



**Village of Mount Prospect
Planning and Zoning Commission
Regular Meeting Agenda
50 S. Emerson St. Mount Prospect, IL 60056**

February 22, 2024

Village Hall - 3rd Floor Board Room

7:00 PM

- 1. CALL TO ORDER**
- 2. APPROVAL OF MINUTES**
 - 2.1. PZ-20-23 / 718 E. Northwest Highway / CU: Massage Therapy
 - 2.2. PZ-22-23 / 2400 E. Oakton Street / CU: Contractor's Storage Yard
- 3. NEW BUSINESS**
 - 3.1. PZ-01-24 / 50 S. Emerson Street / Text Amendments: Zoning and Sign Code Updates / Village Board Final
- 4. CITIZENS TO BE HEARD**
- 5. QUESTIONS AND COMMENTS**
- 6. ADJOURNMENT**

ANY INDIVIDUAL WHO WOULD LIKE TO ATTEND THIS MEETING BUT BECAUSE OF A DISABILITY OR NEEDS SOME ACCOMMODATION TO PARTICIPATE, SHOULD CONTACT THE VILLAGE MANAGER'S OFFICE AT 847|392-6000, EXTENSION 5307

**MINUTES OF THE REGULAR MEETING OF THE
PLANNING & ZONING COMMISSION**

CASE NO. PZ-20-23 Hearing Date: January 25, 2024

PROPERTY ADDRESS: 718 East Northwest Highway

PETITIONER: Enlightenment Massage LLC

PUBLICATION DATE: January 10, 2024

REQUEST: Conditional Use for Massage Therapy Establishment

MEMBERS PRESENT: William Beattie
Norbert Mizwicki
Walter Szymczak
Greg Miller
Donald Olsen
Ewa Weir

MEMBERS ABSENT: Joseph Donnelly
Thomas Fitzgerald

STAFF MEMBERS PRESENT: William J. Cooney – Director of Community Development
Ann Choi – Development Planner

INTERESTED PARTIES: Anna Alexander, Enlightenment Massage LLC

Chairman Donnelly was absent from the January 25, 2024 meeting and Vice Chairman Beattie assumed the role as the acting Chairman. Chairman Beattie called the meeting to order at 7:01 PM. Commissioner Miller made a motion seconded by Commissioner Szymczak to approve the minutes from the Planning and Zoning Commission meeting on December 14, 2023. The minutes were approved 6-0.

Chairman Donnelly introduced case PZ-20-23, 718 East Northwest Highway, a request for a conditional use permit to operate a massage therapy establishment at the subject property. The Village Board's decision is final for this case.

Ms. Choi introduced the case and explained that the subject property is a single-story multi-tenant commercial building with a mixture of restaurant, retail, and office establishments. Ms. Choi noted that the tenant space was most recently occupied by an office use. Ms. Choi stated that adequate parking is available and that the subject property parking lot is striped with 26 parking stalls. Ms. Choi noted that since the proposal does not involve new construction or major rehabilitation (50 percent or more), or a change in use which warrants additional parking, no additional off-street parking is required. Ms. Choi further stated that the business is available by appointments and walk-ins and the petitioner will be the only employee on the premises and only one client will be seen per 90-minute session.

Ms. Choi explained that the petitioner proposes to operate a 420-square-foot shiatsu massage establishment consisting of compression and stretching methods on a client while they are clothed. Ms.

Choi stated that the proposed hours of operation will be Thursday through Tuesday, 9 AM to 9 PM, and will be closed on Wednesdays. Ms. Choi noted that no interior or exterior renovations requiring a building permit are proposed, however the petitioner will need to obtain a sign permit for the awning.

Ms. Choi also stated that the petitioner submitted a business license application and a massage therapy addendum according to the requirements of Village Code. Ms. Choi indicated that the Police Department confirmed that the petitioner has met all ordinance standards.

Ms. Choi reported that staff found that the proposal meets the conditional use standards and that staff is supportive of the request. Ms. Choi recommended approval of the following motion:

“A conditional use permit to operate a massage therapy establishment at 718 East Northwest Highway, subject to the following conditions:

1. The business shall hold a valid Mount Prospect business license;
2. Any massage therapist employed at the business establishment shall hold a valid massage therapist license with the State of Illinois;
3. During business hours, the entrance door shall remain unlocked, and the storefront windows and entrance doors shall be transparent and unobstructed; and
4. Compliance with all applicable Village Code requirements, including but not limited to, fire code and building regulations.”

Ms. Choi stated that the Village Board’s decision is final for this case.

Chairman Beattie swore in the Petitioner, Anna Alexander, 2925 N. 77th Avenue, Elmwood Park IL. Ms. Alexander stated that she will be opening up a shiatsu massage business and explained the difference between shiatsu massage and western massage. Ms. Alexander indicated that western massage heals by opening up the muscles in a vigorous way that can cause injury whereas shiatsu massage uses a gentler approach and instead of using force, the shiatsu method uses mindfulness using compression and stretching that are held for longer periods of time.

Chairman Beattie asked the Petitioner if she would be the sole practitioner and how long she has been practicing. Ms. Alexander stated she has been practicing tai chi and meditation for over five years and has been in massage therapy school in downtown and Zen Shiatsu in Evanston to study shiatsu and has only been licensed for a couple of weeks.

Chairman Beattie asked the Petitioner if she had reviewed the conditions of approval and asked if she was agreeable to the conditions. Ms. Alexander responded in the affirmative.

Hearing no further comments or questions, Chairman Beattie closed the hearing and asked for a motion. Commissioner Mizwicki made a motion seconded by Commissioner Miller to approve the following motion:

“A conditional use permit to operate a massage therapy establishment at 718 East Northwest Highway, subject to the following conditions:

1. The business shall hold a valid Mount Prospect business license;
2. Any massage therapist employed at the business establishment shall hold a valid massage therapist license with the State of Illinois;

3. During business hours, the entrance door shall remain unlocked, and the storefront windows and entrance doors shall be transparent and unobstructed; and
4. Compliance with all applicable Village Code requirements, including but not limited to, fire code and building regulations.”

UPON ROLL CALL

AYES: Szymczak, Weir, Mizwicki, Olsen, Miller, Beattie

NAYS: None

The motion was approved by a vote of 6-0 with a positive recommendation to the Village Board for the scheduled meeting on February 6, 2024.

After hearing one additional case and seeing no citizens to be heard for non-agenda items, Commissioner Mizwicki made a motion seconded by Commissioner Miller, and the meeting was adjourned at 7:55 PM.



Ann Choi
Development Planner

**MINUTES OF THE REGULAR MEETING OF THE
PLANNING & ZONING COMMISSION**

CASE NO. PZ-22-23 Hearing Date: January 25, 2024

PROPERTY ADDRESS: 2400 E. Oakton Street

PETITIONERS: Mark DiMeo, DiMeo Brothers, Inc.

PROPERTY OWNER: Aleksandar Mimic

PUBLICATION DATE: January 10, 2024

REQUEST: CU: Contractor's Storage Yard

MEMBERS PRESENT: William Beattie
Walter Szymczak
Norbert Mizwicki
Ewa Weir
Donald Olsen
Greg Miller

MEMBERS ABSENT: Joseph Donnelly
Thomas Fitzgerald

STAFF MEMBERS PRESENT: William J. Cooney – Community Development Director
Ann Choi – Development Planner

INTERESTED PARTIES: John DiMeo, Mark DiMeo, Rob DiMeo

Chairman Donnelly was absent from the January 25, 2024 meeting; therefore, Vice Chairman Beattie assumed the role as the acting Chairman. Chairman Beattie called the meeting to order at 7:01 PM. Commissioner Miller made a motion seconded by Commissioner Szymczak to approve the minutes from the Planning and Zoning Commission meeting on December 14, 2023. The minutes were approved 6-0.

After hearing one previous case, at 7:12 PM Chairman Beattie introduced case PZ-22-23: 2400 E. Oakton Street for conditional use approval for a contractor's storage yard.

Ms. Choi introduced an aerial and stated that the subject property was annexed into the Village in 2017 as part of an annexation including approximately 40 acres of industrial and commercial property in unincorporated Cook County and noted that the property is zoned I-1 Limited Industrial.

Ms. Choi gave a description of the subject property and indicated that most of the subject property is within the floodplain of Higgins Creek, an unmapped waterway that runs through South Mount Prospect, and along the north and eastern sides of the Subject Property. Ms. Choi stated that the subject property has considerable drainage and flood control issues, and is bound by Oakton Street to the south, Terminal Drive to the north, Badger Road to the west, and I-1 zoned properties to the east. Ms.

Choi noted that the site consists of three lots and is currently vacant. Ms. Choi further noted that the subject property currently provides two driveways along Oakton Street, and both Terminal Drive and Badger Road are privately maintained.

Ms. Choi gave a brief description of the Petitioner and stated that the Petitioner is a sewer and water contractor company that has been in operation since 1973 and is currently located in Elk Grove Village. Ms. Choi stated that the Petitioner is seeking to relocate to Mount Prospect and proposes to construct a two-story 34,500 SF building consisting of office and warehouse space with related improvements. Ms. Choi further stated that the proposed project will provide 31 passenger vehicle parking spaces, 29 truck parking spaces, and storage for materials and heavy machinery including material bins, trench and safety equipment, truck and trailers, and manholes and pipes.

Ms. Choi explained that the western driveway will be located approximately 60 feet east of Badger Road and will provide one inbound lane and one outbound lane with the outbound movements under stop sign control. Ms. Choi further explained that the eastern driveway will be located approximately 190 feet east of Badger Road and will provide one inbound lane and one outbound lane with the outbound movements under stop sign control.

Ms. Choi explained the different circulation paths for different types of vehicles and stated that passenger vehicles would proceed directly to the south parking lot and exit through the opposite driveway; truck vehicles would enter only from the east driveway, proceed past the south parking lot via the drive aisle located east of the proposed building, and travel directly to the truck vehicle parking and storage yard located at the rear of the building. Ms. Choi indicated that trucks and construction vehicles would travel in a clockwise or a counterclockwise rotation around the material storage area and would have the option to park in the heavy machinery parking area or within the truck parking area located south of the material storage area. Ms. Choi further explained that truck traffic would also exit to the east Oakton Street driveway along the east side of the proposed building and that the parking lot setbacks along Oakton Street and along the north, east and west property lines will comply with the Village Code's minimum 10-foot parking lot setback.

Ms. Choi then discussed the accessory structures proposed including a 20-foot tall, dome-like accessory structure for outdoor material storage bins at the northwest corner of the site and a 8-foot tall, solid-style, white vinyl perimeter fence. Ms. Choi noted that as part of the conditional use request, storage materials (such as dirt, asphalt, concrete, stone, topsoil, hard steel, hard plastic, and concrete) measuring up to a height of 12 feet would be visible above the 8-foot-tall solid perimeter fence. Ms. Choi stated that some construction equipment such as excavator arms would go up to 16 feet and that one of the conditions of approval would be modified to reflect the new height. Ms. Choi also pointed out that a trash enclosure will be located northwest of the building.

Chairman Beattie asked where the construction material would be kept and if they would be stored inside and outside. Ms. Choi presented a slide that showed that the materials would be stored at the center of the site and within the accessory structure and would be open to the sky except for the materials stored in the dome accessory structure.

Ms. Choi stated that a large underground storm system is also planned to help alleviate the existing drainage and flood control issues. Per the Petitioner, a hydraulic study of Higgins Creek was previously prepared and approved by the Illinois Department of Natural Resources – Office of Water Resources (IDNR-OWR) and is attached to the staff report. Per the Petitioner, the prior report will be updated to

reflect the current site plan and will define the base flood elevation and floodway limits along Higgins Creek.

Ms. Choi stated that a public water main runs along the north side of Terminal Drive, just north of the subject property, and that the Village is considering the annexation of approximately 47 acres of unincorporated land near the southern border of the Village to provide municipal services to this area, including the provision of Village water. Ms. Choi explained that the Village is requesting a 10-foot-wide easement along the west property line for a public water main that would connect the water distribution system along Terminal Drive to a future Oakton Street water main extension, and eventually to the potential future annexation properties. Ms. Choi noted that the Petitioner is agreeable and a condition of approval requiring the easement has been added to the conditional use request.

Ms. Choi stated that a significant amount of new landscaping is being provided site wide and the modifications to the site are an improvement to the existing conditions. There are some minor revisions that need to be included in the current landscape plan; however, staff is confident that appropriate landscaping can be achieved on the site.

Ms. Choi then advanced to the slides of the floor plans and noted the single floor of warehouse and two floors of offices. Ms. Choi presented the next slides including the building elevations and the renderings. Ms. Choi stated that the elevations indicate the proposed building will be composed of precast wall paneling and clerestory windows and as shown, the proposed building will not exceed the maximum height of 40' permitted in the I-1 zoning district. The building height would measure 27'-6" at its highest point.

Ms. Choi moved onto the Village's long-range planning documents and stated that the Comprehensive Plan's Future Land Use map designates the Subject Property as "mixed-use district" which includes as primary uses: commercial, heavy industrial, manufacturing, office, research, solid waste handling, warehousing uses, and uses that benefit from the proximity to the I-90 tollway and secondary uses that include screened outdoor storage. Ms. Choi pointed out that key characteristics of the district include encouraging larger sites to allow for large-scale employment facilities, with lot consolidation in areas that would benefit from redevelopment. Ms. Choi further stated that the Connect South Mount Prospect 2020: Subarea Plan designates the property as an opportunity site and recommends manufacturing, office, warehousing/distribution, or storage related uses within the site.

Ms. Choi wrapped up the presentation by stating that the proposed development is a redevelopment site and will provide storage-related uses within a modern industrial facility; therefore, the Petitioner's proposal does not conflict with the long-range goals of the Comprehensive Plan. Based on the information submitted, the surrounding uses, and the proposed development's compliance with the Village's long-range planning documents, Ms. Choi stated that staff recommends approval of the conditional use request. Ms. Choi maintained that the proposed project would replace an underutilized industrial site with a suitable, alternative use on parcels that have remained vacant for a long time.

Ms. Choi stated that staff finds that the standards for a conditional use have been met. Based on these findings, staff recommends that the Planning & Zoning Commission make a motion to adopt staff's findings as the findings of the Planning & Zoning Commission and recommend **approval** of the following motion:

“A conditional use to allow for a contractor’s storage yard, including the storage of construction materials, construction equipment, and construction vehicles, for the property located at 2400 E. Oakton Street, Case No. PZ-22-23, in general conformance with the drawings prepared by Civil & Environmental Consultants, Inc., bearing the latest revision date of 12/29/2023, subject to the following conditions:

- a) The Petitioner shall address all comments included in the Village review letters dated December 7, 2023, January 8, 2024 and January 12, 2024;
- b) The construction materials and construction vehicles shall not exceed a maximum height of twelve feet (12’-0”), and construction equipment shall not exceed a height of sixteen feet (16’-0”);
- c) The applicant shall submit a plat of consolidation application prior to building permit submittal; the plat shall be recorded with Cook County prior to the issuance of any Certificates of Occupancy;
- d) A ten-foot (10’-0”) wide easement dedicated exclusively to the Village for water main purposes that runs along the entire length of the west lot line shall be provided by the Petitioner. The easement shall be recorded with the property prior to the issuance of a building permit;
- e) The design shall meet all Village, and other agency (MWRD, IDNR, IDOT, FEMA, etc.) requirements. This includes the possibility of obtaining a Conditional Letter of Map Revision (CLOMR) from FEMA prior to beginning construction;
- f) The appropriate code analysis, architectural, structural, mechanical, electrical, plumbing, energy, and accessibility drawings shall be prepared for permit application review to the Village; and
- g) Compliance with all applicable Village Code requirements, including, but not limited to, zoning, fire code, sign code regulations, environmental health, and building regulations.”

Ms. Choi stated that the Village Board’s decision is final for this case.

Chairman Beattie asked Ms. Choi why a conditional use is required if the zoning was already I-1. Ms. Choi stated that the I-1 district requires that all business be conducted indoors and that the contractor’s storage yard is primarily outdoors and requires a conditional use. Chairman Beattie asked if there are any environmental concerns that come with storing materials outside. Ms. Choi noted that there are concerns related with the Higgins Creek but that the Metropolitan Water Reclamation District (MWRD) would have their own conditions that would address those environmental concerns.

Chairman Beattie asked if there were any questions for staff.

Commissioner Miller stated that since the site is within a flood zone, and water would not be able to get into the site, would the Village experience flooding elsewhere in other parts of the Village. Ms. Choi stated that the Petitioner is working on defining the limits of the flood plain and that the MWRD will also restrict the building of structures within the flood plain if this is not defined, and deferred questions on the flood plain issue to the Petitioner’s civil engineer.

Commissioner Weir asked if all water would be flowing into the storm trap or and if water would be flowing off the site and directly into Higgins Creek. Director Cooney responded that all the water would be going into the creek, whether the water is stored and slowly released at a rate that meets code, and some of the water on the fringes may go into the stream, but the majority of the water will be in the

basin. Commissioner Weir asked if filtration of the water to remove sediments will occur before it goes into the creek. Director Cooney stated he does not know if there is an filtration of sediments but deferred to the Petitioner's civil engineer.

Chairman Beattie swore in the following individuals:

- Petitioner, John DiMeo of DiMeo Brothers at 321 Grand Boulevard, Park Ridge, IL
- Petitioner, Mark DiMeo of DiMeo Brothers at 737 Washington Avenue, Park Ridge IL
- Anastos Sukurti, attorney for the Petitioner
- Brendan May, traffic consultant with KLOA
- Louis Wehrspann, civil engineer with Cicil & Environmental Consultants

Chairman Beattie asked the Petitioners why they are looking to move to Mount Prospect.

John DiMeo explained that they are looking to relocate to Mount Prospect because their business is rapidly expanding and they outgrew the location they are currently in and believe the location at 2400 E. Oakton Street is perfect for their company. Mr. John DiMeo explained that 70% of their clients are municipalities, including Mount Prospect, and they also do mass excavation in the private sector. The current site in Elk Grove is 2 acres and they are hoping to find a permanent home at the subject property in Mount Prospect.

Mr. John DiMeo explained that their company specializes in sewer, water and excavation and that their employees approximately 50-70 people at its peak; approximately 15 of those employees are in the shop and offices and the others would go to the job sites including truck drivers at the site that would leave between 7-8 AM and come back in the evenings. Mr. John DiMeo stated that the use is not a high traffic use.

Chairman Beattie asked how many trucks would be coming and leaving in the mornings and evenings at the facility. Mr. John DiMeo responded that there would be anywhere from 5 to 8 trucks. Chairman Beattie asked if everyone was coming and going off Oakton Street. Mr. John DiMeo stated that Badger Road is a private road and there would be no access to Badger Road or Terminal Drive so Oakton Street will be the primary entrance. Mr. John DiMeo stated that the west entrance would be for the shop employees and office users, and the east entrance located closer to the Higgin Creek would be for larger trucks and equipment.

Chairman Beattie asked if the Petitioner or the Petitioner's civil engineer could address the earlier concern about sediment from the construction materials going into the creek. Mr. John DiMeo deferred to the engineer but stated that there would be coordination with the MWRD to eliminate contamination going into the creek.

Commissioner Weir asked if it was a possibility to eliminate contamination or if the Petitioner was going to design this into the storm trap. Mr. John DiMeo stated that the engineers would design something to prevent any contaminants from going into the creek.

Chairman Beattie noted that this was not included as part of the conditions of approval from the Village. Director Cooney responded that the Village would require approval from the MWRD and the IDNR. Chairman Beattie reiterated that the two agencies would make the decision as to whether or not filtration of contaminants would be necessary.

Chairman Beattie asked the civil engineer to reintroduce himself. Louis Wehrspann of 1230 E. Diehl Road, Naperville IL, introduced himself as the civil engineer for the project.

Mr. Wehrspann addressed the question regarding the sediment basin and stated that this is a requirement of the MWRD who require sediment basins prior to the water entering the storm trap and then all that water will be released into the creek.

Commissioner Weir asked if there was flood plain on the property and if this would be consolidated into the creek. Mr. Wehrspann responded in the affirmative and stated that portions of the property will be filled in and other portions of the property would be excavated. Commissioner Weir asked if the storm trap would serve as both regular detention and compensatory storage. Mr. Wehrspann stated that there will be one storm trap for detention and a second storm trap for compensatory storage. Commissioner Weir asked if the red rectangle would have a division in it. Mr. Wehrspann stated that there is a second rectangle that was not highlighted on staff's slide that would serve as compensatory storage. Chairman Beattie asked to see the slide that shows the rectangles. Mr. Wehrspann stated that the rectangle highlighted in blue would serve as detention and the area located towards the back of the site would serve as compensatory storage. Mr. Wehrspann noted that this area would be located under the parking area.

Commissioner Weir asked if there would be any surface runoff into the creek. Mr. Wehrspann responded that any runoff would be from the areas outside of the curb lines within the grassy areas along the perimeter, and any water that falls on pavement within the curb lines would be treated and released to the detention system.

Chairman Beattie asked where Higgins Creek is in relation to the site. Mr. Wehrspann stated that Higgins Creek is along the north and east sides of the site.

Commissioner Weir asked if there are any wetlands on the property. Mr. Wehrspann stated there are wetlands on the property and they have already been delineated and noted the wetlands are of poor quality. Mr. Wehrspann stated that when the grading is restored around Higgins Creek, that they will be improving the wetlands by providing plantings in those areas. Commissioner Weir asked if the plantings would be native. Mr. Wehrspann stated that they would not be native but they would be plantings that would control erosion, stabilize the banks, and hopefully allow the creek to improve on its own.

Commissioner Weir asked the traffic consultant if the truck traffic would only use the east driveway and if high level impacts were evaluated for Oakton Street. Mr. May with KLOA responded that the traffic impact statement that was prepared shows that Oakton Street carries approximately 20,000 to 21,000 vehicles per day and as was indicated earlier most of the employees would be traveling directly to the field.

Chairman Beattie asked what kind of trucks and construction equipment would be coming in and out of the property. Mr. John DiMeo stated that there would be about 4-5 semis going in and out of that east entrance per day, and 2 low-boys that transport the construction equipment and are not used daily (project-based). Mr. May stated that this would translate to the addition of less than one percent of traffic that currently exists on Oakton Street, so there would be very minimal impact.

Commissioner Weir asked if there would be on-going operational procedures needed for maintaining erosion and dust control within the neighborhood, aside from the erosion control plan during construction.

Mr. John DiMeo responded that they maintain their own dust control, and use tanks on trailers with sprayers to minimize dust, and noted that the materials stored in the accessory structure would be contained by concrete blocks with tarps on top of the materials so no materials would be blowing onto the neighbors' properties. Commissioner Weir asked if the materials would always be covered with tarp and if the materials would be open to the south. Mr. John DiMeo responded in the affirmative to both questions.

There was an inaudible question from one of the commissioners. Mr. John DiMeo responded that the subject property would be their headquarters. Commissioner Mizwicki asked if the Petitioner had any other locations. Mr. John DiMeo stated they have one other location in Wilmette which is used more as a satellite yard to store additional materials and equipment for projects in the Northshore but there would be no office or staff there.

Chairman Beattie asked about the totality of construction vehicles. Mr. John DiMeo stated they operate 5 semi-trucks and 2 low-boys. Chairman Beattie asked if it was standard operating procedure to have materials covered. Mr. John DiMeo stated that this is a general procedure they follow for construction materials loaded onto trucks, and that in Elk Grove they were not required to cover the materials on-site but are willing to do so to comply with Mount Prospect's codes.

Chairman Beattie asked if there was anyone in the audience who had questions for staff or the Petitioner.

Chairman Beattie swore in Randy Spitzer, 14N569 Timber Ridge Drive, Elgin IL. Mr. Spitzer stated that he is a neighbor of the subject property and represents Citgo, Exxon, and West Shore, and noted the flooding problem in the area. Mr. Spitzer stated that MWRD has been tremendously helpful and welcomed the Petitioner into the community. Mr. Spitzer noted that there is an existing MWRD program that would help the flooding in this area if a partnership is formed between the Village and the Petitioner. Mr. Spitzer stated that Terminal Drive and Badger Road become flooded and semis need to drive through a couple of feet of water. About eight years ago, \$1.5 million was invested in Higgins Creek on the south side of Oakton Street and shortened the flooding and drainage issues from one day to half a day. Mr. Spitzer asked if the Village could partner with MWRD to improve the creek conditions.

Chairman Beattie stated he did not know if the Planning and Zoning Commission or Village Board have a recommendation on a partnership and that what they are doing is addressing the question of whether the conditional use for a contractor's storage yard should be approved. Director Cooney stated that he has spoken with Mr. Spitzer about this issue in the past and that the Petitioner is committed and required by MWRD for fixing up the creek and make it function for them and that this would be the opportunity to review any specific plan that MWRD has and would be part of the MWRD permit process. Director Cooney added that this area is also within a TIF district and if there is Village contribution that would benefit the whole area, that is something the Village would consider.

Chairman Beattie stated that it sounds like the Village may already be considering what Mr. Spitzer is proposing. Mr. Spitzer commended the Petitioner on their excellent plans and the separation of truck traffic on the subject property and the truck traffic coming from Terminal Drive.

Commissioner Mizwicki stated that it would be a good idea for Mr. Spitzer to attend the next Village Board meeting to provide his support and ask questions for the Village Board. Director Cooney stated the next Village Board meeting will be held on February 6.

Chairman asked if there were any further questions. Commissioner Weir asked staff if there was a possibility of incorporating an operational dust control condition into the approval or if this is something that cannot be monitored. Director Cooney responded that the Village has property maintenance regulations in place already so if there were any complaints made because of dust, the Village has the ability to address that.

Commissioner asked if the approval can be conditioned based on a regional MWRD cooperation based on storm water detention. Director Cooney replied that MWRD has authority over the site and would need to sign off on the project. Chairman Beattie noted that as a condition of approval, the project would need to follow the other agencies' regulations.

Hearing no further comments or questions, Chairman Beattie closed the hearing and asked for a motion. Commissioner Mizwicki made a motion seconded by Commissioner Miller to approve the following motion:

"A conditional use to allow for a contractor's storage yard, including the storage of construction materials, construction equipment, and construction vehicles, for the property located at 2400 E. Oakton Street, Case No. PZ-22-23, in general conformance with the drawings prepared by Civil & Environmental Consultants, Inc., bearing the latest revision date of 12/29/2023, subject to the following conditions:

- a) The Petitioner shall address all comments included in the Village review letters dated December 7, 2023, January 8, 2024 and January 12, 2024;
- b) The construction materials and construction vehicles shall not exceed a maximum height of twelve feet (12'-0"), and construction equipment shall not exceed a height of sixteen feet (16'-0");
- c) The applicant shall submit a plat of consolidation application prior to building permit submittal; the plat shall be recorded with Cook County prior to the issuance of any Certificates of Occupancy;
- d) A ten-foot (10'-0") wide easement dedicated exclusively to the Village for water main purposes that runs along the entire length of the west lot line shall be provided by the Petitioner. The easement shall be recorded with the property prior to the issuance of a building permit;
- e) The design shall meet all Village, and other agency (MWRD, IDNR, IDOT, FEMA, etc.) requirements. This includes the possibility of obtaining a Conditional Letter of Map Revision (CLOMR) from FEMA prior to beginning construction;
- f) The appropriate code analysis, architectural, structural, mechanical, electrical, plumbing, energy, and accessibility drawings shall be prepared for permit application review to the Village; and
- g) Compliance with all applicable Village Code requirements, including, but not limited to, zoning, fire code, sign code regulations, environmental health, and building regulations."

UPON ROLL CALL

AYES: Szymczak, Weir, Mizwicki, Olsen, Miller, Beattie

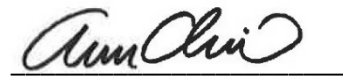
NAYS: None

The motion was approved by a vote of 6-0.

Chairman Beattie stated that it was Village Board Final and asked when the next Village Board meeting will be.

Director Cooney answered that the next Village Board meeting will be February 6th.

After hearing no more items of new business and no citizens to be heard, Commissioner Mizwicki made a motion seconded by Commissioner Miller, and the meeting was adjourned at 7:55 PM.

A handwritten signature in dark ink, appearing to read "Ann Choi", is positioned above a horizontal line.

Ann Choi
Development Planner



Item Cover Page

Subject **PZ-01-24 / 50 S. Emerson Street / Text Amendments: Zoning and Sign Code Updates / Village Board Final**

Meeting February 22, 2024 - REGULAR MEETING OF THE MOUNT PROSPECT PLANNING AND ZONING COMMISSION

Fiscal Impact (Y/N)

Dollar Amount

Budget Source

Category NEW BUSINESS

Type Action Item

Information

The Community Development Department has reviewed both the Village's zoning and sign codes and is recommending the following text amendments to eliminate inconsistencies and ambiguity, and to address recent changes in industry trends and standards.

Discussion

Lodging Accommodations

The Village of Mount Prospect does not distinguish between long-term and short-term lodging accommodations, prompting staff to establish clearer definitions for these uses. Hotels and motels are currently allowed as permitted uses in the B-5 and B-5C districts and as conditional uses in the B-3 and B-4 districts. The following three hotels/motels currently operate in the Village and are listed in **Table 1** below.

Table 1: Existing Hotels/Motels in the Village of Mount Prospect

Name of Hotel/Motel	Address	Zoning
AAA Tower Inn & Suites	303 W. Algonquin Rd	B4
Four Points by Sheraton	2200 S. Elmhurst Rd	B3
Mount Prospect Hampton Inn	1 Randhurst Village Dr	B3*

Staff recommends defining "Extended Stay Hotel" as an accommodation that exceeds 30 days but not more than 90 days and recommends conditional use approval in the B-3 and B-4 districts for this type of accommodation. Staff further proposes separate definitions for "Hotel" and "Motel" and limiting stays at hotels and motels to no more than 30 days. Occupancy in the same hotel or motel for over 30 consecutive days exempts patrons from paying the Illinois Hotel Occupancy Tax. Additional clean-ups include modifying the current definition of "Dwelling" and eliminating any references to "Motor Inn". If the proposed text amendment is approved, all existing lodging accommodations within the Village would retain their classification as either a hotel or motel. Any future hotel, extended stay hotel, or motel in the B-3 and B-4 districts would require conditional use approval and this provision would grant the Village the authority to revoke the conditional use

permit if the lodging establishment violates the time limitations. Additionally, the proposed text amendment would allow existing hotels and motels to request conditional use approval to convert to an extended stay hotel in the future. The proposed text amendments related to lodging accommodations are as follows:

Chapter 14 Zoning, Article VI Zoning Districts, Section 14.604: Land Use Table II

Add "Extended Stay Hotels" to the Land Use Table II as a conditional use in the B-3 and B-4 zoning districts.

Chapter 14 Zoning, Article XXII Off Street Parking Requirements, Section 14.2207

Modify the off street parking requirements to add "Extended Stay Hotel" under the Use category "Hotel/motel" to share the same parking requirement of 1 space per guestroom plus 1 space per employee on peak shift.

Chapter 14 Zoning, Article XXIV Definitions, Section 14.2401

The current zoning code definition of "Dwelling" includes references (excluding) "hotels, motels, rooming, boarding or lodging houses" but the Village does not define rooming, boarding or lodging house, so this reference should be eliminated. The definition of "Hotel, Motel, Motor Inn" should be deleted in its entirety and the definitions of "Extended Stay Hotel", "Hotel" and "Motel" should be added to Section 14.2401 in the appropriate alphabetical locations. Boarding, rooming, lodging houses, and motor inns are not listed in the land use table so any references should also be removed from the Village code.

Chapter 15 Subdivision, Development and Site Improvement Procedures, Article II Rules and Definitions, Section 15.202

The definition of "Dwelling" should refer to the proposed modified definition of "Dwelling" in the zoning code as noted above.

Electronic Messaging Signs

According to the International Dark Sky Association (IDA), electronic message center (EMC) signs are also known as "LED signs, LED displays, solid-state lighting signs, digital billboards, mobile digital billboards, changeable message signs, media facades, media towers, architectural lighting facades, or electric signs". As further noted by the IDA, EMC signs can have a significant impact to the natural and built environment, often producing glare, light trespass, skyglow, and substantially changing the nightscape. Lateral light emission from EMC signs cannot be shielded and are typically aimed outward toward traffic and viewers and may contribute to light trespass into nearby residences.

