



<b>Client Name:</b>	<b>Unico Properties</b>		
<b>Project Number:</b>	C18-000F.2	<b>Date:</b>	8/30/2019
<b>Distribution:</b>	Ty Barker, Unico Properties		
<b>Subject:</b>	Attachment #1 – Egress Performance Analysis		
<b>Referenced Codes and Standards:</b>	2014 Oregon Structural Specialty Code Society of Fire Protection Engineers (SFPE) Handbook, 3 <sup>rd</sup> Edition		
<b>Building Name:</b>	Moda Tower		
<b>Room Area Affected:</b>	Level 09		

## 1. OVERVIEW

The Moda Tower is an existing 24-story high-rise building in downtown Portland. The building contains 6 levels of parking, with Group B (business) tenants located in the stories above. The building is equipped throughout with a fully automatic sprinkler system and an emergency voice/alarm communication system.

The 9<sup>th</sup> floor of the building will be undergoing tenant improvements but will remain as a Group B occupancy space. The two interior exit stairways will remain as existing. Currently, the existing building is permitted with an appeal that restricts the number of occupants to 333 persons per floor based on the 1997 OSSC. Per 2014 OSSC Exception for §1005.3.1 and §1005.3.2, the means of egress components (stair/door/corridor) are prescriptively allowed a higher egress capacity (based on a smaller egress factor) when the building is equipped with an emergency voice/alarm communication system. Utilizing this reduction in the egress width factor, the stairways can accommodate 500 occupants instead of the 333 currently permitted.

The occupant load limit of 333 occupants per floor was established by an appeal. Appeal ID #20705 was submitted to request that the prescriptive 2014 OSSC exception be applied to the stairways and doorways on Floor 09 in lieu of restricting the occupant load to 333 persons in accordance with the existing appeal. However, procedurally that will require a full building analysis. At this time the owner has selected to follow a narrow path for the 9<sup>th</sup> floor only. Code Unlimited has performed the egress analyses documented in this report to demonstrate that the proposed design provides equivalent or additional life safety compared to the permitted existing condition, without analyzing all the floors and all life safety requirements that would apply to this 24-story building.

This is accomplished by a comparison of the proposed design of 500 occupants against the baseline condition of 333 occupants. Our analysis demonstrates that the proposed design

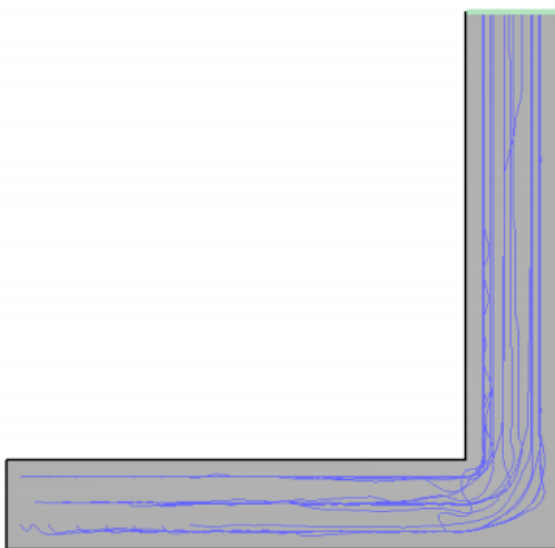
provides faster egress than the baseline existing condition. Based on the widening of the entry door to 48-inches and the voice announcement currently provided throughout the building, all the 500 occupants from the level 09 of this building reach an exit **1 minute and 25 seconds faster** than in the existing permitted condition.

## 2. EGRESS SIMULATION

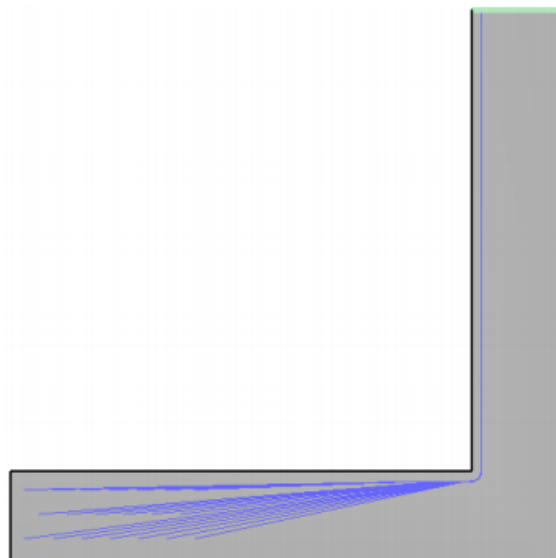
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Pathfinder, an advanced occupant-movement simulation software designed by Thunderhead Engineering, was used to determine building evacuation times. The latest release of the software, (Pathfinder 2019.1) was utilized for the modeling. This software is an agent-based egress simulator that uses steering behaviors to model occupant motion. Pathfinder is also a validated software for use in computer modeling of building evacuation as per Table 60.1 of the SFPE Handbook 5<sup>th</sup> Edition.

