Evaluating Occupant Load Factors for Business Operations

An Interactive Qualifying Project report completed as required of the Bachelor of Science degree at Worcester Polytechnic Institute

Submitted to the Faculty of Worcester Polytechnic Institute

By

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Abstract

The current occupant load factor of 100ft^2/person, as specified by NFPA 101, *Life Safety Code*, and NFPA 5000, *Building Construction and Safety Code*, for business uses has been in effect since the 1930's. Business use areas, specifically office environments, have changed since that time, and questions have arisen regarding the appropriateness of the 100ft^2/person factor for all types of business use areas. This study investigates the origins of the 100ft^2/person factor, previous occupant load studies, changes in office space planning and use, availability of office furnishings, and current office occupant load preferences, then recommends alternate occupant load factors and business use categories.

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1. Executive Summary

Effectively determining the number of people that can occupy a building is a critical design consideration. The proposed occupant load directly impacts the safety of building occupants, and affects other building features such as the means of egress, permitted construction types, required fire protection systems, etc.

Building and fire regulations such as NFPA 101 specify occupant load densities (load factors), based upon the intended use of the space, that architects, designers and engineers must apply in determining the number of people expected within the building. The current occupant load factor of 100ft^2/person of floor area for business operations has remained unchanged since the 1930's, and is based upon traditional office layouts and functions at that time. However, questions have been raised concerning the appropriateness of the current business use occupant load factor for some types of contemporary business operations.

In determining the appropriateness of the current 100ft^2/person occupant load factor for business uses, this study investigated the historical basis for the 100ft^2/person load factor; examined changes in office space function, planning, layout and furnishings; analyzed available data on office space occupant load trends; and conducted a questionnaire of architects, building owners and managers and real estate agents to obtain current data.

This research project recommends i) an increase in the value of the occupant load factor for general business use in the Life Safety Code from 100 ft^2/person to 150ft^2/person, and ii) a new category of business use in the form of high density business use spaces, such as call centers, with an occupant load factor of 100 ft^2/person with an advisory note suggesting that types of

furnishings proposed for the space need to be prudently considered as work stations as small as 25 ft^2 in size are available.

2. Background

The need to evaluate the validity of the current occupant load factor of 100ft^2/person for a variety of business use areas became apparent during the code revision cycle for the 2012 edition of NFPA's *Life Safety Code*, NFPA 101. During their 2011 Report on Proposals (ROP)[1] meeting, the Technical Committee (TC) on Mercantile and Business Occupancies voted to change the occupant load from the current 100ft^2/person to 150ft^2/person, for all business occupancies. At their 2011 Report on Comments (ROC) meeting[2], the TC voted to change the occupant load back to 100ft^2/person based upon several comments that were received and the committee's need to be presented with more documentation and justification. The committee was in agreement that this is an issue they need to address in the future, but that they did not possess sufficient justification to support a change for the 2012 edition of the code.

[1] (NFPA, Report on Proposals 2011)
[2] (NFPA, Cycle Report on Comments 2011)

3. Methodology

For parts of this project, the project team comprised of 3 undergraduate WPI student members: Thomas Carlyle Thackeray, Tyler William and Tudor Muha. The project represented their Interactive Qualifying Project (IQP), required by their curriculum. During the later and final stages of the project, the project team consisted of Tudor Muha and Brian Merrifield, a graduate student research assistant in WPI's Department of Fire Protection Engineering. The project advisor was Professor of Practice, Milosh Puchovsky, from the Department of Fire Protection Engineering. A Project Technical Panel from the Fire Protection Research Foundation (FPRF) also provided input and direction to the project team. Members of the Panel included:

- Amanda Kimball, FPRF
- Ken Bush, Maryland State Fire Marshal's Office
- Kristin Collette, National Fire Protection Association
- Josh Elvove, General Services Administration
- Dave Frable, General Services Administration
- Nancy Hurley, National Fire Protection Association
- Erica Kuligowski, National Institute of Standards & Technology
- Dan O'Connor, Aon Fire Protection Engineering Corp.
- John Tello, Boston Properties

The project started on August 23rd 2011, and the following tasks were proposed for completion:

- Origin and first appearance of the occupant load factor
- Investigate the evolution of the occupant load factor
- Identify trends for the design of business office space

- Determine the validity of using only one category for business occupancy use, by conducting questionnaires
- Conclude by stating the validity of the value of 100ft^2/person for the business occupant load factor
- Recommend changes to be made to the Life Safety Code

The following methods were used to successfully complete the steps presented above:

1) Literature research investigating:
    a) Previous editions of the Life Safety Code
    b) Previous studies analyzing the design and use of office space
    c) General guidelines of institutions concerning the design of office space
    d) Office space planning guides
2) Gathering data using questionnaires sent to the following groups of people:
    a) Architects
    b) Real estate people
    c) Building owners/managers

The paper is organized following the methodology presented above.

4. First Appearance of the Occupant Load Factor

In 1922 Committee on Safety to Life Proceedings[3], an interest was shown to establish an exits code for office buildings. The committee said that it was "logical after the factory and department store codes already approved in 1918 and 1921 respectively". However there were some problems with establishing the exits code for office buildings. The first problem, the only one on which we will focus, was not having sufficient data regarding "the maximum population of a building at any one time". In other words the first thing that they needed to know, was how many square feet of office space was allocated per person. To do this they stated that the best method was to count all persons in and out the buildings. By recording the difference between the two values at frequent intervals, they could assess the number of people that were actually in the building at that time. They did this for twelve office buildings in Philadelphia, "including all the largest and several representative older and moderate sized structures" and in New York where "the fire department made counts of the number of persons in several representative buildings during business hours." [4]

The committee concluded that although it did not have sufficient data to justify an exact value for the occupant load factor for business occupancy, they recommend the value of $100ft^2$/person.

[3] (NFPA, Exits Code for Office Buildings 1922)
[4] (NFPA, Exits Code for Office Buildings 1922)

The following is the passage from the 1922 Proceedings[5] of the Committee on Safety to Life saying exactly that (Appendix A: 1922 Committee on Safety to Life Proceedings):

> *"While the committee has not yet sufficient data to justify any final conclusion, it believes tentatively that it will be wise to figure 100 sq. ft. of gross area per person as the basis upon which stair capacity shall be established. The gross area rather than rentable area has been selected as a basis, because rentable area may vary from time to time and, because generally speaking there is a fairly constant ratio between gross and rentable area."*

In the study conducted in 1996 by James A. Milke and Tony Caro[6] of the Department of Fire Protection Engineering from the University of Maryland, it was stated that the occupant load factor first appeared in the Building Exits Code in the 3rd edition published in 1934. While that was the first time the $100ft^2$/person was in the Building Codes, as seen in the previous paragraph, this was not the first time the committee had reported on this topic, nor was the requirement simply based off preliminary information taken from the NBS study[7] conducted that same year.

[5] (NFPA, Exits Code for Office Buildings 1922)
[6] (Milke 1996)
[7] (Courtney 1935)

5. Variation of the Occupant Load Calculations

The next mention of business occupant load was found in the 1924 Proceedings Report[8] of the Committee on Safety to Life, where they explain the use of an equation to calculate the number of people permitted on each floor based off the stair width, building construction, protection of vertical openings, sprinkler protection, horizontal exits, occupancy and number of exits:

> *"The number of persons allowed on each floor (except ground floors, which are treated separately) is in general determined by the formula given which it will be noted varies the relation between the population and the exits in accordance with the occupancy, character of construction, protection and various other features which have bearing on life safety."*

This equation is far different from how occupancy load is calculated now since it essentially calculated in reverse order compared to today's code. Present day design starts with an architect and owner deciding how large they want their building to be. The occupant load factor is then used to find out how many people can fit in said area, and then the life safety and egress requirements are based off the total occupant load. This equation essentially states that given that you already chose your floor area, AND that you already chose all your egress features (sprinklers, stair widths, number of stairs, etc), how many people can you fit in the given pre-design building. As a result, the equation inherently increases the occupant load if: the stairs are wider, fire resistive construction is used, vertical openings are protected, protected by sprinklers,

[8] (NFPA, Exits Code for Office Buildings 1924)

there are multiple horizontal exits, it is a low hazard occupancy, and the closer it is to the ground floor.

Here, we are given the equation (see Appendix B: 1924):

$$N = \frac{A * B * C * D * E * F}{H}$$

Where:

N = No. of persons permitted on each floor above the first

A = No. of units of stair width (One unit = 22 inches)

B – Building Construction

Ordinary ……..……. B = 4

Mill or Fire Resistive ……..…….. B = 5

C – Protection of Vertical Openings

Open Stairs ……C = 2

Enclosed Stairs (other vertical openings not protected)... C = 3

Enclosed Stairs (All vertical openings protected) …….C = 4

D – Automatic Sprinkler Protection

Unsprinklered …….D = 1

Sprinklered ……. D = 2

E – Horizontal Exits

None ……. E = 2

One ……..……. E = 3

Two ……..……. E = 4

F – Occupancy

Low Hazard…….. F = 3

Moderate Hazard ……..……..F = 2

High Hazard.…….…….. F = 1

H = Number of Stories

Basement.…….. H = 3

Sub-Basement …….…... H = 5

A quick reference table was created in the 1924 Proceedings[9] giving the results of this equation in number of persons per floor, per unit of stair width. After the equation for the upper floors, we are given the following formula for the street or ground floor exits:

$$N = 60 * A * F$$

Where:

N = Maximum number of persons on street of ground floor

A = No. of units of doorway width

F – Occupancy (Business use considered Low Hazard)

Low Hazard...…….. F = 3

Moderate Hazard ……..……..F = 2

High Hazard …….…….…….. F = 1

The proceedings remained with that function method until 1934 when the Committee on Safety to Life incorporated it into Section 2013A of the Building Exits Code. Table 1 tracks the progression of the $100ft^2$/person requirement throughout the various code changes without any change to the value arguably since 1922 when the committee first released its counts of roughly a dozen representative business buildings.

[9] (NFPA, Exits Code for Office Buildings 1924)

History of Occupant Load Changes in NFPA Codes Status relevant top-down (i.e. newest version is true until the year below it)	
Year:	Code Update:
2012	Table 7.3.1.2 states "Occupant Load" as 100ft^2/person for a business occupancy - Section 38.1.7 and 39.1.7 reference Table 7.3.1.2 but states "or shall be determined as the maximum probable population of the space under consideration, whichever is greater".
2006	Still 100ft^2/person but subdivision of Air Traffic Control Towers (40 sq. ft. per person) added.
1997	Table 7.3.1.2 does not exist in this edition but 100ft^2/person requirement still stated under business occupancy Section 26 – 1.7
1976	100ft^2/person requirement in Chapter 13 – 1.4.1
1973	100ft^2/person requirement in Chapter 13 – 13.11
1970	100ft^2/person "Office Occupancy" requirement in Chapter 13 – 11.31
1963	100ft^2/person requirement in Section 11: Table 1102
1942	100ft^2/person requirement in Section 2013A
1934	First recorded 100ft^2/person requirement in Section 2013A
1929	No separate business section found. No 100ft^2/person requirements found.

Table 1 History of Occupant Load Factor changes in the NFPA codes

Having clarified the origin and history of the occupant load factor, the evolution of office space is key to understanding whether the occupant load factor for 1922 design is still relevant to the business office design in modern day business occupancies.

6. Evolution of the Office Space

The history of office design typically begins in 1904 with an American Engineer named Fredrick Taylor. In an effort to make his business more efficient, he often put workers in the center of the room in very organized rows, then assigned one specific job to each person (similar to an assembly line on a factory floor). This style of office layout is referred to as "Taylorism" as shown in Figure 1. Typical businesses such as mail-order forms, insurance companies, government agencies, clerks, typists, engineers, and other repetitive work types utilized this method to save time and money[10]. Using a top-down approach, the workers were often closely supervised by managers on the perimeter of the building from their offices.

Figure 1 "Taylorism" Office Layout[11]

The next and probably greatest change in regards to office design came around 1960, when a style named "Bürolandschaft"[12] or "Office Landscape" was brought from Germany to North America emphasizing an "open office" layout as shown in Figure 2, where the desks were

[10] (Architects n.d.)
[11] (Museum n.d.)
[12] (Kuang n.d.)

grouped based on function (Figure 3) (i.e. side by side for clerks whereas a pinwheel arrangement for designers). Hierarchy was less important in this style which increased communication between members of a group.

Figure 2 "Open Office" Layout[13]

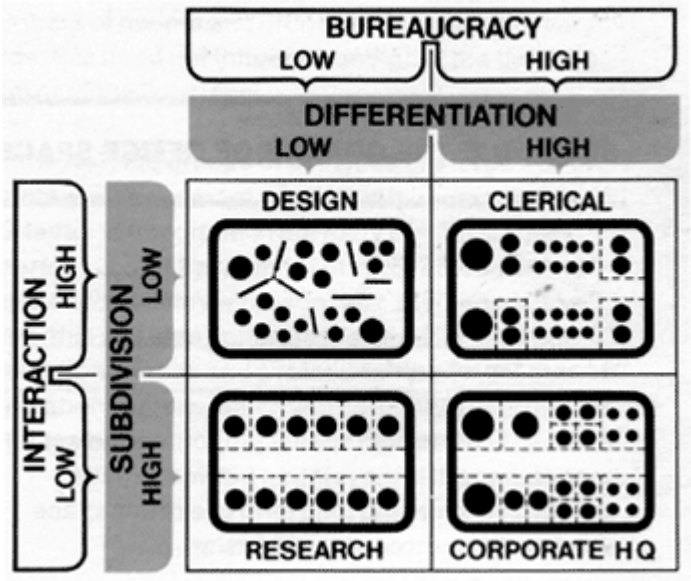


Figure 3 Year 1960's Office Organization Diagram[14]

[13] (Architects n.d.)
[14] (Architects n.d.)

While still considered “open office”, starting in 1968 and culminating around 1980 the rise and domination of modular furniture with fixed partitions around employee’s desks occurred similar to Figure 4, more commonly known as the cubicle.[15] First introduced by Robert Propst and Herman Miller in 1964, the main benefits of the cubicle were that it prevented workers from getting distracted, and it gave each worker more privacy and room for personalization. It was later viewed as a way to give a middle ranked worker an “office” before gaining an official outer office space.

Figure 4 Year 1985 Action Office Cubicles[16]

In an attempt to break free from the sea of cubicles, office furniture manufacturers and designers around the year 2000 began to minimize the cubicle partition heights to promote collaboration between workers and to maximize the natural light usage further into the building. Supervisor fixed offices began to move away from the outer perimeter to allow for more natural light and give a more open atmosphere.

[15] (Schlosser 2006)
[16] (Schlosser 2006)

The open office concept remains the key design method of present day offices where the partition height remains low (if any partition at all), and focus is on sustainability and open sight lines within the office (Figure 5). Office layout is dictated mostly by function with various concentrated sections throughout based on the type of business. For example in design firms where collaboration and teamwork concepts are encouraged, desks are loosely grouped together, often divided into teams and without partitions. On the other hand, where independent work is the key focus, smaller, partitioned off, and often squared off (cubicle style) layouts are preferred to maximize floor area and productivity.