The Village recently approved an EMC sign for an elementary school that was met with significant opposition from a residential neighbor after its installation. Although the EMC sign met the sign code requirements for illumination, the resident complained that the sign causes glare, creates a nuisance, and the sign violates their property rights. EMC signs are currently allowed by-right in single-family districts if they comply with Sections 7.302(H) and 7.401 which provides brightness or illumination requirements. Permits for EMC signs are requested by schools, churches, and park districts – nonresidential uses that are located in single-family residential zoning and conservation recreations districts. After some field inspections, staff has re-evaluated the sign code and recommends modifying the requirements for EMC signs in the C-R Conservation Recreation and the single-family residential districts (R-X, R-1, and R-A) to restrict the hours of operation, reduce the allowable light intensity, and require existing EMC signs to come into compliance with the new regulations. The proposed text amendments related to EMC signs in the C-R, R-X, R-1, and R-A districts are as follows:

Chapter 7 Sign Regulations, Article IV Illumination and Maintenance, Section 7.401 Illumination

Staff proposes to amend Section 7.401 to separate regulations for EMC signs located in zoning districts other than C-R, R-X, R-1 and R-A districts and EMC signs located in the C-R, R-X, R-1 and R-A districts, and to add more stringent requirements for EMC signs in the C-R, R-X, R-1, and R-A districts. Staff proposes to adopt the minimum requirements and best management practices provided by the IDA, Guidance for Electronic Message Centers IDA2019-01, included as Attachment A of the staff report. The proposed text amendment would add a curfew requiring EMC signs to be turned off no later than the later of the following and remain turned off until seven o'clock (7:00) A.M the following morning: one (1) hour after sunset, but no later than seven o'clock (7:00) P.M.; or thirty (30) minutes after the closing of the establishment, but no later than seven o'clock (7:00) P.M. Light intensity shall not exceed 4 foot-candles using the sign's night-mode white screen setting (brightest nighttime setting) when measured with a standard light meter at a distance of ten feet (10') away from the face of the EMC sign. All existing EMC signs within the Village will be required to comply with the proposed curfew.

Building Height

Staff recommends updating the zoning code to reflect the changing nature of industrial development, specifically the height of buildings in the I-1 Limited Industrial districts. Per the publication "Rules of Thumb for Distribution/Warehouse Facilities Design" published by the Commercial Real Estate Development Association (NAIOP), and included as Attachment B of the staff report, one of the primary differentiators in distribution buildings is clear height. The NAIOP defines clear height as "the distance from the floor to the lowest hanging ceiling members or hanging objects, beams, joists, or truss work descending into a substantial portion of the industrial work area. This is the most important measure of the interior height of an industrial building because it defines the minimum height of usable space within the structure." Clear heights in most markets follow building size configurations and the following rules of thumb are recommended. Approximately four feet to six feet are added to the clear height to calculate the overall building height:

- Buildings below 50,000 square feet can be 28-foot clear.
- Buildings between 50,000 square feet and 80,000 square feet can be 30-foot clear.
- Buildings between 80,000 square feet and 150,000 square feet should be 32-foot clear.
- Buildings between 150,000 square feet and 500,000 square feet should be 36-foot clear.
- Buildings above 500,000 square feet (and cross-docked buildings) should be 40-feet or 42-foot clear.

Staff reviewed the most recent industrial developments approved and/or constructed in the Village which are summarized in the following **Table 2**.

Development	Use	Status	Gross Floor Area	Clear Height	Building Height
Cloud HQ 1200 E. Algonquin Road	Data Center	Site Work	585,000 SF/building		54' to 81'
Seefried Industrial Properties 2240 S. Busse Road	Office/Warehouse	Built	80,000 SF	32'	37'-11"
Stotan Industrial	Warehouse	Built	100,400		39'-6"

350 N. Wolf Road			SF	32'	
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The zoning code currently permits buildings in the I-1 district to reach a height of 40 feet. By comparison, the I-2 Railroad District permits a building height of 30 feet and the I-3 Solid Waste Handling District permits a building height of 50 feet. Staff proposes to increase the building height in the I-1 district to fifty feet (50') to align with industry trends. Staff also recommends conditional use approval for a planned unit development as a requirement for buildings that would exceed the 50-foot height limit.

Standards for Text Amendments

The standards for text amendments are listed in Section 14.203.D of the Village's zoning ordinance and Section 7.606 of the sign ordinance for the Planning and Zoning Commission to consider. The standards are:

- The general applicability of the amendment to the community, rather than an individual parcel;
- Consistency of the amendment with objectives of the Zoning Code and Comprehensive Plan; and
- The degree to which the amendment would create non-conformity; and
- Consistency of the amendment with Village policy as established by previous rulings.

The proposed changes are intended to reflect current Village objectives as outlined in the Comprehensive Plan and other accepted planning documents. The proposed amendments satisfy the standards for text amendments as required in the zoning and sign codes.

Alternatives

The proposed text amendments meet the standards contained in Section 14.203.D of the zoning ordinance and in Section 7.606 of the sign ordinance. Based on these findings, staff recommends that the Planning and Zoning Commission make a recommendation to the Village Board to **approve** the following motion:

1. "To approve the text amendments as outlined in the attached documents for case PZ-01-24 which should perform certain amendments to the text of the Village's zoning, sign and development code regulations."
2. Action at the discretion of the Planning and Zoning Commission.

The Village Board's decision is final for this case.

Staff Recommendation

To recommend approval of the text amendments as outlined in the attached documents for Case PZ-01-24 which amend the zoning and sign codes (Chapters 14 and 7).

Attachments

1. PZ-01-24 Staff Report
2. PZ-01-24 Administrative Content
3. PZ-01-24 Attachment A - EMC Guidelines - IDA2019-1
4. PZ-01-24 Attachment B - NAIOP Rules of Thumb
5. PZ-01-24 Attachment C - Redline Changes

6. PZ-01-24 Attachment C - Final Changes



STAFF REPORT FROM THE DEPARTMENT OF Community Development

William J. Cooney, AICP
Director of Community Development

Ann Choi
Development Planner

DATE: February 17, 2024

CASE NUMBER

PZ-01-24

PUBLIC HEARING DATE

February 22, 2024

APPLICANT/PROPERTY OWNER

Village of Mount Prospect

PROPERTY ADDRESS/LOCATION

50 South Emerson Street

BRIEF SUMMARY OF REQUEST

The purpose of this staff report is to discuss proposed code amendments to modify Chapter 14, Chapter 7, and other chapters of the Village of Mount Prospect Village Code as may be required. A summary of the proposed changes is described below.

STAFF RECOMMENDATION

APPROVE

APPROVE WITH CONDITIONS

DENY

DISCUSSION OF STAFF RECOMMENDATION

PROPOSAL

The Community Development Department has reviewed both the Village's zoning and sign codes and is recommending the following text amendments to eliminate inconsistencies and ambiguity, and to address recent changes in industry trends and standards.

Lodging Accommodations

The Village of Mount Prospect does not distinguish between long-term and short-term lodging accommodations, prompting staff to establish clearer definitions for these uses. Hotels and motels are currently allowed as permitted uses in the B-5 and B-5C districts and as conditional uses in the B-3 and B-4 districts. The following three hotels/motels currently operate in the Village and are listed in **Table 1** below.

Table 1: Existing Hotels/Motels in the Village of Mount Prospect

Name of Hotel/Motel	Address	Zoning
AAA Tower Inn & Suites	303 W Algonquin Rd	B4
Four Points by Sheraton	2200 S Elmhurst Rd	B3
Mount Prospect Hampton Inn	1 Randhurst Village Dr	B3*

Staff recommends defining "Extended Stay Hotel" as an accommodation that exceeds 30 days but not more than 90 days and recommends conditional use approval in the B-3 and B-4 districts for this type of accommodation. Staff further proposes separate definitions for "Hotel" and "Motel" and limiting stays at hotels and motels to no more than 30 days. Occupancy in the same hotel or motel for over 30 consecutive days exempts patrons from paying the Illinois Hotel Occupancy Tax. Additional clean-ups include modifying the current definition of "Dwelling" and eliminating any references to "Motor Inn". If the proposed text amendment is approved, all existing lodging accommodations within the Village would retain their

classification as either a hotel or motel. Any future hotel, extended stay hotel, or motel in the B-3 and B-4 districts would require conditional use approval and this provision would grant the Village the authority to revoke the conditional use permit if the lodging establishment violates the time limitations. Additionally, the proposed text amendment would allow existing hotels and motels to request conditional use approval to convert to an extended stay hotel in the future. The proposed text amendments related to lodging accommodations are as follows:

Chapter 14 Zoning, Article VI Zoning Districts, Section 14.604: Land Use Table II

Add "Extended Stay Hotels" to the Land Use Table II as a conditional use in the B-3 and B-4 zoning districts.

Chapter 14 Zoning, Article XXII Off Street Parking Requirements, Section 14.2207

Modify the off street parking requirements to add "Extended Stay Hotel" under the Use category "Hotel/motel" to share the same parking requirement of 1 space per guestroom plus 1 space per employee on peak shift.

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The current zoning code definition of "Dwelling" includes references (excluding) "hotels, motels, rooming, boarding or lodging houses" but the Village does not define rooming, boarding or lodging house, so this reference should be eliminated. The definition of "Hotel, Motel, Motor Inn" should be deleted in its entirety and the definitions of "Extended Stay Hotel", "Hotel" and "Motel" should be added to Section 14.2401 in the appropriate alphabetical locations. Boarding, rooming, lodging houses, and motor inns are not listed in the land use table so any references should also be removed from the Village code.

Chapter 15 Subdivision, Development and Site Improvement Procedures,

Article II Rules and Definitions, Section 15.202

The definition of "Dwelling" should refer to the proposed modified definition of "Dwelling" in the zoning code as noted above.

Electronic Messaging Signs

According to the International Dark Sky Association (IDA), electronic message center (EMC) signs are also known as "LED signs, LED displays, solid-state lighting signs, digital billboards, mobile digital billboards, changeable message signs, media facades, media towers, architectural lighting facades, or electric signs". As further noted by the IDA, EMC signs can have a significant impact to the natural and built environment, often producing glare, light trespass, skyglow, and substantially changing the nightscape. Lateral light emission from EMC signs cannot be shielded and are typically aimed outward toward traffic and viewers and may contribute to light trespass into nearby residences.

The Village recently approved an EMC sign for an elementary school that was met with significant opposition from a residential neighbor after its installation. Although the EMC sign met the sign code requirements for illumination, the resident complained that the sign causes glare, creates a nuisance, and the sign violates their property rights. EMC signs are currently allowed by-right in single-family districts if they comply with Sections 7.302(H) and 7.401 which provides brightness or illumination requirements. Permits for EMC signs are requested by schools, churches, and park districts – nonresidential uses that are located in single-family residential zoning and conservation recreations districts. After some field inspections, staff has re-evaluated the sign code and recommends modifying the requirements for EMC signs in the C-R Conservation Recreation and the single-family residential districts (R-X, R-1, and R-A) to restrict the hours of operation, reduce the allowable light intensity, and require existing EMC signs to come

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Staff reviewed the most recent industrial developments approved and/or constructed in the Village which are summarized in the following **Table 2**.

Table 2: Recently Approved Industrial Developments					
Development	Use	Status	Gross Floor Area	Clear Height	Building Height
Cloud HQ 1200 E. Algonquin Road	Data Center	Site Work	585,000 SF/building		54' to 81'
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- Consistency of the amendment with objectives of the Zoning Code and Comprehensive Plan; and
- The degree to which the amendment would create non-conformity; and
- Consistency of the amendment with Village policy as established by previous rulings.

The proposed changes are intended to reflect current Village objectives as outlined in the Comprehensive Plan and other accepted planning documents. The proposed amendments satisfy the standards for text amendments as required in the zoning and sign codes.

STAFF RECOMMENDATION

The proposed text amendments to the zoning and sign codes are contained in **Attachment C**. Modifications to each of the chapters are indicated as ~~deletions~~ and additions. The proposed text amendments meet the standards contained in Section 14.203.D of the zoning ordinance and in Section 7.606 of the sign ordinance. Based on these findings, staff recommends that the Planning and Zoning Commission make a recommendation to the Village Board to approve the following motion:

1. "To approve the text amendments as outlined in the attached documents for case PZ-01-24 which should perform certain amendments to the text of the Village's zoning, sign and development code regulations."

The Village Board's decision is final for this case.

ATTACHMENTS:

ADMINISTRATIVE CONTENT

(Zoning Request Application, Responses to Standards, etc...)

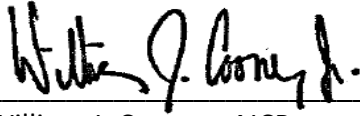
PLANS

(Plat of Survey, Site Plan, etc.)

OTHER

(Supplemental Information, Public Comments Received, etc...)

I concur:



William J. Cooney, AICP

Director of Community Development



Village of Mount Prospect
Community Development Department
50 S. Emerson Street
Mount Prospect, Illinois 60056
Phone: (847) 818-5328

Zoning Request Application

Official Use Only (To be completed by Village Staff)

Case Number: P&Z - 03 - 23 Date of Submission: 2/1/2023 Hearing Date: 3/9/2023
Project Name/Address: zoning code text amendments

I. Subject Property

Address(es): Village of Mount Prospect zoning code
Zoning District (s): _____ Property Area (Sq.Ft. and/or Acreage): _____
Parcel Index Number(s) (PIN(s)): _____

II. Zoning Request(s) (Check all that apply)

- ☐ Conditional Use: For _____
☐ Variation(s): To _____
☐ Zoning Map Amendment: Rezone From _____ To _____
☒ Zoning Text Amendment: Section(s) 14.317, 14.604, 14.240
☐ Other: _____

III. Summary of Proposal (use separate sheet if necessary)

modify ch.14 and other chapters of the village code as necessary for electric vehicle charging stations.

IV. Applicant (all correspondence will be sent to the applicant)

Name: William J. Cooney Corporation: Village of Mount Prospect
Address: 50 S. Emerson St.
City, State, ZIP Code: Mount Prospect, IL 60056
Phone: 847-818-5328 Email: comdev@mountprospect.org
Interest in Property: Director of community development
(e.g. owner, buyer, developer, lessee, architect, etc...)

V. Property Owner	
☐ Check if Same as Applicant <u>N/A</u>	
Name: _____	Corporation: _____
Address: _____	
City, State, ZIP Code: _____	
Phone: _____	Email: _____

In consideration of the information contained in this petition as well as all supporting documentation, it is requested that approval be given to this request. The applicant is the owner or authorized representative of the owner of the property. The petitioner and the owner of the property grant employees of the Village of Mount Prospect and their agent's permission to enter on the property during reasonable hours for visual inspection of the subject property.

I hereby affirm that all information provided herein and in all materials submitted in association with this application are true and accurate to the best of my knowledge.

Applicant: _____

(Signature)

Date: _____

(Print or Type Name)

If applicant is not property owner:

I hereby designate the applicant to act as my agent for the purpose of seeking the zoning request(s) described in this application and the associated supporting material.

Property Owner: _____

(Signature)

Date: _____

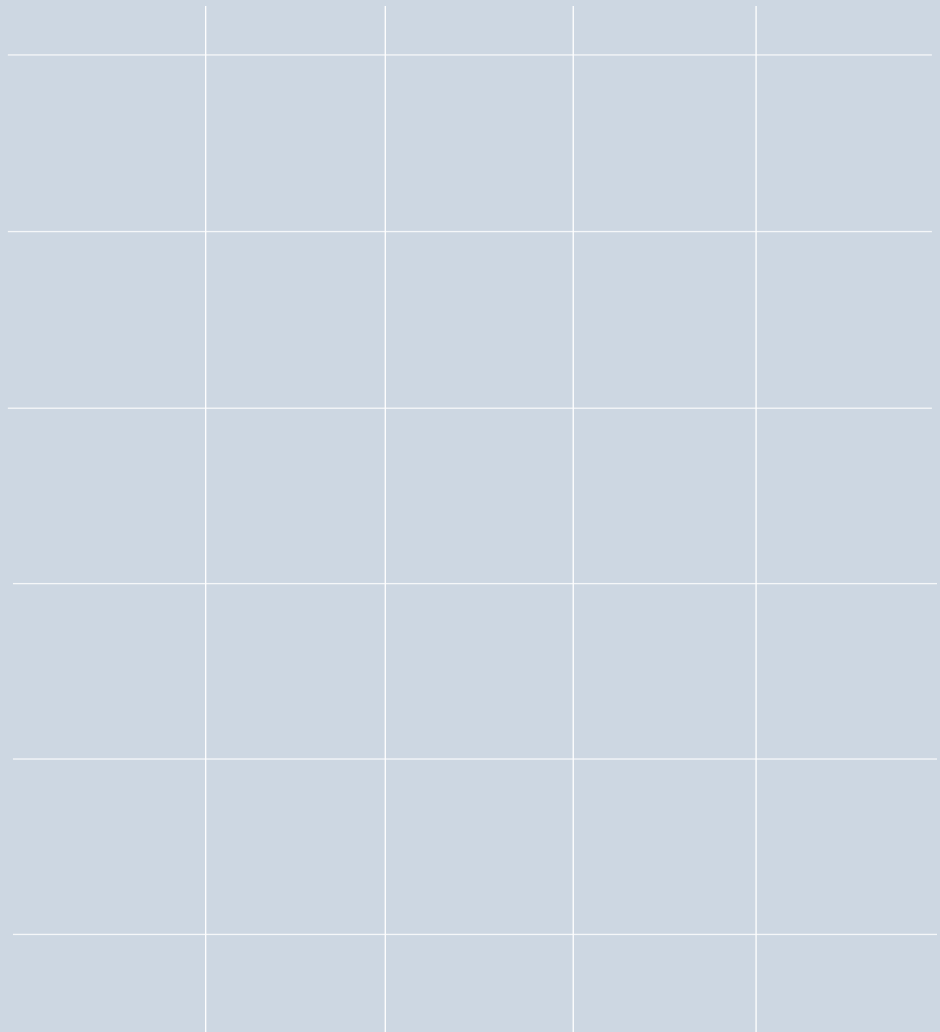
(Print or Type Name)



INTERNATIONAL DARK-SKY ASSOCIATION

INTERNATIONAL DARK-SKY ASSOCIATION

Guidance for Electronic Message Centers (EMCs)



ABOUT IDA

The need to protect and restore the natural nighttime environment is more urgent than ever. Light pollution, defined as light where it is not wanted or needed, affects our health, the environment, wildlife, and our ability to find awe in the natural night. Research indicates that light pollution is increasing at a global rate of five percent per year.

The International Dark-Sky Association, a 501(c)(3) nonprofit organization based in Tucson, Arizona is dedicated to preserving and protecting the natural nighttime environment.



INTERNATIONAL DARK-SKY ASSOCIATION

3223 N. First Avenue
Tucson, AZ 85719 USA
+1-520-293-3198
www.darksky.org

The IDA Guide for Electronic Messaging Centers (EMCs) was prepared for the International Dark-Sky Association (IDA) by the IDA Technical Committee and approved by the IDA Board of Directors.

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Pete Strasser, Staff Liason

Published May 10, 2019

IDA Guidance for Electronic Message Centers (EMCs)

Purpose

Electronic Message Centers (EMCs) are also known as “LED signs,” “LED displays,” “solid-state lighting signs,” “digital billboards,” “mobile digital billboards,” “changeable message signs,” “media facades,” “media towers,” “architectural lighting facades,” or “electronic signs.”¹ This guidance addresses outdoor installations as well as indoor installations that are intended to be viewed from outdoors, such as through store windows. This guidance addresses all EMC installations no matter where situated, whether off or on a public right of way, and whether on- or off-premise.

EMCs have directly-viewed arrays of LED light sources (and potentially fiber optic or backlit display light source) that are electronically controlled to display fixed or dynamic messages. Each LED in the array can be of a different color and brightness and is dynamically controlled. EMCs have been rapidly adopted for commercial sites and advertising. The nature of EMCs makes them a significant impact to the natural and built environment, often producing glare, light trespass, skyglow, and substantially changing the nightscape.

To address deficiencies in many sign codes that only address legacy sign installations, IDA has developed minimum requirements and a set of best practices for EMCs in order to minimize the environmental hazard that often results from carelessly installed and operated signs. These recommendations are intended to be integrated by planners into existing sign ordinances and zoning codes and adopted by lighting practitioners. While IDA does not endorse the use of EMCs at night, it recognizes that these installations will continue to be developed and installed widely. IDA therefore presents the following guidance from a technical and scientific stand-point.

IDA Guidance for Electronic Message Centers (EMCs)

Background

The light-emitting diode (LED) is transforming the way we light our cities and towns. LEDs have now come to dominate the outdoor advertising industry, replacing legacy signs such as conventional flood-lighted billboards, exposed lamp and internally-illuminated (i.e. backlit) translucent signs, as well as ushering in new communication media. EMCs, are appearing with increasing frequency along roadsides and on urban buildings worldwide.

EMCs consist of arrays of many thousands of programmable LED light sources which, when viewed from a distance, make up a composite picture. Multiple advertisements can be displayed in one space, and can also be altered remotely. EMCs can be adjusted by time of day to changing traffic and ambient light conditions, and may require less electricity than legacy installations given the high efficiency of LEDs. However, EMCs are often being applied in novel ways that expand their application and may not be replacing a traditional sign or façade light on a one for one basis; thus may not represent any energy use reduction over past practices.

EMCs can be harmful to the nighttime environment. Much of the implementation of this medium to date has been uncontrolled, has been especially harmful to the environment, and has garnered much public attention. Unlike luminaires (i.e. light fixtures), EMC light emissions cannot be shielded, and the horizontal arrangement of their LEDs – typically aimed outward toward traffic and viewers – means that some of their light is necessarily emitted laterally into adjacent environments and upward into the night sky. Light that is emitted laterally can be a substantial source of

IDA Guidance for Electronic Message Centers (EMCs)

Background, continued

glare, temporarily limiting visual function for passing observers. Animated and/or rapidly cycling messages can be distracting to drivers, cyclists, and pedestrians and are suspected as being a potential traffic safety risk.² The light emission of EMCs can generate more lateral and upward light emission than conventional billboard lighting and thus can be visible to wildlife over long distances,³ affecting breeding, foraging and orientation behaviors in individuals, potentially leading to population level impacts. EMCs may contribute substantially to light trespass⁴ into residences and may thus have an impact upon human health. The primary method of mitigation is through luminance control, limiting hours of operation, and avoiding locating signs adjacent to sensitive areas or residential areas.

Measurement of EMC is different than most other outdoor lighting. The important metric for EMCs is their luminance – the light intensity of the light leaving the sign surface in a given direction, as opposed to most other lighting, which is often quantified by its illuminance – the light falling upon a surface, such as the billboard face or the ground. Proper installation, regulation and monitoring of EMCs requires the proper use of a luminance meter, and may require new measurement tools and procedures. Measurement of EMCs is discussed later in this guidance.⁵

IDA has developed this document to provide planners, lighting designers, architects, biologists, government officials, and the general public with a basic understanding of the environmental hazards and potential solutions to making EMCs less obtrusive and more sustainable. This guidance is particularly

IDA Guidance for Electronic Message Centers (EMCs)

Background, continued

well suited for municipal planning, regional planning, transportation planning, law enforcement, code enforcement, and conservation efforts where a lighting specialist may not be available. For those lighting professionals seeking additional guidance, technical standards from organizations like the International Commission on Illumination (CIE) and Illuminating Engineering Society (IES) can be layered atop this guidance.

Guidance for Electronic Message Centers (EMCs)

Lighting Zones

The following overlay lighting zones (LZs) are referred to in this document:⁶

LZ0: No ambient lighting. Areas where the natural environment will be seriously and adversely affected by lighting, and in which human activity is subordinate in importance to nature. This is the recommended default zone for undeveloped rural areas, including wilderness areas, parks and preserves. (Equivalent to CIE Environmental Zone E1)

LZ1: Low ambient lighting. Areas where lighting might adversely affect flora and fauna or disturb the character of the area. This is the recommended default zone for rural and low-density residential areas. (Equivalent to CIE Environmental Zone E2)

LZ2: Moderate ambient lighting. Areas of human activity where the vision of human residents and users is adapted to moder-

ate light levels. This is the recommended default zone for light-commercial business districts and high-density or mixed-use residential districts. (Equivalent to CIE Environmental Zone E3)

LZ3: Moderately high ambient lighting. Areas of human activity where the vision of human residents and users is adapted to moderately high light levels. This is the recommended default zones for business districts in large cities. (Equivalent to CIE Environmental Zone E4)

LZ4: High ambient lighting. Areas of human activity where the vision of human residents and users is adapted to high light levels. Most cities do not have areas that meet this criterion. This is not a default zone. (Equivalent to CIE Environmental Zone E4)

Minimum Requirements

It is impractical to shield light from EMCs due to its orientation, so many of the traditional approaches to reducing the impacts of artificial light at night do not translate to EMCs. As a result, the potential harm of EMCs cannot be completely mitigated by design alone. Rather, minimizing the harmful effects of EMCs is best accomplished through careful operation, programming, and location of this technology to the greatest extent practical. As of 2019, it is common for EMCs to operate in daytime at luminances in excess of 5000 candelas per square meter (cd/m²), also be known as “nits.” Such high luminances are necessary for visibility due to the high ambient illumination during the day. Achieving proper lighting control at night requires dimming of the LEDs to match the lower ambient illumination and thus render more appropriate visibility. However, sufficient dimming at night is infrequently implemented, resulting in over-lighting, decreased sustainability, and attendant environmental impacts.

These Minimum Requirements for urban, suburban, rural, and natural environments have been developed by practicing scientists and lighting engineers to provide a minimum level of protection to the nighttime environment, while meeting the needs of advertisers. However, IDA strongly recommends also applying the Best Management Practices described

herein, in addition to these Minimum Requirements, to provide greater protection of the nighttime environment and to meet the currently accepted standards of sustainability.

1. Luminance level - During the night hours, which commence no later than one hour after sunset, luminance levels shall not exceed the maximum values provided in Table 1 as measured:⁷

Lighting Zone	Nighttime Maximum Luminance (cd/m ²)
LZ0	0
LZ1	20
LZ2	40
LZ3	80
LZ4	160

2. Curfew - EMCs shall be switched off completely after 2300h/11pm (or 30 minutes after the close of business for on-premises signs, whichever is later), and remain off until one hour before sunrise. EMC applications for traffic and safety information shall be exempt from curfew.

Best Management Practices

A number of best management practices are recommended for EMCs which can further decrease the negative impacts to the environment, reduce visual clutter, and improve the safety of drivers and pedestrians. The combination of adoption of these Minimum Requirements and Best Management Practices has the potential to result in no net increase or even a net reduction in light pollution caused by signage while simultaneously meeting the needs for commerce. Thus, the IDA strongly supports the incorporation of the following Best Management Practices into the relevant codes and regulations covering signs and/or outdoor lighting.

BMP 1. Monitoring – EMC device owner or the permit holder should continuously monitor signs twenty-four (24) hours per day, including monitoring of the reliability of hardware, software, network and other support infrastructure. Should a problem occur, the EMC shall remain unlit.⁸

BMP 2. Sensitive Area Setback – EMCs should not be placed within or adjacent to sensitive areas. These may include, but are not limited to: natural areas, beaches, wetlands, state and national parks, wildlife refuges, residential areas, observatories, and military training grounds. Setbacks in excess of 1 mile (1600 meters) from sensitive areas may be warranted.⁹ Distance setbacks should be assessed on a case-by-case basis, considering the cumulative effect of multiple EMCs, and set forth by the appropriate authority in each community. Mobile EMCs should be addressed as well.

BMP 3. Distraction Limitation – Messages

appearing on EMCs should minimize distraction to vehicle operators and pedestrian by setting a minimum message duration, setting a maximum transition time between messages, and by maintaining adequate spacing between EMCs along thoroughfares.¹⁰

BMP 4. Gradual Brightness Reduction – It is recommended that EMC luminance levels gradually dim between day and night modes (from sunset to 1-hour after sunset) to provide the proper contrast ratio with the ambient illumination level, and similarly before sunrise.

BMP 5. Size Limits – Larger EMCs have a proportionally greater impact upon the nighttime environment. While IDA does not commend a maximum size due to the diversity of EMC uses, it may be appropriate for planners to carefully assess the maximum area of illuminated area in the relevant code or regulation.

BMP 6. Density Limits – Because of the rapid adoption of EMCs, the cumulative impact to the environment of multiple installations should be addressed. The total light emissions from EMCs can be controlled through limiting the number or combined size of signs that are permitted for a given length of roadway or a given area of land.

Measurement

The ideal opportunity to measure luminance from an EMC is at the point of installation. Verification from the

manufacturer of meeting Minimum Requirements is strongly encouraged, in combination with “as installed” measurements. Luminance measures should be of a white screen at the programmed nighttime intensity level. Once installed and operating normally, it is substantially more difficult to obtain accurate luminance measures.

Luminance measures require care in collecting accurate data, and are more exacting to obtain than the use of the more common illuminance meter or “light meter.” Proper setting of luminance meter, a perpendicular viewing angle, and control of stray light from other sources are critical considerations. A good primer on this topic is Alex Ryer’s “Light Measurement Handbook,” which is widely available online.

Guidance on collecting luminance measurements:

- Measure between 1 hour after the sunset and 1 hour before sunrise (use the official daily sunset and sunrise time).
- Take measurements in dry, cloudless weather conditions. Rainy, foggy, snowy conditions will result in erroneous measures.
- The luminance meter should view the EMC perpendicular to the surface and should be aimed at the center of the EMC.
- The luminance meter should be carefully aimed or mounted on a tripod; at least five replicate measurements should be taken and the median (e.g. middle) value utilized.

Once installed and operating, the non-static images and different color composition on EMCs will dramatically complicate measurement. Therefore, every attempt

should be made to verify compliance with IDA Minimum Requirements using the night-mode white screen setting, and to do so before normal EMC operations.

Should there be a need to evaluate existing installation or reevaluate an installation, there are some tools that can be used to provide an approximate measure of luminance. A standard luminance meter used on moving color images will likely produce a measurement that is lower than the actual luminance due to shifting images and non-white colors (even when the luminance meter set to peak luminance mode). Smartphone applications have the potential to aid in this regard, yet there are no ideal solutions as of 2018.¹¹ Illuminance meters, also known as foot-candle or lux meters, can also be used to derive an approximate measurement of luminance, yet are prone to bias from other sources of light and distance from the EMC must be precisely known.¹² Such alternative measures may indicate whether the EMC is grossly out of compliance or not, but will subsequently require that the EMC owner/vendor be contacted to set a pure white screen for proper measurement using a luminance meter and measurements coordinated with the appropriate code enforcement office.

Revisions

Due to the rapidly evolving technology and implementation of EMCs, these Minimum Requirements, Best Management Practices, and in particular measurement guidance in this document may be periodically updated and improved. For the latest information on EMCs, or to learn more about outdoor lighting and dark skies, see the IDA website at www.darksky.org.

Endnotes

1. IDA uses an expansive definition for EMCs, and does not differentiate between signs used for advertising vs. other uses, nor does IDA differentiate between on-premise signs and off-premise signs.
2. Dukic, T; Ahlstrom C; Patten C; Kettwich C; Kircher K. Effects of Electronic Billboards on Driver Distraction. *Traffic Injury Prevention*. 2003;14(5):469-476, doi:10.1080/15389588.2012.731546; Belyusar D; Reimer B. Mehler B; Coughlin J. A Field Study on the Effects of Digital Billboards on Glance Behavior during Highway Driving. *Accident Analysis & Prevention*. 2016 (March) Vol 88: 88-96, doi:10.1016/j.aap.2015.12.014.
3. Luginbuhl, C; Boley, P; Davis, D. The impact of light source spectral power distribution on sky glow. *Journal of Quantitative Spectroscopy and Radiative Transfer*. 2014;139:21-26. doi:10.1016/j.jqsrt.2013.12.004.
4. Ho, C; Lin, H; Huang, K. A Study on Energy Saving and Light Pollution of LED Advertising Signs. *Applied Mechanics and Materials*, 2011;121-126:2979–2984, doi:10.4028/www.scientific.net/AMM.121-126.2979
5. e.g., IES Recommended Practice for Off-Roadway Sign Luminance (RP-39-19).
6. IES/IDA Model Lighting Ordinance (2011); CIE 150:2017 Standard Guide on the limitation of the effects of obtrusive light from outdoor lighting installations, Second Edition.
7. As a point of comparison, conventionally lit signs are typically illuminated to surface brightnesses of between 60 and 100 cd/m². See C.B. Luginbuhl, H. Israel, P. Scowen, J. Polakis, T. Polakis, “Digital LED Billboard Luminance Recommendations How Bright Is Bright Enough?” (white paper, 2010).
8. A typical Best Management Practice is for EMCs to default to an unlit black screen when more than 50% of the LED emitters have failed or are otherwise not displaying properly.
9. A full-size electronic billboard at 50 cd/m² as seen from 1 mile (1600 meters) away illuminates the landscape nearly three times greater than the planet Venus (the “evening star”), and is capable of casting a visible shadow and causing glare for an otherwise dark-adapted human observer. Since EMCs generally produce a range of colors, a broad range of wildlife may be impacted, giving further credence to substantial setbacks from sensitive areas.
10. IES Recommended Practice for Off-Roadway Sign Luminance (RP-39) recommends a minimum duration of at least 20 seconds. Other best practices to reduce distraction include transitions from one message to another in less than 0.5 seconds, and to require a minimum of 1200 feet (366 meters) between installations on roadways.
11. For example, the Candela App is no longer available.
12. IDA disagrees with the 2016 recommendation by the International Sign Association that EMC compliance measurements should use illuminance (foot-candles or lux) instead of luminance (candela per square meter). With EMCs becoming increasingly popular, enforcement efforts should use the proper tool, and the growing market for luminance meters is bringing down the cost of these more accurate tools.