The simulation for the behaviors of the occupant movement utilized Steering Mode. This mode models a realistic simulation of occupant behavior during egress and queuing. Occupants are modeled to avoid collisions and simulate movements of pedestrians in a traffic system (Figure 1). This is more conservative and realistic compared to the SFPE Mode where occupants can occupy a single space simultaneously. SFPE Mode sets limitation on occupant flow rate through egress components (doorways, corridors, stairways) and simulates occupants utilizing the shortest path to egress, which leads to occupants overlapping each other (Figure 2). Occupants do not react with the changing environment during egress in SFPE Mode, such as avoiding collisions with other occupants or walls and boundaries or navigating available space.



**Figure 1:** Occupant trails around a corridor modeled in Steering Mode.



**Figure 2:** Occupant trails around a corridor modeled in SFPE Mode.

**Table 1:** Summary of walking speeds on horizontal surfaces per the SFPE Handbook.

Ambulatory Ability	Percentage of Occupants	Walking Speed
Locomotive Disability	15%	2.62 ft/s
No Locomotive Disability	85%	4.10 ft/s

The SFPE Handbook Table 3-12.4 provides walking speeds on horizontal surfaces. As summarized in Table 1 below, those with full ambulatory abilities have a walking speed of 4.10 ft/s (1.25 m/s). Those with locomotor disabilities are reported to move at 2.62 ft/s (0.8 m/s). Walking speeds on stairs are computed by the software in accordance with Engineering Guide to Human Behavior in Fire (SFPE, 2003).

The inputs to the simulation represent the occupant movement that is expected in the evacuation of the business building. As referenced in the 4<sup>th</sup> Edition of the SFPE Handbook of Fire Protection Engineering, the U.S. Census Bureau reported in 2005 that 14.9% of the U.S. population 5 years and older had some level of disability, excluding people living in institutions. Since this is a business occupancy and majority of occupants will be adult population with standard mobility, 15% of the building occupants have been assumed to have mobility impairment (Table 1).

The percentage of occupants with mobility impairments does not pose a significant limitation on the total egress time in this analysis. The occupants' steering behavior allows occupant avoidance during egress, which permits faster moving occupants to move around slower moving occupants. Therefore, the limits posed by occupants with mobility impairments is based on the one occupant furthest from an exit and with a mobility impairment. The simulations demonstrate that the largest factor affecting total egress times is queueing at "pinch points" such as doorways, corridor entrances from open areas and along stairways on the upper floors.

### 3. PARAMETER COMPARISON

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Two egress simulations were performed using Pathfinder; the first to establish the travel time required to egress all occupants under the 333 occupant appeal scenario both from the 9<sup>th</sup> floor and from the building, and then to establish the egress time for the proposed design with the higher occupant load utilizing wider door widths and emergency voice/alarm communication system. The two simulations were compared to determine if equivalent or better protection is provided by the proposed design. The simulations are based on a comparison of the following parameters:

- Occupant Load
- Doorway Width
- Emergency Voice/Alarm Communication System

### 3.1 Occupant Load

The occupant load in the baseline condition scenario is based on the existing conditions with an approved appeal of 333 occupants per floor. This is based on provisions of the UBC, Table 10-B, under which the appeal was granted, which limited the number of occupants based on the stair width. The stair width of 50” resulted in a maximum occupant load of 333 persons between the two stairs.

The 2014 OSSC includes a prescriptive reduction in the capacity factor for stairways, from 0.3 inches per occupant to 0.2 inches per occupant, that did not exist in the building code at the time of the original appeal. Based on this reduction, the two (2) existing 50” wide stairways can accommodate a total of 500 occupants. Since the focus of this analysis was on the effects of increasing occupant load on the 9<sup>th</sup> floor, the simulation of the proposed design includes 500 occupants on Level 09 but limits all other floors to 333 occupants in accordance with the existing approved appeal.