Figure 5 Open Office Low Partitions[17]

[17] (Schlosser 2006)

7. Typical Office Furniture

In modern day office design for new businesses, architects and interior designers have access to a wide variety of furniture materials, shapes, and styles to specifically match the goals and functions required by each company.

There are a few categories of office furniture that most designs can be broken into. Typically for denser packed occupancies, cubicle style modular furniture, which usually consists of squared off partitioned sections (both low and high partitions) similar to Figure 6 below are used to give each worker enough space to be efficient, but still keep the area per person smaller. These typically come in a variety of sizes according to the business needs. For the carrel type desks on the left of Figure 6, typical widths and depths range from 36", 48", to 60" per person.[18] The typical cubicle on the right used to always be a 9' x 9', but now are becoming smaller into 8' x 8', 7.5' x 7.5', 6.5' x 6.5', 5' x 6' cubicles and every dimension down to 2x'3' for telemarketing.[19]

Figure 6 Typical Modular Office Furniture[20]

[18] (EverythingOfficeFurniture®, Cubicle Systems - Rize Panel System with Privacy Stations - OFM 2012)
[19] (Cubicle.com n.d.)
[20] (EverythingOfficeFurniture®, Cubicle Systems - Rize Panel System with Privacy Stations - OFM 2012), (Cubicle.com n.d.)

Another type of furniture available to designers is if they plan to have more of a spread out design or group divided layout to the office where teams can use low partition desks joined together in smaller groups to facilitate open communication. Often times this style is in a "pinwheel" or X-shaped design that may be more free-flowing rather than ridged 90 degree angles. It can be created in a wide variety in sizes depending on the client's needs.

Figure 7 Typical Pinwheel desks[21]

And lastly we have the style of furniture executives of managers would have in their solid wall offices which is usually consists of multiple larger and more spread out furniture pieces, sometimes one larger work area, other times multiple pieces. While these areas are not typically all throughout the office, they are still taken into account in the area per person calculation. The size of the desks themselves are surprising close to the size of a cubicle, but it's the area around the desk for seating and additional furniture/meeting tables, etc that will typically increase the area per person calculations. Two typical style executive desks are shown below with the dimensions of 6'x 8.5' for the U-shaped desk on the left, and 6' x 8.5' for the separated units.

[21] (Modular Office Furniture: Office Furniture Right Choice For You 2011), (Project 2010)

Figure 8 Typical Executive Furniture[22]

The purpose of looking at office furniture in respect to occupancy load is simply that if a manufacturer is making a 24” x 36” cubical, there are likely businesses that are currently using them and therefore have only a 6ft^2 of desk space for each worker. While in some types of businesses, this may be counterbalanced with a larger amenity areas for employees (i.e. break rooms, lounges, group meeting rooms, etc.) this may not be true for all businesses with high density seating arrangements and therefore strongly must be taken into consideration.

[22] (EverythingOfficeFurniture® 2012)

8. Review of Previous Occupant Load Studies and Planning Guides

In this section we will present the evolution of office space and implicitly the space assigned per worker in an office. We will do this by analyzing previous conducted studies, surveys, general planning guides as well as specific guidelines. The time intervals considered will be 1935, 1960-1990, 1990-2010, and 2010-2012. These intervals were picked depending mainly on the shifts in office design and use as well as material found to reflect these eras.

8.1. 1935:

The study representative for this time was the study conducted by Courtney J., Houghton H., Thompson G., in 1935[23] "Design and Construction of Building Exits". The study involved analyzing the design and construction of building exits in buildings of various occupancy types. The population on typical floors for the office buildings was determined by actual counts of building occupants. In their study, building walk-throughs were conducted to count the number of building occupants in factories and schools, in addition to the offices.[24]

A total of 22 office buildings were surveyed (Table 2) in Atlanta, GA, Greenville, SC, Greensboro, NC, Roanoke, VA, Washington, DC, Frederick and Baltimore, MD, and Pittsburgh, PA[25].

[23] (Courtney 1935)
[24] (Milke 1996)
[25] (Courtney 1935)

Building Number	Number of stories	Floor #	Floor Area (ft^2)	Population on Typical Floor	Gross Area (ft^2/person)
3	33	31-33 23-30 18-22 3-17 1-2	2,500 3,800 6,460 17,700 21,600	142	120
4	21	All	6,900	52	132
5	20	All	8,800	64	137
6	19	All	7,200	100	72
7	17	All	20,000	300	66
9	12	All	6,960	46	151
10	12	All	6,300	92	68
11	11	All	4,850	48	100
12	11	All	8,000	100	80
13	10	All	4,000	25	160
14	9	All	4,700	50	94
17	2	All	8,000	60	133
18	2	All	9,500	70	135
Total			**1,594,370**	**18,302**	**87.1**

Table 2 Office Building Measurements by Courtney, *et al.*[26]

The study found that the average load factor in the buildings surveyed ranged from 66 to 160ft^2/person, the average being 87.2ft^2/person (Table 3).

Year	Name and Type of Reference (study, planning guide	Author(s)	Value of occupant load factor (ft^2/person)
1935	Design and Construction of Building Exits (study)	Courtney J., Houghton H., Thompson G.,	87.2

Table 3 Summary of references from 1935

8.2. 1960-1990:

1969, Nelson investigated the space utilization in federal government office buildings[27]. He collected space planning data from federal office buildings located in Philadelphia, PA and

[26] (Milke 1996)
[27] (Personal Communication ofNelson, Harold E., to J.H. McGuire 1970)

Washington, DC. Nelson determined that the occupant load in these federal office buildings was approximately 150ft^2 /person (gross). [28]

1977, Johnson and Pauls[29] determined the occupant load factor to be 278ft^2 /person (gross). The number of occupants was determined from videotape records of evacuation drills in Canadian office buildings.

1977, The study conducted by Cormier, De Wolf, Henning, and Schneider for Public Works Canada[30], the area of a typical office workstation was determined to be 175 to 185ft^2. By converting the usable floor area to gross floor area, utilizing a conversion factor of 1.25 as proposed by Cormier, *et al.*, the associated occupant load factor ranged from 220 to 230ft^2/person (gross)[31].

We will summarize this period with the study conducted by the Building Owners and Managers Association (BOMA)[32] in 1966. The study consisted of surveys which received approximately 1,000 responses from building managers. The study reported the occupant load factor to be 160ft^2 /person (gross) in 1966. This study has been conducted every year since 1966 and now includes data samples from over 6,500 buildings, 140 cities country wide, and nearly 1 billion ft^2 of office space in the US and Canada. The data is collected voluntarily through an online survey of building managers who give the office and building areas along with the total number of office tenants which can be divided to get the area per office worker. The type of buildings included in this report are any office, corporate facility, or medical office building but it does NOT include any data on industrial office buildings, hotels, apartments/multi-family buildings, or shopping centers.

[28] (Milke 1996)
[29] (Johnson 1977)
[30] (Cormier 1977)
[31] (Cormier 1977)
[32] (BOMA International n.d.)

The occupant load factors reported by BOMA from 1966 to 2007 are presented in Figure 9. From Figure 9 below we can see a steady increase of the occupant load factor up until 2005, when it dramatically decreased to 299.36ft^2/person in 2006. A suspected reason for this decreasing occupant load factor is that businesses are using what space they have currently more efficiently to save cost rather than simply expanding as it had in the past. In talking with the research manager at BOMA, Tracy Glink[33], she indicated that the survey did not change between 2005 and 2006, but "there was a large decrease in the amount of square footage that reported to us (from 700,000,000ft^2 to 570,000,000ft^2). This can account for the large difference from year to year, as we had significantly smaller buildings that reported that year". Regardless, this study shows that since the 1966[34] value of 160ft^2/person, the average value for the area per person had been greatly increasing and is still much greater than the 100ft^2/person found in 1922.[35]

[33] (Glink 2012)
[34] (Milke 1996)
[35] (NFPA, Exits Code for Office Buildings 1922)

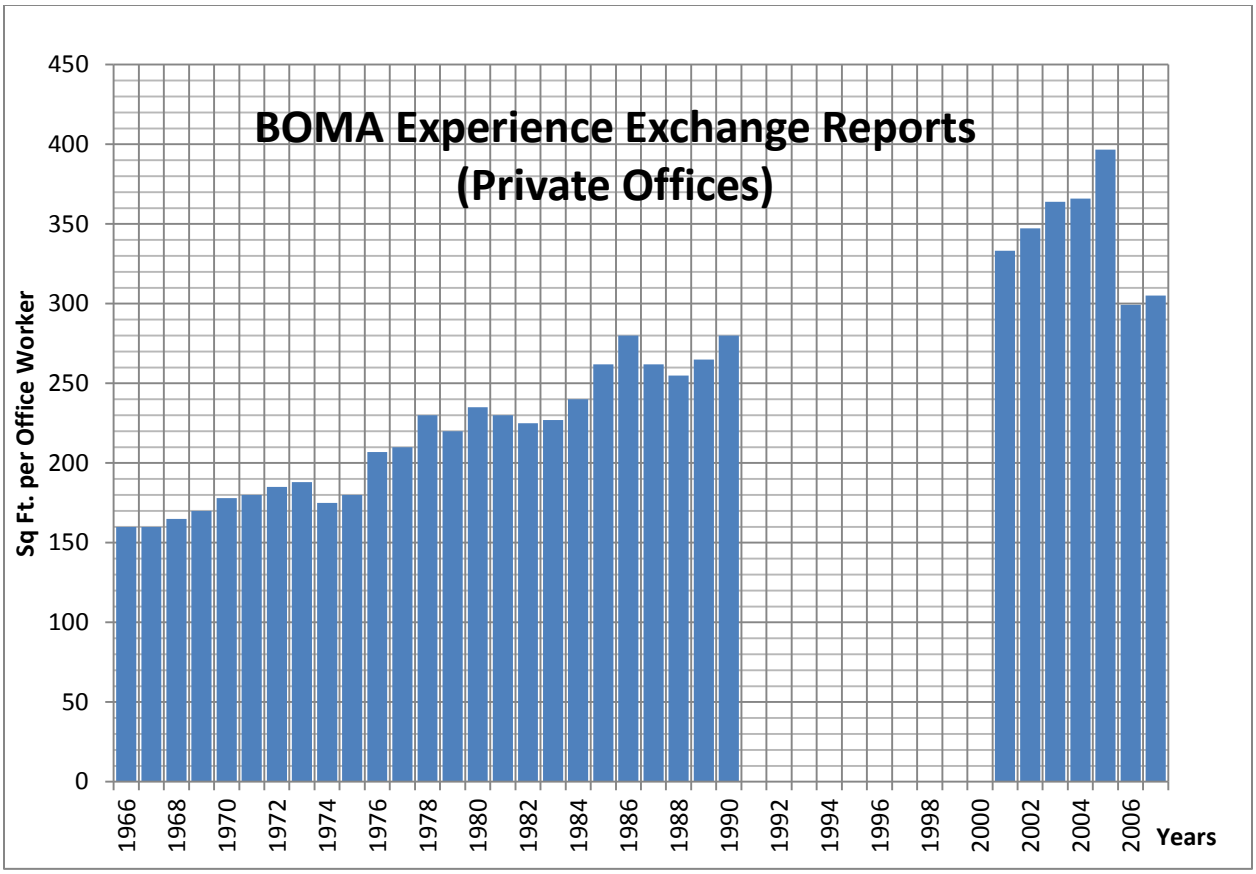


Figure 9 Occupant Load Factors from BOMA Surveys[36]

Year	Name and Type of Reference (study, planning guide	Author(s)	Value of occupant load factor (ft^2/person)
1969	Investigated Space Utilization	Nelson	150
1977	Report of a Study Carried Out In Conjunction With Canada National Health and Welfare - As Part of a Pilot Study On Personnel Movement in Office Buildings	Johnson B.M. Jake Pauls	278
1977	Office accommodation Study Analysis of Existing Floor Plans Supplementary Study No.1	Cormier, Donald, James De Wolf, Donald Henning, and Joanne Schneider	220-230
1966	Experience Exchange Reports	BOMA	160

Table 4 Summary of references from 1960-1990

[36] (Milke 1996)

8.3. 1990-2010:

1992, Bourdeau[37] conducted a study which consisted of walkthrough surveys of buildings at the College Park Campus of the University of Maryland. Bourdeau surveyed occupants on 18 floor levels in eight different office buildings. The occupant load factors ranged from 175 to 200ft^2/person (gross).

1996, Milke and Caro[38] conducted both walk through surveys and telephone surveys of 23 buildings (10 phone survey, 13 walk through) in the Washington DC, Greenbelt, Maryland, Bethesda, Fairfax, Virginia, Manassas, and Silver Springs areas. What is helpful with this study is that the specific buildings are listed which will help in future studies if the same buildings wanted to be evaluated again to find the change over time. The data collected is summarized into a long but detailed breakdown of floor levels, floor layout, and owner type in their report as well to see what factors would make the most difference. The average occupant load for all of the building surveys conducted in this study is 248ft^2/person with a 95% confidence interval from 230-266ft^2/person. The study goes further into subcategorizing well-compartmented buildings having lower occupant load factors than open office designs, and privately owned buildings are les densely occupied than government buildings (Table 5). Telephone survey results seemed to give a slightly higher occupant load factor than walk through surveys as well but similar enough to consider statistically valid.

[37] (Bourdeau May 1992)
[38] (Milke 1996)

Parameter	# of Samples	Mean	Standard Deviation	95% Confidence Interval
Well-compartmented	27	219	66.2	194-244
Open-plan	28	276	55.5	255-297
Government	37	234	62.2	214-254
Private sector	18	279	67.0	248-310
Walk-through	44	244	67.8	224-264
Telephone	11	264	62.5	237-301

Table 5 Occupant Load Factors from Milke Report

1997, GSA conducted a study entitled "Office Space Use Review: Current Practices and Emerging Trends"[39]. As the title suggests their focus was to review office space design and allocation in that period. They used both traditional approaches and on-line search capabilities in the review; also they consulted with private industry (corporate America, trade and professional associations), state and local governments, other Federal agencies and other national governments, and the academic community to identify best practices and emerging trends. They obtained information and made contacts through personal meetings, telephone interviews, fax, traditional mail, electronic mail, and an on-line Facilities Management conference.