Rules of Thumb for Distribution/Warehouse Facilities Design

Second Edition

Content by HPA, Inc.

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About HPA, Inc.

HPA was founded in 1980 by partners Dennis Hill and Byron Pinckert. Although the name of the firm and its values remain the same, the next generation of ownership has been in place since 2008. Yong Nam, Susan Littlefield and Bob Jacob are now the partners leading HPA, Inc.

With offices in Southern California, Northern California and Georgia, HPA services regional, national and global clients. Working with real estate development companies on inventory products and corporations on custom-designed manufacturing and logistical facilities, HPA has a unique knowledgebase of functionality, constructability and cost issues in industrial building design. This deep understanding makes HPA uniquely qualified to assist NAIOP in creating *Rules of Thumb for Distribution/Warehouse Facilities Design*.

Byron Pinckert served as lead author for this publication.

For more information, see hparchs.com.



Byron Pinckert



HPA partners: Bob Jacob, Susan Littlefield and Yong Nam.

About NAIOP

NAIOP, the Commercial Real Estate Development Association, is the leading organization for developers, owners and investors of office, industrial, retail and mixed-use real estate. NAIOP comprises 20,000 members and provides strong advocacy, education and business opportunities through a powerful North American network.

For more information, see naiop.org.

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Introduction

Industrial buildings, to a greater extent than other commercial building types, are designed to maximize the operational functionality of processes and people. Most industrial buildings are constructed by real estate developers looking to make a return on investment by leasing the facilities. Industrial space is typically leased on a triple net basis, usually at the lowest rental rates of any type of commercial use. The buildings are usually located in areas less visible than retail or office developments and the sites are generally not conducive to extravagant architectural branding efforts. Functionality, flexibility and initial construction cost are the most important factors in successful industrial building development.

As an introduction to the issues that determine success in designing industrial facilities for functionality, flexibility and cost, NAIOP published *Rules of Thumb for Distribution/Warehouse Facilities Design* in 2005. Due to the changing nature of industrial development, NAIOP decided to update and expand the first edition in 2019. The architectural firm of HPA, Inc., provided the material for the first *Rules of Thumb* publication and also created the material in this second edition. HPA is not a large company based on employee count, but it is responsible for the design of more square footage of industrial facilities than any other architectural firm in the United States over the last twenty years. Through this broad experience, the firm's architects have developed a deep understanding of the functional requirements,

materials and design principles that underpin a successful industrial building. These rules of thumb represent an introduction to that knowledgebase.

When designing industrial buildings, HPA examines the wide range of functionality that an operator desires along with the return on investment that a developer requires. These form the parameters that guide the design of a building's architectural fabric: floor slabs, column grids, roof geometries and truck-yard configurations. The resulting building is judged by its ability to support the functions of a particular operator, its return on investment for a particular developer, and its visual enhancement of a particular community and location. In short, its success is measured by its real-world performance.

This book is structured in chapters that focus on the aspects of industrial buildings where many criteria intersect. Each chapter has a detailed discussion of the criteria relevant to a specific aspect of the facility, along with how the criteria combine in optimal ways. Each chapter closes with the abbreviated rules of thumb for the design considerations discussed in that chapter. These are presented in a brief bullet-point format as a quick reference guide. For example, if you just want to know how deep to make the truck yard for a standard building, the numbers are listed in the rules of thumb at the end of Chapter 1. If you want to know why that is the rule, and when it might be appropriate to use a different depth for a specific project, read the entire chapter.

Overview

Chapter 1 considers the site-planning aspects of a facility. It addresses design considerations related to truck movement, dock locations and rail service.

Chapter 2 examines the interior of a facility and the systems that determine its internal layout. Topics include material handling equipment, racking systems and Early Suppression Fast Response (ESFR) fire suppression.

Chapter 3 is a discussion of the floor slab and the roof structure of industrial facilities, the key determinants of cost and function. It addresses concrete detailing, sloping buildings and keeping the rain out.

Chapter 4 looks at the ways smaller buildings (80,000 square feet and smaller) differ from larger ones. It addresses how the rules of thumb derived in the previous chapters might change as the scale changes.

Chapter 5 is an overview of how the uses and economics of industrial buildings are changing and how they are being adapted. It focuses on trends, new approaches and disruptions.

Appendix: Warehouse/Distribution Design and Aesthetic Image

Context is one key element of aesthetic design; by definition, it is different for different sites, developers, markets and times. Rather than try to derive aesthetic rules of thumb, this appendix contains a logistics building design portfolio that illustrates past successful approaches.

CHAPTER 1

Moving Materials to and from the Building: Site Planning

A performer balancing on one leg on a precarious perch while juggling bowling pins provides a metaphor for site planning an industrial building. There are many objectives involving several interacting variables. Success requires keeping a careful balance in the overall design while maintaining a focus on a few critical issues.

One primary objective is maximizing coverage, or the amount of rentable area yielded in a site plan. But at the same time, providing functionality for the tenant is also a priority. Municipal regulations, such as setbacks, landscape percentages and parking ratios, must be followed. Eventually, there will be a price tag attached to the construction costs associated with the site plan design. The rules of thumb presented here juggle these variables to maintain an optimum balance in the competitive industrial real estate market.

A Word on Market-Driven Rules of Thumb

Perception and function do not always match up. The real estate market where a project is located will have its own rules of thumb that are guided more by common perceptions than by function. The approach here is to look at the probable worst-case condition and ensure that the derived rules of thumb can accommodate it efficiently. In this section, that

means: *Can the largest legal truck maneuver easily in the space provided and still allow optimal building coverage factors?*

For instance, the derived truck yard depth in the following section is 131 feet, while the recommended depth is 130 feet. The 130-foot number has stuck in the marketplace checklists. It works in most situations since it is based on the probable worst-case condition, which turns out to be fairly uncommon. The natural question, then, is why not fall back to the more common condition, which results in a number of 111 feet? The irrationality of the marketplace says that a shorter depth would result in a Class B building since 111 feet is less than 130 feet. The 111-foot distance sounds so much lower than 130 feet that even in smaller buildings, the market focuses on yard depths of 120 feet instead of the functional 111 feet.

Most developers create buildings that compete in a regional real estate market. Markets are not necessarily driven entirely by functionally derived rules of thumb. Often a “bigger must be better” mindset is at work. In Southern California, the brokerage community generally agrees that the “right” truck yard depth on a large distribution building is 130 feet. In Northern California, the brokerage community sets that number at 135 feet. HPA has shown that a functionally derived depth is 131 feet. Both 130 feet and 135 feet work well in the

current operations of these buildings. This book’s approach is first to understand the actual physical requirements that generate these rules of thumb and then to provide the minimum number that works and is also familiar to the brokerage community. (This can be found in the recommendations section at the end of this chapter.)

Smaller buildings of around 80,000 square feet or less are more constrained regarding site planning in general than larger buildings. As a building gets smaller, it becomes harder to generate coverage factors that make for attractive returns. At the same time, per-square-foot construction costs increase as building size decreases. The rules of thumb will change based on building size, as discussed in Chapter 4.

This chapter begins by looking at the optimal design for a larger building. The prototype illustrated in Figure 1.1 (page 8) would typically be 200,000 square feet or larger.

This hypothetical building would typically have a truck yard area similar to the one illustrated in Figure 1.2 (page 8).

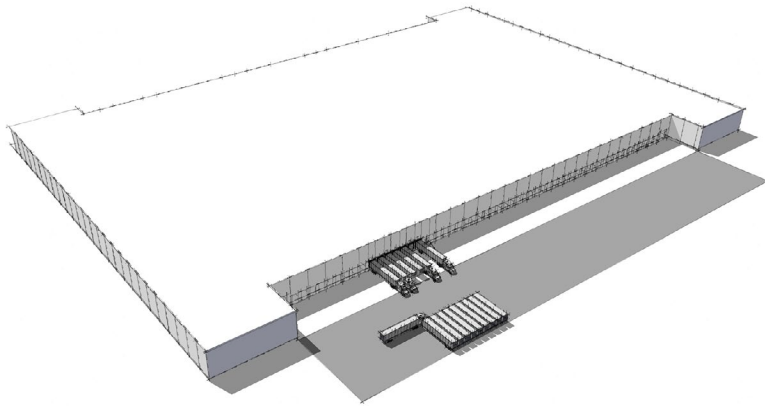


Figure 1.1 Hypothetical warehouse building and truck yard.

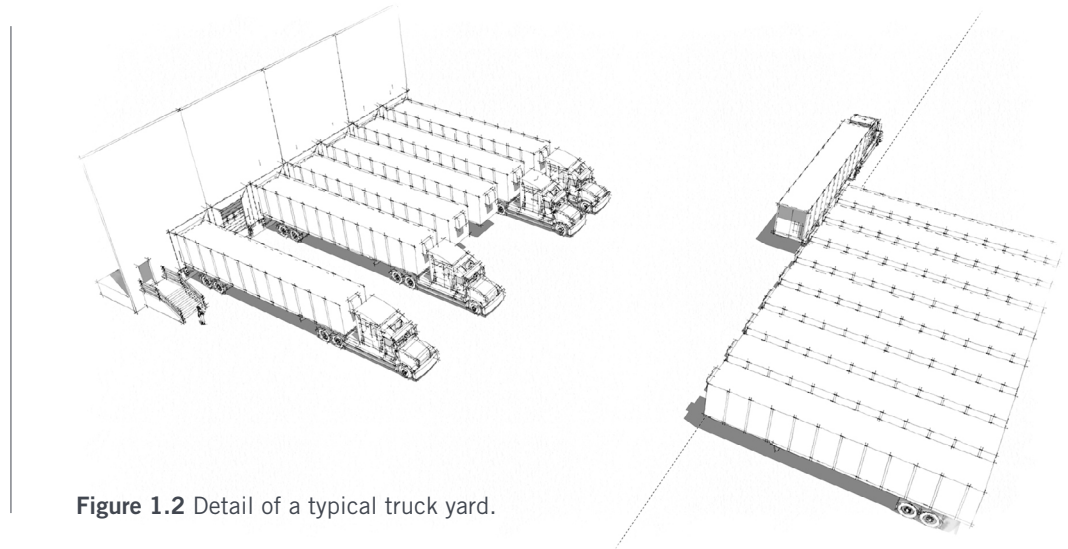


Figure 1.2 Detail of a typical truck yard.

Maneuvering Trucks Around a Facility

Trucks have been gaining share from rail and water-based shipping for the last two decades. For today's distribution operations, trucks are the dominant mode of transportation (Table 1.1). The end of this chapter provides an overview of how rail service is generally planned as a reference for sites that are adjacent to a rail line.

TABLE 1.1 Modes of Goods Transportation in the United States, 2017.

Transportation Mode	Percentage by Ton	Percentage by Value
Truck	66%	73%
Pipeline	17%	8%
Air Freight	Less than 1%	7%
Other	3%	4%
Ship	5%	4%
Rail	8%	3%

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *Transportation Statistics Annual Report 2018* (Washington, D.C.: Bureau of Transportation Statistics, 2018), 4-14, <https://doi.org/10.21949/1502596>.

There are likely to be significant changes in the trucking industry in the near future. Electric-powered rigs will begin to replace gasoline and diesel fleets. Driver-assisted and fully autonomous trucks are being tested on the

roads today. But the impact of these changes on facilities design is not apparent. Will autonomous electric trucks lead to changes in rig sizes? It seems unlikely in the near term, given the current road infrastructure and trailers that are configured for conventional trucks. Will these new driver-assisted and autonomous trucks have tighter turning radii and more precise maneuvering? That is more likely, but the parameters are unknown, and facilities will accommodate conventional trucks and human drivers during any industry transition. HPA maintains that using conventional truck-maneuvering data is currently the best practice in designing site plans.

An intrinsic part of truck loading is backing up to a dock door that is almost the same size as the trailer. Trucks in the U.S. have the driver on the left side of the cab. It is easier for a driver to look over their left shoulder as they back in. Because of this backing-in movement, trucks should move counterclockwise around an industrial building to facilitate visibility over the left shoulder of the driver. The first rule of thumb for site planning, then, is to orient truck circulation to run counterclockwise. Figure 1.3 illustrates trucks entering from a direction that facilitates counterclockwise flow.

Providing counterclockwise circulation is a key concern when identifying optimal locations for driveways to bring trucks from the street onto the site.

Truck queueing is one variable in the site-plan juggling act. Large buildings generate a lot of truck traffic, and most tenants will have some sort of security process to check individual trucks in and out of the facility. If insufficient space is provided for trucks to stack up at these security points, they will start backing up onto the street or back into the operating areas. The largest trucks are about 73 feet long bumper to bumper. In the condition illustrated in Figure 1.4, about two of these trucks could fit between the truck yard and the driveway turning in from the street. A third truck would start to block the street.

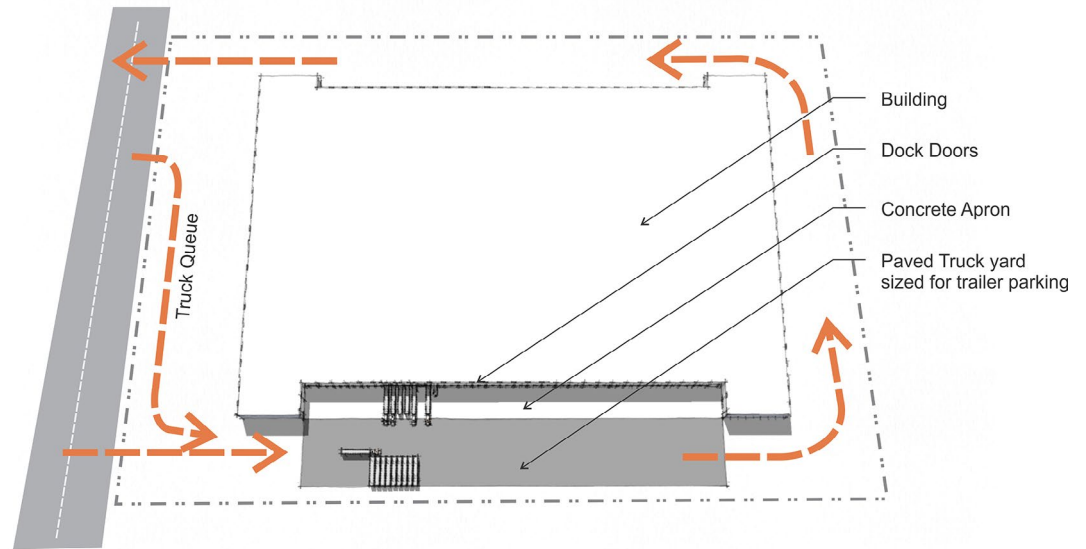


Figure 1.3 Counterclockwise circulation of trucks around a facility.

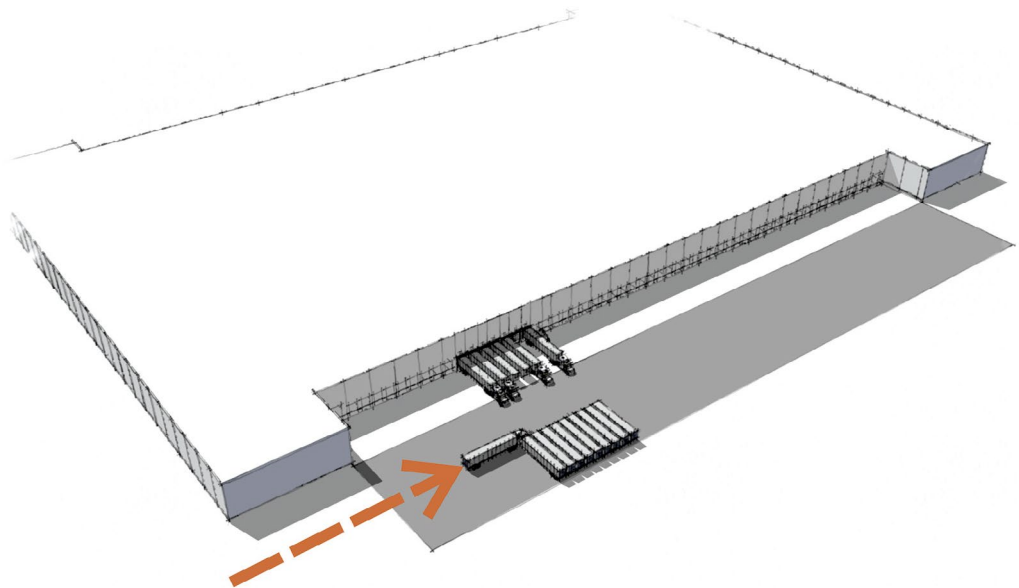


Figure 1.4 Entrance with minimal truck queueing space.

There is no standard for how many trucks need to be accommodated in these queues. Some tenants with high volume and velocity in their operations will expect to queue more than eight trucks, while other tenants will be happy with room for just two at their gate. Generally, as a building gets larger, it requires more truck doors and more queueing lines.

Figure 1.5 illustrates how HPA would address the need for longer truck queueing lines. This approach brings the trucks on-site at a different building corner and provide a drive that leads to the optimized flow point where a guard shack might be located. A drawback is that longer queueing uses site area for truck maneuvering that could instead be used to build rentable area. The decision to implement long queueing drives will depend on the local market, building size and developer preference.

Truck Configurations

While the U.S. Department of Transportation (USDOT) has regulated some standardization in truck configuration across all states, individual states have their own regulations. Many combinations and variations in truck configuration can exist within the combined regulations in any given jurisdiction. There is, however, a finite range of variables in most truck configurations that should be considered when designing distribution facilities. The following variables are the most important:

- Tractor-trailer rig configurations.
- Obstructions adjacent to trailers and rigs.
- Door size and placement.

The minimum turning radius for a specific truck at a particular building is dependent on several variables of tractor rig configuration, trailer size and the location of adjacent objects that obstruct a truck's

inner turn radius. The tractor rig configuration can vary in many ways, including steering angle, lock-to-lock turns, wheelbase and kingpin placement.

Trailer size and wheelbase configurations can also vary from small 30-foot units to “supervan” trailers that can measure up to 60 feet in length. However, all but 19 states effectively limit trailers to 53 feet, and overall length limitations also constrain tractor rig configurations. The American Association of State Highway and Transportation Officials (AASHTO) publishes a configuration called WB-67 (for 67-foot

maximum wheelbase) that works as a standard “biggest” rig in most locations. The following best-practice scenarios are based on a WB-67 configuration.

In addition to the configuration of the tractor-trailer rig itself, the adjacent available space for maneuvering affects the effective turning radius of the truck in a given situation. This means that truck door spacing and the configuration of the adjacent trailer or rig must be considered when determining the minimum turning radius.

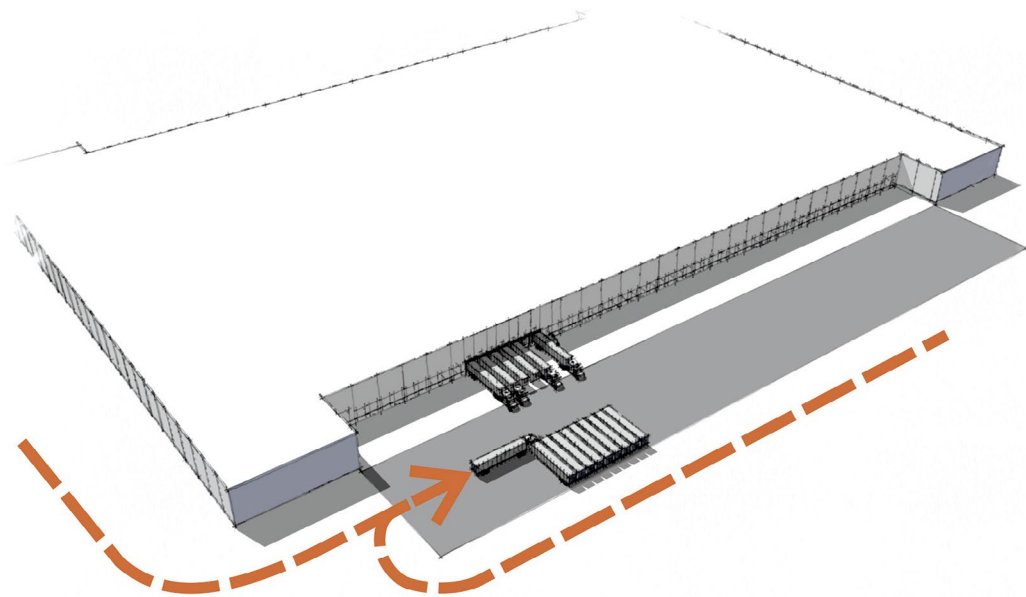


Figure 1.5 Suggested accommodation of truck queueing lines.

The key dimension determining the maneuverability of the full truck rig is the trailer length, which translates closely to its overall length (see Figure 1.6). There are many trailer length standards out there, from shipping container frames measuring 40 feet to common interstate trailers measuring 48 feet and 53 feet. This chapter focuses on a probable “worst-case” scenario that happens nationwide: a 53-foot trailer.

A 53-foot trailer with an overnight truck cab equals an overall length of about 73 feet. This is the longest legal rig in most states. But to understand the maneuverability of this 73-foot-long full rig, it

is critical to know the kingpin to rear axle distance (KPRA). Truck drivers have the ability in many rigs to move the rear axle position back and forth on the trailer to balance weight distribution. Maximum load on a single axle is an important metric that is weighed at interstate inspection stations. That metric interacts with several different opinions of how the rear axle placement affects highway gas mileage, so there is no standard setting for the KPRA distance.

The bigger the KPRA, the larger the maneuvering radius required by the rig. In California and many other states (and per the Surface Transportation Assistance Act federal route standard), the KPRA

has a 40-foot maximum limitation. This leads to the probable worst-case configuration: an interstate overnight cab carrying a 53-foot trailer with a KPRA of 40 feet (see Figure 1.7). Rigs carrying smaller trailers and/or having smaller KPRA distances can maneuver in tighter radii than this probable worst case scenario.

“Probable” is the operative word. It *can* get worse in some locations, or with some non-standard truck/trailer combinations, but that would be unusual. It usually does not make sense to devote space in truck yards to situations that seldom happen in most operations.

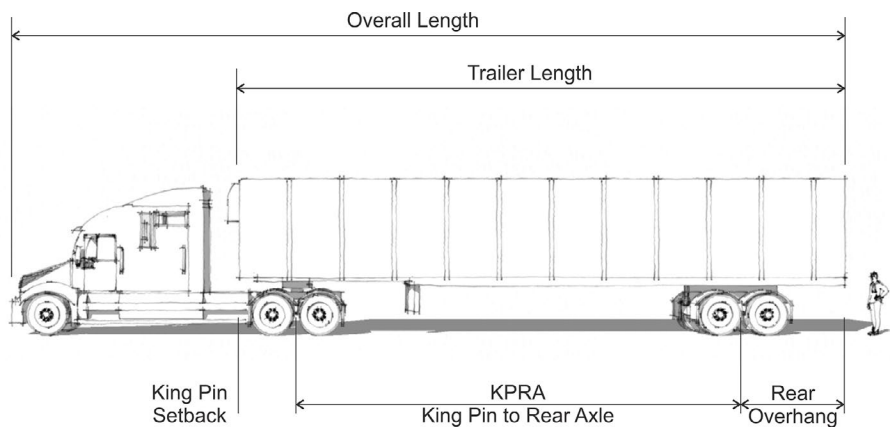


Figure 1.6 Tractor trailer components affecting yard maneuvering.

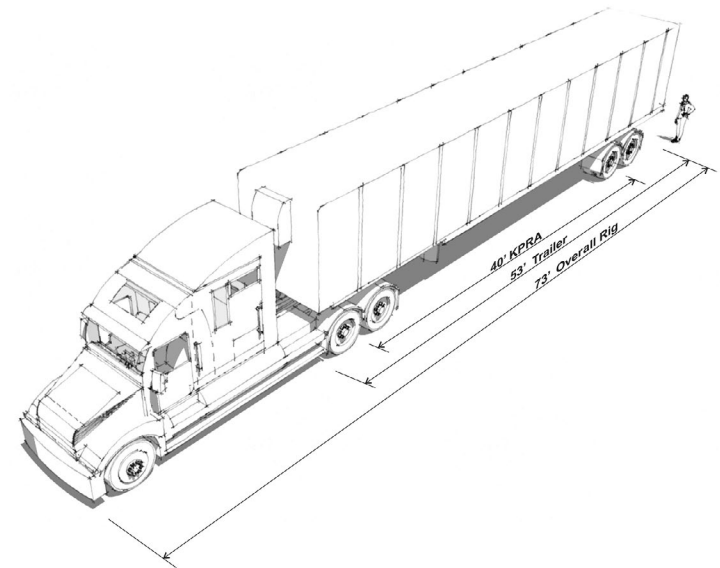


Figure 1.7 Typical large tractor trailer dimensions.

Swing Radii and Obstructions

In day-to-day operations, how far apart the dock doors are in the building determines how close an adjacent truck rig can be located (see page 14 for a detailed discussion on door spacing).

One of the criteria for door spacing is the yard depth required for a truck to back into and move away from an open dock door when doors on either side are occupied, but there are other considerations as well. The recommended truck yard maneuvering distances in this chapter are derived using dock doors spaced at 13 feet on center. The dock door size used is 9 feet wide by 10 feet high. This chapter uses these criteria and demonstrates how changing this standard door spacing affects the depth requirement for the truck yard.

Figure 1.8 shows how dock door spacing affects the maneuvering distances of trucks exiting to the left of the driver. These doors are shown spaced 13 feet on center. The truck rigs are 8 feet, 6 inches wide. That means that if two trucks are perfectly aligned to the doors, they have 4 feet, 6 inches between them. This space between trucks is part of the equation used to determine the clear distance needed by a truck rig to make a 90-degree turn in a single swing.

Another crucial part of the equation is also shown in the illustration. When a full rig is adjacent on the side a truck will turn, it obstructs 73 feet out from the dock face. A trailer without a tractor rig obstructs 53 feet out from the dock. If there is nothing adjacent, there is no obstruction. The maneuvering distance needed for a single swing is largest when a full rig is adjacent, smaller when only a trailer is adjacent and smallest when there is nothing adjacent.

HPA uses a computer program that uses variables such as truck dimensions and placement to draw the actual modeled truck maneuvering paths in CAD software. Since there are more variables than those discussed here (e.g., driver skill, specific truck manufacturer steering setup, etc.), HPA assumes a worst-case scenario for the major variables in its calculations. The resulting numbers have been proven in the field to provide full functionality without excessive wasted space. HPA uses the software tool to verify all site plan designs for truck maneuverability.

The rules of thumb recommendations for truck yard depth for buildings over 80,000 square feet come from this analysis. Market considerations have converted the odd 131-foot actual analysis number to 130 feet, and that has proven to work well in the field (see Figure 1.9, page 13). It is the probable worst-case condition in allowing trucks to get onto or off a dock door in a single swing.

It is interesting to note that if the condition is relaxed from there being a full rig adjacent to the turning truck to there being only a 53-foot trailer, the

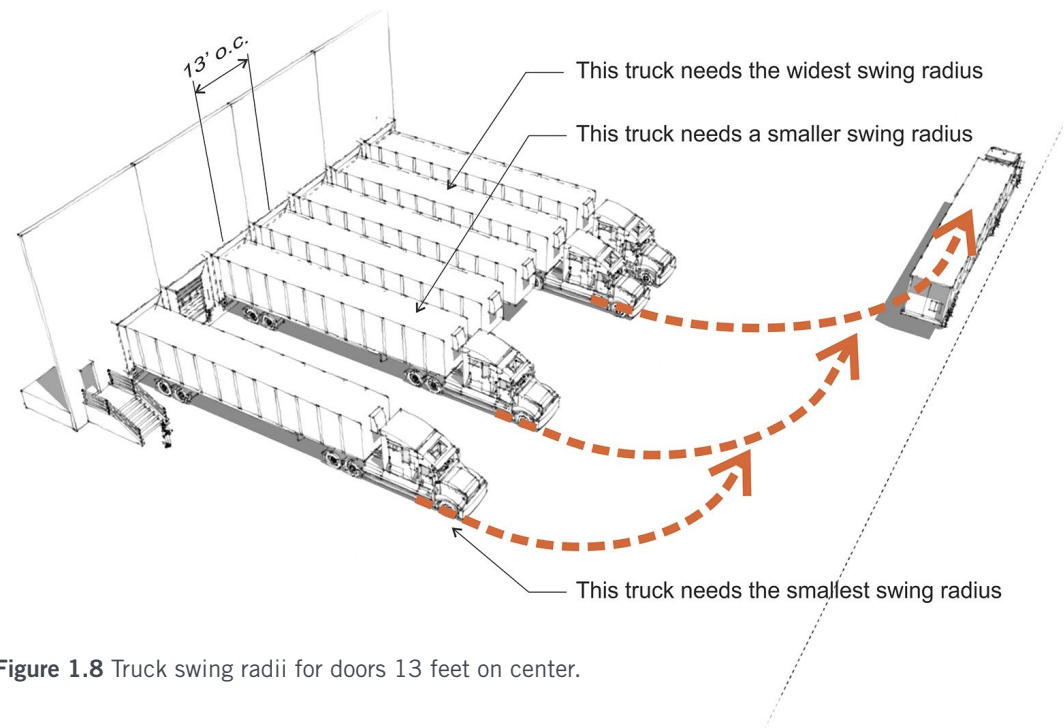


Figure 1.8 Truck swing radii for doors 13 feet on center.

required maneuvering distance drops by 15% from 131 feet to 111 feet (see Figure 1.10). This is the rationale for reducing the recommended yard depth in buildings less than 80,000 square feet. In smaller buildings, truck traffic volume is generally lower, and the tenant has more control of truck rig management door by door. To increase overall coverage, the probable worst condition is relaxed to accommodate single swings with only a trailer adjacent, not a full rig.

Shared Truck Yards

The same analysis can be applied to a condition where two buildings share a truck yard. In this case, two sets of dock doors face each other across a common truck yard, and trucks must share maneuvering space.

Since a full rig at a dock door extends 73 feet and the truck turning out from the building opposite requires 131 feet, the total minimum distance for the probable worst case in a shared yard is 204 feet. This all assumes that the door spacing is still 13 feet on center.

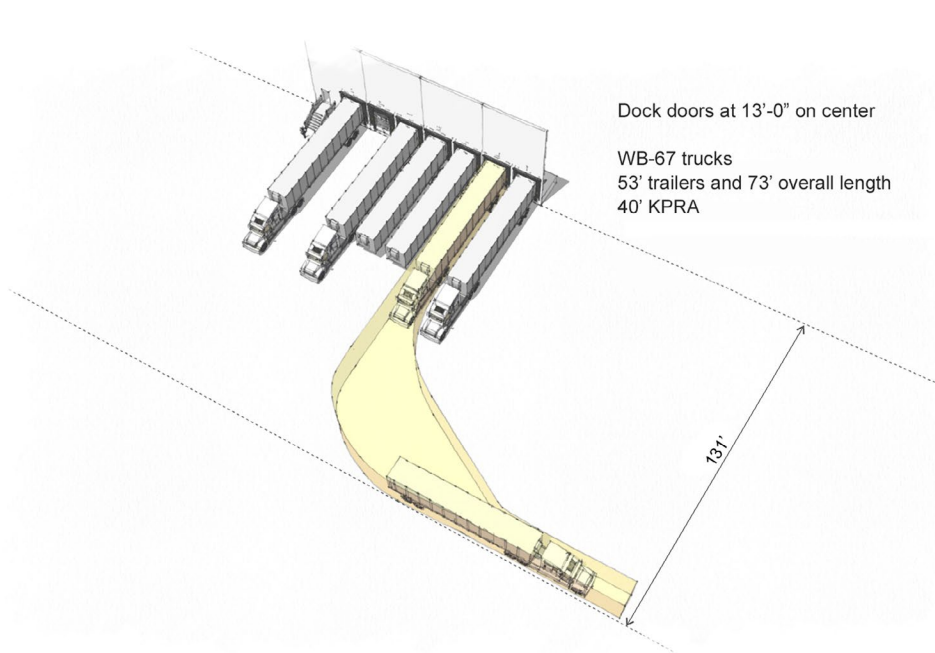


Figure 1.9 Truck maneuvering distance for buildings over 80,000 square feet serving adjacent WB-67 trucks.