### 3.2 Doorway Width

Table 10-B in the UBC, the basis for the 333-occupant appeal, required doors used as a means of egress to be sized at 0.2 inches in net clear width per occupant. Under those requirements, the minimum door width required was 33.4”, which the 36” nominal width doors could meet.

The 2014 OSSC includes a prescriptive reduction in the capacity factor for doors, from 0.2 inches per occupant to 0.15 inches per occupant, that did not exist in the building code at the time of the original appeal. However, even with this reduction in capacity factor, the existing doorways could not provide sufficient egress capacity to meet the needs of egressing an occupant load of 500 as proposed.

Under the prescriptive reduction, door widths would need to be increased to approximately 37.5” clear width to accommodate all proposed occupants. To provide additional protection for the proposed design, the doors to the vestibule and stairways on Level 09 will be increased from the existing 36 inches (approximately 34” net clear width) to 48 inches wide (approximately 46” net clear width). The larger door will allow occupants on Level 09 to enter the rated stairway enclosure more quickly, with less queuing around the doorways, but the travel down the stairs is still limited by the stair widths.

Note: Both interior exit stairways are pressurized in the existing condition. Pressure differentials were measured for the existing doorways. Calculations were performed to evaluate force to open with the wider 48-inch doors in accordance with 2014 OSSC §909.6.2 and found to be within requirements of 2014 OSSC §1008.1.3.

### 3.3 Emergency Voice/Alarm Communication System

The fire alarm system has been updated from horns/strobes to an emergency voice/alarm communication system in accordance with §907.5.2.2. The emergency voice/alarm communication system is installed as Class B pathways, with wiring enclosed in conduit and 2-hour fire-rated shaft enclosures. Since the building is sprinklered, the system classifies as Pathway Survivability Level 1 as defined in NFPA 72 and satisfies the NFPA and OSSC requirements. The emergency voice/alarm system affects the following parameters:

- *Phased Evacuation*

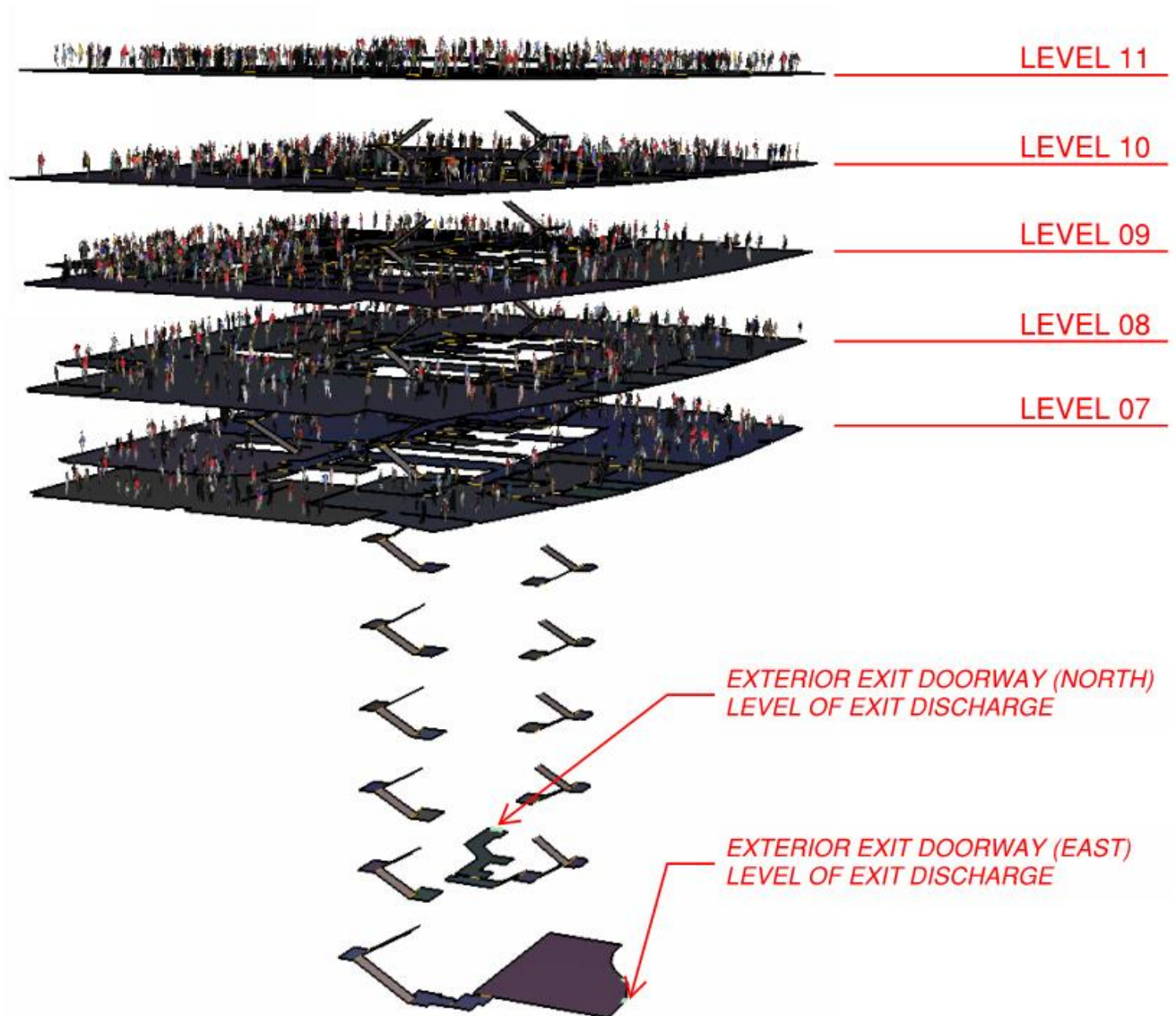
Because the building is now equipped with an emergency voice/alarm communication system, occupants can egress in a phased evacuation. Phased evacuation will result in decreased congestion in the stairs during exiting. At the time the existing building was permitted, the building would not have been installed with an emergency voice/alarm communication system meeting current code requirements and exiting for all floors would occur simultaneously on any alarm.