The following are the findings that are most conclusive to our focus:

a. The workplace is changing, and evaluating space use is more complex as a result. Although all organizations look at some kind of utilization rate as a target or benchmark, a utilization rate is an oversimplified way of looking at space use. There are many issues to consider when using utilization rates to evaluate current space:

    - Agency-specific needs
    - Accounting for all space users (fulltime, part-time, contractors, shift work, vacancies, etc.)
    - Space measurement methodology

[39] (U. G. Administration 1997)

- Actual cost of the space
- Age of facility
- Productivity and moral issues
- Cost of consolidation

This tells us that we should pay very much attention when comparing guidelines or just data gathered from different organizations, because different organizations have different needs, this implies that a better definition of the term “office” is needed.

b. The appropriate U.S. Government average for space use is 200 usable square feet per person, as compared to the U.S. private sector average of 250 usable square feet per person. This is a very powerful statement, regarding our paper, because it tells us very straight and forward that the present occupant load factor of a $100ft^2$/person is not a realistic value. To see if this statement is true, we analyzed how they checked the validity of the values that they offer, this is the methodology they applied:

    - They examined the PBS (Public Buildings Service) inventory data to see if a benchmark of 200 usable square feet per person was a practical number starting with the D-76 standards of 125 occupiable (which is virtually identical to what we now call usable) square feet per person, plus up to 22 percent for support space and concluded that these standards were and still are valid.
    - They calculated ratios of the different space types as classified in the inventory, and determined that the equivalent total space number is around 185 usable square feet per person.
    - They also analyzed GSA’s lease prospect uses submitted to Congress during the fiscal year 1996 and fiscal year 1997 cycles and found that the proposed

utilization rate for total space for the sample as a whole was 181 usable square feet per person.

- They concluded saying that based on the historical trend in the BOMA experience data, their analyses of the PBS inventory and lease prospect uses, the average of 200 usable square feet per person (office, storage and special) is appropriate and typical for Federal space use in office type buildings.

Table 6 was also provided showing a comparison with other space utilization rates:

Source	Description	Usable SF Per Person
BOMA 1997 Experience Report	U.S. private sector	245*
	U.S. government sector	204*
	Canada private sector	220*
	Canada government sector	292*
Arthur Andersen LLP	Private sector (target)	250
	Technology firms (actual sample)	206
Lucent Technologies	Occupancy density targets	174 – 190
Mobil Corporation	Overall target	225
Dun & Bradstreet Corp.	Standards for headquarters	190 – 200
Australian government	Planning figure	161 to 194
State of Virginia	Maximum allowed per person	250
State of Texas	Current statewide average	234
State of Missouri	Current statewide average	200
State of Oregon	Maximum allocation (threshold)	200
U.S. Government	**Overall average**	**200**

*Data converted from BOMA rentable

Table 6 Comparison of space utilization rate GSA 1997 study

As a conclusion, this study states that a value of 200 for the U.S. Government and a value of 250 for the U.S. private sector, of usable square feet per person is realistic for the year 1997.

Next we will see what a general plan guide design of office space, recommended in the year 2000. In their book[40] Alexi Marmot and Joanna Eley state that although the number of office-based work will increase, we will see the need for office floor area declining. The reason for this is that office workers already spend only a small proportion of their time in the office because of weekends, leave, sickness, the working days use only 8 of the available 24 hours, and mostly because office hours are spent elsewhere for meetings, training or work in other locations. So the emphasize for these rather expansive buildings is to use them to their full capacity, to serve people and to accommodate activities that cannot easily take place elsewhere.

They also show that the range of average space per person found in different offices is wide, going from 100 ft^2 to 350-400 ft^2/person. Also a figure of 200-250 ft^2/person in offices in the US is given as an average, as well as stating that the GSA is aiming for an average of 200ft^2/person.

Another aspect that they touch is the case of space standards: these reflect space allocation depending on different factors that reflect the approach adopted. Three different approaches are presented: hierarchical which depends on job title, degree of enclosure, number of days of annual leave, salary etc., functional which depends on specific job requirements and egalitarian which allocates the same space to everybody.

The most feasible one is presented as being the functional one which is the one that we will also recommend. This approach ranges from 75 to 250 ft^2/person having cutoffs at 150 and 100 ft^2/person.

The authors also present a very important problem in present time office design: the advantages and disadvantages of open plan offices versus enclosed offices.

Open plan offices became a trend in the 1950, being developed in Germany, the army officials who worked in Europe came to the US with this option, also because construction technology

[40] (Eley 2000)

was developed that offered the possibility of large open spaces, and so the option of open plan offices became attractive. This method increases most of all, communication among office workers, which is a big advantage as is the fact that open plan offices use less space than enclosed offices. The disadvantage of this method and implicitly the advantage that the enclosed offices bring is the fact that with open plan offices, workers lack privacy which can make working difficult when different distractions disrupts them from doing their job. Also the question of privacy is brought up when certain meetings need to take place and there are not sufficient enclosed offices that could provide privacy.

2003, The Northwest Territories of Canada[41] recommend for their office buildings the following:

- The number of enclosed workstations should be limited to 45% of the total number of workstations on a given floor, this, they say, will promote flexibility, air quality, increase natural light penetration and reduce maintenance costs;
- The next important recommendation is regarding conference rooms, that they should be rented from the private sector rather than having them accommodated in the general office space. Although if no conference rooms are available locally, they recommend providing conference rooms by adjoining meeting rooms with ceiling height, soundproof, moveable partitions.
- To promote open workstations they recommend having quiet rooms, equipped with furniture, computer equipment an communications connections
- The final important recommendation that we will state from their report will be the fact that they very much want the office space to be very flexible and for that they

[41] (Territories 2003)

recommend a modular approach to the design of office space, also giving the information that most existing facilities are constructed on a 5ft by 5ft grid.

Also they state that they are currently using a functional approach of designing their offices. Table 7 represents the distribution of their office space in accordance with its functionality:

Space Type	Functional Assignment	Space Allocation(ft^2)
Enclosed Type A	Frequent meetings with up to four members and/or requiring confidentiality, security, visual and acoustical privacy. Typical assignment for Deputy Minister or equivalent.	**240**
Enclosed Type B	Frequent meetings with up to two members and/or requiring confidentiality, security, visual and acoustical privacy. Typical assignment for Assistant Deputy Minister, Director, senior position in charge of a regional or district office or equivalent.	**150**
Enclosed Type C	Frequent meetings with up to two members and/or requiring confidentiality, security, visual and acoustical privacy. Typical assignment for position involved with counseling, human resources management or other sensitive situations requiring ongoing visual and acoustical privacy.	**100**
Open Type D	Concentrated multi-source paperwork: compiling information, reading, writing, analyzing, calculating and referencing multiple sources of material; allows for manual and automated drafting functions. Typical assignment for managerial, professional or technical staff.	**100**
Open Type E	Multi-task paper intensive work: telephone work, keyboarding, filing, sorting documents, handling mail, editing, operating equipment, scheduling, receiving visitors. Typical assignment for secretary and administrative support staff.	**70**
Open Type F	Specific, task-oriented work, focusing on data input into electronic media. Typical assignment for clerical and data-entry staff.	**50**

Table 7 Distribution of office space in accordance functionality The Northwest Territories of Canada

Next we return to another study conducted by GSA in 2002 with the title “Space Use Update 2002”. They make many comparisons with the study conducted in 1997, previously presented, and try to identify new trends in the design of the office space.

They state that since 1997 trends have shifted because of the increased competitiveness in the marketplace and limited space availability, many private sector organizations move away from the strict space standards based on pay level or employee position. Space planners must weigh space availability, corporate culture, mission, job requirements, cost, and efficiency when determining how to forecast and allocate space usage; however, they continue to monitor space per person to assist with space allocation and space planning.

Based on the private sector overall average standards reported, and the analysis of prevailing trends, they continue to recommend 200 rentable square feet per person as the appropriate overall Government wide average for office space use.

This study gives a very good representation of how office space has changed from 1997 to 2002, mainly because in doing their surveys and analysis, they look at most of the buildings they analyzed in 1997. They conclude their findings from 2002 in Table 8:

Type of company	**USF**[42]
Insurance – target	230
Insurance – actual	215
Consulting – actual	320
Software engineering firm – actual	220
Telecommunications I – actual w/hoteling	152-174
Telecommunications II – actual	325
Energy firm – actual "best in class"	200-250
Range of benchmark averages	152-325
Mid-point of range	238
Recommended Government wide standard	**200**

Table 8 GSA 2002 usable square feet findings

We will next present a study that was referenced in the GSA study made in 2001 and that was done by CoreNet Global who is the world's leading association for corporate real estate and

[42] Usable square feet

workplace professionals, service providers and economic developers. Nearly 7,000 members, who include 70% of the Fortune 100 and nearly half of the Forbes Global 2000, are part of CoreNet.

2009, CoreNet Global[43] did the study which shows the following figures for square feet per employee:

- Less than 75: 3%
- 75-100: 4%
- 100-125: 7%
- 125-150: 11%
- 150-175: 17%
- 200-225: 23%
- More than 250: 19%

For our purpose, we will summarize the results shown above by saying that 77% of the companies allocate more than $100ft^2$/person of office space.

Table 9 is a summary of the references presented for the period 1990 till 2010.

[43] (Global 2009)

Year	Name and Type of Reference (study, planning guide	Author(s)	Value of occupant load factor (ft^2/person)
1992	A Study to Determine the Accuracy of the Occupant Load Factor of 100ft^2/person Gross, for Building Occupancy	Bourdeau, M.A.,	175-200
1996	Evaluation of survey procedures for determining occupant load factors in contemporary office buildings	James A Milke Tony Caro	248
1997	Office Space Use Review: Current Practices and Emerging Trends	GSA	200-250
2000	Office Space Planning- Designing for Tomorrow's Workplace	Alexi Marmot and Joanna Eley	200-250
2003	Office Space Standards and Guidelines	The Northwest Territories of Canada	50-240
2002	Space Use Update 2002	GSA	200-250
2009	Global Workplace Trends: A North American and European comparison	CoreNet	152.75

Table 9 Summary of references from 1990-2010

8.4. 2010-2012

The most important and recent study was done in July 2011 by GSA[44]. Their approach included the following:

- In the summer of 2010, through the winter of 2011, GSA conducted a workspace utilization survey, analyzed data results;
- Conducted Internet research;
- Held telephone interviews with several public and private organizations;

[44] (U. GSA 2011)

- Attended several leading industry workplace conferences to identify and gain insight into emerging contemporary trends, practices, and standards in workspace utilization and allocation.
- Reviewed numerous published sources and other publicly available information—including industry best practice publications, government wide policy bulletins, press releases, and industry surveys—to examine new government and private sector space allocation trends.

What they found was that current workplaces are influenced by a more mobile workforce who makes use to a greater extend of instantaneous wireless communication tools like: mobile phones, smart phones, BlackBerry devices and wireless networking. As a result, many Federal agencies and private organizations have turned to alternative work environments to reduce workspace costs and use workspace in a more efficiently manner.

They also mention a couple of alternative work environments:

- Teleworking;
- Hoteling stations;
- Desk sharing.

They are all major trends in the current real estate marketplace and they also are associated with an increase in productivity and teamwork.

Their survey results consisted of the following percentages of the respondents using alternative workplace arrangements:

In the private sector:

- Telework (68%)
- Hoteling (41%)

- Virtual office (32%)
- Telework centers (15%)
- Desk sharing (39%)
- Hot desking (29%)

Government Organization:

- Telework (77%)
- Hoteling (4%)
- Telework centers (8%)
- Desk sharing (12%)

Approximately 15% of respondent government organizations reported having full-time teleworkers who are not provided office workspace, as compared to 59% of private industry organizations that reported having fulltime teleworkers who are not provided office workspace.

Their study concluded that the prevailing workspace standard average is 190ft^2 of usable space (218 Rentable Square Feet) per person.

They did not find any significant differences between government and private workspace use trends, private sector survey respondents reporting an average space per person of 200 USF[45] (230 RSF[46]), with a median of 193 USF (222 RSF) as compared to the Federal benchmark of 190 USF (218 RSF).

As a result of overall space use costs, the typical office standard has declined since the early 2000's from around 250ft^2 per workstation to around 190ft^2 or less which is a substantial reduction. Table 10 presents a typical workspace allocation from the research that they did:

[45] Usable square feet
[46] Rentable square feet

Position	USF[47]	Configuration
Executive	300	Private Office
Director	250	Private Office
Manager	200	Cubicle
Supervisor	120	Cubicle
Technical	80	Cubicle
Support Staff	80	Cubicle
Clerical	64	Cubicle

Table 10 Typical workspace allocation GSA 2011

As it can be seen they have 6 categories of business use with ft^2 allocation ranging from 64 to 300ft^2/person. We will refer Table 10 later when we propose our categories and values of ft^2/person for every category.

Based on GSA research, today's prevailing standard workspace average is a little more than 190 USF per person.

Year	Name and Type of Reference (study, planning guide	Author(s)	Value of occupant load factor (ft^2/person)
2011	Workspace Utilization and Allocation Benchmark	GSA	190

Table 11 Summary of references from 2010-2012

We conclude this section with the following graph that displays the values that were collected from the references presented in the previous sections (Table 11). For the references that gave ranges (e.g. 100-200ft^2/person) the average of the range is plotted (e.g. 150ft^2/person):

[47]Usable square footage means the square feet used directly by the tenant. It does not include common area square footage which is used in calculating "rentable square feet."

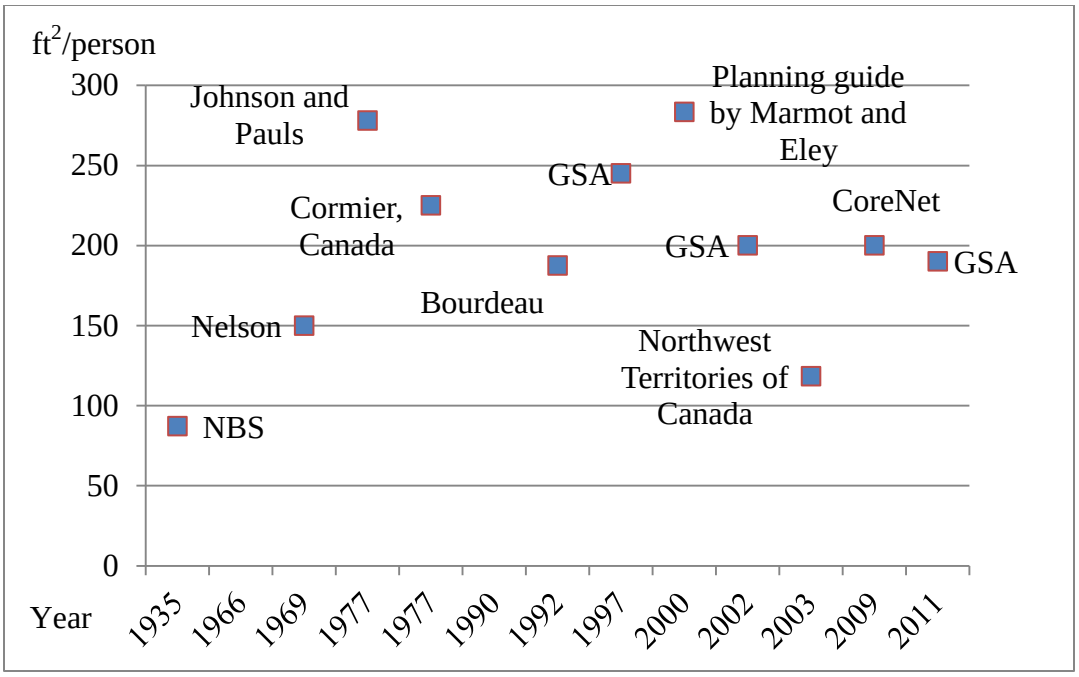


Figure 10 Averages from previous studies and planning guides of the Occupant load factor (ft^2/person) over time (years)

Table 12 summarizes the values found for every reference investigated:

Year	Authors	Occupant Load Factor (ft^2/person) (gross)
1922	Life Safety Committee	100-125
1935	NBS	87
1969	Nelson	150
1966-2007	BOMA	160-350
1977	Johnson and Pauls	243 and 278
1977	Cormier, et al.	220-230
1992	Bourdeau	175-200
1996	Milke and Cara	230-266
1997	GSA	200-250
2000	Alexi Marmot and Joanna Eley	200-250
2003	The Northwest Territories of Canada	50-240
2002	GSA	200-250
2009	CoreNet	152.75
2011	GSA	190
Average		**204.85**

Table 12 Summary table with occupant load factor values

In this section a chronological review of the value of the occupant load factor has been presented. As it can be seen in Figure 10, the value of the occupant load factor has shown quite a variation from the references investigated; however with the previous studies investigated, the trend of the occupant load's value from 1935 till 2000 is going up. A fall is seen in the period 2000 till 2003 after which it picks up again the growing trend. In Table 12 we listed the references investigated (e.g. studies, reports, planning guides) with the values of the occupant load factor in the 3rd column to the right. These values are either stated as averages or ranges after surveys of office buildings have been done (i.e. in the case of the studies presented), are values currently used in institutions (e.g. The Northwest Territories of Canada) or are recommended values (e.g. Alexi Marmot and Joanna Eley). Whatever the case may be, the value is in almost every case (i.e. with two exceptions) greater than $100ft^2$/person with an average of **$204.85ft^2$/person.** Our recommendation will include this high value of the occupant load factor as well as take into account the lower values (i.e. below $100ft^2$/person) that we encountered.