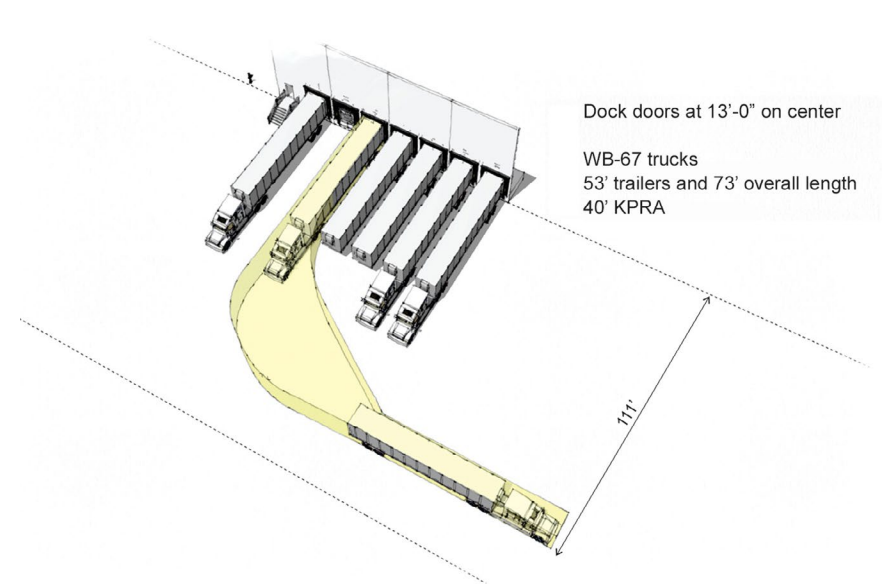


Figure 1.10 Truck maneuvering distance when parked next to a trailer.

Figures 1.11 and 1.12 suggest the shared yard criteria. Shared yards allow overlapping maneuvering space and can lead to better coverage factors. If each facing building were provided its own fully functional yard, they would each be 131 feet deep for a total of 262 feet. The shared maneuvering space saves 57 feet.

Shared yards mingle tenants more than separate yards. Often, with the usually smaller tenants in shared yard configurations, the probable worst-case condition is relaxed and the 111-foot number is used instead of the 131-foot number, resulting in a 184-foot shared yard depth, saving even more space.

The Effect of Door Spacing

The previous dimensions and recommendations are based on truck doors spaced at 13 feet on center. This is currently an industry standard primarily because it provides the maximum number of dock doors in a given length of building without resulting in a significant cost premium for the structure. It has also been proven in the field to provide drivers with sufficient maneuvering space. But what if there was a reason to space the doors differently?

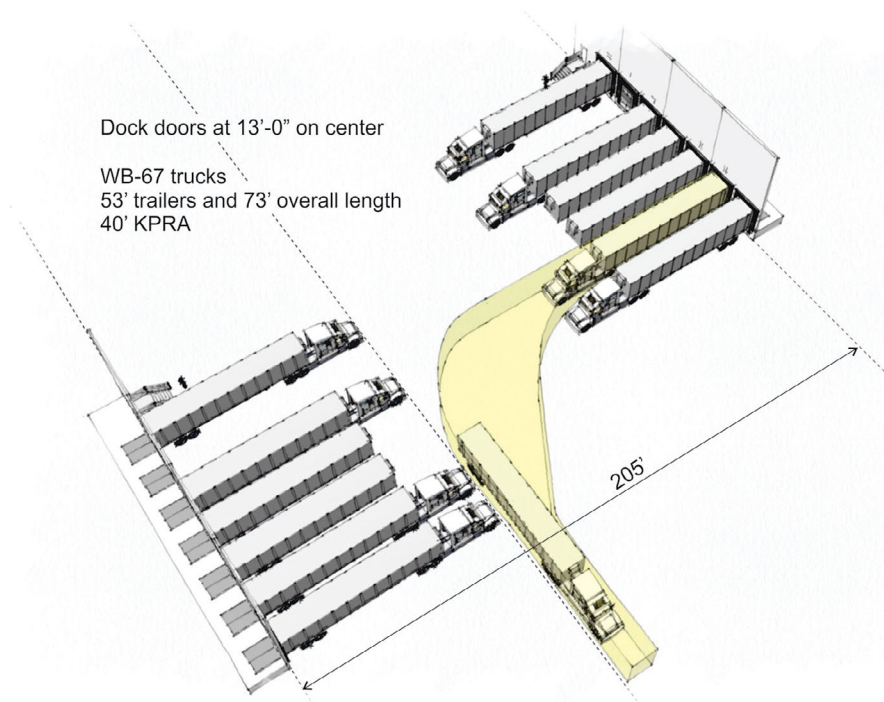


Figure 1.11 Using the worst-case configuration from the earlier analysis yields a shared truck yard depth of 205 feet.

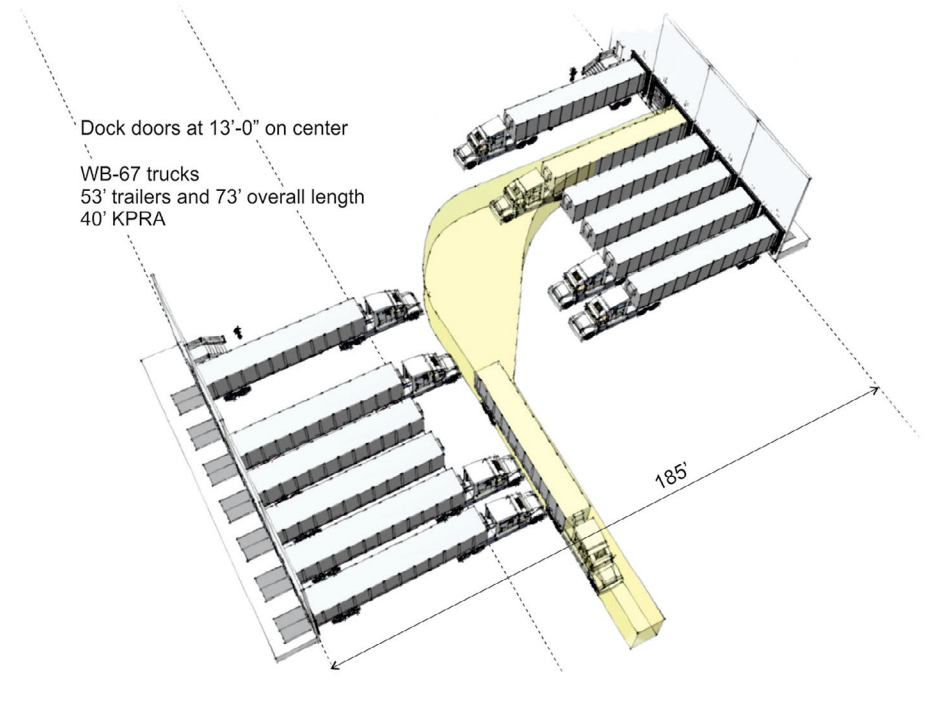


Figure 1.12 Relaxing the condition to accommodate the 53-foot trailer adjacent instead of the full rig means a 111-foot turning dimension opposite for a total minimum distance of 185 feet.

If doors are spaced 17 feet, 4 inches apart, then the yard distance can be 124 feet instead of 131 feet in the most probable worst case (see Figure 1.13). With this wider door spacing, if a truck is parked next to a trailer and not a full rig, it only requires a 103-foot yard (see Figure 1.14).

Planning for Parking Trailers

Trailers are usually parked at all the dock doors of a building, and there is often a row of trailers parked opposite the dock doors as well. Trailer parking affects several design considerations related to wheel stop locations and landing pad locations.

Trailers have landing legs near the front so they can stay reasonably level when the truck is disconnected and pulls away. It is common for trailer legs to hit the pavement at the dock area and any areas where trailers are parked. The KPRA distance and the exact location of landing legs vary enough to create a specific design concern for truck yards that use asphalt for a portion of the yard.

If the paving surface is something like asphalt, the point loads from these legs are likely to damage it. When a truck yard is entirely paved with concrete, this is not a problem, as the concrete can handle the point load from the legs. HPA strongly recommends using concrete for at least 60 feet out from the face

of the dock where trucks and trailers are constantly moving. The wear and tear from the truck's driving rear wheels and the trailer legs means asphalt in this area would always need repair. A 60-foot concrete apron catches trailer legs and the driving rear wheels of most rigs.

A concrete apron solves the problem for trailers parked at dock doors, but let's look at how to address the problem for trailers parked elsewhere in the yard. The variance in rear axle placement means we need to analyze the optimum location of a concrete landing pad for the trailer legs and a wheel stop location at the back of a trailer parking stall.

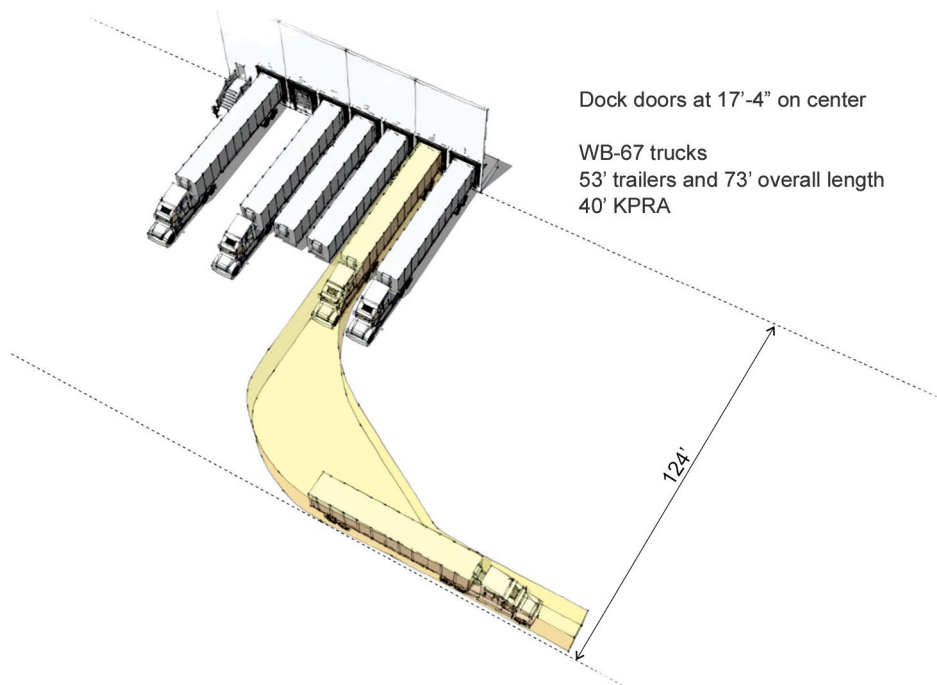


Figure 1.13 Truck yard maneuvering distance for doors 17 feet, 4 inches on center.

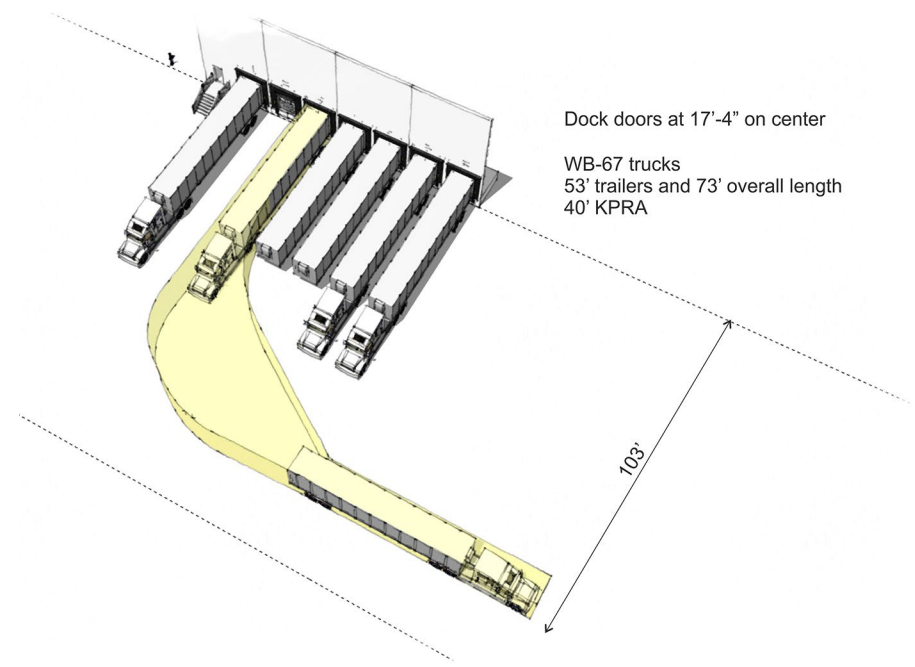


Figure 1.14 Detail of a typical truck yard. Alternative truck yard distance for doors 17 feet, 4 inches on center.

Figure 1.15 illustrates the range of probable configurations that need to be accommodated. The top diagram shows a rig with its rear axle placed forward. The wheel stop should be around 12 feet from the back of the stall and the legs will land about 31 feet back from the wheel stop.

The middle diagram shows a rig with its rear axle moved back. This would represent a configuration legal in California with the maximum 40-foot KPRA distance. Here the wheel stop would be 6 feet from the back of the stall and the legs would land 37 feet from the wheel stop.

The lower diagram shows a rig with its rear axle placed all the way back on the trailer. This is not the most common condition, but does occur in practice. In this situation, the wheel stop should be 1 foot in from the back of the stall and the legs would land 42 feet from the wheel stop.

The diagrams are aligned on the wheel stop location and illustrate that if all rigs were coordinated with the optimum wheel stop, a 12-foot-wide concrete landing pad location for trailer legs would still be required to cover most configurations. Additional variations in landing leg locations also occur.

As there is little control over these variations, a single wheel stop location will see further variations in the landing leg locations of specific trucks. To accommodate this wide range of conditions, HPA would recommend starting the landing pad 40 feet in from the back of the stall and extending to 60 feet from the back of the stall as in the dock apron condition. The resulting 20-foot-wide landing leg strip would pick up all probable landing leg locations.

Alternatively, the entire yard could be paved with concrete.

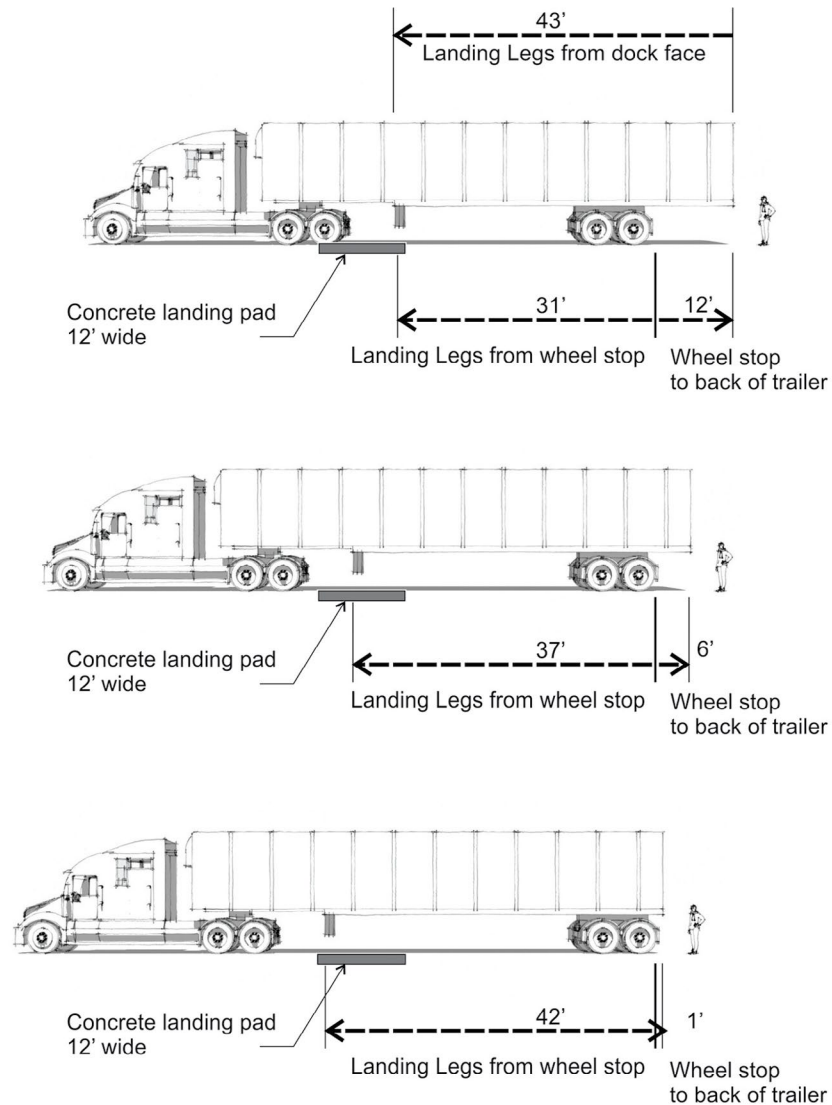


Figure 1.15 Typical configurations of trailer landing legs and wheel stops.

Dock Height

The vertical distance from the paving in the truck yard to the finish floor of the building at the dock door should equate to the distance from the pavement to the bed of the trailer. Truck docks are typically set at 48 inches above the yard pavement, but it is still worth noting how actual bed heights for different trailers and rigs vary. HPA has compiled information on the range of truck beds as they relate to dock heights. Note that the truckbed heights can vary by several inches, even for similar trucks, as noted in Table 1.2.

TABLE 1.2 Types of trailers and bed height ranges.

Type of Trailer	Bed Height Range
City Box Truck	42 to 48 inches
Flatbed Truck	43 to 62 inches
Furniture Van	23 to 36 inches
Trucked Shipping Container	55 to 62 inches
Refrigerated Trailer	50 to 60 inches
Interstate Semi Rigs	45 to 55 inches

A dock leveler mechanism allows for the alignment of dock doors with a wide range of vertical trailer/truck bed heights. An inexpensive version, called an edge of dock leveler, is mounted to the face of the dock opening. These mechanisms' functional limitation is that they can only operate to about 5 inches above or below the finish floor surface. That means a range of bed height accommodation from 43 inches to 53 inches. The geometry is also problematic for continued forklift use as the angle of the leveler will become steep as it approaches the maximum 5-inch difference.

Pit levelers require a recessed box at the dock door but can accommodate bed heights from 38 inches to 60 inches with easy forklift ramp geometries. There are mechanical, hydraulic and air-pressure-powered dock levelers available. They come in many weight and duty service models and are the industry-standard approach to aligning dock doors with truck beds of varying heights.

The long-standing 48-inch standard dock height continues to be the recommended approach in most distribution/warehouse buildings.

Rail Service Rules of Thumb

While requirements for rail service are becoming less common, they do exist. If a site is adjacent to a rail line or spur, it makes sense to at least ensure that a building could accommodate future rail service. The exact layout of rail spurs depends on the rail provider. These companies have been around a long time and have very fixed specifications and approval procedures that are often as formidable as a local planning agency. Unless you are interested in learning things like what a 'frog' does on a rail line, an experienced rail engineer is required for any detailed design, and there will be a long approval process prior to any actual construction.

A good starting point, however, is to use the following rules of thumb for the track and door geometry:

- Minimum radius of track centerline curve.....500 feet.
- Minimum straight-line track between curves.....100 feet.
- Minimum straight-line track from curve to switch.....100 feet.
- Rail door spacing70 feet on center.

There will be situations where these numbers can be smaller, but they are dependent on who owns the property under the rail, who owns the rail itself, who is providing rail freight service and what kind of rail cars are being used. There are 50-foot boxcars and 60-foot boxcars as well as car carriers, flatbeds, gondolas and several types of tankers. Until you are involved in the actual civil engineering on the site, just use the above rules of thumb and 90% of the issues will be covered.

Figure 1.16 shows a 500-foot radius rail line curving around to service rail doors on the left side of the building.

Figure 1.17 is a detail of boxcars servicing a building's rail doors. The track centerline sits about 9 feet off the building wall and the doors are spaced at 70 feet on center. The grade difference from finish floor to rail is 4 feet, about the same as for trucking. The bed height of rail cars varies like the bed height of trucks; like truck dock doors, some sort of leveler is needed on rail doors. Note that to achieve exit/ingress doors along a rail-served wall, the stairs between that finish-floor-to-rail grade difference need to be in the interior of the building.

Once upon a time, rail line easements and right of way could be used as side yards when determining allowed building areas and layouts. Almost all jurisdictions now treat any rail easement edge as a real property line condition and require an additional setback or fire lane as if a building could be built on the adjacent property.

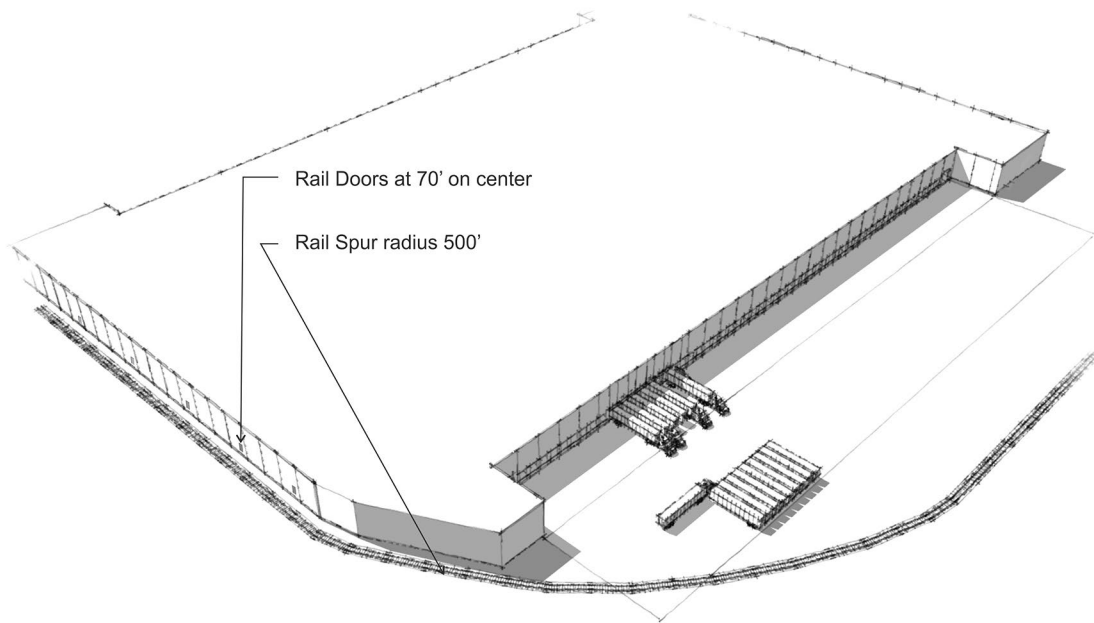


Figure 1.16 Rail doors and rail spur curving around a building.

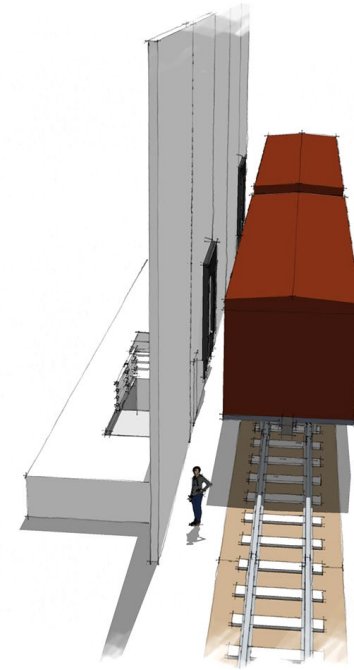


Figure 1.17 Boxcars servicing a building's rail doors.

Recommended Primary Rules of Thumb for Site Planning

These rules focus on providing easy maneuvering for trucks to get from public roadways, through a building site and backed into the dock doors at the building itself. The following truck yard dimensions facilitate easy maneuvering in typical industrial buildings.

These numbers may vary slightly from exact distances derived using objective data and mathematical models. A variation between the derived number and the recommended number is usually a function of marketplace accommodation. These rules identify a range in some cases to cover regional market variations.

It is instructive to review the detailed truck maneuvering section above to understand the conditions that may warrant using different numbers.

Truck drive geometry should accommodate single-turn swings with a WB-67 tractor-trailer rig.

- Build drives 40 feet wide with a minimum 40-foot inside curb radius.

Face of dock to opposite end of truck yard dimensions that should accommodate the same WB-67 in a single swing onto and away from the dock door when a full rig is adjacent to it:

- Buildings above 80,000 square feet: 130 feet in most areas but up to 135 feet in some.

Distance between building dock faces in a shared truck yard that allows for the overlap of some maneuvering space:

- Buildings up to 200,000 square feet: 185 feet in most areas.
- Buildings above 200,000 square feet: 205 feet in most areas but down to 185 feet and up to 210 feet in some.

Size of trailer parking stalls that allow single turn in and out for 53-foot trailers:

- 10 feet by 55 feet.
- Allow a minimum of 65 feet of maneuvering space in front of the stalls.

Vertical dock height, truck yard to finish floor:

- 48 inches.

Minimum rail spur radius:

- 500 feet.

Typical rail door spacing:

- 70 feet on center.

CHAPTER 2

Moving Materials Around Inside the Building: Column Grids and Clear Height

There are wide variations in configurations for specific industrial operations. Manufacturing operations and logistics operations are very different, even though they may both occur in a single building. The problem is not just limited to accommodating both manufacturing and logistics uses, though. Different operators within each type of use have widely varying functional requirements. The rules of thumb for the interior of an industrial building seek to balance flexibility and optimization.

Developers and architects also must balance functionality with construction costs. Wider column spacing means longer structural spans, which means higher structural costs. Other building systems, such as the Early Suppression Fast Response (ESFR) fire suppression sprinkler system, are interdependent on the structural system, and the cost of ESFR construction can vary with changes to the structural grid layout. The cost of foundational systems can vary significantly because they are dependent on local soil conditions. Since all the building systems are interdependent, using past cost data for a new project on a specific site is risky until some preliminary investigation has been completed.

While understanding that construction costs will vary depending on local conditions, it is nonetheless useful to identify the key criteria to optimize functionality for distribution and warehouse buildings. Luckily, there is

a common starting point for most of these operations at the moment: a pallet (see Figure 2.1).

Logistics in the United States have been optimized around moving goods as palletized loads via trucks. This small platform, called a pallet, is about 4 feet square (often 42 inches by 48 inches) and 2 inches high. Usually made of wood, pallets can also be made from plastics. Pallets are simple platforms that hold materials so they can be lifted into selective racking systems and onto and off of trucks with forklift equipment. To keep things simple, this chapter does not address exact sizing, two-way vs. four-way pallets, reversible pallets or all the other pallet nuances. If you want to know all there is to know about pallets, a good starting place is the National Wooden Pallet and Container Association and their publication, “Uniform Standard for Wood Pallets.”¹

Pallets are in common use because they are a cheap, simple way to consolidate merchandise into larger assemblages that are easy to move via forklift equipment. If the merchandise is large, the pallet may hold only one or two pieces. More commonly, it holds several cases of smaller merchandise. Wine comes in cases of 12 bottles, beer comes in cases of four six-packs, shoes come in cases of 12 pairs, t-shirts come in cases of 72 shirts. A pallet load is how many of these cases can be stacked on a 4-foot-square pallet, given a certain height and weight constraint. Figure 2.2 shows a pallet load holding 32 cases.

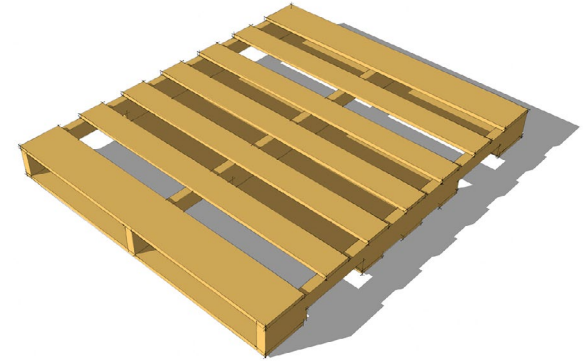


Figure 2.1 A typical 4-foot-square pallet.

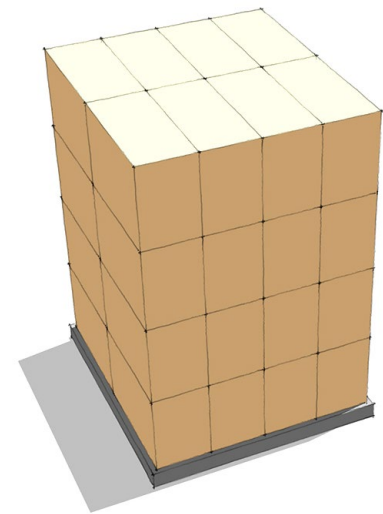


Figure 2.2 A 4-foot-square pallet holding 32 cases of goods.

Historically, most logistics operations concentrated on moving goods from a point of manufacture to a set of distribution centers, and from there to physical stores. Moving pallet loads has been far more efficient than moving individual cases or items in this approach. But changes in retail are rippling through logistics operations, and there is now a greater focus on case and item movement. While most of the rules of thumb presented here relate to numbers derived from pallet-load systems, the chapter also flags instances where new e-commerce logistics operations tend to alter the rules.

Amid all the different interactive design criteria that shape a distribution facility stands a basic question:

What column spacing will create the best balance between competing design criteria in a particular building?

In the case of a custom build-to-suit facility for a specific operation, the answer is simplified by obtaining specific criteria for that user. The most functional layout can be extrapolated from that particular user's operational criteria. This functionally optimal layout can then be integrated with project cost estimates and adjusted as needed to balance construction costs with functionality.

However, almost all industrial buildings are developed with an eye to the overall industrial real estate market for leased space. This is even true of most build-to-suit projects. Industrial facilities have large open areas that are usually shaped

like one big rectangle within four exterior walls to accommodate many different functional layouts. The column grid within this big open space needs to be equally accommodating. Manufacturing operations generally operate on a smaller scale than logistical operations, and the equipment and processes used in manufacturing can often accommodate an inconvenient column location. They also make up a smaller percentage of leased operations in a given regional real estate market. For these reasons, column grid layouts in spec buildings are usually designed with logistics operations in mind. In logistics operations, the rules of thumb for column spacing are derived from the unit of storage, the type of moving equipment used and the system in which units are stored.

Material Storage Systems

Bulk storage operations make up a significant percentage of tenants in most markets in all but the largest buildings. Bulk storage means loading goods on pallets and setting them on the floor or stacking them on top of each other (see Figure 2.3). These operations are simple, require little capital to set up and are very flexible. The disadvantage is that they use the volume available in taller clear-height buildings relatively inefficiently and are typically transport- and labor-intensive with goods spread over a wider area. Since there is no fixed racking system, the column grid is not a significant issue for a bulk storage operation. Storage blocks and aisles are easily configured to work with almost any set of column spacing dimensions.

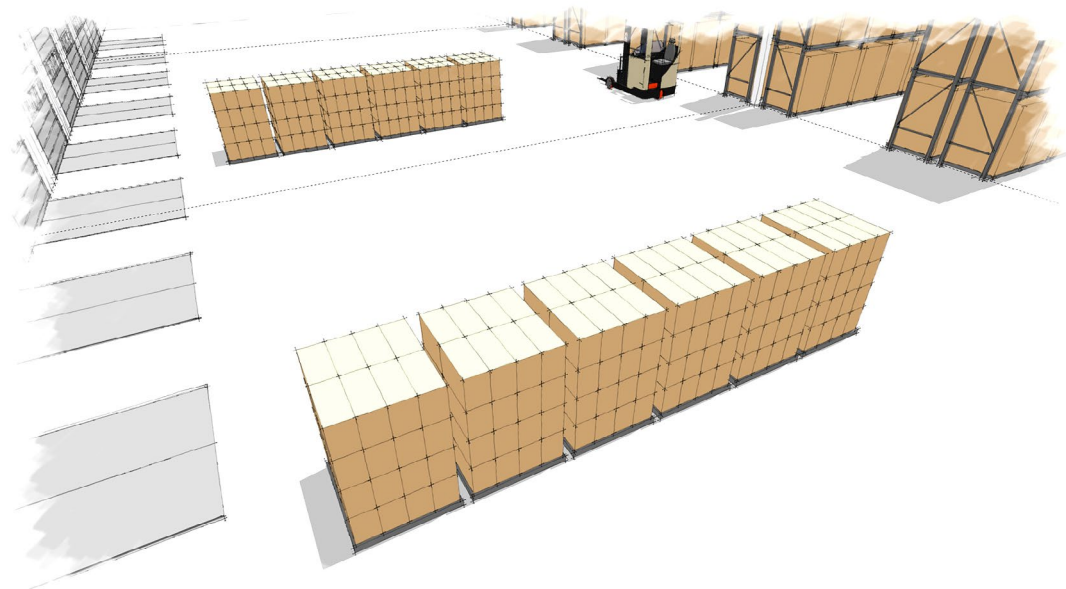


Figure 2.3 One-level bulk storage on pallets.

Palletized racking systems are the primary approach to storing merchandise in today's distribution facilities (see Figures 2.4 and 2.5). Pallet loads are picked up with forklift equipment and stacked on metal rack systems. These rack systems are designed for standard pallets. Each 8-foot-wide rack section holds two pallet loads per level. Pallet load heights vary widely, and the vertical spacing of the racks varies as well. Currently, the most common installed vertical spacing for rack systems in the U.S. is 72 inches, which would equate to a 64-inch pallet height.