To measure the effects of congestion on the stairways, both models included the egress of occupants on Level 09 with simultaneous egress of the two floors above and two floors below (see Figure 3). By limiting the older, non-voice alarm system to phased evacuation for comparison to the current fire alarm system, congestion for the non-voice alarm system would be reduced and the comparison is more conservative.

- *Pre-Evacuation Time*

The recently updated fire alarm system has been improved the building performance beyond the design basis used for the 333-occupant appeal. This is reflected in the 2014 OSSC for means of egress width factors permitted for a building with voice alarm and evacuation.

For egress modeling, the pre-evacuation time (time after fire is detected and alarm is sounded, but before occupants begin to move towards exits) is based on the type of notification that occupants receive. Under the old, 333 occupant load scenario, the pre-evacuation time of 4 minutes was based on an audible alarm which did not provide specific information on fire location and exiting. With the addition of voice alarm/evacuation, response to fire alarms is significantly improved and a pre-evacuation time of 1 minute is more common. For the models evaluated for this study, pre-evacuation times of 4 minutes for the audible-only, 333 occupant scenario was used versus 1 minute for the current, voice alarm/evacuation communication system scenario being proposed. Pre-evacuation times for both conditions was based on Table 3-13.1 in the SFPE Handbook, 3<sup>rd</sup> Edition.



**Figure 3:** Both the Existing and Proposed models included the occupants on Levels 07-11, as well as the path of travel to the building exterior.