In the next section we will analyze future trends of the office space design, which mostly include the mobility of the workforce. These trends are only shown here as future references and are not taken into account in the current value of the occupant load factor. This is done because these trends have not yet made an impact on the value under investigation.

9. Future Trends of Office Space Design

Many agencies have begun to implement mobility programs and have documented successes and lessons learned (i.e. Berkeley with SMCP, (Standford 2009) etc.). The private sector, spurred by the need to accommodate a new generation of workers and to achieve cost savings triggered by the economic downturn of 2008 -2010, is aggressively embracing mobility strategies[48]. GSA in its paper[49] presents three scenarios in order to help agencies assess the impact that mobility will have on their organizations. These are as follows:

Scenario 1: basic telework

- The Basic Telework scenario is an expansion of current practices. It assumes that 15 percent of employees are working from home 2 days per week, but the agency has made no change in real estate or workplace strategy.
- Individual workstations are assigned to all employees, including mobile workers.

Scenario 2: responding to mobility

- This scenario illustrates the impact of redesigning the workplace to respond to a workforce where 80% of employees work at home or another off-site location 2 days per week and is internally mobile while working at the office.
- Each employee has an assigned workstation that is smaller and more densely organized than workstations in the Baseline and Basic Telework scenarios.

Scenario 3: mobility as Strategy

- The overall real estate footprint is reduced by 30%; remaining space is allocated differently.

[48] (GSA 2010)
[49] (GSA 2010)

- Office design is aligned with the needs of its employees and the utilization of various spaces.
- Nearly all workstations and offices are assigned on an ad hoc basis ("Hotelling").
- The target ratio of mobile workers to workstations may approach 8:1.
- The numbers and types of spaces are varied and designed around the variety of work modes employees go through during their typical day in the office.

The third scenario, Mobility as Strategy, offers the greatest benefits and, at the same time, requires the most investment.

A mobility program offers an agency the opportunity for much better space utilization by replacing dedicated workstations with open workstations that employees use only on the days they are in the office. Utilizing this strategy, the USPTO[50] telework program, for example, reported in 2009 that their 9,643 employees currently occupy a space that would accommodate about 5,000 traditional, or non-teleworking, employees.

As an addition to this information we would also want to include other methods of organizations to adopt mobility strategies, by stating the following terms that were included in the GSA study in 1997:

Free Address means multiple offices or workspaces shared by individuals on a first come, first-served basis. Potential candidates for free addressing, also known as motelling, spend a significant amount of time away from the office (for example, at a client base or on the road) and are equipped with portable technology (laptop, portable printer, cellular modem and phone). These candidates may include sales, marketing, outreach, audit, inspectors, examiners,

[50]U.S. Patent and Trademark Office

contractors and customer services. An organization can achieve significant savings by providing one workspace for every 2 to 8 employees.

Hotelling refers to work space that is reserved on a first-call basis and not dedicated to any specific worker beyond a specified occupation time. Most typically, a small staff will handle reservations, reprogram telephones and prepare the reserved space for occupancy. Hotelling can also include teaming and conference facilities, and is similar to free addressing.

Virtual Office is a briefcase approach to the office. Employees have the freedom to work/office anywhere (home, car, plane, hotel) through the use of portable technology. Virtual office workers rarely require main office space. In the ultimate virtual office scheme, workers have no assigned main office space. Potential candidates may include sales, legal, research, audit, investigators, inspection, and customer service functions.

Shared Space is when two or more employees share a single, assigned work space and work tools, either simultaneously or on different shifts/schedules. Telecommuters most typically use shared space.

Teleworking/telecommuting is a combination of assigned off-site workspace and workspace at the main office facility. Such off-site locations could include at home accommodations or remote telecenters. The teleworker generally works from the alternative site 2 to 3 days a week and is linked to the main office by various means such as a desktop computer, fax and telephone. Many job functions lend themselves to telecommuting. Participating occupations could include program analysts, engineers, accountants, administrative assistants, budget analysts, computer specialists, contract specialists, managers, management analysts, personnel specialists, telecommunication specialists, scientists, and other occupations. Previously seen as an employee benefit, telecommuting viewed from a management perspective can mean fewer dollars for space

and improved performance. By providing one workspace for every 3 to 5 telecommuters, space requirements can be reduced.

Telecenters are generally geographically convenient (located near where people live) facilities and have on-site managers. Centers can be an economical way to provide sophisticated office technology computers, high-speed printers, video conferencing) and administrative support not always available at a telecommuter's home. By sharing facility and overhead costs, participating organizations can minimize expenses.

Satellite Offices are remote facilities that are linked to the main facility by technology and are generally located near employees and customers. Employees are assigned to work at the alternative site on a full-time basis. Although satellite offices may not reduce the amount of space needed, they do provide an excellent opportunity to improve customer service and a firm may reduce the cost of space by moving to less expensive locations.

As a conclusion to this we can state that for the future we can see that the aim is to improve the efficiency of office space, reduce costs as well as the carbon footprint. By using mobility strategies, organizations can reduce their office space, keeping the same number of employees. We cannot yet conclude that these methods will decrease the occupant load factor; because although we will have the same space size for a greater number of people, there are very small chances that all the people will be in the office at the same time. Because these strategies have not been yet implemented on a large scale, we cannot see their full effects on the occupant load factor.

10. Business use categories

After reviewing the studies done in the past, it can be concluded that there is a need for having multiple categories for business use. The reasons for this can be seen in the studies presented above which will be summarized next.

In 1997, GSA[51] stated that the workplace is changing, and evaluating space use is more complex as a result. This shows that the term "office" needs a better definition.

The book published in the year 2000 by Alexi Marmot and Joanna Eley[52] presents the aspect of space standards. These reflect space allocation depending on different factors depending on the approach adopted. Three different approaches are presented: hierarchical which depends on job title, degree of enclosure, number of days of annual leave, salary etc., functional which depends on specific job requirements and egalitarian which allocates the same space to everybody. The most feasible method is presented as being the functional one.

In 2003 Northwest Territories of Canada state in their report that they are currently using a functional approach of designing their offices. Table 13 represents the distribution of their office space in accordance with its functionality:

[51] (G. S. Administration 1997)
[52] (Eley 2000)

Space Type	Functional Assignment	Space Allocation(ft^2)
Enclosed Type A	Frequent meetings with up to four members and/or requiring confidentiality, security, visual and acoustical privacy. Typical assignment for Deputy Minister or equivalent.	**240**
Enclosed Type B	Frequent meetings with up to two members and/or requiring confidentiality, security, visual and acoustical privacy. Typical assignment for Assistant Deputy Minister, Director, senior position in charge of a regional or district office or equivalent.	**150**
Enclosed Type C	Frequent meetings with up to two members and/or requiring confidentiality, security, visual and acoustical privacy. Typical assignment for position involved with counseling, human resources management or other sensitive situations requiring ongoing visual and acoustical privacy.	**100**
Open Type D	Concentrated multi-source paperwork: compiling information, reading, writing, analyzing, calculating and referencing multiple sources of material; allows for manual and automated drafting functions. Typical assignment for managerial, professional or technical staff.	**100**
Open Type E	Multi-task paper intensive work: telephone work, keyboarding, filing, sorting documents, handling mail, editing, operating equipment, scheduling, receiving visitors. Typical assignment for secretary and administrative support staff.	**70**
Open Type F	Specific, task-oriented work, focusing on data input into electronic media. Typical assignment for clerical and data-entry staff.	**50**

Table 13 Distribution of office space in accordance functionality The Northwest Territories of Canada

In their 2011 study, GSA presented Table 14 with typical workspace allocation from the research that they did:

Position	USF[53]	Configuration
Executive	300	Private Office
Director	250	Private Office
Manager	200	Cubicle
Supervisor	120	Cubicle
Technical	80	Cubicle
Support Staff	80	Cubicle
Clerical	64	Cubicle

Table 14 Typical workspace allocation GSA 2011

Although they do not use the functional approach to divide the office space, a clear difference can be seen in the value of the *USF*[54] for the different categories chosen.

We developed our own categories of office space use, seeing that most of the studies and planning guides look at particular office types. We wanted to incorporate each of these types of offices in a category. For instance from Table 14, we would incorporate Executive, Director and Manager's office in our category "Private offices with closed floor to ceiling partitions". From the same table for Clerical and Support Staff we created the category "Open Plan Spaces with limited or no seating, with or without semi partitions". These categories reflect how the types of offices that they refer to, are constructed (e.g. with/without partitions, with/without partitions/semi-partitions, closed/opened). Besides these, we included "Public access spaces" and "Laboratory function spaces", feeling that the office space would not be complete without adding these categories.

[53] Usable square footage means the square feet used directly by the tenant. It does not include common area square footage which is used in calculating "rentable square feet."

[54] value of usable square feet of office space per person which is very close with the value of the occupant load factor

The five categories are listed below with the types of offices that they refer to:

1. **Private offices with closed floor to ceiling partitions**

   The following types of offices are included in this category: executive, director, manager, in other words high ranked personnel with a vital functionality in the organization.

2. **Open plan spaces with seating and opened (no doors provided) floor to ceiling partitions.**

   For this category, the types of offices that were included are the following: supervisor, technical, control rooms, cubicles. This category is aimed for middle ranked personnel with an important functionality in the organization.

3. **Open plan spaces with limited or no seating with or without semi partitions**

   The types of offices included in this category are: call centers, mail rooms, printer area, copy machines, spaces mainly designed for low ranked personnel who can easily be substituted.

4. **Public access spaces such as entrance lobbies, waiting areas, etc.**

   As the title suggests, these spaces are mostly identified with functional spaces inside a building. They represent a necessity in every building, although they seem less important.

5. **Laboratory function spaces either wet or dry type**

   This category includes space such as: classroom laboratories, research laboratories, medical laboratories, computer laboratories etc. Although these spaces may not be found in most buildings, it is important that we differentiate them from the other categories.

These categories represent a good assessment of the present office environment; however they may change with time, as a consequence they should be reassessed whenever needed in the future.

We felt the need to assess the current occupant load factor for these categories. We did this by sending questionnaires to 3 focus groups; however as it will be shown, the response rate from our questionnaire was very low, allowing us to only take basic concepts from the results rather than exact values. More about the questionnaire is presented in the next section.

11. Questionnaires

The questionnaires were sent out in February 2012. It focused three groups of people: architects, real estate people and building owners. Beginning with architects, the purpose for choosing each group as well as the questionnaire and the results will be presented. It is also noted that besides directly contacting specific firms, the questionnaires were also made available to BOMA for distribution to their members. The questionnaires were also made available to some Fire Protection Engineering firms for distribution to their clients.

11.1. Architects

Being involved in the design process of office buildings, architects were very important for this study. The number of contacts, that the team gathered was 163. They encompassed architects mainly from the West Coast (California) and East Coast (Massachusetts) of the U.S. Because the group was closer to the knowledge of the occupant load factor, the questionnaire directly asked for the value of the occupant load factor for the five categories of interest. The questionnaire is presented in Figure 11 as well as the results in Table 15:

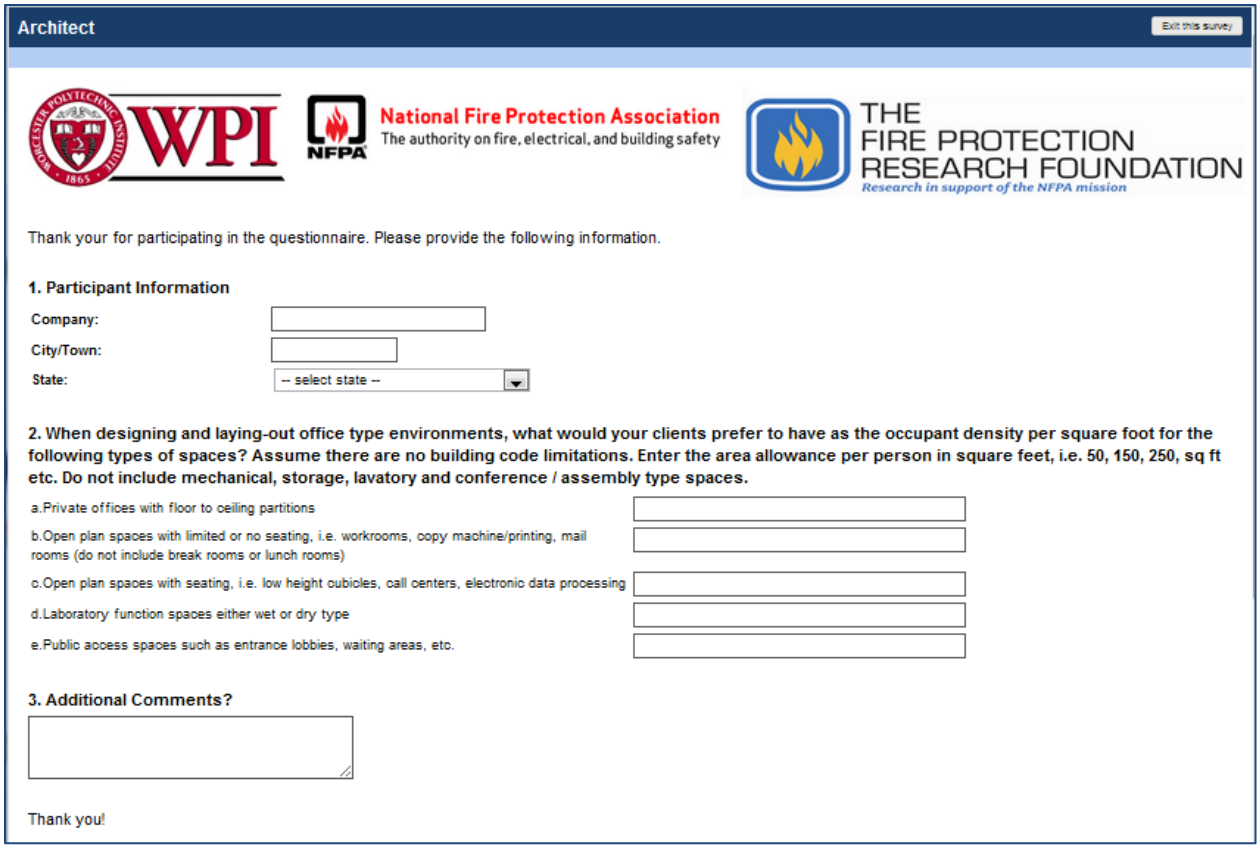


Figure 11 Questionnaire sent to architects

Category of office space	Square feet per person							Avg.
	Rsp[55]1	Rsp 2	Rsp 3	Rsp 4	Rsp 5	Rsp 6	Rsp 7	
Private offices with closed floor to ceiling partitions	150	200	200	150	150	100	100	150
Open plan spaces with seating and opened (no doors provided) floor to ceiling partitions	100	25	150	80	-	150	200	117.5
Open plan spaces with limited or no seating with or without semi partitions	75	70	100	100	100	50	150	92.2
Public access spaces such as entrance lobbies, etc.	200	-	50	400	100	100	50	150
Laboratory function spaces either wet or dry type	400	200	800	150	200	50	-	300

Table 15 Result from architect's questionnaire

[55] Rsp: response

Each column below the one entitled “Square feet per person” represents a different response, with the average for every category shown in the “Avg.” column. Although we received 10 responses for this questionnaire, we only present here 7, because 3 of the 10 results were inconclusive (i.e. they either showed unrealistic results or were completed incorrect).