There are many variations on palletized rack storage arrangements. There are flow racks, push-back racks, double-deep racks and other configurations. However, the large majority of systems installed in distribution centers are single-row selective racks.

Many e-commerce operations that ship direct to a purchaser do not want to deal with entire pallet loads. In those operations, the racking systems start to accommodate individual cases instead of pallet loads. They are smaller in footprint and have smaller vertical spacing. With smaller spatial increments, these systems are inherently more flexible and can usually be accommodated within the rules of thumb for pallet-load racking systems that are identified here.

By focusing on pallet loads, the most common units of storage, and the racking systems that hold them, we can then sort suitable column grid layouts by the type of material-handling equipment used to move goods around within a building.

The following list of material-handling equipment was used to derive functionally optimized column grid layout criteria:

- Standard aisle – SA (counterbalance lift trucks).
- Narrow aisle – NA (reach lift trucks).
- Very narrow aisle – VNA (order pickers, turret lift trucks).

Standard Aisle – Counterbalance Lift Truck Operations

Counterbalance lift trucks are the simplest, least-expensive material-handling option (see Figure 2.6). They are propane or electrically powered, can be found in sit-down and stand-up models, and in three-wheel and four-wheel options. They are relatively fast but require a wide aisle and have

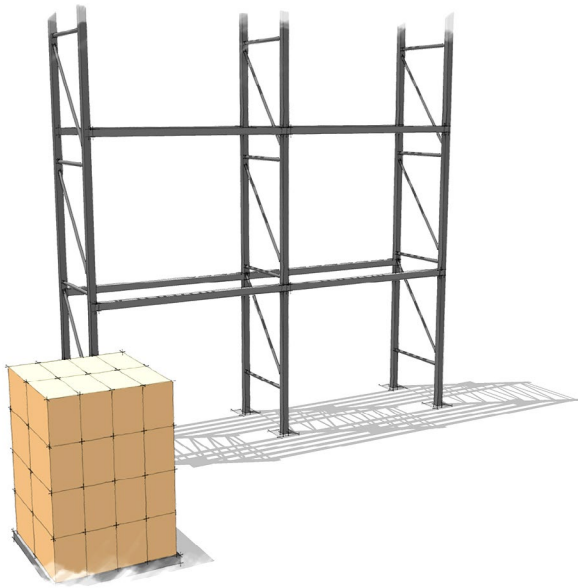


Figure 2.4 Single loaded pallet and pallet rack.

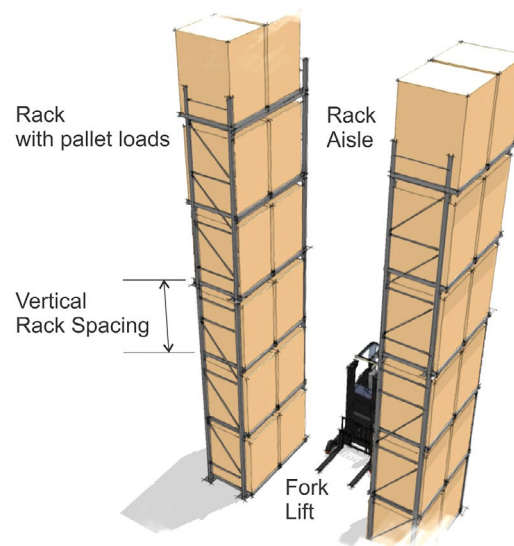


Figure 2.5 Palletized racking system showing loaded pallets placed within racks.

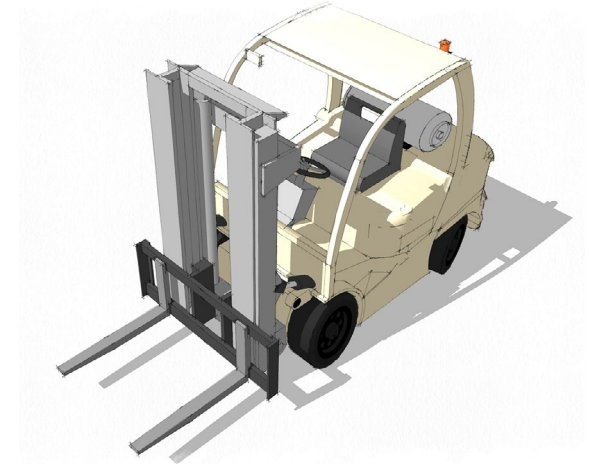


Figure 2.6 A counterbalance lift truck requires 12 feet of aisle in pallet rack systems and is limited to about 22 feet of picking.

limited lift heights. These are used in almost all bulk-storage operations where pallets or units are set on the slab or stacked on each other instead of on palletized racking systems. They also work well in shorter rack systems.

Narrow Aisle – Reach Lift Truck Operations

Reach lift trucks represent the most common material-handling equipment in most large-scale logistics facilities (see Figure 2.7). They are electrically powered and available in a wide range of configurations customizable to specific operations. These lift trucks were designed to operate in narrower aisles and at higher pick heights than counterbalance trucks. Because of that, they cost substantially more. They are optimized for palletized racking systems and are not often deployed in bulk storage operations where lower-cost counterbalance equipment works best.

Palletized racking systems used in conjunction with correctly configured reach lift trucks can efficiently operate in taller clear-height buildings. This equipment can easily lift above the 22-foot range of counterbalance lifts in buildings that are 28-foot to 32-foot clear. By adding extra height masts and larger battery packs, reach trucks can pick into the 30-foot range and effectively operate in 36-foot to 40-foot clear buildings.

In the standard configurations operating in 28-foot to 32-foot clear buildings, this equipment can operate in an aisle as narrow as 102 inches (8.5 feet). In the enhanced lift truck configurations set up to operate in 36-foot to 40-foot clear buildings, this equipment is most efficient with aisles at least 118 inches wide.

Very Narrow Aisle – Turret Truck or Order Picker Operations

Very narrow truck lifts are available that can take maximum advantage of tall clear-height buildings and achieve product densities per square foot of leased facility higher than those in reach lift truck operations. This equipment represents another level of complexity and cost above the reach lift truck. There are several designs in this high-priced market: swing reach trucks, turret trucks, order pickers and other systems (see Figure 2.8). In this equipment, the operator typically rides up to the pick level instead of working from a floor-level view. These costly systems require higher precision and are

often paired with wire guidance operation. The aisle widths required for this equipment are somewhat customizable within a manufacturer's range but are much narrower than what a reach forklift requires. This equipment is seldom used in anything lower than a 36-foot clear building since a less expensive reach truck can effectively operate at lower heights.

Palletized racking systems in conjunction with correctly configured very narrow aisle (VNA) equipment can efficiently operate at 40-foot clear or taller buildings. Often the equipment is wire-guided and at least semi-automated. Sometimes these units operate a semi-automated system at higher speeds with a rail-guided connection at the roof.

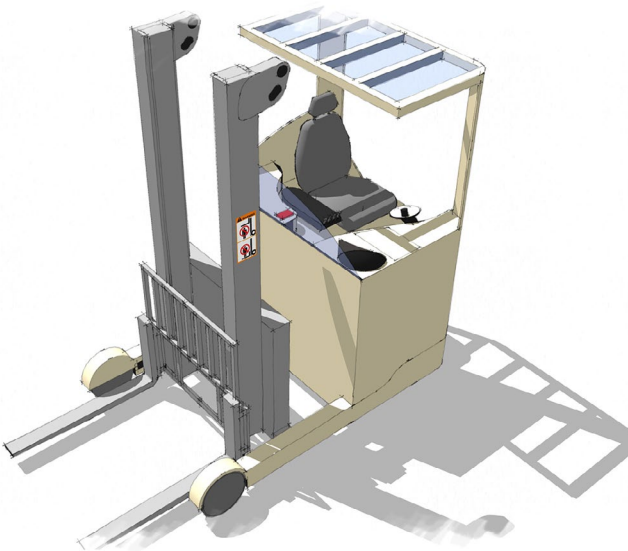


Figure 2.7 A reach lift truck requires 8-foot, 6-inch to 10-foot, 6-inch aisles in pallet rack systems, depending on picking height.

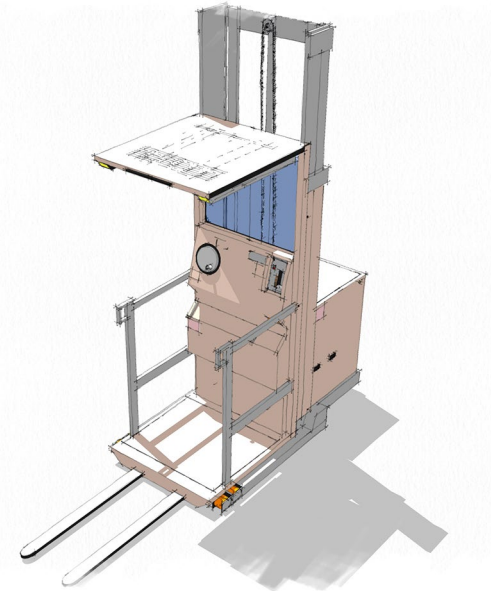


Figure 2.8 An order picker or turret lift truck requires 4-foot, 6-inch to 6-foot, 6-inch aisles depending on the equipment, with picking heights of 50 feet possible.

In the standard configurations operating in 36-foot to 40-foot buildings, this equipment can operate in an aisle as narrow as 54 inches (4.5 feet). However, different systems vary considerably in their configurations and can require aisle widths up to 72 inches.

Column Grids

The following analysis assumes pallet loads as the unit of storage, single-row selective palletized racking as the storage system and three types of forklifts as material-handling equipment.

The aisle spacing required for the efficient operation of lift trucks in pallet rack systems provides a functional basis for determining optimal column

spacing. The aisle, in fact, becomes the only variable in a common distribution rack layout. The rack itself accommodates a standard pallet and can be considered constant at 4 feet deep. Fire codes require a minimum of 6 inches of clear flue space between rack storage placed back to back. That only leaves variation in aisle width.

The clear dimensions between the faces of the pallet loads determine optimum column spacing. When a rack manufacturer designs their rack, they only measure the metal members. The pallets sitting on the rack extend past the horizontal supports a few inches. The dimensions shown in Figure 2.9 will likely be slightly different than the dimensions shown on a racking consultant's drawings.

For any given aisle requirement, one can lay out a number of aisles and racks to determine the structural grid spacing where a column falls into the flue space on a set of back-to-back racks. The structural system can get expensive if spans become very large or very small, so it is important to balance this analysis with structural cost considerations.

The column spacing derived from aisle widths generally runs the long direction of the building, parallel to the exterior wall with the dock doors. Forklifts move in this orientation up and down the speed bay between the dock doors and the first column line and then make a right-angle turn to go up and down an aisle (see Figure 2.10). The column spacing perpendicular to the truck doors is not

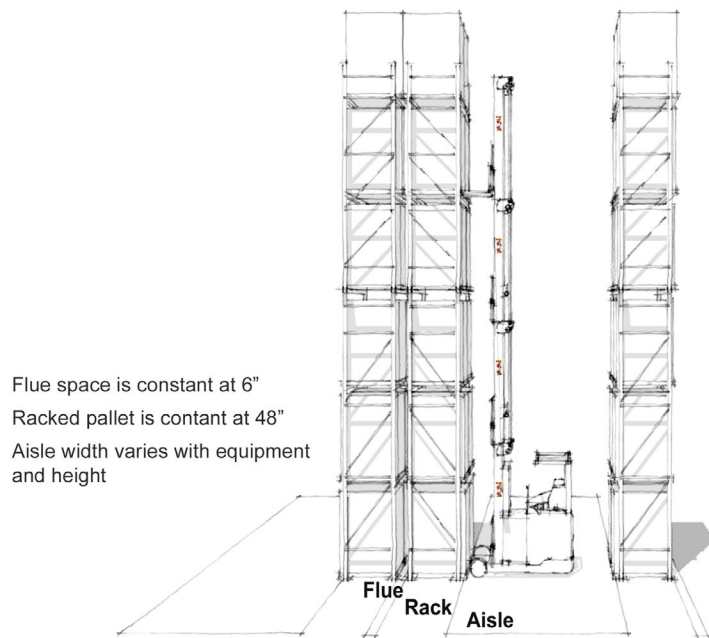


Figure 2.9 Aisle spacing variables.

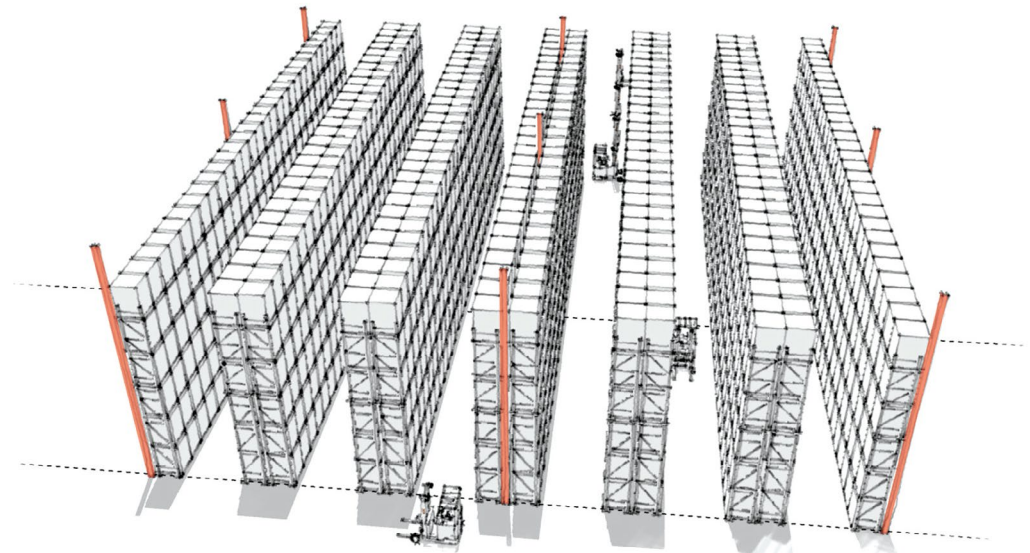


Figure 2.10 Column spacing between racks.

operationally critical as it doesn't affect aisle spacing (see Figure 2.11). For column spacing perpendicular to the dock doors, HPA uses criteria based on structural cost and optimization of the ESFR fire sprinkler lines.

ESFR sprinkler heads have a very tight head-spacing criterion. The main sprinkler lines of this system run the long direction of the building, parallel to the dock doors. When the column spacing perpendicular to the dock door is set on a 10-foot module, the number of main sprinkler lines can be minimized. A typical structural bay is set in the direction parallel to the truck doors by optimizing aisle width spacing and, in the direction perpendicular to the truck doors, by optimizing ESFR sprinkler lines.

Now we can do the math to determine rules of thumb associated with the column spacing of the structural bay in the illustration. Using the different aisle width requirements of different forklift equipment in different clear-height buildings leads to different spacing options.

Tables 2.1 to 2.5 calculate the minimum distances between column centerlines required to place a series of racks and aisles for different aisle widths associated with specific forklift equipment. The calculations account for the size of the columns that sit in the flue space of the racks.

The calculations in Table 2.1 relate to the counterbalanced forklift identified earlier. This equipment is used to service pallet racking with pick heights at 22 feet or lower and would typically be found in a building no higher than 28-foot clear.

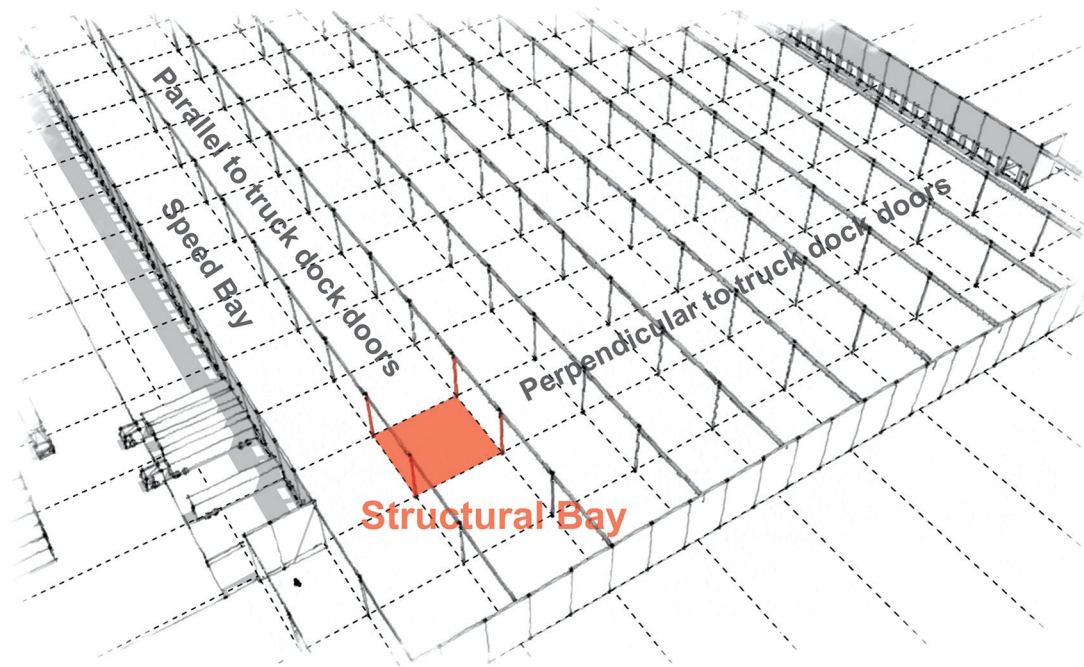


Figure 2.11 Column spacing perpendicular and parallel to truck dock doors.

TABLE 2.1 Rack spacing for counterbalanced forklift.

	Inches	Feet	Two-aisle spacing	Three-aisle spacing	Four-aisle spacing
Aisle Width	144 in	12 ft	288 in	432 in	576 in
Flue	6 in		18 in	24 in	30 in
Pallet	48 in		192 in	288 in	384 in
			498 in	744 in	990 in
Industry Norm 52'			41.5 ft	62 ft	82.5 ft

Counterbalance forklifts need an aisle at least 144 inches wide to be efficient in rack storage systems. The calculations in Table 2.1 show that a column spacing of 42 feet or 62 feet would be optimal for operating this configuration. But HPA would not use these numbers in a spec building because this use of counterbalance lifts and rack storage is relatively uncommon in the marketplace for larger buildings.

More likely is an operation using reach forklifts (see Table 2.2). These forklifts are referred to as narrow-aisle (NA) equipment because they require less aisle width than the counterbalance forklifts.

TABLE 2.2 Rack spacing for narrow aisle (NA) reach forklifts.

	Inches	Feet	Two-aisle spacing	Three-aisle spacing	Four-aisle spacing
Aisle Width	104 in	8.67 ft	208 in	312 in	416 in
Flue	6 in		18 in	24 in	30 in
Pallet	48 in		192 in	288 in	384 in
			418 in	624 in	830 in
<i>Industry Norm 52'</i>			<i>34.83 ft</i>	<i>52 ft</i>	<i>69.17 ft</i>

Most reach forklifts can operate in an aisle 104 inches wide unless the pick elevation is getting high and special options are needed. In buildings 32-foot clear or lower, the combination of reach forklifts and 104-inch aisles is a common configuration. This reveals why the recommended column spacing in these buildings is 52 feet.

In taller clear-height buildings where the tenant is likely to use higher racks to take advantage of the additional vertical capacity, reach fork trucks need additional options to pick pallet loads at the top rack positions. They need extra-large battery systems and more robust mast assemblies. As a consequence, these high-pick reach forklift models require larger aisles to operate efficiently (see Table 2.3).

TABLE 2.3 Rack spacing for narrow aisle (NA) high-pick research forklifts.

	Inches	Feet	Two-aisle spacing	Three-aisle spacing	Four-aisle spacing
Aisle Width	118 in	9.83 ft	236 in	354 in	472 in
Flue	6 in		18 in	24 in	30 in
Pallet	48 in		192 in	288 in	384 in
			446 in	666 in	886 in
<i>Industry Norm 56'</i>			<i>37.17 ft</i>	<i>55.5 ft</i>	<i>73.83 ft</i>

These calculations show the 118-inch aisles required by most reach forklifts when they are picking to the top position in a 36-foot clear building. It is possible to push this to the top position in a 40-foot clear building in some configurations, but the reach forklift equipment will begin to exceed its effective operational limitations. This reveals why the recommended column spacing for a 36-foot to 40-foot clear building is 56 feet.

There are a few reach forklift models available that offer pick heights that are needed for the 40-foot to 42-foot clear building range. These extended service forklifts require even wider aisles (see Table 2.4). Buildings at 42-foot clear are just becoming possible under new widely accepted ESFR configurations.

TABLE 2.4 Rack spacing for narrow aisle (NA) extended-service forklifts.

	Inches	Feet	Two-aisle spacing	Three-aisle spacing	Four-aisle spacing
Aisle Width	126 in	10.5 ft	252 in	378 in	504 in
Flue	6 in		18 in	24 in	30 in
Pallet	48 in		192 in	288 in	384 in
			462 in	690 in	918 in
			<i>38.5 ft</i>	<i>57.5 ft</i>	<i>76.5 ft</i>

To pick at the uppermost range of the extended reach fork truck lifts requires a 126-inch aisle. This reveals why the recommended column spacing in a 42-foot clear building is 58 feet.

Very narrow aisle forklift equipment is designed to pick effectively in very tall buildings (see Table 2.5).

TABLE 2.5 Rack spacing for very narrow aisle (VNA) forklifts.

	Inches	Feet	Two-aisle spacing	Three-aisle spacing	Four-aisle spacing
VNA Aisle Larger Variation	70 in	5.83 ft	140 in	210 in	280 in
Flue	6 in		18 in	24 in	30 in
Pallet	48 in		192 in	288 in	384 in
			350 in	522 in	694 in
			<i>29.17 ft</i>	<i>43.5 ft</i>	<i>57.83 ft</i>

	Inches	Feet	Two-aisle spacing	Three-aisle spacing	Four-aisle spacing
VNA Aisle Narrow Variation	56 in	4.67 ft	112 in	168 in	224 in
Flue	6 in		18 in	24 in	30 in
Pallet	48 in		192 in	288 in	384 in
			322 in	480 in	638 in
			<i>26.83 ft</i>	<i>40 ft</i>	<i>53.17 ft</i>

These calculations show the common range in aisle width required for VNA equipment. Tenants using this equipment are not as common as tenants using NA equipment, and the recommendations in spec buildings are weighted to the reach forklift NA configurations. Notice, however, that the recommended 56-foot or 58-foot column spacing in 36-foot to 42-foot clear buildings, which is derived from three-aisle NA equipment, matches up well to four-aisle configurations of VNA equipment.

The Speed Bay

The first structural bay next to the truck docks is called the speed bay. Typically, this area does not have any storage function. It is used to move material to and from trucks and the rack storage. Forklifts unload trucks and stage materials in the speedbay for transfer to specific places in the racking system. Forklifts also bring materials from locations in the racking system to the speedbay and stage them to be loaded into trucks. With all the traffic, this zone should be column-free and sufficiently deep to allow unloading and staging with cross-traffic movement behind.

The longest cost-efficient span using the currently preferred steel joist roof system is 60 feet, and that is HPA's standard recommended speed bay depth. A 70-foot bay is only slightly more expensive, and some developers and users prefer the extra depth. As previously noted, there is a pervasive notion in the marketplace that bigger is better.

Building Clear Heights and ESFR

One of the primary differentiators in distribution buildings is clear height. The industry has standardized on a definition of the term “clear height” by agreement. NAIOP defines it this way:

Clear Height

Distance from the floor to the lowest hanging ceiling member or hanging objects, beams, joists or truss work descending down into a substantial portion of the industrial work area. This is the most important measure of the interior height of an industrial building because it defines the minimum height of usable space within the structure.²

In practice, the substantial industrial work area measurement used to define clear height begins 6 inches inside the first column grid at the back of the speed bay.

The speed bay isn't typically used for racked storage and doesn't use the space vertically, so the definition excludes that area. The definition starts 6 inches in from the column line so that it avoids the bottom of the roof truss on that line. The roof usually slopes up from the outside walls to the center of the building footprint, and the roof trusses are about 4 feet to 5 feet deep. This means that the second column line in from the outside dock wall will be the critical determinant of “clear height.” The actual usable height varies with the slope of the roof and the location of the deepest structural members. The clear height metric represents a minimum.

Why is clear height a critical metric? One reason is that it determines the volumetric capacity of the building. For bulk-storage use, it is not important; the building area is the only useful metric for capacity. But for racked storage, the predominant distribution configuration, the vertical dimension is equally important. Another reason is that racked storage arrangements are regulated by the fire code under a section called “high-piled storage.” These regulations create a metric to identify maximum cost-efficient ceiling heights. On most distribution buildings,

ceiling height is equivalent to the underside of the roof deck, which is directly related to a building's clear height.

Building clear height is a measure of the number of rack levels a building can contain and also a measure of how it can meet the fire code for high-piled storage using an ESFR fire suppression system. Almost all distribution buildings today use ESFR systems in their design and construction. These systems allow a wide range of commodity types to be stored in rack storage configurations without requiring that fire sprinkler lines drop down into the storage racks.

In the recent past, ESFR systems have been limited to maximum ceiling heights (effectively roof deck heights) of 45 feet with a maximum storage height of 40 feet. That arrangement has led to today's standard 36-foot clear configuration, (and 40-foot clear with special roof designs). The National Fire Protection Association (NFPA) is the accepted code authority across the U.S. regarding sprinkler systems like ESFR. A couple of years ago, they included an approved system for a 48-foot deck height and 43-foot top of storage in the NFPA code. However, it came with a restriction of 8-foot minimum aisle width. There are two primary private organizations involved with testing and certifying fire protection sprinkler systems: Underwriter Laboratories (UL) and FM Global. The 48-foot deck height ESFR configuration mentioned above was a UL certified system but was not recognized by FM Global.

Recently a new set of tests with heads by Viking resulted in FM-approved arrangements for both a 50-foot and 55-foot maximum deck height. The 50-foot deck height arrangement has a 6-foot minimum aisle requirement, and the 55-foot deck height has an 8-foot minimum aisle restriction. A UL approval

was also recently granted for a system using heads manufactured by Tyco with a 48-foot deck height that allows aisles as narrow as 5 feet. An earlier section noted how VNA forklift equipment uses aisles less than 8 feet wide. Aside from the brand-new UL-listed configuration for 48-foot deck height using Tyco ESFR heads, racking configurations that are compatible with most VNA equipment cannot currently be used in anything with a deck height above 45 feet without in-rack sprinklers. A limited selection of VNA equipment can be used in 6-foot minimum aisles in buildings with 50-foot deck heights.

A range of different ESFR configurations approved by different codes and testing bodies are available for building design today. From a practical point of view, distinctions between UL- or FM-approved ESFR configurations may not matter when the fire-suppression contractor applies for permitting. Local jurisdictions will typically approve configurations that are formally approved by UL or FM even if they haven't been adopted into the NFPA yet.

Table 2.6 lists the current range of system configurations likely to be approved by most local jurisdictions. Developers can now build ESFR-serviced buildings with deck heights up to 55 feet that store up to 50 feet high if the aisles are wide enough.

TABLE 2.6 Current range of system configurations likely to be approved by local jurisdictions.

ESFR Design Configurations				
Max Deck Height	Max Storage Height	Typ. Clear Height	Approved By	Aisle Restrictions
35'	30'	30'	NFPA, FM	NA
40'	35'	32'-36'	NFPA, FM	NA
45'	40'	36'-40'	NFPA, FM	NA
48'	43'	42'	NFPA, UL	8'
48'	43'	42'	UL (Tyco)	5'
48'	43'	42'	FM (Viking)	6'
50'	45'	44'	FM (Viking)	6'
55'	50'	49'	FM (Viking)	8'

These are current as of 1/3/20.

Each approval is for specific head designs, pressure ratings and number of heads.

Commodities allowed are consistent across these approved configurations.

Types of racking allowed are consistent across these approved configurations.

Using Heights Efficiently

Figure 2.12 illustrates the usual rack storage arrangements in relation to the ESFR requirements and clear height. Going from 32-foot clear to 36-foot clear provides significant advantages for increasing storage capacity with most rack configurations. Going from 36-foot to 40-foot clear provides a less compelling set of advantages but would still make sense for some users. A 40-foot clear building can be designed with a 45-foot deck height, but that requires special roof designs that add cost.

The advantages of going from 36-foot clear to 42-foot clear can be seen in the green shaded pallet layers. Going from 36-foot to 40-foot provides one extra pallet layer for the 72-inch pallet arrangement. Going to 42-foot clear also adds an extra layer for the 64-inch and 56-inch pallet arrangements. There are also many users today that can flexibly configure pallet or case racking to take advantage of any incremental increase in clear height. There appears to be little advantage in a 45-foot clear condition for a pure pallet rack operation. The next level that provides a significant advantage would be the 50-foot clear condition.

Keep in mind the earlier discussion on forklift equipment and column spacing. The type of forklift equipment used by a tenant relates to the height of the storage racks they use. Most tenants use rack systems that fit within a 36-foot clear building and service them with NA reach forklifts. They have aisles larger than 8 feet. Some tenants use VNA equipment that requires aisles less than 8 feet. As the building climbs above 45-foot deck height, which equates to 36-foot clear, many ESFR configurations do not allow the narrower aisles. When contemplating deck heights over 45 feet, be cognizant of the resulting limitations on tenant use.

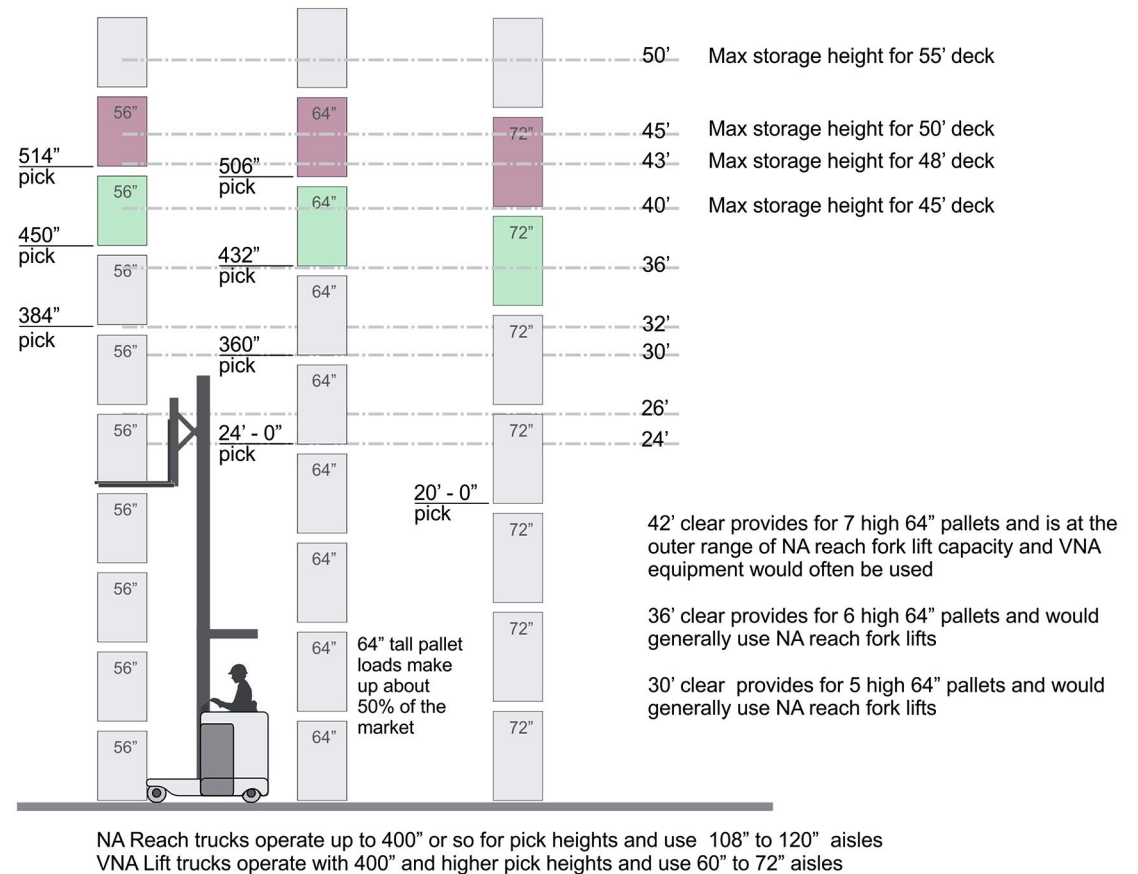


Figure 2.12 Usual rack storage arrangement in relation to ESFR.

Putting these interior rules of thumb together, the resulting building starts to resemble Figure 2.13.