## 4. RESULTS ANALYSIS

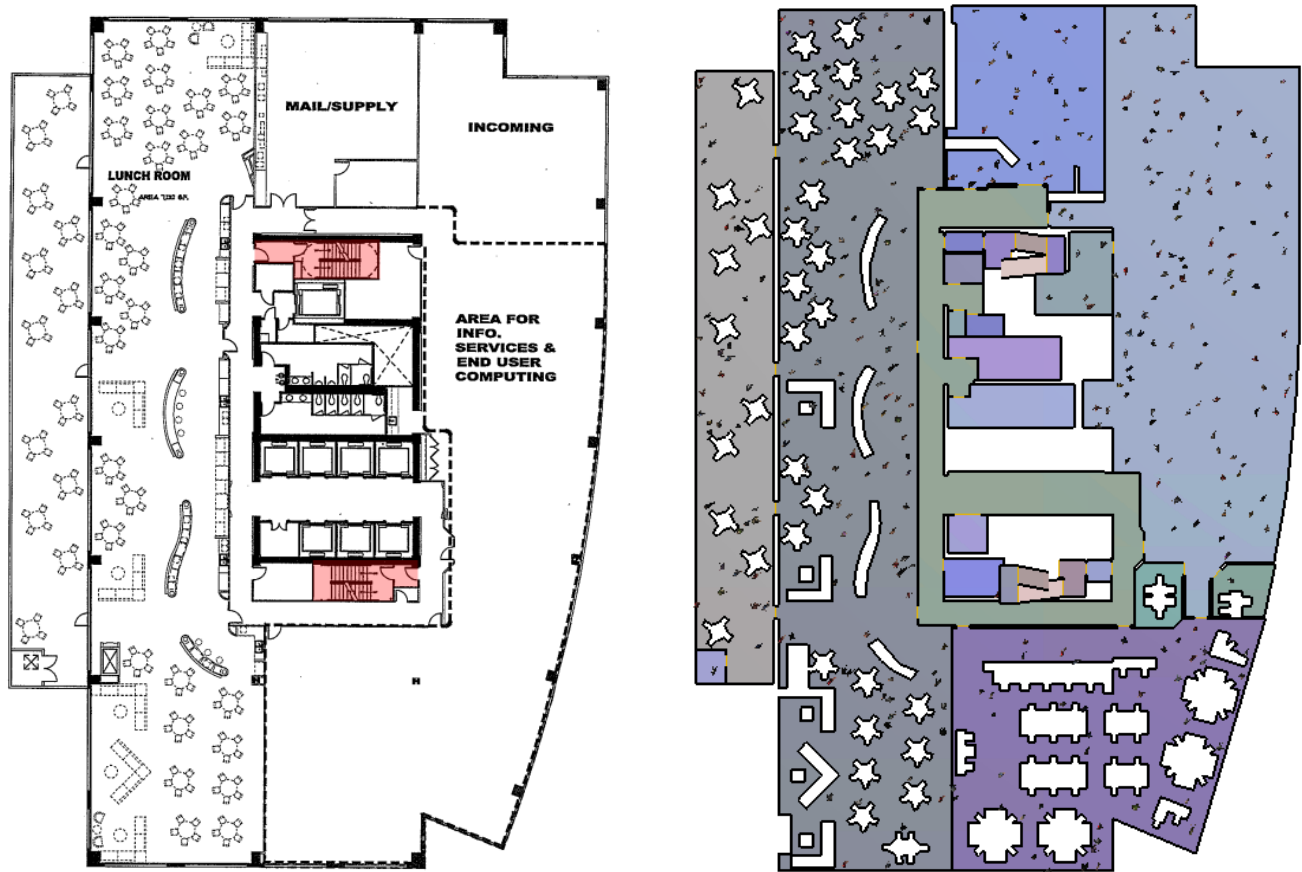
For modeling purposes, the occupants were randomly distributed in the rooms within each level, with no occupants starting in the corridors.

The success criterion for the egress models was based on comparing the egress time of occupants on Floor 09. The code does not restrict the travel distance once an occupant is within a fire-resistance rated enclosed exit stairway. However, to include the effects of congestion from surrounding floors, the five floors were modeled with stairways leading to exterior exit doorways on the level of exit discharge.