11.2. Real estate contacts

The inclusion of this group in the questionnaire was due to the fact that real estate people face on a daily basis the demands of businesses which are looking for office space. They know best what the trend of the office space is. The questionnaire is presented below in Figure 12 ; unfortunately no results could be gathered due to a very low response rate.

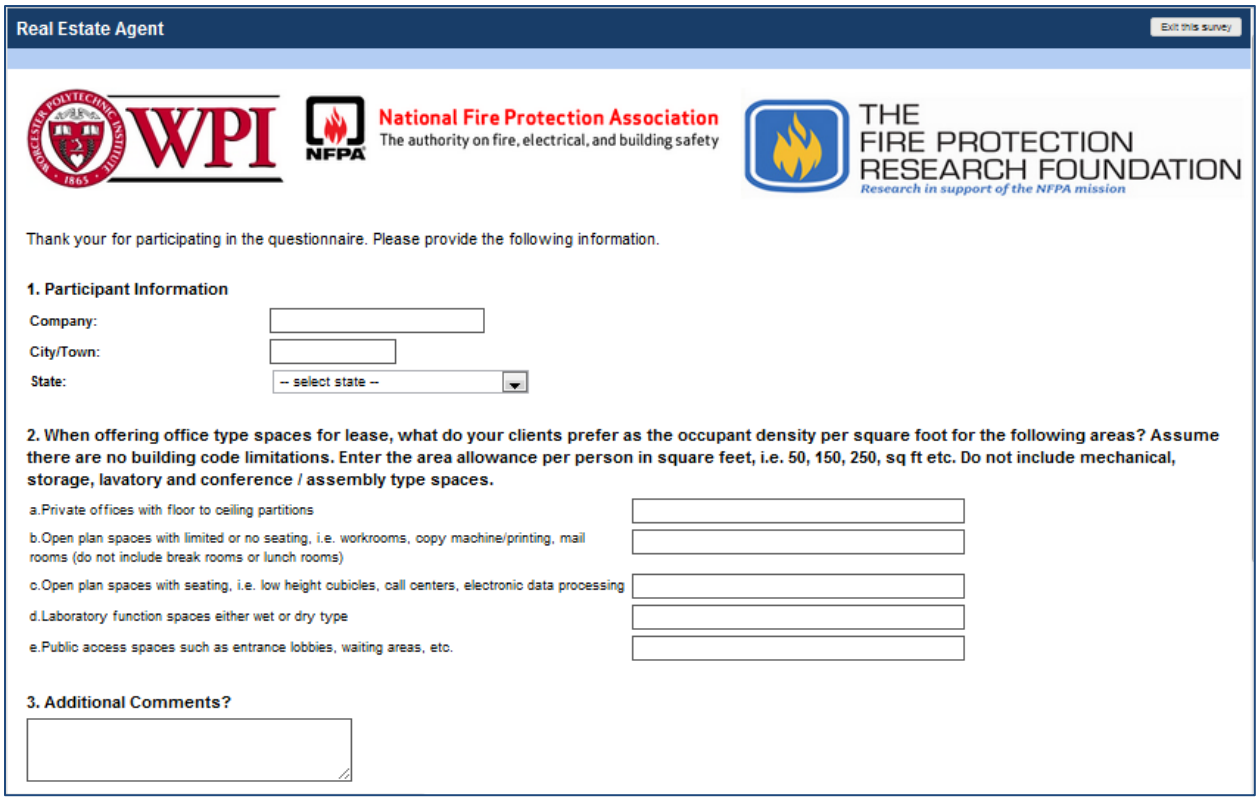
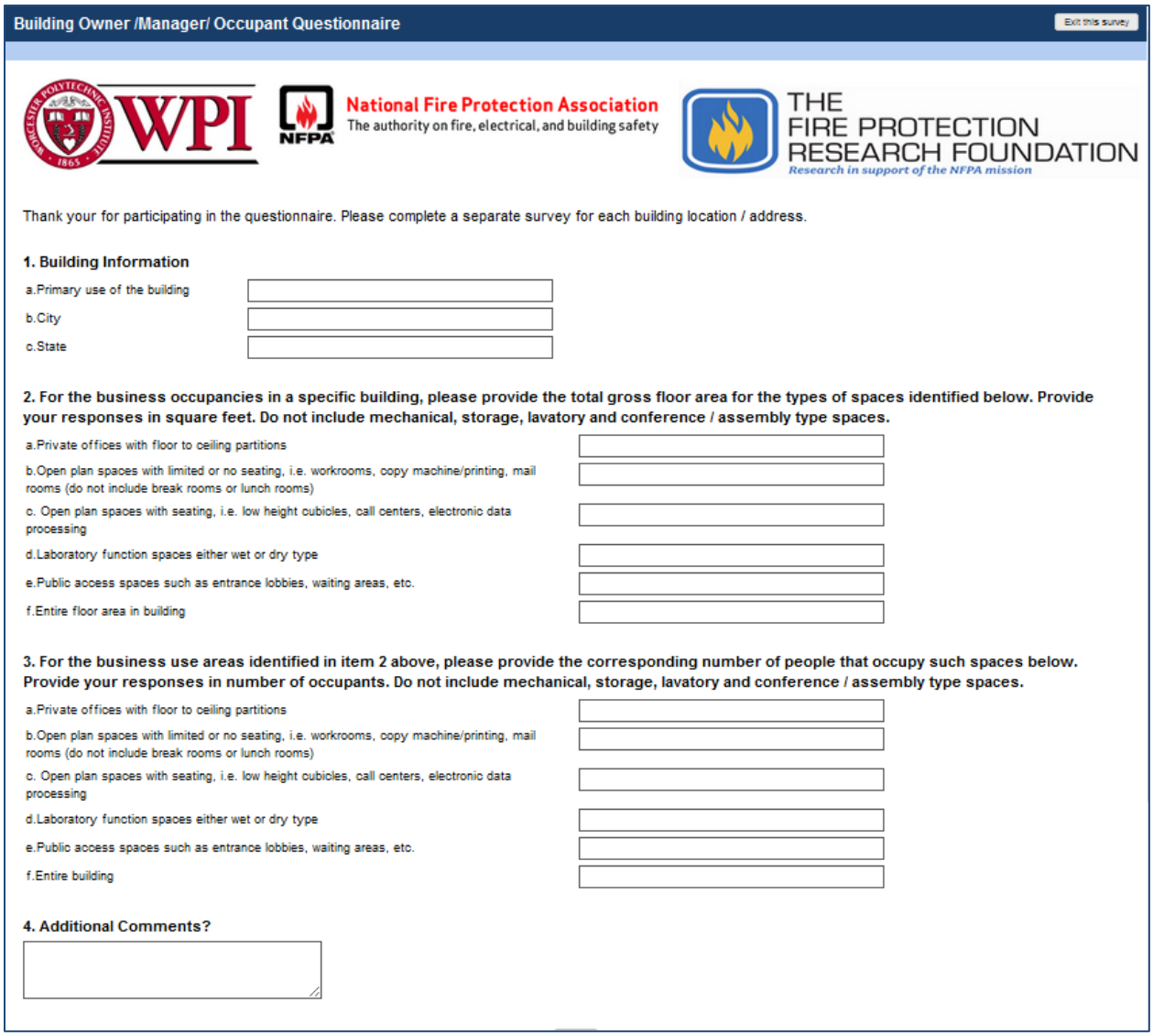


Figure 12 Questionnaire sent to real estate people

11.3. Building owners

This group was considered due to the fact that many businesses choose to rent their office space; as a consequence building owners adapt themselves to the demands of office space seekers, doing so they follow closely the needs of business owners looking for office space. The questionnaire Figure 13 and the results Table 16 are presented below.



Building Owner /Manager/ Occupant Questionnaire

Exit this survey

WPI

NFPA National Fire Protection Association
The authority on fire, electrical, and building safety

THE FIRE PROTECTION RESEARCH FOUNDATION
Research in support of the NFPA mission

Thank your for participating in the questionnaire. Please complete a separate survey for each building location / address.

1. Building Information

a.Primary use of the building

b.City

c.State

2. For the business occupancies in a specific building, please provide the total gross floor area for the types of spaces identified below. Provide your responses in square feet. Do not include mechanical, storage, lavatory and conference / assembly type spaces.

a.Private offices with floor to ceiling partitions

b.Open plan spaces with limited or no seating, i.e. workrooms, copy machine/printing, mail rooms (do not include break rooms or lunch rooms)

c. Open plan spaces with seating, i.e. low height cubicles, call centers, electronic data processing

d.Laboratory function spaces either wet or dry type

e.Public access spaces such as entrance lobbies, waiting areas, etc.

f.Entire floor area in building

3. For the business use areas identified in item 2 above, please provide the corresponding number of people that occupy such spaces below. Provide your responses in number of occupants. Do not include mechanical, storage, lavatory and conference / assembly type spaces.

a.Private offices with floor to ceiling partitions

b.Open plan spaces with limited or no seating, i.e. workrooms, copy machine/printing, mail rooms (do not include break rooms or lunch rooms)

c. Open plan spaces with seating, i.e. low height cubicles, call centers, electronic data processing

d.Laboratory function spaces either wet or dry type

e.Public access spaces such as entrance lobbies, waiting areas, etc.

f.Entire building

4. Additional Comments?

Figure 13 Questionnaire sent to building owners/managers

Category of office space	Square feet per person										Avg.
	Rsp 1	Rsp 2	Rsp 3	Rsp 4	Rsp 5	Rsp 6	Rsp 7	Rsp 8	Rsp 9	Rsp 10	
Private offices with closed floor to ceiling partitions	300	170	360	330	240	280	163	501	-	-	293
Open plan spaces with seating and opened (no doors provided) floor to ceiling partitions	175	114	166	533	330	235	265	305	189	324	263
Open plan spaces with limited or no seating with or without semi partitions	140	200	100	500	181	111	75	50	-	-	170
Public access spaces such as entrance lobbies etc.	-	-	-	-	-	-	-	-	-	-	-
Laboratory function spaces either wet or dry type	-	-	-	-	-	-	-	-	-	-	-

Table 16 Result from building owner's questionnaire

The same happened with the results for the "Building owners" as for the "Architects" in the sense that, although we received 10 responses, we can see that not every category is given a value. This is because for those categories either the response was missing from the questionnaire or it was inconclusive.

Although the response to the questionnaires was rather dismal, it did provide indication of occupant loads for business uses. The few responses received do suggest a general increase for occupant load factors above $100ft^2$/person, and that, subcategories for higher density office spaces might be worth considering further.

12. Other References

Besides gathering data from questionnaires, we also searched other references such as Office Space Planning Guides (see Appendix C: Other References) that might directly or indirectly address occupant load factors. Values of the occupant load factor, if not directly cited in the reference, were calculated, measured or interpreted from the references identified. In some cases we had to approximate the area of the office space from an office plan layout which didn't have any scale given. In this case we took the width of a typical door to be 36".

The categories in which we were interested in finding values of the occupant load factor were the same categories that we identified in the questionnaires. The information was extracted from planning guides, studies, recommendations and layout plans of office space as referenced. We will present plot of the values extracted from our references shown in Appendix C: Other References

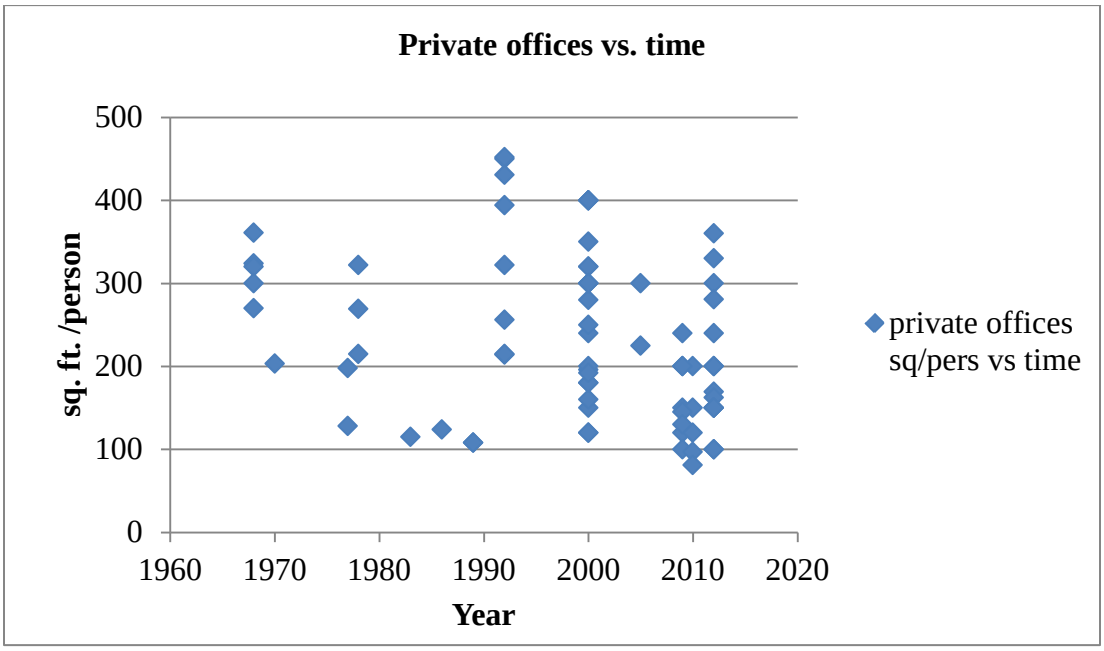


Figure 14 Other references: Private Offices vs. Time

As it can be seen from Figure 14 above, the values of the occupant load factor for Private offices with floor to ceiling partitions have a range between 100-450ft^2/person. An important aspect to mention here is that most of the values are above 100ft^2/person.