The column bay spacing is dependent on the planned type of forklift equipment and pallet racking system. The selection of forklift equipment is generally determined by clear height. This illustration depicts a 36-foot clear building that will most likely have single selective pallet racks that are serviced by high pick level NA reach forklifts.

You can find the dimensions recommended for other clear heights and forklift equipment in the rules of thumb summary section.

Dock Door Spacing

The total number of dock doors on a building is an important metric in the industrial real estate leasing market. Developers strive to maximize the number of dock doors on a building. In addition to the site-planning criteria of the previous chapter, interior functionality and construction criteria also affect optimal dock door spacing.

The previous illustration shows truckloads being assembled in the speed bay. The process of transferring material to and from trucks and racks centers on staging a full truckload in the speed bay area as a truck is unloaded, or conversely, as it is loaded. Reach forklift equipment moves pallets between this staged load and the racks while counterbalanced equipment moves pallets between the staged load and the truck. This means a truck-loading operation is most efficient when it has an area adjacent to the truck door that can be used to stage a load.

But if the dock doors are spaced far enough apart to reserve that amount of staging space at each door, the dock door count is not maximized. The typical case is that the staging area for an active door extends into space adjacent to a neighboring inactive door so that there is no loss of total door positions.

To determine a rule of thumb for spacing dock doors, we need to examine several variables. Minimum dock door spacing is a balance between truck

maneuvering, the width of the panel leg wall between doors and structural costs. Wall construction is a significant component of structural cost in an industrial building. Concrete tilt-up construction is the most common way to build a large industrial building today. The exterior walls are made of large concrete panels that are cast flat on top of the floor slab and picked up by a large crane that “tilts” up the panels to form a wall.

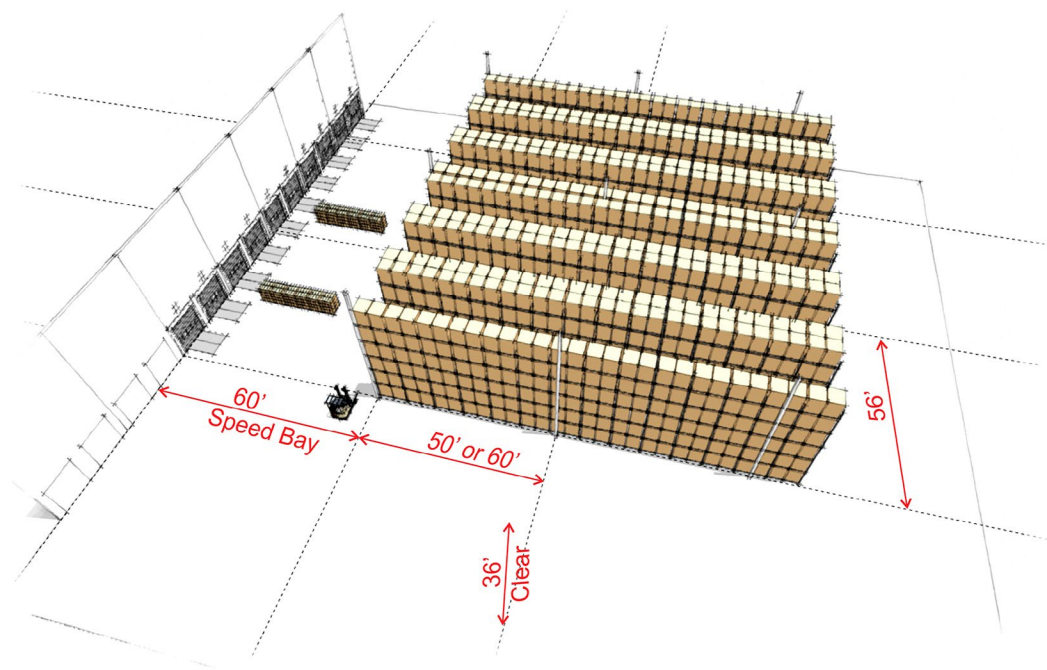


Figure 2.13 A layout using the combined interior rules of thumb.

Figure 2.14 shows a concrete tilt-up panel facing the truck dock area.

Arrayed dock doors along one of these walls means creating a sequence of openings in the panels for doors, with a piece of wall for structural support between each door that are commonly called “legs.” Panel legs that are 2 feet wide are economical to construct, but panel legs less than 2 feet wide start to cost more. Standard dock doors are 9 feet wide; as they are placed along a wall, the minimum leg condition will occur at the joint between two tilt-up concrete panels. If each panel leg is set at 2 feet wide, that equates to a 4-foot spacing between doors. This 4-foot spacing is based on the structurally optimal width of the concrete tilt-up panel leg. This combined panel leg width between doors creates a door spacing of 13 feet on center.

That same 13-feet-on-center door spacing works well for truck maneuvering, as discussed in Chapter 1. While wider door spacing can be structurally sound, it results in fewer overall truck doors. Narrower door spacing would require a larger truck turn radius and result in higher structural costs. Making every other door active allows a staging area for truck loading and unloading. This balancing act results in the rule of thumb to space dock doors at 13 feet on center.

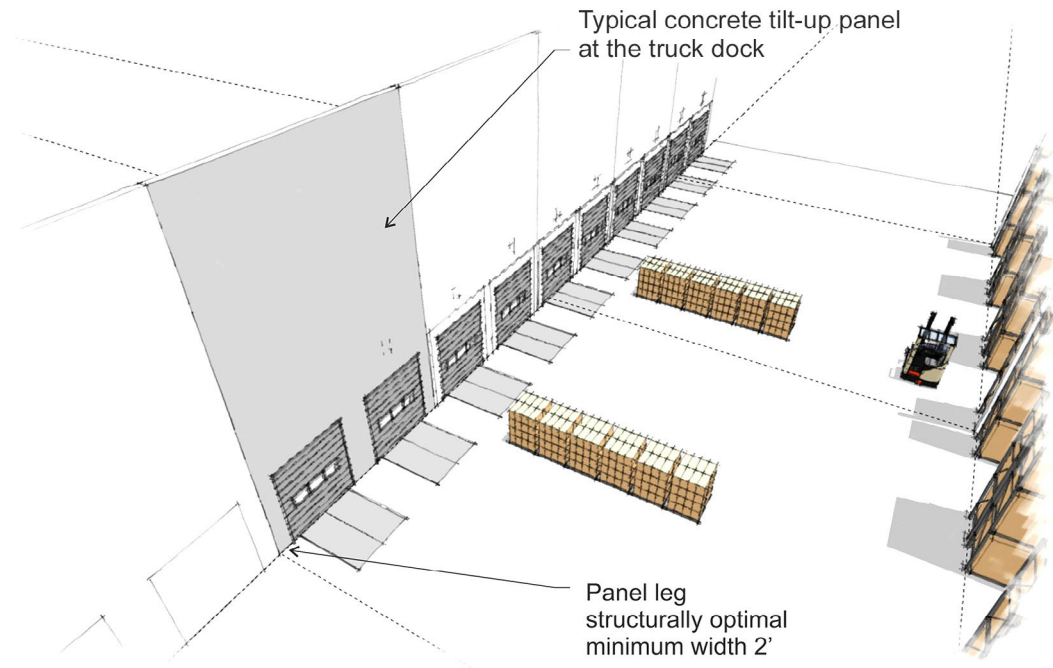


Figure 2.14 Concrete tilt-up panel facing truck dock area.

Recommended Primary Rules of Thumb for Column Grids and Clear Height

Clear heights in most markets follow building size considerations. This can vary according to how the market participates in regional distribution networks. In smaller, more local markets, lower clear heights may suffice. Construction cost can become a big issue on smaller buildings, so while some developers adhere to 32-foot clear as a minimum, there is more latitude for a lower clear height if cost savings are paramount. HPA's recommended ranges for most markets are:

- Buildings below 50,000 square feet can be 28-foot clear.
- Buildings between 50,000 square feet and 80,000 sf can be 30-foot clear.
- Buildings between 80,000 and 150,000 square feet should be 32-foot clear.
- Buildings between 150,000 and 500,000 square feet should be 36-foot clear.
- Buildings above 500,000 square feet (and cross-docked buildings) should be 40-foot or 42-foot clear.

Space columns in the long direction of the building (parallel to the dock doors) according to criteria developed from pallet racking systems and material-handling lift trucks.

- For 32-foot clear or lower, use 52-foot bays.
- For higher than 32-foot clear, up to 40-foot clear, use 56-foot bays.
- For 42-foot clear and higher, use 58-foot bays.

Space columns in the short direction of the building (perpendicular to the dock doors) according to criteria for ESFR head spacing, which is optimized in 10-foot increments.

- Use even multiples of 10 feet in 40-foot, 50-foot or 60-foot bays.

Space the first bay immediately along the dock doors according to criteria for staging truck loads and facilitating lift traffic to rack aisles.

- Use a 60-foot speed bay.
- Buildings up to 36-foot clear have 45-foot maximum deck heights and offer wide flexibility for tenant NA and VNA equipment configurations.

Two new ESFR systems, a UL-listed system using Tyco heads with 48-foot deck heights and an FM-listed system using Viking heads with 50-foot deck heights, provide similar flexibility in a configuration with clear heights between 42 feet and 44 feet. The UL system with a 48-foot deck allows 5-foot-minimum aisles, while the FM listing with a 50-foot deck is limited to 6-foot-minimum aisles. Currently, other ESFR systems with deck heights from 50 feet to 55 feet do not allow aisles less than 8 feet wide.

CHAPTER 3

Building the Building: Slabs and Roofs

This chapter discusses the rules of thumb for designing the actual construction systems of a building. The two most important are the floor, which is a slab on grade, and the roof. In distribution facilities, construction is all about the sky above and the earth below.

Concrete Slab on Grade

Slab design is in some ways like baking. In baking, there are several essential ingredients that are common to most recipes, but the nuances of their proportion and the techniques of mixing and cooking can vary from region to region and baker to baker. Some recipes also contain a “secret” ingredient that is unique to a baker. Slab design is similar, and no slab recipe can be easily deemed wrong or right.

For these rules of thumb, we will identify the basic ingredients in slab design and explain HPA's approach to mixing them together. This approach is informed by the firm's location in the western U.S., but it exports well to other areas. This chapter also examines a few “secret” ingredients that others use in alternative recipes.

At the surface of the slab is what is typically called the finish. It describes how a slab has been worked as it has cured and if any sealers have been applied. Going down from that is the slab itself, composed of concrete and sometimes steel reinforcement.

The slab sits upon a prepared sub-grade. It may be separated from that sub-grade by a vapor barrier plastic sheet. The sub-grade can have several layers of sand, gravel, rock, recompact soil and natural soil (see Figure 3.1).

Sub-grades vary widely by region and even by specific site. They are specified by a soil engineer after samples and soil cores on the site are analyzed. A soil engineer will need to determine if a high water table requires that a vapor barrier be placed over the subgrade. If the soils are highly expansive, the soil engineer may also identify the need for a slab reinforcement, as discussed later in this section.

A slab on grade transfers load directly into the sub-grade and soil below. A good slab is dependent

on a good sub-grade. The soil engineer's geo-tech report will specify criteria for working the subgrade. It is important to follow their criteria, but they may not always go far enough. The industry standard compaction rate for recompacting soils under the floor slab during grading is 90% of optimum, but HPA believes it is an excellent investment to compact to 95% of optimum.

There is a go-to technical reference for concrete slabs: The American Concrete Institute (ACI) publications. For a detailed discussion oriented to structural engineers, refer to ACI publications on slabs, 302.1R-15, 360R-10, and other publications about reinforced concrete in general, like SP-17(4).³ This chapter provides a brief overview of the concepts addressed in these publications for readers who are not structural engineers. Check the ACI documents for extended discussions and details.

Cracking in Concrete Slabs

A slab on grade is not technically a structural slab. It does not span any distance; it transmits forces vertically into the ground below it. Small cracks do not change a slab's transfer capacity and are not a structural issue. But they are an issue for small-wheeled forklift equipment rolling over them at speed. Under heavy use, small cracks chip and spall and become a problem for the smooth operation of forklift equipment.

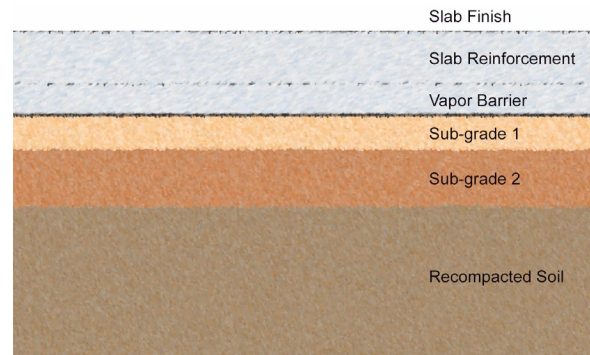


Figure 3.1 Slab and subgrade components.

Concrete is a result of a chemical reaction process called hydration: *cement + water + filler = concrete*. To get just a bit more technical, using a Portland Cement example, it is *calcium silicate + water + filler = calcium hydroxide + filler + heat*. The filler is a mixture of sand and aggregate. As the calcium silicate transforms to hydroxide and the heat dissipates, the volume of the concrete mass shrinks. Concrete cracks when it shrinks.

ACI has useful definitions for three types of slabs on grade in relation to cracking, (they prefer to use the term “slabs-on-ground”):

1. Unreinforced concrete slabs.
2. Slabs reinforced to limit crack widths.
3. Slabs reinforced to prevent cracking.

Regardless of the recipe and which ACI category it follows, a slab will crack. The classification is oriented around how the particular recipe attempts to mitigate the cracking. It is also important to note that when ACI says “unreinforced,” it really means “relatively unreinforced.” The “unreinforced” label applies to most slab-on-grade recipes, as reinforcing in slabs is usually minor.

Using ACI Approach 1: Relatively Unreinforced Concrete Slabs as Defined by ACI

More cracks form the faster concrete cures. It is best for the concrete to cure as slowly as possible to eliminate the small hairline cracks that come with a fast cure. HPA specifies a “wet” cure for slabs, which entails covering them with a material and keeping it wet to slow evaporation. This takes time, and in construction, time equals money. Some developers choose to take the savings of time and/or money associated with chemical-based curing applications to speed up the process. This does not necessarily result in a lot of cracks, but it does increase the

probability of increased hairline cracking compared with our preferred wet cure approach.

A primary strategy to mitigate cracking in unreinforced slabs is to make a specific place for cracks to form and treat them in a way that reduces associated issues. This can be achieved through the use of sawcut control joints. The most recent (2016) ACI recommendation on sawcut control joint spacing in unreinforced concrete slabs, described in Figure 3.2, is taken from ACI 360R-10.

Figure 3.2 indicates that *maximum* joint spacing for low shrinkage concrete is:

- 16 feet, 8 inches for a 6-inch-thick slab.
- 18 feet, 8 inches for a 7-inch-thick slab.
- 20 feet, 8 inches for an 8-inch-thick slab.
- 22 feet for a 9-inch-thick slab.
- 23 feet, 8 inches for a 10-inch-thick slab.

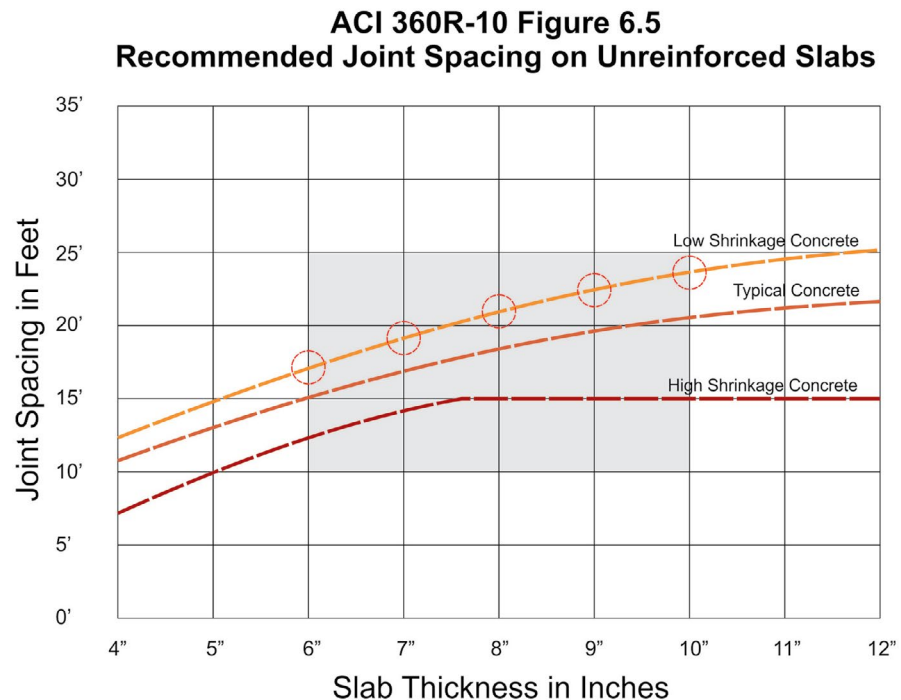


Figure 3.2 ACI recommended joint spacing on unreinforced slabs.

Source: “360R-10 Guide to Design of Slabs on Ground,” American Concrete Institute, 2016.

HPA's slab-on-grade recipes specify mixes that would follow the upper low-shrinkage concrete curve and equate to the range of 4,000 pounds per square inch (psi). But if a little more water is added to the mix at any point, the shrinkage factor rises quickly. Experience tells us to be cautious about exceeding the recommended spacing on the low shrinkage concrete curve.

Figure 3.3 is a sketch of a piece of floor slab defined by a structural bay that is 50 feet by 52 feet with a thickness of 6 inches. This would represent a typical 32-foot clear building configuration, although some developers might use a 7-inch slab.

It shows three sawcut joints in each direction within the column lines of the structural bay. In the 50-foot direction, that means a spacing of 12 feet, 6 inches; in the 52-foot direction, that's a spacing of 13 feet.

That spacing is well below the ACI recommendations. HPA prefers this approach because it can eliminate stray cracks, not just minimize them. However, there are alternatives on this structural bay size. If two control joints are used instead of three, the spacing in the 50-foot direction is 16 feet, 8 inches and 17 feet, 4 inches in the 52-foot direction, which exceeds the ACI recommendation.

Technically the ACI curve would allow for two control joints in the 50-foot direction, which would produce a safe spacing of 16 feet, 8 inches. But this would require three joints in the 52-foot direction to stay within the recommended spacing. That would mean described rectangles of 13 feet by 16 feet, 8 inches. This is problematic as ACI also cautions against getting away from square shapes in the control joint pattern, which can create unequal strain forces in

the slab. For that reason, rectangles are uncommon in the field. Three sawcut joints in each direction, as in the first example, are the norm.

When the building gets taller, as noted in Chapter 2, the structural bay gets bigger, and will usually call for a thicker slab. The increased thickness is not really for load-carrying capacity, it is for uplift forces that are induced by earthquakes when racks are attached to the slab. For a structural bay of 60 feet by 56 feet on an 8-inch-thick slab, HPA would require three joints each way for a 14-foot spacing along the 56-foot dimension, and 15 feet along the 60-foot dimension.

To reduce the number of joints, some experienced developers have decided to accept the greater possibility of stray cracks when going with a spacing above the ACI recommendations. In a regular slab, HPA would continue to recommend the ACI spacing guide, but the firm has had good results with slightly enlarged spacing on some projects. The other ingredients in the recipe become more important as joint spacing is increased, and HPA would not recommend deviating on any other factors if the spacing is increased above ACI recommendations.

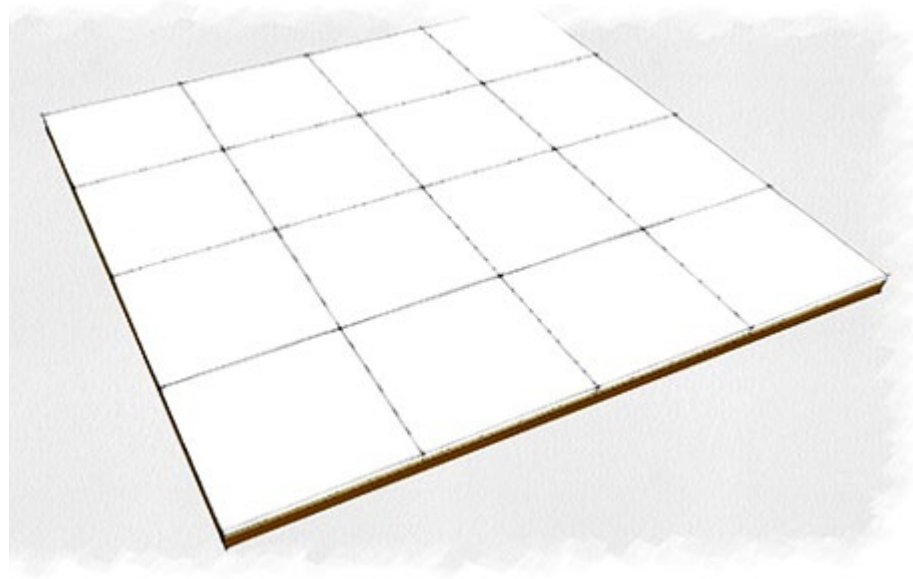


Figure 3.3 A section of a 6-inch floor slab from a 50-foot by 52-foot structural bay.

All these saw cuts into the surface of the slab tell the concrete where it should crack as it shrinks (see Figure 3.4).

Concrete starts shrinking quickly, and these cuts need to be made immediately after the finishers move off the slab — within minutes of the pour, not hours. The saw cuts a slot about 1/8 of an inch wide. The weak line created by the sawcut is where the slab cracks as it shrinks. The sawcut joints isolate the cracks from the traffic surface of the slab. While the clean-edged narrow slot of the sawcut will be less susceptible to erosion than a jagged crack, HPA goes one step further and fills the sawcut slot with a hard epoxy material such as Metzger/McGuire MM-80. This filler provides a surface that is on par with the hardness of the slab and binds

tightly to the concrete, reducing spalling and wear. HPA recommends waiting as long as possible after the slab pour to apply the epoxy filler. Concrete continues to shrink for a long time, and the filler can hold so tight that a crack alongside the sawcut can form if the filler is applied too early. The best situation is to let the concrete shrink until just prior to tenant rack installation, before locking the surface back together at the saw cuts.

In addition to classifying different types of slabs in relation to cracking, ACI also classifies slabs in relation to their intended use. Table 2.1 in the ACI 302.1R-15 publication shows the characteristics of nine different classes of slabs on grade, identified according to number of courses (layered pours), type of traffic, use, special considerations and final

finish.⁴ Only a small segment of that data is relevant for industrial buildings. Classes 1 through 4 are lightweight and not recommended for warehouse and distribution facilities. Class 5 is the go-to specification for most industrial buildings. Class 6 is overkill for most operations; it describes a more heavy-duty floor that has special hardener surfacing. Class 7 and 8 are two pour systems that facilitate a special top finish like the hardeners of Class 6. Class 9 is for operations requiring “super flat” floor criteria. Generally, for-lease inventory buildings require slabs complying with ACI Class 5 that have a concrete mix associated with at least 3,500 psi.

Reinforcing in Concrete Slabs

Most slabs that are casually described as being reinforced would actually be categorized by ACI as “unreinforced.” That is because the ACI definition of reinforcement requires that reinforcement of a slab be sufficient to work against the strain forces of shrinkage. Most slab reinforcement is not designed for this, and instead aims to achieve two other objectives. The first is to give the slab the ability to withstand forces from soil pushing upward, in those situations where expansive soils are present. The second is to withstand uplift from rack installations.

When pallet storage racks are installed, they are required to support themselves from lateral forces that might tip them over, like earthquakes. To counteract this tipping action, the rack installation shoots bolts into the slab to keep the racks from lifting up. Reinforcement may be required to withstand this uplift in taller installations. This is also a primary reason for specifying thicker slabs in taller buildings. HPA recommends reinforcement for rack installation uplift forces in buildings 32-foot clear or above. Table 3.1 (page 38) is HPA’s recommendation for slab thickness based on clear height.

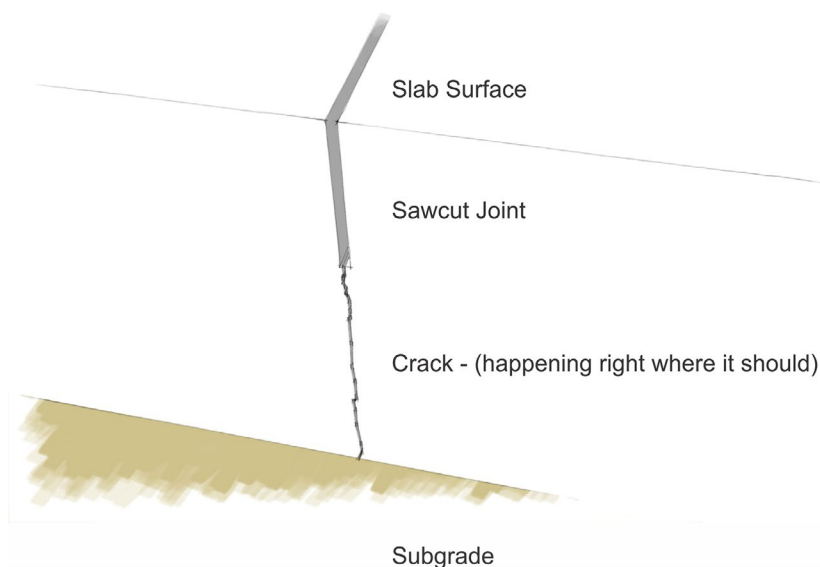


Figure 3.4 A sketch of a typical sawcut joint.

TABLE 3.1 Recommended floor slab thickness based on clear height.

Clear Height	Slab Thickness	Reinforcement
Up to 32 feet	6 inches	optional
32 feet to 40 feet	7 inches to 8 inches	recommended
Above 40 feet	9 inches to 10 inches	recommended

Source: HPA, Inc.

It is important to eliminate any vertical movement at slab control joints. Dowel basket and diamond plate reinforcement assemblies are designed to hold the slabs on either side of a joint in vertical alignment while allowing horizontal movement related to shrinkage. ACI slab publications provide detailed recommendations for designing this kind of reinforcement. HPA recommends using dowels or plates and the reinforcing baskets that support them in all slabs (see Figure 3.5).

To summarize, HPA's recommended slab recipe starts with subgrade preparation that follows the soils engineer's specifications. Although the soils report may ask for placing subgrade materials at 90% compaction rates, HPA typically asks for re-compacting of the subgrade layers to 95% of optimum. The use of a vapor

barrier is a project-by-project call, but we mostly ask for a sturdy one at 30-millimeter thickness. HPA has found that 15-millimeter-thick membranes are too easily punctured.

HPA's opinion is that a wet cure of several days provides the best chances for a crack-free slab. The firm specifies control joints in accordance with ACI recommendations and adding dowels and baskets according to ACI recommendations at these joints. HPA's mix design is performance-based, producing about 4,000 psi in tests. We recommend a joint filler like Metzger/McGuire MM-80 at all control joints. After all that careful design, cranes or concrete trucks should not be allowed on the slab during construction.

This recipe results in a slab that has a good finish with few cracks and is economical to construct. ACI considers this a Type 1 unreinforced concrete slab and a Class 5 slab in relation to its use. While this is HPA's most common slab recipe, there are other approaches to slabs, and HPA uses them in certain circumstances.

Using ACI Approach 2: Reinforcement to Reduce Crack Width

This strategy starts to move away from allowing the concrete to shrink according to its natural reactions by using reinforcing steel to act against strain forces. This involves more reinforcing steel bars than what would typically be used to account for expansive soils or uplift from rack supports. Additional reinforcing bars are introduced to hold against the shrinkage force to prevent cracks from opening up. In some ways, this is the opposite approach to facilitating cracks at the control joints that are large enough to eliminate strain. The increased use of steel reinforcement means an increase in construction cost for this approach over HPA's recommended recipe.

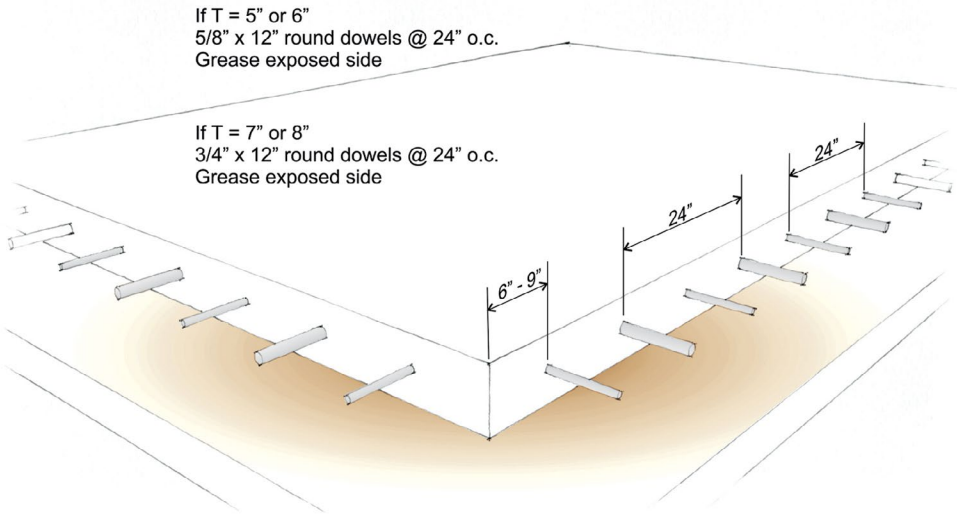


Figure 3.5 A structural diagram of a set of slab dowels.

Demand for slabs with fewer joints is growing. They represent a construction cost and can become a maintenance issue. The steel bar reinforcement approach increases reinforcement costs but seeks to reduce costs associated with saw cutting and filler epoxy. In projects where HPA has used this approach to reduce the sawcut joints, there have been a larger number of fine hairline cracks, but they usually hold tight and produce an acceptable general-purpose floor. HPA is working with one developer and a special slab consultant to perfect a recipe that requires joints only on the column lines, uses significant reinforcement in between column lines to resist major cracking and uses steel fibers to minimize hairline cracks as described in the next section.

Using ACI Approach 3: Reinforcement to Eliminate Cracks

Concrete will crack, no matter what. This section title seems at odds with that statement. It would be clearer if ACI said these types of strategies *minimize* cracks. Slabs using these strategies are generally more expensive than the recipes discussed earlier, but they can be successful in reducing cracking in the slab.

One of the secret ingredients in this type of slab is a chemical additive that mitigates the natural shrinkage inherent in concrete reactions. These additives create “shrinkage compensating” concrete. They add cost but are generally successful at reducing the amount of shrinkage. They all come in specific proprietary packages.

Sometimes a shrinkage-compensating mix is coupled with small fiber reinforcement. This reinforcement can consist of metal fibers or synthetic fibers like those mentioned above. In either case, these fibers are introduced to provide enough binding force to keep hairline cracks from forming. These fibers are

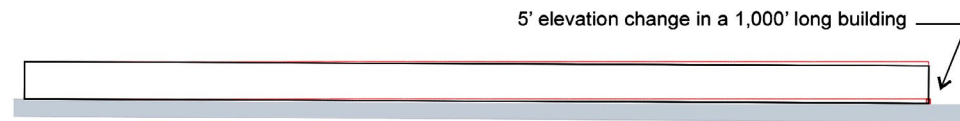


Figure 3.6 A building sloped at .5%.

not meant to counteract a slab's overall shrinking forces. They are instead designed to withstand the very local forces that can create hairline cracks.

This approach counteracts a slab's overall shrinkage using a shrinkage compensating mix, combined with a steel reinforcement system that is designed to reduce crack width (as in ACI Approach 2, page 38). All of these puzzle pieces are designed to work together. The resulting complexity of this approach lends itself to proprietary systems. Kalman Floors has installed variations of this system since before HPA was founded in the 1980s. More recently, the Ductilcrete system has become a common method to produce slabs with reduced numbers of control joints. Some consulting companies specialize in the specification and design of these types of slabs.

HPA has seen mixed success with these special ingredient recipes. Some projects that used these recipes produced very nice slabs and reduced joints, and some had various kinds of performance problems. The allure of floors with fewer joints is strong, and these systems continue to improve and become more numerous in the marketplace.

There is another approach to reducing the number of joints: post-tensioned slabs. These introduce a weave of steel cables into the slab. The cables are tightened as the slab shrinks, which compresses any cracks as they try to form. The overall slab

dimensions shrink, but few cracks form. Generally, this is an expensive strategy to eliminate cracks, and it also creates obstacles to future tenant improvements, as new cores and trenches that are put into the slab must avoid the embedded tensioned cables.

Sloping Floor Slabs

This section is not a discussion on sloping floors to drain water like in a shower or a big wet process area. It is about reconciling floor design with the fact that the earth is not flat, and about the difference between floor flatness and slope. This section will attempt to clarify the confusion that exists in calling a slab “flat” or sloped.