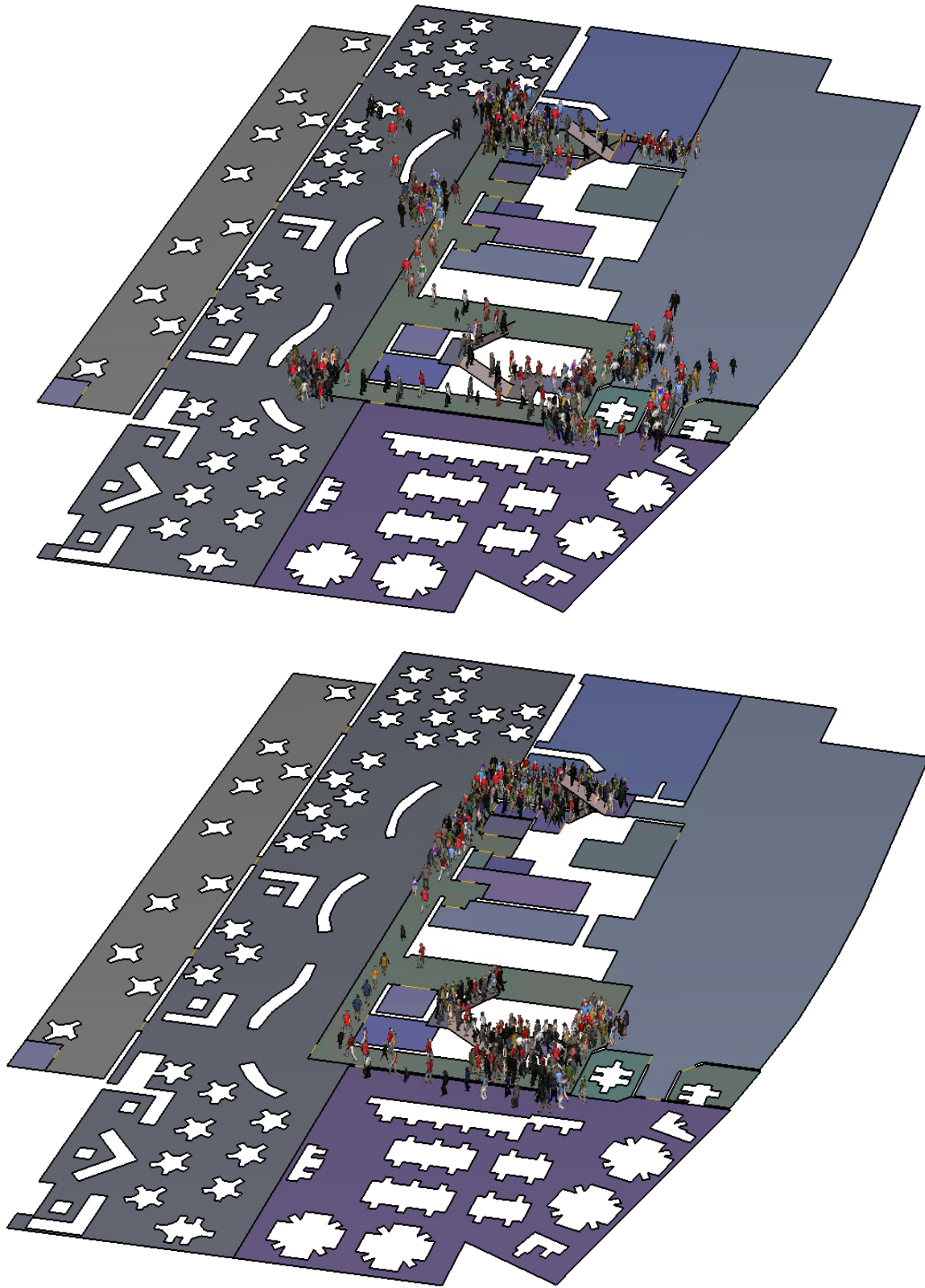
## 4.1 Existing Design

The existing design included 36-inch doorways leading to the enclosed interior exit stairway with 333 occupants on all floors.

The egress time, including pre-evacuation time, required for all occupants on Level 09 to reach a rated stairway enclosure was found to be **16 minutes and 10 seconds**.



**Figure 4:** Level 09 floor plan of the existing design with interior exit stairways highlighted in red (left); Pathfinder model of Level 09 with 333 occupants (right).