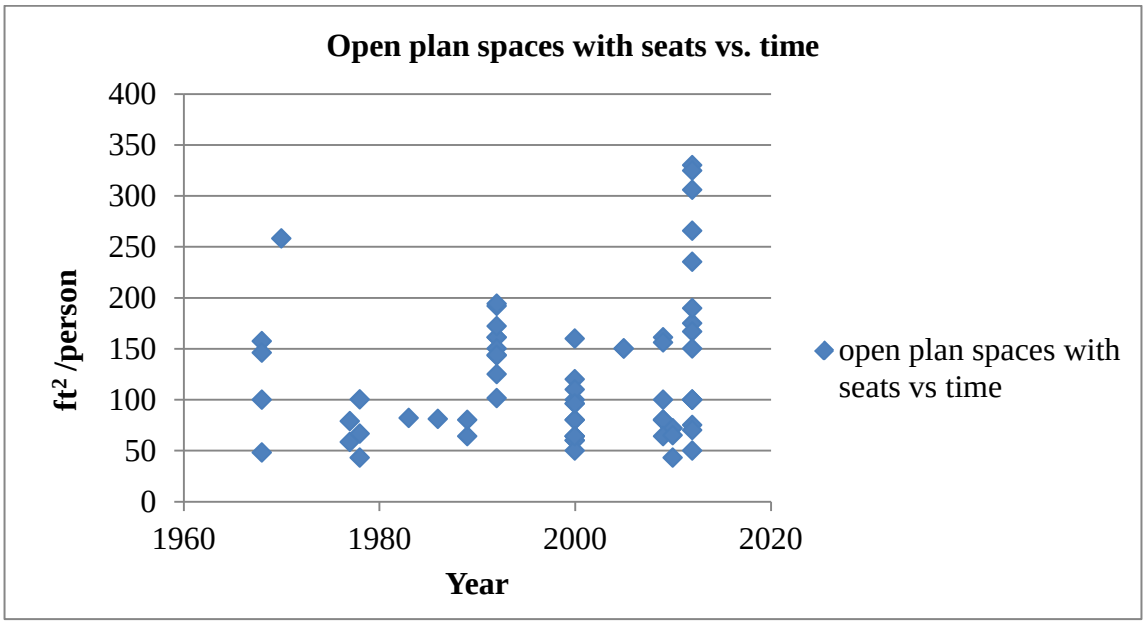


Figure 15 Other references: Open Plan Spaces with Seats vs. Time

In this graph of the occupant load factor for Open plan spaces with seating vs. Time, we can see that the trend is going up, however the values are divided. Half of the values are above 100ft^2/person while the other half is below. This will enforce our conclusion of increasing the occupant load factor while proving a subcategory with a value below 100ft^2/person.

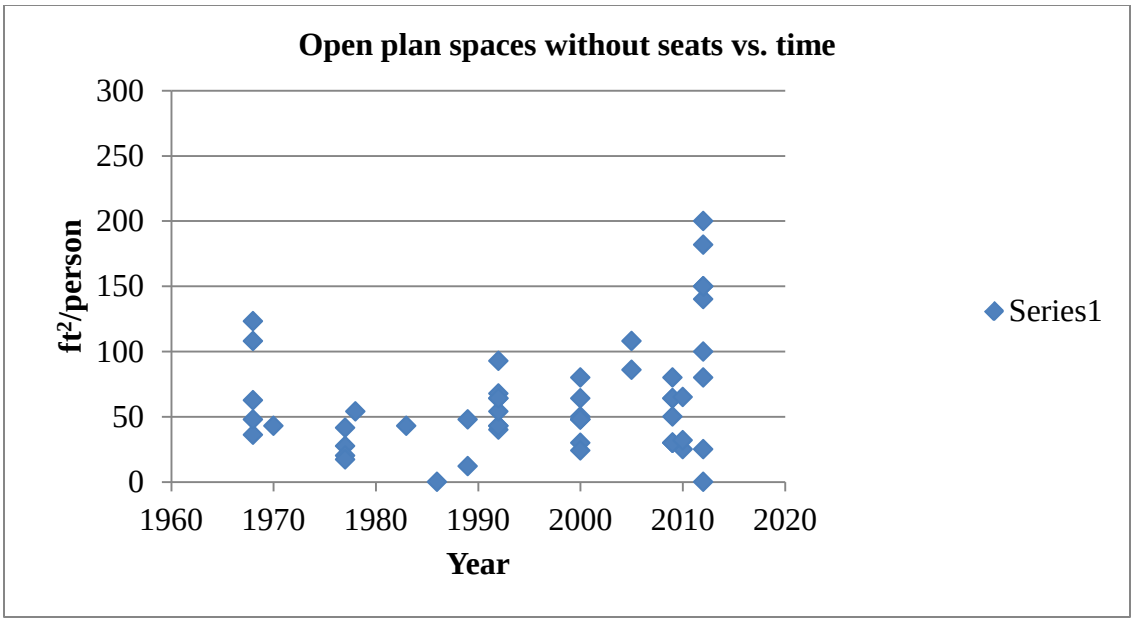


Figure 16 Other references: Open Plan Spaces without Seats vs. Time

Figure 16 shows the variation of occupant load factor open plan office space without seats vs. time. These values were determined from recommendations given in the references studied, not from approximating of office plan layouts or similar resources. We notice that now more values are below the value of 100ft^2/person. However the trend shows the value going up, still for the 2010 data most of the values are below 100ft^2/person.

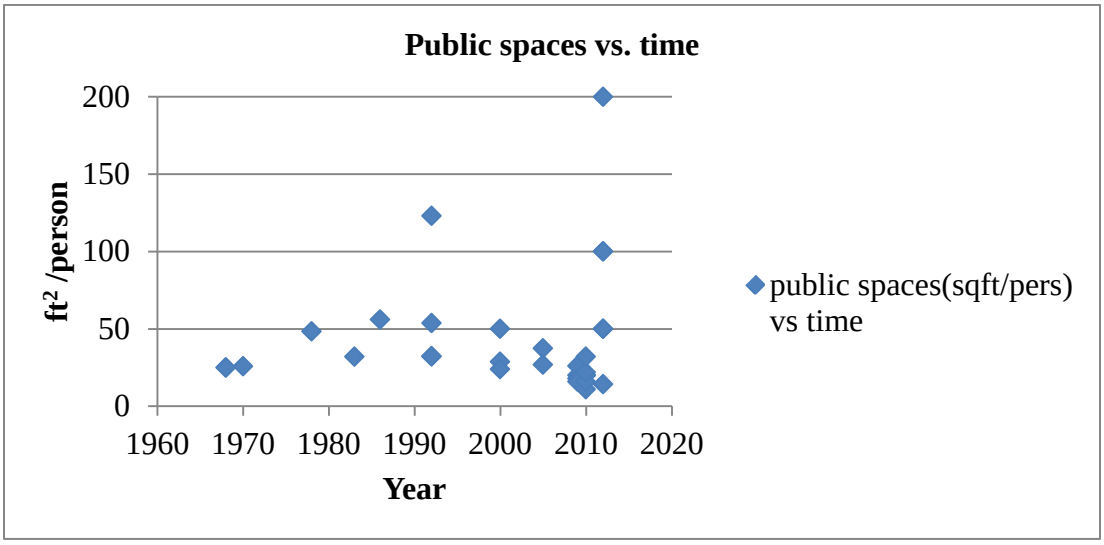


Figure 17 Other references: Public Spaces vs. Time

For the value of the occupant load factor for public space the value for the occupant load factor is very much below 100ft^2/person. This might have happened because many of the public spaces might have been confused with assembly spaces in our references. Nevertheless the graph shows the values extracted from the references shown in Appendix C: Other References.

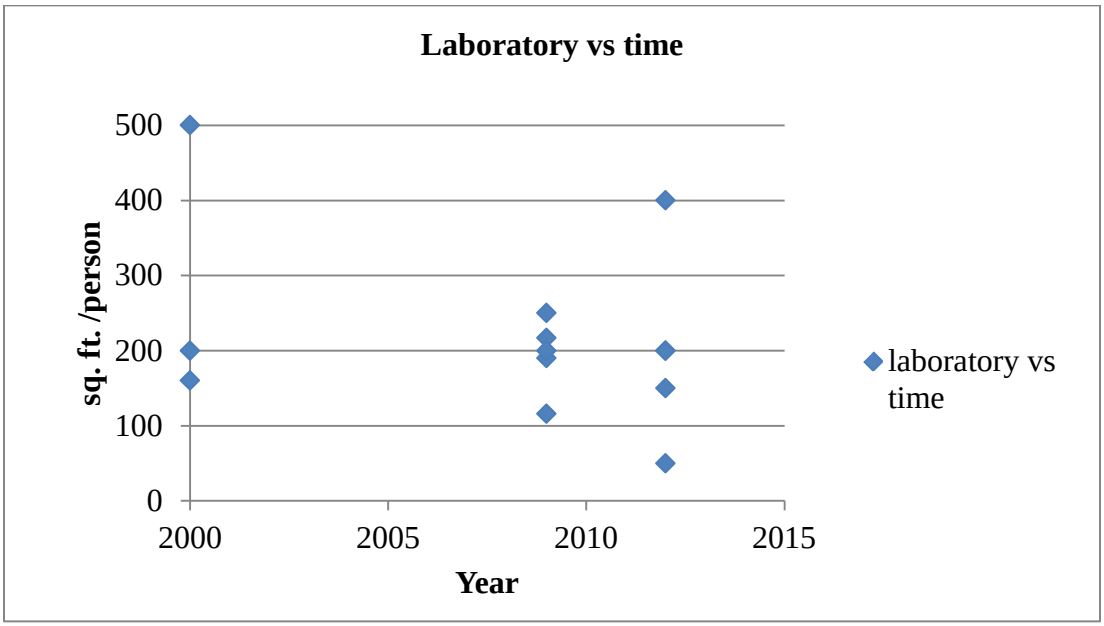


Figure 18 Other references: Laboratory Spaces vs. Time

The last graph shows the variation of the occupant load factor for laboratory spaces. These category has proven the most difficult to gather data for; however, for this type of spaces the occupant load factor is above 100ft^2/person with a rising trend, at least from our references.

In the next section we will draw our conclusion from the data shown so far which will encompass the review of previous studies, planning guides, questionnaires done as well as these latest references analyzed.

13. Conclusion

This paper presented a study conducted to evaluate the current applicability of the occupant load factor of 100ft^2/person as presented in the latest edition of the Life Safety Code. In evaluating this value we conducted literature research in the form of past studies, current studies, as well as current planning guides and guidelines of office space design of certain institutions. After evaluating these studies we decided that the business occupancy use should be divided into more than one category. In order to encompass every office type we created five categories of office space use. These reflect the way different office types are constructed and used as well as our personal understanding of office space design. The categories are as follows:

1. Private offices with closed floor to ceiling partitions
2. Open plan spaces with seating and opened (no doors provided) floor to ceiling partitions
3. Open plan spaces with limited or no seating with or without semi partitions
4. Public access spaces such as entrance lobbies etc.
5. Laboratory function spaces either wet or dry type.

We tried to gather present data of the occupant load factor for these categories. This was done through questionnaires. The questionnaires were sent to architects, real estate agents and building owners/managers. The results lack the ability to suggest clearly defined occupant loads for the categories presented; however the trend of the occupant load factor being higher than 100ft^2/person for most of the categories was enforced.

Our conclusion is drawn based on the fact that all of the previous studies, although encompassing a period of 70+ years (i.e. from 1935) show that the occupant load factor is higher than the value

of 100ft^2/person. The questionnaires that were conducted, although they didn't show conclusive data due to the poor response rate, did support the notion that the value of the occupant load factor should be greater than 100ft^2/person for most of the categories chosen. For this reason and in light of the past studies and references presented, we conclude that, in our opinion, the occupant load factor should be increased to 150ft^2/person. Note that the average occupant load for business uses from previous studies is 204 ft^2/person as discussed earlier in the report.

Until now we only talked about increasing the value of the occupant load factor, however we need to account for the few values that we got below 100ft^2/person. For this reason and seeing that this value occurs for high density spaces (e.g. call centers), we propose that a new category be formed to account for high density spaces. The value for the occupant load factor for this category should be somewhat conservative. The least amount of work space per person we encountered (i.e. in office furniture as well as recommended values) was 25ft^2/person. For example The Northwest Territories of Canada lay out their offices on a 5ft by 5ft grid, and some of the smallest furniture workspaces provide a 5 ft by 5 ft area for individual office workers. Note however that these individual workspaces do not take into account circulation and public spaces in the office floor plate. It is also not reasonable to suggest that all concentrated work area will be provided with workspaces that provide for only 25ft^2/person. Our evaluation of Other References also suggests an occupant load factor below 100ft^2/person for these concentrated use areas. A value of 100ft^2/person is suggested with guidance language added to inform designers to prudently evaluate the type of workstations proposed for the space.

14. Recommendation

Our recommendation is that the value of the occupant load factor for general business use spaces should be increased to 150ft^2/person, and that a new category of concentrated business use be introduced with an occupant load factor or 100 ft^2/person as summarized in Table 17. It is noted however that smaller occupant load factors might be more appropriate for concentrated business use areas depending upon the size of work space anticipated, i.e. workstations as small as of 25ft^2/person are available.

Category of office space	Occupant Load Factor (ft^2/person)
General office space	150
High density spaces (e.g. call centers)	100

Table 17 Summary of recommendation

.

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Appendix A: 1922 Committee on Safety to Life Proceedings

stairs are 44" wide between faces of walls or 40" between face of wall and open balustrade; maximum rise 7¾"; minimum tread excluding nosing 9½".)

54. Stair enclosures grades 5 or 6 may be substituted for requirements of §26. *(Reference to section of the Code not yet ready, to be incorporated when adopted. No. 5 enclosure is wired glass with metal framing. No. 6 is wood covered with metal lath and cement plaster, or plaster board covered with sheet metal.)*

55. A unit of stair width may be taken as 18" instead of 22" as specified in §35.

EXITS CODE FOR OFFICE BUILDINGS.