Figure 3.6 is an accurately scaled depiction of a building sloped at 0.5%. Just as in this illustration, real buildings sloped at 0.5% do not look or perform like they are sloped at all. That red square in the lower right is the difference in elevation between a sloped building and a “flat” one.

It has become a standard practice to add a slope to large-scale distribution buildings, and the industry-standard slope is 0.5%. There are no sites out there that are truly “flat.” Sloping the building facilitates connections with municipal street and utility infrastructure and reduces grading costs. Typically, a slope is created across the length of a building, but there are some instances when a slope is applied

in the width. Cost savings for a sloped building vs. a “flat” building can be more than \$1 million for a large facility or a particularly steep site.

This is not a new approach, but as buildings have gotten larger, adding a slope to them has become more common. A typical large-scale building today might contain about a million square feet and measure 600 feet wide by more than 1,600 feet long. The street in front of a typical building usually slopes at 2%. That existing slope creates differential street elevation from one end of the site to the other that might amount 20 to 30 feet. You may not even perceive it because of the scale, but one end of the site can be 30 feet higher than the other. If the building is sloped in the same direction as the street at the accepted standard of 0.5%, it means a differential elevation in the building itself from one end to the other of about eight feet.

Eight feet difference from one side of a building to the other sounds severe, but 1,600 feet is a long distance. When HPA first started designing slope into buildings in the 1980s, the firm was faced with accounting for the slope in all the pieces of construction. It was necessary to figure out how to accommodate it in the door openings, in the glazing systems, in the utility runs and in the roof slopes. However, the world is not flat, and a building that slopes works as well as one that is “flat.” Actually, at this scale, it works better. Now HPA simply makes sure to communicate the slope accurately as it relates to the floor slab elevations and the roof elevations, and everything else takes care of itself. Nobody who is building or using the facility can tell that it is not perfectly horizontal without taking precise measurements. Put a ball bearing on the floor, and it will not move.

All of this discussion so far has nothing to do with what people in the industry generally mean when they talk about a floor’s “flatness.” They usually mean a set of measurements invented by Sam Face, an influential designer who developed many advances in concrete flooring. *FF* measurements stand for “floor flatness” and *FL* measurements stand for “floor levelness.” This raises the question: *“But what about the specifications for FF and FL numbers? Don’t they measure flatness and levelness?”* Yes, they do, but on a very localized scale. Face developed an entirely new approach to specifying and measuring the planar surface of floor slabs a few decades ago. This approach disrupted the entire industry and created the system of specification, construction and testing that is in use for today’s warehouse floor slabs.

This system revolves around the familiar floor flatness, floor levelness, floor flatness local and floor flatness minimum numbers in use today to specify and test floor slabs. While familiar, these numbers are generally not well understood by most people in the industry. There are many resources available that attempt to make these numbers easier to understand for those of us without doctoral degrees in statistics and mathematics. This chapter discusses some highlights but does not get into the details of calculating *FF* and *FL* numbers.

The F-number specifications establish standards for the degree to which a constructed slab surface approaches a smooth geometric plane. They capture a precise measurement of the surface deformations in small local areas and translate this measurement through math and statistical analysis into single measurements for an entire floor slab. Today that may mean a slab over a million square feet in area.

George Garber of ASTM International wrote an article in 2009 on the history of the leapfrogging technology of the slab construction world in the 1980s. His article describes F-number specifications as one leg of a tripod of systems that transformed the floor slab industry. The other two legs are the laser screed, which was invented in 1985, and the ride-on power trowel that came into use about the same time. The F-numbers provide a measurable metric, and the laser screed and ride-on trowel provide construction technology that allows contractors to build to that metric with ever-increasing productivity. Garber describes the metric currently in standard use this way:⁵

At the heart of the new method lay a pair of numbers called Face floor profile numbers, or F-numbers for short. The flatness number, *FF*, measures flatness or planarity — the degree to which a surface approaches a geometric plane. The plane is not necessarily horizontal. The levelness number, *FL*, measures levelness — the degree to which a surface approaches the horizontal. *FF* is based on readings of vertical curvature measured over a span of 600 mm. *FL* is based on readings of slope (difference in elevation) measured over a span of 3 m. Both F-numbers can be, and in practice always are, derived from a single test, which involves taking elevation or slope readings on 300-mm centers along survey lines spaced a few meters apart.

These readings are manipulated statistically with regard to the mean and standard deviations of the data to obtain an overall pair of floor slab F numbers. A scale is utilized that establishes a set of values varying between 10 and 100, with 10 being a floor nobody would be happy with, and 100 being

an almost perfect slab. Today's standard for a speculative distribution building is an overall FF of 50 and an FL of 35. There are also local requirements of FF 33 and FL 21. These are usually exceeded in construction with no special effort.

What is being measured is the difference between the slab's measurements and an absolute smooth plane in a localized area. F-numbers measure smoothness and levelness on a relative, not absolute basis. Key in the discussion below is the qualifier above: *"The plane is not necessarily horizontal."*

The Dipstick and DIN machines from Face Consulting can calculate exact FF and FL numbers on the floor even as it slopes at 0.5%. The FF and FL numbers we specify are the same whether the slab is designed to be "flat" or with a 0.5% slope. Face Consulting puts it this way:

Can a floor be "super flat" even if it is designed to slope?

Yes. Design slope can be compensated for in "super flat" measurements.

It's important to remember that the floor profile characteristics that are critical to efficient, full-speed vehicle operation are the flatness/levelness characteristics under the wheels of the vehicle.

In most cases, the truck really doesn't care if one end of the aisle is higher or lower than the other. It only cares how many bumps and dips it encounters in getting from one end to the other.⁶

There are tens of millions of square feet of distribution facilities constructed over the past 30 years that have been designed with a 0.5% slope in recognition that the world around them is not flat. The practice has become increasingly common as building sizes have increased, slab construction

technology has advanced and slab measurement methodology has advanced. Today it is an industry standard to slope a large building at 0.5%.

The technology and use of racking systems and automated material handling equipment has also evolved at a rapid pace over the past 30 years. These systems have historically been placed into a shell facility that was designed on its own construction standards and logic. Today the material-handling systems and the building shell construction have become highly integrated, but many standards, such as the RMI/ANSI 16.1 section, are still looking at isolated systems rather than integrated construction.⁷ Robotics manufacturers are also unsure of many physical performance aspects of their new systems and tend to specify excessively strict environmental criteria requirements. If a developer wants to be "bullet-proof" regarding a tenant's theoretical criteria for robotic systems, they may want to forgo the cost savings of a sloped floor so that they can advertise a "flat" floor. However, no one should be concerned about the utility of facilities that are sloped at 0.5%

Structural Roof Design

As noted earlier, the roof is an industrial building's other major construction system. The functional criteria and maintenance aspects that were of primary concern on the floor slab do not impact the roof design in the same manner. Up there, the primary concerns are cost per square foot and avoiding leaks.

When HPA was founded, the dominant roof structural system for industrial facilities was glulam girders, timber or mini-lam joists, and panelized plywood. That has changed, and today's dominant roof structure in the western U.S. is an engineered

system of steel trusses for girders and joists with panelized oriented strand board (OSB) for the diaphragm. This system is often referred to as a hybrid roof, since it combines steel-carrying members with a wood diaphragm. In the eastern U.S., the panelized wood diaphragm is typically replaced by a steel deck.

The glulam roof was dominant a few decades ago for the same reason the hybrid roof is dominant in the western U.S. today: they each represent the least expensive way to construct a roof for a given bay size at a particular point in time. There are some regions and environmental conditions that make using metal deck instead of panelized OSB a reasonable choice. In the eastern U.S., steel decking is more commonly used for the diaphragm than OSB. In the Pacific Northwest, there is a roughly equal mix of wood roofs and steel roofs. In both wood and steel roof decks, the engineered system of steel girders and joists is essentially the same.

The girders span from column to column in the long direction of the building, parallel to the dock doors. Using the rules of thumb for column spacing, that means bays of 52 feet to 58 feet. The joists span from girder to girder on a spacing of 8 feet or 10 feet. On the two end bays, where there are typically dock doors, the joists frame into the tilt-up walls. The overall system in this direction is optimized for spans from 40 feet up to 60 feet (see Figure 2.10, page 24).

An interesting aspect to this system of roof construction is the approach to optimizing the steel girder and joist members. The building structural engineer sets loading for the roof. They specify dead load distribution and live load distribution and set criteria for allowable deflection. The manufacturer of the steel roof members does the actual calculations for each girder and joist within the parameters of

their system. This means that the amount of steel is minimized at the manufacturing stage for each member. This is more efficient than picking standard members from a table, which would be oversized in some cases.

This system of girders and joists also applies to buildings that use steel deck instead of an OSB panelized roof deck. The advantage of steel over wood is its strength and longevity, if properly detailed. There is, however, an additional structural issue that must be addressed with steel deck roofs. Steel is more rigid and has a higher coefficient of expansion and contraction than wood. It is most common to address the thermal movement of steel deck systems by providing expansion joints in the deck. Different structural engineers address the issue in different ways, but most designs incorporate an expansion joint at maximum spacing of between 400 to 600 feet. That means a building longer than 600 feet will likely require an expansion joint.

Figure 3.7 shows the typical configuration required in a large building with a steel deck roof.

While the expansion joint allows the steel deck to expand and contract in a way that doesn't introduce significant forces into other building components, it also means that the roof has two more edges that require lateral support for wind and seismic loads. A large building with a steel deck roof is likely to have a set of paired columns in the middle of the building defining an expansion joint. Each side of the joint has its own supporting columns and set of lateral frames. Again, different engineers may have alternative solutions to the issue, but most buildings will have paired columns and frames where they have an expansion joint.

Roof Design Coordination with ESFR

While there is no forklift traffic at the roof to worry about, there is the ESFR fire suppression system noted in the prior chapter. The advantages of an

ESFR system for a rack storage tenant are huge, and almost all buildings today have ESFR fire suppression systems.

These systems have specific design criteria. The allowable variance on head spacing is very tight; the slope of the roof deck must be in a certain range; the height of the roof deck limits configurations and storage options; there are criteria for obstructions from equipment or ducts; and there are limits on airflows. Experience coordinating roof structural systems with ESFR systems has taught HPA methods for optimizing these combinations. The column spacing derived from the rack storage systems applies to one direction while the other direction uses a module of 10 feet for 40-foot, 50-foot or 60-foot bays. This 10-foot module generally results in a minimum number of ESFR laterals, but still makes for economical joist designs.

ESFR systems limit the slope of the ceiling to a maximum and designing for drainage limits the slope of the roof to a minimum. The practical range for roof slope is consequently small, and the ESFR deck height limits essentially set building clear heights as shown in the table in the chapter on column grid design.

Issues of Insulation and Condensation

In those old glulam buildings from a few decades back, there was no thought of environmental control for the inside of the warehouse. It was only about keeping rain and dust out, but that is no longer the case. Today, there are concerns for many products that are temperature sensitive as well as for the employees working in the warehouse space. There is a strong trend toward including HVAC systems to provide environmental control of the warehouse space.

The lowest-cost approach to insulating the roof of the warehouse space was problematic even before this trend took hold and needs some discussion.

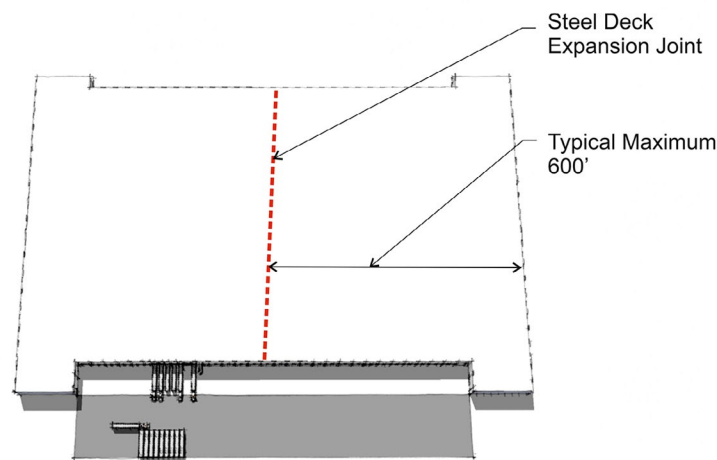


Figure 3.7 Typical configuration required in a large building with a steel deck roof.

Temperature differentials can cause condensation, and warehouse roofs can be subject to periodic condensation that forms under the roof deck, especially on metal hangers and nails. The simple solution to this problem is to place insulation on top of the roof structure. This ensures that the dew point where condensation forms is above the structural members. With steel deck roofs, it is common to insulate above the deck since some type of construction material is required between the steel and the roofing membrane. Wood roofs, however, usually have a roof membrane directly on the wood diaphragm. Placing rigid insulation on top of the wood roof carries a construction cost that most developers are unwilling to absorb.

Non-insulated roofs have been an industry standard in the southwestern U.S. for more than 50 years. In the early 1970s, foil-faced paper products became a standard addition. They are attached to the bottom of the smallest wood members, (2x4s or 2x6s). They were initially used as an aesthetic device to reflect more light from the roof of large warehouse buildings. They evolved into products that provided reflective value on the upper face to reduce heat gain from solar radiation (sometimes referred to as emissivity) inside the building. Some products have multiple layers with air spaces between them to generate an insulation R-value at minimal cost.

It is possible that when relative humidity is high in the air directly under a panelized wood roof and the temperature above the roof is low, sufficient cold can be conducted into the metal elements below the roof to create condensation. This is also true of steel deck roofs that do not have adequate insulation above the deck. Because of relatively low humidity and warm temperatures in the southwestern U.S., condensation of this type is not a universal problem

in industrial buildings in the region. In areas with lower temperatures and higher humidity, the industry standard is often to put some insulation above the roof to combat the problem. It can be a serious issue for a percentage of buildings that have high relative humidity in the air under the roof deck and inadequate insulation above the roof deck.

Several factors can contribute to relatively high humidity in the air under the roof deck:

- High relative humidity in the ambient air, such as at a coastal location.
- Foil membranes attached to the underside of the roof deck in a manner that traps air with high humidity at the time of construction.
- High moisture content in the wood deck and framing when foil membranes are attached to the underside of the deck in a manner that traps the moisture.
- Roof leaks that allow moisture to get into the wood members of the roof deck.
- Operations or materials inside the facility that contribute a high moisture content to the inside air, especially in low-ventilated situations.

In order to avoid the problems that can occur with high-moisture content in wood materials at the time of construction, HPA's specifications call for a maximum moisture content level in the wood. Testing for this can add cost and time during a critical period of construction, and is sometimes waived by owners and contractors, but moisture from wood materials can be a potential source of problems if combined with non-vented foil applications.

The roof will need to be insulated when the warehouse space is serviced by an HVAC system. With a wood roof, the simple solution of putting

the insulation on top of the roof is more expensive than securing batt insulation below the roof deck. However, installing batt insulation below the roof deck, whether wood or steel, causes the same condensation situation that occurs in non-insulated warehouses with foil below the roof deck.

HPA has concluded that the current industry-standard construction for non-insulated panelized wood roofs, where insulation is secured below the roof deck, will exhibit some degree of condensation in certain situations. The same would be true of steel deck roofs that do not have insulation on top. The expected lifespan of these systems will be dependent on the degree of this condensation and its corrosive effect on the steel hangers, nails and fasteners that are part of the roof system. Short of insulating the top of the roof deck, the best approach is to focus on minimizing condensation and drying it out as soon as possible. The only way to eliminate condensation is to insulate on top of the roof deck at significant added expense.

The recommended rule of thumb for insulating a building is to use rigid insulation on top of the structural deck for both wood and steel systems and batt insulation on the inside of the concrete outer walls down to 10 feet above floor level. Anything below 10 feet is likely to incur damage from material handling operations.

Skylights

Skylights are an integral part of the roof system in the southwestern U.S. In the past, they provided all code-required ventilation. They could also double as smoke hatches and brought light into a spec building, so it showed well without the cost of a lighting system. Today they can supply the daylighting required by California energy codes while showing well for tenants. Skylights are now used in

concert with photocell controls to bank electrical lighting systems, providing significant operational energy savings.

In other parts of the country, rain tends to sully the reputation of skylights. Skylights require a hole in the roof, which means roof flashing details and a greater possibility of rain leaking into the building. As the trend toward mechanical environmental controls in warehouses grows, the use of skylights for ventilation diminishes. As the trend toward energy conservation grows, the use of skylights in daylighting systems grows.

Another approach to bring natural light in without introducing a problematic hole in the roof is to place clearstory windows high up on the exterior wall. It is easier to make a hole in the wall watertight than a hole in the roof. Clearstory windows also offer an opportunity to introduce contrasting architectural elements in large expanses of planar walls. We often incorporate them in buildings that also have skylights.

Clearstory windows cannot replace skylights as smoke hatches, though, and they are less effective at lighting up an empty warehouse for leasing.

Warehouse/distribution buildings are deep, and the light from clearstories does not penetrate to their center. A clearstory can also have the unintended effect of making a warehouse interior appear darker than it is because walls appear darker in contrast to bright clearstory windows.

Unless the project is in the Southwest (in particular California) or in a state that has adopted an energy code, then skylights are an option, not a requirement, and may not be desirable in locations that experience frequent rain. But they can make warehouse space much more visually appealing (see Figure 3.8).

Roofing Membranes

On top of everything is the roofing membrane: it is what keeps out the rain and snow. Almost everyone in the industry has a story to tell about roof leaks that has informed their opinion of what the best roofing membrane system is. Today, there are two types of membrane systems in wide use on large buildings, and two that are sometimes used on smaller buildings.

Large buildings:

- Four-ply built-up roofs.
- Single-ply roofs.

Smaller buildings sometimes have:

- Spray foam roofs.
- Steel roofs.

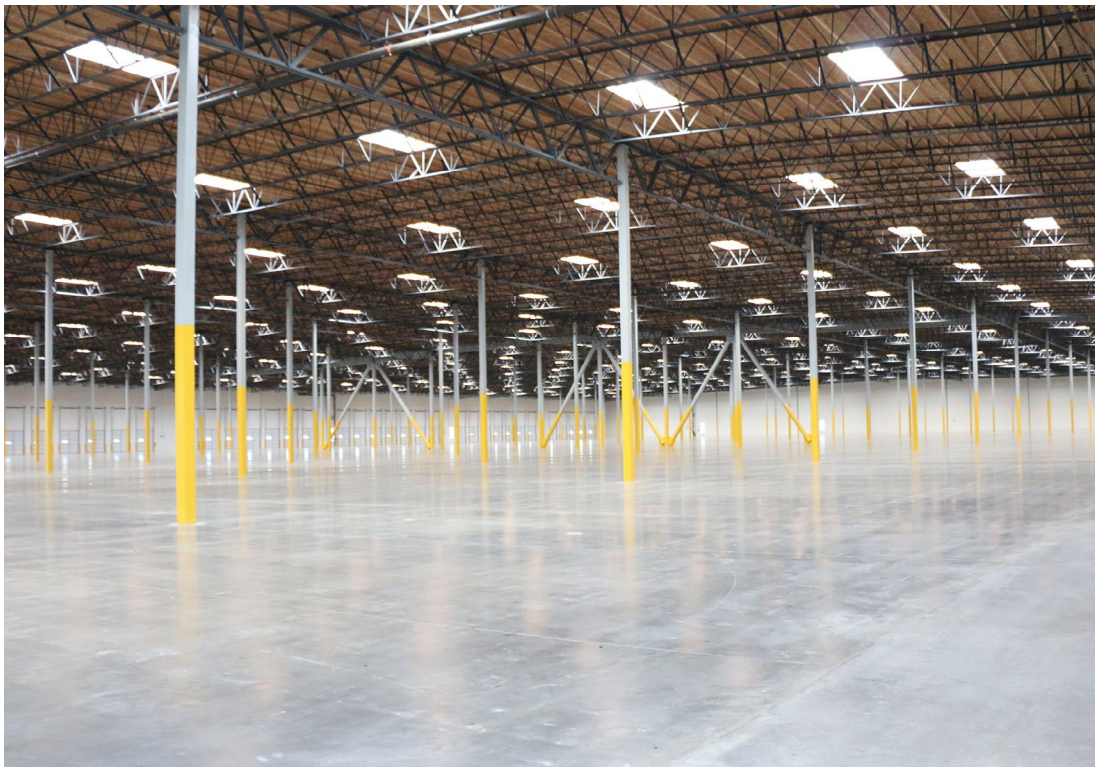


Figure 3.8 Typical interior with skylights and clearstory windows.

Across the U.S., the single-ply roof seems to be the favorite. It is installed as a single membrane, is often the least expensive system and performs well in rainy climates. Several types of single-ply roofs use different membrane materials. HPA typically recommends a TPO (thermoplastic polyolefin) roof, which can be installed several ways. It requires an extra attachment medium to meet the FM Global requirement for being mechanically fastened, but it is still price-competitive in this situation. TPO seams and flashings are completed using hot-air welding systems.

PVC (polyvinyl chloride) and EPDM (ethylene propylene diene terpolymer) are other types of single-ply roofs, but very few of these are currently being installed. They are generally more expensive than TPO.

Proponents of a four-ply built-up roof system like to point out the redundancy provided by the multiple layers as an advantage over single-ply systems. The old line is that a single-ply membrane provides a “one goof, no roof.” It seems intuitive that a single membrane is more likely to suffer a puncture than

a four-layer system, but a multi-ply membrane also has a drawback: the path for a water leak in a multi-ply system may travel between layers, making it difficult to locate the source of the problem. Seams and flashings in a built-up roof are completed with a hot-mopped asphalt emulsion. HPA sometimes specifies built-up roofs, particularly in the regions where they are price competitive with TPO roofs. They are almost always less expensive in Southern California and sometimes less expensive in Northern California. There is also a three-ply roofing approach that HPA does not recommend; a fourth sheet is preferable.

Spray foam roofs can be price competitive with TPO and built-up systems on some occasions. They are not as well tested in the marketplace, and HPA usually recommends a TPO or built-up system instead.

There are a couple of developers that HPA works with who swear by steel roofs. They are generally more expensive, and their advantages are unclear.

Recommended Primary Rules of Thumb for Slabs and Roofs

Slab thickness is a function of clear height. Follow these rules of thumb:

Clear Height	Slab Thickness	Reinforcement
Up to 32 feet	6 inches	optional
32 feet to 40 feet	7 inches to 8 inches	recommended
Above 40 feet	9 inches to 10 inches	recommended

Tell the slab where to crack by using sawcut control joints using ACI spacing recommendations as in these rules of thumb:

- 16 feet, 8 inches maximum spacing for a 6-inch-thick slab.
- 18 feet, 8 inches maximum spacing for a 7-inch-thick slab.
- 20 feet, 8 inches maximum spacing for an 8-inch-thick slab.
- 22 feet maximum spacing for a 9-inch-thick slab.
- 23 feet, 8 inches maximum spacing for a 10-inch-thick slab.

Use these ingredients in your slab recipe:

- 95% of optimum compaction for subgrade layers.
- A mix design yielding low-shrinkage concrete and a Class 5 slab as defined by ACI (about 4,000 psi strength).
- A seven-day wet cure (really, it's worth it).
- Dowels and baskets or diamond plates at control joints using ACI-recommended details.
- A filler such as Metzger/McGuire MM-80 at all control joints.
- Specify overall FF 50 and FL 35 with local FF 33 and FL 21.
- Do not allow cranes or concrete trucks on the slab during construction.

Consider sloping the overall building at 0.4% or 0.5% if there is significant savings.

If you are insulating the roof, consider placing the insulation on top of the deck. If insulation is placed under the roof, make sure it is detailed to provide air movement to allow any condensation to dry out.

In the western U.S., stick with the current industry-standard hybrid roof structure with a TPO or four-ply built-up roofing membrane.

In the eastern U.S., a steel deck roof with insulation on top and a TPO roofing membrane is the popular choice, but remember that roofs spanning more than 600 feet will require an expansion joint.

CHAPTER 4

Notes on Smaller Buildings: Fitting Functionality into a Small Package without Busting the Budget

The rules of thumb for warehouse/distribution facilities discussed in this chapter are focused on balancing functionality for the user with a financial return for the developer. The functionality rules are relevant for any size building. For smaller buildings, however, the per-square-foot cost of construction climbs rapidly. It also becomes more difficult to obtain optimal coverage numbers and the floor area ratio (FAR) tends to go down as buildings get smaller.

HPA's definition of smaller buildings starts at a bit below 100,000 square feet. There are code requirements that change for buildings that are less than around 80,000 square feet (the exact number varies depending on the site plan). Buildings above 80,000 square feet will tend to follow the rules of thumb discussed in this publication while those below 80,000 square feet will tend to need some adjustments to increase FAR and reduce costs.

Site Plans

The size of trucks and trailers will vary more in smaller buildings than the larger ones discussed in Chapter 1. Some tenants will not have the big rigs with 53-foot trailers at all. HPA suggests relaxing the truck-turning criteria on smaller buildings. Instead of the worst-case analysis of a full rig adjacent at the dock, the firm plans for an adjacent 53-foot trailer without the attached tractor rig.

This approach reduces the 131-foot distance for a single swing in/out of the dock position to 111 feet. HPA has noticed, however, that the marketplace usually prefers a deeper yard. To meet market preferences, the firm typically uses a 120-foot distance in California. A 111-foot-deep truck yard will work fine from a functional point of view for most tenants in small buildings, but check the regional market to see if there is a more commonly accepted yard distance. Figure 4.1 (page 48) shows a range of 111 feet to 120 feet.

Smaller buildings usually mean a lower volume of truck traffic, and the number of dock doors becomes less critical. Typically, these smaller buildings will be on grade with truck wells to the dock doors, while the larger buildings are dock high with yards sloping away from the building. The car-parking stalls are often overlaid with truck-maneuvering distances to increase FAR.

One of those code changes as a building gets below 80,000 square feet is that a minimum 40-foot distance to the property line on all sides of the building is no longer required. While the exact floor area threshold can differ in certain regions, all the codes HPA is aware of eliminate this minimum distance for buildings under a certain floor area. There are still requirements for fire lanes to consider, but one side of a smaller building can often be pushed right up to a property line to optimize the FAR factor (see Figures 4.1 and 4.2, page 48).

Small Building Examples

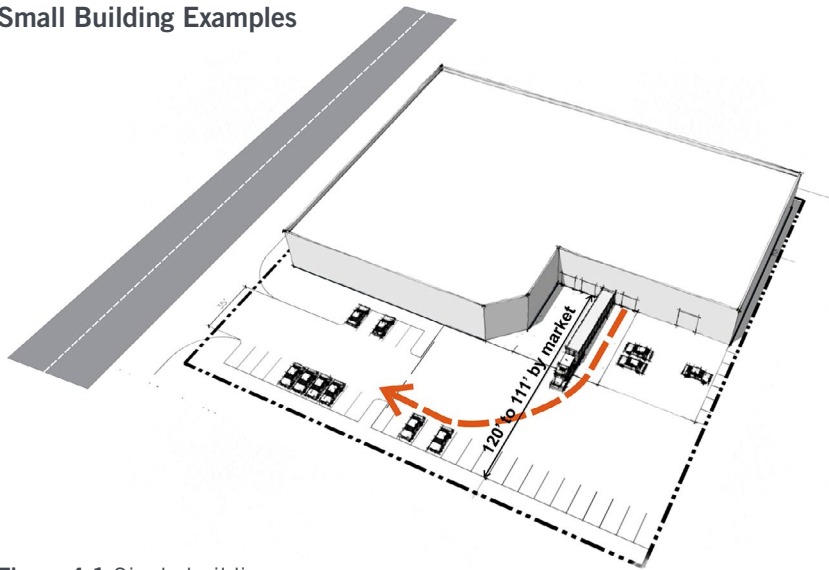


Figure 4.1 Single building.

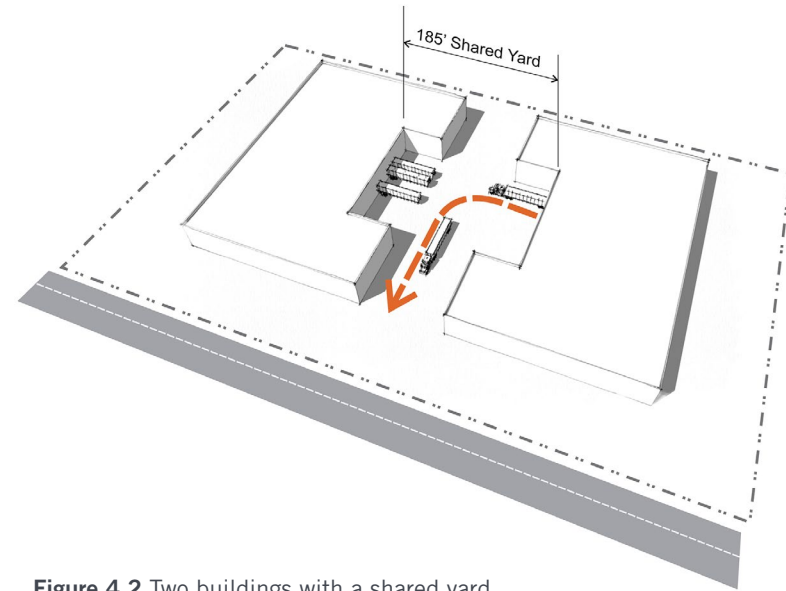


Figure 4.2 Two buildings with a shared yard.

Clear Heights and Column Grids

Tenant operations vary widely in smaller buildings. Uses may include equipment sales and service, small-scale assembly, manufacturing, small-scale distribution and even fully improved back offices. Optimizing column grid sizes for rack storage systems is not as critical since a lower percentage of tenants will be configured that way. These buildings generally have lower clear heights to minimize construction costs. At 80,000 square feet, HPA would recommend staying at 32-foot clear, but some developers are beginning to go to 36-foot clear to differentiate their product. As the building size drops below 50,000 square feet, lower clear heights might make sense, depending on the market. The absolute minimum height HPA would recommend on small buildings would be 24-foot clear.

All buildings today should feature ESFR fire suppression systems and comply with the roof deck height and sprinkler head requirements of one of the code-approved configurations.

In smaller buildings, HPA lets the specific geometry resulting from the constraints of the site plan dictate column grid locations. Most of these buildings will not be simple rectangles, but more complex footprint shapes to optimize FAR factors. Most grids will still be on the order of 50 feet by 52 feet, but there will sometimes be conditions that make other dimensions desirable.

Slabs and Roofs

The wider variation in use that comes with a smaller building makes slab thickness more of a judgment call. In buildings at 32-foot clear, HPA recommends

a minimum 6-inch slab. At that clear height, there is the possibility of tall racks being attached to the slab that induce uplift forces. If the buildings are below 32-foot clear, it may make sense to consider a 5-inch slab thickness, but the 6-inch slab is less likely to show hairline cracks in any size building. Always follow the ACI recommendations highlighted in the earlier slab discussion for whatever thickness is chosen. HPA does not recommend slabs less than 5 inches thick for any size building.

The optimum roof structure system for smaller buildings remains the same, as size does not determine the roof structure system. As noted previously, hybrid roofs are usually ideal in the western U.S., while in the eastern U.S., steel deck roofs have a following. Steel deck roofs with spans smaller than 400 feet usually do not require an expansion joint.

Recommended Primary Rules of Thumb for Smaller Buildings

As building size gets smaller, it becomes more difficult to obtain needed FAR coverage. The rules of thumb are more often adjusted in small buildings than in larger ones. Keep in mind, however, that numbers less than these may require functional compromises.

Truck drive geometry should accommodate single turn swings with a WB-67 tractor-trailer rig at a slower speed than on larger buildings.

- Make drives 35 feet wide with a 35-foot inside curb radius.

Face-of-dock to opposite end of truck yard dimensions that will accommodate the same WB-67 in a single swing onto and away from the dock door when only a trailer is adjacent:

- Buildings less than 80,000 square feet: 120 feet in most areas but down to 111 feet in some.

Distance between building dock faces in a shared truck yard that allows for the overlap of some maneuvering space:

- Buildings less than 200,000 square feet: 185 feet in most areas.

Vertical dock height, truck yard to finish floor:

- 48 inches.

In small buildings, clear heights vary more widely than in large ones. HPA's recommendations would be:

- Buildings below 50,000 square feet can be 28-foot clear.
- Buildings between 50,000 and 80,000 square feet can be 30-foot clear.
- Buildings between 80,000 and 150,000 square feet should be at least 32-foot clear.

CHAPTER 5

Trends in Warehouse/Distribution Design

Most of this book was written in 2019, when the industrial real estate industry was in a boom phase with historically low vacancy rates and historically high absorption rates. The global pandemic caused by the coronavirus SARS-CoV-2 has disrupted global supply chains and altered patterns of consumer spending. At the time of this book's publication, it is not yet clear whether there will be short-term impacts on the demand for warehouses and distribution centers, and whether the effects of the outbreak will substantially slow the pace of new industrial development in the longer term. However, most brokerage, consulting and development firms believe that the industrial sector will weather disruptions associated with the outbreak better than most other real estate sectors. Many also expect that the outbreak may contribute to growth in long-term demand for warehouses and distribution centers.