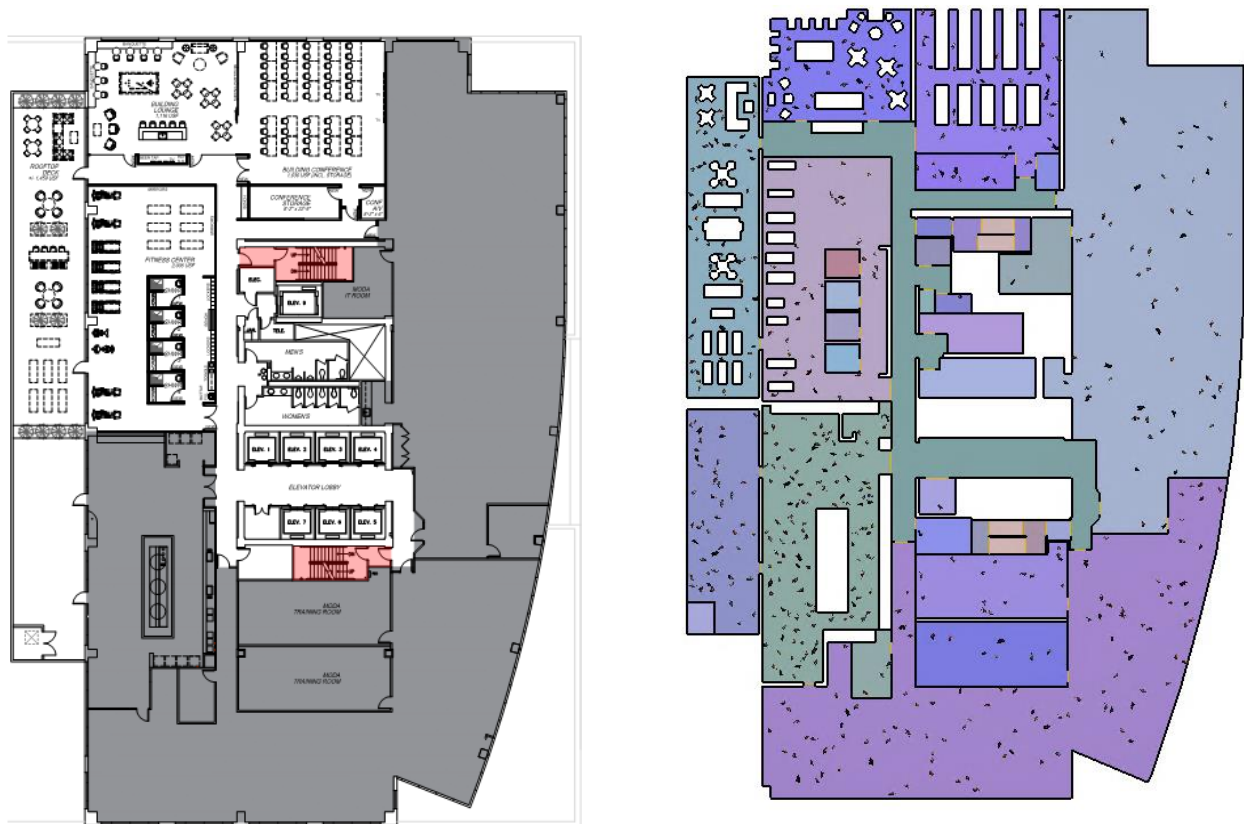


**Figure 5:** Egress on Level 09, including 4 minutes of pre-movement time. At 4 minutes 30 seconds, occupants begin queuing at doorways (upper); at 6 minutes, stairways are congested, and the flow rate of occupants has decreased (lower).