Your Committee has felt that the development of an exits code for office buildings followed logically after the factory and department store codes already approved in 1918 and 1921 respectively. No code is submitted for approval at this meeting, but we do present a brief statement of the problem as the committee sees it, and we ask the co-operation of the Association membership, especially along lines of constructive criticism.

The first problem that arose was the maximum population of a building at any one time, especially from the second floor up, as persons in the second story and above would use the stair system. As with department stores, we found that there was very little data. Counts of persons in and out of buildings during a working day, or total elevator counts, did not give maximum population at one time. Hence the committee planned to count all persons in and out representative buildings, and by recording at frequent intervals the difference, establish the actual occupancy at those periods. This was done with twelve office buildings in Philadelphia, including all the largest and several representative older and moderate sized structures. The fire department and the fire marshal loaned us men for this purpose.

In New York, the fire department made counts of the number of persons in several representative buildings during business hours, and certain other data regarding the number of employees of tenants is available through post office department registers which certain managements maintain.

While the committee has not yet sufficient data to justify any final conclusion, it believes tentatively that it will be wise to figure 100 sq. ft. of gross area per person as the basis upon which stair capacity shall be established. The gross area rather than rentable area has been selected as a basis, because rentable area may vary from time to time, and, because, generally speaking, there is a fairly constant ratio between gross and rentable area.

Congested Occupancies.

The committee realizes that certain occupancies, notably large aggregations of clerks of banks, insurance companies, railroads, and others, may materially increase the density of population and that certain provisions may have to be made to meet this situation. The 100 sq. ft. figure is for a miscellaneous tenancy office building.

As regards the hazard class, the committee feels that the office building belongs in the same class with the low hazard factory.

Figure 19 Year 1922's Committee on Safety to Life Proceedings

Appendix B: 1924 Committee on Safety to Life Proceedings

CODE SIGNALS.

1017. Code signals indicating where the alarm originates should not be used except where needed to indicate the choice of exits. In such cases the occupants shall be drilled in the interpretation of code signals.

NOTE. It is often advisable to give code signals to those in authority and those who will assist the occupants in leaving the building—as, for example, to principals, superintendents, managers, engineers, members of private fire brigades, etc.

CONNECTIONS TO MUNICIPAL DEPARTMENTS.

1018. Alarm systems in localities under protection of regularly organized fire departments or private fire brigades should be arranged to cause automatic transmission of alarms to such fire departments or brigades upon operation of any alarm sending station if the area protected by the system is subject to use by 100 or more persons.

NOTE. When no such connection is provided, it is recommended that a municipal fire alarm box be installed either at the main entrance to the building or at the nearest street corner if plainly visible from the main entrance and not more than 300 ft. distant therefrom.

1019. Automatic fire department connections (§1018) shall be so arranged as to permit drills to be conducted by those in authority without calling out the fire department, and so that the actuation of any required alarm sending station will surely call such department.

PART B.

OCCUPANCY EGRESS REQUIREMENTS.

Section 20.

GENERAL REQUIREMENTS.

Introduction.

2000. The following "Occupancy Sections" indicate the manner in which the various standards given in Part A should be applied to the several occupancies. In all cases where there may be differences between the requirements of the Occupancy Sections and those of the various "Engineering Standards" in Part A the provisions of the Occupancy Sections take precedence.

2001. The fundamental principle of the code is to provide exits sufficient to empty buildings promptly in case of fire, and to provide for construction and protection such that buildings may be emptied without danger to life by fire, smoke, or resulting panic. Property damage is not the concern of this code, although many of the requirements for life safety will incidentally contribute towards fire safety for property.

2002. The several Occupancy Egress Sections specify certain minimum standards of construction and protection; buildings not complying with these minimum standards are not considered safe no matter what exit facilities are provided. For buildings which comply with these minimum requirements rules are made specifying the number and character of exits required which vary in accordance with the occupancy and the safety of the building.

2003. Fundamental principles of this Code are that there must always be two ways of escape, exits being as remote from each other as possible, and that there must always be an available exit within a reasonable short distance.

2004. The number of persons allowed on each floor (except ground floors, which are treated separately) is in general determined by the formula given in §2013 which it will be noted varies the relation between the population and the exits in accordance with the occupancy, character

of construction, protection and various other features which have bearing on life safety. This formula is applied to all buildings, subject to suitable modifications for special occupancies. It governs the relation between population and exits. In occupancies such as factories where control of the population is possible, the occupants are limited in accordance with the exits. In other occupancies, such as department stores, where no control of the population is possible, the average maximum density of population has been determined by counts and reduced to a figure which represents the most dense population likely to occupy a given area. Exits are then specified accordingly.

2005. The assumptions used in developing the formula §2013 are as follows:

(*a*) Rate of travel down stairways, 45 persons per minute per unit of stairway width.

(*b*) Average capacity of stairway enclosures from floor to floor per unit of stairway width, 15 persons. This is an approximation based on an average story height of 14 ft., one person standing on every other step of the stairs, and a landing area within the enclosure of 16 sq. ft. per story per unit of stairway width, in which people can stand on the basis of one person for every four square feet.

(*c*) One third of the stairways unavailable by reason of fire or smoke. On this basis the average capacity per floor of stairway enclosures is reduced from fifteen to ten persons.

2006. The formula §2013 represents a practical compromise between two recognized methods of determining exit capacity. The first is the principle that exits should be sufficient to provide for getting all the people out of a building in some specified maximum time, this being usually two or three minutes in the case of schools, theatres, etc. The other theory is that if the stairways are provided with fire-resistive enclosures the population of the building is safe when once inside the stairway enclosure, that if the stairway enclosures are sufficient to accommodate the entire population of the building there is no need for any time limit of emptying. It is obvious that neither of these principles has unlimited application; the time limit rule, for example, not being applicable to very high buildings of the better type, whereas to require that stair enclosures be large enough to accommodate all or nearly all of the population would not be reasonable for a two or three story building. The results of this formula it will be found approximate the results of a "time of emptying" rule for low buildings and the rule based on the accommodation of the population in the stair enclosure for a higher structure.

GENERAL REQUIREMENTS.

2010. The following general requirements apply to buildings of all occupancies, subject to the detailed specifications of the several occupancy sections. Where there are differences between these general requirements and those of the several occupancy sections following, the provisions of the occupancy sections take precedence for the specific occupancies to which they apply.

NOTE. Each occupancy section will be found to be complete in itself so that except where specific cross references are given it will not be necessary to refer to this section in the application of the code. The primary purpose of this section is to establish (in convenient form for reference) the fundamental principles on which the following occupancy sections are based.

2011. From every building or section there shall always be two ways of escape, exits being as remote from each other as practicable.

2012. The exits shall be so arranged that the maximum travel to reach them is as follows:

High hazard occupancy,	75 ft.
Moderate hazard occupancy,	100 ft.
Low hazard occupancy,	150 ft.

(For classification of occupancy hazard see §§2017-2021.)

2013. The relation between the maximum number of persons on each floor (except the street or ground floor which is treated separately by §2014) and the exits shall be determined by the following formula, subject to the provisions of the several occupancy sections. (In some occupancy sections will be found other formulas derived from this basic formula, which take the place of the formula for the occupancies covered.)

$$N = \frac{A \times B \times C \times D \times E \times F^*}{H}$$

Where

N=No. of persons permitted on each floor above the first. [This assumes equal population on each floor; see also §2320.]

A=No. of units of stair width (One unit=22 inches). [Ramps or other types of exit may be substituted for stairs if desired, subject to the rules applying.]

B—Building Construction
Ordinary .....B=4
Mill or Fire Resistive.....B=5
[This means that a building of mill or fire-resistive construction is entitled to 25% more population for given exits than a similar building of ordinary construction.]

C—Protection of Vertical Openings
Open Stairs .....C=2
Stairs enclosed but other vertical openings not protected .....C=4
Stairs enclosed and all other vertical openings protected .....C=5
[The building with stairways enclosed is entitled to 100% more population for given exits than the building with open stairs, and a building with all vertical openings (such as elevator shafts) as well as stairs enclosed is entitled to 150% greater population than the same building with open stairs.]

D—Automatic Sprinkler Protection
Unsprinklered .....D=1
Sprinklered .....D=2
[The buildings with automatic sprinkler protection may have twice the population for given exits that is allowed in the unsprinklered building.]

E—Horizontal Exits
None .....E=2
One .....E=3
Two or more .....E=4
[For description of horizontal exits see Section 4, and §402 for explanation of credits.]

F—Occupancy
Low Hazard .....F=3
Moderate Hazard .....F=2
High Hazard .....F=1
[These values of F show the relative populations permitted for given exits under the three occupancy classifications. See §§2017-2021.]

H=Number of stories [As this factor works out in the formula, if a two-story building were of such size as to require two stairways, a similar three-story building of the same occupancy would require three stairways, a four-story building four stairways, etc.]

Make separate calculation for floors below grade and in such cases for basement use value H=3. For sub-basement H=5. [A basement is considered to have the same life hazard as the third story, and a sub-basement the same hazard (and accordingly the same exits) as the fifth story.]

But N shall never be less than 10 A, provided that the stairs are enclosed. [This means that in high buildings where the number of required stairways increases with the height, it is not required to provide additional stairways beyond the point where all the population can be accommodated in the stairway enclosure.]

For table giving results of this formula see §2022.

NOTE: It should be noted that the absolute values of the factors B, C, D, E, and F have no significance. The ratio between them is what counts.

*This formula will be further considered by the committee, and is subject to change as respects arrangement and values of the several factors.

2014. The street or ground floor exits shall be determined by the following formula. (In some occupancy sections will be found other formulas, derived from this basic formula, which take the place of this formula for the occupancies covered):

$$N = 60 \times A \times F^*$$

Where,

N=Maximum number of persons on street or ground floor.
A=No. of units of doorway width. (See §504.)
F—Occupancy. (See §§2017-2021.)
Low Hazard, F=3.
Moderate Hazard, F=2.
High Hazard, F=1.

NOTE. The doors specified by this paragraph are for the first floor population and are in addition to those required at the foot of stairways.

2015. The maximum height of buildings shall be in accordance with the following formula, subject to the provisions of the several occupancy sections.

$$\text{Maximum height} = B+C+2D+E+F-10^*$$

The terms have the same value as defined in §2013. Basements shall be limited the same as three story buildings and sub-basements the same as five story buildings. Buildings exceeding the height limit shall not be used for any except storage purposes, in the stories above the height limits. But, new or existing buildings of fire-resistive construction, with sprinkler protection and all vertical openings enclosed or protected, may be used for low or moderate hazard occupancy, to any height, provided such buildings over ten stories and used for moderate hazard occupancy shall have horizontal exits.

For tabulation showing results obtained from this formula see §2022.

NOTE. This height limitation is based solely on the safety of the occupants. It is recognized that lower maximum limits will and should be provided by building codes from the standpoint of property hazard, conflagration hazard, light and air, and city planning.

2016. Existing buildings may be allowed one third higher than the height determined by the formula §2015; where this gives a fractional result the nearest whole number shall be taken.

Occupancy Classification.

2017. The hazard of occupancy of buildings shall be determined in accordance with the following paragraphs, subject to the provisions of the occupancy sections applying. (The several occupancy sections in general classify the hazards of the specific occupancies treated.) For some occupancies, such as factories, the hazard of the materials stored or used varies widely and the occupancy classification should be varied accordingly by the enforcing authority.

NOTE. The hazard of the contents of a building is an important factor in life safety and in the exits required. (See §2013.)

*This tentative formula will be further considered by the committee and is subject to change as respects arrangement and values of the several factors.

2018. Where more than one occupancy classification hazard is found in a single building, the most hazardous occupancy found shall govern exit construction and height requirements, except that where higher hazard occupancies are found on upper floors and lower hazard occupancies are found on lower floors, so that the safety of egress of the population of the lower hazard area will not be endangered by fire in the higher hazard area, exceptions may be made by the enforcing authority.

2019. LOW HAZARD occupancies are those having contents which do not ordinarily burn rapidly or with excessive smoke and from which neither poisonous fumes or explosions are to be feared in case of fire.

The following list indicates the types of occupancy coming within this class:

Schools.
Office Buildings.
Industrial properties with occupancies such as:

Asbestos.
Baking Powder.
Black lead.
Buttons (pearl or bone).
Canneries (for fish, fruit, and vegetables).
Chalk and crayon.
Condensed and powdered milk.
Electrolytic reducing works.
Glass.
Glue, mucilage, paste, and size.
Ivory.
Leather (excluding boots and shoes and japanning or enameling).
Metals (excluding japanning or enameling).
Porcelain and pottery.
Talc and soapstone.
Tanneries (excluding japanning or enameling).

2020. MODERATE HAZARD occupancies are those having contents which are liable to burn with moderate rapidity and to give off a considerable volume of smoke, but from which neither poisonous fumes nor explosions are to be feared in case of fire.

The following list indicates the types of occupancy coming within this class:

Department Stores.
Industrial properties with occupancies such as:

Bags (cloth, burlap, and paper).
Bagging and burlap.
Bakeries.
Baskets.
Belting (canvas).
Boots and shoes.
Buttons (metal or cloth covered).
Canvas.
Cardboard.
Carpets and rugs.
Clothing (woolen).
Cordage.
Furs.
Hair goods.

Horn and combs (not pyroxylin plastic).
Packing houses.
Paper mills.
Printing, lithographing, bookbinding.
Soap.
Textile mills.
Tobacco, cigars, cigarettes, and snuff.
Woodworking (excluding dipping or varnishing).

2021. HIGH HAZARD are those having contents which are liable to burn with extreme rapidity or from which poisonous fumes or explosions are to be feared in the event of fire.

The following list indicates the types of occupancy coming within this class:

Dry Cleaning Establishments.
Industrial properties with occupancies such as:
Artificial flowers.
Artificial leather.
Carpet linings.
Celluloid.
Cereal mills.
Chemicals of all kinds (except where serious flame, fume, or explosion hazards are not present).
Clothing (cotton).
Cotton batting.
Cotton waste.
Explosives.
Feather renovating.
Feed, flour, and grist mills.
Fireworks.
Japanning or Enameling.
Imitation Leather.
Matches.
Rag sorting (cotton).
Shoddy mills.
Starch mills.
Straw goods.
Varnish.
Woodworking (with dipping or varnishing).

Tabulation.

2022. For convenience the formulae of §§2013 and 2015 are expressed in the following table which gives the number of persons allowed on each floor per unit of stair width (= N/A in the formula). The values given are for buildings within the height limitations. Where no figure appears the building is not permitted by §2015 to be used for any except storage purposes. Where the figure appears in parenthesis this applies to existing buildings only (see §2016). This table may also be used in solving the several formulae for stairways, etc., given in the following occupancy sections, subject to the explanatory notes given in each case.

