Pipe

Water Supply

Information: Static: 60 psi

Residual: 55 psi

Flow: 914 gpm

Date: 8/19/2011

Location: N. Poly View Drive

Performance Based Analysis

Stairs 3 and 4 are both classified under **communicating spaces** by the *Life Safety Code*.

The *Life Safety Code* requires that the communicating space has **ordinary hazard contents protected throughout by an approved automatic sprinkler system** or has **only low hazard contents**.

Life Safety Code Handbook: “**Very few occupancies qualify as having low hazard contents.**” Most combustibles would have to be prohibited from these areas in order to comply with the prescriptive requirements of the *Life Safety Code*.

Since complying with the *Life Safety Code* would entail either installing a fire sprinkler system or extreme administrative control of combustibles, fires in the areas of stairs 3 and 4 are chosen for the Design Fire Scenarios.

Performance Based Design

The *Life Safety Code*, Chapter 5 sets forth criteria for performance based design:

5.2.2* Performance Criterion.

Any occupant who is not intimate with ignition shall not be exposed to instantaneous or cumulative untenable conditions.

A.5.2.2 One of the methods that follows can be used to avoid exposing occupants to untenable conditions...

Of the five options presented methods 2 was chosen as the most appropriate for this building.

Method 2. For each design fire scenario and the design specifications, conditions, and assumptions, the design team can demonstrate that each room or area will be fully evacuated before the smoke and toxic gas layer in that room descends to a level lower than 6 ft (1830 mm) above the floor.

Design Fire Scenario 1

Evacuation times are hand calculated, with **stair 3 presumed to be unusable due to the fire.**

The FDS fire modeling program was used to model the fire. The time for the smoke layer to reach 6 feet (1.83m) above floor was measured in several locations.

LSC Design Fire Scenario 1:

Represents a typical fire expected in this occupancy and location.

Location:

Near Stair 3, at first floor, north end of the building

Fuel:

Trash Bag (trash can fire, possibly in a janitor's cart)

Max Heat Release Rate: 350 kW.

Source:

SFPE Handbook, Figure 3-1

Evacuation Time Calculation

Stair 3 is presumed to be unusable due to the fire.

By far, stairway 2 is the most demanding egress path and will be examined.

Design Fire Scenario 1 Summary

Smoke detector activation time: 0.66 minute (40 seconds)
(from FDS)

Pre-movement time: 1.00 minute

Time to pass through exit: 6.25 minute

Stair movement time: 0.60 minute

Reqd Safe Egress Time (RSET): 8.51 minutes

Avail Safe Egress Time (ASET): 1.0 to 6.8 minutes (from FDS)

RSET is greater than ASET, so life safety criteria fail.

Design Fire Scenario Second Floor

Design Fire Scenario 1

Design Fire Scenario 1
Time 40 seconds
Smoke Detector Activates

Design Scenario 1
Time 410 Seconds
2nd floor north becomes untenable

Design Fire Scenario 2

Evacuation times are hand calculated, with **stair 4 presumed to be unusable** due to the fire.

The FDS fire modeling program was used to model the fire. The time for the smoke layer to reach 6 feet (1.83m) above floor was measured in several locations.

LSC Design Fire Scenario 8:

Assumes that **self-closing doors at the second floor do not close**.

Location:

Near Stair 4, at first floor lobby at center of the building

The fuel chosen for this model was intended to represent any of the **more demanding, possibly transient fuel sources**.

Fuel	Max Heat Release Rate	Source: SFPE Handbook
CEA Standard Commodity: Pallet load of cardboard boxes Containing polystyrene chips	3300 kW	Figure 3-1.42
Kiosk	2000 kW	Figure 3-1.54
Christmas tree (20% moisture content)	3000 kW	Figure 3-1.68
Sofa	3000 kW	Figure 3-1.102
Representative HRR	3000 kW

Design Fire Scenario 2

Design Fire Scenario 2 First Floor

Evacuation Time Calculation

Stair 4 is presumed to be unusable due to the fire. This divides the building at the center. The egress time for the north and south sections will be individually calculated.

Design Fire Scenario 2 Summary

	North	South
Smoke detector activation time (from FDS, see appendix 15)	2.33 minutes	2.33 minutes
Pre-movement time:	1.00 minute	1.00 minute
Time to pass through exit:	3.20 minutes	9.00 minutes
Stair movement time:	0.60 minute	0.60 minute
Reqd Safe Egress Time (RSET):	7.13 minutes	12.93 minutes
Avail Safe Egress Time (ASET):	2.0 to 3.0 minutes	2.0 to 3.0 minutes

RSET is greater than ASET, so life safety criteria fail.

Design Fire Scenario 2

Recommendations

Alarm System

The Alarm System section of this analysis details alarm annunciation deficiencies to be verified and corrected.

Exiting

Both **stairs 3 and 4** are classified under **communicating spaces** per the *Life Safety Code*, which applies to both new and existing buildings.

It requires that the communicating space has ordinary hazard contents protected throughout by an approved automatic sprinkler system or has only low hazard contents.

This arrangement is acceptable under the 1985 UBC they were last remodeled under and the current IBC, so it is not a code violation.

However it does not comply with the LSC requirements for existing buildings, which is commonly accepted as an accepted minimum level of safety for existing buildings, the following applies if LSC compliance is desired.

Fires in the areas of stairs 3 and 4 were chosen for performance based analysis. Unfortunately, neither simulation produced passing results.

This leaves the prescriptive options to comply with the *Life Safety Code*.

Recommendations

Stair 4

Institute stringent administrative controls, allowing only low hazard contents that are of such low combustibility that no self-propagating fire therein can occur. This would entail **extreme control on the placement, use, storage and staging of combustibles in the main lobby and stairway 4**. Such controls may be difficult to impossible to practically implement.

Alternatively, install an approved automatic sprinkler system in accordance with Section 9.7 of the *Life Safety Code*.

Recommendations

Stair 3

In addition to the issues noted for Stair 4, Stair 3 has the additional issues of:

A fire in any part of the space will not be readily obvious to the occupants of the space prior to the time it becomes an occupant hazard.

Each occupant not in the communicating space does not have access to not less than one exit without having to enter the communicating space.

One way to comply with the prescriptive LSC requirements would be to convert stair 3 into an enclosed stair by adding rated walls and doors at each floor.

It is possible that this is impractical or undesirable.

Another potential solution would be to deem that the addition of a code complying sprinkler system would be considered to provide at least an equivalent level of safety.

Design Fire Scenario 1 First Floor