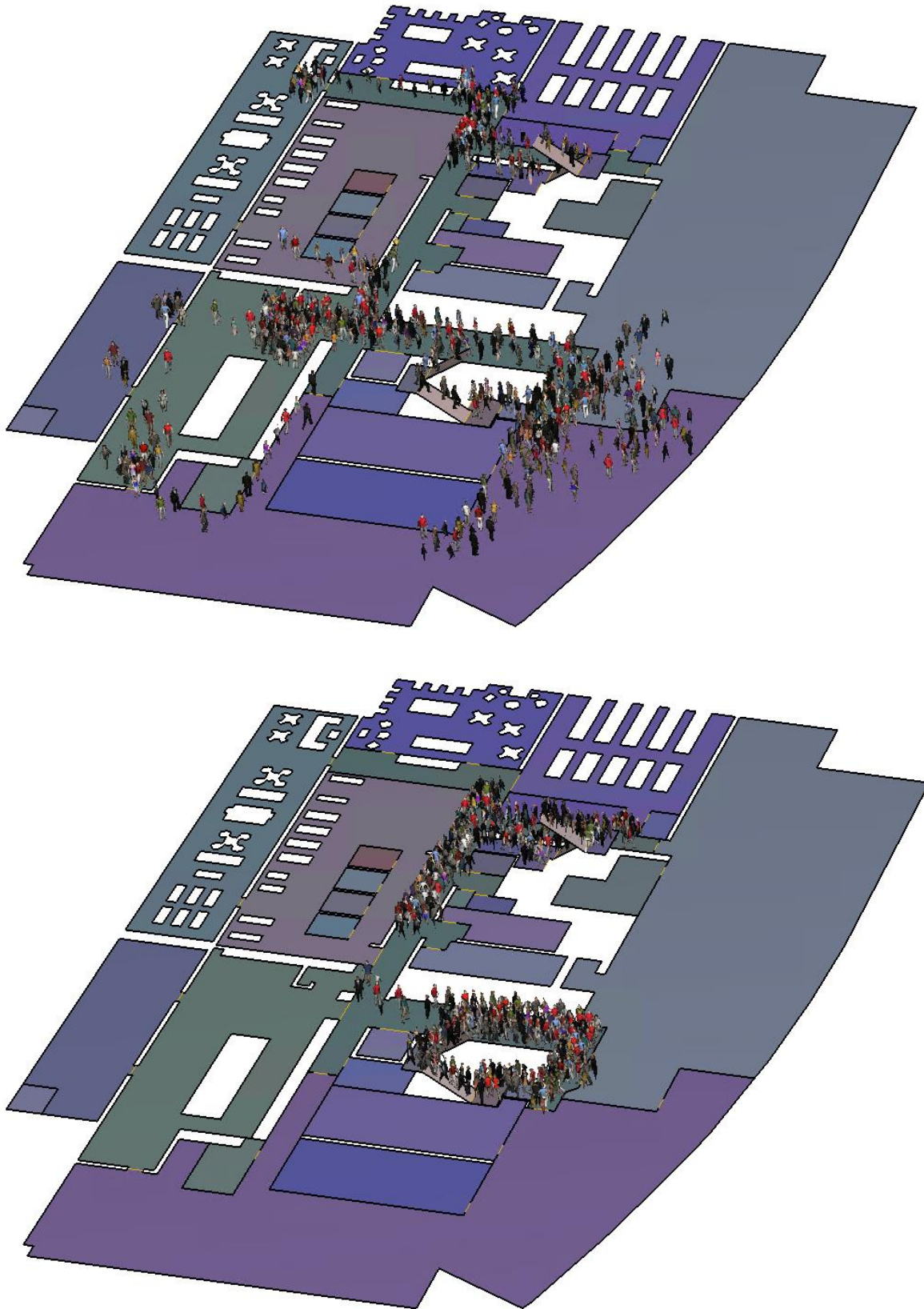
## 4.2 Proposed Design

The proposed design increased the width of the doorways to 48-inches each leading to the enclosed interior exit stairway on all floors, with 500 occupants on Level 09 and 333 occupants on all other floors included in the simulation. It also took credit for the use of voice alarm/evacuation to aid in pre-movement times.

The egress time required for all occupants on Level 09 to reach a rated stairway enclosure, including pre-movement time, was found to be **14 minutes and 45 seconds**.



**Figure 6:** Level 09 floor plan of the existing design with interior exit stairways highlighted in red (left); Pathfinder model of Level 09 with 500 occupants (right).



**Figure 5:** Egress on Level 09, including 1 minute of pre-movement time. At 1 minutes 30 seconds, occupants begin queuing at doorways (upper); at 6 minutes, stairways are congested, and the flow rate of occupants has decreased (lower).

## 5. SUMMARY

Table 2 summarizes the design parameters of the two simulated egress models.

**Table 2:** *Design parameters of the egress models.*

Parameters	Existing Design	Proposed Design
1. Interior Exit Stairway Width	50 in.	50 in.
2. Stairway Capacity	167/stair	250/stair
3. Exit Door Width – vestibule and enclosed exit stair doors	36 in. (34 in. net clear)	48 in. (46 in. net clear)
4. Doorway Capacity	App. 170/door	App. 307/door
5. Occupant load	Level 07 – 333 Level 08 – 333 Level 09 – 333 Level 10 – 333 Level 11 – 333 No occupants modeled on other floors.	Level 07 – 333 Level 08 – 333 Level 09 – 500 Level 10 – 333 Level 11 – 333 No occupants modeled on other floors.
6. Pre-Evacuation Time	4 minutes	1 minute
7. Level 09 Egress Time	<b>16 minutes and 10 seconds</b> (970 seconds)	<b>14 minutes and 45 seconds</b> (885 seconds)
8. Total Egress Time	<b>29 minutes and 24 seconds</b> (1,764 seconds)	<b>28 minutes and 8 seconds</b> (1,688 seconds)

## 6. CONCLUSION

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The proposed design of 500 occupants on Level 09 with wider doorways at the vestibule at the interior exit stairways and the use of a voice/alarm communication system performs better in an egress simulation than the conditions of the existing appeal. The proposed design includes:

- An emergency voice/alarm communication system meeting the requirements of 2014 OSSC and a Survivability Level 1 in accordance with NFPA 72, reducing pre-movement time of occupants.
- Wider doorways at the vestibule and interior exit stairways (48 inches) than prescriptively required by the 2014 OSSC (37.5 inches), increasing the capacity and flow rate of occupants into the rated stairway enclosure.

The egress simulation accounted for the effects of queuing and congestion at the doorways and stairways by including two floors above Level 09 and two floors below. Based on the results of the simulations, occupants of Level 09 egress the proposed design **1 minute and 25 seconds faster** than the existing design. All occupants of the five floors reach an exit on grade in the proposed design **1 minute and 16 seconds** faster than the existing design. Therefore, the proposed design will exceed the protection for egressing occupants intended by the existing appeal and meet the requirements of the 2014 OSSC prescriptively on Level 09.



EXPIRES: 12/31/2019

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