2022. STAIRWAY AND HEIGHT REQUIREMENTS

Construction	Vertical Opening Protection	Horizontal Exits	Height in Stories	No. Persons per Floor, per Unit of Stair Width					
				High Hazard		Moderate Hazard		Low Hazard	
				Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.
Ordinary	Open	None	2		16	16	32	24	48
			3		11	(11)	22	16	32
			4		(8)		16	(12)	24
			5				(13)		19
			6						(16)
			7						(14)
Ordinary	Open	One	2	12	24	24	48	36	72
			3	(8)	16	16	32	24	48
			4		12	(12)	24	18	36
			5		(10)		19	(14)	29
			6				(16)		24
			7				(14)		(21)
			8						(18)
Ordinary	Open	Two or More	2	16	32	32	64	48	96
			3	11	21	21	43	32	64
			4	(8)	16	16	32	24	48
			5		13	(13)	26	19	38
			6		(11)		21	(16)	32
			7		(9)		(18)	(14)	27
			8				(16)		(24)
			9						(21)
Ordinary	Stairs Enclosed but Other Vertical Openings not Protected	None	2	16	32	32	64	48	96
			3	11	21	21	43	32	64
			4	(10)	16	16	32	24	48
			5		13	(13)	26	19	38
			6		(11)		21	(16)	32
			7		(10)		(18)	(14)	27
			8				(16)		(24)
			9						(21)

2022. STAIRWAY AND HEIGHT REQUIREMENTS (Continued)

Construction	Vertical Opening Protection	Horizontal Exits	Height in Stories	No. Persons per Floor, per Unit of Stair Width					
				High Hazard		Moderate Hazard		Low Hazard	
				Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.
Ordinary	Stairs Enclosed but Other Vertical Openings not Protected	One	2	24	48	48	96	72	144
			3	16	32	32	64	48	96
			4	12	24	24	48	36	72
			5	(10)	19	19	38	29	58
			6		16	(16)	32	24	48
			7		(14)	(14)	27	(21)	41
			8		(12)		(24)	(18)	36
			9				(21)		(32)
			10						(29)
			11						(26)
Ordinary	Stairs Enclosed but Other Vertical Openings not Protected	Two or More	2	32	64	64	128	96	192
			3	21	43	43	85	64	128
			4	16	32	32	64	48	96
			5	13	26	26	51	38	77
			6	(11)	21	21	43	32	64
			7	(10)	18	(18)	36	28	55
			8		(16)	(16)	32	(24)	48
			9		(14)		(28)	(21)	43
			10				(26)		(38)
			11				(23)		(35)
			12						(32)
Ordinary	Stairs Enclosed and All Other Vertical Openings Protected	None	2	20	40	40	80	60	120
			3	13	27	27	53	40	80
			4	10	20	20	40	30	60
			5	(10)	16	16	32	24	48
			6		13	(13)	27	20	40
			7		(11)	(11)	23	(17)	34
			8		(10)		(20)	(15)	30
			9				(18)		(27)
			10						(24)
			11						(22)

2022. STAIRWAY AND HEIGHT REQUIREMENTS (Continued)

Construction	Vertical Opening Protection	Horizontal Exits	Height in Stories	No. Persons per Floor, per Unit of Stair Width					
				High Hazard		Moderate Hazard		Low Hazard	
				Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.
Ordinary	Stairs Enclosed and All Other Vertical Openings Protected	One	2	30	60	60	120	90	180
			3	20	40	40	80	60	120
			4	15	30	30	60	45	90
			5	12	24	24	48	36	72
			6	(10)	20	20	40	30	60
			7	(10)	17	(17)	34	26	51
			8		(15)	(15)	30	(23)	45
			9		(13)		(26)	(20)	40
			10				(24)		(36)
			11				(22)		(33)
			12						(30)
Ordinary	Stairs Enclosed and All Other Vertical Openings Protected	Two or More	2	40	80	80	160	120	240
			3	27	53	53	107	80	160
			4	20	40	40	80	60	120
			5	16	32	32	64	48	96
			6	13	27	27	53	40	80
			7	(11)	23	23	46	34	69
			8	(10)	20	(20)	40	30	60
			9		(18)	(18)	36	(27)	53
			10		(16)		(32)	(24)	48
			11		(15)		(20)	(22)	(44)
			12				(27)		(40)
			13						(37)
Mill or Fire Resistive	Open	None	2	10	20	20	40	30	60
			3	(7)	13	13	27	20	40
			4		10	(10)	20	15	30
			5		(8)		16	(12)	24
			6				(13)		20
			7				(11)		(17)
			8						(15)

2022. STAIRWAY AND HEIGHT REQUIREMENTS (Continued)

Construction	Vertical Opening Protection	Horizontal Exits	Height in Stories	No. Persons per Floor, per Unit of Stair Width					
				High Hazard		Moderate Hazard		Low Hazard	
				Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.
Mill or Fire Resistive	Open	One	2	15	30	30	60	45	90
			3	10	20	20	40	30	60
			4	(8)	15	15	30	23	45
			5		12	(12)	24	18	36
			6		(10)	(10)	20	(15)	30
			7		(9)		(17)	(13)	26
			8				(15)		(23)
			9						(20)
Mill or Fire Resistive	Open	Two or More	2	20	40	40	80	60	120
			3	13	27	27	53	40	80
			4	10	20	20	40	30	60
			5	(8)	16	16	32	24	48
			6	(7)	13	(13)	27	20	40
			7		(11)	(11)	23	(17)	34
			8		(10)		(20)	(15)	30
			9				(18)		(26)
			10						(24)
			11						(22)
Mill or Fire Resistive	Stairs Enclosed but Other Vertical Openings not Protected	None	2	20	40	40	80	60	120
			3	13	27	27	53	40	80
			4	10	20	20	40	30	60
			5	(10)	16	16	32	24	48
			6		13	(13)	27	20	40
			7		(11)	(11)	23	(17)	34
			8		(10)		(20)	(15)	30
			9				(18)		(27)
			10						(24)
			11						(22)

2022. STAIRWAY AND HEIGHT REQUIREMENTS (Continued)

Construction	Vertical Opening Protection	Horizontal Exits	Height in Stories	No. Persons per Floor, per Unit of Stair Width					
				High Hazard		Moderate Hazard		Low Hazard	
				Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr
Mill or Fire Resistive	Stairs Enclosed but Other Vertical Openings not Protected	One	2	30	60	60	120	90	180
			3	20	40	40	80	60	120
			4	15	30	30	60	45	90
			5	12	24	24	48	36	72
			6	(10)	20	20	40	30	60
			7	(10)	17	(17)	34	26	51
			8		(15)	(15)	30	(23)	45
			9		(13)		(26)	(20)	40
			10				(24)		(36)
			11				(22)		(33)
			12						(30)
Mill or Fire Resistive	Stairs Enclosed but Other Vertical Openings not Protected	Two or More	2	40	80	80	160	120	240
			3	27	53	53	107	80	160
			4	20	40	40	80	60	120
			5	16	32	32	64	48	96
			6	13	27	27	53	40	80
			7	(11)	23	23	46	34	69
			8	(10)	20	(20)	40	30	60
			9		(18)	(18)	36	(27)	53
			10		(16)		(32)	(24)	48
			11		(15)		(29)	(22)	(44)
			12				(27)		(40)
			13						(37)

2022. STAIRWAY AND HEIGHT REQUIREMENTS (Continued)

Construction	Vertical Opening Protection	Horizontal Exits	Height in Stories	No. Persons per Floor, per Unit of Stair Width					
				High Hazard		Moderate Hazard		Low Hazard	
				Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.
Mill or Fire Resistive	Stairs Enclosed and All Other Vertical Openings Protected	None	2	25	50	50	100	75	150
			3	17	33	33	67	50	100
			4	13	25	25	50	38	75
			5	10	20	20	40	30	60
			6	(10)	17	17	33	25	50
			7	(10)	14	(14)	29	21	43
			8		(13)	(13)	25	(19)	38
			9		(11)		22[1]	(17)	33
			10				20		30[2]
			11				(18)		27
			12						25
			13						23
			14						21
			15						20[3]
Mill or Fire Resistive	Stairs Enclosed and All Other Vertical Openings Protected	One	2	38	75	75	150	113	225
			3	25	50	50	100	75	150
			4	19	38	38	75	56	113
			5	15	30	30	60	45	90
			6	13	25	25	50	38	75
			7	(11)	21	21	43	32	64
			8	(10)	19	(19)	38	28	46
			9		(17)	(17)	33	(25)	50
			10		(15)		30[2]	(23)	45
			11		(14)		27	(20)	41[4]
			12				25		38
			13				23		35
			14				21		32
			15				20		30
			16				19		28
			17				18		27
			18				17		25
			19				16		24
			20				15[3]		23[3]

[1] Applies only to fire resistive buildings. For mill construction height limit is 8 stories for new and 11 stories for existing buildings.

[2] Applies only to fire resistive buildings. For mill construction height limit is 9 stories for new and 12 stories for existing buildings.

2022. STAIRWAY AND HEIGHT REQUIREMENTS (Continued)

Construction	Vertical Opening Protection	Horizontal Exits	Height in Stories	No. Persons per Floor, per Unit of Stair Width					
				High Hazard		Moderate Hazard		Low Hazard	
				Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.	Not Sprklr.	Sprklr.
Mill or Fire Resistive	Stairs Enclosed and All Other Vertical Openings Protected	Two or More	2	50	100	100	200	150	300
			3	33	67	67	133	100	200
			4	25	50	50	100	75	150
			5	20	40	40	80	60	120
			6	17	33	33	67	50	100
			7	14	29	29	57	43	86
			8	(13)	25	25	50	38	75
			9	(11)	22	(22)	44	33	67
			10		(20)	(20)	40	(30)	60
			11		(18)	(18)	36[4]	(27)	55
			12		(17)		33	(25)	50[6]
			13				31		46
			14				29		43
			15				27		40
			16				25		38
			17				23		35
			18				22		33
			19				21		32
			20				20		30
			21				19		29
			22				18		27
			23				17		26
			24				17		25
			25				16		24
			30				13		20
			40				10[7]		15[8]

[3] No height limit for fire resistive buildings in this class. Values in this column above 15 stories are: 16, 17, 18, 19, 20 stories, 19, 18, 17, 16, 15 respectively; 21 and 22 stories, 14; 23 and 24 stories, 13; 25 and 26 stories, 12; 27 and 28 stories, 11; 29 stories or higher, 10.

[4] Applies only to fire resistive buildings. For mill construction height limit is 10 stories for new and 13 stories for existing buildings.

[5] No height limit for fire resistive buildings in this class. Values in this column above 20 stories are: 21 stories, 21; 22 and 23 stories, 20; 24 stories, 19; 25 stories, 18; 30 stories, 15; 45 stories or higher, 10.

[6] Applies only to fire resistive buildings. For mill construction height limit is 11 stories for new and 14 stories for existing buildings.

[7] No height limit for fire resistive buildings in this class. For buildings over 40 stories, number persons per floor per unit stair width = 10.

[8] No height limit for fire resistive buildings in this class. For buildings over 40 stories, values in this column are: 50 stories, 12; 60 stories or higher, 10.

Appendix C: Other References

A	Private offices with floor to ceiling partitions
B	Open plan spaces with limited or no seating, i.e. workrooms, copy machine/printing, mail rooms (do not include break rooms or lunch rooms)
C	Open plan spaces with seating, i.e. low height cubicles, call centers, electronic data processing
D	Laboratory function spaces either wet or dry type
E	Public access spaces such as entrance lobbies, waiting areas, etc.

	Reference	A	B	C	D	E
		ft^2/person	ft^2/person	ft^2/person	ft^2/person	ft^2/person
1	"The ergonomics payoff" by I. Lueder, Rani, 1986	124.0	43-59	81.0		56-32
2	Brill (Bosti) 1983	115.0	43.0	82.0		
3	"Planning the office landscape" by Alvin E. Palmer 1977	198.0	27.5	78.8		
4	x[56]	128.0	41.5	58.5		
5	x		20.1			
6	x		17.3			
7	"A rational approach to office planning" by M. Arthur Gensler 1978	215.0	54.0	66.7		
8	x	322.0		100.3		
9	x	269.0		43.0		48.4
10	"Office planning and design desk reference" by James E. Rapport 1992	256.0	40.0	192.0		

[56] x = the same reference

12	x	450.0	92.8	125.0		
13	x	214.0		101.3		
14	x	215.0	64.0	161.0		32.3
15	x	322.0	43.0	161.0		32.3
16	x	452.0	43.0	172.0		123.0
17	x	430.5	54.0	194.0		53.8
18	x	394.0	67.7	143.3		
19	x		64.0	150.0		
20	x			144.0		
21	"Designing the Cost-Effective Office) by Jack M. Fredrickson 1989	108.0	48.0	64.0		
22	x	108.0	12.0	80.0		
23	"Office planning and design" by Michael Saphier1968	324.0	108.0	157.5		
24	x	360.8	123.3	146.0		25.0
25	x	320.0	62.5	100.0		25.0
26	x	270.0	36.0	48.0		
27	x	300.0	48.0			
28	"Profit Through Design" by Maurice Mogulescu 1970	516.0	43.0	258.0		25.9
29	x	203.3				
30	Space Planning: How Much Space Do YouReally Need? by Ned Fennie, Jr. January 2005	300.0	108.0	150.0		37.5
31	x	225.0	86.0	150.0		26.8
32	University of Michigan (recommended NASF)	400.0	80.0	160.0		
33	x	300.0	64.0	100.0		
34	Idaho University Oct. 2009 (recommended NASF)	200.0	50.0	100.0		
35	Space Allocation Standards Manual Dec 2009	150.0	64.0	80.0		20.0
36	x	120.0	30.0	80.0		
37	Office Planning Guidelines Gouv. Of Manitoba, Dec. 2010	120.0	25.0	72.0		20.0
38	x	150.0				20.0

39	x	200.0				20.0
40	SPACE PLANNING POLICY AND PROCEDURES For Commonwealth of Virginia Departments, Agencies and Institutions	196.0	48.0	96.0		28.8
41		150.0	48.0	64.0		
42		120.0				
43	University of California, Berkeley Office Space Guidelines	120.0		64.0		
44	x	180.0		80.0		
45	Stanford University Space and Furniture Planning Guidelines 2009	240.0	80.0	161.0	217.0	26.0
46	x		64.0	156.0	116.0	18.0
47	x		30.0		190.0	16.0
48	Cornell	400.0		80.0	200.0	
49	x	320.0		60.0	160.0	
50	x	280.0				
51	x	200.0				
52	x	160.0				
53	State University of New York	400.0	30.0	60.0		
54	x	320.0				
55	x	300.0				
56	x	240.0				
57	x	180.0				
58	Western Interstate Commission for Higher Education	300.0		120.0		
59	x	350.0		110.0		
60	x	250.0				
62	Planning Guidelines for Office Space ARM Space Planning and Management 2009	200.0	30.0	80.0	250.0	
63	x	145.0		64.0	200.0	
64	x	130.0				
65	x	100.0				

66	UN	192.0	48.0	64.0		24.0
67	x		24.0	96.0		
68	Planning Office Spaces a practical guide for managers and designers by Juriaan van Meel, Yuri Martens, Hermen Jan van Ree 2010	97.0	32.0	43.0		11.0
69	x	81.0	65.0	65.0		16.0
70	x					22.0
71	x					32.0