In mid-April 2020, developers responding to shifting demand said they expected that the outbreak will lead retailers to adopt more robust e-commerce operations and expand inventories to improve supply chain redundancy. Analysts speculate that the outbreak could lead consumers to permanently shift more of their purchases online, including for goods they had previously been reticent to order online, such as groceries. Collectively, these trends could spur long-term demand for industrial real estate.⁸

It remains to be seen if the industrial real estate market will resume a rapid pace of growth after the coronavirus outbreak ends. However, the

importance of a resilient logistical infrastructure has been made clear, and it is possible that changes already underway to create more efficient and robust distribution systems will accelerate. To that end, this chapter examines three current drivers of change in the design of warehouses and distribution centers:

- Logistics and supply chain innovation.
- Material handling innovation.
- Productivity innovation and worker accommodation.

New Supply Chains Mean New Kinds of Distribution Facilities

The retail revolution is a key component of this dynamic. Logistics models are being re-imagined for e-commerce, and a new set of supply chain models is emerging. As the demand for brick-and-mortar retail space declines, the demand for new, efficient distribution space near consumers increases at an exponential pace.

One of the largest industrial developers in the world has created an algorithm that evaluates property for industrial development opportunities based on a new logistics framework. In a September 2019 report, Prologis lays out its current view of industrial market segmentation.⁹ Its algorithm creates a taxonomy that divides logistics facilities into four types based on aggregate income and delivery timeframes. The algorithm analyzes consumer-based data. Prologis maps out areas based on the density of consumer

purchasing power. The taxonomy they use looks like this:

Last Touch™ (Prologis has trademarked the label):

- Facilities focused on reaching a maximum number of affluent consumers within a few hours. These are typically located on in-fill sites.

City Distribution:

- Facilities focused on one- or two-day shipping across a large urban center.

Multi-Market:

- Facilities focused on distribution to multiple centers. These are typically located at transportation hubs.

Gateway:

- Facilities focused on major intermodal locations for sea, air and rail shipping.

In this model, the rules of thumb discussed in previous chapters fully apply to the Multi-Market and Gateway segment definitions. The City-Distribution segment is where it starts to get blurry. Most of these rules will still apply, sometimes with the smaller building accommodations, but an emphasis on small trucks, vans and parking is added. Since the land for this segment is likely to be valuable and in short supply, many are exploring ways to increase the density of these facilities over conventional .45 floor-area-ratio targets while also adding more parking.

Multistory distribution configurations are a response to this desire to increase density.

The Last Touch™ segment describes a new type of warehouse distribution facility. Prototype designs are currently in flux and optimizing principles are hard to determine. The 800-pound retail gorilla tenant of Last Touch™ has many projects of this type underway that will have coverage factors less than 0.2 floor area ratio *based on a ratio of actual process use to land utilized*. Many of these projects convert existing buildings into parking to service the primary distribution buildings. A 180,000 square-foot facility of this type may require over a thousand parking spaces for delivery vans in addition to employee parking. Some of these facilities lease multiple existing buildings and refit some of them as parking garages. This is not something a developer can currently consider on a speculative basis.

Whether you think the Prologis algorithm is useful or not, it is clear that a new type of distribution building oriented to e-commerce and dense urban delivery is becoming part of the logistics supply chain. Location is of prime importance, as noted by Prologis. These projects require a different mix of design criteria than traditional industrial buildings:

- A high number of parking spaces for delivery vehicles.
- A large number of on-grade doors to facilitate loading vans using carts.
- A small number of large truck dock doors, primarily for incoming product.
- High clear heights (36-foot to 40-foot) on small footprints for future pick mezzanines in new buildings.

It is useful to consider some land-use responses to this new demand.

Repurposing Opportunities

Existing large-box retail facilities offer some of the desired criteria for these buildings. They generally have a low FAR factor with lots of space for parking, are on-grade facilities with minimal truck docks and are near population centers. There now exists a trend toward repurposing large retail properties into last-mile delivery locations.

Down-Zoning Redevelopment Opportunities

In addition to rezoning and repurposing existing retail facilities, there has been some recent activity around rezoning and redeveloping office facilities into industrial operations. This is a regional activity where suburban office demand is in decline. One example would be the Seattle market, where vacant midrise office buildings previously occupied by Boeing have become targets for industrial redevelopment due to a shortage of industrial properties.

Industrial Redevelopment Opportunities

As older manufacturing and warehouse operations near population centers fall into disuse, they may become optimal redevelopment opportunities. The traditional model might be to transform these properties as mixed-use retail, office and residential complexes to maximize value. However, the climbing rents for last-mile distribution facilities make them competitive in the value proposition and, unlike mixed-use facilities, they can take advantage of a former manufacturing site's existing zoning.

Multilevel Building Redevelopment Opportunities

The existing 18-acre Sunset Industrial Park in Brooklyn is now being demolished by Bridge Development Partners to make way for a new four-level industrial facility. It will be an example of a fully-functional distribution facility optimized for large truck traffic and high rack storage systems.

There are several similar projects in various stages of development around the country. The high cost of land and the dramatically increased cost of construction for these multilevel facilities will redefine the industrial development pro forma in urban areas.

The rules of thumb for this new multilevel approach are currently fluid. Optimum design choices will not be clear until more projects come to market and can be tested. One of the key challenges that these buildings will need to address is the vertical movement of material. Bridge Development Partners' project in Brooklyn is planning for full truck rigs to docks at all four levels. Prologis has a three-level, fully-leased facility in Seattle named Georgetown Crossing, which has truck dock access on levels one and two, but services the third floor solely via mechanical lifts. HPA has designed four- and five-level build-to-suit facilities that only have truck docks on the ground floor, with levels two through four or five serviced solely with mechanical lifts and conveyor systems.

Floor loading and column spacing will be other interesting aspects of multilevel facility design. Pallet loads sitting on the floor may require heavier live-load accommodation than many rack storage systems. As the load factors climb to 300 per square feet or higher, the spans typically seen in a one-level building become extremely expensive.

Once a building rises above two stories, or gets within 40 feet of a property line, the construction type changes from the non-rated systems used in single-story buildings to fully fire-rated systems. This also increases cost and construction time dramatically. In the four-story build-to-suit designed by HPA, an *alternative means and methods* approach to the building codes was used, with a more robust fire suppression system that replaced

fire-rated construction. However, similar solutions will not be achievable in all jurisdictions.

Multilevel distribution facilities represent a new frontier opened up by rising rents, rising land costs and new supply chain demands. Before a winning formula is identified, some projects will be successful, and others will not.

New Technology Means New Kinds of Material-Handling Technology

The automation of distribution warehouse space is underway, but it is still too fluid to adapt reliable rules of thumb to accommodate these new technologies. Since almost all the automated systems are custom-designed to fit within a shell building that has already been constructed, they take the physical layout as a given. As a consequence, all the site plan and floor plan rules of thumb identified earlier currently work well for automated warehouse operations. The rules of thumb for slab and roof construction also work well.

One caveat is in clear height. It comes from two directions: automated storage and retrieval systems (ASRS) and multiple pick mezzanines. These systems are implemented in speculative industrial buildings that are consistent with the rules of thumb presented here, as well as build-to-suit projects; however, sometimes these systems will require some retrofitting of a speculative building.

ASRS systems pick up a pallet load at the receiving dock area and use automated mechanisms to route it to a position in a storage rack system. The automated system then retrieves it when called upon and delivers it to a shipping dock location. Sometimes these systems fill a warehouse volume and may or may not be covered by the ESFR fire

suppression system design. As the installation costs are far larger than a forklift-serviced set of storage racks, the planned life of the initial system configuration is longer, and the installation of in-rack fire suppression may buy higher storage densities. This makes the clear height definitions approved by codes for ESFR systems less relevant. Build-to-suit facilities planned from the start for an ASRS system will tend to be taller than most speculative buildings of similar size.

Pick mezzanines were initially designed to facilitate manual picking of individual products from low, 6-foot-high racks. That is still true in many cases, but these mezzanines are now also being utilized

for low racks serviced by mobile robots. While the vertical dimension of the warehouse volume has typically been optimized by tall rack storage systems serviced by high pick forklifts, there are a growing number of examples of warehouse spaces being filled by layers of human or robotic pick mezzanines. The higher the clear height, the more levels can be constructed. In some cases, this fuels a discussion around 32-foot to 40-foot clear heights. For some tenants, the difference between 32-foot and 36-foot, or 36-foot and 40-foot, allows for an extra mezzanine level. The diagram below shows potential mezzanine configurations for buildings with different clear heights (see Figure 5.1).

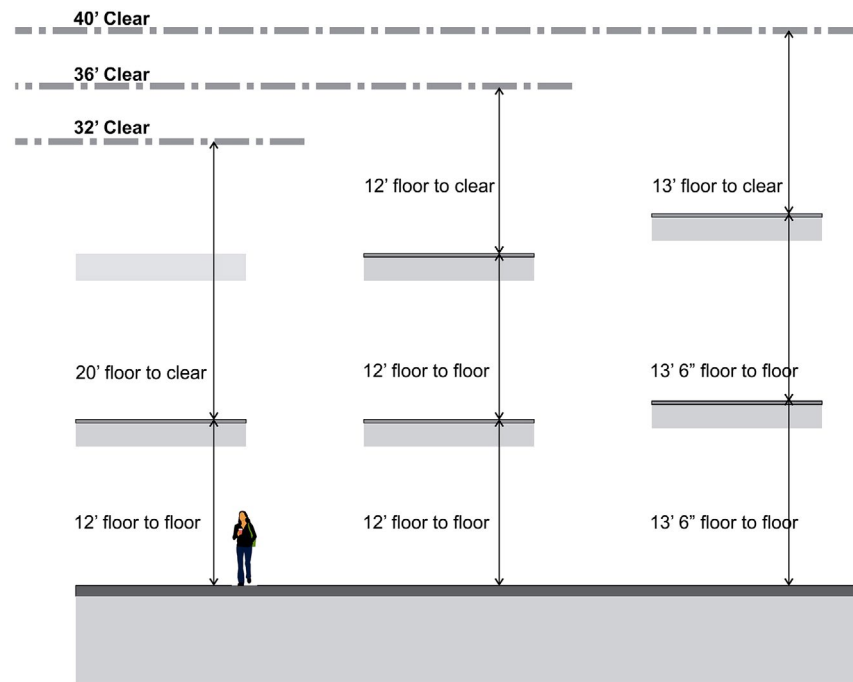


Figure 5.1 Typical mezzanine configurations for common building clear heights.

The technical distinction between “mezzanine” and “story” is an important one when interpreting building codes. Many buildings with pick mezzanines would be defined as multistory in some jurisdictions. The difference is getting murkier over time as code authorities react to these new configurations. There is a four-story pick mezzanine prototype by a specific retail distributor that no longer attempts to define the pick levels as mezzanines. These levels are serviced by robots that bring products to packing stations to be packed by workers. The building is four stories and over 75 feet tall.

New Productivity Objectives Mean New Worker Accommodations

While robots may be the future of warehouse operations, all facilities currently employ at least some human workers. Even the four-story robotics building mentioned above has hundreds of human workers. Warehouse workers are in short supply in most regions, and companies are beginning to adjust their approach to facility design and amenities to attract a stable, productive workforce.

At a site plan level, tenants are demanding more parking, especially when pick mezzanines are added to a building's improvements. Tenants often convert one side of a cross-dock building from a truck yard with dock doors into an employee parking lot.

Amenities and ancillary functions are increasingly added to tenant improvements. A large break room is often provided that serves as an accommodation suite. It may have extensive seating areas with extended rows of microwave ovens. It is likely to include exercise rooms, showers, lockers and outdoor patios. Training rooms are also becoming common. Worker entry areas often house security systems.

In regions like the southwestern U.S., active environmental controls are commonly being added to the warehouse space for employee comfort. Most new facilities in this region have some sort of active HVAC system to lower temperatures in the warehouse during the summer. These systems add significant construction cost and ongoing energy costs and would not have been considered just a decade ago.

Recommended Primary Rules of Thumb for the Future

Identify and communicate clear objectives at the beginning of a project.

The rules of thumb described in this book will apply to buildings representing a large majority of leased space, but targeting new kinds of uses in some buildings may require different rules of thumb. A one-size-fits-all approach will not be suitable to many new logistical facilities. For this reason, it is important to clearly communicate the intended market for a new building to the design and construction teams.

Spend time and resources on thoughtful design to ensure that a building will adequately support its intended uses.

This book is focused on providing quick answers with specific numbers. However, as the use of buildings evolves, it will be important to understand how these numbers are derived to know when they should change.

This rule also applies to older buildings. New types of supply chains may create new types of adaptive-reuse opportunities. Keep in mind that reuse renovations always face more unknowns than conventional new-building development.

APPENDIX

Warehouse/Distribution Design and Aesthetic Image

Architectural design requires more than manipulating the functionally derived numbers discussed in this book. Architects use words and phrases like “sense of place,” “sense of scale,” “metaphor,” “visual impact,” “context,” “vernacular,” “urban fabric” and, of course, “city planning requirement” to communicate the aesthetic nature of a building’s design. But this book has concentrated on optimizing the functional characteristics of the buildings that serve logistical operations. Aesthetic preferences are far more subjective, and related design considerations are not easily encapsulated in standard rules of thumb.

HPA takes aesthetic considerations into account as it designs buildings that optimize functionality and flexibility in an economical way. Like other architects, HPA strives to design buildings that “look better” than others in a given area. But the best approach to aesthetic design can differ dramatically from project to project. Context is one key element of aesthetic design and, by definition, is different for different sites, developers, markets and times. Rather than try to derive aesthetic rules of thumb, this chapter contains a logistics building design portfolio that illustrates past successful approaches.

The portfolio illustrates a few common approaches to aesthetic design. For instance, most of the visual impact in large buildings is concentrated at the building corners where the tenant offices are typically located (see Figure A.1). For large-scale buildings, the use of painted scale elements and the articulation of parapet heights can effectively break down the scale of imposing, large flat walls. Look for these techniques in the following building photos.

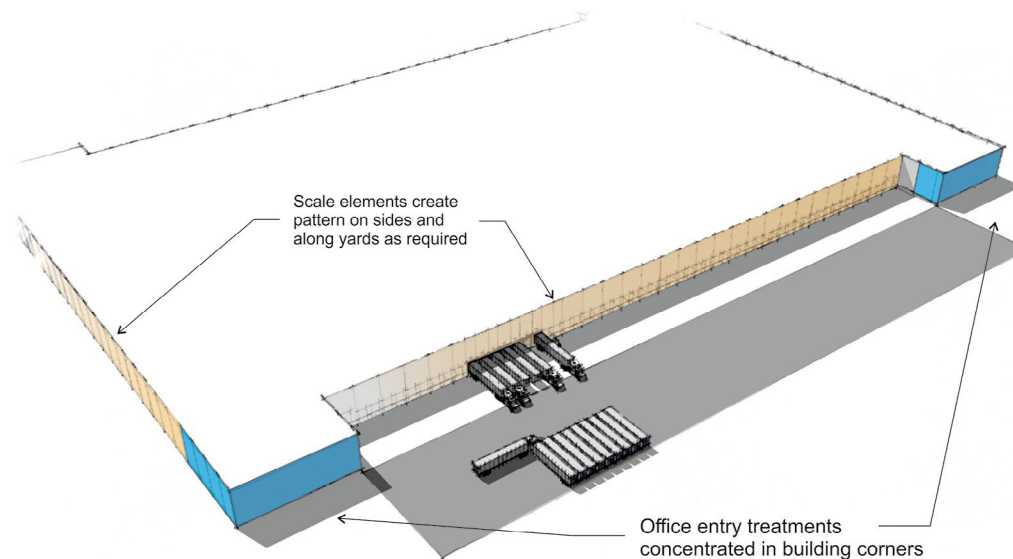


Figure A.1 Aesthetic design focuses on an industrial building’s corners and sides.



Figure A.2 An example of using a building corner to make an architectural entry statement.



Figure A.3 An example of a corner architectural treatment using contrasting paint colors for effect.



Figure A.4 Contrasting materials used on a smaller multitenant building.



Figure A.5 A build-to-suit facility with an office mezzanine and clearstory windows on the right.



Figure A.6 An example of an extreme approach to breaking down scale that is being demanded in some cities.



Figure A.7 A build-to-suit that shows an architectural corner office treatment carried through the sides to break down scale and incorporate clearstory windows.



Figure A.8 A speculative building that shows an architectural corner office treatment carried through the sides to break down scale and incorporate clearstory windows.



Figure A.9 A build-to-suit four-story robotics facility with a total of 2.4 million square feet of space. The vertical movement shafts create opportunity for breaking down the scale of the walls.

ENDNOTES

- ¹ “Uniform Standard for Wood Pallets,” National Wooden Pallet and Container Association, 2014, [https://cdn.ymaws.com/www.palletcentral.com/resource/collection/E8AADDDE-7CBA-4298-8341-C7F29D0C14FF/Uniform-Standard-for-Wood-Pallets-2014\(REV\).pdf](https://cdn.ymaws.com/www.palletcentral.com/resource/collection/E8AADDDE-7CBA-4298-8341-C7F29D0C14FF/Uniform-Standard-for-Wood-Pallets-2014(REV).pdf).
- ² Maria Sicola, “Commercial Real Estate Terms and Definitions,” NAIOP Research Foundation, March 2017, 22, <https://www.naiop.org/Research%20and%20Publications/Reports/Terms%20and%20Definitions>.
- ³ “302.1R-15 Guide to Concrete Floor and Slab Construction,” American Concrete Institute, 2015, https://www.concrete.org/store/productdetail.aspx?ItemID=302115&Language=English&Units=US_AND_METRIC; “360R-10 Guide to Design of Slabs-on-Ground,” American Concrete Institute, 2010, https://www.concrete.org/store/productdetail.aspx?ItemID=36010&Language=English&Units=US_AND_METRIC; “SP-17 (14) Reinforced Concrete Design Handbook,” American Concrete Institute, 2016, https://www.concrete.org/store/productdetail.aspx?ItemID=SP1714FN1&Format=PROTECTED_PDF&Language=English&Units=US_Units.
- ⁴ “302.1R-15 Guide,” 2015.
- ⁵ George Garber, “On the Level: How Flat is Flat?” *ASTM Standardization News*, May/June 2009, https://www.astm.org/SNEWS/MJ_2009/garber_mj09.html.
- ⁶ “The 40 most asked questions about F-Numbers,” Face Construction Technologies, <https://facecompanies.com/docs/40%20Questions%20June%202012.pdf>.
- ⁷ “ANSI MH16.1-2012: Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks,” American National Standards Institute, <https://webstore.ansi.org/standards/mhia/ansimh162012>.
- ⁸ Jennifer Smith, “Real-Estate Firms Expect Coronavirus-Driven Shifts Will Spur Warehouse Demand,” *The Wall Street Journal*, April 13, 2020, https://www.wsj.com/articles/real-estate-firms-expect-coronavirus-driven-shifts-will-spur-warehouse-demand-11586806285?mod=hp_minor_pos13.
- ⁹ “The Modern Supply Chain: A New Model for Defining Logistics Real Estate,” Prologis, September 2019, <https://www.prologis.com/logistics-industry-research/the-modern-supply-chain>.



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Modifications to each of the chapters are indicated as ~~deletions~~ and additions. No rearranging of language is proposed.

LODGING ACCOMMODATIONS:

Delete the definition of “Hotel, Motel, Motor Inn” in its entirety and add the following definitions to Section 14.2401 in the appropriate alphabetical location. Revise the definitions of “Dwelling”.

Chapter 14 Zoning, Article XXIV Definitions, 14.2401: PURPOSE:

DWELLING: A building, or portion thereof, designed or used exclusively for residential occupancy, including single-family dwellings, two-family dwellings and multiple-family dwellings; but not including Hotels, Extended Stay Hotels, or Motels. ~~Not included are hotels, motels, rooming, boarding or lodging houses.~~

Multiple-Family: A building, or portion thereof consisting of three (3) or more dwelling units.

Single-Family, Attached: A building, structure or portion thereof containing three (3) or more attached single-family dwellings where the units are primarily connected horizontally.

Single-Family, Detached: A building containing a single dwelling unit only, which is separated from all other dwellings by open space.

Two-Family: A building consisting of two (2) dwelling units which have been attached.

EXTENDED STAY HOTEL: A building, with each guest room having a full kitchen, providing transient lodging accommodations, limited to no more than ninety (90) consecutive days, to the general public for compensation and which may include ancillary facilities and services such as restaurants, meeting rooms, personal services, and recreational facilities.

HOTEL: A building providing transient lodging accommodations, limited to no more than thirty (30) consecutive days, to the general public for compensation and which may include ancillary facilities and services such as restaurants, meeting rooms, personal services, and recreational facilities.

MOTEL: A building or group of detached, semi-detached or attached buildings on a lot containing guest rooms each of which has a separate outside entrance leading directly from the outside of the building, with garage or parking space conveniently located to each unit, and which is designed, used or intended to be used primarily for lodging accommodations for automobile transients, limited to not more than thirty (30) consecutive days. Motels do not include hotels or extended stay hotels.

~~HOTEL/MOTEL/MOTOR INN: An establishment which provides lodging accommodations for transient guests where less than twenty percent (20%) of the rooms are used or intended for occupancy by permanent guests. A hotel shall provide maid service, linen~~

~~service, telephone and desk service, and the use and upkeep of furniture. Said establishments shall exclude boarding or lodging houses, and apartment hotels.~~

Add “Extended Stay Hotels”, in the appropriate alphabetical location, to the Land Use Table II in Chapter 14 Zoning, Article VI Zoning Districts, Section 14.604, as a conditional use in the B-3 and B-4 zoning districts.

14.604: LAND USE TABLES:

LAND USE TABLE 2

COMMERCIAL AND INDUSTRIAL ZONING DISTRICTS

Land Use	B-1	B-2	B-3	B-4	B-5	B-5C	I-1	I-2	I-3
<u>Extended stay hotels</u>			<u>C</u>	<u>C</u>					

Modify Chapter 14 Zoning, Article XXII Off Street Parking and Loading, Section 14.2207, to add “Extended Stay Hotel” under the Use category “Hotel/motel” to share the same parking requirement of 1 space per guestroom plus 1 space per employee on peak shift.

14.2207: OFF STREET PARKING REQUIREMENTS:

The required number of off street parking spaces shall be calculated as listed below:

TABLE OF OFF STREET PARKING REQUIREMENTS

Use	Parking Requirements
Hotel, extended stay hotel, and motel	1 space per guestroom plus 1 space per employee on peak shift. (Restaurants and lounges require separate parking calculations.)

The definition of “Dwelling” provided in Chapter 15 shall be referenced back to the proposed modified definition of “Dwelling” in Chapter 14 Zoning, Article XXIV Definitions, Section 14.2401.

15.202: DEFINITIONS:

DWELLING: ~~A building, or portion thereof, designed or used exclusively for residential occupancy. Not included are hotels, motels, rooming, boarding or lodging houses.~~ Refer to section 14.2401 of this code.

Modify Section 7.401 to separate regulations for EMC signs located in zoning districts other than C-R, R-X, R-1 and R-A districts and EMC signs located in the C-R, R-X, R-1 and R-A districts.

7.401: ILLUMINATION:

Any sign permitted under these regulations may be illuminated, provided such illumination complies with the following:

- A. Hours Of Operation: All illuminated signs within one hundred feet (100') of any residential property (lot) line shall be turned off between the hours of eleven o'clock (11:00) P.M. and seven o'clock (7:00) A.M. unless the establishment is engaged in the operation of its business with employees on the premises during such period.
- B. Installation Or Application: Illumination shall be installed or applied such that:
 - 1. The light source is contained within the sign and is visible only through a translucent surface or recessed into the sign structure; or
 - 2. The light source is external to the sign and is directed to and concentrated on the sign; or
 - 3. The light source is supplied by neon tubing.
- C. Glare: Illumination shall be prevented from striking or causing a glare on the street or nearby properties.
- D. Protection Of Light Source: Floodlights, gooseneck reflectors or other external sources of illumination shall be contained within a protective casing.
- E. Motion: Illumination shall be constant in intensity and color and shall not consist of flashing, animated, chasing or scintillating lights. Electronic message centers, as defined herein, shall not be considered "flashing" signs for the purposes of these regulations.
- F. Brightness Limitations: In no instance shall the lighting intensity of any sign, whether resulting from internal or external illumination, exceed seventy five (75) foot-candles when measured with a standard light meter perpendicular to the face of the sign from a distance equal to the narrowest dimension of the sign.
- G. Electronic Message Center **(EMC)** Signs:
 - 1. For EMC signs located in districts other than the C-R, R-X, R-1 and R-A districts:**
 - a. ~~Electronic message center~~ EMC signs must not exceed 0.3 foot-candle over ambient lighting conditions when measured at the recommended distance, based on the electronic message center size. The recommended distance = ~~-~~the square root of (the area of sign sq ft x 100).**
 - b. Sensor: All EMC signs shall be equipped with a sensor or other device that automatically determines the ambient illumination and programmed to automatically dim according to ambient light**

conditions, or that can be adjusted to comply with the 0.3 foot-candle measurements.

- 2. For EMC signs located in the C-R, R-X, R-1 and R-A districts: For the purposes of establishing rules and regulations for EMC signs in the C-R, R-X, R-1 and R-A districts, the minimum requirements and best management practices provided by the International Dark-Sky Association, Guidance for Electronic Message Centers IDA2019-01, as amended from time to time, are hereby adopted in its entirety, except such portions thereof as may be modified by subsection G2 of this section.**

- a. Curfew: EMC signs shall be turned off no later than the later of the following and remain turned off until seven o'clock (7:00) A.M the following morning:
 - i. One (1) hour after sunset, but no later than seven o'clock (7:00) P.M.; or
 - ii. Thirty (30) minutes after the closing of the establishment, but no later than seven o'clock (7:00) P.M.
- b. Light Intensity: For any/all establishments with an EMC sign that is open one (1) hour after sunset, the light intensity from the EMC sign shall not exceed 4 foot-candles using the sign's night-mode white screen setting when measured with a standard light meter at a distance of ten feet (10') away from the face of the EMC sign.
- c. Glare: Illumination shall be prevented from striking or causing glare on the street or nearby properties.
- d. Sensor: All EMC signs shall be equipped with a sensor or other device that automatically determines the ambient illumination and programmed to automatically dim according to the maximum light intensity permitted.
- e. Existing EMC signs shall comply with the curfew provided in subsection G2 of this section.

~~—H. Sensor: All electronic message centers shall be equipped with a sensor or other device that automatically determines the ambient illumination and programmed to automatically dim according to ambient light conditions, or that can be adjusted to comply with the 0.3 foot-candle measurements.~~

HEIGHT OF INDUSTRIAL BUILDINGS IN THE I-1 DISTRICT:

Amend Section 14.2104(C) to increase the maximum height of buildings in the I-1 district to fifty feet (50') and to require buildings that exceed the maximum height in the I-1 district to apply for a planned unit development.

14.2104: BULK REGULATIONS:

C. Building Height: The maximum height of any building in an I-1 district shall be ~~forty feet (40')~~ fifty feet (50'). A building that exceeds the permitted height in an I-1 district shall not be authorized except in conjunction with a planned unit development.

Chapter 14 Zoning, Article XXIV Definitions, 14.2401: PURPOSE:

DWELLING: A building, or portion thereof, designed or used exclusively for residential occupancy, including single-family dwellings, two-family dwellings and multiple-family dwellings; but not including Hotels, Extended Stay Hotels, or Motels.

Multiple-Family: A building, or portion thereof consisting of three (3) or more dwelling units.

Single-Family, Attached: A building, structure or portion thereof containing three (3) or more attached single- family dwellings where the units are primarily connected horizontally.

Single-Family, Detached: A building containing a single dwelling unit only, which is separated from all other dwellings by open space.

Two-Family: A building consisting of two (2) dwelling units which have been attached.

EXTENDED STAY HOTEL: A building, with each guest room having a full kitchen, providing transient lodging accommodations, limited to no more than ninety (90) consecutive days, to the general public for compensation and which may include ancillary facilities and services such as restaurants, meeting rooms, personal services, and recreational facilities.

HOTEL: A building providing transient lodging accommodations, limited to no more than thirty (30) consecutive days, to the general public for compensation and which may include ancillary facilities and services such as restaurants, meeting rooms, personal services, and recreational facilities.

MOTEL: A building or group of detached, semi-detached or attached buildings on a lot containing guest rooms each of which has a separate outside entrance leading directly from the outside of the building, with garage or parking space conveniently located to each unit, and which is designed, used or intended to be used primarily for lodging accommodations for automobile transients, limited to not more than thirty (30) consecutive days. Motels do not include hotels or extended stay hotels.

14.604: LAND USE TABLES:

LAND USE TABLE 2

COMMERCIAL AND INDUSTRIAL ZONING DISTRICTS

Land Use	B-1	B-2	B-3	B-4	B-5	B-5C	I-1	I-2	I-3
Extended stay hotels			C	C					

14.2207: OFF STREET PARKING REQUIREMENTS:

The required number of off street parking spaces shall be calculated as listed below:

TABLE OF OFF STREET PARKING REQUIREMENTS

Use		Parking Requirements
	Hotel, extended stay hotel, and motel	1 space per guestroom plus 1 space per employee on peak shift. (Restaurants and lounges require separate parking calculations.)

15.202: DEFINITIONS:

DWELLING: Refer to section 14.2401 of this code.

7.401: ILLUMINATION:

Any sign permitted under these regulations may be illuminated, provided such illumination complies with the following:

A. Hours Of Operation: All illuminated signs within one hundred feet (100') of any residential property (lot) line shall be turned off between the hours of eleven o'clock (11:00) P.M. and seven o'clock (7:00) A.M. unless the establishment is engaged in the operation of its business with employees on the premises during such period.

B. Installation Or Application: Illumination shall be installed or applied such that:

1. The light source is contained within the sign and is visible only through a translucent surface or recessed into the sign structure; or
2. The light source is external to the sign and is directed to and concentrated on the sign; or
3. The light source is supplied by neon tubing.

C. Glare: Illumination shall be prevented from striking or causing a glare on the street or nearby properties.

D. Protection Of Light Source: Floodlights, gooseneck reflectors or other external sources of illumination shall be contained within a protective casing.

E. Motion: Illumination shall be constant in intensity and color and shall not consist of flashing, animated, chasing or scintillating lights. Electronic message centers, as defined herein, shall not be considered "flashing" signs for the purposes of these regulations.

F. Brightness Limitations: In no instance shall the lighting intensity of any sign, whether resulting from internal or external illumination, exceed seventy five (75) foot-candles when measured with a standard light meter perpendicular to the face of the sign from a distance equal to the narrowest dimension of the sign.

G. Electronic Message Center (EMC) Signs:

1. For EMC signs located in districts other than the C-R, R-X, R-1 and R-A districts:
 - a. EMC signs must not exceed 0.3 foot-candle over ambient lighting conditions when measured at the recommended distance, based on the electronic message center size. The recommended distance = the square root of (the area of sign sq ft x 100).
 - b. Sensor: All EMC signs shall be equipped with a sensor or other device that automatically determines the ambient illumination and programmed to automatically dim according to ambient light conditions, or that can be adjusted to comply with the 0.3 foot-candle measurements.
2. For EMC signs located in the C-R, R-X, R-1 and R-A districts: For the purposes of establishing rules and regulations for EMC signs in the C-R, R-X, R-1 and R-A districts, the minimum requirements and best management practices provided by the International Dark-Sky Association, Guidance for Electronic Message Centers IDA2019-01, as amended from time to time, are hereby adopted in its entirety, except such portions thereof as may be modified by subsection G2 of this section.
 - a. Curfew: EMC signs shall be turned off no later than the later of the following and remain turned off until seven o'clock (7:00) A.M the following morning:
 - i. One (1) hour after sunset, but no later than seven o'clock (7:00) P.M.; or
 - ii. Thirty (30) minutes after the closing of the establishment, but no later than seven o'clock (7:00) P.M.
 - b. Light Intensity: For any/all establishments with an EMC sign that is open one (1) hour after sunset, the light intensity from the EMC sign shall not exceed 4 foot-candles using the sign's night-mode white screen setting when measured with a standard light meter at a distance of ten feet (10') away from the face of the EMC sign.
 - c. Glare: Illumination shall be prevented from striking or causing glare on the street or nearby properties.
 - d. Sensor: All EMC signs shall be equipped with a sensor or other device that automatically determines the ambient illumination and programmed to automatically dim according to the maximum light intensity permitted.
 - e. Existing EMC signs shall comply with the curfew provided in subsection G2 of this section.

14.2104: BULK REGULATIONS:

C. Building Height: The maximum height of any building in an I-1 district shall be fifty feet (50'). A building that exceeds the permitted height in an I-1 district shall not be authorized except in conjunction with a planned unit development.